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THE MOOSE PASS-HOPE DISTRICT KENAI PENINSULA, ALASKA

BY

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Investigations in Alaska Railroad belt, 1931
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NOTE.—Bulletin 849 will not be issued as a complete volume, but this chapter (the last) contains a volume title page and index for the use of those who may wish to bind together the separate chapters.

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FOREWORD

By Philip S. Smith

To help the mining industry of Alaska and to assist in the development of the mineral resources of the Territory have been the prime motives of the Geological Survey's investigations in Alaska during the past 35 years, in which nearly one half of the Territory has been covered by its reconnaissance and exploratory surveys. It was natural, therefore, that the Alaska Railroad, when it undertook intensive consideration of the problem of finding tonnage that would increase its revenues, should look to the Geological Survey to supply technical information as to the known mineral deposits along its route and to indicate what might be done to stimulate a larger production of minerals and induce further mining developments and prospecting that would utilize its service. Realization of the need for this information had long been felt by the officials responsible for the operation of the Alaska Railroad, and the need had been partly supplied by the Geological Survey, but funds to carry through an extensive inquiry of this sort had not been available until 1930, when a special committee of the Senate, composed of Senators Howell, Kendrick, and Thomas, visited Alaska, studied some of the railroad's problems, and successfully urged Congress to grant it $250,000 for investigations of this kind.

On the invitation of the Alaska Railroad the Geological Survey prepared various plans and estimates for the investigations that appeared to be most likely to contribute the desired information as to the mineral resources. Selection of the problems to be attacked proved difficult, because the choice necessarily was hedged about with many practical restrictions. For instance, each project recommended must give promise of disclosing valuable deposits—a requirement that was impossible to satisfy fully in advance, as it involved prophecy as to the unknown and undeveloped resources. Then, too, it was desirable that the search should be directed mainly toward disclosing deposits which if found would attract private enterprises to undertake their development in the near future. Finally, some of the deposits that might be worked profitably did not appear likely to afford much tonnage to be hauled by the railroad. Under these limitations it should be evident that the projects that could be recommended as worth undertaking with the funds available by no means exhausted the mineral investigations that otherwise would be well justified. In a large sense, all of Alaska may properly be regarded as indirectly contributory to the welfare of the railroad, but even in that part of Alaska contiguous to its tracks there are large stretches of country that are entirely unexplored and large areas that have had only the most cursory examination. Although areas of this sort might well repay investigation, they were excluded from the list of projects recommended because they were not known to contain mineral deposits of value, and it therefore seemed better to make the selection from other areas that had been proved to hold promise. Furthermore, several areas within the railroad zone were excluded because their value was believed to lie mostly in their prospective placers, which would not yield much outgoing tonnage; others because their lodes carried mainly base metals, for which development and the recovery of their metallic content in a readily salable condition were relatively expensive; and still others because their resources consisted mainly of granite, building stone, or some other product for which at present there is only a small local demand.

After careful consideration ten projects were selected, and the funds required for undertaking them were made available. The projects that were selected involved the examination of two areas principally valuable for their coal (Anthracite Ridge and Moose Creek), five areas likely to be principally valuable for gold (Fairbanks, Willow Creek, Girdwood, Moose Pass, and Valdez Creek), and three areas whose lodes consisted mainly of mixed sulphides (the Eureka area in the Kantishna district, Mount Eielson, formerly known as Copper Mountain, and the head of West Fork of Chulitna River). The general position of these different areas is indicated on the accompanying diagram (fig. 1). A general study of the nonmetalliferous resources of the entire region traversed by the railroad was included in the projects to be undertaken, but the results obtained were not such as to permit adequate determination of their extent at this time.

Examinations were made in the field in each of the selected areas, all the known prospects and mines being critically examined and sampled so far as time and other conditions permitted. The records thus obtained, together with all other information bearing on the problems, were then subjected to further study in the laboratory and office, in the course of which other Geological Survey specialists whose knowledge and experience could be of assistance were freely consulted. The outcome of all these lines of analysis has been the reports which make up this volume. Although each chapter is presented as embodying the latest and most authoritative information available regarding the districts and properties described up to the time field work in them

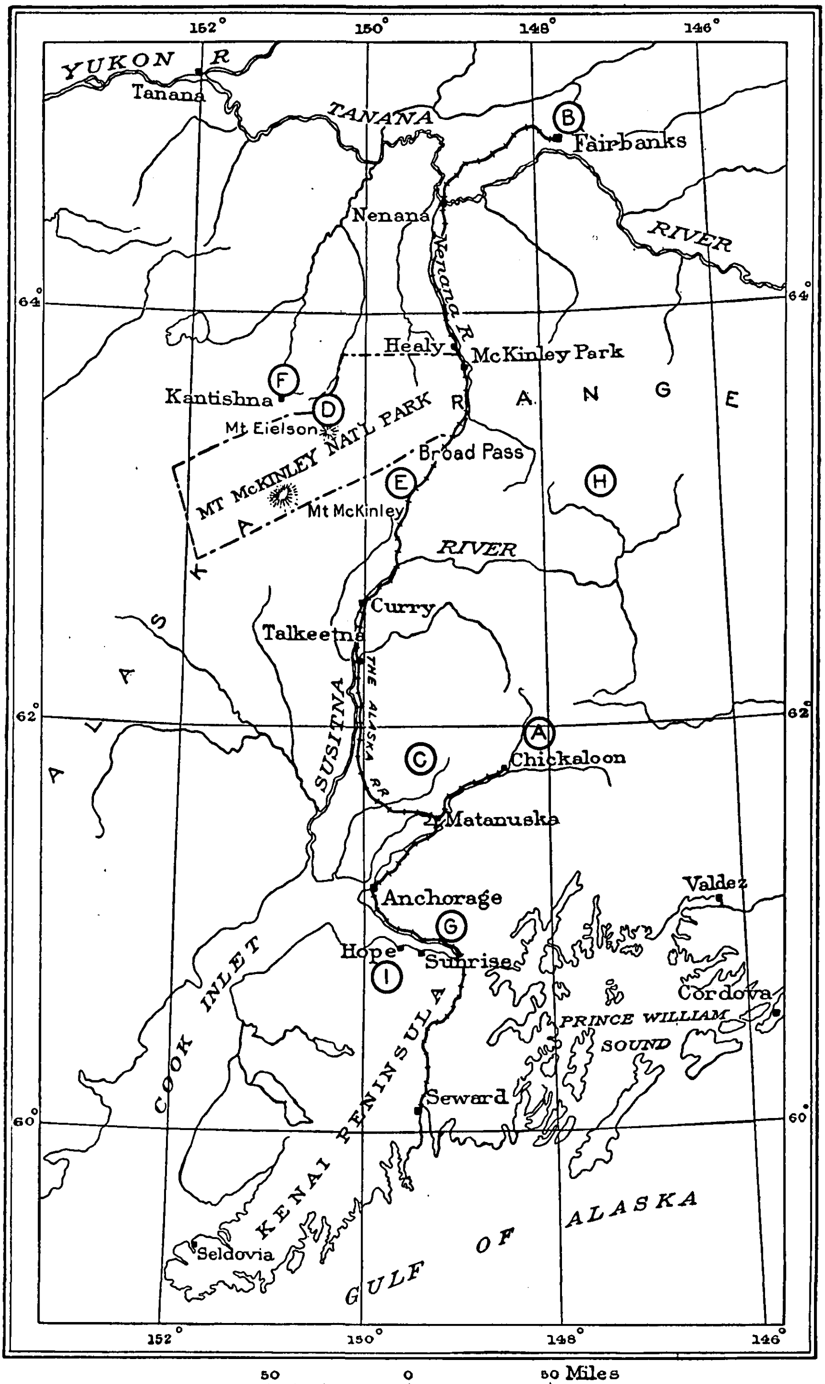

FIGURE 1.—Index map showing areas investigated in Alaska Railroad belt, 1931. A, Anthracite Ridge B, Fairbanks; C, Willow Creek; D, Mount Eielson; E, West Fork of Chulitna River; F, Eureka and vicinity; G, Girdwood; H, Valdez Creek; I, Moose Pass and Hope.

was finished, the authors make no claim that all the results they have presented are to be regarded as final nor as solving all the problems that have arisen. Actually none of the mines have been developed to such an extent as to furnish all of the evidence desired to solve the problems involved. At none of the properties is any considerable quantity of ore actually "blocked out" in the engineering sense of that term, so that instead of specific measurements as to the quantity and grade of ore the different camps will yield, the Survey geologists and engineers have necessarily had to make numerous assumptions and be content with estimates and generalizations as to the potential resources. Furthermore, the work was planned so as not to invade the proper field of the private mining engineer in the valuation of individual properties, but rather to occupy the open field of considering the districts as a whole.

In two of the districts, Anthracite Ridge and Moose Creek, whose value lay in their prospective coal resources, the examinations that could be made by ordinary geologic means were not adequate to arrive at a final judgment of the resources of the area but pointed to the desirability of further tests by drilling. As a consequence additional exploration of these districts by means of diamond drilling was authorized, and this work was undertaken in the season of 1932. The results of these tests were not available at the time the manuscripts of the other reports were completed, and rather than delay their publication until the later reports could be finished and incorporated in the volume these reports have been omitted here and will be published later elsewhere.

This is not the place to summarize the detailed findings of the geologists as to the merits of the different districts, as those findings are explained in detail and summarized in the respective chapters. Suffice it to say here that on the whole the principal purpose of the investigations was carried through satisfactorily and that while the studies in some of the districts indicate that they hold little promise of extensive mineral development in the near future, others appear to encourage development under existing conditions, and still others seem to be worth development when some of the existing factors such as transportation or price of base metals are improved. That conditions which are now temporarily retarding the development of some of the deposits will become more favorable cannot be doubted. The entire region is becoming more accessible each year, and as a result costs are being lowered and experience is being gained as to the habit of the various types of deposits, so that the conclusions expressed in this volume as to the resources of the different districts should be reviewed from time to time in the light of the then current conditions.

THE MOOSE PASS-HOPE DISTRICT, KENAI PENINSULA

By Ralph Tuck

ABSTRACT

The Moose Pass-Hope district lies in the Chugach Mountains, in the northern part of the Kenai Peninsula, directly adjacent to the Alaska Railroad and to Turnagain Arm. More than 60 miles of well-constructed roads within the district make it one of the most accessible mining areas in the railroad belt. The topography is typical of the Chugach Mountains, the elevation ranging from sea level to more than 5,000 feet. Vegetation is heavy along the streams, and the timber line is around 2,000 feet above sea level.

The bedrock throughout most of the district consists of a series of interbedded slate and graywacke, probably of late Cretaceous age. The bedrock in the northwest corner of the district is a series of tuff and agglomerate whose age is not definitely known. The only intrusive rocks in the area are fine-grained acidic dikes that are remarkable for their continuity across the country in spite of their small width. The region has been glaciated up to an elevation of about 4,000 feet, and glacial outwash sand and gravel cover the valley bottoms and walls.

The structure is highly complex, and the lack of any recognizable horizons makes interpretation difficult. Close folds with overturning are the rule. Numerous strike faults occur, and transverse faulting of unknown displacement has taken place.

Auriferous gravel was early discovered in this district, which was one of the first gold-producing districts in Alaska, but lode mining has never been very successful. Two types of lode deposits are recognized—mineralized dikes and fissure veins. Both types are identical in mineralization and have the same origin. The mineralized dikes are the acidic dikes that in places have been fractured and the fractures subsequently filled with vein material. The gold content of the dikes is erratically distributed, and they have not yet been found to have sufficient value to be worked at a profit. The fissure veins have been worked profitably in a few places but only on a small scale. The veins have well-defined walls but are narrow and have not been found to be continuous for more than a few hundred feet. The tenor of the ore in the veins is usually good.

In both the dikes and the veins the chief value lies in gold, which occurs free and also combined with the sulphides. The gangue is predominantly quartz, with small amounts of calcite. The sulphides present are arsenopyrite, pyrite, galena, sphalerite, and chalcopyrite, but the total forms only a small percentage of the vein material. The presence of galena and sphalerite is usually a good indication of a high gold content.

The genesis of the ores is closely associated with the origin of the dikes, as both ores and dikes were probably derived from the same parent magma. After the intrusion of the dikes the region was subjected to stresses that

fractured the dikes and the country rock. Subsequently mineral-bearing solutions from an underlying source filled the fissures and deposited the present vein material.

Lode deposits of sufficient size for large-scale operations have not been found, but some of the veins can be worked successfully by careful operations on a small scale. Of the placer deposits only low-grade gravel remains.

INTRODUCTION

LOCATION AND AREA

The district described in this report lies in the northern part of the Kenai Peninsula bordering Turnagain Arm. (See fig. 1.) It is approximately rectangular in shape and extends from latitude 60°30′ to 60°55′ and longitude 149°10′ to 149°50′, with an area of about 600 square miles. The district is a part of what may be called the Chugach Mountain province and lies entirely within the boundaries of the Chugach National Forest. The town of Hope is in the northwest corner, and Moose Pass station (mile 29 on the Alaska Railroad) is in the southeast corner.

PREVIOUS INVESTIGATIONS AND ACKNOWLEDGMENTS

Previous reports which contain much information on the resources of this area are as follows:

Becker, G. F., Reconnaissance of the gold fields of southern Alaska: U.S. Geol. Survey Eighteenth Ann. Rept., pt. 3, pp. 7–86, 1898.

Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River: U.S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 265–340, 1900.

Moffit, F. H., Gold fields of the Turnagain Arm field: U.S. Geol. Survey Bull. 277, pp. 7–52, 1906.

Johnson, B. L., Geology and mineral resources of Kenai Peninsula: U.S. Geol. Survey Bull. 587, pp. 113–208, 1915.

Ellsworth, C. E., and Davenport, R. W., A water-power reconnaissance in south-central Alaska: U.S. Geol. Survey Water-Supply Paper 372, 1915.

The annual bulletins "Mineral resources of Alaska, report on progress of investigations," published by the United States Geological Survey, contain notes on current developments. Many of the annual reports of the mine inspector for the Territory of Alaska contain information as to activity on individual properties at the time of publication. Private reports on some of the mines and prospects have been made by consulting geologists and engineers, but unfortunately very few of them are available to the Geological Survey or to the general public.

All the above sources of information have been drawn upon freely by the writer of this report, particularly for the record of early activity in the district. Grateful acknowledgment is here made to the earlier workers, particularly to B. L. Johnson, also to numerous individuals and operators in the Moose Pass-Hope area who have contributed much information; to Mr. Paul Hopkins, of the Bureau of Mines, Fairbanks, Alaska, who assayed all the samples that were taken; and to the officials of the Alaska Railroad, who have cooperated in every way possible.

PRESENT INVESTIGATION

The present investigation was undertaken under the direction of the Geological Survey at the request of the Alaska Railroad to determine the mineral potentialities of the Moose Pass-Hope district and to estimate the probable tonnage of minerals that might contribute to the general development of the area.

The active field work was conducted from June 6 to September 10, 1931. It consisted of the examination of all properties that were being worked during the summer of 1931, as well as most of those that had been worked in the past but were dormant at the time of the investigation. Samples of the veins were taken wherever it was deemed necessary. In addition to the study of the individual prospects, much time was spent in traversing the region, in observing the general geology and the structure, and in attempting to find what relations they might have to the ore deposits and thus to determine if any guide for prospecting exists. Laboratory as well as field studies were undertaken to determine the genesis of the ore deposits and the probability of their continuation in depth.

In view of the small size of the veins, both in width and length, very little ore has been blocked out. It has therefore been impossible to form any trustworthy estimate of the probable tonnage of the district, and instead only the general dimensions of the ore bodies have been stated.

As this report is primarily concerned with the mineral resources, only such general description of the area and its geology as appears to be directly pertinent to the availability and ultimate development of the mineral deposits is included.

GEOGRAPHY

TRANSPORTATION

The Moose Pass-Hope district is one of the most accessible in Alaska, as the Kenai Peninsula is practically surrounded by water and is traversed by the Alaska Railroad. The area also has over 60 miles of roads built and maintained by the United States Bureau of Public Roads.

The easiest route into the district is by way of the Alaska Railroad, through Moose Pass station, which is 29 miles from Seward. From Moose Pass station there is a well-surfaced road 45 miles to Hope, by way of Moose Pass, Canyon Creek, Sixmile Creek, Sunrise, and Turnagain Arm. (See pl. 36.) From Hope 12 miles of graveled road, called the Palmer Creek road, leads to the head of Palmer Creek. There is also a 3-mile wagon road from Hope up Resurrection Creek that can be traversed during dry weather by automobiles. Several years ago a road, called the Johnson Pass road, ran from mile 34 on the Alaska Railroad to Sunrise. At the present time this road can be traveled during dry weather by automobile from mile 29 on the Moose Pass-Hope highway to Lynx Creek, a distance of 7 miles. During 1931 2 miles of this road was surfaced, and it is the plan of the Bureau of Public Roads to complete a small portion each year. From Lynx Creek to mile 34 on the railroad only a trail remains from the old road.

At the present time there is a surfaced road from Seward to the south end of Kenai Lake, a distance of 20 miles. A plan has been projected by the Bureau of Public Roads to close the gap of 9 miles between Moose Pass and the south end of Kenai Lake and make the whole Moose Pass-Hope district accessible by car from Seward. In addition to the roads, many trails exist throughout the region (see pl. 36), several of which were built and are maintained by the United States Forest Service.

As the railroad runs along the north side of Turnagain Arm, Hope and Sunrise can be reached directly from the railroad by water, although navigation is difficult, owing to the 30- to 40-foot tides. Small boats can be obtained, one of which maintains a regular service from Hope and Sunrise to Anchorage (mile 114, Alaska Railroad), Rainbow (mile 93), and Girdwood (mile 74).

TOPOGRAPHY AND DRAINAGE

The district is rough and rugged, as it is geographically and geologically a part of and continuous with the Chugach Mountains. The relief is over 5,000 feet, but there are no outstanding peaks; instead, a number of the ridges attain an elevation that is close to the maximum of the region, and many of the crests culminate in a high point by a long, gradual slope. The ridges are rounded and smooth up to an elevation of 4,000 feet, probably the limit of glaciation, and above that they are more rugged. The slopes are usually steep, ranging from 25° to 45°. As a rule the valleys of the tributary streams are narrow, except at the headwaters, where they invariably terminate in rounded, amphitheaterlike basins. On account of the steep slopes and the narrow valleys, landslides and snowslides are frequent in the spring, necessitating the careful selection of sites for development work on mining properties and for all mining buildings.

The greater part of the district is drained by two major streams, Resurrection Creek and Sixmile Creek. (See pl. 36.) These major streams flow to the north, and their course is probably dependent on the general structure of the region; but their tributary streams have irregular courses and show no relation to the structure. U-shaped valleys resulting from glaciation are the rule, although in the lower courses of the major streams these valleys have been partly filled with gravel that forms benches 1 to 2 miles across. Many of the tributary streams also show gravel benches, and the benches on both the major and tributary streams slope toward the center of the valley and downstream.

CLIMATE

The summers are characteristic of the Pacific coast country, being cool and rainy, but the winters are more severe, as the area lies on the north side of the Kenai Mountains. The only recorded temperature and precipitation records[1] are for the period 1902–10 and were taken at Sunrise. The average annual precipitation during this period was 34.5 inches. June was the warmest month, with an average temperature of 53.34°, and January the coldest, with an average temperature of 8.7°. The snowfall is heavy, particularly on the mountains.

TIMBER

The fact that the entire district lies within the Chugach National Forest does not signify that timber is distributed uniformly. The timber line lies around 2,000 feet, and in this mountainous region much of the surface is above this elevation; consequently, only a small portion of the region, along the lakes and streams, is forested. Spruce is the most abundant timber, but there are also growths of hemlock, cottonwood, birch, poplar, willow, and alder. In the burned areas much of the second growth is poplar and birch, with occasional spruce and hemlock. Although there is sufficient timber for mining operations for some time to come, most of it is small, a tree 2 feet in diameter being rare.

There are several small sawmills that supply the local market and are also engaged in cutting ties and piles for the railroad. The supply of timber for fuel is plentiful for local use. Tracts of timber suitable for use in construction are found on Resurrection, Palmer, and Sixmile Creeks and at Trail and Grant Lakes.

WATER POWER

Water power sufficient for small operations is abundant throughout the district, and usually an operator would not have to go any great distance from his property to obtain adequate power. Many

[1] Martin, G. C., Johnson, B. L., and Grant, U. S., Geology and mineral resources of Kenai Peninsula, Alaska: U.S. Geol. Survey Bull. 587, p. 27, 1915.

of the streams with small drainage basins lose much of their volume in late summer, and others freeze early in the fall, so that for year-round operations the selection would have to be made with more care. Usually the streams from the east are more reliable, having larger drainage basins that contain more snow. If the smaller and more accessible streams would not be sufficient, the larger streams with a more constant flow could be utilized.

At Grant Creek,[2] the outlet of Grant Lake, it is estimated that at least 1,500 horsepower could be developed throughout the year by utilizing storage; without storage, the low-water flow would not be sufficient to produce more than 300 to 400 horsepower.

From Juneau Creek, which flows south into the Kenai River, it is estimated that 500 to 1,000 horsepower could be developed from May until October, but the minimum flow in winter would not produce more than 100 to 200 horsepower. Other favorable sites are Lost Lake and Sixmile, East Fork, Palmer, and Canyon Creeks.

Measurements of stream discharge, 1913

Locality	Date	Gage height (feet)	Discharge (sec.-ft.)
Grant Creek	Oct. 9		155
Do	Oct. 18		84
Quartz Creek at Fairman's cabin	Aug. 24	3.43	83.6
Do	Sept. 4	3.19	58.1
Do	Oct. 18	3.09	46.2
Lost Creek 3 miles below outlet of Lost Lake	Oct. 17		61
Sixmile Creek at Sunrise	Aug. 27	5.75	1,600
Do	Sept. 6	4.86	597
Do	Sept. 25	6.95	6,150
Do	Oct. 15	4.64	503
Mills Creek 2 miles above mouth	Aug. 25	3.48	140
Do	Sept. 5	3.02	76.7
Canyon Creek above Mills Creek	Aug. 25		90
Do	Sept. 4		60
Do	Oct. 14		44
Juneau Creek in lake 500 feet above ditch	Aug. 25		23
Resurrection Creek above Gold Gulch	Aug. 8		120

Jurisdiction over the development of the water power in this district is in the hands of the officials of the Chugach National Forest.

POPULATION AND INDUSTRIES

The normal year-round population in the district between Moose Pass and Hope is from 60 to 70 people. This number is increased during the summer by about 25 miners and prospectors. During the last several years the Bureau of Public Roads has had a crew of 20 to 40 men engaged in road construction, but this will not be permanent.

[2] Ellsworth, C. E., and Davenport, R. W., A water-power reconnaissance in south-central Alaska: U.S. Geol. Survey Water-Supply Paper 372, pp. 121–125, 1915.

The chief means of gaining a livelihood is through mining, and about 25 people earn their living in this manner. Maintenance of the roads employs about a dozen people. As both of these operations are conducted only in the summer, it is necessary to gain from them enough income to last through the winter or else to augment the summer income by some other means. The only winter occupations are trapping and small logging operations, such as the cutting of ties and piles for the railroad. A few of the inhabitants have small fur farms, and one or two serve as guides for hunting expeditions.

Fortunately, living conditions are good. Fuel can be obtained from the neighboring woods; fishing and hunting are excellent; and garden produce grows luxuriantly, particularly at Hope and Sunrise.

In 1931 the average wage for unskilled labor was $5 a day. Skilled labor was proportionately higher. The cost of board averaged about $1.50 a day.

MINING CONDITIONS

Most of the mines and prospects are located at considerable elevations above sea level and high above the streams. This is because the valleys are filled with great thicknesses of gravel, slide material, and heavy vegetation. Only on the crests of the ridges and in a few of the stream valleys is bedrock sufficiently exposed for prospecting. It is certain that as many veins exist under the overburden as are exposed, and many of them will never be found. In only about a third of the area is bedrock exposed or prospectable.

As the veins are exposed on the high ridges or steep slopes, very heavy ground is often encountered, and much timbering is necessary. Mechanical disintegration, due to the great range in temperature, and downward creep on the steep slopes have been effective in breaking the surface rock. The fractured zone usually extends down about 100 feet, and where it is penetrated good walls are usually obtained.

The active working season for placer mining extends from June to October. On the present lode properties surface prospecting and development can be conducted only between June and October. At the Hirshey mine, which lies at an elevation of 2,000 feet, water power is not available during the other months. This makes an extremely short working season, but with proper equipment and the careful location of mine buildings it would be possible to continue lode-mining operations throughout the year, regardless of weather conditions.

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GENERAL GEOLOGY

PRINCIPAL FEATURES

The rocks of the area are predominantly interbedded slate and graywacke, which Mendenhall [3] originally termed the "Sunrise series." They comprise over 95 percent of the bedrock exposed (see pl. 36) and everywhere are highly folded and faulted. Attempts to subdivide them and work out the structure and stratigraphy in detail have proved unsuccessful because of their lithologic similarity.

In the northwestern part of the district, west of Hope, there is a series of volcanic rocks, principally tuff and agglomerate, but with a few interbedded flows. This formation is also highly folded and faulted, but whether it is younger or older than the slate and graywacke is not definitely known. Deposits of economic value have not yet been found in the district underlain by the volcanic series.

The only intrusive igneous rocks in the district are fine-grained feldspar dikes, which are exposed at a number of localities. They are younger than the interbedded slate and graywacke, which they cut; they are probably also younger than the volcanic series, although their relation to that series is unknown. Many of the dikes, though narrow, are remarkable for their length.

The only other noteworthy formations are the unconsolidated postglacial gravel deposits, which are widespread, occupying the bottoms of all the valleys and at many places occurring on the valley walls as terraces or benches.

STRATIGRAPHY

SLATE AND GRAYWACKE

DISTRIBUTION AND CHARACTER

The interbedded slate and graywacke are almost everywhere abundantly exposed except in the northwest corner of the district. As a whole the unit consists of almost equal amounts of slate and graywacke, although locally one type may predominate over the other. The upper part of the drainage basin of Palmer Creek is dominantly slate, and there are also large exposures of slate on Slate and Summit Creeks. Areas in which graywacke is abundant are near the head of Bear Creek, on Sixmile Creek about 4 miles above its mouth, and north of mile 7 on the road between Moose Pass and Hope. At most of the other localities the two are interbedded in almost equal amounts.

The slate is gray to black, is fine grained, and usually shows cleavage, though the cleavage is rarely so good that the slate could

[3] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: U.S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 305–307, 1900.

serve as roofing material. Locally the slate may be foliated, either owing to greater pressure or to a larger proportion of impurities, so that it might more properly be termed a schist. The more massive portion of the slate should be termed argillite. The slate occurs in beds and lenses from 1 inch to over 100 feet thick. Microscopically the slate is very fine grained and is composed of small rounded quartz grains, oriented sericite flakes, and kaolin. Accessory minerals are rounded feldspar grains, irregular masses of calcite, and chlorite. Cleavage, folding, and faulting are conspicuous in the thin sections.

The graywacke differs from the slate in that it is coarser grained and contains more quartz. It occurs in varying shades of gray and gray-green, and in only a few localities is it clean enough to be called quartzite. The texture ranges from fine to coarse. Individual beds are lenticular and cannot be traced far along the strike without varying in thickness or pinching out. The range in thickness may be from a few inches to several hundred feet. They occur interbedded with the slate or in massive bodies and show schistosity, cleavage, and joints, but not in the same degree as the slate. Under the microscope the graywacke is seen to be composed chiefly of subangular grains of quartz and orthoclase and plagioclase feldspar. Accessory minerals are calcite, hornblende, chlorite, sericite, kaolin, and pyrite.

Interbedded with the slate and graywacke and of only local extent are lenses of conglomerate, limestone, and greenstone. It is doubtful whether they comprise more than 1 percent of the slate and graywacke mass. Locally the conglomerate may be sheared and the pebbles stretched out, but usually it is massive. On Mills Creek above its confluence with Juneau Creek large boulders of conglomerate are abundant. The pebbles in the conglomerate are as much as 5 inches in diameter and consist of slate, graywacke, chert, and granite. In this area bedrock exposures were not found, but they no doubt occur within the drainage basin.

ORIGIN

The slate and graywacke beds were originally laid down as clay, sand, limy sediments, and gravel in a basin of deposition comparable to that of many of our present shallow seas. Proof of their sedimentary origin is plainly apparent in the bedding or stratification, the composition, and the occurrence here and there of fossils in similar formations in adjacent districts. Subsequent to deposition the beds were consolidated and uplifted, as a result of great pressure, which metamorphosed the graywacke into its present indurated condition and produced cleavage and foliation in the more clayey rocks. The metamorphism, however, was not so great as to destroy their original sedimentary characteristics. To give the present repeated alternation of slate and graywacke, conditions during their deposition must have been such that there were almost rhythmic recurring cycles of sedimentation. As the sediments are probably at least 5,000 feet thick, the basin of deposition must have been gradually sinking, although with minor fluctuations.

AGE AND CORRELATION

Although the slate and graywacke of the Moose Pass-Hope district is part of a series that is regional in extent, their age is difficult to determine, as fossils are scarce. Mendenhall,[4] Johnson,[5] Capps,[6] and Landes[7] have shown the similarity of this series of rocks from Resurrection Bay to the Matanuska Valley. Mendenhall, in calling it the "Sunrise series", placed it as pre-Cretaceous and, tentatively, as Paleozoic, in view of its association with the Cretaceous of the Matanuska Valley. He also suggested that it may be a part of the Valdez group of Prince William Sound, which had been placed tentatively in the Paleozoic. Johnson and Martin,[8] from a few fossils collected at the head of Crow Creek, in the Girdwood district, considered its age to be Jurassic or Cretaceous. Reeside, through his identification of fossils collected by Park[9] in the Girdwood district, believes it to be definitely Cretaceous and probably Upper Cretaceous. Stratigraphically and lithologically the metamorphic rocks of the Moose Pass-Hope district are similar to those of the Girdwood district, and there is no reason to think that their age is different, or other than Cretaceous.

VOLCANIC SERIES

DISTRIBUTION AND CHARACTER

In the northwest corner of the district is exposed a series of massive tuff and agglomerate of volcanic origin. This formation is exposed about 1½ miles west of Hope on the shore of Turnagain Arm. From that point it extends to Gull Rock, 6 miles west of Hope. No geologic work was done west of Gull Rock, but it is probable that this formation continues to the lowland that forms the

[4] Mendenhall, W. C., op. cit., pp. 305–307.
[5] Martin, G. C., Johnson, B. L., and Grant, U. S., op. cit., pp. 113–119.
[6] Capps, S. R., The Turnagain-Knik region, Alaska: U.S. Geol. Survey Bull. 642, pp. 155–161, 1916.
[7] Landes, K. K., Geology of the Knik-Matanuska district, Alaska: U.S. Geol. Survey Bull. 792, pp. 56–57, 1927.
[8] Martin, G. C., Johnson, B. L., and Grant, U. S., op. cit., p. 118.
[9] Park, C. F., U.S. Geol. Survey Bull. 849–G, p. 393, 1933.

northwestern part of Kenai Peninsula. The same formation also occurs on Cripple Creek and on the divide between Big Indian River and Resurrection Creek. As shown on plate 36 it is exposed as a wedge-shaped mass lying west of the slate and graywacke. Still farther west it is overlain by the Kenai formation (Eocene).

Outcrops of the agglomerate and tuff show a massive, dense rock that ranges in color from gray to green to red. Hand specimens of the agglomerate contain angular fragments of graywacke and slate as much as half an inch across. The tuff is usually fine-grained and similar to the graywacke in appearance.

Under the microscope the tuff is seen to be composed of angular grains of quartz, altered feldspar, hornblende, and kaolin material; the agglomerate contains angular fragments of argillite, slate, graywacke, quartzite, and fine-grained volcanic rocks, embedded in a fine-grained groundmass of quartz, orthoclase and plagioclase feldspar, sericite, hornblende, chlorite, and kaolin. All the feldspars have been altered to sericite and paragonite.

ORIGIN

The tuff and agglomerate represent a period of volcanic activity during which ash and large amounts of the fragments of the underlying rock were thrown out by volcanoes whose locations are not known. The general appearance of the groundmass suggests the possibility that the tuff was water-laid. Subsequently this material was cemented and has undergone practically the same metamorphism and deformation as the slate and graywacke.

AGE AND CORRELATION

Precise information as to the age of the volcanic series is lacking, as no fossils have been found in these rocks. The included fragments of slate and graywacke might suggest that it is a part of or younger than the slate and graywacke, but on the north side of Turnagain Arm this same volcanic series is known to contain interbedded slate, graywacke, and limestone. Near Gull Rock small sections of slate and graywacke have been faulted into the volcanic series. Structurally, the volcanic series seems to be identical with the slate and graywacke, as in this area it apparently has undergone the same amount of deformation; this would suggest that it is close in age to the slate and graywacke. If it is younger, it would still be older than the Kenai formation and therefore late Cretaceous.

A similar formation has been recognized at several localities. This volcanic series probably extends from this district north to the Matanuska Valley. To the south it has not been traced to its limit, but it may extend to the Kenai River in the vicinity of Skilak Lake, as Martin[10] mentions some apparently igneous rocks that are intimately associated with the slate and graywacke.

The rocks on the north side of Turnagain Arm west of Indian Creek, believed to be a continuation of this belt, are described by Capps[11] as undifferentiated metamorphic rocks. Capps considers this series older than the slate and graywacke and finds it a very complex assemblage of andesite, andesite porphyry, peridotite, dunite, serpentine, pyroxenite, altered gabbro, tuff, and agglomerate of igneous origin, with argillite, graywacke, chert, and limestone of sedimentary origin. Farther north, in the vicinity of the Eagle River, Capps[12] was able to differentiate another formation of volcanic tuff, which he believes to be younger than the slate and graywacke. Landes[13] found in the region between the Knik and Matanuska Rivers an assemblage similar to that which Capps found, except that greenstone is more abundant; he describes this as a greenstone formation and on structural grounds considers it younger than the slate and graywacke.

The volcanic series in the Moose Pass-Hope district is structurally continuous with and probably a part of the general assemblage of predominantly volcanic formations of the region. Detailed work will no doubt make subdivision possible, but at present all that can be said is that the age of the volcanic series is probably close to that of the slate and graywacke.

DIKES

DISTRIBUTION AND CHARACTER

The only intrusive rocks in this area are fine-grained dikes which cut the slate and graywacke. These dikes are widespread over the district, although they form only a small fraction of 1 percent of the total bedrock exposures. They are found on Devils, Slate, Summit, Colorado, Fresno, Pass, Frenchy, Donaldson, Palmer, Bear, Cub, Resurrection, and Groundhog Creeks. They may be even more numerous than indicated (see pl. 36), but on account of their small size they are difficult to locate. They are characteristically narrow—the maximum is about 15 feet and the average about 4 feet—but some are very long. The so-called "Gilpatrick dike" can be traced a distance of 11 miles, from Slate to Donaldson Creek; another dike can be traced from a point south of the Palmer Creek Glacier northward along the east wall of Palmer Creek for 3 miles; the dike on the Kenai Star property extends from a point near the

[10] Martin, G. C., Johnson, B. L., and Grant, U. S., op. cit., pp. 50–51.
[11] Capps, S. R., op. cit., pp. 154–155.
[12] Idem, pp. 162–165.
[13] Landes, K. K., op. cit., pp. 58–62.

Palmer Creek Glacier to the headwaters of Cub Creek, a distance of 6 miles. These three dikes trend almost south, following closely the general structural trend of the slate and graywacke, and are usually vertical but may flatten out to 30°. Only the long continuous dikes follow this structural trend; the shorter dikes, such as those on Bear Creek, strike irregularly across the formation.

The dike rock in fresh hand specimens has a slightly greenish, translucent appearance. In texture it is very fine grained. Upon weathering it assumes a creamy-white hue, although where sulphides are present it is stained brown by iron oxide.

Under the microscope all the dike rocks are seen to be essentially the same texturally and mineralogically. They are very fine grained and in places microporphyritic, with well-formed phenocrysts of albite, although the rock is usually so highly altered that the feldspar is difficult to recognize. Plagioclase feldspar, probably albite, forms the greater part of the groundmass. Quartz occurs as an original constituent of the rock but has also been introduced later as veins and replacement masses. A few specimens show unaltered albite as small veins cutting the altered dike rock. Fine-grained mica and a kaolinic mineral are common as a result of the alteration of the feldspar. Calcite occurs in irregular masses and veins throughout the rock. Chlorite is common in small flakes and is the cause of the greenish color of the rock in the hand specimens. Certain parts of the dikes contain disseminated crystals of arsenopyrite, which near the surface have weathered to limonite.

In the past these dikes have been termed "acidic dikes", and in view of the acid nature of the feldspar and the presence of quartz the term is used in this paper. The origin of these acidic dikes is similar to that of other igneous intrusions, as they have solidified from a liquid state. Small fragments of slate are included in some of the dike rock, but for the most part the evidence indicates that the liquid rock entered and solidified in open fractures without having materially absorbed and assimilated the enclosing country rock. The actual mechanics of the process is difficult to explain, as it is difficult to understand how such long, narrow, continuous fractures, the size of the present dikes, could have stayed open for a sufficient length of time to permit the entrance of the liquid rock.

After its solidification, portions of the dike rock were fractured, and the fractures were filled with solutions bearing quartz, calcite, feldspar, and a few metallic minerals. Locally within the dikes the fractures are parallel and the quartz veinlets strike uniformly across the trend of the dike. These fracture-filling solutions did not materially alter the dike rock, as both the fractured and unfractured portions exhibit the same altered condition. It is probable that the alteration is regional and that the mineralization is only scattered.

AGE AND CORRELATION

Similar acidic intrusions occur in the vicinity of Kenai Lake, on the north shore of Turnagain Arm, and in the Girdwood and Port Wells districts, although they vary in size and shape of intrusion and in texture.

Lithologically all these dikes are similar, and it is probable that they are from the same magmatic source and of the same period of intrusion. In the Moose Pass-Hope district they cut the folded slate and graywacke, but they themselves are not folded; therefore they must have been intruded after the deformation of the slate and graywacke. As the slate and graywacke are regarded as Cretaceous, the dikes are late Cretaceous or post-Cretaceous. Of the intrusions in the Girdwood district Johnson [14] says:

> The best evidence available as to the age of the quartz diorite and diorite porphyry intrusions is furnished at a locality on Crow Creek, where they cut folded sedimentary beds containing Jurassic or Cretaceous fossils. It appears probable that the intrusions were also pre-Tertiary.

As there are no recognized Tertiary deposits in the district, and as the Kenai formation to the west is only slightly consolidated and no dikes have been found cutting it, these dikes are probably pre-Tertiary.

UNCONSOLIDATED DEPOSITS

PRINCIPAL FEATURES

The unconsolidated or only partly consolidated deposits consist of clay, sand, gravel, and boulders and constitute over one third of the surface exposures. They directly overlie the interbedded slate and graywacke and the volcanic series in the valleys and on the valley slopes. No unconsolidated deposits of preglacial origin are known to exist, and probably the glaciers that occupied the valleys during Quaternary time eroded and transported the earlier stream deposits. The unconsolidated deposits may be classified into three groups—(1) glacial deposits consisting of unstratified clay, sand, pebble, and boulders deposited directly by the melting glaciers; (2) glaciofluviatile or bench deposits, consisting of stratified and unstratified clay, sand, gravel, and boulders deposited by water from the melting ice and made up mostly of reworked glacial material; (3) recent deposits, consisting of clay, sand, gravel, and boulders deposited by the present streams. In addition to these three types there are some small lake deposits, but as they are of slight areal extent and of no economic importance, no further mention of them will be made.

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[14] Martin, G. C., Johnson, B. L., and Grant, U. S., op. cit., p. 120.

GLACIAL DEPOSITS

Few extensive glacial deposits remain in this district. Glacial till consisting of a dense clay in which angular pebbles and boulders are embedded is present in some of the stream valleys and rests directly on the grooved and polished bedrock. Johnson[15] observed a terminal-moraine deposit on Canyon Creek. The lack of glacial deposits in this highly glaciated region is due to the tremendous amounts of water released from the melting glaciers, which, having been concentrated in the glaciated valleys, reworked all the previous unconsolidated deposits.

GLACIOFLUVIATILE OR BENCH DEPOSITS

The glaciofluviatile deposits constitute the greater part of the unconsolidated material in the district. They consist of clay, sand, gravel, and boulders, usually stratified, although in places only partly so. Locally they may be slightly cemented by iron oxide or calcium carbonate. Their distribution over the region is widespread. Some form benches or terraces that are as much as 2 miles wide and extend the entire length of the stream. The benches slope toward the middle of the valley and downstream. Their formation began at the end of the active glacial epoch, when enormous quantities of water from the melting ice reworked and deposited the material that had been left by the glaciers. At that time the sea was at a higher level than now. Benches at several different levels in the valleys and along Turnagain Arm indicate that there were several fluctuations of the sea level. Many of the bench deposits originated as deltas and alluvial fans and are particularly conspicuous at the points where the tributary streams emerge into the valleys of the main streams. These postglacial deposits range in thickness from a few feet to several hundred feet, the thickness depending on the topography of the valley prior to their deposition.

RECENT DEPOSITS

The Recent unconsolidated deposits are found in the channels and flood plains of the present streams wherever they are aggrading. This material consists of clay, sand, gravel, and boulders, and the greater part of it represents reworked bench gravel, as the most of the main streams are still actively cutting in the glaciofluviatile deposits.

Gravel, sand, and silt are being deposited in deltas at the mouths of the present streams, as on Turnagain Arm, which has been a gradually filling basin of sedimentation since the end of the Pleisto-

[15] Martin, G. C., Johnson, B. L., and Grant, U. S., op. cit., p. 121.

cene epoch. Owing to the high tides, which are sometimes as great as 40 feet and are often accompanied by a bore, this material is spread out as mud flats across almost the entire Turnagain Arm and eventually will completely fill it.

The deposits along the present streams are usually not more than 10 feet thick, but the deposits in Turnagain Arm must be hundreds of feet thick in places, the depth depending on the topography of the old Turnagain Arm Valley.

STRUCTURE

The consolidated rocks exhibit a highly complex structure, as they are everywhere intricately folded, and the lack of any conspicuous or recognizable formation makes interpretation difficult. The monotonous character of the interbedded slate and graywacke succession prevents easy recognition of the broader aspects of the structure, and only small details can be gathered and pieced together.

The general structural trend is N. 10° E.[16] The dip is usually steep, ranging from vertical to 20° or 30° either east or west. It is difficult to account for this large area of steep dips by thickness of formation alone, as this would call for an incredible thickness of almost identical formations. A more plausible assumption is that there is repetition of beds, caused either by isoclinal folding or by a large number of strike faults. Both folding and faulting have caused this apparent great thickness of formation, as in small outcrops isoclinal folds are common as well as small strike faults. The axes of these isoclinal folds may be steeply inclined either to the west or to the east. On Slate Creek seven small strike faults were exposed in an 8-foot section of a crosscut.

FOLDS

A few broad folds were recognized. One anticline strikes down Palmer Creek, and the headward part of the creek is flowing on the crest of the fold. The axis of this fold strikes a little east of north, continuing along the divide between Bear and Cub Creeks, and probably passes into Turnagain Arm about 2 miles west of Sunrise. At this location on Turnagain Arm the fold appears to be plunging north at an angle of about 10°.

It is probable that another anticline, striking north, cuts across Slate, Summit, and Colorado Creeks in the vicinity of the dike, but dips are so steep, except on what appears to be the crest of the fold, that satisfactory recognition of this fold is difficult.

The folds are difficult to identify, not only because of the lack of a marker bed but also because of their complexity, as folding was

[16] All compass readings are given with reference to true north.

not the only expression of the relief from stress. Intense faulting, crumpling, and mashing accompanied the folding. Many of the faults occur on and parallel to the axes of the folds. In the cliff at the head of Palmer Creek, which is probably at the crest of a fold, a large mass of graywacke has been squeezed into the slate and is entirely isolated from any other graywacke bed.

Drag folds, which occur in the less competent rocks, such as the slates, are common throughout the region. In the best exposures, as along Turnagain Arm and in the railroad cuts along Trail Lake, the plunge of these small folds is from 10° to 50° N., indicating a general structural plunge in that direction. One observed exception to this northward plunge is in the vicinity of Slate and Summit Creeks, where observations on slate indicate a 20° to 30° plunge to the south, and in this same locality the Oracle vein, which trends with the formation, has a similar plunge.

CLEAVAGE

Rock cleavage is widespread throughout the slate and graywacke. The effect of the competency of the rock on the development of the cleavage is strikingly shown, not only by its better development in the slate, which is less competent than the graywacke, but also by the fact that in the slate the cleavage is closely parallel to the bedding, whereas in the graywacke it is widely spaced and at larger angles with the bedding. As a whole, the cleavage closely parallels the strike of the beds. The effect of the relative competency of the rock on the structural features produced is apparent on a small scale where slate and graywacke are exposed side by side; the slate is folded and the graywacke is faulted. This suggests that the same effects might be produced on a regional scale.

JOINTS

Well-developed joints are found at localities scattered throughout the region. The best-developed set has a general east-west strike and a vertical dip. They are smooth, clean-cut, typical shear joints, usually spaced at intervals of 6 inches to 2 feet. A poorly developed set striking northeast is represented in a few places. The well-developed set of joints may show minor horizontal movement, causing a cellular structure in quartz that apparently had been deposited in the joints prior to the movement.

FAULTS

Faults are one of the most common structural features of the district. No large faults of regional extent were recognized, and it is believed that their absence is explainable by the presence of numerous faults of small displacement. It is probable that much of the relief from stress was accomplished through the small faults. The aggregate displacement of these small faults would be sufficient to account for the apparent repetition of formations.

The major faulting occurred along north-south lines, and most of it took place prior to the mineralization. Premineral transverse faults are present, and some of them probably represent the existing vein systems, as most of the veins occur in fissures along which movement took place prior to ore deposition.

Postmineral faults of small displacement, probably not more than 100 feet as a maximum, are numerous. In one set the faults that offset the veins and dikes have a general strike of N. 60° E. and are chiefly vertical. The movement along these faults has usually been such that the block on the northwest side has been relatively displaced to the northeast. A rule generally applicable is that if a fault is encountered in drifting on a vein or mineralized dike, a crosscut should be made to the right along the fault plane until the faulted portion is intercepted.

Other types of postmineral movement occur, but usually the displacement is slight, so that it is manifested only in fracturing, brecciation, pinching, swelling, or lensing of the vein. It is probable that this movement has been so slight that locally the quartz veins control the resulting strain.

GEOLOGIC HISTORY

The geologic history of this district is probably similar to that of the Chugach Mountain province, of which it is a part, and will be given here only briefly.

PRE-TERTIARY

Of the pre-Cretaceous history nothing is known, as there are no rocks of probable pre-Cretaceous age in the district, unless the volcanic series west of Hope should prove to be pre-Cretaceous, which seems unlikely. However, as their age is not known at present, it will be sufficient to say that the volcanic rocks represent a period of intense volcanism during which ash and rock fragments were showered down upon a low-lying area, a portion of which was covered by water, as the nature of some of the tuffs suggests deposition in water. Probably during the later part of the Cretaceous period the area was submerged beneath the sea, and streams flowing into the sea deposited a great thickness of sediments, which have formed the interbedded slate and graywacke of this report. That there were frequent fluctuations of this sea level is suggested by the alternation of beds of slate and graywacke, with scattered lenses of limestone and conglomerate, but in general this basin must have been gradually sinking in order to accumulate so great a thickness of sediments. After the deposition and consolidation of all this material it was subjected to enormous pressures, which resulted in the folding, faulting, and uplift of these sedimentary deposits. During this time of stress the shale and sandstone were changed and altered to the present slate and graywacke. The direction from which this stress came is not exactly known, but the north-south strike of the cleavage and folds in the district and the arcuate trend of the entire Chugach Mountains suggest that it might have been from the east and southeast. It was not a simple, direct stress, but probably a differential movement, continually changing in direction and point of application.

The last phase of this mountain-making movement was characterized by the intrusion of the acidic dikes; only minor movement occurred after their formation, as they are only slightly fractured and folded. After the fracturing of the dikes mineral-bearing solutions emanated from the still molten underlying magma and were deposited in fractures and fissures, forming the present veins and mineralized dikes. Since this period of mineralization some deformation has taken place. This deformation was widespread, although slight in magnitude, as the veins and mineralized dikes are only fractured and sheared, having suffered little or no displacement.

TERTIARY

During the Tertiary period erosion progressed vigorously. It is probable that the whole region was reduced to baselevel and later uplifted, but the only evidence of this peneplanation lies in the partial concordance of the ridge and mountain tops. The lack of Tertiary deposits prevents the further deciphering of the Tertiary history.

QUATERNARY

At the beginning of the Quaternary period the topography was much like that of today, being mountainous and having drainage, in general, along lines similar to those of the present time. Climatic changes resulted in a yearly increase and excess of snowfall. The snow, becoming compacted into ice at several centers in the higher portions of the mountains, formed glaciers, which gradually moved down the slopes as a result of the increasing pressure behind. The valleys were thus filled with ice up to an elevation of 4,000 feet. Later other climatic changes caused the melting of the ice and the retreat of the glaciers.

The chief action of the moving ice was to gouge out the valleys and smooth the slopes up to an elevation of 4,000 feet. Above that height the mountains are unglaciated and are rough and rugged, chiefly from mechanical disintegration. The preglacial V-shaped valleys were broadened to U-shaped valleys, ridges were truncated, many of the valleys tributary to the main streams were left as hanging valleys, and the bedrock was scoured and polished. The water liberated from the retreating glaciers reworked much of the glacial debris and deposited it as bench gravel. Although there may have been several advances and retreats of the glaciers, this area shows evidence of only one such movement. At the end of the active glaciation the streams renewed their courses, and since that time they have been engaged in cutting and reworking the glacial outwash material. In a few places they have removed it entirely and are cutting in the bedrock, but most of the streams have not completed the removal of the unconsolidated clay, sand, gravel, and boulders.

ECONOMIC GEOLOGY

PRODUCTION

Although the Kenai Peninsula is one of the oldest placer gold producing districts in Alaska, its production is minor in amount compared with that of other parts of the Territory. The total value of gold produced from 1895 to 1930 has been estimated at approximately $2,302,000.[17] The Girdwood district is included in this total, but the major part of the gold came from the Moose Pass-Hope district.

There was practically no lode production from this district prior to 1911. Since that time the yearly production of lode gold has fluctuated between a few thousand dollars and $30,000. No steady growth has taken place, as there has been but an alternation of production from a number of small properties, which from time to time have received fresh impetus in the form of new working capital. Only one lode mine has been able to keep in continuous operation for the last 10 years. The total lode-gold production of the Kenai Peninsula for the period 1911 to 1930 was $312,000.[17] In addition to the Moose Pass-Hope district, this figure includes five or six lode mines between Seward and Moose Pass that reached their peak production in 1914, the mines of the Girdwood district, and of late years a rising production from the Nuka Bay district. The Moose Pass-Hope district has produced considerably more than half of the total.

The first recorded placer production was in 1895, when $50,000 in gold was obtained, chiefly from Bear Creek. The maximum production was only 2 years later, in 1897, when $175,000 was obtained.

[17] Smith, P. S., unpublished estimate.

Since that time there has been a gradual decline. The total placer-gold production of the Kenai Peninsula and the Girdwood district from 1895 to 1930 is $1,990,000.[17] The greater part has come from the Moose Pass-Hope district.

GOLD LODE DEPOSITS

HISTORY OF LODE MINING

The history of lode mining in the Moose Pass-Hope district has been one of many disappointments, with only a few of the prospects ever coming to the producing stage and only one of the producers being able to continue operations for more than a few years. The early history of the district appeared bright. Small but rich gold-bearing lodes were discovered in the years when the primary interest was in placer mining, but at that time the development of these lodes was neglected for the quicker and easier profits derived from the gravel. So, for many years after the discovery of gold, there was but slight prospecting and little development of the gold-bearing veins.

The possibility of gold-bearing veins was first noted by John C. Gilpatrick, who found rich quartz float on Summit Creek in June 1896. In 1898 locations were made on Bear, Palmer, and Sawmill Creeks, and some picked ore was milled on Sawmill Creek. The locations on Bear and Palmer Creeks were made on both quartz veins and mineralized dikes.

In 1905, 1906, and 1907 locations were made on Falls Creek, which lies a few miles southeast of Moose Pass station. In 1906 J. C. Gilpatrick located quartz leads on Slate and Summit Creeks. In 1908 a mineralized dike was located on what is now known as the Gilpatrick property. In the years 1909 to 1912 considerable development work was done on Falls and Slate Creeks. In 1911, with the erection of several small mills, the first notable production of gold was made, coming chiefly from the Falls Creek properties but including small amounts from the Slate Creek prospects. Since 1915 developments have been only sporadic on the Falls and Slate Creek properties, which at one time appeared so promising.

In 1911 John Hirshey located the Lucky Strike vein, near the head of Palmer Creek. It has been worked almost continuously since that year, and the mine is the only producer in the district at the present time.

In 1921 Robert Heaston located the Alaska Oracle vein on Summit Creek. Numerous other locations have been made, but the lack of success of the older prospects has tended to discourage new pros-

[17] Smith, P. S., unpublished estimate.

pectors, so that of late years there has been little active prospecting and only a few new discoveries. Most of the recent work has been confined to restaking old discoveries.

GENERAL CHARACTER OF THE DEPOSITS

The mineralized deposits of the district are of two distinct types—fissure veins and mineralized dikes. The mineralization is identical in each type, and genetically the metals have the same origin from a similar underlying magmatic source. The dikes have not yet been found to be economically valuable, although several attempts have been made at working them and considerable development work has been done. The fissure veins have been the sole source of lode gold produced in the district.

FISSURE VEINS

The fissure-vein type of deposit occurs as a simple fissure filling, usually with smooth, clean-cut walls. The veins range in width from a few inches to 5 feet, with an average around 6 to 8 inches. Along the strike they are usually not persistent for more than a few hundred feet. In depth they are known to persist for at least several hundred feet. As a rule the veins cut across the bedding and cleavage of the country rock, but a few parallel it. There do not appear to be any definite sets of veins, as veins are found striking in all directions; however, the richer and larger veins more commonly have a general east-west strike. The dip of the veins ranges from 20° to vertical, with an average around 45°, and the direction of dip is in general predominantly north or west. The veins are all of the same period of mineralization.

MINERALIZED DIKES

The mineralized dikes are the acidic dikes that in places have been fractured and penetrated along the fractures by mineral-bearing solutions similar to those of the fissure veins. The veins in the dikes are all small, a fraction of an inch to 6 inches across, although in places they are so numerous as to form 30 percent of the total dike rock. They may occur irregularly within the dike or have a rough orientation, paralleling each other and cutting across the dike. Not all the dikes are mineralized, and even those mineralized are not uniformly so.

The dike that occurs on the Gilpatrick property has been traced from Slate Creek north 8 miles to Pass Creek, and it has been reported as found on Frenchy and Donaldson Creeks, making a total length of 11 miles, which is remarkable considering its slight width and its relatively regular trend. (See pl. 36.) This dike was not found south of Slate Creek; it is reported to have been located on

EXPLANATION

Area in the northwestern part of the map contains tuff and agglomerate and all the remaining area slate and graywacke

Acidic rocks

MINES AND PROSPECTS

GOLD LODES

- 2. Coon
- 4. Taylor
- 5. Gold Stamp
- 6. Nearhouse & Smith
- 7. Robinson & Bowman
- 11. Kenai Star
- 12. Robin Red Breast
- 13. Downing
- 14. Sunshine
- 15. Teddy Bear
- 16. Hirshey
- 19. Donaldson Creek
- 20, 21. Frenchy Creek
- 23. Pass Creek
- 24–26. Fresno Creek
- 29. Mascot
- 30. Iron Mask
- 31. Independence
- 32. Johnson
- 33, 34. Colorado
- 35. Johnson
- 36. Alaska Oracle
- 37. Ronan
- 38. Swetman
- 39. Gilpatrick
- 40. State Creek—south
- 41, 42. McMillan
- 43. Devil Creek
- 44. Quartz Creek
- 47. Brewster
- 48. Seward Gold
- 49. Case
- 50. Sollars

COPPER LODE

- 46. Ready Bullion Copper Co.

GOLD PLACERS

- 1. Dark & Leach
- 3. Gallagher
- 8. Clark & Beiswanger
- 9. St. Louis Mining Co.
- 10. Pearson
- 17. Connolly
- 18. Bruhn & Ray
- 22. Allison
- 27. Dahl
- 28. Miller, Plowman & Tolson
- 45. Jacobs

Base from part of map The Alaska Railroad by Alaskan Branch

WILLIAMS & HEINTZ CO., WASH., D. C.

MAP SHOWING MINES AND PROSPECTS IN MOOSE PASS-HOPE DISTRICT, ALASKA

By Ralph Tuck

5 0 5 Miles

Contour interval 200 feet
Datum is mean sea level
Broken lines indicate probable topography of unsurveyed areas

1933

the south side of the creek by William Farnum and John Madsen in 1909, but no evidence of their location remains. The dike is best mineralized on the north side of Slate Creek, and there is sparse mineralization on Colorado and Fresno Creeks, but development to date shows that the greater part is practically barren.

The dikes that occur on the Teddy Bear and Kenai Star claims, on the east side of Palmer Creek, and also in the vicinity of Bear Creek are slightly mineralized in spots.

Individual assays running as high as $40 a ton in gold were obtained from these dikes, but the average of samples from any particular part did not give minable values, as there are long stretches of barren or very low grade material.

MINERALOGY

The mineralogy of the ore deposits is extremely simple and is identical in both the veins and the mineralized dikes. The predominant gangue mineral is quartz, although calcite is usually present in small amounts. In the dikes calcite is still subordinate to quartz but is more abundant than in the fissure veins. Ankerite occurs in a few of the veins. Arsenopyrite is the chief metallic mineral, with galena, sphalerite, pyrite, and chalcopyrite present in small amounts. Molybdenite and pyrrhotite have been reported from several localities. Free gold occurs in the quartz and at many places is closely associated with the galena and sphalerite; therefore the presence of these two minerals is usually a good indicator of gold. Some of the arsenopyrite carries gold, but most of it is apparently barren.

Silver is known to occur in all the veins, as all the assays show small amounts, which increase directly as the gold increases. Some of the silver probably occurs with the galena, but much of it is directly alloyed with the gold. At many of the prospects the visible gold has a light color due to the silver content. Limonite and scorodite are commonly found as alteration products of the arsenopyrite.

As a rule the metallic minerals form only a very small percentage of the total vein material, although portions of a few of the veins may contain as much as 20 percent of metallic minerals.

PARAGENESIS

Polished sections of ore specimens from a number of deposits all give the same order of crystallization. Arsenopyrite is by far the most common metallic mineral present and occurs in euhedral and subhedral crystals, having been the first mineral to be deposited by the ore-bearing solutions. Subsequent to its formation it was fractured, and quartz, with galena, sphalerite, gold, and chalcopyrite, was introduced. The quartz, galena, sphalerite, chalcopyrite, and gold are all closely contemporaneous, although definitely later than the arsenopyrite, as they cut across it in veins. The galena and sphalerite are of the same age, but generally the galena crystallized out a little later than the sphalerite. All the gold seems to have been introduced after the fracturing of the arsenopyrite, and this may explain why some of the arsenopyrite appears to be auriferous, though in other deposits it is barren.

The possibility of two ages of quartz is apparent in some of the underground workings. The older quartz is barren, massive, and contains many terminated quartz crystals. At the Downing prospect, on Bonanza Creek, a 2- to 4-inch vein of quartz carrying gold cuts an older massive barren quartz.

STRUCTURAL FEATURES

Few marked structural characteristics are shown by the veins. In some there is a rough banding of the sulphides in the quartz, and in the smaller veins this banding becomes more pronounced and the quartz exhibits comb structure. A few of the veins show a brecciated condition, with angular fragments of the wall rock, either slate or graywacke, embedded in the quartz vein material.

The most conspicuous structural feature shown by the veins is that resulting from the postmineral movement to which they have been subjected. This movement has caused a fracturing and shearing of the vein material. All of the movement has been closely parallel to the vein, and locally it may cause a pinching, swelling, or even lensing out of the vein, thus greatly increasing the difficulty of following the vein during mining.

ENRICHMENT

Many of the prospects that have been worked intermittently for the past 15 years appear to have been much richer near the surface than those subsequently encountered in the underground development work. Whether or not this was due to primary or secondary agencies is not known, although enrichment of the surface outcrop of a vein to a depth of several feet is common, owing to the concentration of the gold by the removal of the valueless gangue minerals; but the formation of a zone of enrichment to any great depth seems unlikely because of the severity of the climate, the high topographic relief of the region, and the comparative recency of glaciation.

If there has been an actual movement of gold in the upper zone, the evidence is insufficient to prove it. Probably the transfer of gold in the vein by solutions would be reflected in the fineness, but attempts to find whether the fineness of the gold was greater or less near the surface have been unsuccessful, as adequate records have not been kept, and on only a few of the properties has underground work been carried to a depth sufficient to give conclusive evidence.

TENOR OF THE ORE

The veins of the district have a remarkably high tenor, the average of the ore that has been mined in the past being about $45 in gold to the ton. This high tenor is economically necessary to offset high cost of operation, narrowness of veins, and poor mill extraction. The value of the concentrates usually averages between $500 and $1,000 a ton.

GENESIS OF THE ORE DEPOSITS

The origin of the vein deposits is obviously similar to that of the mineralized dikes, as the mineralization in each is identical. After the intrusion and solidification of the dikes the region was subjected to stresses that fractured the brittle dike rock. It is probable that the same stresses also slightly fractured the country rock of slate and graywacke, and along many of the fractures some movement took place, affording suitable open fissures for the deposition of the ores. The intrusion of the dikes is evidence of the presence at that time of an underlying magmatic reservoir. The last phase of this magmatic activity was the giving off of ore-bearing solutions, which probably represent the end products of crystallization of the cooling rock. The fact that much of the mineralization occurred in the dikes or in veins close to the dikes suggests that the ore-bearing solutions came up through channels close to those through which the dike material itself entered. The ore-bearing solutions, upon coming to open fissures, and under the necessary conditions of temperature and pressure, deposited their burden of minerals in the fractures in the dikes and throughout the country rock.

The first event of this period of mineralization was the deposition of the arsenopyrite. The crystals of arsenopyrite were then fractured, and the gold, galena, sphalerite, and chalcopyrite were deposited slightly later. Since the deposition of the ores the region has been eroded to such an extent that the veins are now exposed at the surface.

FUTURE OF THE DISTRICT

The future of the district appears to lie in the careful and economical mining of the small veins. The highly faulted and folded condition of the country rock and the past mining experience show that the veins will not warrant heavy overhead or large-scale development work, as structural conditions necessary for ore deposition change within short distances. Milling equipment should be adapted for small-scale operations, and development work should be confined to following the vein or with a very short distance between crosscuts, as the veins pinch out abruptly. The mineralization is of a type that should persist in depth, but the structure that controlled the sites of mineralization is not everywhere persistent.

Development work on the mineralized dikes has been insufficient to determine the possibility of mining them on a large scale, but in only a few places do they appear to merit further development under present conditions. The erratic nature of the mineralization in the dikes indicates that considerable underground work and a thorough sampling would have to be done before any conclusions could be drawn. Prospecting the dikes is exceedingly uncertain in its results, and with our present knowledge well-mineralized portions would be found only by chance.

Further prospecting will no doubt uncover many more small veins, but many will never be found because of the enormous overburden in the valleys. No easy, simple rules for searching for profitable deposits can be laid down, as the veins occur scattered throughout the district, in either slate or graywacke, and may trend in any direction. Usually the east-west veins are more profitable, and the presence of galena and sphalerite, even in small amounts, is a favorable indication for gold. The fact that many of the veins are in close proximity to the dikes is suggestive of a possible guide for prospecting, as the ore-bearing solutions may have ascended through channels similar to those through which the dike material itself came; but areas in which dikes have not been found should not be condemned for further prospecting, as dikes may be present though undiscovered, perhaps lying close beneath the surface.

MINES AND PROSPECTS

PALMER CREEK

HIRSHEY

During the summer of 1931 and for several years past, the Hirshey mine (no. 16, pl. 36), on the Lucky Strike vein, has been the only producing lode mine in the Moose Pass-Hope district. It is on Palmer Creek, within half a mile of its head, and is 12 miles from Hope by the Palmer Creek Highway, which extends from Hope to the Hirshey camp and mill. From the mill it is three quarters of a mile by trail to the mine, which lies on the east side of the valley 1,000 feet higher than the mill.

The property was discovered by the present owner, John Hirshey, who personally has operated it except in 1922–27. The discovery was made in 1911, and for several years little except assessment work was done. Later a one-stamp mill was erected and continued in operation until 1922, when the property was purchased by the Alaska

Minerals Co., of Anchorage. Shortly after this time a road was constructed from Hope, and a five-stamp mill was erected. In 1928 the property reverted to Mr. Hirshey.

The milling equipment consists of a jaw crusher, five stamps, a Wilfley table, and amalgamating plates. The ore is brought to the mill by a 3,000-foot tram line. During the summer of 1931 cyanide tanks were put in, and the tailings from the mill, which had been ponded, are now being worked. Sufficient power is obtained from

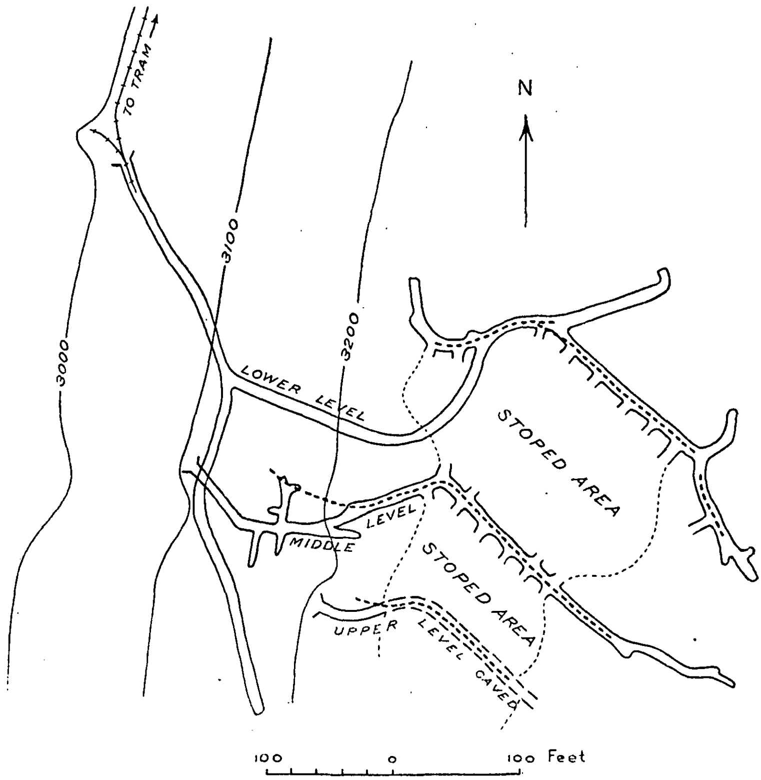

FIGURE 57.—Plan of underground workings and position of the vein at Hirshey mine.

a nearby stream to operate the mill and compressor. The working season for a mine and mill at this elevation is short, owing to snow and the freezing of the water available for power. Ordinarily operations begin June 1–15 and continue until October 1.

The underground workings consist of three levels at vertical intervals of 100 feet. (See fig. 57.) At the present time the upper tunnel, which lies about 30 feet below the discovery, has caved to a point within 30 feet of the portal, and therefore the greater part is inaccessible. The middle tunnel, about 500 feet in length, is in good condition and is used only for ventilation and safety, as practically all of the ground between the upper and middle levels has been stoped. The lower tunnel is the present working tunnel, and nearly all of the ground above it has been stoped. The underground work at present consists of development on the east face of the lower level and the stoping of the few remaining blocks above it.

The country rock is slate, the cleavage of which has a strike ranging from north to N. 35° E., with a dip of 60°–80° E. Near the surface the slate may show an inclination as low as 40° E., owing to the surface creep. Bedding in the slate was not visible underground, and the only place at which it was observed was at the portal of the lower tunnel, where it had been brought out by weathering. It is highly contorted at that point, but in general it is horizontal.

The vein occurs in a curving and branching fracture that cuts across the cleavage of the slate at approximately right angles, so that the strike of the vein ranges from N. 45° W. to west. The dip of the vein ranges from 20° N. on the west end of the middle level to 75° NE. on the east end. The average inclination is about 40° N. The width of the vein ranges from a few inches to 5 feet, with an average of about 18 inches. On the lower level the vein is about 300 feet long, but it is not all minable. On the middle level it is about 350 feet long, but here also it is not all ore. The stoping length on both the lower and middle levels is about 200 feet. Measurements on the upper level were not available, but it is probable that the length was somewhat less, owing to the slope of the hill, as on the upper level the vein crops out and a portion has been eroded, whereas on the lower level and probably also the middle level the vein pinches out before reaching the surface. This is due not only to the slope of the hill but also to the fact that the ore shoot rakes to the northeast. (See fig. 57.) On both the middle and the lower levels the vein curves, and the apex of the curve occurs in the middle of the shoot, so that structurally it has the appearance of a plunging nose. This curvature appears to increase in depth, and it is probable that the vein may split into two; there is a suggestion of this on the lower level, where the vein splits at the apex of the curve. On the dip of the vein developments have proved a distance of 350 feet, with ore still showing in the bottom of the lower level. Vertically, this means a proved depth of about 250 feet.

Associated with the vein is considerable gouge, sheared slate, and in a few places a vein breccia. Considerable postmineral movement has taken place, but this has been in the nature of small faults parallel to the vein, which have sheared the vein material, forming considerable gouge between the vein and the country rock, and at places have sheared the slate as well as the quartz. In a few places the movement has caused slicing in the vein closely parallel to the walls, giving it a greater width, but elsewhere it has caused pinching, making the vein exceedingly difficult to follow and greatly increasing the cost of the development. The walls are usually well defined, and the ore breaks clean from them. In a few places both footwall and hanging-wall stringers are abundant. In several places irregular masses of what appears to be a different quartz intercept the vein and increase the cost of development, as they carry little gold.

The mineralogy of the vein is typical of the district. The vein material consists chiefly of quartz with small amounts of calcite and ankerite. The metallic minerals, in order of abundance, are arsenopyrite, pyrite, galena, sphalerite, and free gold, with the arsenopyrite greatly in excess of the others. The proportion of sulphides to vein quartz varies greatly from place to place, ranging from a fraction of 1 percent to as much as 20 percent, the average being about 2 percent. The gold occurs both free and combined with the sulphides, but there does not seem to be any direct relation between the amount of sulphides and gold—in fact, the richer portions of the vein have the smaller percentage of sulphides.

The gold is almost entirely in the vein material. In some of the richer portions of the vein the wall rock may carry some gold but in general not enough to warrant mining. Assays are as high as several hundred dollars to the ton and usually are highest where the vein has a width of 6 to 12 inches. It has been said that the upper level and the discovery cut contained very rich ore, portions of which averaged several hundred dollars to the ton. It was rich enough to make a profit with a 1-stamp mill before a road was put into the district, when handling of the ore several times from the mine to the mill was necessary. It is probable that the ore mined from the lower level averages around $40 a ton, although portions running much less than this have been left unstoped. In a few places where the footwall stringers are abundant $3 to $5 channel samples have been obtained from 4-foot widths of quartz stringers and slate. As elsewhere, the mineralization has been erratic, and close sampling is necessary, although in general the oxidized and sheared quartz, which can be easily identified with the eye, is found to carry the most gold.

The future production is problematic, as the ore above the lower level has been stoped and the vein appears to have pinched laterally and cannot be traced. Future development work must be downward, either by a winze, which would necessitate pumping and hoisting equipment, or by a long crosscut tunnel lower down on the side of the hill. The mineral associations would suggest that there is an excellent chance of continuation in depth if suitable structural conditions exist. The fractures in the district are as a rule very erratic and do not persist over any great length or depth, although in general the depth exceeds the length.

During the summer of 1931 from 8 to 10 men were working on the property. Late in the summer work was stopped at the mine, owing to the breaking of the tram line, but operations continued at the mill until the freeze-up.

SUNSHINE

Five claims called the Sunshine group (no. 14, pl. 36) were located in 1923 by Pete Kopovich and Tom Sobel. These claims are on the west side of Palmer Creek adjacent to the Palmer Creek road and about 10 miles from Hope. The vein that has received most attention lies at an elevation of 2,700 feet, about 1,200 feet above the road. The development work consists of an open pit at the discovery and a 130-foot tunnel. The tunnel lies 60 feet vertically below the discovery pit. For a distance of 40 feet from the portal it is in barren rock, but the remainder is on the vein.

The country rock consists of massive graywacke that strikes N. 10° E. and dips 40°–60° W. The development work shows the graywacke cut by an irregular quartz vein that has a general east-west strike and an almost vertical dip. It ranges in width from 6 to 12 inches. A second vein 2 to 12 inches wide is horizontal and intersects the first at the tunnel level. These veins have very tight walls and appear to have been originally small fractures from which issued very mobile quartz-bearing solutions that replaced the country rock. This replacement has been irregular; in places the veins lose their fissurelike appearance and the quartz occurs in irregular masses. About 40 feet from the portal of the tunnel are several small thrust faults that strike N. 20° E. and dip 15°–30° W. These faults contain from 2 to 8 inches of gouge in which are some small seams of quartz that carry visible gold.

The vertical vein and the horizontal vein carry very small amounts of chalcopyrite, pyrite, and gold. Three channel samples across the vein in the tunnel gave only traces of gold and silver. The main lead does not appear favorable, in view of the narrow veins, small amount of gold, and structural conditions, and it is doubtful if this lead deserves further work. The small faults give a good showing of free gold, but they are narrow, and it is extremely doubtful whether they are persistent.

TEDDY BEAR

About a quarter of a mile west of the southerly continuation of the dike that occurs on the Kenai Star property, lying roughly parallel and en échelon with it, is a similar acidic dike. It was originally located by John Hirshey on what are known as the Teddy Bear claims (no. 15, pl. 36). Since the discovery the claims have changed hands several times, and at present they have been relocated by Pete Kopovich. The claims lie east of the Palmer Creek road and about 1,100 feet above it, at a point about 11 miles from Hope.

The development work consists of a number of open cuts and a 50-foot tunnel, which have exposed a slightly mineralized dike that has a general north-south strike and a dip of 45°–60° E. The country rock is slate and graywacke with the same general strike as the dike and with a variable dip. From the Teddy Bear claims the dike has been traced north for about a mile; beyond that point it is hidden, as the overburden becomes great where the dike trends toward the valley of Palmer Creek, the bottom of which is filled with glacial outwash and slide material. To the south it is easily traced for about 3 miles; it cuts across the small basin east of the Hirshey mill and is also exposed on the north and south walls of the cirque that is occupied by the Palmer Creek glacier. In its southern part the dike is inclined more to the vertical but still maintains a general north-south trend. In a few places it splits into smaller dikes, so that two dikes may parallel each other for a short distance. The width of the dike ranges from 1 to 8 feet, with an average of 2½ feet. In several places it is offset by transverse faults, but the observed horizontal displacement is nowhere more than 20 feet; usually the northern part of the dike is offset to the east, relative to the southern part, a condition analogous to that at several other dikes in the district.

The character and conditions of mineralization are also similar to those of all other dikes in the region. The dike rock, being more brittle than the surrounding rock, has been fractured, in some places severely and in other places very slightly. The fractures have been filled with quartz and, to a less extent, with calcite. In some parts of the dike quartz may be absent; in others it may constitute as much as 30 percent of the dike. Accompanying the quartz are small amounts of arsenopyrite, chalcopyrite, galena, sphalerite, and free gold. The dike rock contains many small, well-formed crystals of arsenopyrite, but the sulphides nowhere form more than 1 percent of the quartz veinlets and usually much less. The gold is very erratically and sparsely distributed. Between Palmer Glacier and the Teddy Bear claims five channel samples were taken across the dike on what appeared to be the most favorable portions. These samples gave only traces of gold and silver, although close examination of the vein material in the dike often discloses small flakes of free gold.

The dike as now exposed does not show ore. However, the development work has been slight. It is entirely possible that further exploration will disclose more heavily mineralized portions, but these portions, if found, would be erratic both in value and in continuity, and with our scanty knowledge of these dikes, the possibilities of striking rich portions would depend entirely upon chance.

Very little work has been done on the Teddy Bear claims since 1920. During the summer of 1931 several men signified their intention of driving a tunnel in order to tap the dike at greater depth in the hope that mineralization might be better in depth, but the outcrops in the creek bottoms do not tend to encourage the enterprise. There are no buildings or equipment of any kind on the property.

DOWNING

J. W. Downing's property consists of three claims, the Bonanza, Francisco, and Whistler (no. 13, pl. 36), on Bonanza Creek, a small tributary that enters Palmer Creek from the east. This property lies adjacent to the Palmer Creek road, the point where the trail takes off from the road being about 9 miles from Hope and at an elevation of 1,300 feet. The Francisco claim, the nearest to the road, lies at an elevation of 2,000 feet and is about three quarters of a mile by trail from the road. These claims were located in 1921 by Mr. Downing.

At the present time the work is being confined to the Francisco claim. The country rock consists of massive graywacke. Work was originally begun on an irregular quartz mass that has a general trend of N. 70° W. This mass is only erratically mineralized, but a small, fairly regular vein 1 to 5 inches in width occurs in a fracture later than the irregular quartz mass. This later vein strikes about north and dips vertically. In places it is heavily mineralized, containing massive arsenopyrite, some galena, and free gold. In August 1931 a tunnel had been driven in 30 feet, with good tenor continuing to the face. This small vein is rich but is so narrow that it could not be considered minable.

About half a mile east of the Francisco tunnel a vein occurs on the Whistler claim. The country rock is slate that strikes N. 25° E. and dips 72° E. The vein ranges in width from 2 to 6 inches and closely parallels the cleavage of the slate. A tunnel was driven in on the vein for a distance of 50 feet, and the vein was lost by a fault that strikes N. 70° E. and dips 80° N. It is probable that the displacement is slight and that with a small amount of development work the continuation could be found. The metallic minerals consist of arsenopyrite, galena, and free gold. The present showing was not sufficiently encouraging for further development, as the vein is too narrow to be minable and its tenor is low.

Several other veins are exposed by open cuts and pits, but they do not look sufficiently encouraging for further expenditure. At one place midway between the Francisco and Whistler showings there is a 6-foot width of quartz stringers which are 2 to 3 inches wide and are interbanded with and parallel to schistose slate. Some arsenopyrite and pyrite are visible. Several samples across the stringers gave only traces of gold and silver.

KENAI STAR

The old Kenai Star property (no. 11, pl. 36) is located on a mineralized dike in the bottom of Coeur d'Alene Gulch, about a mile from its mouth. It is accessible from the Palmer Creek road at a point about 7 miles from Hope. Formerly, there was a wagon road from the Palmer Creek road to the property, but it is so overgrown that only a trail remains. The point where this trail leaves the Palmer Creek road lies at an elevation of 1,250 feet, and the property is at an elevation of 1,750 feet.

The original location was made in 1898, but the property has been relocated several times since. At one time a 5-stamp mill was erected, and during the summer of 1922 several tons of rock from the more heavily mineralized portions of the dike was worked, but this did not prove profitable, and the mill was dismantled and moved to the Hirshey property.

The developments consist of an upper tunnel at 1,790 feet, which is a drift on the dike for a distance of about 60 feet, and a lower tunnel at 1,740 feet, which consists of a 70-foot crosscut to the dike and a 50-foot drift on the dike, a total length of 120 feet. There are also numerous open cuts and strippings on the dike in the valley.

The dike as observed in Coeur d'Alene Gulch is a fine-grained acidic rock, identical with the other dikes of the region. It has a general north-south strike and a vertical dip and ranges in width from 3 to 6 feet. The country rock is a slate that strikes N. 30° E. and stands almost vertical. Regionally the dike cuts across the slate, but locally, owing to later movements, the slate may parallel the dike.

The dike is erratically fractured and cut by quartz veins and stringers that at many places form as much as 30 percent of the dike rock. The mineralization of the dike produced quartz and calcite, contained in which are arsenopyrite, pyrite, chalcopyrite, galena, sphalerite, and free gold. The sulphides form only a small portion of the vein material and are very erratically distributed. Here and there the dike rock may contain small well-formed crystals of arsenopyrite, but the minerals of value are usually confined to the quartz veins and stringers. Some fine specimens of gold are said to have been found, but at the present time the face and the dumps show very little gold. Two samples taken in the upper tunnel from a 30-inch channel on dike rock containing 30 percent of quartz showed gold as follows: Face of tunnel, 23 cents to the ton; 15 feet from portal, trace.

The dike is continuous across the valley except for some minor faults, none of which have caused great displacement. In the upper tunnel there has been a 15-foot displacement almost parallel to the dike. In places considerable gouge is found between the dike and the country rock, all of which suggests postdike and postmineral movement. The quartz stringers in the dike do not extend into the adjacent country rock but terminate abruptly upon reaching it. The dike rock, being much more brittle than the slate, has been more severely fractured, and this has determined the location of the mineralization.

North from Coeur d'Alene Gulch the Kenai Star dike has been traced for a distance of about a mile to the divide between Bear and Cub Creeks. To the south it runs along the divide between Alder and Palmer Creeks for about 4 miles. In general the dike rock is barren, with only here and there a few quartz veinlets. South of Coeur d'Alene Gulch, at the point where the dike crosses Bonanza Creek, it shows a width of 6 inches to 3 feet and contains from 1 to 10 percent of quartz with a small amount of visible arsenopyrite. A sample across a 20-inch face in which quartz formed 10 percent of the rock gave only a trace of gold. Most of the stringers of quartz in the dike have a definite orientation and appear to be shear and tension fractures due to a regional stress acting on the comparatively brittle dike rock.

On the north side of Bonanza Creek a 20-foot tunnel has been driven in and shows a 3-foot width of dike containing about 2 percent of quartz veinlets with a small amount of arsenopyrite. A sample across the face gave only a trace of gold. At this point the dike strikes N. 30° E. and dips 45°–60° E. Other exposures of the dike farther south show comparatively little mineralization. At present no work is being done on the Kenai Star dike.

Nowhere on the dike was there observed anything that might be considered ore. The probability that the dike may be of commercial value depends on the amount of fracturing. Further underground work might disclose some well-mineralized portions, but the finding of these portions would be extremely uncertain, as there is apparently no guide to their location, even if they are present.

ROBIN RED BREAST

On Coeur d'Alene Creek about 800 feet east of the Kenai Star dike, and at an elevation of 2,110 feet, there are several open cuts that represent the old Robin Red Breast prospect (no. 12, pl. 36). It is reported that from 1920 to 1923 some underground work was done here, but those workings are not accessible. At the time of the writer's visit one open cut showed a 10-foot face of quartz stringers 1 to 6 inches in width, which are parallel to the cleavage of a schistose slate. The quartz stringers form about 30 percent of the 10-foot width. The mineralization is scant, and the stringers do not show any continuity along the strike. Two channel samples across the quartz stringers gave only traces of gold and silver. About 70 feet west of the large open cut is a small exposure showing a 1-foot quartz vein that parallels the cleavage of the country rock. A small amount of pyrite is visible, but a sample assayed showed only a trace of gold and silver. The small width, low tenor, and lack of persistence along the strike indicate that this vein has little value.

NEARHOUSE & SMITH

The Nearhouse & Smith group (no. 6, pl. 36) consists of nine claims on the ridge between Palmer, Bear, and Cub Creeks. These claims lie directly north of the Palmer Creek road and adjacent to it, at a distance of about 6½ miles from Hope. Considerable prospecting on several small veins has been done, as is indicated by numerous small pits and tunnels. Several acidic dikes are exposed on the crest of the ridge between Bear, Palmer, and Cub Creeks. These dikes are in places cut by quartz veinlets and show some arsenopyrite and a small amount of gold, but for the most part the mineralization has been very erratic and sparse.

The most promising vein on this group of claims occurs on the south side of the ridge between Bear and Palmer Creeks, at an elevation of 3,050 feet, or about 1,800 feet above the Palmer Creek road. On the west end of this showing a 30-foot shaft had been sunk but has since caved in. At the east end of the lead a 38-foot shaft was sunk, but it is now accessible only to a depth of 20 feet. Between these two shafts, which are about 500 feet apart, float and outcrops of the vein have been found, suggesting that the vein may be continuous. In 1931 a tunnel was being driven below the east shaft. This tunnel lies 100 feet vertically below the outcrop of the vein, and it was expected that about 250 feet of crosscutting would be required to hit the vein. Late in November 1931 about 165 feet had been driven, and operations were to be discontinued until spring because of lack of fuel at the prospect.

The vein at the east shaft has a strike of N. 45° W. and a dip of 65° NE. The country rock is interbedded slate and graywacke; it strikes N. 20° E. and dips 60° W., so that the vein trends across the formation. It is probable that at the west shaft the strike of the vein is considerably more to the west than on the east end of the lead.

In the east pit, which has the only good exposure, the width of the vein ranges from 24 to 36 inches. The quartz has been highly fractured by postmineral movements and also shows considerable disintegration resulting from its proximity to the surface. The vein is in an old shear zone, but that there has been subsequent minor movement is suggested by the sheared quartz, the gouge, and the presence of small slate horses. The walls of the vein are well defined, and the ore breaks clean from them.

The mineralogy is simple. Sulphides occur only in very small amounts, and chief among them are pyrite, arsenopyrite, and galena. Very fine free gold appears to be disseminated uniformly throughout the quartz. The gold is unusually light-colored, probably owing to combined silver, which shows in the assays of all samples.

Samples from Nearhouse & Smith claims

Number	Gold (ounces to the ton)	Silver (ounces to the ton)	Source and character
1	0.32	0.2	Dump of west shaft; average sample of material.
2	.18	.3	Dump of west shaft; average sample of unaltered quartz.
3	.16	.3	Small pit 30 feet west of west shaft; average sample of undecomposed quartz.
4	1.36	3.8	28-inch channel sample from west face of east shaft at a depth of 15 feet; quartz disintegrated and with much gouge.
5	.66	1.4	36-inch channel sample from east face of east shaft at a depth of 15 feet; quartz disintegrated and with much gouge.
6	1.04	1.8	35-inch channel sample across vein on west face of east shaft at a depth of 9 feet; quartz disintegrated and with much gouge.
7	.62	2.2	29-inch channel sample across vein exposed on west face of east shaft at a depth of 3 feet; quartz decomposed and contains gouge and small slate horses.
8	.03	0.3	Small pit 60 feet west of east shaft; characteristic sample of quartz.

Samples 4–7, from the east shaft, give an average width of 32 inches and an average value of $18.80,[18] which would indicate that the property is worthy of further development. The average of three samples taken from the dump of pits 500 feet west of the east shaft is $4.45. If the underground developments prove the presence of veins of width and value approximating those of the east shaft, it is probable that the property could be worked successfully in a small way, as the location and accessibility are unusually favorable.

[18] Gold at $20 an ounce and silver at $0.30 an ounce.

There is a cabin at the road and another at the portal of the new tunnel. During the summer of 1931 one or two men were working at the property.

ROBINSON & BOWMAN

The property formerly owned by A. O. Robinson and C. P. Bowman (no. 7, pl. 36) is on the south side of Palmer Creek about 75 feet above the creek and three quarters of a mile from its junction with Resurrection Creek. It can be reached from Hope by traveling about 5 miles along the Palmer Creek road, thence about a mile over a trail, part of which is an old wagon road. Since the death of Mr. Robinson, the original locator, the property has changed hands several times, and at present it has been restaked by Pete Kopovich.

A tunnel reported to be 220 feet in length was driven, but owing to caving only 150 feet of it was accessible in the summer of 1931. The country rock is slate, with intercalated beds of graywacke 1 to 12 inches thick. The beds strike N. 10° E. and dip 45°–60° E. Exposed in the tunnel is a small vein that ranges in width from a gouge seam to 6 inches of quartz. The vein cuts slightly across the structure of the slate and graywacke, as it trends northeast and dips 60° SE.

The vein material consists of white quartz, somewhat disintegrated, small amounts of calcite and ankerite, and a little disseminated arsenopyrite and galena. A picked sample of the quartz gave $2 in gold and an ounce of silver to the ton. No work has been done on this property in recent years, and the only equipment is an old cabin in the creek bottom about 1,000 feet east of the prospect.

BEAR CREEK

The area drained by Bear Creek is directly accessible from Hope by an old wagon road that leaves the road to Moose Pass at about mile 4. This road at one time extended to the head of Bear Creek, but at present only about half a mile of it can be used, the remainder of the distance being covered by a trail.

In the cirque at the head of Bear Creek there are numerous acidic dikes. The dikes are more abundant here than in any other locality, and they trend in all directions, unlike those in other parts of the district, which in general trend north. Some prospecting has been done on these dikes, but they have not yet shown the fracturing and mineralization found in the dikes in the adjacent territory, and as a result but little development work has been done on them.

More than 25 years ago a small shaft was sunk near the head of Bear Creek on quartz stringers in massive graywacke in the bottom of the valley. The amount of mineralization was insignificant, and the prospects of anything better were poor, so the project was abandoned after a considerable amount of money had been spent in bringing equipment to the property.

In spite of the fact that Bear Creek was one of the richer placer streams and that it has only a small drainage basin, there have been few new developments on the creek in the last 15 years. Exploration work to date seems to indicate that the gold in the gravel was concentrated from several lodes that would be impracticable to work on account of their small size.

GOLD STAMP

From 1912 to 1914 the Gold Stamp Mining Co. did considerable underground work on some claims near the head of the creek (no. 5, pl. 36). A 5-stamp mill was erected, but as there was insufficient ore the plant was subsequently dismantled.

TAYLOR

Six claims have been staked by W. K. Taylor about 1½ miles from the head of Bear Creek (no. 4, pl. 36). Two of the claims are in the bottom of the valley on what is known as the Livewire vein. The only outcrop of this vein is in the bed of the creek. It shows the vein striking north and dipping 30° W., with a wall rock of slate. At the single exposure the width is about 10 inches, and the vein material shows a banding that is suggestive of simple fissure filling. Arsenopyrite is abundant in the quartz and occurs both massive and in well-developed crystals.

Because the vein is in the bed of the creek it could not be developed by following the vein, as this would necessitate diverting the stream and sinking a shaft, with the accompanying expense of pumping. The banks of the stream at this point consist of stream gravel and slide rock. An attempt has been made to develop the vein by driving through the slide material in hopes of hitting the vein, where the bedrock would be encountered. A 130-foot tunnel has been driven, but bedrock has not been reached.

Four claims have also been staked on the south side of Bear Creek, in Snow and Cub Gulches and running up to the crest of the ridge between Bear and Palmer Creeks. These veins are all very small but contain some galena, associated with which is free gold.

COON

About 2 miles from the head of Bear Creek (no. 2, pl. 36) a showing was discovered in the bed of a small tributary on the north side of the creek, about 300 feet above the present trail. Since the death of the original owner, Mr. Coon, the property has been relocated at various times, but no new work has been done.

At the outcrop a 40-foot tunnel has been driven on the vein, which parallels the country rock, striking N. 30° E. and showing a vertical dip. The vein shows a width of 2 to 12 inches of decomposed quartz that contains a small amount of sulphides, chiefly arsenopyrite, pyrite, and galena. High tenor in silver has been reported, and it was originally staked as a silver prospect. The only equipment on the property is a cabin about 200 feet below the tunnel.

SUMMIT CREEK

ALASKA ORACLE

Two patented claims, the Oracle No. 2 and the Oracle Extension, on Summit Creek about a mile from the point where it flows into Quartz Creek (no. 36, pl. 36), are known locally as the Heaston mine but are held at the present time by the Alaska Oracle Corporation, which has head offices at Seattle.

The property is easily accessible, being 16 miles from Moose Pass station and within a mile of the road from Moose Pass to Hope, with which it is connected by a road up Summit Creek. The original discovery, near the creek on its south side, was made by Robert B. Heaston on August 3, 1921. The total development work to date (1931) consists of approximately 912 feet of crosscuts, 400 feet of drifts, and 200 feet of raises. The buildings and equipment on the ground consist of workshops, bunkhouses, an office building, a small mill, a compressor, and the accessory mining equipment. The mill, which is at present partly dismantled, was erected for test runs on the ore during the development work, the power being furnished by a water wheel. The recovery was not very efficient, as it is said that the tailings will run around $12 a ton in gold.

A drift on the south side of the creek close to the discovery and about 15 feet above the stream is 120 feet in length and follows the vein for about 100 feet, to a point where the vein appears to begin to feather out and curves into the footwall. On the north side of the creek a tunnel in slide material is on the strike of the vein, but it probably never penetrated to the bedrock. This tunnel is badly caved and inaccessible. From the camp site a 900-foot crosscut tunnel has been driven and the vein intersected, proving it to a depth of 110 feet. On this lower level 275 feet of drifting has been done and two raises put up. One of the raises connects with the upper level, which was put in on the discovery. (See fig. 58.)

The vein strikes N. 15° E. and has an average dip of 60° W. In width it ranges from a few inches to 3 feet, with an average of about

12 to 14 inches over a length of 175 feet on the lower level. The country rock is interbedded slate and graywacke, in which the bedding is usually very obscure on account of the gradation in texture of the slate to the graywacke. The finer-textured phases possess good cleavage, which has a general strike of N. 15° E. and dips ranging from 60° W. to 80° E. In the few places where the bedding could be distinguished it is parallel to the cleavage. The graywacke is usually very massive, with only scattered joints.

The vein occupies a fracture along which movement had taken place prior to ore deposition. This fracture in general parallels the structure of the graywacke and slate but here and there deviates from it, so that as a result of the movement along the fracture there is in some places a footwall of graywacke and a hanging wall of slate. It has been thought that these walls determine the position of the vein and that the vein formed at the contact of the slate and graywacke; but this is only a coincidence: the position of the vein was determined by the fracture. As shown by both the upper and the lower levels, the south end of the vein takes a flat roll into the footwall, and in the development work this roll was not followed out. The position of the roll on both levels and the development in the north end of the lower level, where the ore pinches out, suggest that the ore shoot has a rake of 20°–45° SW. (See figs. 58, 59.) Whether the ore feathers out or continues at the point where it takes the flat roll remains to be proved by further development work.

Slickensides and grooves having the same rake as the ore body were observed on the lower level. On both upper and lower levels footwall stringers are common, particularly in the massive graywacke. These stringers or gash veins have the appearance of quartz-filled tension fractures, and their position confirms the impression gained from the fault surfaces that the premineral movement was such that the hanging wall moved to the southwest on a slope of 20° to 45°, which is the same as the rake of the ore shoot.

Not all the movement occurred prior to the mineralization, as is shown by the slickensided and sheared quartz. The postmineral movement has been in general parallel or closely parallel to the vein, as no transverse faults were observed. The weathering of the vein material has proceeded to depths of 50 to 75 feet below the surface, so that the quartz is very friable and iron-stained.

The minerals contained are arsenopyrite, pyrite, galena, and sphalerite, named in decreasing order of abundance, but in total they probably form only 0.5 percent of the ore. The gangue mineral is chiefly quartz with small amounts of calcite. The pyrite is usually well crystallized and commonly impregnates the wall rock for a few inches. The galena is fine grained and is disseminated in the quartz.

The arsenopyrite is commonly euhedral and as a rule is confined to fractures in the quartz. The sphalerite is very scant and is of the ferruginous variety. Chalcopyrite, pyrrhotite, and molybdenite have also been reported. Gold occurs both free and with the sulphides. Free gold is difficult to find in hand specimens, as it is apparently very fine.

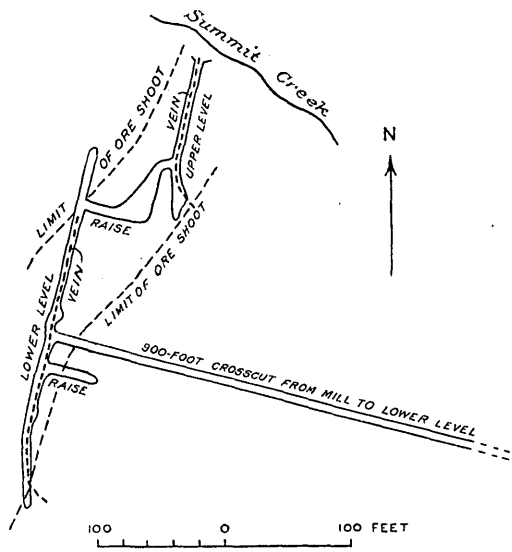

FIGURE 58.—Plan of underground workings of the Oracle mine, showing position of the vein.

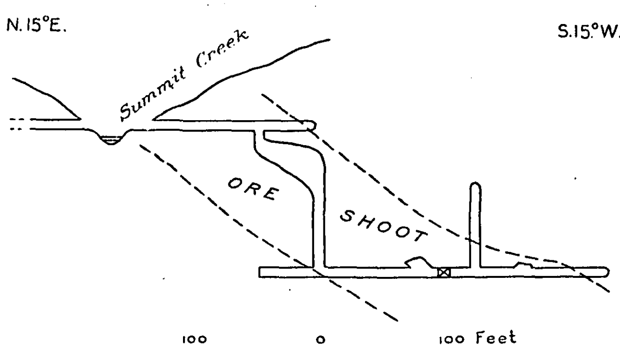

FIGURE 59.—Longitudinal section of the Oracle vein, showing limits of the ore shoot.

Samples assayed showed values as high as $350 a ton, with an average of around $40 to $45, over a length of 150 feet, a vein depth of 110 feet, and an average width of 14 inches. There is apparently no diminution in value on the lower level as compared with the upper. In places where the vein is richest the wall rock is also somewhat mineralized, but in general the valuable minerals are confined to the vein material.

It is reported that gold to the value of several thousand dollars was taken out during the development work, but in 1931 the property was lying idle. At that time there was probably about $60,000 in ore in sight. The chance of proving a greater length to the vein does not appear good, but the roll that the ore takes at the south end of the vein should be followed. Mineralogically the vein should continue in depth as far as suitable structural conditions prevail. Further development work should be confined to following the vein at the south end and to sinking a winze from the lower level on the vein.

RONAN

The Champion and Gladiator claims, locally known as the Ronan mine (no. 37, pl. 36), are on the south side of Summit Creek, at an elevation of about 3,500 feet. (See fig. 60.) These claims were leased by Ronan & James, who in 1916 and 1917 erected a small mill on Summit Creek directly below the mine. Several tons of ore was milled, but since 1917 there has been but little work on the property.

At the present time the portals of the two tunnels, one about 60 feet below the other, are visible; but they are inaccessible owing to caving and to accumulations of ice in them. Johnson,[19] in 1917, wrote:

> Present underground developments on the property consist of a 137-foot crosscut to the lead, a 210-foot drift on the vein, an 85-foot raise to the surface at the point where the lead was struck, and a 30-foot shaft on the outcrop of the ore body.

It is said that the vein was about 12 inches wide and had a strike of N. 60° E., with a dip to the southeast, and that operations ceased because of the exhaustion of the ore body. The claims have been restaked by W. H. Whittlesey, of Seward.

JOHNSON

On the north side of Summit Creek several claims (no. 35, pl. 36) have been staked by Harry Johnson on the continuation of the dike that occurs on the Gilpatrick property. These claims were originally staked as a part of the Colorado group and are reached by a trail half a mile long from the Oracle mine, to which a road extends. The dike at this point strikes N. 12° E., stands vertical, and ranges in width from 4 to 8 feet.

The development work consists of a 40-foot tunnel at an elevation of 2,600 feet and several open cuts at 3,550 and 4,300 feet. The highest cut is within 100 feet of the top of the ridge, where the dike cuts across the divide between Summit and Colorado Creeks. Here

[19] Johnson, B. L., Mining in central and northern Kenai Peninsula: U.S. Geol. Survey Bull. 692, p. 175, 1917.

also the mineralization is confined to quartz stringers in the dike, some of which are 4 to 6 inches wide. Associated with the quartz are calcite, arsenopyrite, and pyrite. Although gold was not seen on hand specimens, a few colors were obtained by panning.

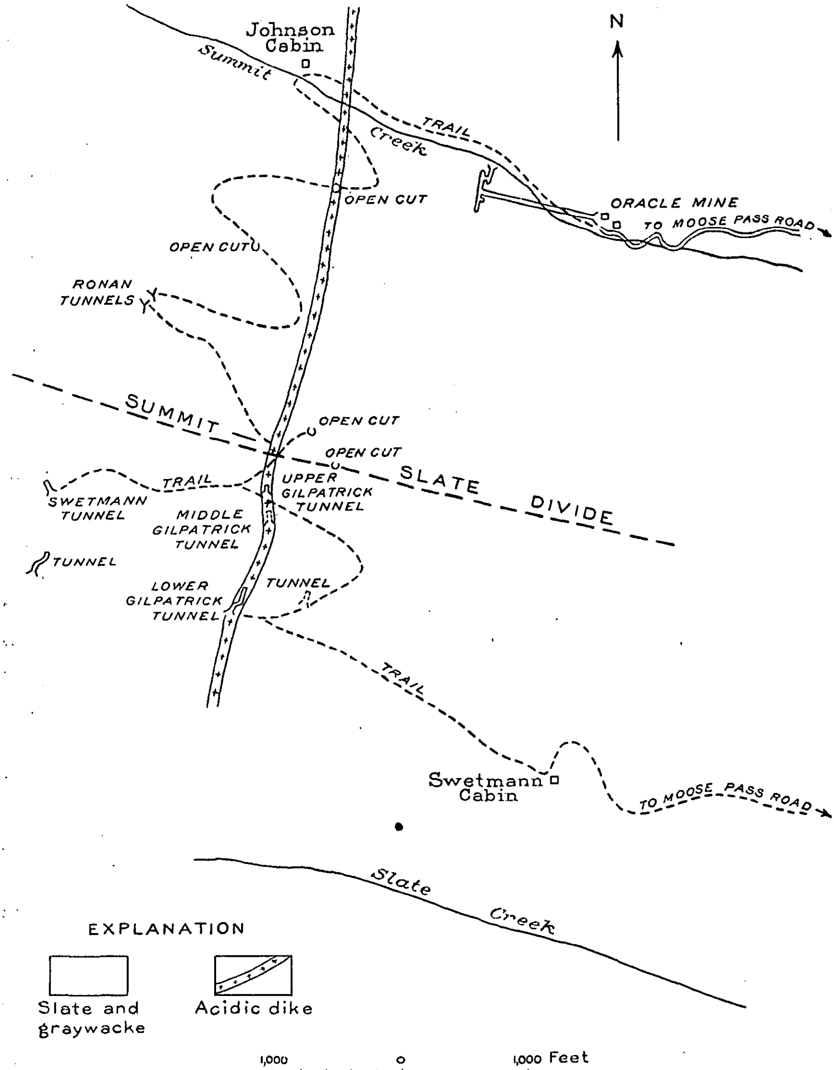

FIGURE 60.—Sketch map of the mineralized area between Slate and Summit Creeks.

A sample taken across a 4½-foot width in the 40-foot tunnel at 2,600 feet gave gold 0.03 ounce and silver 0.1 ounce to the ton. Picked samples of quartz from stringers in the dike at the open cut at 4,300 feet gave gold 0.02 ounce and silver 0.1 ounce. The dike at these exposures does not contain as much quartz or metallic minerals as on Slate Creek.

SLATE CREEK

GILPATRICK

The group generally known as the Gilpatrick property (no. 39, pl. 36) consists of seven claims extending from Slate Creek to Summit Creek. The portion of the claims on which the greater amount of development work has been done is in the Slate Creek drainage basin and is accessible from mile 14 on the road between Moose Pass and Hope, at an elevation of 1,200 feet. From that point the distance is about 1¼ miles by trail. The claims on the Summit Creek side are more easily reached from mile 15, from which there is a road 1¼ miles to the Oracle mine and thence a trail leading up the south side of Summit Creek.

Gold-bearing quartz veins were first discovered in this vicinity in 1906 by J. C. Gilpatrick. The mineralized dike which is covered by four of the seven claims in the group was found in 1908. The property has been leased and optioned several times but has always reverted to the original locator.

The development work on the dike consists of three tunnels on the Slate Creek side of the ridge and one open cut on the Summit Creek side. The lower tunnel lies at an elevation of 2,650 feet, is 265 feet in length, and is in excellent condition. (See fig. 60.) The middle tunnel is at an elevation of 3,100 feet, and the first two or three sets of timber have caved so that it is inaccessible at the present time. The upper tunnel, at 3,230 feet, goes in about 50 feet but is in poor condition, so that retimbering and cribbing are necessary. The open cut on the Summit Creek side is at an elevation of 2,300 feet and exposes the dike for about 20 feet.

In addition to the dike claims, three other claims are located on quartz veins in close proximity to the dike. One of them lies on the Slate Creek side about 500 feet east of the lower dike tunnel. On this claim a 200-foot tunnel was driven in the fall of 1910 by the Wanowky Gold Mines on a vertical shear zone that ranges in width from 3 to 30 inches and strikes N. 60° E., in slate. This tunnel is caved at the portal and inaccessible.

Another quartz vein less than 500 feet east of the dike and at the crest of the ridge is on what is known as the Summit claim. It lies in massive graywacke, strikes northwest, and stands vertical, cutting across the structure, as the general trend of the formations is north. It is said that a 120-foot tunnel had been driven in on the Summit Creek side, but this has long since collapsed, and the open cut is largely covered with slide material. At an elevation of 2,800 feet on the Summit Creek side there is an open cut that is too badly caved to permit examination. All of the work on the property represents development during the first few years after discovery, and little, if any, work has been done during the last 15 years.

The dike ranges in width from 1 to 12 feet, with an average of 4 to 5 feet. It is best exposed in the lower tunnel. Here it lies in slate, the cleavage of which strikes north to N. 15° E. and dips 65°–85° E. The trend of the dike, which stands vertical, is closely parallel to the cleavage of the slate but in general is a few degrees east of north.

The dike is cut by a number of transverse faults that cut across it in a direction N. 60° E. and with a dip from 75° NW. to vertical. Along these transverse faults the movement has invariably been the

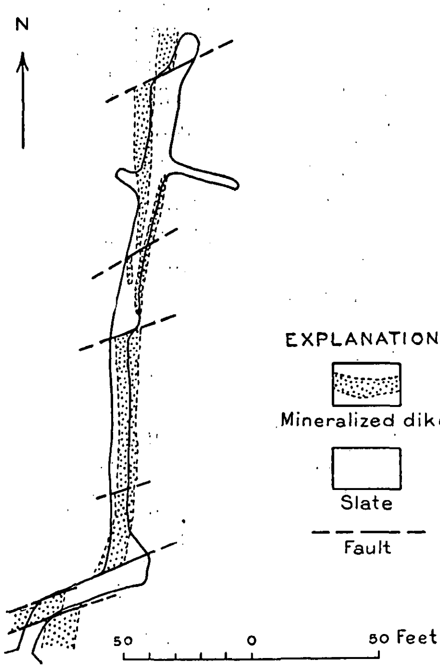

FIGURE 61.—Geologic map of mineralized dike in lower tunnel of the Gilpatrick property.

same, so in drifting on the dike and finding it offset, a good general rule is to turn to the right along the fault surface. (See fig. 61.) The relative movement has been such that the north block has moved down and to the right in respect to the south block. In some places where slickensided surfaces indicate a purely vertical movement, the offset to the right can be explained only by assuming that the dike has a steep west dip. The horizontal component of the movement where actually observed is usually from a few inches to 15 feet.

In addition to these transverse faults there are numerous faults that parallel the dike, as in many places there is several inches of gouge between the dike and the wall rock, and both faces may be highly polished from the movement. Between the lower and middle tunnels there are probably several transverse faults, as the position of the dike is considerably to the right of the point where it should be expected if the strike of the lower tunnel were projected. The middle tunnel as observed at the portal trends N. 7° W. and has been driven in massive graywacke.

At the upper tunnel the dike strikes about north and shows a width of at least 10 feet. The west wall consists of slate that dips west, but the rock of the east wall has more the character of graywacke. The dike is cut again here by faults that strike N. 45°–60° E. and stand about vertical.

Associated with the dike and in general parallel with it are quartz veins, 2 to 12 inches in width. At some places these veins lie at the contact of the dike and the country rock; elsewhere they may be separated from the contact by 2 to 10 feet of slate or graywacke. The dike itself has been highly fractured in many places, and the fractures have been filled with vein material. The fractures may be irregular but more commonly have a similar orientation, suggesting that the deformation of the dike is due to a regional stress. The veins and veinlets in the dike range in width from a fraction of an inch to 8 or 10 inches; they do not extend from the dike into the country rock but terminate abruptly and are apparently due to the greater brittleness of the dike rock in comparison with the country rock.

The vein filling is predominantly quartz with small amounts of calcite. Contemporaneous with the quartz are small amounts of arsenopyrite, pyrite, galena, sphalerite, and free gold. The massive dike rock contains many well-formed crystals of arsenopyrite. The fracturing of the dike has been highly erratic, and the amount of quartz filling varies greatly from place to place. In some places the dike may contain as much as 35 percent vein material; in others it may be massive and blocky with negligible quartz.

The valuable minerals are in the quartz stringers and veinlets, but the richness is not proportional to the amount of quartz. The tenor is very erratic, although in places free gold is easily visible. Only very thorough sampling as well as systematic development could determine the feasibility of mining the dike.

Samples were taken in the upper and lower tunnels. The middle tunnel is inaccessible. Systematic sampling was not undertaken, as it would take considerable time and with the small amount of underground development work already done would not add materially to any tonnage estimate for the property. It is well to note that these samples may give an erroneous idea of the dikes on account of the erratic distribution of the gold; they are included here only to aid in giving a general impression of the dike.

In all, 12 samples were taken over the 265-foot length of the lower tunnel, and assays show gold from a trace to $39 a ton over widths of 3 to 6 feet. The ratio of silver to gold is 2 to 1 by weight. Most of the samples gave only traces of gold. Samples of the quartz from the dump of the middle tunnel assayed $1 to $2 a ton.

Samples from the upper tunnel gave values ranging from a trace to $32 a ton over widths of 1 to 4 feet. The general average of the upper tunnel was higher than that of the lower tunnel, and there was also more visible free gold in the quartz. A sample of the quartz from the dump of the old tunnel on the Summit claim gave only traces of gold and silver.

SWETMANN

Elwyn Swetmann, of Seward, holds 3 unpatented claims on the ridge between Slate and Summit Creeks (no. 38, pl. 36)—2 on the south side and 1 on the north side. The property is reached by about 2 miles of well-constructed trail that leaves the road from Moose Pass at mile 14. The outcrop of the vein is at an elevation of 3,700 feet, or about 2,500 feet above the highway.

The development work to date consists of a pit on the discovery, which is on the Slate Creek side of the ridge, and a 260-foot tunnel at an elevation of 3,200 feet. The 260-foot tunnel lies 500 feet directly below the discovery and was driven with the intention of intercepting the vein, but this project has been abandoned. The most recent development, which is the work of 1930 and 1931, is a 120-foot tunnel that intercepts the vein 60 feet below the outcrop and has been completed since the writer's visit. Several open cuts on the north side of the ridge are caved, but it is said that they are on what is believed to be the extension of the vein found on the south side.

The vein at the discovery pit strikes N. 5° W. and dips 60° W., paralleling the cleavage of the country rock. The footwall of the vein is a massive graywacke, but the hanging wall is somewhat slaty. The vein ranges in width from 10 to 16 inches, with some veinlets 2 to 3 inches wide cutting into the hanging wall. It appears to be in an old shear zone.

The vein material is predominantly quartz with only small amounts of arsenopyrite, pyrite, chalcopyrite, and galena. A channel sample 16 inches long across the vein gave gold 0.16 ounce and silver 0.2 ounce to the ton; another channel sample 12 inches long gave gold 0.03 ounce and silver 0.2 ounce to the ton.

During the summer of 1931 two men were working on the property.

UNNAMED PROSPECT

Directly across Slate Creek from the dike on the Gilpatrick property, at an elevation of 3,000 feet, is an old open cut (no. 40, pl. 36) on a quartz vein that ranges in width from 4 to 12 inches. The quartz vein parallels the schistosity of the graywacke country rock, which strikes N. 15° E. and dips 60° W. A characteristic specimen of the quartz at the open cut gave gold 0.04 ounce and silver 0.2 ounce to the ton.

COLORADO CREEK

COLORADO

From the crest of the divide between Summit and Colorado creeks the dike that occurs on Slate and Summit Creeks trends N. 12° E., cutting across a cirque. The Colorado Creek prospects are accessible by a trail on the south side 2 miles from mile 17 on the Moose Pass Highway. The dike has been exposed on the south side of Colorado Creek by a 20-foot tunnel at an elevation of 2,200 feet and by open cuts at 2,240 and 2,350 feet. The original claims located at this point constituted the Colorado group (nos. 33, 34, pl. 36). The exposures at the tunnel and the open cuts show that the dike has an average width of 5 to 6 feet and that quartz stringers compose about 20 percent of it. The wall rock is slate, with cleavage parallel to the strike of the dike. The metallic minerals are characteristic, being arsenopyrite and pyrite, with little visible free gold.

At the 20-foot tunnel two 5-foot channel samples gave, respectively, gold 0.05 ounce, silver 0.2 ounce to the ton; and gold 0.01 ounce, silver 0.2 ounce to the ton.

INDEPENDENCE

On the north side of Colorado Creek there are several open cuts on the dike on what was originally known as the Independence group and the Peel & Iverson claims (no. 31, pl. 36). In general the mineralization has been slight, and the widths are less than to the south. At an elevation of 3,250 feet, on a small tributary of Colorado Creek, there is a 12-foot tunnel on the dike that shows a 4-foot width with about 10 percent of quartz stringers.

MASCOT AND IRON MASK

Two other claims, the Mascot (no. 29, pl. 36) and the Iron Mask (no. 30) are reported to have been located on dikes. No outcrops of these dikes were seen, but only a few pieces of float scattered on the slope on the north side of Colorado Creek. To judge from the float these dikes are similar to the one on the Colorado and Independence properties.

FRESNO CREEK

On the crest of the ridge between Colorado and Fresno Creeks the dike crops out at an elevation of 4,250 feet and is next seen about half a mile to the northeast, on the more rounded hills south of Fresno Creek. The offset to the east would suggest either that the trend of the dike is N. 30° E. or else that it is cut by a transverse fault between the two exposures. Outcrops are exposed at 3,000 and 3,600 feet by small open cuts, which at the time of the writer's visit were largely covered by slide material (nos. 25, 26, pl. 36). From these open pits a trail leads to the bottom of Fresno Creek, where at an elevation of 2,000 feet are the remains of an old arrastre erected several years ago by John Slator. A few tons of the dike rock from the open cuts had been milled. The poor exposures prevented sampling of the dike rock in place. The rock on the dumps is very quartzose, but two picked samples of the quartz gave only traces of gold and silver.

On the north side of Fresno Creek the dike becomes very irregular in width, strike, and dip, although it has a general trend of N. 5° E. A few hundred feet above the creek it shows a width of 5 to 6 feet, dips 84° E., and appears to strike N. 10° E. (no. 24, pl. 36). It is fractured and cemented with gashlike veins of quartz that have a maximum width of 8 inches and are much iron-stained. On the crest of the ridge the dike is 8 feet in width and dips 43° E., but farther north, toward Pass Creek, it is very irregular in width and in some places almost completely pinches out.

PASS CREEK

Several prospects have been located on Pass Creek and its largest branch, Tributary Creek (no. 23, pl. 36), but there has been little mineralization, as the dike is not extensively fractured.

FRENCHY CREEK

On the divide between Pass and Frenchy Creeks four claims (nos. 20, 21, pl. 36) were originally located by S. L. Colwell and J. C. Robertson, along a dike that extends from a point on the north side of Frenchy Creek southward to the Pass Creek drainage basin. This is probably a continuation of the dike that occurs to the south. At one point on Frenchy Creek it has a width of 12 feet.

DONALDSON CREEK

On Donaldson Creek two claims (no. 19, pl. 36) were located on a similar dike which also is probably a continuation of the dike to the south, but the mineralization is very slight.

QUARTZ CREEK

A number of years ago considerable prospecting was done on Quartz Creek near the mouth of Devils Creek (no. 44, pl. 36). Several quartz veins were located, but it is reported that the veins were too small and the gold content insufficient to mine profitably.

M'MILLAN

The original locations of the claims known as the Columbia and Ophir were made by Totten & Gaydon in 1908. From 1910 to 1917 the prospects were developed by Imhoff, Weidlich & Saulsbury, and during this time a small prospect mill was installed on Quartz Creek and several tons of ore was milled. Later these claims (nos. 41, 42, pl. 36) were restaked by Dan McMillan, who still holds them. The property is reached by a trail leading west from mile 13½ on the highway from Moose Pass.

Most of the ore that was milled came from an old tunnel that lies at an elevation of 3,200 feet and is about 1½ miles by trail from the road. About 100 feet of drifting has been done on a vein in a shear zone that strikes N. 75° E. and dips 30° N. The country rock is slate and graywacke, the footwall of the vein being predominantly graywacke and the hanging wall slate. The cleavage of the slate, which is probably nearly parallel to the bedding, strikes N. 30° E. and dips 45° NW. The vein has a width of 1 to 3 feet and lenses out to the northeast, within 50 feet of the portal of the tunnel. A 40-foot incline to the north, almost down the dip of the vein, shows the same termination as in the northeast drift. Laterally, the dimension of the vein is small, as it crops out on the south slope of the ridge, and there is a small draw to the west. To the north and northeast a fault closely parallels the vein but cuts across it at a very acute angle, so that the ore body has the appearance of lensing out.

The vein quartz is highly sheared and disintegrated, owing to the postmineral movement and also to the proximity of the vein to the surface. Sulphides are very scant, with only a small amount of arsenopyrite and pyrite visible. Free gold is occasionally seen.

About 700 feet northeast of the tunnel, at an elevation of 3,200 feet, there is an open pit on a 12-inch quartz vein that strikes N. 40° W. and dips 70° NE. Footwall stringers that parallel the cleavage of the country rock are prominent. The country rock is a schistose graywacke that strikes N. 30° E. and dips 60° NW. Prospecting has failed to disclose a continuation of this exposure.

About 800 feet northeast of the open cut, at an elevation of 3,300 feet, a 120-foot crosscut tunnel strikes a shear zone in massive graywacke. About 40 feet of drifting has been done on this shear zone, showing irregular masses of quartz that are very slightly mineralized. The original discovery, which lies above the tunnel, has been covered with slide rock. The sheared zone, as exposed in the underground work, strikes N. 60° E. and dips 70° NW.

DEVILS CREEK

A small amount of prospecting has been done on an acidic dike near the head of a small tributary of Devils Creek (no. 43, pl. 36). The dike has been fractured and recemented by quartz in a manner similar to the dike that occurs on the Gilpatrick property on Slate Creek. Assays of several samples of the more mineralized portions gave only traces of gold.

AFANASI CREEK

JOHNSON

Harry Johnson and Frank Skeen in 1914 located two small leads, one on Afanasi Creek (no. 32, pl. 36) and the other on East Fork Creek, both near the headwaters of Resurrection Creek and 12 miles west of mile 15 on the Moose Pass highway. Three tunnels 50 to 90 feet in length were driven on these leads and disclosed veins from a few inches to several feet in width but of no great length. Portions of the veins were rich, but in general they were erratic. From one of the veins in which the quartz was highly disintegrated over 4 ounces of gold was separated by a rocker. The country rock is slate and graywacke with a north-south strike. Some of the veins are parallel with the structure, and some cut across it.

GROUNDHOG CREEK

BREWSTER

During the last few years E. H. Brewster has been prospecting on Bench Creek in the vicinity of Groundhog Creek and has located several veins (no. 47, pl. 36). Free gold occurs in much of the vein material, but the veins are narrow and not continuous enough for commercial production.

SEWARD GOLD

A prospect formerly known as the Seward Gold is located at an elevation of 4,200 feet on the south side of Groundhog Creek (no. 48, pl. 36). Some prospecting has been done on a shattered zone that contains quartz stringers, and also on a nearby dike. Although the quartz contains some gold, the mineralized zones as exposed at the present time are too small to mine at a profit.

GRANT LAKE

CASE

Several claims known as the Case prospect are located on the north side of Grant Lake (no. 49, pl. 36). It is reported that several thousand dollars in gold was mined from some small quartz veins that occur in graywacke, but at the present time the property is dormant.

SOLLARS

On the south side of Grant Lake about 1,500 feet above the lake, there are some small quartz veins that parallel the cleavage of slate that strikes north (no. 50, pl. 36). No development work has been done on them, as assays of several samples of the quartz showed only traces of gold.

COPPER LODE PROSPECT

READY BULLION COPPER CO.

Although the finding of copper ore represents one of the earliest lode discoveries in the Moose Pass-Hope district, the only copper prospect (no. 46, pl. 36) has not become a producer. Most of the development work was done in the years 1904 to 1907. The United States Geological Survey party that visited it in 1906 [20] obtained the following data:

The country rock at this locality is a part of the graywacke-slate series composing the central and northern mass of the Kenai Mountains. The dominant cleavage at this point is N. 10° E., a direction nearly parallel with the ridge in which the copper deposit to be described occurs.

At an elevation approximating 3,000 feet a tunnel has been run 350 feet S. 80° W. into the mountain, a direction nearly at right angles to its trend. A drift from a point near the end of the tunnel was driven 150 feet to the south and 90 feet to the north, along a zone characterized by intense slickensiding or shearing in a nearly vertical direction. A short distance beyond this zone a fault dipping 35° W. was observed. Such a dip would not interfere with the continuation of the ore in depth.

Chalcopyrite ore accompanied by pyrrhotite and pyrite with much quartz has been deposited along the zone of shearing disclosed by the drifts. Irregular masses as thick as 2 feet were observed, but their horizontal linear extension was short, the vein fluctuating between 6 inches and 2 feet in thickness. At the south end of the drift the vein was narrow, and at the north end the face did not disclose ore. It was reported that gulches cutting the mountain north and south of the tunnel showed no signs of copper. Stripping, however, had not been done.

A thousand feet below the entrance of the upper tunnel an adit is being driven to catch the ore in depth. A length of 800 feet has now been completed. A rough estimate shows that with continued vertical dip the shear zone would be reached within a distance of 2,000 feet from the mouth of the adit.

[20] Paige, Sidney, and Knopf, Adolph, Reconnaissance in the Matanuska and Talkeetna Basins, with notes on the placers of the adjacent region: U.S. Geol. Survey Bull. 314, pp. 124–125, 1907.

Little work has been done on this property for the last 25 years, and as a result the workings are inaccessible.

GOLD PLACERS

GENERAL FEATURES

The productive gold placers of the Moose Pass-Hope district lie on Resurrection and Sixmile Creeks or on tributaries immediately adjacent. Tributary streams that have been productive in the past are Bear, Palmer, Canyon, East Fork, Lynx, Silvertip, Gulch, Granite, Quartz, Mills, and Juneau Creeks. The streams on which work was done during the summer of 1931 were Resurrection, Bear, Sixmile, Canyon, Mills, and Lynx Creeks.

The major streams exhibit broad U-shaped valleys from their lower courses to the upper portions. These broad valleys have been filled with gravel that is as much as 500 feet thick in some places, and it is in this thickness of gravel through which the present streams are flowing that well-defined benches have been formed. The valleys are usually wider where the streams flow in gravel than in the part where they have cut through the gravel into the bedrock; in the bedrock the valleys may be narrow and steep-walled. Although the valleys of the tributaries are generally narrower, many of them have gravel fill in their lower courses and near the confluence with the major streams alluvial fans are common.

HISTORY OF OPERATIONS

The first recorded discovery of gold in Alaska was made in 1848, in the gravel of the Kenai River, by P. P. Doroshin, a Russian mining engineer. During 1850 and 1851 there was an attempt to exploit this discovery, but gold was not found in commercial quantities, and the effort was abandoned.

In 1884 Joseph Cooper, of Kachemak Bay, reported the discovery of gold on Cooper Creek, but no locations were made.

The next discovery, and the first in the Moose Pass-Hope district, was made in 1888 by Charles Miller on Resurrection Creek 2 miles above Hope. This ground was worked for several years. In the same year Robert Michaelson and Neil McCush discovered gold on Sixmile Creek at a point opposite Sunrise.

In 1894 George Beady, F. R. Walcott, and Patrick Riley found gold on Bear Creek, and this creek has been worked at intervals since. The presence of old workings at the time of the location suggested the possibility of an earlier discovery by the Russians. In the same year George Palmer located claims on Palmer Creek. These finds inspired prospectors, with the result that new locations were made in 1895 by S. J. Mills, Robert Michaelson, John Renner, Albert

Brown, W. W. Price, and H. C. Pierce on Mills and Canyon Creeks. Other discoveries during that year were on Lynx Creek, by Fred Smith and W. P. Powers, and on the north side of Turnagain Arm, by F. J. Perry and Christopher Spillum.

The interest aroused by these discoveries stimulated a rush into the district during 1896, and it is reported that at times several thousand people were living in the vicinity of Sunrise and Hope.

With the exhaustion of the channel gravel, pick-and-shovel methods had to be abandoned and the lower-grade gravel exploited by hydraulic methods. No new finds of importance have been made since the early discoveries, and present operations are confined to the lower-grade gravel of the early finds. Several attempts have been made at dredging, but after a short time these experiments have been abandoned.

ORIGIN OF THE PLACER DEPOSITS

Although colors of gold are found in almost all of the sand and gravel in the district, the productive placers can be divided into two types—those in the bench gravel and those in the gravel of the present streams.

Throughout the district thick deposits of assorted or rudely assorted boulders, gravel, sand, and clay are found in the valleys, at some places as high as 500 feet above the present stream and usually exhibiting a benchlike or terrace form. Many of these deposits are partly consolidated and represent material that was laid down at the end of the period of glaciation, at a time when the valley glaciers were retreating and an enormous amount of water was available for the reworking and depositing of the glacial material. This material was deposited so rapidly that there was little time for the segregation and concentration of the gold from the material of lower specific gravity, so that the colors of gold are disseminated throughout the gravel, with only here and there a concentration, usually at the point where the glaciofluviatile gravel lies directly on bedrock, as is in the deposits that are being worked at the present time on Lynx Creek. Elsewhere the bench gravel is not workable, and even if concentrations are located, they could not be worked by pick and shovel methods on account of the amount of overburden.

The placers in the gravel of the present streams have been the largest contributors to the total production of the district. After the deposition of the gravel by the waters from the retreating glaciers, the whole region was uplifted relative to sea level, increasing the gradients of the streams flowing in the gravel-filled valleys so that they began to cut and rework the earlier deposits, which contained only disseminated gold. Through this reworking the gold was brought together in a more concentrated form and is now found in the present stream channels or in old channels that were occupied by actively cutting streams. The early discoveries were made in deposits of this type and proved to be very rich, although very slight in extent. Similar later concentrations may occur on bedrock if the downcutting of the stream has progressed so far, but in many places they are found on a so-called "bedrock" of clay.

In some of the streams that have narrow valleys and steep walls, such as Bear Creek, the stream deposits have been covered by slides from the valley walls; consequently old channels are sometimes found under slide material that may consist of the shattered bedrock or of old gravel that had been left hanging on the sides of the valley.

Glaciation in the region was so complete that no preglacial gravel was left undisturbed, and the oldest gravel is that deposited as a result of the melting of the ice.

SOURCE OF THE GOLD

From an examination of the gravel there appears to be but little diversity in the type of material, as the pebbles and boulders are predominantly of the bedrock of the region—slate and graywacke. In Resurrection and Sixmile Creeks, as well as a few of the tributary streams, a few granite boulders are found. As the nearest outcrop of granite is about 30 miles to the south, it is probable that there was some movement of the ice from the south. All the evidence indicates that the ice moved down valley and that the center of glaciation on the Kenai Peninsula was probably a little south of the central part. Under these conditions it is apparent that the gold is all of local origin and was derived by disintegration and erosion from the small quartz stringers that occur in great abundance throughout the region. In general, the gold is not well worn, and much of it has quartz adhering to it.

MINING METHODS AND CONDITIONS

All the richer creek-gravel deposits were worked out in the first few years of the camp by pick and shovel, so that at the present time only low-grade gravel is left. This gravel has a value of only 30 to 40 cents a cubic yard, necessitating methods suitable for the handling of large quantities of material. As conditions of water supply and topography in the region are particularly suitable for hydraulicking, this method has been used entirely in recent years.

The moving of large amounts of gravel necessitates a large supply of water under a fairly high pressure, and it is only where the combination of these two factors has been favorable that operators in this district have been successful, as the margin of profit is very small. Another hazard that tends to slow down the rate of operations is the presence of large numbers of boulders scattered throughout the gravel. Most of the boulders are removed by hand, either by rolling them aside or loading them into a sling and swinging them aside with a hydraulic hoist, but many are so large that blasting, or drilling and then shooting them, is necessary, usually the latter, for those of massive graywacke are very hard.

Several of the streams, such as Resurrection and Sixmile Creeks, have gradients so low as to necessitate the stacking of the tailings away from the end of the boxes. A large volume of water under high pressure is necessary to do this satisfactorily, and almost as much water is consumed for this purpose as is used in piping the gravel into the boxes; therefore, when the water supply is low, it is necessary to stop hydraulicking operations so as to have sufficient water to remove the tailings.

On several of the properties on the main streams, Resurrection and Sixmile Creeks, it has been more economical to obtain water from the tributary streams, as they have steeper grades and the length of ditch and pipe line is less. Usually the tributary streams from the west have a much less reliable water supply than those from the east, owing to the fact that the east tributaries have larger drainage basins, receive greater accumulations of snow, and are more protected from melting during the summer.

The length of working season is variable, depending upon the opening up of the streams in the spring and the time of freezing in the fall and also upon whether the water is obtained from the main stream or its tributaries. The average active working season is from June 1 to October 1, about 120 days. During the winter a large amount of "dead work", such as moving equipment, building ditches, and putting in pipe line, is done.

Several plans have been formulated to use dredges on the Kenai River and Sixmile and Resurrection Creeks, but all of them have been unsuccessful, because of shallowness of the gravel, the low tenor, and the presence of boulders.

MINES AND PROSPECTS

Twenty men were engaged in placer mining in the Moose Pass-Hope district during the summer of 1931. Their activities were confined to Resurrection, Bear, Sixmile, Canyon, Mills, and Lynx Creeks.

RESURRECTION CREEK

CLARK & BEISWANGER

Earl, Carl, and Frank Clark and A. Beiswanger were working on what is known as the Mathison ground, at a point about 3 miles above Hope, on Resurrection Creek (no. 8, pl. 36). The stream at this point is flowing entirely in gravel that forms a valley floor about 1,000 feet wide, on both sides of which are high gravel benches. It is the valley floor that is being worked. The so-called "bedrock" is a bluish-yellow clay, which lies on the older glaciofluviatile gravel and is overlain by gravel of an average thickness of 6 feet, from which most of the gold is obtained. The gravel below the clay has been piped several times but has not been found to be productive. In a few places the gravel is slightly consolidated, and boulders as much as 4 feet in diameter are common.

The ground is worked in a series of pits approximately 75 feet square. The set-up consists of two or three giants piping into three 12-foot boxes, with one giant to stack tailings. On account of the scarcity of water usually only one giant can be used in piping into the boxes, and often it is compelled to shut down in order to provide water for the tailings giant. Water is obtained from Wildhorse, Bedrock, and Rimrock Creeks and Gold Gulch by a system of ditches and pipes, but as all these streams are tributaries from the west, with small drainage basins, they are extremely sensitive to weather conditions. It is said that there is a 300-foot head from these streams.

The pits are reported to average $900, with no distinct pay streak, the gold being disseminated through the gravel of the creek bottom. It is the intention of the present operators to improve the condition of the ditches during the winter and to continue operations.

ST. LOUIS MINING CO.

The property of the St. Louis Mining Co. (no. 9, pl. 36) is 4 miles above Hope on Resurrection Creek, and conditions are essentially the same as those on the Clark & Beiswanger property, the productive gravel lying in the creek bottom. For the last few years this property has been worked spasmodically without much profit, and there is a complete equipment on the ground. The water has been obtained from Resurrection Creek, and it is probable that the last operations were conducted with pressure insufficient to handle successfully large quantities of gravel. It has been proposed to remedy this factor by changing the pipe line to Palmer Creek, which has a much steeper gradient and also contains sufficient water.

With this in mind a group of men are conducting negotiations with the St. Louis Mining Co., which has temporarily abandoned working the claims.

PEARSON

About 6 miles above Hope on Resurrection Creek is what is known as the Pearson property (no. 10, pl. 36). In the past the creek gravel has been worked, but for the last few years there has been no activity on this property.

BEAR CREEK

DARK & LEACH

John Dark and Tom Leach have been working on claims about a mile up Bear Creek (no. 1, pl. 36), endeavoring to find an old channel on the valley wall about 50 feet above the present stream. Bear Creek here is flowing in a narrow, steep-walled canyon, and the old stream channel has been covered by slide rock from the valley wall. From 20 to 100 feet of overburden is being piped off by one giant having about a 250-foot head. Other difficulties of operation are the presence of large boulders and the partly cemented condition of the underlying gravel.

GALLAGHER

H. P. Gallagher has been prospecting for several years at a point about 5 miles from the mouth of Bear Creek. At this point the valley is wider than below, and, although the stream is in a narrow channel, benches occur on both sides and about 20 to 30 feet above it. The creek gravel was worked several years ago, and in prospecting the bench gravel, about 8 feet of slide material has been removed, exposing 4 feet of stream gravel lying on bedrock. It is said that good returns have been obtained from the lower gravel.

PALMER CREEK

In the early days of the district Palmer Creek was thoroughly prospected and portions mined, but of late years there has been no activity.

SIXMILE CREEK

The property of Michael Connolly borders Sixmile Creek from Sunrise to a point 3 miles above (no. 17, pl. 36). This part of Sixmile Creek usually has a rock bottom bordered on both sides by higher gravel benches. For many years Mr. Connolly has been prospecting on these benches and has picked up several old pay channels. At the present time this property is under option to a group of Oregon and Washington men, who have been prospecting it. If successful, they will move their hydraulic plant from California Creek, in the Girdwood district, to this property.

CANYON CREEK

Canyon Creek, from Sixmile Creek to a point 8 miles above, flows in a narrow, steep valley bordered on both sides by high gravel benches. Most of the early production from this creek came from the stream gravel, and exceedingly rich pockets have been found. In addition to the stream gravel, productive channels have been found in the bench gravel and have been worked sporadically.

Bruhn & Ray hold a number of claims on Canyon Creek near its confluence with East Fork (no. 18, pl. 36).

Tom Allison has been prospecting and hydraulicking the bench gravel for several years at a point about 3 miles above Sixmile Creek (no. 22, pl. 36).

During the summer of 1931 Oscar Dahl and a crew of men were engaged in prospecting and mining bench gravel at a point 7 miles above Sixmile Creek (no. 27, pl. 36). All the bench gravel contains gold, but the tenor is low and recovery is costly, owing to the thickness of the overburden.

MILLS CREEK

Mills Creek has been the most productive stream in the district, and most of the gold has been obtained from the lower mile. The greater part of the gold has come from the channel gravel, but this has been augmented somewhat by the bench gravel, which is characteristic of the lower part of this stream, as of other streams in the district.

H. L. Miller, C. P. Tolson, and O. G. Plowman have been prospecting and mining about half a mile above the mouth of the creek on the bench gravel (no. 28, pl. 36). It is reported that some gold has been obtained. Most of the gold-bearing gravel lies on the bedrock.

Fred Metz has been prospecting the gravel on Mills Creek about 3 miles above its mouth.

LYNX CREEK

R. R., C. H., and H. O. Jacobs have been mining for several seasons on Lynx Creek, about a mile above its mouth (no. 45, pl. 36). The channel gravel was worked in the early days of the district, and the present activities are confined to bench gravel lying about 100 feet above the present channel of the stream. No definite former channel exists, and gold occurs scattered over the bedrock. Much of the gold is coarse.

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