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MINERAL DEPOSITS NEAR THE WEST FORK OF THE CHULITNA RIVER ALASKA

BY

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Investigations in Alaska Railroad belt, 1931

(Pages 289-333)

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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

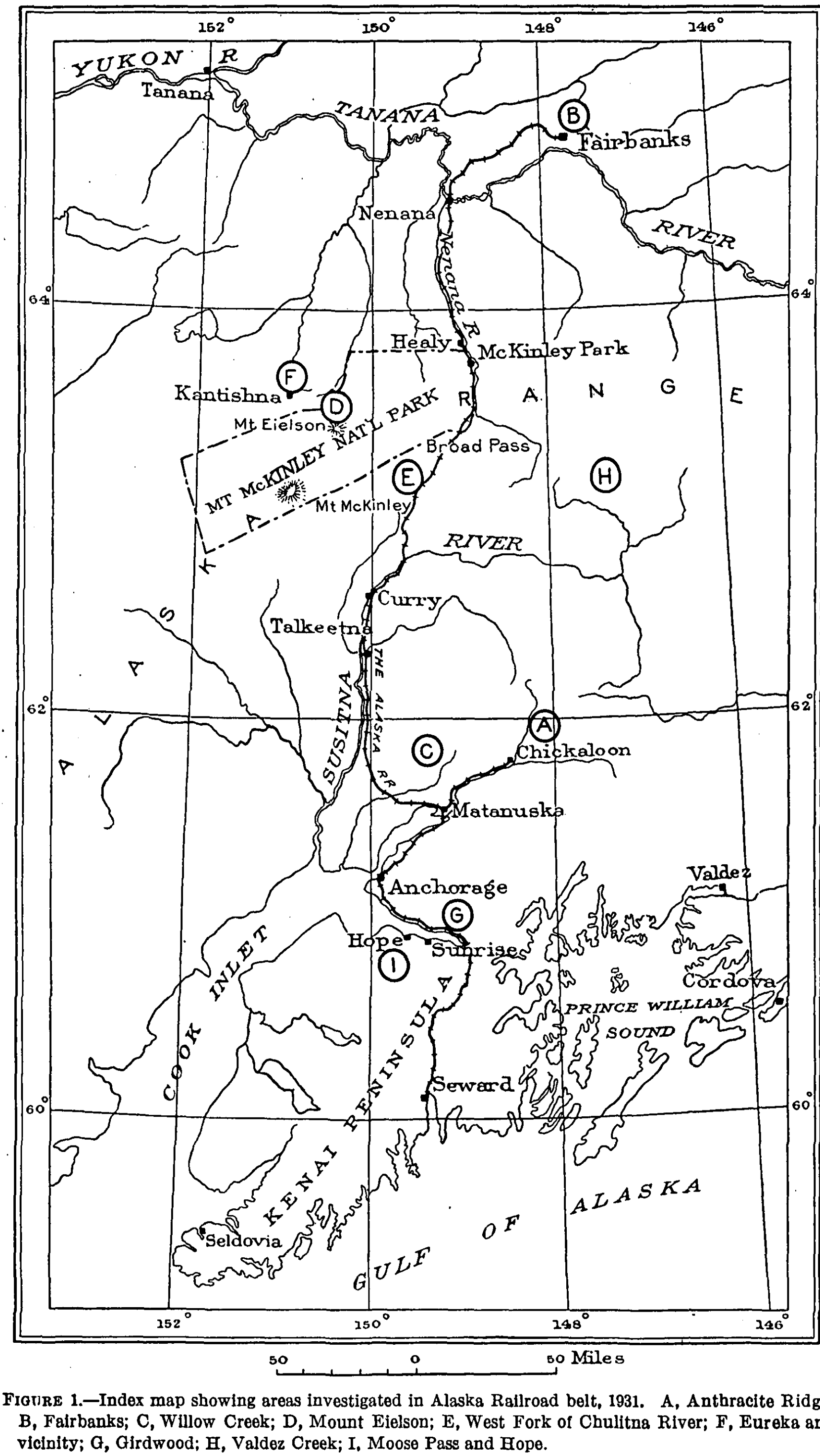


FIGURE 1.—Index map showing areas investigated in Alaska Railroad belt, 1931. A, Anthracite Ridge; B, Fairbanks; C, Willow Creek; D, Mount Eielson; E, West Fork of Chulitna River; F, Eureka and vicinity; G, Girdwood; H, Valdez Creek; I, Moose Pass and Hope.

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.

MINERAL DEPOSITS NEAR THE WEST FORK OF THE CHULITNA RIVER, ALASKA

By Clyde P. Ross

ABSTRACT

The area in the vicinity of the West Fork of the Chulitna River, Alaska, one of those examined in 1931 in connection with the study of mineral resources in districts tributary to the Alaska Railroad, contains numerous prospects but, as yet, no productive mines. Its placer deposits are negligible but some of its lodes may prove valuable for gold and silver and perhaps also for copper and arsenic.

The area is underlain by a steeply inclined succession of Devonian (?), Carboniferous (Permian?), and Triassic sedimentary and volcanic strata of diverse kinds. These beds have been cut by a zone of thrust faulting with associated normal faults and have locally been much contorted. They are intruded by small stocks and dikes of quartz diorite, biotite-quartz diorite porphyry, and related rocks. The lodes, which are genetically related to the porphyry, are of three interrelated and intergradational kinds—(1) disseminated deposits, mainly in the porphyry, (2) replacement deposits along the bedding in calcareous rocks, (3) tabular and lenticular lodes with conspicuous vein quartz, along fissures and shear zones. The principal metallic minerals are arsenopyrite, pyrite, pyrrhotite, chalcopyrite, sphalerite, and galena. The lodes are not sufficiently developed for quantitative estimation of grade of ore or of available tonnage, but there are considerable quantities, mostly in individually small bodies, of ore ranging from $5 to $20 a ton in precious metals and locally containing as much as 20 percent of arsenic. A few of the lodes contain 5 to 10 percent of copper in addition to some gold and silver, but the quantity of such material now exposed is very small.

INTRODUCTION

SCOPE OF THE WORK

The mineral deposits in the general vicinity of the West Fork of the Chulitna River were examined in 1931 as a part of the investigation of the mineral resources of the region tributary to the Alaska Railroad. Those studied include nearly all the prospects in the area termed by Capps[1] the upper Chulitna region. The area mapped

[1] Capps, S. R., Mineral resources of the upper Chulitna region, Alaska: U.S. Geol. Survey Bull. 692, p. 207, 1919.

lies west of the Chulitna River and includes about 84 square miles in the drainage basins of Ohio, Copeland, Long, Colorado, and Costello Creeks and a section of the West Fork of the Chulitna River. (See fig. 1.)

The field examination in this area began July 19 and ended September 5, 1931. It was conducted by a party comprising the writer and Marion Peel, packer and rodman. The area was sketched topographically and geologically on a field scale of 1 to 96,000 by means of a plane table and explorer's alidade. Control was obtained from an enlarged copy of a plane-table survey made by D. C. Witherspoon, of the United States Geological Survey, on a scale of 1 to 180,000. The location of the principal peaks on this sheet proved satisfactory for use as triangulation points for the new map, it being impracticable to measure a base line or otherwise establish independent control. Elevations were originally referred to these earlier determined points, but subsequently they have been approximately adjusted so as to conform to the elevation of the Copeland triangulation station of the United States Coast and Geodetic Survey, which is on one of the peaks in the southern part of the area mapped during the present investigation. Because of limitations of time and personnel the map shown as plate 25 is somewhat deficient in both horizontal and vertical control but it represents the topographic forms with essential correctness. The geologic sketching for plate 25 was done concomitantly with the topographic sketching and is of comparable accuracy. In addition to the study of the general geology, 11 prospects were examined, of which 8 are held for gold, 1 for copper, 1 for silver and lead, and 1 for coal. The major factors concerned with ore deposition there were determined, and some insight was obtained into the details of the occurrence of individual lodes.

ACKNOWLEDGMENTS

The work was greatly facilitated by the cooperation of Henry Stevens and Alonzo Wells, owners of the principal prospects, and of other residents of the vicinity. The reports of Capps [2] and Moffit [3] on this and neighboring regions have been freely drawn upon and furnish an invaluable setting for the present study.

HISTORY

Mineral deposits were first discovered in the area in 1907. As usual the placer gravel was the first to be found and worked, but the returns were so meager as to result in prompt abandonment. The

[2] Capps, S. R., Mineral resources of the upper Chulitna region, Alaska: U.S. Geol. Survey Bull. 692, pp. 207–232, 1919; The eastern portion of Mount McKinley National Park, Alaska: U.S. Geol. Survey Bull. 836, pp. 219–300, 1932.

[3] Moffit, F. H., The Broad Pass region, Alaska: U.S. Geol. Survey Bull. 608, 1915.

presence of lodes was soon recognized, but the remoteness of the region prevented much development at that time. From 1911 to 1915 much prospecting was done, and nearly all the existing development was accomplished during this time. A large part of the territory shown in plate 25 was covered with lode claims, and many pits were dug. In a few places, notably at the Golden Zone and Ready Cash prospects, short tunnels were driven. Since then many of the claims have been abandoned, and the annual assessment work on the others has been carried out under such handicaps that little has been accomplished. In the summer of 1931 outside persons arranged for the extension of the Golden Zone tunnel with a view to further development if the results were favorable.

GEOGRAPHY

TOPOGRAPHY

The area studied is in the part of the foothills of the Alaska Range which is tributary to the upper Chulitna River and its branches. It is crossed by several streams that flow southeastward toward the Chulitna River and its West Fork. The trunk stream flows southwestward and borders the Alaska Range almost to the southern terminus of the range. In the northern part of the area considerable parts of the major streams flow S. 65° E., and the average trend of their tributaries is N. 30°–35° E. Farther south the main streams tend to flow about S. 50° E., and the average trend of the minor streams is N. 45° E.

The West Fork of the Chulitna River and Ohio Creek, the two largest streams, are braided and carry much silt from the glaciers at their heads. The water in some channels of these streams in midsummer exceeds 4 feet in depth. McCallie and Copeland Creeks are also silt laden and in part braided. The other streams are clear, although several have small glaciers at their heads. The effects of recent rejuvenation are visible along most streamways, and the narrow, rock-cut inner gorges of Colorado, Long, and lower Copeland Creeks are especially striking. The walls of these gorges are 30 to over 50 feet high.

The elevation within the area mapped ranges from less than 2,000 feet above sea level at the confluence of Ohio and Copeland Creeks to nearly 6,000 feet in the peaks at the head of Long Creek. Below an elevation of about 4,500 feet the country is generally open, with gentle slopes, except on the immediate borders of the streams. Above this the topography is rugged, and many slopes are precipitous. In the areas of gentle slopes rock outcrops are poor and scanty, but in the rugged country exposures are almost continuous, except where masked by talus slopes, snow, and ice. Much of the country here mapped is below the more rugged mountains, and the locally unsatisfactory exposures and brush cover are the cause of uncertainty as to the precise position of geologic boundaries. This uncertainty is indicated on plate 25 by dashed lines.

The Alaska Range rises on the west to elevations of over 10,000 feet above the sea and is generally rugged. Many of the valleys are glacier-filled, and slopes above an elevation of 6,500 feet have extensive banks of perennial snow.

Timber is absent above an elevation of about 2,700 feet and is poor and scanty above 2,200 feet. Spruce and cottonwood are the only trees of any size and the cottonwood extends somewhat farther up the stream valleys. The timber is of potential value mainly for local use, as trees over 2 feet in diameter are exceptional and, on the average, are neither tall nor straight. For rough mine timbers and similar uses, however, there is a considerable supply.

The valley sides up to elevations locally as high as 3,500 feet are mantled with a thick growth of brush which hampers travel but, on the other hand, is of value for firewood. In most places the country above 2,500 feet is almost devoid of vegetation other than grasses and mosses. Grass suitable for forage grows in favorable places up to 4,500 feet. Most of it, however, is of inferior quality.

MEANS OF ACCESS

The region is now served by the main line of the Alaska Railroad, which in this vicinity follows closely the Chulitna River and after crossing its East Fork proceeds up its Middle Fork. A trail extends westward from Colorado station, on the railroad, with branches to the principal prospects on both sides of the West Fork of the Chulitna. Other trails lead from Honolulu station to points in the Alaska Range. One of these formerly served the prospects on Ohio Creek, but considerable stretches of it are now impassable. Practicable routes of travel for pack horses in summer can be found through most of the country below an elevation of 4,500 feet. Marshes and cliffs cause numerous detours, and it is occasionally necessary to cut a way through brush.

Development of the mineral deposits will require the construction of roads 10 to 15 miles long from points on the railroad. Colorado is the nearest railroad point to many of the existing prospects and can be reached from them by several alternate routes without special difficulty. It will be necessary to bridge the flood plain of the West Fork as well as to throw relatively short bridges across a number of minor streams. A small amount of pack-horse traffic soon reduces sections of existing trails to quagmires, and it is evident that any road in this region that is to be used for truck transportation will require care in draining and local reinforcement or surfacing. Locally, aerial tramways may supplement the roads, but the topography does not readily lend itself to their use.

CLIMATE

Few climatic records are available for this area or its vicinity. Snow generally covers the ground from October or early November until April or May, and many drifts remain until June and later. Snowfall is frequent and persistent but rarely heavy. Winter temperatures are generally not extreme, although they may occasionally range as low as 50° below zero. Summer temperatures may reach 90° but are in general materially lower, and frosts occur at intervals throughout the summer. The annual precipitation may be roughly estimated at 40 to 45 inches. Drizzling rain and dense fog are very frequent, especially in July and August. High winds are common at elevations over 3,000 feet above sea level.

Of the 49 days the party was in the field in the summer of 1931, 18 were rainy, 20 showery, 6 cloudy, and 5 fair. Heavy downpours were exceptional, but the frequent wet and foggy weather interfered materially with outdoor work.

GENERAL GEOLOGY

Both stratigraphically and structurally the area has features which distinguish it from others in this part of Alaska. The presence of strata of Carboniferous (probable Permian) age and of thrust faults are among the more striking of these features. Many of the rocks are distinctively colored, permitting subdivision into relatively small stratigraphic units. Fossils at several horizons help to date these units. Faulting, not completely understood, causes minor uncertainties in correlation. In view of the incompleteness of present knowledge regarding the stratigraphy of the region in general and this area in particular it has not seemed wise to assign any formation names. The principal units are designated in accordance with their provisional age assignments, and the minor subdivisions of the Permian (?) rocks are distinguished as unit A, B, etc.

The lowest stratigraphic unit comprises ancient, possibly Devonian, metamorphosed sedimentary rocks in which silicified limestone is prominent. Unconformably above these are tuff, lava, limestone, chert, and argillite of probable Permian age, succeeded, with some unconformity, by Triassic limestone, followed by Triassic argillite with some limestone, pyroclastic rocks, and lava. There are some small dikes and bosses of moderately silicic porphyritic rocks of undetermined, presumably Tertiary age, and Tertiary sediments of late Eocene or later age.

STRATIFIED ROCKS

DEVONIAN (?) CHLORITIC ROCKS

Character.—The southeastern part of the area is underlain by metamorphosed sedimentary rocks. They trend in general northeast and dip steeply south, with numerous irregularities. The base of the formation is not exposed within the area mapped, and as there may be repetitions by folding and perhaps faulting, available data afford no estimate as to the aggregate thickness of these beds, except that it is probably great.

Most of the rocks are light gray to nearly white, generally with a greenish cast, in upland exposures and dark gray to nearly black in fresher outcrops, especially in stream gorges. Most of them are thin-bedded, but in weathered exposures the banding is inconspicuous. They are calcareous sedimentary rocks containing considerable siliceous and argillaceous material. Some, especially beds near the upper contact, contain much chlorite. Most beds look cherty and have probably been silicified during metamorphism, but many of these retain enough calcite to react readily with dilute acid.

Age.—The overlying Permian (?) beds rest in angular unconformity on these calcareous and cherty rocks, which are obviously the oldest in the area. The contact trends more nearly north than the average strike of the beds above. Wherever satisfactory outcrops of the old rocks and the Permian (?) beds are close together, differences in the attitude of the beds are evident, but except where there has been faulting the divergence in attitude is rarely great.

Further direct evidence as to the age of the older beds is lacking. The strata in the general vicinity of Broad Pass, which include fossiliferous Devonian limestone, have lithologic similarities to the old strata here described and are among the nearest known Paleozoic rocks.[4] Hence the metamorphosed strata in the vicinity of the West Fork of the Chulitna may be of Devonian age.

CARBONIFEROUS (PERMIAN ?) ROCKS

General features.—A thick and heterogeneous sequence of rocks of probable Permian age stretches through the middle portion of the area and includes most of the known mineral deposits. Tuff, volcanic breccia, and lava predominate, but argillite, limestone, chert, and conglomerate are each locally plentiful. In the southwestern part of the area mapped these rocks are mainly of volcanic origin, with the exception of certain limestone beds. Farther north-

[4] Moffit, F. H., The Broad Pass region, Alaska: U.S. Geol. Survey Bull. 608, pp. 24–26, 1915.

east both the thickness and the heterogeneity increase and the proportion of sedimentary rocks is progressively greater. The aggregate thickness of these rocks in and near Long Creek exceeds 10,000 feet. These conditions are represented on plate 25 by grouping similar or related beds that are colored distinctively into units designated by letters. The beds that are almost exclusively volcanic and are characterized by an abundance of red tuff and breccia are grouped for purposes of description as unit A, although intercalation of different beds and other causes separate these rocks into several areas. So far as the area here mapped is concerned, the other units may all be regarded as local members intercalated in unit A, which constitutes the major and locally the sole part of the formation. In different parts of the area mapped unit A ranges from the base to the top of the Permian (?) sequence. In the vicinity of Long Creek chloritic argillite, conglomerate, and lava, with some limestone are grouped as unit B. Stratigraphically above unit B and in places separated from it by part of unit A, there are beds composed mainly of black argillite, which are designated unit C. This unit is in places separated from the underlying portion of unit A by a narrow band of fossiliferous limestone. Above unit C and in places separated from it by an isolated mass of unit A is a thick aggregate of beds characterized by abundant chert and cherty limestone but containing also much argillite and some conglomerate and volcanic material. This is called unit D. It is succeeded by more of unit A, followed by other beds called unit E, in which chert and limestone are also locally prominent but which contain more volcanic material and less argillite than unit D.

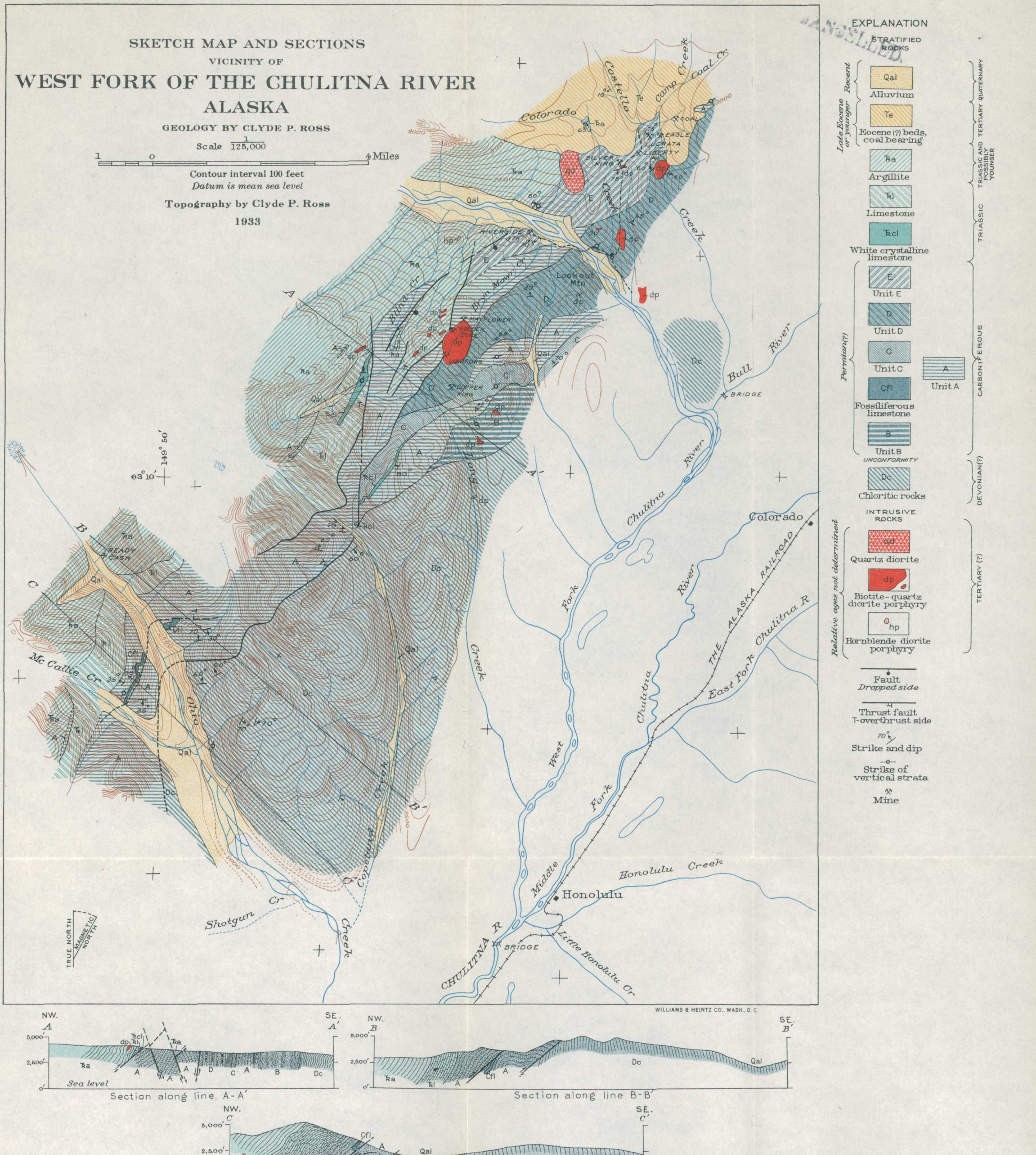
Unit A.—The striking feature of unit A, the principal component of the Permian (?) rocks, is the abundance of tuffaceous beds colored deep rose and related shades. Some of these are moderately fine, even-grained rocks; others are breccias in which either the cement or most of the fragments or both are colored red by disseminated hematite. All are composed mainly of fragments of lava and of igneous minerals, mainly plagioclase. Quartz and locally calcite are plentiful in the cement. The lava fragments are mainly aggregates of plagioclase with trachytic texture. Chlorite and other alteration products are present, but original ferromagnesian minerals are generally absent. Some of the coarser breccias include in addition to the igneous materials fragments of black argillaceous rock, quartz, and other materials. The pieces are generally of irregular shape and poorly sorted, but in some beds they are fairly well rounded and the rock approaches a conglomerate in appearance. Along Long Creek local beds of conglomerate with well-rounded pebbles are grouped with unit A in mapping. Interbedded with the red beds there are considerable quantities of green and nearly black tuffs composed of irregular fragments of lava, devitrified glass, and other material. The cementing material is mainly quartz and calcite. Some of the lava has pisolitic texture. Chlorite is abundant.

Lava flows are widely distributed but are almost everywhere subordinate in amount to the tuffaceous beds. The small masses mapped as unit A near Costello Creek are, however, mainly lava. The lavas are gray, purple, and green andesite, in part amygdaloidal, in part porphyritic. They are composed mainly of plagioclase, ranging in composition from oligoclase to andesine in different flows, with small amounts of quartz and considerable chlorite and other alteration products. Some contain hornblende, but in most of them any ferromagnesian minerals which may have originally been present are altered beyond recognition. The amygdules are filled with calcite.

Nonvolcanic strata are rare in unit A. Approximately midway in the sequence, along Ohio Creek and between units A and C south of Long Creek, there are persistent beds of crystalline limestone which south of Long Creek are fossiliferous. The beds in the two localities are probably approximately equivalent stratigraphically. These are the only Permian (?) limestones which have been mapped separately. Their light-colored cliffs are prominent features of the landscape. The beds are about 100 feet thick, or locally more. Small amounts of limestone, argillite, and conglomerate are included in unit A as mapped in several other localities and are particularly well exposed on Long Creek.

The Long Creek gorge cuts three separate masses assigned to unit A. These have an aggregate thickness of 3,500 feet, of which about 350 feet consists of greenish tuffs and breccias and about 600 feet of conglomerates with comparatively well rounded pebbles and without conspicuous red color. Along Ohio Creek unit A is fully 3,500 feet thick and may be materially thicker. In both localities faults prevent accurate determination of the thickness.

Unit B.—The strata which on Long Creek are locally at the base of the Permian (?) sequence constitute unit B. In the inner gorge of this creek unit B includes green to black chloritic argillite, conglomerate, and limestone. Some of the chloritic rock may be intensely altered lava, but most of it is of probable sedimentary origin. In some exposures it shows almost no trace of bedding, but elsewhere it is banded and much contorted. A few beds are coarse grit with a green matrix that is probably tuffaceous. The chloritic rocks have an aggregate thickness of about 2,500 feet. The conglomerate contains pebbles that are better sorted and more waterworn than any seen elsewhere in the area. The pebbles are mostly



SKETCH MAP AND SECTIONS
VICINITY OF
WEST FORK OF THE CHULITNA RIVER
ALASKA
GEOLOGY BY CLYDE P. ROSS
Scale 1/125,000
1 0 4 Miles
Contour interval 100 feet
Datum is mean sea level
Topography by Clyde P. Ross
1933
EXPLANATION
STRATIFIED ROCKS
Qal
Alluvium
Recent
Te
Eocene (?) beds, coal bearing
Late Eocene or younger
TERTIARY QUATERNARY
Ŧra
Argillite
TRIASSIC AND POSSIBLY YOUNGER
Ŧrl
Limestone
Ŧrcl
White crystalline limestone
TRIASSIC
E
Unit E
D
Unit D
C
Unit C
A
Unit A
Cfl
Fossiliferous limestone
B
Unit B
Permian(?)
CARBONIFEROUS
UNCONFORMITY
Dc
Chloritic rocks
DEVONIAN(?)
INTRUSIVE ROCKS
qd
Quartz diorite
dp
Biotite-quartz diorite porphyry
hp
Hornblende diorite porphyry
Relative ages not determined
TERTIARY (?)
Fault
Dropped side
Thrust fault
T-overthrust side
Strike and dip
Strike of vertical strata
Mine
Colorado
Costello
Camp Creek
Coal Cr.
SILVER KING
EAGLE
LUCRATA
LIBERTY
COAL
RIVERSIDE
Lookout Mtn
Bryn Mawr Cr.
Ohio Creek
Elima Cr.
MAYFLOWER
GOLDEN ZONE
JUNCTORS
COPPER KING
Long Creek
Bull River
BRIDGE
Chulitna River
Colorado
THE ALASKA RAILROAD
East Fork Chulitna R
West Fork
Middle Fork
Chulitna
Honolulu
Honolulu Creek
Little Honolulu Cr
CHULITNA R
BRIDGE
READY CASH
Mc Callie Cr
Copeland Creek
Shotgun Cr
TRUE NORTH
MAGNETIC NORTH
63° 10′
149° 50′
WILLIAMS & HEINTZ CO., WASH., D. C.
NW. A
SE. A′
Sea level
Section along line A-A′
NW. B
SE. B′
Section along line B-B′
NW. C
SE. C′
Section along line C-C′

andesitic lava, and the largest are about 5 inches in diameter. The thickness of the conglomerate is somewhat less than 200 feet. Limestone is exposed at two places in the Long Creek gorge within the limits of unit B and has an aggregate thickness of nearly 150 feet. It is somewhat rusty, crystalline, and, at least in part, magnesian. It contains fragmentary fossils, but nothing which appeared determinable was found.

On the ridges to the north chloritic material persists, but neither conglomerate nor limestone appears at this horizon. There are a number of porphyritic and amygdaloidal lava flows. Some are dacite, consisting mainly of plagioclase laths of intermediate composition with about 10 percent of interstitial quartz and considerable amounts of chlorite, sericite, and epidote. The amygdaloidal flows are largely basalt containing roughly 20 percent of augite, 70 percent of plagioclase with the composition of andesine or labradorite, and chlorite, calcite, epidote, and other alteration products.

Unit C.—Unit C is composed of black to greenish argillite, which resembles the Triassic argillite above but is in part more chloritic. Most of it is thin-bedded but some is indistinctly laminated. Where this unit is cut by the Long Creek gorge it has a thickness of only about 200 feet, but on both sides it appears to be materially thicker.

Unit D.—Unit D is a comparatively heterogeneous assemblage of strata in which chert, cherty limestone, and chloritic argillite predominate. Locally it includes green and gray andesitic lava, tuff and tuffaceous breccia, mainly green and black, and some fine conglomerate. Most of the cherty beds are light greenish, but some are black and red. The argillite resembles that in unit B. The aggregate thickness of unit D in the Long Creek gorge is about 1,600 feet, but the unit appears to thicken northeastward. In the vicinity of Bryn Mawr Creek the unit includes some coarse tuffaceous breccia in which angular fragments of black argillite are abundant. Most of the rock on and near Lookout Mountain is sheared, almost schistose chloritic argillite with small limestone lenses.

Unit E.—Unit E crosses the West Fork of the Chulitna near the Riverside prospect. It resembles unit D in the local abundance of chert and cherty limestone but contains more tuff and less argillite. In the vicinity of the Riverside prospect the principal rock is banded light-colored limestone, in part cherty, in part rather coarsely crystalline. There are a few conglomerate beds with rounded pebbles. The hills just south of the prospect contain chert, limestone, and green tuff, somewhat silicified. West of the prospect there are gray and purplish rather fine grained and massive sedimentary rocks composed largely of quartz, calcite, and sericitized feldspar.

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In the canyon of Colorado Creek near the Silver King prospect there are cherty and chloritic beds with some conglomerate and limestone. At the Silver King and Liberty prospects the prevailing rocks are thin-banded cherty limestone. Along Costello Creek the beds assigned to unit E include some cherty and calcareous rocks, but most of them are chloritic tuff. Some argillite is also present.

In all exposures of unit E the beds are much disturbed, and the thin-banded ones commonly are crenulated. The variety of dips and strikes recorded on plate 25 illustrates the impracticability of determining accurately the thickness of the unit. Presumably it is of the order of 2,500 feet.

Age.—The strata described as units A to E are of Carboniferous age, probably Permian. They are stratigraphically above the old Devonian (?) rocks and below Triassic beds. A collection of fossils made from limestone beds immediately below unit C near the crest of a spur of the ridge southwest of Long Creek has been examined by George H. Girty, who states that it is clearly of Carboniferous age and probably Permian, "though the facies of the fauna is by no means identical with that of the typical Alaskan Permian as we know it from Kuiu Island and from the Yukon." The species recognized are listed below, all the identifications being more or less provisional. The lot is no. 6942 of the permanent collections of the United States National Museum.

Cyathophyllum sp.
Chonetes aff. C. geinitzanus
Productus semireticulatus
Productus n. sp.
Pustula aff. P. horrida
Pustula aff. P. pustulata
Rhynchopora aff. R. nikitini
Camarophoria? sp.
Dielasma sp.
Spirifer aff. S. rectangulus
Spirifer aff. S. fasciger
Martinia? sp.
Spiriferina? sp.
Rustedia sp.
Platyceras sp.

TRIASSIC LIMESTONE

Character.—Immediately above the Permian (?) rocks are prominent beds of Triassic limestone. A few of these beds, which cross upper Long Creek, are somewhat more coarsely crystalline than the others and form conspicuous white outcrops. These have been distinguished from the rest in mapping. The fossil collection described first in the discussion of the age of the beds (see pp. 299–300) came from sandy, rusty limestone just above this unit. The crystalline unit appears to be unfossiliferous, whereas fossils are widely distributed in the rest of the Triassic limestone, most of which weathers in brownish cliffs, is gray to black on fresh fractures, is interbedded with argillite, and is somewhat more impure, some beds being sandy and others argillaceous. On the south side of Ohio Creek groups of such beds separated by argillaceous strata are exposed. The whole is much contorted, and the limestone and argillite are intricately interbedded on the south side of Ohio Creek, making it impracticable to separate them on a map of the scale of plate 25. The aggregate thickness is probably at least 1,500 feet. On Copeland Creek the proportion of argillaceous material is less; the limestone is intricately and closely folded (see fig. 38) and is probably fully as thick as on Ohio Creek. On the south side of Long Creek the total thickness of the Triassic limestone appears to be materially greater than 2,000 feet. On the north side of Long Creek the exposed thickness is much diminished by faulting, and fully 250 feet of rusty limestone with minor amounts of argillite overlies the crystalline unit. There is perceptible angular discordance between the rusty limestone and the main body of argillite, but this presumably records merely local unconformity.

Age.—Fossil evidence shows that these limestones are Triassic, probably Upper Triassic. Structurally, as is more fully discussed on pages 301–302, there is reason to doubt that the hiatus, if there is any such hiatus, between the Permian (?) beds and the limestone and associated argillite, is sufficiently great to account for the absence of representatives of the Lower and Middle Triassic.

Sandy limestone immediately above the prominent crystalline limestone beds mapped separately on Long Creek contains abundant fossils. A collection was made from an outcrop on a terrace on the north side of the creek at an altitude of 4,125 feet. J. B. Reeside, Jr., comments on this collection (U.S.Nat.Mus. no. 15952) as follows:

> Several unnamed and interesting species of *Spiriferina* make up this lot. It has been examined by G. H. Girty, who finds the species unlike any familiar to him. They could very well be Triassic forms, and it is suggested that they be so assigned until other evidence is available. Rather similar species are present in a Triassic fauna from Oregon which contains ammonites.

Another collection of fossils was made from the limestone immediately south of the conspicuous ice-filled gorge on upper Copeland Creek at an altitude of 3,250 feet. Reeside reports that this material (U.S.Nat.Mus. no. 15954) contains the following species:

Thecosmilia sp.	Halobia? sp.
Terebratula? sp.	Cardinia? sp.
Cassianella n. sp.	Borings, undetermined

Reeside says: "This is an unfamiliar assemblage. Only the form determined as *Cassianella* is well preserved and abundant. It should be Triassic and more likely Upper Triassic."

Fossils were noted in several places in the Triassic limestone along Ohio Creek but were not collected, as Capps [5] had previously made

[5] Capps, S. R., Mineral resources of the upper Chulitna region, Alaska: U.S. Geol. Survey Bull. 692, p. 217, 1919.

a collection from limestone talus 1½ miles above the mouth of McCallie Creek. T. W. Stanton reported that this collection (U.S.Nat.Mus. no. 10094) contains *Avicula* sp., *Cassianella* sp., *Undularia?* sp., and *Coelostylina?* sp., and is of Triassic age.

Capps also made four collections of fossils from boulders in stream bars along Copeland Creek, which were identified by Stanton as indicated below, the collection numbers listed being those of the United States National Museum. As the Triassic limestone from which a collection was obtained during the present study is the only limestone exposed along Copeland Creek, there seems little doubt that the fossils in the boulders came from this horizon.

10090. Terebratula sp.
Pecten sp.
Probably Triassic.

10091. Terebratula sp.
Lima? sp.
Astarte? sp.
Probably Triassic.

10092. Terebratula sp.
Pecten sp.
Aviculopecten? sp.
Probably Triassic.

10093. Terebratula sp.
Lima sp.
Avicula sp.
Myophoria? ? sp.
Cassianella sp.
Coelostylina? sp.
Loxonema (Anoptychia) ? sp.
Loxonema? sp.
Triassic.

Stanton's comment regarding the material as a whole was that "the presence of *Cassianella* in these collections suggests the Triassic fauna of Gravina Island of southeastern Alaska." The Gravina Island fauna is now regarded as of Upper Triassic age.[6]

TRIASSIC ARGILLITE

Character.—The mountains along the northwest border of the area mapped, which extend westward beyond the limits of vision, are composed mainly of dark-gray to black argillite and argillaceous sandstone. These rocks are interbedded at their base with the Triassic limestone above described, with local unconformity in some places. At and just above the upper contact of the Triassic limestone there are lenses of tuffaceous material lithologically identical with unit A of the Permian (?) rocks. Most of such exposures are in zones of intense folding and faulting, but the distinctive reddish strata appear to be integral parts of the sedimentary sequence. Locally, especially on Ohio Creek, dark-greenish lava and pyroclastic rocks are abundant. As these rocks can be distinguished from the coarser beds in the associated argillite only on close inspection, considerable quantities of them may be present in the rugged mountains around the head of Ohio Creek. Some are altered andesitic or possibly more calcic lava, of which roughly 50 percent is made up of

[6] Martin, G. C., The Mesozoic stratigraphy of Alaska: U.S. Geol. Survey Bull. 776, pp. 70–71, 1926.

plagioclase laths nearly 1 millimeter long, which approximate oligoclase in composition, almost equally abundant bladed blue to brown pleochroic hornblende of secondary origin, and some chlorite and sericite. Other rocks are coarse breccias composed of irregular fragments of this lava and of argillite in a green tuffaceous matrix. The fragments are somewhat rounded and range in maximum diameter from a few inches to several feet.

In several places near the eastern border of the argillite, particularly near the headwater branches of Blind Creek and on the hill east of the mouth of this creek, there are lenses of conglomerate containing moderately well rounded pebbles an eighth to half an inch or more in maximum diameter. The pebbles include quartz, argillite, quartzite, chert, and several fine-grained igneous rocks. The matrix is a grit composed mainly of quartz, feldspar, and rock fragments. Conglomerate of this kind is locally associated with the tuffaceous lenses mentioned above.

The high mountains northwest of Long Creek, beyond the limits of the area shown on plate 25, contain several lenses of rusty limestone. The brown outcrops of this rock are most conspicuous in contrast to the surrounding black rocks and are identical in general appearance with the main part of the Triassic limestone within the area mapped, suggesting repetition of calcareous deposition higher in the sequence.

Age.—Fossils were not found in the argillite, but its intimate relation to the fossiliferous Triassic limestone on Long and Copeland Creeks shows that at least the lower part of the apparently very thick sequence is of Triassic age. The presence near its base of beds lithologically identical with distinctive tuff of Permian (?) age led to the conclusion in the field that there is no great difference in age between these units. The paleontologic evidence (pp. 298–300) tends to indicate that there is a gap corresponding to the whole of Lower and Middle Triassic time, but as both the Permian (?) and the Triassic fossils obtained are unfamiliar assemblages, the data are inconclusive on this point. The possibility is suggested that early Triassic sedimentary rocks are present here, though they have not been found in other known parts of Alaska.[7] The presence of lava and tuff strengthens this possibility, as volcanic strata of probable early Triassic age exist in many localities such as Chitina Valley, Kenai Peninsula, and Kodiak Island.[8]

Though the argillaceous rocks within the area here considered are thus, at least in part, of Triassic age, strata higher in this very thick and complexly deformed sequence are evidently materially younger, as Capps[9] has found fossils of Upper Jurassic or Lower

[7] Martin, G. C., op. cit., pp. 128–130.
[8] Idem, p. 6.
[9] Capps, S. R., The eastern portion of Mount McKinley National Park, Alaska: U.S. Geol. Survey Bull. 836, p. 261, 1932.

Cretaceous age in an intercalated limestone lens some distance to the west. Capps [10] states that the beds associated with this fossiliferous lens are more uniformly shaly and are without the coarser beds prominent in the argillaceous rocks associated with the Triassic limestone here described. For the purposes of the present report all the dark-colored, dominantly argillaceous rocks associated with and stratigraphically above the Triassic limestone are grouped on plate 25 as Triassic argillite, although it is recognized that future work may show that the upper part of the group thus mapped is younger.

TERTIARY (EOCENE?) ROCKS

Character.—At the northeast end of the area there are extensive deposits of more or less thoroughly consolidated gravel, sand, and clay, with local coal beds, which are of Tertiary age. In fresh exposures, either natural or artificial, this material is well-cemented rock, but the cement, which is largely calcareous, readily disintegrates on weathering. In most places these beds are somewhat deformed, dips of 10° and more being common.

Conglomerate is the most abundant material in most places. Where fresh it is a hard rock, but in cliff faces it is soft enough to yield to the pick, and weathering has reduced most of it surficially to loose gravel. Interstream areas are mantled with such gravel, but the hard material exposed in most gulches proves its origin. Here, as in other areas of similar rolling topography in the region, there are scattered large erratics and thin, entirely unconsolidated beds of gravel and sand, which are doubtless Pleistocene glacial outwash. Such material is difficult to distinguish from the weathered Tertiary conglomerate, but the amount present everywhere within the area mapped appears to be small. The Tertiary conglomerate was evidently derived from erosion from the nearby mountains, as it is composed largely of argillite pebbles and cobbles. Granitic cobbles are also plentiful, doubtless derived from such granitic intrusions as those which crop out near Costello Creek both northwest and southeast of the area mapped.[11] Some of the characteristic reddish tuff of unit A, which is not known to crop out in the tributary area, and other representatives of the Permian (?) rocks are locally present but are not abundant.

Much of the sandstone and grit associated with the conglomerate is composed largely of argillite. On Camp Creek and its tributary Coal Creek the most abundant beds are light-colored calcareous sandstone. Similar light-colored sandstone is locally interstratified with the conglomerate on Costello Creek and in gulches in the in-

[10] Capps, S. R., personal communication.

[11] Capps, S. R., op. cit. (Bull. 836), p. 284.

tervening area. These beds appear to have been derived mainly from the erosion of granitic rocks but have abundant calcite cement. In the vicinity of Camp Creek light-colored clayey and shaly beds, locally darkened by carbonaceous material, are more abundant than farther south, and conglomerate less so. The coal exposed on Coal Creek is described on pages 331–332. Other exposures of coal are stated by Henry Stevens to exist in the area north of the limits of the present study.

Age.—The character and structural relations of these beds show obviously that they are post-Triassic and pre-Pleistocene. Abundant and unusually well preserved plant remains in beds of calcareous sandstone associated with the coal on Coal Creek have been examined by Roland W. Brown, who regards them as "at least of upper Eocene age, if not a little younger." He identified the following forms in the collection (U.S.Nat.Mus. no. 8291):

Taxodium dubium	Alnus alaskana
Sequoia?	Carpinus grandis
Populus richardsoni	Hicoria magnifica

QUATERNARY DEPOSITS

Within the area mapped distinctly glacial deposits are scanty. The glaciers at the heads of Ohio, Copeland, and Long Creeks have built small moraines, but there is little suggestion of older morainal material in the valleys below. The rolling interstream uplands on the eastern border of the area have erratic boulders sparsely distributed on their surfaces and locally have thin gravel deposits mantling the bedrock. All the larger streams, especially the West Fork of the Chulitna River, are bordered by terraces, more or less obscured by weathering, landslides, and frost creep. Some of these still show that they were originally covered by gravel and sand, but the deposits are nowhere deep.

All the streams are floored to a greater or less extent by alluvium. Wherever sufficiently extensive, this has been shown on plate 25. Along the West Fork silt and sand predominate, though gravel bars are locally present. The deposits along Ohio and McCallie Creeks contain less silt and more and somewhat coarser gravel. In most places in the other valleys gravel is abundant and silt rare.

INTRUSIVE ROCKS

Small andesite dikes occur in the Permian (?) volcanic rocks south of Copeland Creek and are similar to and doubtless of essentially the same age as the nearby lava flows. Some of the other porphyries included in the Permian (?) rocks may likewise be of intrusive rather than effusive origin. None of these were mapped separately.

In addition to these old intrusive rocks there are numerous small bodies, generally rendered inconspicuous by alteration, which are doubtless much younger. Most of these appear to differ among themselves mainly in details of alteration, and they are grouped as biotite-quartz diorite porphyry. One relatively coarse-grained mass between Colorado Creek and the West Fork of the Chulitna is somewhat more calcic and is termed quartz diorite. Dikes on the hill east of the mouth of Blind Creek which contain conspicuous hornblende may be distinguished as hornblende diorite porphyry.

BIOTITE-QUARTZ DIORITE PORPHYRY

There are numerous bodies of light-colored, fine-grained biotite-quartz diorite porphyry which, where not too much altered, are characterized by prominent biotite phenocrysts. These range from dikes a few feet wide to the stock at the Golden Zone prospect, which, as mapped, has a maximum diameter of somewhat over 4,000 feet. This stock is probably more irregular in outline than is indicated on plate 25 and has apophyses leading from it which are, for the most part, too small and too poorly exposed to be mapped. The numerous generally small masses of this rock shown on plate 25 indicate somewhat diagrammatically the position of most of the exposures, although many of the dikes are far too small to be shown individually on a map of this scale. Most of the dikes tend to follow in general the trend of the steeply dipping beds they intrude, but in detail they cut across the bedding planes irregularly.

This rock is everywhere so much altered hydrothermally as to prevent accurate determination of its original composition. The groundmass is a mat of irregular feldspar grains 0.2 to 0.4 millimeter long, with interstitial quartz. The phenocrysts are biotite, feldspar, and quartz and are 1 to 2 millimeters in maximum dimension.

Zoned and sericitized plagioclase, mainly of the approximate composition of oligoclase, makes up about 80 percent of the rock. A small amount of potassium feldspar may be present in some of the intrusive bodies. Chloritized biotite and quartz each make up about 10 percent of the rock. One variety that crops out in a small mass north of Long Creek, near the east border of the area, contains about 68 percent of feldspar, 15 percent of augite, 12 percent of biotite, and 5 percent of quartz. These estimates are based on measurements in which the attempt was made to get original composition, ignoring the abundant alteration products, which include calcite, chlorite, quartz, epidote, sericite, and, locally, iron and other sulphides.

QUARTZ DIORITE

The quartz diorite is a fairly even grained aggregate with few phenocrysts. The feldspar occurs in frayed laths with a maximum length of 1 millimeter, and the quartz tends to be interstitial. The rock contains about 45 percent of sericitized andesine, 24 percent each of biotite and hornblende, 5 percent of quartz, and some hematite, magnetite, sericite, chlorite, and epidote. It is less altered than any of the biotite-quartz diorite porphyry.

HORNBLENDE DIORITE PORPHYRY

The hornblende diorite porphyry consists of hornblende blades 2 millimeters or more long in a fine-grained mat of plagioclase too thoroughly obscured by sericitization for more exact determination. The rock contains roughly 70 percent of plagioclase, 20 percent of pleochroic brown hornblende, 5 percent each of secondary calcite and quartz, and a little epidote.

AGE

The intrusive rocks are later than the Triassic and earlier than the Eocene (?) sedimentary strata. The small size of the bodies and the prevailing fine-grained and porphyritic texture suggest intrusion at no great depth, which in turn suggests that the intrusions are not very old geologically. Capps [12] notes that the Cantwell formation, of supposed Eocene age, exposed at the head of the West Fork of the Chulitna has been intruded by dikes. The sediments within the area mapped that contain pebbles of intrusive rock are not older than upper Eocene and may be younger. Thus the scanty available evidence leads to the inference that intrusion took place near the beginning of the Tertiary period.

STRUCTURE

FOLDING

In general, the strata strike northeast and dip steeply northwest, but there are many local variations due to both folding and faulting. The great width of outcrop of the Devonian (?) rocks may perhaps result from repetition by folding. The observed dips in the area between Ohio and Copeland Creeks (see pl. 25) suggest the presence of an anticline in the Devonian (?) rocks, but this has not been proved because of the lack of horizon markers and the paucity of

[12] Capps, S. R., op. cit. (Bull. 692), pp. 220–221.

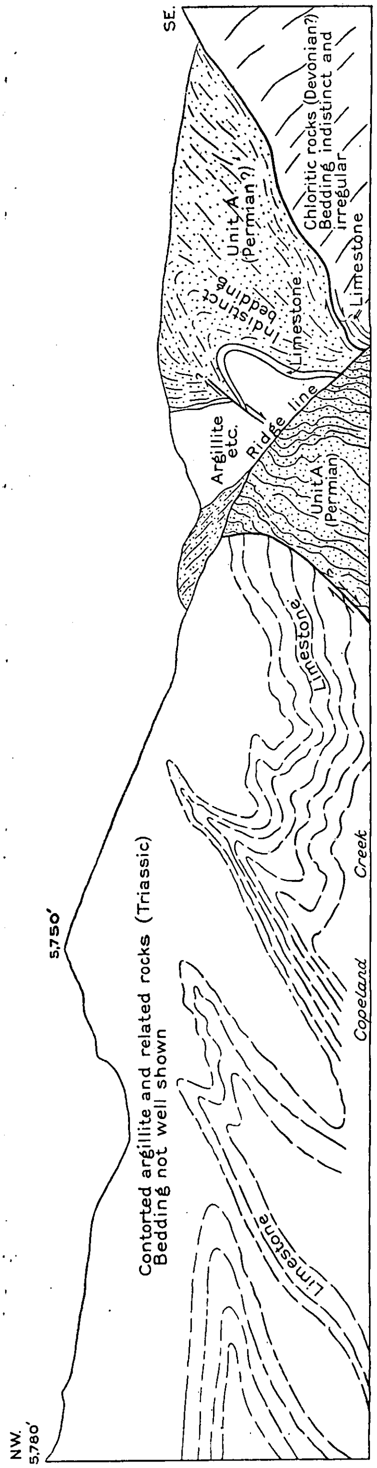

FIGURE 38.—Diagrammatic view of the north flank of the valley of Copeland Creek near the ice-filled gorge. Based on sketches made from the ridges on the south side of Copeland Creek; scale and proportion approximately correct.

good outcrops in much of this area. In the gorges of Copeland and Long Creeks the Devonian (?) strata exhibit considerable variations in attitude. Some exposures show intricate crenulation.

The Permian (?) beds show much local variation in attitude, and the thin-banded members are somewhat crenulated. In some places, such as the vicinity of the Riverside prospect, the beds tend to strike transverse to the general structural trend, suggesting cross folding. Though regional deformation has tilted the Permian (?) beds steeply, there is no evidence of any folds within the area of these beds here mapped. Most of the variation in attitude probably results from faulting.

The Triassic rocks include many beds comparatively susceptible to folding. In the vicinity of the zone of thrusting, the Triassic rocks are closely and intricately folded. The folding is especially well displayed on the north flank of the upper valley of Copeland Creek. As is somewhat diagrammatically shown in figure 38 the Triassic limestone here has been thrown into a number of intricate, overturned, and recumbent folds. The associated argillaceous and sandy beds are similarly deformed, but the bedding in these is not sufficiently distinct to be visible in a distant view such as figure 38 represents.

FAULTING

The major structural feature of the area is a zone of thrusting which extends throughout its median portion. This zone trends about N. 30° E. and contains two or more related thrust faults, which are inclined 30°–40° NW. The result is to cause the Triassic and part of the Permian (?) rocks to override Permian (?) and Devonian (?) strata. Thrust planes are exposed with diagrammatic clarity in the valley of Copeland Creek. (See fig. 38.) On the north and south the exposures are less perfect, but crumpling and brecciation, with the general distribution of the rocks, make it possible to trace the

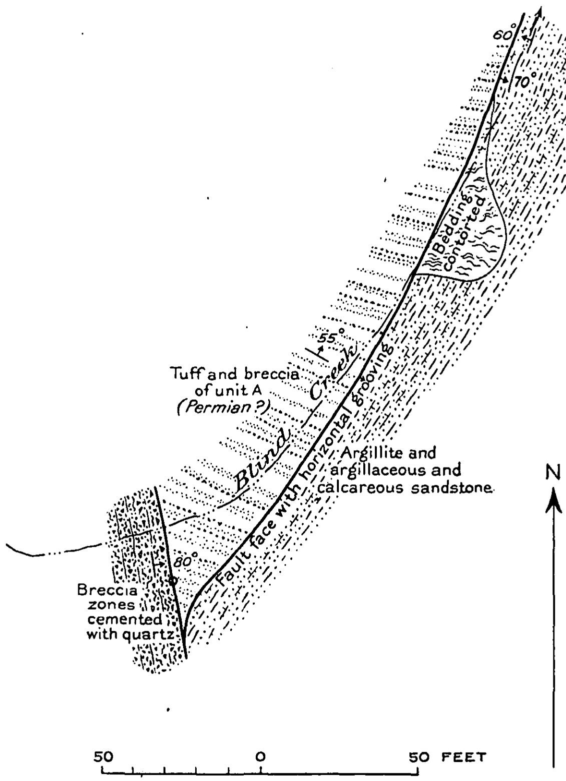

FIGURE 39.—Diagrammatic sketch of faulting along upper Blind Creek.

position of the thrust faults with essential correctness. As almost the entire width of the steeply tilted Permian (?) strata is traversed by the thrust zone in the vicinity of Copeland Creek, the horizontal component here appears to be fully 2 miles. Near Ohio Creek the displacement seems to be less, but more complete knowledge of the stratigraphy of the region might show that this is not the case.

Between Long Creek and the West Fork of the Chulitna there are steep faults, evidently associated with the thrusting. These trend north to N. 30° E. and are vertical or inclined steeply to the east. The last movement along these faults was essentially horizontal, as shown by well-marked horizontal grooving on fault planes. It seems probable that the absence of Triassic limestone near the West Fork is to be accounted for by lateral shift along such faults. A sketch of an exceptionally well exposed segment of one of these steep faults, in the inner gorge of Blind Creek a short distance below the point where the headwater branches of this stream come together at the border of the mountains is shown in figure 39. Both on Blind Creek and in the bank of the West Fork just west of the Riverside prospect it is clear that the deposition of vein quartz and the mineralization in the rocks were later than the faulting. On the West Fork a vertical fault is exposed. Bending in the contiguous beds indicates downthrow to the east, and immediately east of the fault plane there is a horizontal zone of shearing and brecciation.

Most of the steep faults are not so well exposed as those at the localities cited and have been mapped mainly on the basis of the distribution of the rocks. In most places where faulting is shown on plate 25 the evidence is strengthened by brecciation and variation in attitude in nearby rocks. There are undoubtedly more faults than are shown, but those omitted for lack of evidence are probably comparatively minor.

The tongue of Triassic argillite that is prominent on upper Blind Creek and ceases shortly after crossing Long Creek is probably a segment of the overthrust mass. In several places near Blind Creek small patches of argillite and kindred rocks cap hills composed of rock classed as unit A of the Permian(?) strata. These are doubtless outlying remnants of eroded portions of the overthrust rocks. It is clear that the steep faults have affected the argillite tongue, and the most probable explanation of its relatively low position in the gorge of Long Creek is that the argillite was dropped along such faults after being overthrust. Original irregularities in the thrust plane and subsequent folding would aid in bringing about the relations observed. So far as they have been determined, however, the contacts between the argillite tongue in the Long Creek gorge and the reddish tuff and breccia on both sides are so steep as to suggest faulting rather than folding. The actual contacts were zones of weakness and hence have been obscured by erosion, but disturbance of the beds and minor amounts of mineralization are visible nearby.

The two largest of the intrusive masses in the area lie on probable faults and as mapped appear to be of somewhat later date. It is possible that some of the other intrusions are similarly related to zones of movement, but those of the numerous small dikes that are well exposed were introduced approximately along bedding planes rather than along faults.

ECONOMIC GEOLOGY

The area contains numerous prospects but as yet no productive mines. Most of the lodes are valued mainly for their gold and silver content, although they contain also notable quantities of arsenic, and several carry copper, lead, and zinc. One is valued solely for its copper, another for its silver and lead, and one of the gold lodes contains antimony and perhaps also bismuth. Gold occurs in the gravel of several of the creeks, but no valuable deposits have yet been found. In the northern part of the area there are coal beds that may be of value in connection with the development of metal mines.

All the metallic deposits appear to be closely related. The differences between them result largely from differences in the environment in which deposition took place. For purposes of description and in order to emphasize characteristics of some moment in planning for the development of the prospects, the lodes are grouped into three types. The first type includes deposits in which sulphides and related material are disseminated through a broad expanse of rock in which there has been a relatively minor amount of fracturing. Though mineralization of this type was common, only locally, as at the Golden Zone, has it been so concentrated as to produce a possible ore body. The second type, exemplified by the Copper King, includes deposits formed by intense local replacement along certain calcareous beds which proved especially favorable to this process. The third type, to which most of the prospects belong, includes veins containing quartz as a conspicuous constituent. Although these veins were deposited within fairly definite zones of fracture and shearing, in part by fissure filling, they all show replacement of the wall rocks and hence are closely allied to the deposits of the first two types in which replacement is the outstanding characteristic.

LODES

DISSEMINATED DEPOSITS

Sulphides are disseminated through the rock in numerous localities and over wide areas, but in only a few spots are the products of this process sufficiently concentrated to be of economic interest. Much of the dioritic porphyry, chert, and impure limestone, as well as some of the argillite and other rocks, contain enough pyrrhotite (FeS_{1+}) and pyrite (FeS_2) to be visible with a hand lens. Such disseminated sulphide is more abundant in the dioritic porphyry than in any of the other rocks, and this porphyry commonly shows other evidences of hydrothermal alteration, such as a general bleaching, alteration, and disintegration of the ferromagnesian constituents, and sericitization of the feldspar. Carbonate is generally present and in the more thoroughly altered rock is fairly abundant. Most of this is calcite ($CaCO_3$), but locally it is ferruginous and approaches ankerite $Ca(Mg,Fe)(CO_3)_2$) in appearance. The intrusive rock is in places partly silicified. Where sufficiently altered to be of economic significance the rock is cut by fracture planes and by breccia and shear zones, along which alteration is in places so intense as to obliterate its original characteristics. Irregular veinlets and lenses of vein quartz and associated minerals occur in these zones. All gradations exist between such zones and those in which fissure filling is the dominant feature. Although mineralization of the disseminated type is generally most intense within the dioritic rock, it is neither uniform throughout the intrusive mass nor limited by its boundaries. The Lindfors prospect, for example, is largely in stratified rock, but its mineralization is evidently an extension of that at the Golden Zone. Most of the zones of fracturing and shearing within the disseminated deposits appear to be individually of small extent. Arsenopyrite (FeAsS) and pyrite, with small amounts of other sulphides, are concentrated in streaks and bunches in these zones. Locally, sulphides compose considerably more than half the lode matter, but generally they make up less than a third; and most of the relatively unsheared rock contains less than 10 percent of disseminated sulphide. Arsenopyrite is by far the most abundant, and consequently some zones contain enough arsenic to be of possible future value. Chalcopyrite ($Cu_2S.Fe_2S_3$), sphalerite (ZnS), and galena (PbS) are locally present but, in the exposures that were examined, not in amount to be of economic interest except insofar as they may carry gold and silver. Stibnite (Sb_2S_3) occurs in one shear zone at the Silver King and may also be present at the Golden Zone. Bismuthinite (Bi_2S_3) and marcasite (FeS_2) have been identified by Charles Milton, of the United States Geological Survey, in placer concentrate from Colorado Creek near the Silver King and were presumably derived from the lodes of that prospect or others in the immediate vicinity. Under present conditions the economic value of the disseminated mineral deposits rests solely on their content of gold and silver. The assays quoted in the descriptions of the deposits show that locally notable amounts of these metals exist.

DEPOSITS ALONG BEDDING

The type of lode characterized by replacement along the bedding is exemplified by the Copper King and, to a somewhat less extent, by the Riverside and Liberty prospects. Limestone, probably originally impure and siliceous, has suffered replacement by fine-grained silica and the development of silicates, particularly sericite, chlorite, epidote, and pyroxene. Locally, portions of certain beds have been more or less completely replaced by sulphides. The stratification has tended to guide replacement even down to microscopic details. At the Copper King, so far as can be judged from the scanty development, this is the only structural factor that has influenced the mineralization. Along the strike, however, replacement has terminated within short distances and without apparent cause. At the Riverside prospect shearing inclined at small angles with the bedding has locally controlled deposition somewhat, and at the Liberty prospect shearing planes nearly at right angles to the bedding show about as much mineralization as those along the bedding.

The Copper King prospect is unique in that almost the only sulphides present are pyrrhotite and chalcopyrite, and it is the only deposit in the area held primarily for its copper content. Here, as elsewhere in the area, the chalcopyrite consolidated somewhat later than the other sulphides, but the relations are so intimate that the interval cannot have been long. The more thoroughly mineralized material exposed at this prospect contains approximately 31 percent of chalcopyrite, 20 percent of pyrrhotite, and 49 percent of gangue, as judged from microscopic measurements.

The other lodes in which stratification played a major part in guiding deposition contain mineral assemblages similar to those in most of the lodes of the disseminated and lenticular types and are clearly more closely allied to them than the Copper King. Arsenopyrite is relatively plentiful, pyrite and pyrrhotite are common, and chalcopyrite, sphalerite, and galena are so rare as to be easily overlooked, although close examination discloses their presence in most exposures. Mineralization in the gold lodes persisted farther along the strike than at the Copper King, but the sulphides are more irregularly distributed. At the Copper King, wherever mineralization has been intense enough to be of any economic interest, a bed is completely replaced throughout its width, and except for faintly perceptible banding the lode matter has a uniform texture and averages about half sulphide. At the other prospects the sulphides are much more irregularly distributed in scattered grains and in small irregular aggregates that are only locally abundant. It is the precious-metal content alone that makes these lodes of possible value, although further development may disclose shoots containing enough arsenic and perhaps other metals to be of some value as byproducts.

TABULAR OR LENTICULAR LODES

The Ready Cash, Little Lead, Mayflower, Lucrata, and Eagle prospects are on lodes that tend to have a tabular or lenticular form and to contain relatively more abundant coarse-grained vein quartz and hence are more veinlike than the disseminated deposits or the deposits along bedding. The lodes occur, however, in shear and fracture zones that are irregular in detail and only exceptionally and locally possess definite walls. Altered country rock, more or less thoroughly impregnated with quartz, carbonate, and sulphides, constitutes a large part of the lode matter. Rock alteration within and bordering these lodes has been essentially similar to that characteristic of the disseminated mineral deposits.

In other respects also there is an obviously close relation between the tabular or lenticular lodes and the disseminated mineral deposits. For example, the so-called Little Lead, on Golden Zone ground, and the Mayflower, just north of the Golden Zone end line, are tabular lodes, yet both in position and in characteristics they have affinities to the mineralized shear zones within the Golden Zone disseminated ore body. The tabular lodes tend to be relatively persistent along the strike. The Little Lead is the only one that appears to have been shown by development to have an uninterrupted length of as much as 1,000 feet, and even here there are gaps in the record. It seems probable, however, both from the character of the mineralization and from the evidence afforded by existing development that some of these lodes are persistent both laterally and in depth. Some of them, such as the Ready Cash, have been much disturbed by postmineral faulting. In some, such as the Eagle, irregularity in original deposition and later faulting have combined to produce discontinuity and irregularity in trend. In others, such as the Lucrata, original deposition was confined to lenses of small dimensions.

The individual masses of vein quartz are nowhere persistent throughout the extent of the lodes. They tend to be lenticular and to be arranged en échelon. They are rarely more than a few score feet long and a few feet wide, and most of the lenses are very much smaller. In all the quartz lenses the texture is massive, with little suggestion of banding or comb structure, and small open vugs are rare. In a few places vein quartz cements breccias composed of angular fragments of the country rock.

In the massive quartz lenses much of the quartz consolidated later than the sulphides. Some calcite fills crevices in the quartz. In the Little Lead there are small irregular chert veinlets, probably of considerably later origin than the other minerals of the lode. Similar veinlets are sparsely distributed in the altered porphyry traversed by the Golden Zone tunnel nearby.

GENERAL CHARACTERISTICS OF THE SULPHIDES

Sulphides are irregularly distributed and rarely compose as much as 50 percent of the lode matter. Arsenopyrite is generally the most abundant sulphide and appears everywhere to have been the first to form. Pyrite consolidated next and was somewhat shattered before being followed by pyrrhotite. Sphalerite, galena, and part of the chalcopyrite are intimately associated with one another and are commonly interstitial between and formed later than the more abundant grains of the arsenopyrite, pyrite, and pyrrhotite. Some of the chalcopyrite occurs in veinlets traversing the other sulphides and hence must have been of comparatively late origin. This same order of deposition occurs in all varieties of lodes in the area.

Nearly all the bands and irregular masses of comparatively solid sulphide consist dominantly of coarse, bladed arsenopyrite. As some assays show more than 20 percent of arsenic, this metal is a possible byproduct of the development of the lodes should conditions of marketing and metallurgy become sufficiently favorable. Qualitative chemical tests by Charles Milton and the writer show that much of the arsenopyrite has relatively more arsenic as compared to sulphur than typical arsenopyrite and hence approaches löllingite ($FeAs_2$) in composition. It is possible that a mixture of these minerals exists, but microscopic study of the available material gives no evidence of it. It seems probable that there is isomorphous gradation and that part or all of the arsenopyrite of the lodes in this area is intermediate in composition between pure arsenopyrite and löllingite.

Galena and sphalerite are rarely abundant but are present in almost all the lodes in which any considerable quantity of sulphides is exposed. So far as present development shows, they are nowhere sufficiently abundant to constitute lead or zinc ore of commercial value.

The Ready Cash claim contains a larger proportion of these minerals than any of the other prospects, and is reported to be valued mainly for its lead and silver content, but the assays listed in the description of that prospect are not encouraging.

Chalcopyrite is as widely distributed as sphalerite and galena and perhaps a little more abundant, but it is not sufficiently abundant in the more tabular lodes, with the possible exception of the lode on the Mayflower claim, to offer much hope that copper ore of commercial value will be found.

Argentite has been recognized only as a film coating cleavage cracks in galena from the Ready Cash claim, and there it was visible only in etched specimens under the microscope. It is doubtless present in galena elsewhere and may also occur in other sulphides. Assays commonly show a disproportionately high content of silver with reference to the gold, indicating that argentite or some other silver mineral is present. As telluride is reported by Henry Stevens to have been found in placer concentrates from this area it is possible that some of the silver is present in this form. No telluride

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was, however, detected in any of the material examined during the present investigation.

Assays show that the amount of gold is not proportional to the abundance of sulphide in the lode matter, indicating that part of the gold, at least, is free rather than in solid solution in the sulphides. Some samples containing abundant sulphide assay lower in gold than others in which neither sulphides nor their oxidation products are plentiful. The absence of visible gold in the polished sections examined suggests that the sulphides did not act as precipitants for gold in solutions of later origin. The lack of recognition of gold is by no means conclusive as to its absence, because very finely divided gold might well escape detection. Placer prospecting in Bryn Mawr Creek below the Golden Zone lode prospect showed that some free gold was present, but it was in such small particles that losses are reported to have been inordinately high. Placer concentrate from Colorado Creek contained a few flakes of rather coarse gold when examined by the writer. The apparent scarcity of conditions favorable to the formation of supergene gold leads to the inference that much of such native gold as exists is hypogene—that is, formed by original deposition rather than through the agency of oxidation and weathering.

OXIDATION

Oxidation is relatively shallow, being far from complete at a depth of 5 feet in any of the lodes in which development has penetrated to that depth. Exposures in cliff faces generally show sulphides with only superficial oxidation. The principal oxidation products are limonite (hydrated ferric oxide) and scorodite ($Fe_2O_3.As_2O_5.4H_2O$). Small amounts of malachite ($Cu_2(OH)_2.CO_3$), azurite ($Cu_3(OH)_2(CO_3)_2$), chrysocolla ($CuSiO_3.2H_2O$), and anglesite ($PbSO_4$) are present wherever the corresponding sulphides occur. Locally a little hematite and manganese oxide exist, but both are rare in all the deposits visited. In some of the shear zones clay of presumable supergene origin is abundant.

Microscopic study shows that films of chalcocite (Cu_2S) and covellite (CuS) coat some of the sulphide grains. This is proof of enrichment, but the quantity is too meager to be of economic significance.

ORIGIN

Evidently all the metallic lodes in the area are closely related in origin. Some of them are so closely associated with the larger intrusions of biotite-quartz diorite porphyry as to indicate genetic connection between mineralization and the intrusion of this rock. The texture of the porphyry and the small size of the exposed masses suggest consolidation at moderate to fairly shallow depth, possibly of the order of thousands of feet rather than of miles below the then existing surface. The mineral composition and the structural characteristics of the lodes are such as are generally considered to indicate deposition under moderate temperature and pressure. Evidence of mineralization is wide-spread over an area about 2 miles wide and 6 miles long, from Costello Creek to Long Creek, and appears again along Ohio Creek, nearly 7 miles farther southwest. In the area between Costello Creek and Long Creek particularly, the mineralizing solutions permeated large areas, and deposition took place in numerous spots. Both this fact and the characteristics of the lodes indicate that the solutions were tenuous. Crystallization of the different sulphides followed a definite order, which is essentially the same in all the lodes. Although this is evidence that the mineralization, as usual, occupied a considerable period of time, there is little to suggest distinct or widely separated periods of deposition.

ECONOMIC OUTLOOK

Insofar as the character of the mineralization indicates that the parts of the lodes now exposed are neither the uppermost tips nor the eroded roots of a lode system, it argues for persistence in depth and uniformity in tenor of individual lodes. The wide-spread extent of the mineralization, particularly the dissemination of sulphides at a distance from the lodes, is unfavorable in that it suggests dilution through permeation of the country rocks rather than concentration in well-defined lodes. Though some of the metallic constituents of the original solutions have doubtless been scattered so thinly that they cannot be profitably recovered, the evidence does not preclude the possibility that valuable ore shoots are locally present. In many places exposures are poor, and near the larger streams the outcrops are concealed by brush. Many of the lodes are inconspicuous, as they have neither enough quartz to resist erosion greatly nor enough sulphide to stain the rocks deeply through oxidation. Consequently, in spite of the systematic surficial prospecting that part of the area has received, future discoveries are possible.

The following generalizations as to probable tenor of the ore in the different kinds of lodes are offered, though with some hesitation because of insufficient data. In the disseminated deposits some of the more thoroughly mineralized shear zones contain over $10 a ton in precious metals, and locally their content may be more than double this amount. It seems probable that some of the relatively unsheared rock may average as much as $5 a ton, but much of this material is of extremely low grade. Some of the shear zones contain over 20 percent of arsenic.

The precious-metal lodes that follow stratification contain precious metals and arsenic in quantities roughly comparable to those of the shear zones in the disseminated deposits. Presumably the material that averages as much as $10 a ton in gold and silver will be found in shoots, with lower-grade material in the adjoining beds and in the intervening parts of the same beds. Present development suggests that in the copper replacement lodes the lode matter will prove to be either ore containing 5 to 10 percent of copper and about $5 to the ton in gold and silver or of a grade too low to be of economic value.

In the more tabular and lenticular lodes the tenor is variable. Locally it may be as much as $20 a ton in gold and silver, or perhaps even more, but much of the lode matter is of materially lower grade. Presumably much of the more thoroughly mineralized material in these lodes averages $5 a ton in precious metals. Much of that in which sulphides are abundant contains 25 percent of arsenic. The data obtained from the Ready Cash prospect indicate that lodes containing comparatively conspicuous quartz, galena, and sphalerite are relatively low in precious metals. With the possible exception of arsenic, none of the tabular lodes have been proved to contain enough base metals to be of much economic interest, although some may locally contain as much as 5 percent of copper.

Development has nowhere been sufficient to block out any ore, and therefore any estimate of possible tonnage can be nothing more than a first approximation. There are probably 10,000,000 tons of mineralized rock in the disseminated deposits that have been prospected, but what proportion of this rock can be mined profitably under a given set of conditions remains to be determined.

Present development would permit crediting the precious-metal replacement deposits in stratified rock with only a few thousand tons of possible ore, but it is likely that much material similar to that exposed exists at depth. In the single prospect on a copper replacement lode the exposed ore is of small extent, and the size of possible ore shoots at depth is problematical. Oxidized copper ore commonly has such striking green, blue, and red colors that outcrops of such material are unlikely to have escaped the notice of prospectors.

The total quartz and mineralized rock of the tabular lodes doubtless aggregates tens and possibly hundreds of thousands of tons. There is at present no way of determining how much of this material is of relatively high grade or what proportion of the lower-grade ore can be profitably handled.

The metallurgical treatment of ore of the character of most of that in this area presents problems requiring careful consideration. It is probable that much of the gold is in the metallic state but is very finely divided. The silver is in part alloyed with the gold and in part chemically combined in argentite and similar minerals. Probably only a small proportion of either metal is readily recoverable by amalgamation. Presumably some combination of fine grinding, flotation, or possibly gravity concentration and cyanidation will prove applicable, but such a process would require an elaborate plant.

In other respects conditions affecting mining are good. Most of the rock stands well with little or no timbering and is only moderately resistant to blasting. There is little available timber close at hand, but considerable amounts suitable for rough construction and for a rather poor grade of mine timber can probably be found within about 20 miles. Coal can be obtained locally or can be shipped from mines in operation within reasonable distances. Once camps are built and roads constructed the climate will not seriously interfere with underground operation, though special provision will need to be made for milling in winter if required. Mill sites will have to be selected with a view to having a readily available and adequate supply of sufficiently clear water, and at some places, therefore, the mills may have to be situated at some distance from the mines. The problem of obtaining sufficient water in winter will require some consideration. The distance from the railroad to most of the prospects is little more than 10 miles. Roads can be built without special difficulty and will not have excessive grades. The railroad haul from Colorado station to Seward, the ocean terminus, is only 297 miles.

PROSPECTS

The existing prospects are here described in geographic order, starting at the southwest end of the area and proceeding northeastward. It is reported that at one time a strip of country seven claims wide from Long Creek past the coal prospect near Costello Creek was covered with lode claims. Most of the corresponding "discovery" pits were shallow, and in their present slumped condition they reveal little. Only prospects that have received more development are here considered. Along Ohio Creek there are traces of numerous camps, many of which were set up by prospectors about 1915. A few of their pits were found, but the Ready Cash is the only prospect in this vicinity that has received enough development to warrant description in this report.

All the samples collected by the writer were assayed by Paul Hopkins, of the United States Bureau of Mines, Fairbanks, Alaska, whose cooperation is gratefully acknowledged. The assay content of a number of samples from other sources is listed for comparison. The well-known difficulties of sampling gold deposits make it essential to consider the weighted mean of many samples to arrive at an approximation of the average content of the ore in this area. Even samples from the same localities yield divergent results, emphasizing the difficulty of getting representative samples of gold ore. Consequently, the few assays available are regarded as merely indicative of the character of the ore in the present meager exposures and do not constitute an adequate basis for calculation of the value of the ore in the ground.

READY CASH

The Ready Cash prospect is on Ohio Creek about 8 miles above its junction with Copeland Creek and 2½ miles below the glacier at the head of Ohio Creek. The prospect is about 12 miles from Honolulu, the nearest point on the Alaska Railroad, but the trail is now in disrepair. The history of the prospect, as gleaned mainly from notices on the property and from the patent documents, is as follows: The ground was located in May 1915 by Otto Tangel, J. P. Frisly, William Murry, and E. Miller; later ownership was acquired by J. H. McCallie, who patented the property in 1927; there are nine claims covering an area of 132.627 acres, developed by two tunnels and nine discovery pits. It appears from the description by Capps [13] that all this work had been done prior to his visit in July 1917. The two tunnels and their relations to the veins found during the present study are shown in plate 26. The rest of the patented ground was not studied in detail, but other mineralized outcrops exist.

The bedrock in the vicinity of the tunnels is uniformly a coarse, somewhat chloritic rock without discernible bedding, which microscopic examination shows to be altered andesite or related rock. As shown in plate 26, three segments of quartz veins exist. The segment on the west side of Canyon Creek is 3 feet wide, strikes about N. 58° W., and stands vertical. There are several minor quartz stringers and lenses of oxidized sulphide south of this vein. The main vein here contains arsenopyrite, galena, and other sulphides, rather sparsely disseminated. A sample from it yielded on assay 0.01 ounce of gold and 4.20 ounces of silver to the ton and 0.52 percent of lead. Obviously, such low assay returns do not indicate ore. Some of the rusty lenses south of it were probably high in sulphide before oxidation, but none of these are more than a few inches wide and apparently none much more than 2 feet long.

Another vein segment is exposed for about 30 feet on the east side of Canyon Creek about 80 feet above the tunnel portal. It strikes about N. 25° E. and stands vertical. Its walls are curved so that their strike ranges from N. 40° E. to N. 20° E. At the north end of the ex-

[13] Capps, S. R., op. cit. (Bull. 692), pp. 228–229.

posure the vein is about 10 feet wide. A sample from this place contained a trace of gold and 0.70 ounce of silver to the ton. Its lead content was not determined but is obviously small. About 25 feet to the south the vein has a width of only 4 feet. On the east wall there are slickensides which dip 55° N. Sulphides are less abundant in this vein segment than in that to the west and occur mainly in small streaks and bunches. They include arsenopyrite, pyrite, and some chalcopyrite. Most of the quartz has been fractured and locally is stained and impregnated with the oxidation products of iron, copper, and manganese. The tunnel below trends N. 83° E. for 169 feet and hence extends well beyond the line of the vein as exposed 80 feet above it. As figure 40 shows, however, it exposes only broken ground and minor stringers of quartz and calcite with small amounts of sulphides, mainly pyrite.

The third vein segment is exposed on the hillside above and east of the segment just described. A tunnel in the face of a steep bluff has

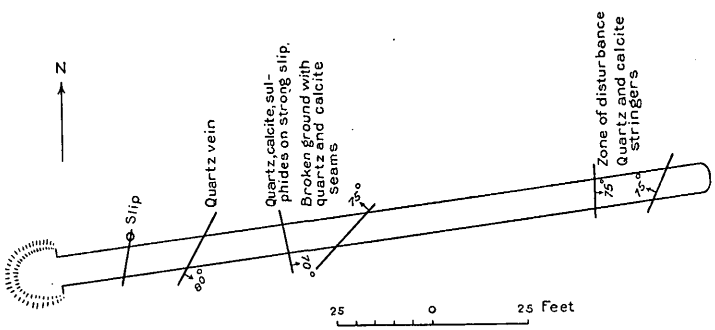


FIGURE 40.—Sketch map of the lower Ready Cash tunnel. From compass survey, August 22, 1931, by C. P. Ross.

been driven 60 feet to this vein, and a drift tunnel off from it to the southeast follows the vein for a distance of 16 feet. The vein as exposed in this tunnel is 5 feet wide, strikes N. 20° W., and dips about 60° NE. The face of the lower tunnel is within 120 feet of the point where this vein would be if projected northwestward with the same strike and dip. A sample across the southeast face of the drift yielded on assay a trace of gold and 1.80 ounces of silver to the ton, but no lead. This vein contains numerous stringers and bunches of sulphides, some as much as 10 inches wide. They include arsenopyrite, pyrrhotite, pyrite, galena, chalcopyrite, and sphalerite, listed roughly in the order of decreasing abundance. Most of the bands of nearly pure sulphide consist mainly of arsenopyrite. Some of the pyrite is in imperfect cubes as much as an inch wide. There are small amounts of supergene covellite. The gangue is white, rather coarsely crystalline quartz, somewhat fractured.

The three vein segments described above may be fragments of a single lode, displaced by faulting. The shearing and brecciation of northerly trend revealed in the lower tunnel were probably related to the faulting. This theory, if correct, explains the marked differences in attitude of the three segments and the failure of the vein segment on the east side of Canyon Creek to be exposed in the lower tunnel. It implies that extension of the lower tunnel on its present course would probably fail to reach the vein disclosed in the upper tunnel. In order to find an ore body of commercial value it would doubtless be necessary to seek a less shattered portion of the lode.

COPPER KING

The Copper King prospect, formerly the Hector, comprises four unpatented claims in a gulch on the north side of Long Creek. They

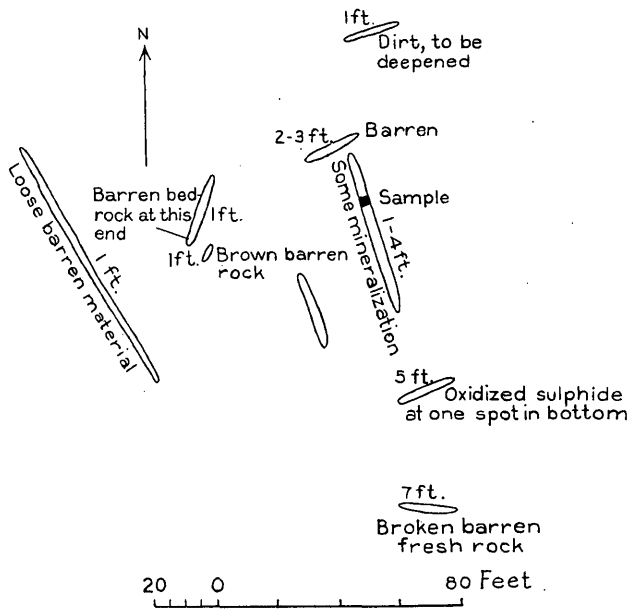
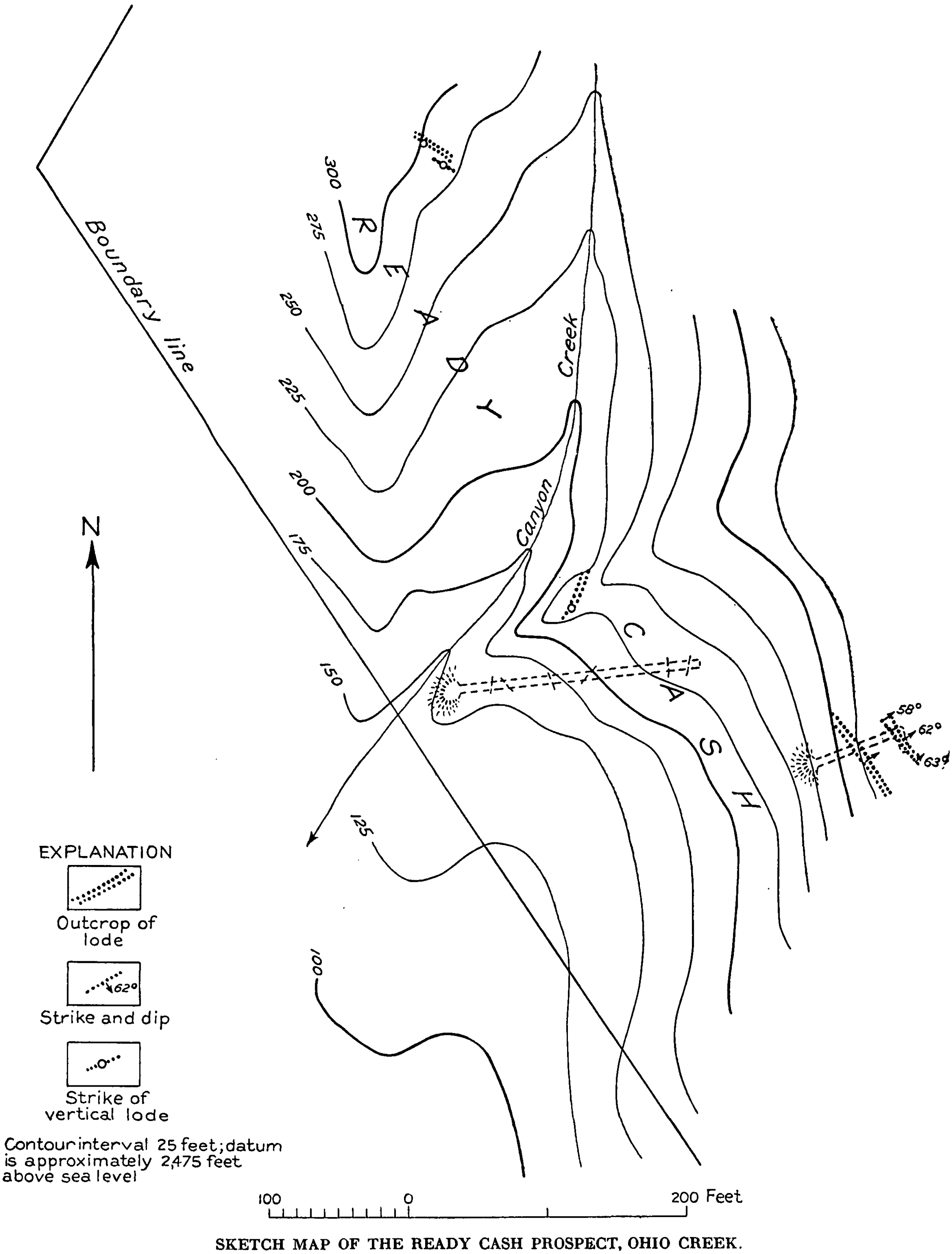


FIGURE 41.—Sketch map of the Copper King prospect. From pace and compass survey, August 27, 1931, by C. P. Ross. Figures refer to depth of trenches.

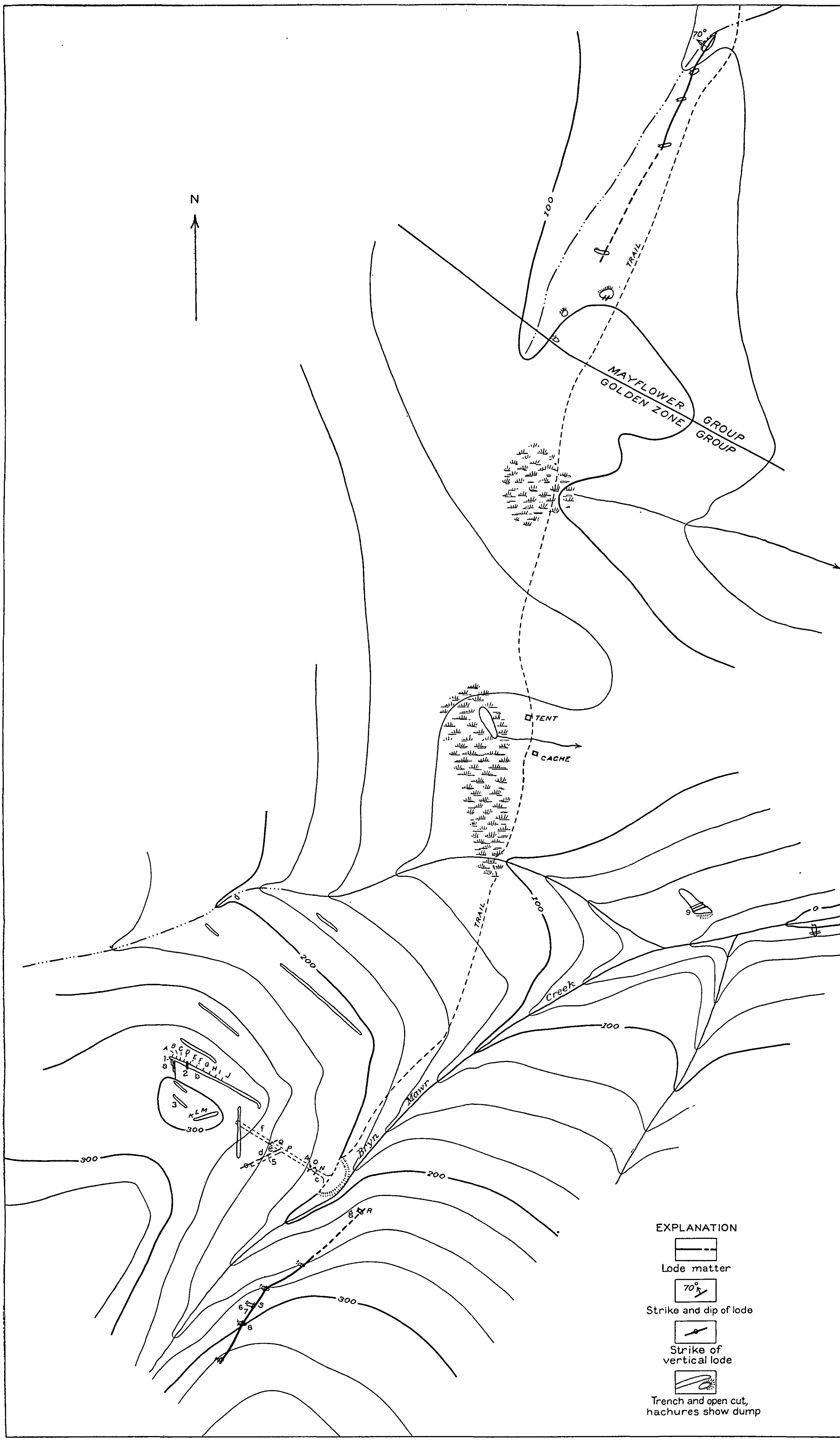
are about a mile south of the Golden Zone and are generally approached from the Golden Zone. Development is confined to the trenches shown in figure 41, several of which were dug in August 1931.

The mineralized rock comprises lenses and seams of massive pyrrhotite and chalcopyrite in silicified limestone containing chlorite and probably other silicates. The larger masses parallel the bedding of the cherty rocks and were formed by replacement of them. The strike of the beds in this vicinity ranges from N. 20° E. to N. 55° E.,



SKETCH MAP OF THE READY CASH PROSPECT, OHIO CREEK.

Surveyed August 22, 1931, by C. P. Ross and Marion Peel.



1000 0 1000 2000 3000 4000 Feet

Contour interval 25 feet
Datum is approximately 3,540 feet above sea level

SKETCH MAP OF THE GOLDEN ZONE AND MAYFLOWER PROSPECTS.

Surveyed July 28 and August 7, 1931, by C. P. Ross and Marion Peel.

with the average closer to the latter. The main trench shows mineralization at intervals throughout its length of about 70 feet but exposes massive sulphide only over a width of 2 or 3 feet about 15 feet from its northwest end. A sample of freshly blasted material from this place yielded on assay 0.22 ounce of gold and 4.90 ounces of silver to the ton and 7.34 percent of copper. Trenches about 45 feet to the southwest on the line of strike show little mineralization. The continuation of the same beds in bluffs about 1,000 feet to the northeast contains no visible copper minerals. A very little copper stain and a little pyrite are present in a limestone bed on the approximate line of strike in the gorge of Long Creek about 2,000 feet to the southwest. There are several scattered pits in the vicinity, outside the area shown in figure 41, but copper was not observed in any of them.

The assay indicates that the massive sulphide is sufficiently rich to be mined if found in large enough bodies. The present scanty development has disclosed only small masses, and the paucity of indications of copper in neighboring exposures, both artificial and natural, is evidence against the presence of a large body of ore close to the surface. Replacement ore bodies of this general type are erratic in distribution, size, and shape. It is possible that deeper development would disclose an ore body of commercial size.

LINDFORS

The Lindfors prospect lies at the head of Bryn Mawr Creek adjoining the Golden Zone claims. No work had been done here for some time, but the prospect was restaked in the summer of 1931. The developments comprise a number of trenches and shallow ditches with which a very small amount of ground sluicing was done. Most of the trenches do not expose bedrock. They are in frost-shattered material, largely rusty dioritic porphyry but including representatives of the clastic rocks of the vicinity. Capps [14] notes that at the time of his visit in 1917 one open cut exposed a vein of massive arsenopyrite 4 to 20 inches thick on the contact of a decomposed dike and altered tuff. Another cut showed disseminated sulphides and veinlets containing sulphides, quartz, and a carbonate resembling ankerite, in calcareous strata. He reported that arsenopyrite, pyrite, chalcopyrite, and sphalerite were present there and that gold is reported in encouraging amounts.

GOLDEN ZONE

The Golden Zone prospect comprises four claims held by A. O. Wells, at the head of Bryn Mawr Creek, a tributary of the West

[14] Capps, S. R., op. cit. (Bull. 692), p. 226.

Fork of the Chulitna River. This prospect is reported to have been first staked in 1909. A little placer gold has been produced from the gravel of the creek immediately below the prospect, but the returns were so meager that the attempt to work the gravel was soon abandoned.

The workings consist of one tunnel with a short, partly caved drift leading off from it (see fig. 42) and several pits and trenches (see pl. 4). A small amount of ground sluicing has been attempted. When examined during the present study very little development had been accomplished since the prospect was visited by Capps [15] in 1917.

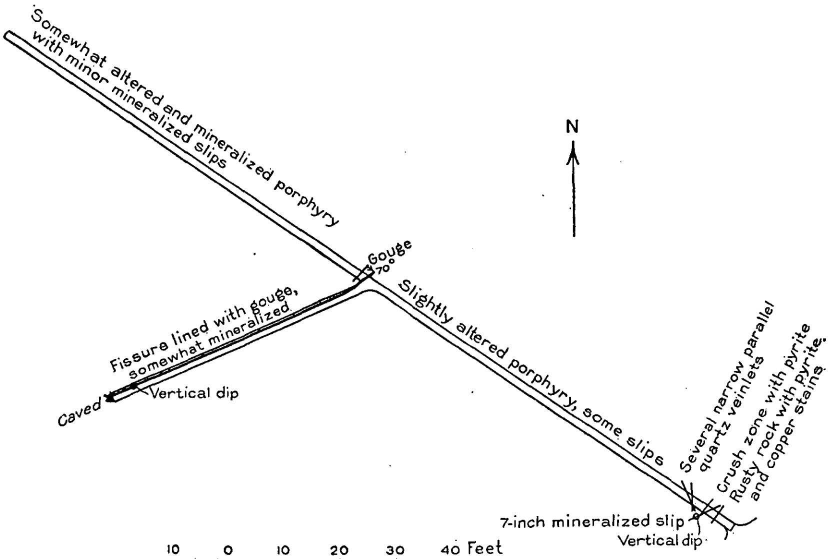


FIGURE 42.—Tunnel on the Golden Zone prospect. From compass survey, July 28, 1931, by C. P. Ross.

In August 1931 work was started with the intention of extending the tunnel an additional 125 feet.

The results of sampling by Harry Townsend (date unknown), J. G. Shepard (July 1925), and the writer (July 1931), all members of the United States Geological Survey at the time they made their examinations, are given in the table below. Townsend's samples are designated in the table and on the sketch map (pl. 27) by capital letters, those of Shepard by small letters, and those of the writer by numbers.

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[15] Capps, S. R., op. cit. (Bull. 692), pp. 226–227.

Assay of samples from Golden Zone prospect

No. of sample	Width sampled (feet)	Gold (ounces to the ton)	Silver (ounces to the ton)	Arsenic (percent)	No. of sample	Width sampled (feet)	Gold (ounces to the ton)	Silver (ounces to the ton)	Arsenic (percent)
A	5	1.44	2.00	26.53	S	1	0.48	2.40	23.61
B	5	1.20	2.80	16.69	a	7	2.52	5.10	22.91
C	5	.28	1.20	12.08	b	100	.24	1.20	
D	5	.14	.70	9.56	c	35	.10	3.00	
E	10	.04	.10	2.01	d	6	.10	.50	
F	10	.12	.10	1.12	e	6	.16	.80	
G	10	.22	8.10	4.37	f	60	.08	.30	
H	10	.08	.80	1.05	g	(a)	.86	11.60	18.10
I	10	Trace.	.40	1.00	1	9	.59	1.40	
J	10	Trace.	.20	.47	2	3	.06	.80	
K	10	.08	.80	4.41	3	23	.37	1.10	
L	10	.38	1.30	7.34	4	.6	.03	.30	
M	6	.20	.70	8.11	5	.75	.04	.30	
N	5	.16	2.39	2.00	6	3	.16	2.40	
O	5	.32	2.39	2.00	7	.6	.99	6.60	
P	10	.04	.40	1.23	8	4	.36	2.40	
Q	10	Trace.	.30	1.00	9	7	.03	2.70	
R	Dump.	2.58	4.70	33.22					

a Grab sample from Little Lead cuts.

The Golden Zone lies within a small stock of biotite-quartz diorite porphyry intruded into argillite and breccias. Almost the entire stock contains disseminated pyrite. Some portions are otherwise nearly unaltered, so far as can be judged in the hand specimen, but the major part of the mass has been colored a rusty red from the oxidation of iron sulphides, and this portion has been partly silicified and its original igneous minerals have been bleached and altered. In several places this altered rock has been fractured and closely sheeted. Mineralization has been more intense along these zones. One of them, referred to as the main zone, lies on the west side of Rusty Hill, which is the most prominent surface feature of the property. This zone is 9 feet wide where cut by one of the trenches (samples A, B, a, 2). It is exposed in the next trench up the hill but has not been reached by any of the others. Natural exposures in the small creek on the northwest show no indication of its continuation along the line of strike. In the two trenches it strikes about N. 10° W. and dips about 60° W.

The other trenches on this hillside, represented by samples C to J, b, and 1, 2, and 3, also uncover mineralized and locally sheared rock. Shearing and abundant sulphides do not necessarily indicate high precious-metal content, as sample 2 shows. It is noteworthy that sample G yielded 8.10 ounces of silver to the ton and comparatively small amounts of both gold and arsenic. The location of samples K, L, and M could be only approximately identified, and may, therefore, not be correctly shown on plate 27.

Near the portal of the tunnel (see fig. 42) there is a nearly vertical zone of shearing, which strikes about N. 66° E. and stands vertical. Samples N, O, and c indicate the average content of the rock in this zone, and sample 4 shows that a 7-inch streak selected because of apparently more abundant sulphide was of materially lower grade than that of the zone as a whole.

The drift leading off from the tunnel follows a pronounced fissure with abundant gouge which locally contains abundant fine-grained sulphides. It strikes N. 67° E. and dips 65°–90° NW. Samples P, Q, d, and e show the content of the rock in the neighborhood of the fissure, and sample 5, taken from a 9-inch wide mass of gouge with sulphide, shows once more that material of promising appearance is not necessarily of high grade. This selected sample proved to be of slightly lower grade than sample f, which was taken over a width of 60 feet in the inner portion of the main tunnel, where there is no evidence of intense mineralization, although the rock throughout has been somewhat altered and mineralized and contains minor mineralized seams, mostly striking N. 40°–65° E. Some of these are lined with gouge and others with quartz. As plate 27 shows, the tunnel had not yet penetrated far enough westward to get below the more favorable showings on the hill above it.

A line of pits on the east side of Bryn Mawr Creek opposite the tunnel entrance (see pl. 27) traces a shear zone, locally termed the Little Lead, over a distance of about 300 feet. Other cuts farther down and on the west side of the creek disclose ore which appears to be the continuation of this lead. If so, the Little Lead has a length of about 1,000 feet. In the closely spaced pits near the tunnel the shear zone strikes N. 30°–45° E., dips 50°–60° SE., and is about 3 feet wide. There are no definite limiting walls, and further development might show a greater width. Samples R, S, g, 6, 7, 8, and 9 show the tenor of the ore in this lode. The cuts from which samples R and S were taken have not been positively identified. Sample 6 was taken across a width of 3 feet of intensely sheared and mineralized lode matter in the freshest of the cuts, and sample 7 came from a 7-inch band of sulphide within this zone. Unlike other samples containing sulphide, sample 7 proved to be comparatively rich.

The unoxidized porphyry in the tunnel, away from the shear zones, is partly silicified and cut by numerous quartz stringers. Pyrite occurs both in the silicified rock and in the stringers. In the stringers it is generally in cubical crystals, locally as much as half an inch in diameter. Small amounts of chalcopyrite and arsenopyrite are also present. In the shear zones, especially that followed by the drift, there is considerable gouge, and this contains disseminated sulphides, mainly pyrite.

In all other exposures the character of the original mineralization is obscured by oxidation, which, however, has in few places extended to a depth of more than 5 feet. Evidently in the more intensely mineralized shear zones there are numerous veinlets of quartz with some pyrite and other sulphides and somewhat irregular streaks of nearly massive sulphide, largely arsenopyrite, rarely more than 6 inches wide, in a gangue of quartz, with locally some carbonate. In places in the Little Lead there are veinlets and irregular bodies of brown chert, locally enclosing lenses of sulphide. Capps[16] reports that the metallic minerals which have been recognized on this property include arsenopyrite, pyrite, sphalerite, chalcopyrite, galena, malachite, and probably stibnite.

MAYFLOWER

The Mayflower prospect comprises two claims adjoining the Golden Zone on the northeast, held by Henry Stevens. It is developed only by a few pits, shown in plate 27. The rock here is brecciated, iron-stained, and soaked with quartz, so that identification is difficult, but it appears to be, at least in part, a continuation of the fine-grained intrusive mass of the Golden Zone. The lode can be traced with fair accuracy by means of the pits for a length of 350 feet. It trends N. 30°–35° E. and dips 70° SE. One of the pits shows mineralization off the line of this lode. The most northerly pit is the largest and the only one in which bedrock was satisfactorily exposed at the time of visit. Here the well-mineralized part of the zone of shearing and brecciation is 32 inches wide. A sample across it yielded on assay 0.07 ounce of gold and 2.60 ounces of silver to the ton. Some specimens from this pit contain considerable chalcopyrite, but the average copper content of the lode as now exposed is low.

Samples taken by Henry Stevens at the Mayflower prospect and assayed by Paul Hopkins September 15, 1929, yielded the results listed below:

Assay of samples from Mayflower prospect

Bureau of Mines sample numbers	Gold (ounces to the ton)	Silver (ounces to the ton)	Copper (percent)
5076	0.12	3.00	
5077	.34	5.80	
5078	.26	1.20	
5080	.06	15.80	5.3

The mineralization disclosed on this property was a continuation of that on the Gold Zone claims, but it is improbable that the main lode here is to be correlated exactly with any of those on the Golden

[16] Capps, S. R., op. cit. (Bull. 692), p. 227.

Zone ground. The available assays indicate that the ore is of low grade. The exposures in the principal pits show that brecciation and mineralization were so intense as to encourage the hope that further development may yield satisfactory ore.

RIVERSIDE

The Riverside prospect comprises five claims held by A. O. Wells, on the southwest bank of the West Fork of the Chulitna River. There are numerous cuts and pits on the property. Several tunnels have been started, but none were carried far. The principal cuts now open are shown in figure 43. They disclose two nearly parallel lodes about 80 feet apart, both of which are replacement deposits that approximately follow the bedding of limestone lenses. The eastern lode strikes N. 15° W. and dips about 70° NE. Ore deposition has

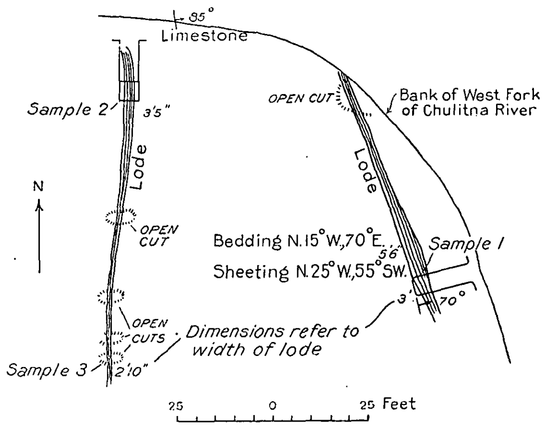

FIGURE 43.—Sketch map of the Riverside workings. From compass survey, July 23, 1931, by C. P. Ross.

in part been controlled by a poorly defined sheeting that trends N. 25° W. The maximum observed width of mineralization is 5½ feet, but most of the ore is contained within a width of 3 feet. This lode has been traced for about 60 feet along the strike. The second lode is similar, but its average strike is north and it stands nearly vertical. It has been traced for fully 80 feet on the strike, and the ore averages about 3 feet in width. Small cuts and outcrops in the general vicinity show that there are several other lenses of mineralized rock. One of these accords with the bedding of banded limestone which stands vertical and trends N. 6° E., suggesting faulting or other structural disturbance.

The lode matter comprises irregular bunches and lenses of vein quartz with sulphides, in partly silicified and chloritized limestone. The principal sulphide is arsenopyrite, but pyrrhotite, pyrite, and chalcopyrite are also abundant, and sphalerite and galena are locally present. There is a very small amount of supergene chalcocite. Within a few inches of the surface the lode matter is thoroughly oxidized and in part clayey.

Information in the files of the United States Geological Survey office at Anchorage gives the results of assays of samples from the Riverside. The exact source of these samples is not known to the writer.

Assays of samples from Riverside prospect

[Assays made by Paul Hopkins, of the U.S. Bureau of Mines, Sept. 16, 1926]

No.	Source	Gold (ounces to the ton)	Silver (ounces to the ton)
1	East cut	0.02	2.10
2	West cut	.52	.40
3	do	.64	.60

Three samples were taken July 23, 1931, by the writer from this prospect and assayed by Mr. Hopkins. Sample 1, from a channel across a width of 3 feet 6 inches on the north side of the principal cut on the eastern lode, contained 0.14 ounce of gold and 0.60 ounce of silver to the ton. Sample 2, across 3 feet 4 inches in the face of a tunnel one set long on the second lode, contained 0.02 ounce of gold and 0.30 ounce of silver to the ton. Sample 3, across 2 feet 10 inches in another cut on the second lode, contained 0.72 ounce of gold and 0.40 ounce of silver to the ton.

The small amount of development on this property renders a tonnage estimate impracticable, but it is clear that there are at least two lodes 2 to 5 feet wide and persistent for scores of feet. The assays quoted range in value from 50 cents to a little less than $15 a ton, the average being over $7 a ton. Clearly, the ore so far exposed is so low in grade that it can be handled profitably only under more advantageous conditions than now exist.

SILVER KING

The Silver King or Stibnite prospect is on a hillock on the northeast side of Colorado Creek nearly 2 miles above its mouth. It is developed by trenches and pits but has been abandoned for some time. The hillock is composed largely of biotite-quartz diorite porphyry, which intrudes sedimentary beds, in part cherty, which strike N. 70° E., dip 70° NW., and have major joints trending N. 25° W. and standing vertical. Much of the rock is rusty, and the excavations show streaks and bunches of sulphide. apparently very irregular and discontinuous. Pyrrhotite and pyrite are the most abundant sulphides, with some chalcopyrite and arsenopyrite and in one pit considerable stibnite. The mineralized rock contains calcite. Capps [17] noted in one cut a body of massive stibnite 6 to 12 inches thick, which strikes east and dips 23° S. This is a larger mass than was found by the present writer, some additional digging having been done in the intervening period. Paul Hopkins assayed two samples obtained here by Henry Stevens in 1926 and found that one consisting largely of stibnite contained traces of gold and silver and another contained 0.04 ounce of gold and 0.20 ounce of silver to the ton. The irregularity and sparseness of the mineralization, so far as can be judged from the slight development, are not encouraging.

LIBERTY

The Liberty prospect comprises two claims held by Henry Stevens and Jack Colvin, nearly 0.4 mile east of the Silver King. The principal development is a pit nearly 10 feet deep in altered cherty sedimentary strata which strike N. 30° E. and dip 70° NW., cut by a shear zone that strikes N. 50° W. and dips 75° NE. Within the pit the shear zone forks, and part of it swings until it is parallel to the bedding. Mineralization has occurred along the shear zone in both directions. Oxidation is nearly complete, but there are residual bunches of sulphide, mainly arsenopyrite. A sample across a width of 2½ feet in the shear zone parallel to the bedding yielded on assay 0.06 ounce of gold and 1.20 ounces of silver to the ton; a sample across 2 feet of the major shear zone that cuts across the bedding yielded 0.14 ounce of gold and 8.60 ounces of silver to the ton. A shallow trench, now slumped in, followed the shear zone along the bedding a short distance north of the pit. These assays and the appearance of the shear zone, however, suggest that if more work is to be done it might be well to investigate the shear zone with northwesterly trend.

LUCRATA

The Lucrata prospect, heretofore described as the Lucrative group (Bull. 692), now abandoned, is on the west side of Costello Creek a short distance below the mouth of Camp Creek. Its principal development is a cut in the upper part of the wall of the inner gorge of Costello Creek, which reveals a zone of mineralization about 15 feet long, 3 feet wide, and 7 feet in height, containing cherty quartz and bunches of partly oxidized sulphide. At its northwest end this lens is cut off by an irregular lamprophyre dike about 2 feet wide, which strikes N. 30° E. There has been little displacement along the dike, as another small lens of mineralized rock is exposed in the cliff

[17] Capps, S. R., op. cit. (Bull. 692), p. 225.

face beyond the dike on the line of strike of the main lens. Sulphides are relatively abundant, and a sample taken some years ago by Harry Townsend, then of the United States Geological Survey, yielded on assay 1.26 ounces of gold and 3.80 ounces of silver to the ton and 21.25 percent of arsenic, showing that some of the ore lenses here are of comparatively high grade. The mineralized mass now exposed, however, is much too small to be profitably mined.

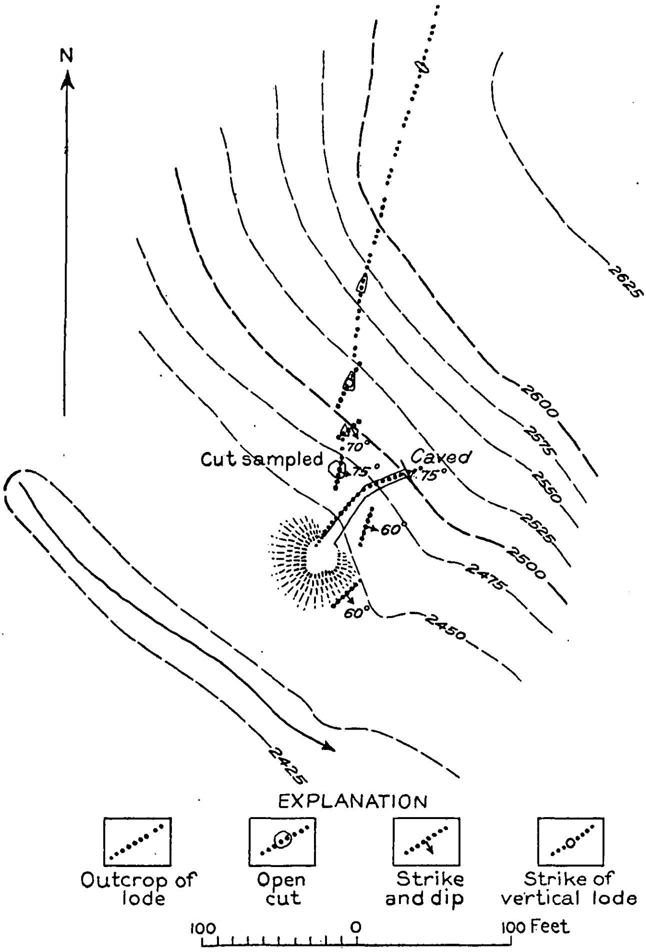

FIGURE 44.—Sketch map of the Eagle prospect. Surveyed August 29, 1931, by C. P. Ross and Henry Stevens. Contours have sketch value only.

EAGLE

The Eagle prospect, formerly called the Northern Light, comprises two claims on the east side of Costello Creek a short distance below the mouth of Camp Creek. As shown on figure 44, it is developed by a tunnel 62 feet long and several small cuts. The country rock is chloritic and cherty argillite and tuff, with some lava in the vicinity. The average trend is northeast, but locally the beds trend northwest, probably because of faulting. The average trend of the mineralized zones is somewhat east of north, but there is much local variation, resulting in part from irregular deposition, in part from later faulting. The dip is generally steep to the east. If the pits are all on the same lode, it has, as shown in figure 44, a known length of about 300 feet, but it is doubtful if underground development would show continuous ore throughout this distance. The width of the mineralized shear zones varies in different exposures, ranging from 1 to 10 feet. The vertical range between the tunnel and the highest cut is roughly 185 feet. The shear zones generally contain bands of white, coarsely crystalline quartz from a few inches to 2½ feet in width. Locally, the quartz contains numerous vugs. Most of the sulphides were deposited along fissures, and the best samples are reported to have been taken along the fissures that traverse the bedding at considerable angles. Most of the rock in and near the shear zones contains sparsely disseminated sulphides, mainly pyrite. There are a few lenses of massive arsenopyrite with a little pyrite, which are several inches wide. Small amounts of somewhat oxidized chalcopyrite are present at some places. Two samples were taken in the cut immediately north of the tunnel, which is reported to contain the best ore so far exposed. One of these, taken across a quartz lens somewhat more than 2 feet wide, yielded 0.20 ounce of gold and 6 ounces of silver to the ton. The other, taken across the full 4 feet of exposed lode, yielded 0.18 ounce of gold and 2.10 ounces of silver to the ton. A sample from this vicinity and probably from the quartz lens in this pit, assayed by Paul Hopkins, contained 0.56 ounce of gold and 3.20 ounces of silver to the ton. Capps [18] stated that at the time of his visit in 1917 the area of heaviest mineralization had been traced along the surface for a distance of about 800 feet, considerably farther than it can now be traced. He noted the presence of arsenopyrite, pyrite, chalcopyrite, sphalerite, and a little stibnite.

The results of the scanty development here are fairly encouraging. The mineralized zones have been shown to have considerable extent and contain ore which, locally at least, ranges in value from $5 to $10 a ton. Apparently the zone marked by the pits, rather than that followed by the tunnel, is the principal lode, although it is evidently interrupted by various irregularities. The pits suggest that approximately 12,000 tons of mineralized rock exists in this lode above the level of Costello Creek. Discontinuity resulting from numerous minor faults is likely to prove a handicap in development.

[18] Capps, S. R., op. cit. (Bull. 692), p. 224.

COAL

The northern part of the area contains coal that is probably adequate in quantity and quality for local use in development of the metal mines, though it would be unable to compete with the larger and more favorably situated deposits elsewhere in Alaska.

STEVENS

Henry Stevens is developing under permit a coal prospect on Coal Creek, a minor gulch that enters Camp Creek from the east just above the confluence of Camp and Costello Creeks. At the time of visit, September 4, 1931, the principal working was a slope a little over 20 feet long, whose portal starts in the face of an open cut about 10 feet deep and 7 feet wide and follows a coal bed that strikes about N. 30° E., dips 10°–12° SE., and is nearly 7 feet thick. This bed contains a few small lenses of shaly and sandy material, the largest of which is about an inch thick. A bed of sandstone about a foot thick at the base of this bed has been cut through, revealing more coal beneath, which has the glistening appearance of cannel coal. Above the main bed in the slope is about 4 feet of clay with considerable carbonaceous material, followed successively by 3 feet 8 inches of coal with platy fracture, 1 foot 4 inches of sandstone, 4 feet of coal with platy fracture containing clay streaks, and finally the loose overburden, mainly gravel, on the upper part of the bank. The upper coal bed strikes N. 20° E. and dips 7° SE. At all visible contacts between coal and sandstone there is distinct evidence of erosional unconformity. This unconformity, with the variations in attitude and small lateral extent of individual beds, indicates that the material forming the coal is of transported rather than residual origin.

When Capps[19] visited the prospect in July 1917 he noted three coal beds, 6, 5, and 9 feet thick (listed in descending order), which dip 14° E., in a vertical section of 24 feet. There was a 15-foot tunnel, now caved, in one of these beds, presumably the uppermost. It showed a 6-foot face of coal, and neither the top nor the bottom of the bed was exposed. The bank below the portal of the present slope is largely covered with loose material, but in places here and in the creek channel beds of coarse calcareous sandstone are exposed. Most of these contain numerous well-preserved plant remains.

The following analysis of coal from this prospect, kindly furnished by Henry Stevens, indicates that according to the classification adopted by the United States Geological Survey it is of approxi-

[19] Capps, S. R., op. cit. (Bull. 692), pp. 231–232.

mately subbituminous rank. It has been shown to be resistant to weathering, although the coal mined close to the surface makes a considerable proportion of fines. It has been used in blacksmith forges with fair satisfaction. Present exposures show a number of clay partings. The fact that no coal is visible either in the west bank of Coal Creek or in the walls of a gorge entering this creek from the east a few hundred feet south of the prospect proves the small lateral extent of the beds. From the present scanty exposures it may be assumed that there is a minimum of 10,000 tons of coal in the two beds that have been entered, and it is probable that deeper development will disclose a materially larger tonnage. Sufficient coal probably exists to supply a small power plant, such as might be required to develop one of the metalliferous lodes in the vicinity, for a considerable period. The small extent and isolated situation of the coal beds will prevent their coming into competition with more favorably situated and larger deposits for a long time to come.

Analysis of coal from Stevens prospect

[Sample submitted by Henry Stevens; analyzed Oct. 25, 1927, by A. L. Glover, Inc., Seattle, Wash. Air-drying moisture content lost before sample reached laboratory]

Moisture (combined)	7.00
Volatile matter	46.60
Fixed carbon	40.90
Ash	5.50
	100.00
Sulphur	.41
British thermal units	11,190

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