UNITED STATES DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary

GEOLOGICAL SURVEY
W. C. Mendenhall, Director

Bulletin 844—B

MINERAL INVESTIGATIONS IN THE ALASKA RAILROAD BELT, 1931

BY

S. R. CAPPS

Mineral resources of Alaska, 1931
(Pages 119-135)

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1933

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - - Price 5 cents

CONTENTS

ILLUSTRATION

MINERAL INVESTIGATIONS IN THE ALASKA RAILROAD BELT, 1931

By S. R. Capps

PURPOSE OF THE INVESTIGATIONS

Early in 1931 an appropriation was made by the United States Congress to the Alaska Railroad for the purpose of carrying out an intensive study of the mineral resources of the area tributary to the railroad, with special attention to such mineral deposits as were likely to yield revenue tonnage to it. One of the major objects of this investigation was to determine whether or not there was a commercial field of anthracite in the upper Matanuska Valley, but other mineral resources, including both metallic and nonmetallic minerals, were to receive attention. To carry out the purpose for which this appropriation was made, the Alaska Railroad called upon the Geological Survey, which has a personnel that is expert in such work and which has for more than 30 years been engaged in similar investigations, both within the belt now served by the railroad and throughout Alaska as a whole.

FIELD WORK

After a careful consideration of the whole problem, 10 distinct projects (see pl. 1) were determined upon, all of which required detailed geologic field work. On four of them special topographic surveys were necessary to provide base maps upon which the geologists could plot their results; on two others the geologists made their own base maps as they proceeded. For the field administration of these parties the writer was designated geologist in charge to direct the general conduct of the projects and participate personnally in the field work so far as time and other conditions permitted. To advise and assist in the technical phases of the work, D. F. Hewett, a geoligist of the section of metalliferous deposits, visited most of the parties in the field and served as special consultant.

The largest field party was assigned to the Anthracite Ridge district of upper Matanuska Valley for the purpose of determining the extent of the anthracite coal deposits there. R. W. Richards was in charge of the geologic work, assisted for part of the season by G. A. Waring;

L. O. Newsome made a topographic survey of the area of chief interest on a scale of 1 to 12,000, using a 10-foot contour interval for the map. The party was equipped with a pack train of 7 horses to transport supplies from the head of the railroad branch line, at Chickaloon, and from 8 to 12 field assistants and laborers were employed. An intensive study was made of the geologic structure of the most promising part of the anthracite field; but surface indications were found insufficient for definite conclusions as to the extent and character of the coal there, and diamond drilling of the field was recommended.

In the Moose Pass-Hope district of Kenai Peninsula Ralph Tuck made a special study of the gold lodes, many of which have been extensively prospected and a few of which have yielded a small output of lode gold.

Similar studies were made in the Girdwood area, just north of Turnagain Arm, by Charles Park, and a topographic base map of the area was prepared by W. G. Carson on a scale of 1 to 48,000, with a 50-foot contour interval.

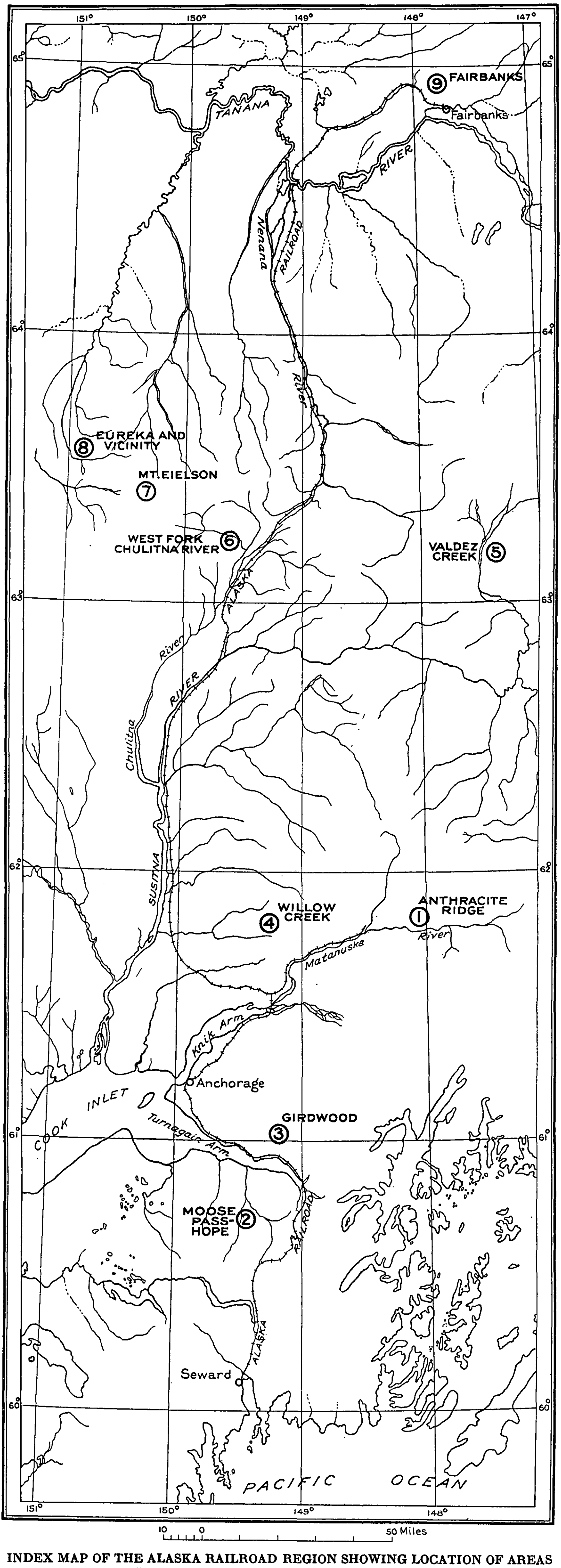
The Willow Creek district, which has long been a considerable producer of lode gold, was examined in detail by J. C. Ray. A matter of great importance to the operators there was the problem whether or not the rich ore shoots of the district could be expected to continue in depth. Fortunately, the results of this study indicate that valuable ore shoots may reasonably be expected at greater depths than those already reached.

During the early part of the summer C. P. Ross made detailed studies of the lode deposits of the Valdez Creek district, preparing his own topographic base map as he proceeded. Later in the season he did similar topographic and geologic mapping and examined the lode prospects in the basin of the West Fork of the Chulitna River.

The Kantishna district has yielded placer gold for many years. Its gold and silver lodes also have been extensively prospected, and a small amount of lode mining has been done. F. G. Wells made a careful study of the lodes of Eureka and vicinity, in this district, and for this study a topographic base map was prepared by S. C. Kain on a scale of 1 to 48,000 with a contour interval of 50 feet.

The Mount Eielson district has for many years been known to contain extensive deposits of silver-lead-zinc minerals, and many claims have been staked there. This district was studied by J. C. Reed, for whom a topographic base was prepared by S. N. Stoner. The most promising part of the area was mapped on a scale of 1 to 24,000, and the remainder on a scale of 1 to 48,000, with a 50-foot contour interval throughout.

The gold lodes of the Fairbanks district have produced steadily for many years and are believed to hold promise of increased productivity in the future. This district was studied in detail by J. M. Hill.



INDEX MAP OF THE ALASKA RAILROAD REGION SHOWING LOCATION OF AREAS IN WHICH INVESTIGATIONS WERE MADE

Within the railroad belt but not situated in any recognized mining district are many localities in which there are deposits of both metallic and nonmetallic minerals of possible commercial value. These deposits include such materials as clay, limestone, building stone, and manganese, some of which afford raw materials for local needs and some of which may prove valuable for export. G. A. Waring was assigned to the study of the miscellaneous nonmetallic mineral deposits.

SUMMARY OF REPORTS

The following pages contain preliminary statements as to the more significant results of the nine specific investigations of definite areas. Reports describing the areas in greater detail will be issued later.

ANTHRACITE RIDGE COAL BASIN

Anthracite Ridge is in south-central Alaska, on the north side of the upper Matanuska Valley, about 200 miles north of Seward, the coastal terminus of the Alaska Railroad. The coal basin lies between the ridge and the Matanuska River and is about 4 miles wide and 7 miles long. The structure of the basin is in general synclinal, sharply folded and faulted along its north border. The coal beds are in the Chickaloon formation, which consists of Tertiary fresh-water deposits, intruded by igneous dikes and sills, and which unconformably overlies marine Cretaceous beds.

The stratigraphic section as partly exposed in the valleys of the creeks crossing the coal basin shows that the coal-bearing formation consists chiefly of shale, with minor lenticular beds of sandstone and conglomerate. A dozen or more coal beds are found in a zone several hundred feet thick belonging to either the lower or the middle portion of the Chickaloon formation.

Many of the coal beds range in thickness from a few inches to about 8 feet, but in one locality on the northwest border of the basin exceptional thicknesses of 24 and 34 feet were measured. These thickest beds and others near by consist of low-rank anthracite (or semianthracite) and are found in closely folded, faulted sediments further complicated by igneous intrusions. Most of the coal exposed in the southern and eastern parts of the basin occurs in relatively thin beds and is of semibituminous to bituminous rank.

In the absence of actual development work little reliable information is available from surface exposures for estimating the coal reserves of the basins. The most definite data are furnished by the locality that shows the coal of highest rank, in the S. ½ NW. ¼ sec. 12, T. 20 N., R. 7 E., where a conservative estimate indicates 750,000 tons of coal. In this isolated locality, however, such an amount can not be regarded as sufficient to justify an attempt at commercial development.

The synclinal area immediately adjacent on the south holds possibilities for development, although it has not yet been proved to contain thick beds of coal of rank as high as that in the hills to the north. However, as it is part of the same basin of deposition and as the thin beds of lower-rank coal exposed on the south side of the basin may thicken and improve in quality across the area into the exceptionally thick beds on the north, this area undoubtedly warrants further study.

Additional surface prospecting on the flanks of the syncline would only partly serve to clear up the problems involved, but core drilling is regarded as the most practical means of reaching definite conclusions as to the presence of coal and as to its quality and other features.

Several sites were selected at which it is inferred that there is the best possibility of determining the presence of one or more beds of low-rank anthracite within reasonable drilling depth, and a contract has been entered into to obtain cores from these holes during the summer of 1932. These drill holes and samples should supply data for conclusive estimates whether or not coal of the higher rank is present in sufficient amount to justify further investigation with a view to its commercial development.

MOOSE PASS-HOPE DISTRICT, KENAI PENINSULA

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 altitude ranging from sea level to more than 5,000 feet. Vegetation is heavy along the streams, and the timber line is about 2,000 feet above sea level.

The bedrock throughout most of the district consists of a series of interbedded slates and graywackes, probably of Cretaceous age. In the northwest corner of the district the bedrock is a series of tuffs and agglomerates 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 altitude 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 gold content of the dikes is erratically distributed, and they have not yet been found to have sufficent 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 gold.

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.

GIRDWOOD DISTRICT

The Girdwood district has been known for about 35 years to contain placer gold, but its source in veins was not discovered until about 1909. When the Alaska Railroad was completed through Girdwood it was hoped that the improved transportation facilities would enable the lode mines to operate at a profit and also to furnish tonnage to the railroad. Production from the quartz veins, however, has been negligible, although one placer mine has been operating steadily for several years.

The predominant sedimentary rock of the region is a series of thinly banded argillites and graywackes, containing some conglomerate, impure limestone, and well-indurated sandstone. On the basis of fossils obtained at six different localities within the district the rocks are considered of Upper Cretaceous age. The thickness of the argillite-graywacke series is unknown but must be at least 4 or 5 miles. These Upper Cretaceous rocks were deposited apparently unconformably above an undifferentiated metamorphosed series of lavas, tuffs, agglomerates, intrusive rocks, and sedimentary rocks of undetermined age.

The metamorphic rocks, whose thickness is unknown, form the western part of the district. Greenstone tuffs, several thousand feet thick, probably of Upper Cretaceous age, unconformably overlie the argillite-graywacke series.

The rocks intruded into the argillite-graywacke series are classified as quartz diorite, dacite, and dacitic aplite. The igneous rocks are in the form of dikes, sills, and exceedingly erratic pipes composed essentially of a network of thin, medium-grained dikes. Some of the individual dikes are only an inch or even less in thickness, but they are granitoid in texture, and several have been traced on the surface for 100 feet or more. The district is peculiar in that the details of the intrusions are apparently independent of any observed structural control.

The region has been the site of considerable widespread structural deformation, and the beds are highly tilted, folded, and faulted. The main axes of deformation follow the general trend of the Chugach Mountains, 10° to 20° east of north. Both normal and reverse faults occur, and their strikes also tend to aline themselves with the main axes of folding. A minor system of tear faulting is developed in a general east-west direction. Much but not all of the faulting took place before the intrusion of the igneous rocks, and in places dikes tend to follow the fault planes for short distances.

The rocks of the region are not greatly altered, although some recrystallization due to processes of rock deformation has begun. Fine brown tourmaline needles and small reddish-brown garnets have been observed in argillite bordering an irregular intrusive pipe. Near the dike contacts silicification has taken place, but the introduction of silica is much more intense within an inch or two of the intrusive rock than farther away. Especially in the vicinity of the pipelike intrusive masses silicification is intense and extends 20 feet or more from the contact; chlorite, muscovite, sericite, and some epidote are also usually developed.

The ore deposits are small arsenopyrite-gold-quartz veins and the placer deposits derived from these veins. The most promising vein deposits are grouped in a small area near the headwaters of Crow Creek. The veins are thin and irregular but in places contain small pockets of rich gold ore with minor quantities of sulphides—chalcopyrite, galena, sphalerite, pyrrhotite, and molybdenite. Most of the deposits lie approximately parallel to the bedding planes or cross them at low angles. There has been considerable postmineral movement along many of the veins, and the quartz and sulphides in places form a breccia in gouge and sheared wall rock. It is thought that the veins will continue in depth with essentially the same mineral composition.

The veins are all grouped around the irregular pipelike intrusive rocks, and this constant association, together with the hydrothermally altered condition of the intrusives and the noticeable contact alteration in the veins, indicates that they are closely related in history. The fine-grained dikes and sills are apparently not closely associated with the ores.

WILLOW CREEK DISTRICT

The Willow Creek gold lode district is in the southwestern part of the Talkeetna Mountains, a few miles north of the head of Cook Inlet, at approximately latitude 61° 47′ N. and longitude 149° 15′ W. The district is easily accessible by automobile road from Wasilla, a small town on the Alaska Railroad 45 miles north of Anchorage.

In the northern portion of the district the country rock is quartz diorite. It is cut by numerous dikes of dacite, aplite, and pegmatite. All the gold quartz veins of proved value occur in the quartz diorite, which is part of an extensive igneous intrusion of batholithic character. Flow structure, schlieren, and swarms of angular fragments of an earlier crust in the diorite suggest that the present erosional surface is not far below the original roof of the intrusive mass.

The southern portion of the district is occupied by Tertiary sediments, which contain bituminous coal in commercial quantities. The Tertiary beds lie unconformably on an eroded surface of the quartz diorite, are tilted to the south, and are broken into blocks by post-Tertiary faulting. The southwestern portion of the district is occupied by a mass of mica schist, presumably of pre-Cambrian age. Its structural relations to the quartz diorite are uncertain. It may be a roof pendant, a floated-in block, or a faulted-up portion from the floor of the intrusive.

Mineralizers were active at an early period after the intrusion of the quartz diorite magma. Bornite is occasionally found as a result of magmatic segregation in the unaltered quartz diorite. It also occurs with chalcopyrite replacing a pegmatite dike. High-temperature chalcopyrite-molybdenite-quartz veins occur at a number of places in the district, as well as an early type of chalcopyrite-galena-gold-quartz deposits in slightly opened joint planes.

The intrusion of the dike rocks and the metallic mineralization mentioned above were all earlier than the introduction of the gold quartz that formed deposits of commercial value. The commercial lodes are of the intermediate-temperature type. Structurally they occur as a combination of composite veins or lodes, fissure fillings modified by wall-rock replacement, and quartz lenses which in places reach a thickness of 14 feet. The vein filling is predominantly massive quartz, which exhibits coarsely crystalline hypidiomorphic and comb textures. Banding is developed in much of the quartz and is due partly to the later reopening of the veins and partly to the distribution of impurities. No crustified included wall-rock fragments, cavities, or drusy deposits are present. Quartz of three periods has been recognized. An earlier massive quartz has been brecciated and cemented by a later massive quartz. Pyrite and arsenopyrite, with minor amounts of chalcopyrite and sphalerite, were deposited with these two generations of quartz, but no appreciable amounts of gold. A third generation of quartz was introduced after further shattering of the earlier quartz. With this third generation were introduced tetrahedrite, galena, native gold, and possibly a small amount of gold telluride. The late quartz has a prevailing microcrystalline texture and develops ribbon structure in the earlier vein filling.

The gold occurs as isolated interstitial fillings in and near the late quartz and replacing all the earlier sulphides. It was the last metallic mineral to be deposited.

Alteration of the country rock is intense in the zones of the composite veins and in most of the rock inclosed between the main walls of the fracture zones. The rock alteration is due to heated solutions which have developed chlorite, pyrite, sericite, secondary microcrystalline quartz, and large amounts of ankerite. The vein mineralization and texture and the character of wall-rock alteration are typical of veins formed at intermediate temperature, and the veins bear a striking similarity to those of the famous Grass Valley district, California. As the veins are characteristic of those formed at moderate to intermediate depths (4,000 to 12,000 feet), it follows that the fractures through which the solutions circulated must have attained at least the same depths. It is estimated that erosion has not removed more than a few thousand feet of the earth's surface in this district since the intrusion of the quartz diorite, and therefore the parts of the vein still remaining can be expected to continue downward for several thousand feet. Mining operations to date have been confined to exploiting the ore shoots at or near the various points of discovery, usually high on the walls of the glacial valleys. Throughout the district the altitudes of the ore shoots thus far exploited show a variation of about 1,500 feet, but this difference may be accounted for in part by postmineral faulting.

Postmineral movements in the plane of the veins have formed slickensided walls, which cause pinches and swells in the veins that can not always be attributed to the original distribution of the vein filling; segments of the veins are known to lie outside of these slickensided walls. Exploration has generally been confined to following postmineral slickensided walls, and the actual limits of mineralization are not known. It is certain that in many places valuable ore has been passed by owing to lack of crosscutting. It is believed that judicious crosscutting on present mine levels will lead to the discovery of valuable bodies of ore thus far unsuspected. In the Fern mine, near the winze about 600 feet from the portal of the lower level, a crosscut has exposed a 12-foot zone of crushed quartz and country rock which averages $21 to the ton in gold. This mineralized zone is in the hanging wall of a quartz stringer which was stoped above and below the drift. A few feet east of this crosscut, in the footwall under the stope, channel samples cut from the floor of the drift assay as much as $47.38 to the ton across 2½ feet of composite vein matter, and the footwall was not exposed. At a point 240 feet in from the portal a portion of the composite vein is exposed from which quartz stringers 4 inches or less in thickness assayed $98.52 to the ton. None of these promising leads have been developed, stoping and drifting having been confined more particularly to massive quartz that lies between postmineral slickensided walls.

The Gold Cord mine, on upper Fishhook Creek, is at present stoping in a quartz lens above the drift, about 350 feet in from the portal. This lens has widened to 14 feet in thickness and is said to average $45 to the ton in gold. Assay of samples cut from the face of this lens by the survey geologist during the summer of 1931 gave the following showings in gold: 6 feet of quartz, $78.52 to the ton; 3 feet of quartz, $85.69; 2½ feet of quartz, $140.92. In the same mine samples cut in the floor of the drift 126 to 162 feet from the portal gave showings as follows: 7 inches of quartz, $109.29; 30 inches of quartz and "fill," $15; 12 inches of quartz, $50.52; 36 inches of quartz and "fill," $36.03; 36 inches of quartz and "fill," $16.03. Future development in this mine must be carried on through a shaft, as it is the one mine in the district in which the vein is exposed near the valley floor.

The Lucky Shot mine, on Craigie Creek, and the Fern mine, on Archangel Creek, have workings approximately 500 feet below the outcrops of the lodes. In all other properties the workings are much shallower. These two mines are about 8 miles apart, and productive ore bodies have been developed in each of the three mountain ridges that lie between them. This mineralized zone extends in a general northeasterly direction across the district and contains all but one of the mines that have made significant gold production. These mines, beginning on the southwest, are the Lucky Shot and War Baby, on the northwest wall of the Craigie Creek Valley; the Gold Bullion, topping the ridge between Craigie Creek and the head of Willow Creek; the Martin and Independence, on the east side of the ridge between Willow and Fishhook Creeks; the Gold Cord, low on the eastern slope of Fishhook Creek; and the Talkeetna and Fern, on the west side of Archangel Creek. The Mabel mine is high on the northwestern slope of Reed Creek near its confluence with the Little Susitna River. It is the only producing property in the eastern part of the district, and the extent and direction of the mineralized zone are as yet undetermined.

Transverse postmineral faults have cut and displaced the veins. The vein segments thus formed vary in length, but some reach 1,200 feet. The horizontal displacement is as much as 800 feet.

The total lode-gold production for the district in the past has had a value of several million dollars, the largest part of which has come from three mines on Craigie Creek. The difference in the relative production of the several portions of the district is due in part to the original discoveries of extensive ore shoots and in part to the more efficient exploration and exploitation of the mines on Craigie Creek. The average gold value of the total ore milled is $50 to the ton in the southwestern portion of the district and gradually decreases to $25 to the ton in the northeastern portion. General milling practice in the district consists of concentration, amalgamation, and cyanidation. At the Lucky Shot mine the ore concentrates in the ratio of about 69 to 1.

Adequate spruce timber for mining is available along the lower reaches of the Talkeetna Mountains facing the Susitna Valley. All-year hydroelectric power can be produced on the lower courses of Willow Creek and the Little Susitna River. Coal is readily available in the Matanuska Valley for the production of electric power. Power might also be obtained from the hydroelectric plant at Eklutna, about midway between Anchorage and the Willow Creek district, which furnishes power and light to Anchorage.

The open season is about four months, from the middle of June to the middle of October. Adequate winter camps can be maintained, as is now being done at the Lucky Shot mine. All-year operations are necessary to a successful exploitation of the mines.

The mining prospects of the district may be summarized as follows: The occurrence of many valuable ore shoots at various depths ranging from outcrops at the present surface to 500 feet below has been proved. The character of the veins justifies the belief that mineralized rock essentially similar to that known in the higher levels of the mines continues downward for several thousand feet and that valuable ore shoots may reasonably be expected at greater depths than those already reached and should be encountered in the course of well-directed exploration. On account of postmineral transverse faults and the resultant offsets of the vein segments great caution should be exercised in explorations to locate the extensions of proved veins. Crosscutting should be carried beyond slickensided walls to determine the total thickness of the composite veins. That the district contains valuable ore deposits has been demonstrated by its past production, and its potential resources are considered to be at least several times greater than those already developed.

In addition to the Lucky Shot and War Baby properties of the Willow Creek Mines (Inc.), where active development is in progress, the Fern and Gold Cord mines appear to offer great incentive to early exploitation, as development can be begun at known exposures of potential ore. Other properties have demonstrated the presence of ore shoots which, though the known parts have been largely mined out, belong to the intermediate-temperature type and therefore encourage further exploration as likely to disclose additional ore bodies.

VALDEZ CREEK DISTRICT

The Valdez Creek district, which lies east of the upper Susitna River, is known principally for its placer mines, which have been more or less productive since 1903. Most of the placer operations have been on a rather small scale, and large quantities of potential placer ground remain untested. Much of this untouched ground can not be conveniently mined by small-scale plants such as are now in use. As the bench deposits that have been mined by hydraulic methods appear to have averaged over 60 cents a cubic yard in gold, testing of the less accessible ground seems warranted. If this ground proves to be of adequate tenor, it could be handled with the aid of more suitable equipment than is now being used. The future of the district appears to depend mainly on expansion of the placer operations.

There are several gold-bearing lodes near the placer workings, but these have been only superficially prospected. One of the veins is as much as 1,000 feet long and several feet wide, but it does not appear to be of high average grade. All the veins appear to have possibilities for future development, but it is doubtful whether they can be extensively developed until, either because of the placers or for some other reason, the transportation facilities are improved. There is reason to hope that small pockets of gold ore, with tellurides, may exist in the district. Systematic search might result in finding such pockets, which would give rich returns without the use of much equipment.

Just east of the present confines of the Valdez Creek district along Clearwater Creek there is evidence of widespread alteration of limestone, schist, and other rocks, with the deposition of some pyrite and other metallic minerals. This area has received almost no attention from prospectors and might repay examination by one interested in the discovery of metallic lodes.

WEST FORK OF CHULITNA RIVER

Although most of the mineral deposits near the West Fork of the Chulitna River have been known since 1911 or earlier, none of the prospects have become commercially productive. Their potential value appears to lie mainly in their gold and silver content, but some contain notable quantities of arsenic and copper. A coal prospect in the area is of interest principally as of possible aid in the development of lode mines. The lodes are not sufficiently explored for quantitative estimation of grade of ore or of available tonnage, but there are considerable quantities of ore, mostly in small bodies, ranging from $5 to $20 in precious metals to the ton and locally containing as much as 20 per cent of arsenic. Some larger bodies of lower-grade ore also exist. A few of the lodes contain 5 to 10 per cent of copper in addition to a little gold and silver. The ore is so constituted that much of its metallic content can not be extracted by simple amalgamation. Most of the prospects are within 10 to 15 miles of the railroad, and general conditions on the whole are regarded as favorable to mining. The outlook for future expansion of mining here is favorable, provided economic conditions warrant the handling of ore of this grade.

In their origin the lodes are related to and in part included in a dioritic porphyry of supposed Tertiary age which intrudes volcanic and sedimentary strata. They are of three interrelated and intergradational kinds—(1) disseminated deposits, mainly in the porphyry; (2) replacement deposits along bedding planes in calcareous rocks; (3) tabular and lenticular lodes along fissures and shear zones in various rocks.

MOUNT EIELSON DISTRICT

The Mount Eielson district lies in south-central Alaska on the north side of the Alaska Range, about 30 miles east of Mount McKinley. The most widely distributed rocks of the district include a thick series of thin-bedded limestone, calcareous shale, and graywacke, of Paleozoic (probably Devonian) age. These sediments are cut by a mass of granodiorite which forms most of Mount Eielson and which was intruded probably in late Mesozoic time. The intrusive mass sent a multitude of dikes and sills into the associated sediments, and material given off by the granodiorite permeated the inclosing sediments, effecting selective replacement.

South of Mount Eielson the regional strike is about N. 55° E. and the dip is low toward the southeast. North of the mountain the strike of the sediments conforms in general to the curve of the base of the mountain, being about N. 65° W. on Bald Mountain and north of the eastern peak of Mount Eielson, nearly due west north of the central peak, and about N. 50° E. on the northern slopes. In most places the dip is steep toward the north. A normal fault of large displacement abruptly terminates the granitic area on the south.

An ore-bearing zone can be definitely traced for about 4 miles along the north side of the granodiorite mass. Its width on the surface is not uniform, but its thickness is about 2,000 feet. Sphalerite is the most abundant sulphide and is several times as abundant as galena.

Chalcopyrite is present in minor quantities. The small amount of silver in the ore appears to be irregularly distributed.

The ore deposits of the Mount Eielson district have been formed by the selective replacement of thin-bedded limestone and calcareous shale by minerals of the epidote group, pyrite, chalcopyrite, sphalerite, galena, and other minerals. The main ore-bearing zone exhibits a definite relation to the granodiorite mass of Mount Eielson.

Unpatented claims cover most of the better showings. Very little development work has been done in the district, and as much of the potentially valuable ground lies beneath a cover of postmineral deposits, the most urgent need is for much more systematic prospecting. The present natural exposures and prospect pits indicate a reserve of many hundreds of thousands of tons of zinc and lead bearing material, which, from the indications of the few assays, should carry at least 10 per cent total sulphides. Silver would no doubt be recovered from any ore mined at Mount Eielson, but the assays show that the silver content of the ores is in general low and spotted. The silver content does not seem to bear any very definite relation to the lead content, and although some of the silver undoubtedly occurs in the galena, either in solid solution or as inclusions of definite mineral species, some of it is probably associated with sphalerite. It is possible that copper would also be recovered, but it would be a very subordinate product.

The mining conditions at Mount Eielson are good, especially for a large-scale operation. Most of the ore zone, to a depth of several hundred feet, could be developed by a tunnel. The rock and ore are massive and would require little timbering. The individual ore bodies are large enough to lend themselves to mining by some method of caving. Some of the other conditions, however, are not favorable. There is no timber in the district. Sufficient coal could probably be mined a few miles to the north, but unless a road were built it would have to be transported to Mount Eielson in the winter over frozen ground. It is possible that Grant Creek could be developed on a small scale for power. The winter season is long and cold, but operations could no doubt be carried on all year round.

The ore would probably be concentrated in a mill at Mount Eielson. Its mineralogy is simple, and galena, sphalerite, and chalcopyrite could be separated.

Transportation of concentrates would be one of the greatest problems to any mining venture. The concentrates could be trucked during the summer over the park highway to McKinley Park station. Perhaps a cheaper way would be to haul them by tractor in the winter, either through the same passes that the road follows but shortening the route by making greater use of stream bars, or by a longer but not so hilly route down Stony Creek to the low country and thence east to Kobe. The cost of this part of the journey would be nearly negligible compared to the cost of shipment to Seward by the Alaska Railroad, according to the present (1931) quoted rate of $1.63 per 100 pounds of lead concentrates for a 50,000-pound minimum shipment from McKinley Park station to Seward and $1.22 for a corresponding shipment of zinc concentrates. From Seward lead concentrates would probably go to Selby, copper to Tacoma, and zinc to Trail, British Columbia, or some more distant smelter equipped to handle such concentrates.

It seems doubtful that a successful mining enterprise could be carried on at Mount Eielson under the existing metal prices and the adverse transportation conditions. However, the factors of cost are many and variable, a large ore reserve exists at Mount Eielson, and it is entirely possible that with changed conditions profitable operations could be instituted there.

EUREKA AND VICINITY, KANTISHNA DISTRICT

The Kantishna mining district is about 90 miles west of McKinley Park station on the Alaska Railroad. The area around Eureka, described in this report, comprises about 72 square miles in the form of a strip 6 miles wide and 12 miles long.

The bedrock is mainly a metamorphic series of rocks which, within the area, has been differentiated into a quartz-muscovite schist and a calcareous facies that ranges from limestone to chlorite schist. A few small dikes of quartz porphyry and diabase intrude the schist. The general structure trends N. 70° E., and from an axis that extends from Eldorado Creek northeastward to Spruce Peak the schistosity dips to the northwest and southeast. It is along this axis that the heaviest mineralization has occurred.

All the veins in the area strike N. 50°–70° E., and most of them dip at high angles toward the southeast, though a few dip toward the northwest. The veins are rudely tabular, swelling and pinching along both the strike and dip, and range in thickness from 23 feet to a fraction of an inch. Some of the larger veins have been opened by drifts or other excavations along the strike for 500 feet, but their surface outcrops have been recognized for even greater distances.

The veins are of three types—gold quartz veins, silver-bearing galena veins, and stibnite veins. The gold quartz veins consist of white quartz containing small amounts of arsenopyrite and pyrite with scattered nests of galena or sphalerite. The gold is largely associated with the sulphide minerals, except in the oxidized parts of the vein, where it is found as free gold. The galena-sphalerite veins are composed predominantly of sulphides carrying only small amounts of quartz and carbonate gangue. The ratio of galena to sphalerite is variable, and associated with these minerals are small amounts of tetrahedrite, stromeyerite, stephanite, and chalcopyrite, as well as pyrite and arsenopyrite. The stibnite veins are composed of stibnite with some quartz gangue, and many are massive stibnite. Enrichment appears to be almost totally lacking in all the veins, and they have been only superficially oxidized.

Some years ago about 1,300 tons of sulphide ore was mined and shipped. Most of this ore assayed better than $175 a ton, with the major value in silver, then worth $1 an ounce. The workings from which this ore was taken are now inaccessible. Of 104 samples taken from accessible quartz veins throughout the district the highest assay was 3.74 ounces of gold and 1.60 ounces of silver to the ton, and the average was 0.21 ounce of gold and 6.41 ounces of silver.

The area shows excellent indications of mineralization, and it is highly probable that other veins not yet mined contain ore of as high grade as that so far discovered. The type of mineralization, the character of the ore, and the absence of appreciable enrichment indicate that the ore extends to considerably greater depths than those so far reached by mining developments.

FAIRBANKS DISTRICT

The Fairbanks district is underlain by pre-Cambrian metamorphic schists of sedimentary origin that have a considerable range in composition and are known collectively as the Birch Creek schist. The schists are overlain in the valleys by extensive deposits of gold-bearing gravel and muck, and natural exposures are extremely rare even on the hillsides and the summits because of the heavy cover of moss and bushes. The cleavage of the schists has a general well-defined structural trend, which in the eastern part of the district, or Pedro Dome area, is about east, with dips of 15° to 45° both north and south. In the western part of the area, in the vicinity of Ester Dome, the trend is slightly east of north, and this trend has influenced both intrusion and mineralization in that area.

The schists have been intruded by igneous rocks of several types. The earliest is a fine-grained quartz diorite, which is well exposed on Pedro Dome. The diorite was followed by a coarse-grained biotite granite porphyry, and this by finer-grained quartz porphyry, which in some dikes is represented by aplitic rock. There are two principal areas of these intrusive rocks in the district, and they occur as elongated, nearly parallel bodies following the general structural trend, one north and one south of the Goldstream Creek drainage basin, northeast of Fairbanks. There are probably a large number of small offshoots, or dikes, from these large masses, but the deep surface cover has obscured most of the outcrops, and only a few of them have been traced and mapped. There is relatively little igneous rock in the more highly mineralized area on the southeast side of Ester Dome, but a few small outcrops show that the dikes follow the northward-trending structure.

In the Fairbanks district the principal mineral deposits of economic interest, aside from the extensive gold placers, are the gold quartz veins, which are from a few inches to 15 feet wide. Many of these veins carry from 1½ to 2 per cent of sulphides and free gold. The principal sulphides are arsenopyrite and stibnite, but galena, jamesonite, sphalerite, and löllingite have been recognized. Most of the gold accompanied the sulphides and was deposited in a third stage of reopening of the veins. Adequate evidence is available to show that the gold is largely primary and that the tenor of ore probably will not change with depth to any appreciable amount. Much of the gold is free and can be recovered from the ore by simple metallurgical treatment. The economic conditions, though presenting some difficulties, are much superior to those in many other mining camps in northern latitudes, for transportation is available throughout the year, and the camp is not isolated.

In 1931, when the camp was studied, there were nearly 100 gold-lode properties at which sufficient work had been done to allow some measure of examination. Of these there were about 40 at which prospecting and development were under way and 10 that were producing. The most underground development work has been done at the Ready Bullion, Billy Sunday, Ryan, Little Eva, and Mohawk mines, on Ester Dome, and at the Soo, Newsboy, Cleary Hill, Henry Ford, Tolovana, Wyoming, and Hi-Yu properties, in the Pedro Dome area. The deepest working in the district had reached 350 feet below the surface, but in 1931 no workings below 250 feet were open for inspection.

The Fairbanks district produced nearly $80,000,000 from placer deposits in the years 1904 to 1930. It is estimated that dredges or other mechanical devices, reworking the same streams and others that could not be worked by hand methods, may produce an even greater amount during the next 25 years. It is believed that the lode gold deposits, which produced nearly $2,000,000 from 1910 to 1930, can produce in the next 25 years, under adequate financial support and skilled technical and administrative direction, an amount of gold that will compare favorably with that so far yielded by the placer deposits.

Deposits of stibnite (sulphide of antimony) also occur in the Fairbanks district and were mined in the past, when high prices for antimony prevailed, and it is by no means unlikely that they may be mined again if prices reach a sufficiently high level. The antimony ores occur in the gold lodes, but usually as minor segregated deposits. In a few places stibnite was deposited in these lodes to the practical exclusion of the other sulphides and gold.

The tungsten deposits of the district were mined only under the stimulus of a very high price during the World War, and it is not regarded as likely that mining of them will be resumed in the near future, chiefly because of their small size and low tenor but partly because of their great distance from markets. These deposits are quartz-scheelite veins, which have either replaced small lenticular bodies of limestone or occur as contact-metamorphic deposits in the vicinity of acidic intrusive rocks. They may therefore be sought in widely separated tracts, but they are likely to be irregular and sparse.