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GEORGE OTIS SMITH, DIRECTOR

BULLETIN 525

A GEOLOGIC RECONNAISSANCE

OF THE

FAIRBANKS QUADRANGLE, ALASKA

BY

L. M. PRINDLE

WITH A

DETAILED DESCRIPTION OF THE FAIRBANKS DISTRICT

BY

L. M. PRINDLE AND F. J. KATZ

AND AN

ACCOUNT OF LODE MINING NEAR FAIRBANKS

BY

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WASHINGTON

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PREFACE.

By Alfred H. Brooks.

The facts and conclusions set forth in this bulletin are based on geologic explorations in the Yukon-Tanana region, of which the Fairbanks quadrangle forms a part, begun by L. M. Prindle in 1903 and continued by him until 1909. During this work emphasis was laid on the study of the larger geologic problems and on the investigations of the auriferous gravels, and to these objects areal mapping was subordinated. For this reason the field observations, even in some of the best-known parts of the quadrangle, are by no means complete, and therefore the distribution of the geologic units into which the rocks of the quadrangle have been subdivided is by no means definitely established. But as it is believed that even an incomplete map may be useful to the prospector it has appeared better to publish the accompanying map (Pl. VIII, in pocket) in its present inexact form rather than to defer its publication until several more years of investigation have made it possible to decipher the numerous intricacies of the geology. Only by means of such an investigation can a complete and accurate geologic map be prepared.

Those who may be led to believe that the results are not commensurate with the time spent in the survey are reminded that the area here mapped is about twelve times as large as the average quadrangle in the States; also that on this area less than 250 days was spent, about half of which was devoted to detailed work in the vicinity of Fairbanks.

Considerable time has been spent in investigating the region adjacent to Fairbanks. Unfortunately, as this region lies entirely within the area of the older schists, its study yielded but few data that could help in deciphering the stratigraphic sequence and structure of the rest of the quadrangle. Moreover, it is a field in which outcrops are few and are in large part deeply weathered.

On the other hand, the extensive mining operations in the vicinity of Fairbanks have yielded much information as to the distribution of the alluvial gold. Therefore the part of the paper dealing with these gold placers is presented with more confidence of its accuracy than is felt in regard to the rest of the report. It is hoped that the facts set forth may not only be of immediate practical importance to the Alaskan mining industry but may also be of more permanent value as a contribution to a knowledge of the mode of occurrence of gold placers. (See Pl. XI, in pocket.)

The marked progress of auriferous quartz mining in the Fairbanks district since the completion of Mr. Prindle and Mr. Katz's field work made further investigations very desirable. Therefore Philip S. Smith was detailed to make this investigation. As no money was available in 1912 until midsummer only a brief time could be devoted to the work, but in spite of this Mr. Smith was able to collect a large amount of new data bearing on the occurrence of the auriferous lodes. Delay in the publication of this report has made it possible to incorporate in it Mr. Smith's results. (See pp. 153–216.)

The interpretation of the data relating to auriferous gravels here presented indicates that the placer-gold reserves of the Fairbanks district, even if only those deposits that can be mined by methods now in use are considered, are still very large. It indicates also that there are still larger deposits of auriferous gravels whose content of gold is so small that they can be profitably handled only by improved methods of mining. These facts and the existence within the quadrangle of extensive alluvial deposits, which have not been thoroughly prospected, make the outlook for placer mining in this region exceedingly hopeful. It is therefore by no means certain that the placer-mining industry will continue to decline as it has declined in the last two years. It should be added, however, that a large expansion of the placer-mining industry in this field can be brought about only by lessening the operating costs through improved means of communication.

Of the auriferous-lode mining industry it is not possible to speak with so much confidence, for the causes that determine the occurrence of such deposits are more complex than those that determine the occurrence of placers. As compared with alluvial mining, the lode-mining operations have been insignificant and have yielded no great body of facts upon which to base conclusions as to the persistence of the lodes. The facts presented in this report, however, show that the geologic conditions on the whole appear to be favorable to the occurrence of lode deposits and that these are not limited to the localities near Fairbanks which have been prospected.

A GEOLOGIC RECONNAISSANCE OF THE FAIRBANKS QUADRANGLE, ALASKA.

By L. M. Prindle.

INTRODUCTION.

EARLY EXPLORATIONS.

The area covered by the Fairbanks quadrangle (Pl. I, in pocket), which is near the center of the Yukon basin, first became known to the Russians by the reports of natives who visited the trading posts on the Yukon. Soon after the transfer of the territory to the United States and in the early seventies prospectors and traders visited Tanana River, but they left few records of their journeys. Some of these men made the first discovery of gold in inland Alaska [1] on Tanana River. Many years elapsed, however, before the mineral resources of this district attracted any attention. The first definite information concerning Tanana River was obtained by Allen in 1885 in the course of his remarkable Alaskan explorations.[2] Allen made a sketch map of the river, and his report contains many valuable observations.

Spurr's investigation of the Yukon basin,[3] made in 1896, did not extend into the area here under discussion, but his account of the geology of adjacent areas throws much light on the general geology of the Fairbanks quadrangle. Brooks,[4] who accompanied W. J. Peters in his survey of the Tanana in 1898, was the first geologist who actually visited any part of the Fairbanks quadrangle. Two years later Brooks traversed the western margin of the quadrangle,[5] and in the same year Collier [6] obtained additional information about the geology along Yukon River.

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[1] Petroff, Ivan, Report on population, industries, and resources of Alaska: Tenth Census U. S., 1884, p. 5.

[2] Allen, H. T., Report of an expedition to the Copper, Tanana, and Koyukuk rivers in the Territory of Alaska, 1887, 172 pp.

[3] Spurr, J. E., Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 87–392.

[4] Brooks, A. H., A reconnaissance in the White and Tanana river basins, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 425–494.

[5] Brooks, A. H., The Mount McKinley region, Alaska: Prof. Paper U. S. Geol. Survey No. 70, 1911.

[6] Collier, A. J., The coal resources of the Yukon, Alaska: Bull. U. S. Geol. Survey No. 218, 1903.

LATER INVESTIGATIONS.

Systematic surveys.—More systematic work was begun in this province in 1903, when the writer was detailed to study the geology of the Yukon-Tanana region, which is bounded on the east by the international boundary, on the north and west by Yukon River, and on the south by Tanana River. This province includes an area of more than 50,000 square miles, and the seven seasons devoted to its investigation are far from sufficient to permit more than very general statements regarding its areal, stratigraphic, structural, and economic problems. The difficulties were increased by the fact that much of the field work was done before the topographic base map had been prepared. Therefore the geologists have been forced during much of the investigation to obtain locations by foot traverses and to trust to the accuracy of these to adjust the geology to the base map. Only the region immediately adjacent to Fairbanks has been examined in detail, and there the natural rock exposures are so poor as to make their interpretation anything but satisfactory. Some of the results of these geologic surveys, as well as those of the investigations of the surface, begun in 1907, have been published in the following reports:

The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, by L. M. Prindle. Bulletin 251, 1905, 89 pp.

Yukon placer fields, by L. M. Prindle. In Bulletin 284, 1906, pp. 109–131.

Reconnaissance from Circle to Fort Hamlin, by R. W. Stone. In Bulletin 284, 1906, pp. 128–131.

The Yukon-Tanana region, Alaska: Description of the Circle quadrangle, by L. M. Prindle. Bulletin 295, 1906, 27 pp.

The Bonnifield and Kantishna regions, by L. M. Prindle. In Bulletin 314, 1907, pp. 205–226.

The Circle precinct, Alaska, by A. H. Brooks. In Bulletin 314, 1907, pp. 187–204.

The Yukon-Tanana region, Alaska: Description of the Fairbanks and Rampart quadrangles, by L. M. Prindle, F. L. Hess, and C. C. Covert. Bulletin 337, 1908, 102 pp.

Occurrence of gold in the Yukon-Tanana region, by L. M. Prindle. In Bulletin 345, 1908, pp. 179–186.

The Fortymile gold placer district, by L. M. Prindle. In Bulletin 345, 1908, pp. 187–197.

Water supply of the Fairbanks district in 1907, by C. C. Covert. In Bulletin 345, 1908, pp. 198–205.

Water-supply investigations in Alaska, 1906 and 1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper 218, 1908, 156 pp.

Water-supply investigations in Yukon-Tanana region, 1907 and 1908, by C. C. Covert and C. E. Ellsworth. Water-Supply Paper 228, 1909, 108 pp.

The Fortymile quadrangle, by L. M. Prindle. Bulletin 375, 1909, 52 pp.

The Fairbanks gold-placer region, by L. M. Prindle and F. J. Katz. In Bulletin 379, 1909, pp. 181–200.

Water supply of the Yukon-Tanana region, 1907 and 1908, by C. C. Covert and C. E. Ellsworth. In Bulletin 379, 1909, pp. 201–228.

Sketch of the geology of the northeastern part of the Fairbanks quadrangle, by L. M. Prindle. In Bulletin 442, 1910, pp. 203–209.

Auriferous quartz veins of the Fairbanks district, by L. M. Prindle. In Bulletin 442, 1910, pp. 210–229.

Placer mining in the Yukon-Tanana region, by C. E. Ellsworth. In Bulletin 442, 1910, pp. 230–245.

Water supply of the Yukon-Tanana region, 1909, by C. E. Ellsworth. In Bulletin 442, 1910, pp. 251–283.

Placer mining in the Yukon-Tanana region, by C. E. Ellsworth and G. L. Parker In Bulletin 480, 1911, pp. 153–172.

Water supply of the Yukon-Tanana region, 1910, by C. E. Ellsworth and G. L. Parker. In Bulletin 480, 1911, pp. 173–217.

Water supply of the Fairbanks, Salchaket, and Circle districts, by C. E. Ellsworth. In Bulletin 520, 1912, pp. 246–270.

Systematic topographic mapping was begun in this field in 1903 and continued until 1910, when a reconnaissance survey on a scale

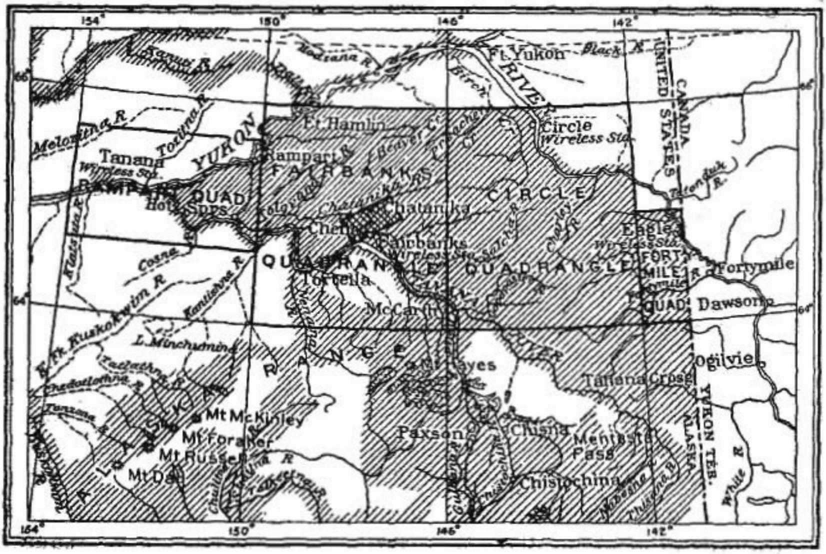


FIGURE 1.—Index map showing location of quadrangles and surveyed areas in Yukon-Tanana region.

of 4 miles to the inch had been extended over the entire Yukon-Tanana region with the exception of the flats lying in the great bend of the Yukon and parts of the Tanana Valley lowland. The maps resulting from these surveys are published on a scale of 1:250,000, with 200-foot contours. The quadrangles, which are the units of publication, include 2° of latitude and 4° of longitude. (See fig. 1.) The following is a list of the published maps:

Circle quadrangle; scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, and others. In Bulletin 295, 1906.

Fairbanks quadrangle; scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, R. B. Oliver, and J. W. Bagley. In Bulletin 337, 1908.

Fortymile quadrangle; scale, 1:250,000; by E. C. Barnard. In Bulletin 375, 1909.

Rampart quadrangle; scale, 1:250,000; by D. C. Witherspoon and R. B. Oliver. In Bulletin 337, 1908.

Fairbanks and Birch Creek districts, reconnaissance map; scale, 1:250,000; by T. G. Gerdine. In Bulletin 251, 1905. Not issued separately.

Fairbanks special map; scale, 1:62,500; by T. G. Gerdine and R. H. Sargent.

The Bonnifield region, reconnaissance map; scale, 1:250,000; by J. W. Bagley, D. C. Witherspoon, C. E. Giffin, R. B. Oliver, and D. L. Reaburn. In Bulletin 501, 1912.

The following are still in preparation:

Upper Tanana River and Ladue Creek region; scale, 1:250,000; by D. C. Witherspoon and J. W. Bagley.

Ruby Creek to Iditarod, reconnaissance map; scale, 1:250,000; by C. G. Anderson.

The present report.—The actual basis of the present report consists of work done at different times during several years. In only two years—1908, when the Fairbanks district was studied in some detail, and 1909, when an areal reconnaissance was made of the portion of the Fairbanks quadrangle lying between Yukon and Tanana rivers—has the entire field season (about two and one-half months in each year) been devoted entirely to the area under consideration. The rest of the material was derived largely from geologic reconnaissance trips of the writer made in the years 1903 to 1907, inclusive, and in 1909, and from more detailed work in the Fairbanks district in 1908, though free use has been made of all Survey reports bearing on the region. The writer was assisted in 1904 in a reconnaissance from Eagle to Fairbanks and Rampart by F. L. Hess, in 1905 in a reconnaissance from Dawson to Fairbanks by Adolph Knopf, in 1906 in a reconnaissance of the Bonnifield and Kantishna regions by C. W. Blair, in 1908 in the detailed studies of the mining district adjacent to Fairbanks by F. J. Katz, and in 1909 in areal reconnaissance of the Fairbanks quadrangle by B. L. Johnson. Special acknowledgment is due to the miners for their helpfulness in the field and their readiness to respond to all requests for information.

In the detailed survey of the Fairbanks district (Pl. II, in pocket) Mr. Katz studied the gold-placer deposits and methods of mining, and the writer investigated the bedrock geology. A similar subdivision of the office work was made. Mr. Johnson also rendered valuable aid in the office work incidental to the preparation of this report. For areas in the northern part of the Fairbanks quadrangle data were procured by R. W. Stone in 1905, and both his published report[1] and his unpublished notes have been freely drawn upon.

The present report comprises a general description of the geology and mineral resources of the Fairbanks quadrangle and a more detailed description of the geology, mineral resources, and mining developments of an area lying adjacent to the town of Fairbanks.

[1] Stone, R. W., Reconnaissance from Circle to Fort Hamlin: Bull. U. S. Geol. Survey No. 284, 1906, pp. 128–130.

About one-quarter of the Fairbanks quadrangle lies south of Tanana River, but this part will not here be considered. It has recently been investigated by Capps, to whose report[1] those interested in this part of the field are referred.

Even had the conditions for geologic work been all that could have been desired, the size of the area explored and the short time available for field work precluded more than fragmentary results for most of the area. An important body of fact, however, was collected regarding the geographic features, the nature and material relations of the different kinds of bedrock, the character and distribution of the deposits overlying the bedrock, the occurrence of gold, and mining developments in progress, the consideration of which forms the object of this report.

GEOGRAPHY OF THE YUKON-TANANA REGION.

The Yukon-Tanana region, which includes the Fairbanks quadrangle, forms part of the central plateau province of Alaska. (See Pl. III.) It is an upland, which may be termed a dissected plateau, diversified by many broad valleys and their smaller tributaries and characterized by broad, flat interstream areas (Pl. IV, *A*), above which rise numerous rounded domes and some rather large mountain masses. (See Pl. X, *B*, p. 40.) The surface of the upland maintains remarkable uniformity of altitude throughout considerable areas; it stands at an altitude of 3,000 to 3,500 feet in the eastern part of the region, gradually falls off westward to the vicinity of Fairbanks, where it is only about 2,000 feet in altitude, and rises again to 3,000 feet near the Yukon at Rampart. In many parts of the region flat-topped spurs stand below the general level of the plateau.

The domes, which rise above the general level of the upland, are irregularly distributed and attain altitudes of 4,000 to 5,000 feet. Some mountains with well-defined crest lines also stand 4,000 to 5,000 feet above sea level; among them are the Glacier Mountains, in the Fortymile region, 5,000 to 6,000 feet high; the Crazy Mountains, near Circle, 3,000 to 3,600 feet high; the White Mountains, in the Beaver Creek drainage basin (Pl. I, in pocket), 3,000 to 4,000 feet high; and the Sawtooth Mountains, near Rampart, nearly 5,000 feet high. The domes are almost entirely composed of stocks of igneous rock and owe their present prominence to the resistance to weathering of these rocks. Some of the mountains are made up of igneous rocks and some of closely folded sediments, but in both types the relief is due to the greater resistance to erosion of their constituent rocks.

The Yukon-Tanana region is drained by the two rivers from which it is named. At the international boundary the Yukon flows through

[1] Capps, S. R., The Bonnifield region, Alaska: Bull. U. S. Geol. Survey No. 501, 1912.

a steep-walled valley, whose floor stands about 2,500 feet below the plateau level. Within the valley walls the river meanders over its flood plain. This type of valley is continued to a point near the town of Circle, where both walls recede and the valley opens out into the broad Yukon Flats. Here the river widens and flows in many intricately winding channels. About latitude 65° 50′ the Yukon leaves the flats and flows through a narrow, steep-walled valley to its junction with the Tanana.

Tanana River rises in the Wrangell Mountains, far to the south of the Fairbanks quadrangle. Its two chief headwater streams traverse the Nutzotin Mountains through narrow valleys and debouch on a broad lowland, where they unite to form the Tanana. Below this junction the valley walls gradually contract, and as far down as the mouth of Delta River the Tanana flows through a series of connected steep-walled basins having a rectangular outline. Below Delta River the south wall of the Tanana Valley recedes, and thence to the Yukon the river traverses a broad lowland similar to the Yukon Flats.

Many streams rising in the region here described are tributary to Yukon and Tanana rivers. Most of the larger rivers flow in broad alluvium-filled valleys whose walls rise by gentle slopes to the plateau level. Fortymile River is an exception to the usual type, for in its lower course it flows between rock walls which rise abruptly 300 or 400 feet to a bench that marks an old valley floor. Minook Creek, near Rampart, also flows through a steep-walled valley whose slopes rise to a gravel-covered bench about 800 feet above the floor. The master streams of the Yukon-Tanana region have a southwesterly course roughly paralleling the Yukon Valley below the big bend at Fort Yukon.

GEOGRAPHY OF THE FAIRBANKS QUADRANGLE.

POSITION AND EXTENT.

The Fairbanks quadrangle lies between parallels 64° and 66° north latitude and meridians 146° and 150° west longitude. (See Pl. I, in pocket.) It measures approximately 138 miles from south to north and 116 miles from east to west, and its total area is about 16,000 square miles. The quadrangle lies in the Yukon-Tanana region, which forms a part of the central plateau province of Alaska.

TOPOGRAPHY.

RELIEF.

SUBDIVISIONS.

The surface of the Fairbanks quadrangle has an altitude above the sea varying from less than 400 feet on Tanana River to nearly 5,000 feet in the Sawtooth Mountains. (Pls. I and II, in pocket.) The mean altitude of the main valley floors is from 500 to 800 feet, of the ridges and summits from 1,500 to 3,500 feet. Three topographic subdivisions are recognizable within the quadrangle; named from south to north, they are the Tanana lowland, the upland north of it, and the Yukon lowland. A fourth province is the upland which bounds the Tanana Valley on the south and merges still farther south with the foothill belt of the Alaska Range. This fourth province, though in part included within the Fairbanks quadrangle, is outside the area here under discussion.

TANANA LOWLAND.

At Delta River the Tanana emerges from a rather narrow valley to a broad flat, here called the Tanana lowland, which widens toward the Yukon. (See Pl. III.) This lowland is extended in the highlands north of the Tanana by many reentrants which mark the valley mouths of the larger tributaries of the river. On the south it is bounded by the upland plateau already referred to. The largest of the northern reentrants is that of the Tolovana Valley, where a lowland 25 miles wide stretches northward for 30 miles. Each of these tributary lowlands merges toward the north into the valley of a confluent stream.

The highland rim north of the Tanana lowland in general rises steeply from the plain, and the river in most places hugs it closely. The alluvium-floored lowland is here and there heavily timbered and is dotted with numerous lakes and swamps, the remnants of former watercourses. Some low hills that lie out in the flat are probably portions of a gravel sheet that once filled much of its upper part.

UPLAND NORTH OF THE TANANA.

The upland north of the Tanana (Pl. IV, *A*), which occupies much the larger part of the quadrangle, is a part of the Yukon-Tanana upland and partakes of its general character. Its dominant topographic type is one of similar flat or slightly rounded, even-topped ridges, reaching elevations of 2,000 to 3,500 feet above sea level, separated in most of the area by comparatively narrow, closely spaced valleys, 1,000 to 1,500 feet below the level of the ridges. (See Pl. V, *A*.) Similar ridges and similar valleys are monotonously repeated throughout the greater part of the area between Yukon and Tanana rivers; they form about three-fourths of that part of the Fairbanks quadrangle lying between these streams.

A second type of upland is that formed by the White Mountains and adjacent areas in the northeastern part of the quadrangle and by the group of hills near the western border. These two areas rise conspicuously above the uniform level of the surrounding country.

The White Mountains especially form one of the most prominent and persistent groups of ridges lying between the Yukon and the Tanana. (See Pl. X, *A*, p. 40.)

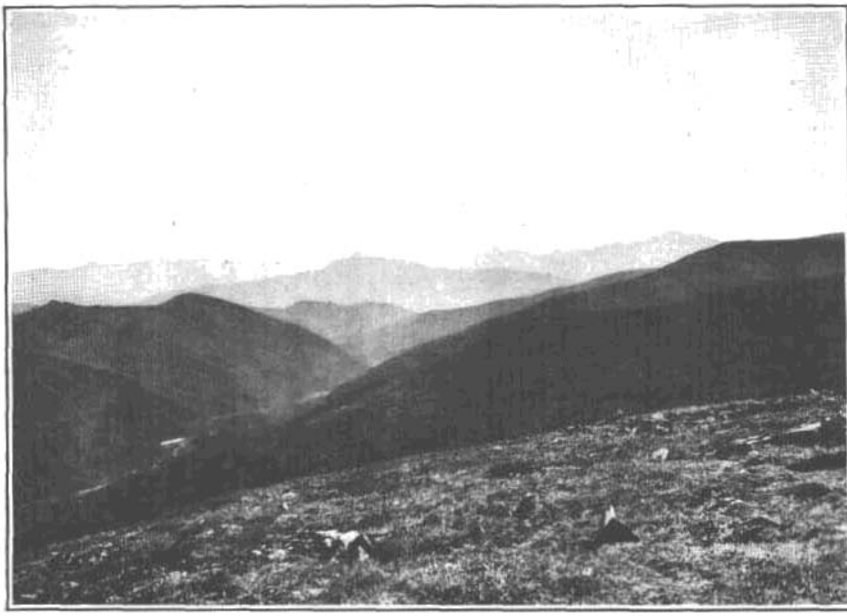
The ridge and valley country breaks off rather abruptly on the north to the level of the Yukon Flats and with less abruptness on the south to the Tanana Flats, which widely separate the highlands north of the Tanana from the ridges forming the foreground of the Alaska Range. A large reentrant from the Tanana Flats extends far northward into the western portion of the quadrangle and well-nigh separates the ridge land into two distinct parts.

The divide between the Yukon and Tanana drainage basins is not marked by prominent topographic features. It follows a most irregular course, in places among the higher ridges and in places near the lowland. It parallels to some extent the course of Tanana River and the greater part of the drainage from it flows to the Tanana.

The ridge and valley type is best developed in the eastern part of the quadrangle, where, throughout large areas, the uniformity of ridge level is the predominant characteristic of the topography. Few of the ridges are sharp; many of them, in fact, especially near the heads of valleys, are conspicuously flat over areas of considerable extent, while the valley bottoms are narrow.

Isolated prominences, locally known as domes (Pl. V, *B*), many of them flat on top, rise a few hundred feet above the general level of the ridges, and local depressions known as saddles sink below it. The general northeast-southwest trend of the ridges is largely veiled by numerous bulky lateral spurs, which are more or less equivalent in amplitude to the main ridges, some being even larger. The average elevation is somewhat higher along the northern part of the western boundary of the quadrangle, where altitudes above 3,500 feet are more common than among the ridges adjacent to the Tanana, where few elevations rise above 2,500 feet. (See Pl. II, in pocket.) Most of the ridges slope rather unsymmetrically to the valleys, one slope being generally rather steep (with a grade up to about 20°) and the other being gradual and merging into a gently sloping valley floor. Many of the valleys, though approximately counterparts of the ridges, have a somewhat smaller development.

The valleys are 2,000 feet or more vertically below the ridge lines. They are either narrowly V-shaped or amphitheatral near their heads and rather symmetrical in their upper portions. Downstream they become open and increasingly unsymmetrical until they develop a valley floor from a few hundred feet to a mile or more wide. (See Pl. V, *B*.) The streams as a rule occupy comparatively narrow flats on the steeper sides of the valleys, and the valley floors, though in some places rather flat, generally rise gradually to merge with the ridge slopes.



A. TYPICAL VALLEY AND UPLAND TOPOGRAPHY IN SALCHAKET REGION.

B. VIEW UP DOME CREEK NEAR FAIRBANKS.

In the western part of the quadrangle, nearer the convergent courses of Yukon and Tanana rivers, long, broad ridges with gradually diminished height separate open, flat valleys. The northern edge of the hill country, sharply demarcated from the Yukon Flats save for low, flanking ridges and comparatively intact except where cut by Beaver River, is fluted by the deep, narrowly V-shaped valleys of many minor streams. The ridge country facing the Tanana, on the contrary, is divided far into the interior of the quadrangle by many open valleys that flare widely toward the Tanana Flats.

Of the areas that rise above the general level, the White Mountains are the most conspicuous. Their ridges are sharply demarcated from the surrounding country, the higher ridges rising 3,000 feet or more above the level of the valleys at their base. They form a group of ridges trending northeast and southwest and terminating to the southwest in a sharp, narrow ridge overlooking Beaver Creek. The uneven ridges exhibit a variety of forms. In places disconnected, precipitous masses of rock, rising above the general outline, impart to these mountains a jagged appearance as conspicuous as the whiteness of the limestone composing them. (See Pl. X, *A*, p. 40.) Their rocky slopes are made less precipitous by the piles of débris into which they plunge, and these in turn give place to gradual slopes that flatten toward the valley of Beaver Creek.

Fifty miles west of the White Mountains, beyond the intervening ridge land, rises a group of prominent hills, the Sawtooth Mountains. These hills, together with Wolverine Mountain, just off the western edge of the area mapped, form the most conspicuous topographic feature in the western portion of the Yukon-Tanana region. Their crest line is irregular and studded with angular points. The upper slopes are steep and have furnished abundant accumulations of talus, which grade into the more gradual grassy slopes that form their base.

YUKON FLATS.

The third topographic province—the Yukon Flats—fringes the northern edge of the quadrangle. Its surface stands at about 600 feet, and to this level the upland falls by gentle slopes. The Yukon Flats are unsurveyed but are known to include innumerable meandering streams with many lakes and swamps. Although the flats are timbered, it is only near the watercourses that the trees grow to considerable size.

UPLAND SOUTH OF THE TANANA.

South of the Tanana Valley the main ridges flanking the northern base of the Alaska Range are comparable in altitude with the ridges already described. They have an east-west trend and are cut by the transverse streams draining the Alaska Range. The valleys of the major streams are narrow canyons where they cross the ridges but open out in the intervening areas, coalescing more or less and forming east-west valleys that parallel the trend of the ridges.

DRAINAGE.

The drainage of the greatest part of the area between Yukon and Tanana rivers is controlled by the Tanana, the divide between these two streams paralleling to a considerable degree the course of the Yukon and lying mostly within the northern half of the quadrangle. The adjoining drainage systems are most intimately intergrown. The drainage is for the most part sharply depressed below the level of the ridges, a feature that is more pronounced toward the Yukon Flats than in the ridges immediately north of the Tanana. The depressed character of the valleys persists nearly to their heads, where there is a more or less abrupt ascent to the ridge level. A large proportion of the valleys are markedly unsymmetrical in cross section. Some of them, especially those tributary to the Yukon, contain gravel benches.

Most of the streams head at about the same level, have about the same grade, and at corresponding positions contain approximately equivalent quantities of water. The relations of the drainage systems to one another, the grades of the streams, the comparative elevations and grades of different valleys are all brought out on the map (Pl. I, in pocket), from which many other facts of economic importance can be determined. The feasibility of ditches or roads or railways, for example, can be approximately ascertained by study of the map.

The Yukon Flats, on the north edge of the quadrangle, and the Tanana Flats, which form a large part of its area, are two of the most striking features of central Alaska. Both appear to be unconformable to the ridge land, but the change from ridge land to lowland is the more pronounced between the upland and the Yukon Flats. Uneven and somewhat ridged near the hills, the sparsely timbered surface flattens to form an ill-drained, lake-flecked lowland of several hundred square miles. The drainage from the hills finds its way by ill-defined meandering courses to the Yukon, which here spreads in many meandering channels over a width of many miles.

The great embayment extending northeastward from the Tanana Flats into the western portion of the quadrangle contains large areas of grass. Patches of spruce, birch, and aspen grow near the bases of the ridges, and narrow lines of timber mark the courses of sluggish streams that cross the lowland in channels sunk 20 feet between silty banks. The surface, like that of the Yukon Flats, is ill-drained and flecked with numerous lakes. some of them of considerable size.

South of Tanana River the flats widen westward and cover an area so large that they form an impressive foreground to the Alaska Range. The larger streams, coming swiftly from the mountains, lose velocity and meander more or less as they approach the Tanana. Some of the small streams from the foothills sink below their beds and reappear lower down their valleys. Much of the surface is drained by small swampy ill-defined streams.

The Tanana, like the Yukon, tends to become distributed into many interlacing channels, especially in the eastern part of the quadrangle, where its waters flow swiftly among numerous sand bars. In places side channels, like the Chena Slough, leave the main river and flow for many miles in independent courses before rejoining it. Through the greater part of the western half of the quadrangle the river flows in a single channel.

CLIMATE.

GENERAL CONDITIONS.

The climate, although influenced by the position of the Fairbanks quadrangle in the interior of Alaska, far from the coast line, and by the elevation above sea level, owes its most striking characteristics to the high latitude. The snowfall is not excessive, but during the long, intensely cold winters the circulation of water is reduced to a minimum and the ground is frozen to great depths, alluvial deposits having been reported to be frozen for more than 300 feet below the surface. Differences in material, however, and in the position of the material with reference to drainage have to some extent governed the distribution of frozen ground, and considerable areas of alluvial deposits are unfrozen.

Notwithstanding the continuance of temperature far below freezing, with ice on the larger streams and lakes to a thickness of 5 or 6 feet, much water circulates, frequently breaking through ice already formed and overflowing, thus thickening the ice by successive accumulations on the surface. On the larger streams such overflows are a source of delay and danger in travel, and on the smaller streams they form great deposits of ice that may linger till late in summer and interfere with mining.

The dates at which the rivers become closed to navigation by ice and open again in the spring are fairly constant from year to year. The last boats from Fairbanks in 1906 for Dawson and St. Michael are reported to have left on September 24 and October 2, respectively; in 1907 on September 22 and October 2. The earliest and latest reported dates for the closing of navigation at Fairbanks for the years 1901 to 1907 inclusive are October 14 and November 23;

at Fort Gibbon, on the Yukon, for the same period of years, October 15 and November 9. The Yukon and Tanana break up at dates ranging from May 10 to May 15. A few days after the ice breaks the rivers are generally clear of ice.

The conditions in summer are similar to those prevailing in temperate regions except for the longer days and shorter seasons characteristic of northern latitudes.

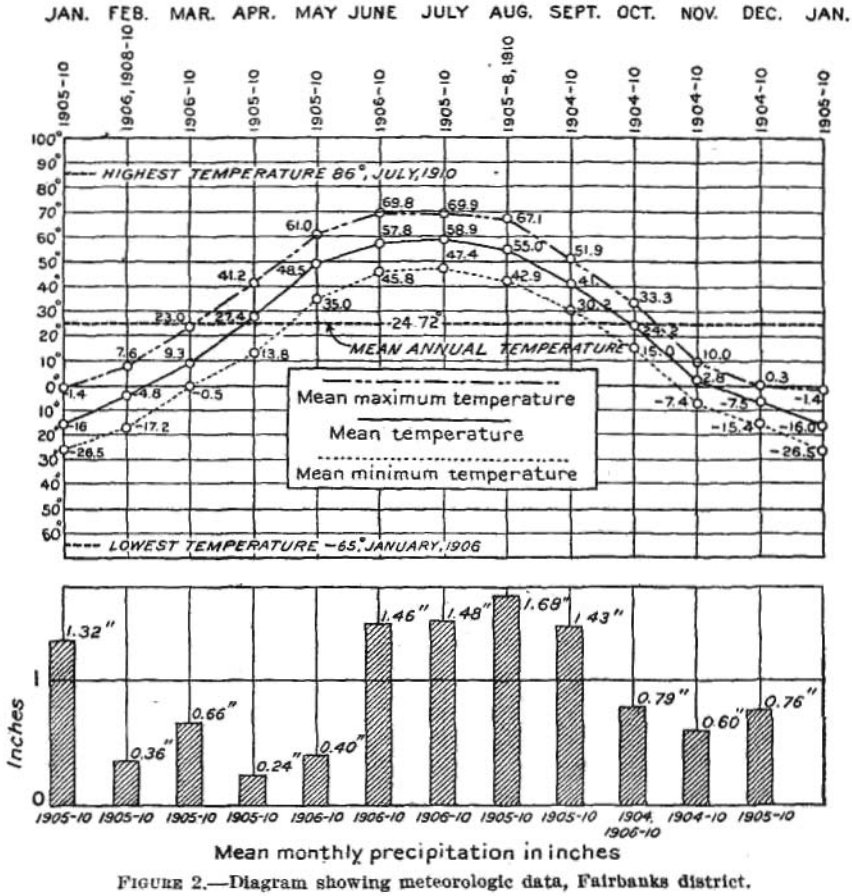


FIGURE 2.—Diagram showing meteorologic data, Fairbanks district.

The data available regarding temperature and precipitation have been assembled by Mr. Katz. (See fig. 2.) The records show frosts in June and July, but as a rule killing frosts do not occur in these months. The last killing frosts are likely to occur between May 15 and some date early in June. At Fairbanks and Fort Gibbon the first fall frost comes about August 15, and at Rampart and Fort Egbert about August 1. Killing frosts come somewhat later.

METEOROLOGIC DATA.

RECORDS.

The Fairbanks district is in the eastern portion of the "interior climatic province," discussed by Cleveland Abbe, jr.,[1] after a study of climatic records including the year 1902. Since that time more records have been obtained at Fairbanks, on Tanana River, and at Fort Gibbon, Rampart, and Fort Egbert, on Yukon River, and less satisfactory records at Circle and a few other points. A thorough discussion of the climate is still impossible, because the records are yet incomplete and cover only a few years. The tables which follow are, therefore, presented with only brief comments. They are compiled from the United States Weather Bureau records, supplemented by a few data on precipitation collected by hydrographers of the Geological Survey.

TEMPERATURE.

The greatest extreme annual range in temperature shown in the tables is 164° at Rampart, and the least extreme annual range is 120° at Fort Gibbon. The extreme monthly ranges are also large. The greatest occur in January and February, and are 92° at Fairbanks, 97° at Rampart, 98° at Fort Gibbon, and 101° at Fort Egbert. The least extreme monthly ranges occur from June to October and are between 27° in June at Fairbanks and 41° in October at Rampart.

The highest temperatures recorded are 86° in July at Fairbanks, 90° in June at Fort Gibbon, 96° in August at Rampart, and 92° in July at Fort Egbert. It will be seen from the tables, however, that these are exceptionally high, the *mean maximum* July temperatures being below 80°. January is the coldest month, with the extreme temperatures of −65° at Fairbanks, −68° at Rampart, −76° at Fort Gibbon, and −75° at Fort Egbert. The highest absolute minimum recorded for any winter at these stations is −48°.

The mean annual temperatures, which are very unsatisfactorily determined from these meager records, are 24.7° at Fairbanks, 22.1° at Fort Gibbon, 16.3° at Rampart, and 22.9° at Fort Egbert.

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[1] Brooks, A. H., The geography and geology of Alaska: Prof. Paper U. S. Geol. Survey No. 45, pp. 154 et seq.

Temperature records at Fairbanks.

Mean maximum temperature.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904	......	......	......	......	......	......	......	......	49.7	36.8	−3.5	−6.0
1905	−14.2	......	......	50.2	61.4	......	61.1	66.5	46.3	31.4	24.3	− .6
1906	29.4	13.1	33.7	40.5	61.9	73.2	72.2	67.5	58.7	40.3	10.2	−9.1
1907	8.9	......	19.0	46.3	63.3	70.2	71.5	67.1	51.9	27.0	6.6	3.8
1908	− 1.7	13.7	17.2	39.5	58.5	70.3	69.2	64.5	45.6	30.4	16.7	8.2
1909	−18.7	3.4	26.6	35.6	58.6	69.3	72.7	......	52.5	32.9	7.2	11.9
1910	−11.9	.2	18.61	35.0	62.5	66.1	72.9	70.0	58.4	34.5	8.4	−5.7
Mean	− 1.4	7.6	23.0	41.2	61.0	69.8	69.9	67.1	51.9	33.3	10.0	.3

Mean minimum temperature.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904	......	......	......	......	......	......	......	......	29.3	19.1	−17.8	−15.6
1905	−19.9	......	......	23.0	32.9	......	42.9	43.0	30.1	15.2	.8	−26.1
1906	−43.7	−12.7	1.7	10.5	36.8	47.7	48.5	43.7	29.2	22.0	−10.3	−24.3
1907	−15.5	......	8.5	14.1	36.2	44.1	47.8	43.7	33.2	10.9	− 1.5	−10.6
1908	−21.3	− 8.1	−6.8	13.6	38.5	46.2	48.5	44.1	29.9	13.2	− 2.8	− 9.0
1909	−33.9	−24.4	−6.2	12.4	35.6	45.1	48.9	......	27.6	10.2	−10.0	− 2.7
1910	−24.8	−23.7	−2.0	9.3	35.1	45.8	48.1	40.1	32.3	14.7	−10.3	−19.3
Mean	−26.5	−17.2	− .5	13.8	35.0	45.8	47.4	42.9	30.2	15.0	− 7.4	−15.4

Mean temperature.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1904	......	......	......	......	......	......	......	......	39.5	28.0	−10.6	−10.8	......
1905	−17.0	......	......	36.6	47.2	......	52.0	54.8	38.2	23.3	12.6	−13.4	......
1906	−36.6	0.2	17.7	25.5	49.4	60.4	60.4	55.6	44.0	31.2	0.0	−16.7	24.26
1907	− 3.3	......	5.2	30.2	49.8	57.2	59.6	55.4	42.5	19.0	2.6	− 3.5	......
1908	−11.3	2.7	5.2	26.0	48.6	58.2	59.9	54.3	37.8	21.8	7.0	− .4	25.61
1909	−26.2	−10.5	10.2	24.0	47.1	57.2	60.8	......	40.0	21.6	8.6	4.6	......
1910	−18.4	−11.7	8.3	22.3	48.8	56.0	60.5	55.1	45.3	24.5	.6	−12.5	26.30
Mean	−16.0	− 4.8	9.3	27.4	48.5	57.8	58.9	55.0	41.0	24.2	2.8	− 7.5	24.72

Maximum temperature.

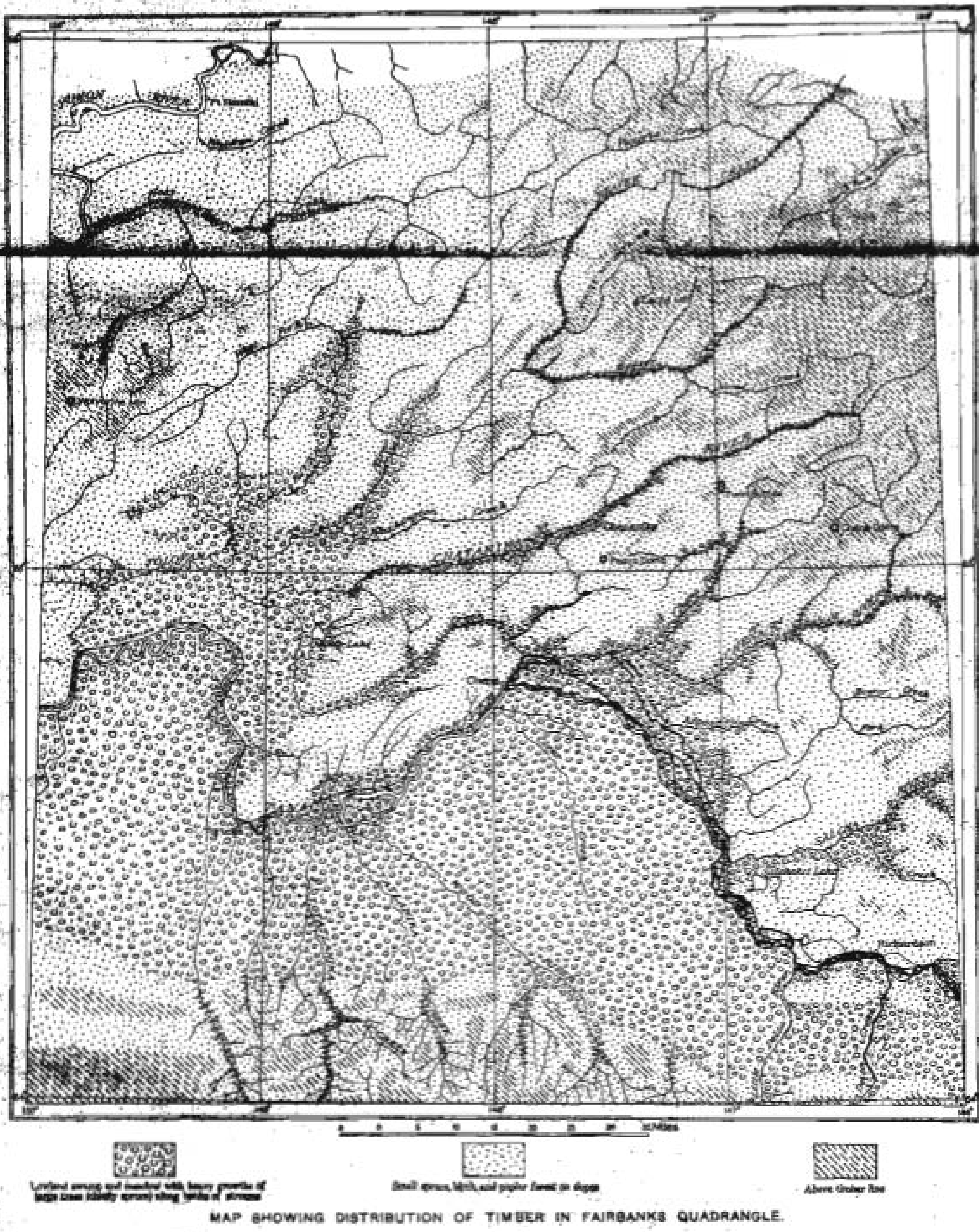
Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1904	......	......	......	......	......	......	......	......	62	52	28	23	......
1905	20	......	......	60	72	......	79	82	59	53	40	33	......
1906	13	21	46	58	81	84	83	77	70	58	37	30	......
1907	34	......	35	64	80	79	82	84	63	42	38	20	......
1908	32	38	36	55	74	83	79	80	64	51	46	33	......
1909	25	14	43	54	74	77	82	......	74	49	29	40	......
1910	28	35	44	56	76	86	[a] 86	76	78	49	25	32	......
Highest	34	38	46	60	81	86	86	84	78	58	46	40	[a] 86

[a] Highest temperature recorded.

Minimum temperature.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1904	......	......	......	......	......	......	......	......	17	− 7	−35	−47	......
1905	−48	......	......	......	24	......	30	29	18	− 8	−25	−55	......
1906	[a] −65	−38	−22	−12	27	41	40	32	13	2	−50	−46	......
1907	−58	......	−48	−31	26	37	38	36	20	−16	−41	−36	......
1908	−51	−32	−35	−19	30	35	40	31	15	−21	−30	−48	......
1909	−54	−45	−21	− 8	26	35	42	......	11	−10	−54	−42	......
1910	−55	−57	−32	−14	25	59	36	30	12	−15	−30	−58	......
Lowest	−65	−57	−48	−31	24	35	30	29	11	−21	−54	−58	[a] −65

[a] Lowest temperature recorded.



MAP SHOWING DISTRIBUTION OF TIMBER IN FAIRBANKS QUADRANGLE.

PRECIPITATION.

The region is semiarid. The average annual rainfall (rain and melted snow), computed from the fragmentary records, is 11.13 inches at Fairbanks, 11.80 inches at Fort Gibbon, 13.18 inches at Rampart, and 11.79 inches at Fort Egbert. The greatest annual rainfall recorded is 18.71 inches at Fairbanks in 1907. The rains are very local, are small in amount (rarely measuring as much as 0.5 inch at a time), and are of short duration. From June to September, particularly July and August, is the season of heaviest rainfall; from February to April that of least precipitation. There are about 80 rainy days in the year, of which half occur in June, July, August, and September.

Precipitation records at Fairbanks.

Precipitation.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1904	......	......	......	......	......	......	......	......	......	0.10	0.45	......	......
1905	0.92	0.50	0.05	0.20	......	......	......	2.63	0.86	......	1.20	0.60	......
1906	1.71	.37	.33	.10	0.36	1.05	2.82	1.50	.25	.30	.65	1.15	10.59
1907	3.30	.86	2.42	.03	.35	1.47	1.51	1.81	3.58	2.44	.35	.59	18.71
1908	.42	.21	1.10	.11	.52	.96	.73	.71	1.57	.47	.51	.65	7.76
1909	.90	.08	.05	.66	.38	1.64	1.90	1.73	.39	.80	.52	.80	8.85
1910	.70	.14	.02	.36	.39	2.16	.46	1.69	1.91	.66	.50	.76	9.75
Mean	1.32	.36	.66	.24	.40	1.46	1.48	1.68	1.43	.79	.60	.76	11.13

Number of days of precipitation.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1904	......	......	......	......	......	......	......	......	......	2	3	......	......
1905	3	2	......	1	......	......	......	13	15	......	6	4	......
1906	10	4	2	2	5	6	17	15	7	8	4	9	89
1907	15	......	11	......	4	12	14	11	16	12	4	9	......
1908	6	5	11	4	7	10	11	14	12	5	2	7	94
1909	6	1	2	4	4	11	16	(+2)	7	6	4	(6)	......
1910	4	1	2	2	2	4	4	6	7	4	2	1	39
Mean	7.3	2.6	5.6	2.6	4.4	8.6	12.4	11.8	10.7	6.2	3.6	6	81.8

VEGETATION.

Vegetable life is abundant throughout most of the Fairbanks quadrangle, its distribution being controlled largely by the altitude. (See Pl. VI.) Timber line is approximately 2,500 feet above sea level, and the only areas practically bare of vegetation are the highest rocky ridges. The broken bedrock forming the surface of most of the ridges from 2,500 to 3,500 feet above sea level is covered by only a thin mantle of vegetation, composed of low bushes, grass, and moss with some more or less stunted spruce. The dwarf birch is one of the commonest bushes, and dwarf willows only a few inches high appear numerously among the grass and blueberry bushes. The lower ridges and spurs are covered with a dense growth of small spruce and abundant moss.

On the slopes of the larger valleys and on portions of the valley floors timber is more or less abundant, but in the quadrangle as a whole the supply is rather small. Spruce, poplar, and birch are the commonest and, with some tamarack in the southern valleys, are practically the only trees. Timber is more plentiful toward the Tanana, and in some of the valleys near that river it is comparatively abundant. Spruce predominates. Most of the trees are less than a foot in diameter, but many in favored localities attain 2 feet, and one spruce observed by the writer in the valley of Goldstream Creek was 3 feet in diameter about 3 feet above the ground.

Timber suitable for mining purposes grows in parts of the stream flats of most of the streams throughout the area, and some spruce timber is available in most of the valleys nearly to their heads. In some localities the largest timber grows near the timber line, the size gradually diminishing toward the stream flats. The stream flats of the smaller streams are generally covered with strips of willows and alders which contrast rather strongly with the vegetation of the slopes and form a characteristic element in the landscape, being especially prominent in the autumn, when the frost-tinted leaves of the willows become a brilliant yellow.

Among the most characteristic and generally distributed forms of vegetable life are moss and lichens of many varieties. Some, on which the caribou feed, grow in the areas above the timber line; others form a practically continuous mantle in the valleys. The moss has some economic uses; it has been utilized for roofing and chinking cabins, for stopping leaks in ditches, and for filtering water from sediment for use in the boilers connected with mining machinery.

Feed for horses is generally common on the southward-facing slopes of valleys, and grass covers large areas in the Tolovana Flats.

Blueberries are found in abundance throughout much of the area, and currants, cranberries, and red raspberries are locally abundant. It has been demonstrated that many vegetables and grains can be grown successfully. Large areas in the Tanana Valley and adjacent region are favorable for cultivation, and considerable land is being taken up for ranches. A Government farm has been in successful operation near Fairbanks for several years, and farming is being profitably done on many private ranches, which supply the local markets with potatoes and other vegetables and also with hay.

Inroads upon the fine growth of birch and spruce in valleys where mining is in progress are resulting in rapid deforestation, and this process is greatly accelerated by the forest fires that occur nearly every season.

POPULATION AND LOCAL INDUSTRIES.

The town of Fairbanks, located on a slough of Tanana River (Pls. I and II, in pocket), is the commercial center of the most important part of the quadrangle, namely, of the placer district which lies close at hand. Its permanent population numbers probably several thousand. Chena, the second largest town in the quadrangle, with a population of several hundred, is situated on Tanana River where the slough connecting with Fairbanks discharges. Many smaller settlements have been established in accord with the needs of the placer-mining industry, several being located on Tanana River. It is probable, however, that the total permanent population of the quadrangle outside of Fairbanks and Chena does not exceed 2,000 persons. In addition there is an influx each summer of transients, whose number varies with the demands of the mining industry or with the excitement caused by new discoveries of gold. The sawmills in the Tanana Valley and the near-by region supply the local needs for lumber, and the neighboring ranches provide potatoes, vegetables, hay, milk, and eggs. With an excellent local market, competing only with supplies brought in at heavy expense, farming has been very profitable, and the further expansion of the industry is dependent only on the continued prosperity of the mining operators. Outside of the articles mentioned above, the region supplies nothing but fish and game and some wild fruits. Fur-bearing animals are too scarce in the immediate vicinity of the mining camps to supply even the local demand.

Fairbanks is an attractive town, built on the flood plain of Tanana River and provided with all the essentials and many of the luxuries of modern life. It has two banks, several hotels and newspapers, an electric-light plant, and a telephone system that connects with the placer camps of the vicinity. The military telegraph lines keep it in touch with the outside world.

MEANS OF COMMUNICATION.

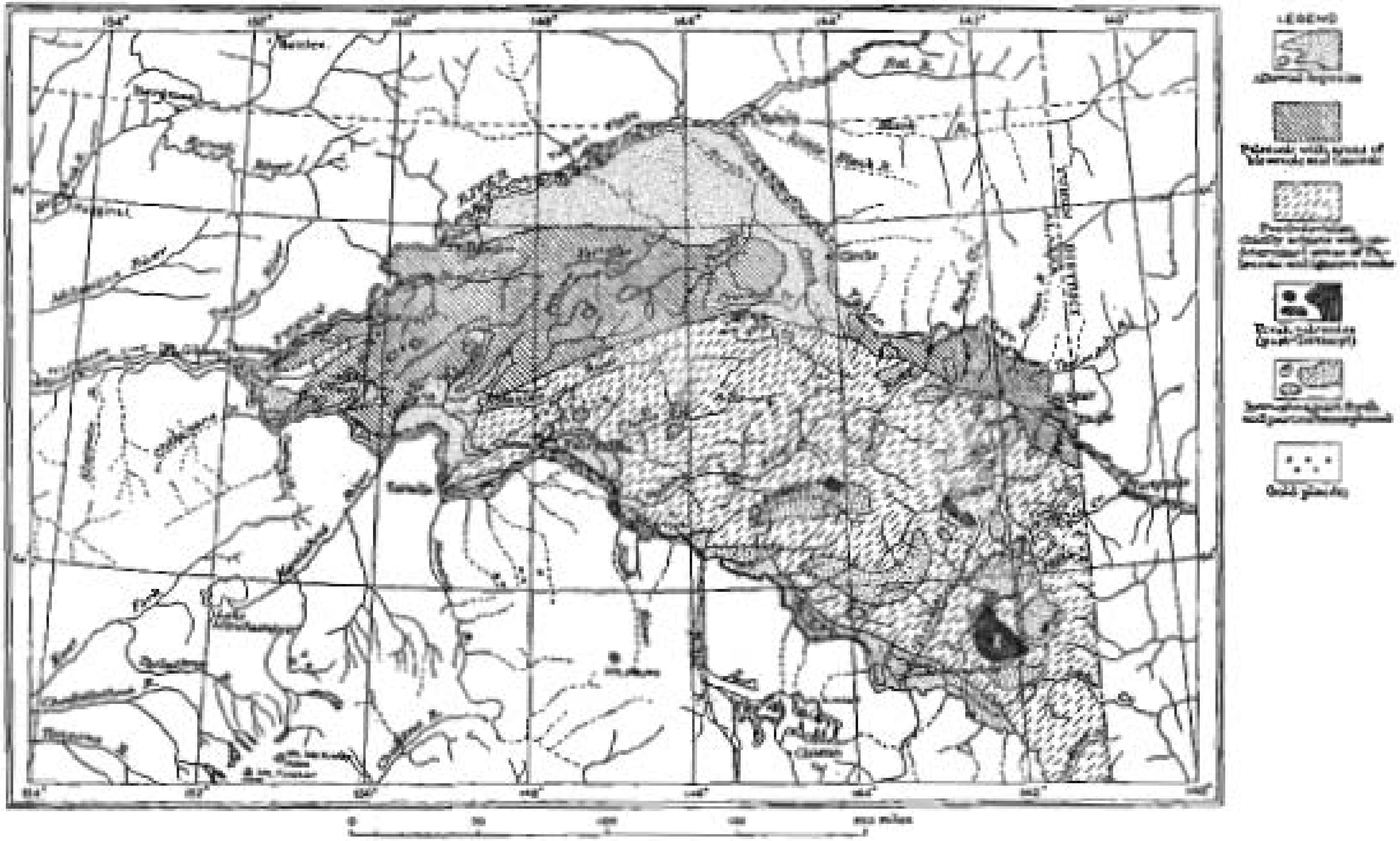
The transportation of freight from points on the Pacific coast to the Fairbanks region is accomplished by way of Dawson and the upper Yukon and by way of St. Michael and the lower Yukon. Freight brought by the largest boats plying on the Yukon must transship at Tanana to boats of lighter draft. Transportation rates from Seattle during 1908 averaged about $75 a ton on ordinary freight and $125 to $140 for a first-class passage. At least three weeks is required from Pacific coast points to Fairbanks by either route. The supplies are brought by steamer to the towns of Chena and Fairbanks, which are the intermediary points between the outside world and areas where mining is in progress. The areas of present importance are well within about 30 miles of these supply points. Local transportation is afforded by the Tanana Valley Railroad, about 45 miles long, extending between Fairbanks and Chena and from an intermediate point to Chatanika. This railroad (Pl. XII, *B*, p. 86) and a system of excellent wagon roads greatly facilitate the transportation of the heavy machinery rendered necessary by present conditions. Through their agency the freight rates from Fairbanks to the creeks, which were formerly about 5 cents a pound in winter and 25 cents a pound in summer, have been reduced to a few cents a pound for summer freights to the most extreme points.

Through the improvements the Alaska Road Commission has been making the Valdez trail has become the important winter route from Fairbanks to the coast and has been changed to a wagon road that is available for summer travel also. The region, however, is still dependent for the most part on routes that are available during the summer only, and travel is often subjected to costly delays in the spring by low water in the upper river and by ice in Bering Sea. A direct route, open throughout the year, for the transportation of supplies from Pacific coast points, is not yet available.

Although travel and transportation in the region immediately tributary to the town of Fairbanks have been rendered easy and, compared with the past, inexpensive, the conditions outside of this zone are almost as primitive as they were a decade ago, when the first influx of prospectors took place. The Salcha and Tenderfoot placer camps can be reached in summer by horse trail and in winter by sled roads. The placers on the upper Chena are even less accessible under favorable water conditions. Small steamers ascend the Tanana above the town of Chena as far as the mouth of Delta River, but at best they afford unreliable means of communication. Small boats can ascend streams like the Tolovana, Chena, and Salchaket, but they are very expensive for handling freight. A horse trail connecting Fairbanks with the Birch Creek placer camp passes near the gold deposits of the upper Chatanika. Supplies for this region are sledded in winter, as they are elsewhere in the region outside of the zone near Fairbanks tapped by wagon roads and the railway. With the exceptions noted above, the means of communication are entirely inadequate to the needs of the country. Until more railways and wagon roads are built there is little incentive to develop any except the richest placer deposits.

GEOLOGY OF THE YUKON-TANANA REGION.

Two dominant structural trends of Alaska, one southeast and northwest and the other northeast and southwest, intersect in the Yukon-Tanana region and give to the province an important structural position. Numerous individual formations also possess complicated structures. The field has been one of sedimentation, diastrophism, widespread metamorphism, abundant intrusion, and vol-



GEOLOGIC SKETCH MAP OF YUKON-TANANA REGION.

canic action. (See Pl. VII.) Its position, furthermore, in the basin of the Yukon, one of the great drainage systems of the world, has subjected it to long-continued and intricate fluviatile modeling. Its bedrock is mantled with unconsolidated deposits that, although but the product of an episode of geologic history, are nevertheless of great importance with reference to the distribution of placer gold. As it lies outside of the widely glaciated region, its topography is due almost exclusively to subaerial denudation.

The rocks include essentially two great groups, one of metamorphic, complexly folded schists predominantly of sedimentary origin and probably of pre-Ordovician age; and another, unconformable in its relation to the schists, made up of argillites, quartzite, conglomerate, sandstone, altered volcanic rocks, and limestone ranging in age from Ordovician to Carboniferous. Besides these two groups areas of Lower Cretaceous slate occur along the Yukon, Upper Cretaceous sandstone and shale in the Rampart region, and Tertiary clay, lignite, sandstone, and conglomerate in several areas.

Large areas of intrusive rocks occur in the eastern part of the region, and smaller isolated bodies are widely distributed throughout the province, notably in the vicinity of Fairbanks. Granitic rocks and those of intermediate composition are most common among these intrusives. Some of the granites have been metamorphosed to granitic gneiss and have been later intruded by other granites. Intrusives occur in pre-Ordovician rocks and in rocks as young as Devonian, and near Rampart igneous rocks of intermediate composition have intruded the Cretaceous sandstones. In some parts of the region diabase dikes are not uncommon. The Paleozoic greenstones are largely altered diabasic and basaltic flows. Fresh volcanic rocks, believed to be of Quaternary age, are rather common in the eastern part of the region, where they occur generally as masses capping the hills of schist or as plugs with surrounding masses of volcanic material.

The unconsolidated deposits, including silts, sands, and gravels, fall into two groups, those of the present streams and those of earlier streams, now found as terrace deposits or benches up to elevations of 500 or 600 feet above the present watercourses. The first are of Recent age; the second are probably Pleistocene, though possibly late Tertiary.

The geologic character of the Yukon-Tanana region may be summed up as follows: In the eastern portion large batholithic masses of granitic rocks have wide distribution, but toward the west these masses are more and more covered with the sedimentary rocks till only isolated areas of granitic rocks protrude through the sediments; the sedimentary rocks, though aggregating probably many thousand feet in thickness, form probably but a comparatively thin cover to the igneous mass beneath; in general, metamorphism gradually decreases from gneissoid rocks in the vicinity of the main intrusive bodies, through highly schistose rocks, to phyllites and but slightly altered argillites that exhibit contact phenomena where intruded by the isolated masses of granitic rocks; close folding is the rule, even in the Tertiary rocks, and in the oldest rocks closely appressed folds recumbent to the northwest are common; the distribution of mineralization is wide and appears to be more or less directly due to the intrusive rocks.

GEOLOGY OF THE FAIRBANKS QUADRANGLE.

GENERAL FEATURES.

It has been explained above (pp. 11–17) that the data at hand are by no means sufficient to permit the making of a complete geologic map of the Fairbanks quadrangle or the discussion of details of succession. Therefore the geology must be sketched on broad lines and many blanks must be left on the map. (See Pl. VIII, in pocket.) The areal mapping of the region adjacent to Fairbanks has been finished and the account of its geology will be made as complete as the facts warrant. The bedrock of this area is, however, in a large measure covered, on the slopes by a mantle of products of weathering and in the valleys by a heavy filling of alluvium, and study of it yields but little definite evidence of the stratigraphic sequence.

Although this report nominally covers the entire Fairbanks quadrangle, the geology of the region lying south of Tanana River will be touched upon only incidentally, for that region, which includes a part of the Bonnifield mining district and of the Tanana coal field, has recently been described by Capps, to whose report[1] those interested are referred.

The dominant structures of the Fairbanks quadrangle are closely appressed folds striking northeast and southwest. This trend has determined the general distribution of the stratigraphic units, which stretch in more or less irregular bands between the northeast and southwest quarters of the quadrangle. Near the central part of the western margin of the quadrangle, however, the formations show marked variation from the dominant strike, trending nearly east and west. The dominant folds are overturned to the northwest, so that the prevailing dips are to the southeast. The older schists are intensely crumpled and show many minor faults. Definite evidence of larger faults was not observed, but there is some reason to believe that such faults are present and that some of the contacts between the formations as mapped may have been planes of movement. The intrusive rocks are less regularly distributed, but these also have locally a roughly zonal arrangement, due probably to the fact that erosion has followed structural lines and thus revealed the underlying igneous rocks. (See Pl. VIII, in pocket.)

[1] Capps, S. R., The Bonnifield region, Alaska: Bull. U. S. Geol. Survey No. 501, 1912.

STRATIGRAPHY.

GENERAL SUCCESSION OF THE ROCKS.

The sketch of the geology of the Yukon-Tanana region (pp. 30–32) serves as an outline of the geology of the Fairbanks quadrangle. In this quadrangle the oldest rocks belong to the Birch Creek schist, which is probably of pre-Ordovician age. Above it lie Paleozoic rocks ranging from Ordovician to Carboniferous. The lowest, which unconformably overlies the Birch Creek schist, is the Tatalina group, made up chiefly of feldspathic fragmental rocks, with some argillites, tuffs, etc. Above the Tatalina group lie Paleozoic limestones 1,000 feet thick, which can not yet be differentiated but which range from Ordovician to Middle Devonian in age. As mapped, they are probably chiefly Devonian, except in the White Mountains, where older limestones may predominate. The Ordovician limestone is a massive, highly siliceous blue and white rock; the Devonian limestone is typically blue, is in large part argillaceous, and contains only a subordinate amount of chert.

A succession of black, red, and green argillites and sandstones, with some conglomerate and chert, called the Tonzona group, forms the next well-defined geologic division. These rocks, which are probably early Devonian in age and older than the Devonian limestone mentioned above, appear to rest unconformably on the older formations. Next above come undifferentiated greenstones, made up of basic volcanic lavas and tuffs, including, as mapped, some limestones, cherts, and slates. The greenstones are probably in the main Devonian, but some may be as old as Ordovician and some as young as Carboniferous.

The Carboniferous rocks include gray and black shales, slates, and cherts. Their relation to the Devonian has not been determined but is probably one of unconformity.

The Mesozoic is represented by carbonaceous shales, sandstones, and conglomerate of Upper Cretaceous age, unconformable on the older series. The extensive bodies of intrusive granites and granodiorite are probably chiefly of Mesozoic age.

Tertiary conglomerates, sandstones, and shales, with some lignitic coal beds, occur in two isolated patches. At one locality there is a basalt flow, which is probably also of Tertiary age. The numerous intrusive diabases which occur in some parts of the quadrangle are not indicated on the map. These were probably intruded in Tertiary time.

Terrace deposits, consisting of silts, sands, and gravels, are abundantly developed and are here provisionally assigned to the Pleistocene. Recent deposits include the silts, sands, and gravels of the present watercourses.

The following table shows the stratigraphic sequence:

Stratigraphy of Fairbanks quadrangle.

System.	Series.	Group or formation.	Description.	Notes.
Quaternary.	Recent.		Silts, sands, and gravels.	
			Unconformity	
	Pleistocene.		Terrace silts, sands, and gravels.	20 to 500 feet thick.
			Unconformity	
Tertiary (?).			Basalt.	Occurs only near Fairbanks.
Tertiary.	Eocene (?).		Conglomerate, sandstone, and shale, with some lignitic coal beds.	Occurs in only two small areas. Thickness probably 200 to 5,000 feet.
			Unconformity	
Cretaceous.	Upper Cretaceous.		Carbonaceous shales, sandstones, and conglomerate.	Occurs only in a small area near western margin of quadrangle. Thickness probably several hundred feet.
			Unconformity	
			Granitic and granodioritic intrusives (probably chiefly Mesozoic).	
Carboniferous.	Probably Pennsylvanian.		Gray and black shales, siliceous slates, with some cherts.	
			Unconformity (?)	
Probably chiefly Devonian.			Undifferentiated greenstones (tuffs, lavas, breccias), with some cherts and limestones.	Probably locally many thousand feet thick.
Devonian.	Middle Devonian.		Blue limestones and argillites.	Mapped with Silurian and Ordovician limestones.
			Unconformity (?)	
Devonian and Silurian (?).		Tonzona group.	Red, green, and black argillite, sandstone, and conglomerate. Includes locally some limestone and chert.	Probably several thousand feet thick.
			Unconformity	
Silurian.			Heavy blue magnesian limestone and interbedded shale.	Mapped together. Probably aggregating, with the Middle Devonian limestone, 1,000 feet or more in thickness.
Ordovician.			Heavy blue and white semicrystalline siliceous limestone.	
			Unconformity	
Ordovician (?).		Tatalina group.	Feldspathic fragmental rocks, with argillites and locally limestones, cherts, lavas, tuffs, and breccias.	Probably several thousand feet thick.
			Unconformity	
Pre-Ordovician (?).		Birch Creek schist.	Schistose quartzites and quartz-mica schists, with some garnet, amphibole, and carbonaceous schists and lenses of crystalline limestones.	Probably several thousand feet thick.

SEDIMENTARY ROCKS.

PRE-ORDOVICIAN (?) ROCKS.

BIRCH CREEK SCHIST.

Lithologic character.—The rocks grouped as Birch Creek schist are predominantly rather highly metamorphosed siliceous rocks, which, in most of the Yukon-Tanana region, probably rest on gneissoid intrusive rocks that are a phase of the batholithic intrusive masses. The Birch Creek consists of quartzite schists alternating with quartz-mica schists (Pl. IX, *B*), garnetiferous schists, feldspathic schists, carbonaceous schists, amphibole schists and more basic schistose rocks, and crystalline limestones. Their main characteristic and that in which most of them differ distinctly from the younger rocks is their content of mica.

The Birch Creek schist has in places been but partly metamorphosed and retains many evidences of its derivation from sedimentary rocks. In some occurrences the original detrital character of the constituents and the original structures are preserved. In rocks showing a somewhat more advanced stage of metamorphism the detrital character of the constituents has become obscured by the development of secondary quartz and mica, and the original structure has given place to secondary structures, the most prominent of which is the tendency of the rocks to split nearly parallel to the arrangement of the mica. Finally, by solution and recrystallization, the rearrangement of the material has become so complete that the structures and textures characteristic of sedimentary rocks have nearly disappeared and have been replaced by those characteristic of recrystallization under pressure. At the same time igneous rocks that were present in the original sedimentary beds have also been metamorphosed and converted into schists and gneisses. The most common types, however, are the quartzite and quartz-mica schists, and it is the preponderance of these types that gives the formation its character.

The amount of work done is not yet sufficient to warrant the subdivision of the Birch Creek schist. Apparently it becomes carbonaceous and in places somewhat calcareous. There is some evidence that the calcareous part of the formation is near its top.

Structure.—The geologic structure of the Birch Creek schist is very complex. Its general strike is northeast and southwest. In most places the rocks have been closely folded, and the planes of the axes of the folds have been thrust over to a nearly horizontal position, giving a pseudo-horizontal structure to many of the outcrops. (See Pl. IX, *A*.) Cleavage and jointing are generally developed in the schists, and cleavage is prominent in the more micaceous varieties.

Quartz veins are common. Some of them were formed previously to part of the folding and have been folded and crumpled along with the inclosing rock. Other veins formed at a later period cut across the structure of the schist or follow joint planes. (See p. 71.) Although the close folding precludes definite estimates, the Birch Creek schist is probably many thousands of feet in thickness.

Distribution.—The Birch Creek schist forms a broad belt extending northeast and southwest through the central part of the quadrangle, between the ridge northwest of the valley of the Chatanika on the west and the valley of Chena River on the east. This belt extends northeastward beyond the limits of the area shown on the map to the Birch Creek district, most of whose placers, like those of the Fairbanks district, lie within it. The schists also occur in the extreme southeastern part of the quadrangle, and similar schists south of the Tanana in the northern foothills of the Alaska Range are regarded as belonging to the same formation.

Age and correlation.—The Birch Creek schist was so called by Spurr[1] because it forms the bedrock in the Birch Creek region. Its age has not been definitely determined. The earliest fossils found in passing from it into the overlying rocks are Ordovician in age, and it is therefore possible that the Birch Creek is in whole or in part Cambrian.

PALEOZOIC ROCKS.

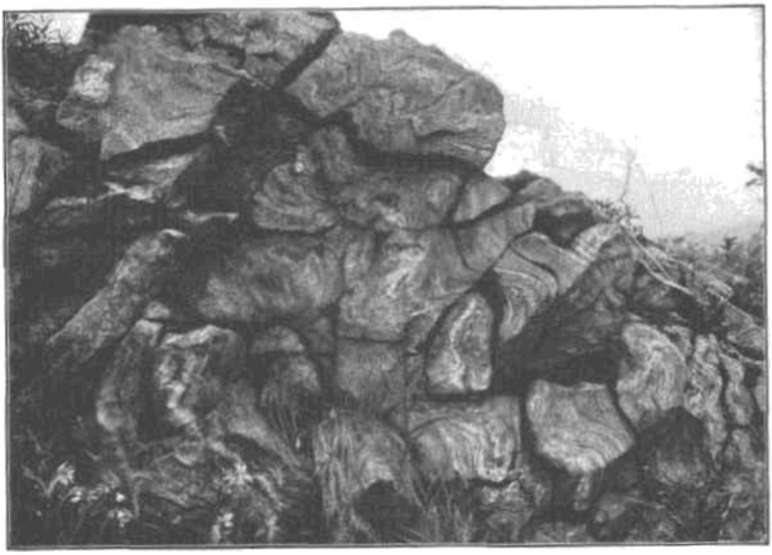
GENERAL FEATURES.

Nearly the entire western portion of the quadrangle is occupied by rocks regarded as Paleozoic. The evidence of fossils found at a few localities indicates that Ordovician, Silurian, Devonian, and upper Carboniferous rocks are present; and undoubtedly close study and detailed mapping will eventually resolve these into many formations.

This report discriminates four large divisions of Paleozoic sediments and one of undifferentiated greenstones, also of Paleozoic age (p. 51). The units used on the geologic map leave much to be desired, but they represent as high a degree of stratigraphic refinement as the information at hand will permit. Even the cartographic representation of these large divisions is far from being as accurate as that of the older Birch Creek schist. The difficulty in the mapping lies in the fact that in many places lithologic phases of one division closely resemble phases of another division. Lithology alone is therefore often an unsafe criterion of stratigraphic position, and fossils have been found at but few localities. The boundaries of these Paleozoic divisions should be regarded as approximate only.

The Paleozoic rocks are regarded as unconformable to the Birch Creek schist, but this relation is by no means evident everywhere

[1] Spurr, J. E., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 140.



A. CONTORTED SCHIST ON RIDGE NORTH OF MOSQUITO FORK.

B. INTERBEDDED SCHISTS AND QUARTZITES OF BIRCH CREEK SCHIST.

along the contact. Northwest from the area of the Birch Creek schist toward the White Mountains, near the Beaver Valley, the rocks lose their micaceous character to a large extent and give place to feldspathic quartzites and conglomerates interbedded with phyllites. These rocks are in places so schistose as to resemble the older Birch Creek schist, but their original sedimentary character is everywhere clearly evident. Therefore, though this section might be interpreted as representing a transition from the schists to less metamorphosed equivalents, the separation of these rocks from the Birch Creek schist is justified by the change in the lithology (the coarser beds of the oldest Paleozoic group being uniformly characterized by the presence of abundant feldspars) and by the abruptness with which the younger rocks begin to appear along a rather definite line extending northeast and southwest. The oldest Paleozoic rocks are in places considerably altered and resemble some of the less metamorphosed types of the Birch Creek schist.

TATALINA GROUP (ORDOVICIAN?).

Lithology.—The Tatalina group can be defined as an aggregate of feldspathic fragmental rocks, including conglomerates, sandstones, and graywackes, interbedded with argillites that are in places altered to phyllites. With these rocks occurs considerable chert. As mapped the Tatalina includes some limestone, which may or may not represent an integral part of the group. In the White Mountain region the Tatalina group includes considerable greenstone in the form of ancient tuffs and lavas lithologically similar to the rocks described as undifferentiated greenstones (pp. 51–52) but older than most of them. This group of rocks has been named from Tatalina River, within the valley of which they are typically exposed.

The most prominent types are the quartz-feldspar rocks, the argillites, and the cherts. The quartz-feldspar rocks are generally massive but locally schistose and occur interbedded with phyllites and argillites in beds from a few inches to many feet in thickness. They comprise both fine-grained and rather coarse-grained varieties, with feldspars up to half an inch in diameter. They are composed of rounded quartz and feldspar grains in a matrix of finely granular quartz, feldspar, and argillaceous material. In many outcrops much carbonaceous material is present, giving a dark color to the rock. A more common type is one containing a considerable proportion of ferruginous matter, which gives to the rock a rusty appearance. The schistose varieties of these rocks show the reduction of the quartz and feldspar grains more or less to augen and the development of considerable mica. The schistose character is not confined to the eastern margin of the Paleozoic rocks, in the vicinity of the Birch Creek schist, although it is there more pronounced, but is found also on the west side of the White Mountains. The rocks of argillaceous origin are phyllitic in the eastern part of the field and are rather perfect slates in places along the eastern base of the White Mountains. Some of the purple varieties split into slabs of considerable size and will apparently afford a roofing slate of good grade. The cherts are interbedded with black shaly slates and are whitish, bluish, gray, red, and black in color, flinty in character, and in thin section very finely cryptocrystalline. They are associated in some places with thin-bedded bluish limestone. Some red and green slates interbedded with sandstones in the area mapped as Tatalina are lithologically similar to those of the younger and unconformable Tonzona group.

The Tatalina group is distributed in broad zones stretching southwest and northeast through the central part of the quadrangle. These zones are bounded on the southeast by the Birch Creek schist and are interrupted by belts of younger rocks, to be described below. Rocks provisionally correlated with this group occur on the north side of the Chena Valley and south of the main schist belt.

Near the contact with the Birch Creek schist the Tatalina group consists predominantly of feldspathic conglomerate and sandstone, with interbedded argillites and cherts. In the White Mountains the group is represented by chert conglomerates and greenstones, with subordinate amounts of argillites and some limestone. In the west-central part of the quadrange the group is represented by graywacke, feldspathic conglomerates, phyllites, and cherts.

Structure and thickness.—The rocks of the Tatalina group are closely folded, many of the folds being overturned to the northwest. They have probably also been considerably faulted, but of this no direct field evidence is available. No measure of their thickness was obtained, but it probably aggregates several thousand feet.

Age.—The Tatalina group rests unconformably on the Birch Creek schist and is overlain in the White Mountains by limestone ranging in age from Ordovician to Devonian. In the conglomerate and tuff phase of this group, occurring in the eastern flank of the White Mountains, some fossils were found, most of which were pronounced Richmond (late Ordovician) by E. O. Ulrich. These and the other Paleozoic fossils are listed below.

Fossils from limestone of White Mountains, near contact of limestone and conglomerate, 56 miles N. 10° E. of Fairbanks.

Halysites gracilis.
Columnaria sp.
Cyathophylloides thomii.
Streptelasma rusticum.
Rhombotrypa cf. quadrata.
Plectambonites sericeus var.
Plectambonites n. sp.
Rafinesquina sp.
Dinorthis sp.
Triplesia sp.
Rhynchotrema aff. increbescens.
Raphistomina sp.
Cyclonema sp.
Dyeria? sp.
Liospira cf. progne.
Fragments of Isotelus sp.

All but five or six of the fossils in the collections are so imperfectly preserved that accurate determinations are almost impossible. However, from the general aspect of the faunule the bed from which it was procured seems quite certainly of Richmond age.

Later Silurian deposition (probably of Niagaran epoch) is indicated by a species of *Pentamerus* which occurs very abundantly in a magnesian limestone displayed in Brachiopod Gulch. The same species is known to occur at many localities in the Western States as far south as New Mexico. In all it succeeds a Richmond fauna similar to that listed above.

Finally, several poorly preserved specimens of two corals, both apparently of the genus *Favosites*, were collected in Limestone Creek. These indicate a Silurian or an early to middle Devonian age.

The fossil evidence indicates that the upper part of this group is Ordovician. It is by no means impossible that the lower part may be Cambrian, but provisionally these rocks will be referred to the Ordovician.

PALEOZOIC LIMESTONES.

Difficulties of differentiation.—The age of the Paleozoic limestones of the quadrangle is still the most important unsolved stratigraphic problem of the area. Unfortunately the exigencies of the field work did not permit the differentiation of the several limestones which on fossil evidence are known to range in age from Ordovician to Devonian, and all of them, together with some interbedded slates and other rocks, have been mapped as a single unit. The limestones, however, show certain lithologic differences, which in connection with the evidence afforded by fossils will eventually serve as a basis for their separation. These rocks, which may aggregate 1,000 feet or more in thickness, will be described so far as the notes in hand will permit.

No direct evidence has been procured in regard to the stratigraphic relations of the different limestones. It is probable, however, that the Ordovician limestone is unconformable to the older Tatalina group and that no stratigraphic break occurred between the Ordovician, Silurian, and Devonian limestones.

Character and distribution.—The White Mountains, where these limestones are typically developed, present an instructive section. Along the eastern base lie the interbedded quartzites and slates, succeeded, toward the main ridge, by cherts and interbedded dark shales, basalt, tuffs, conglomerate, all referred to the Tatalina group, and finally by the limestones that form the top of the ridge. (See Pl. X, *A*.) The contrast between the dark-green color characteristic of the volcanic and associated rocks and the whiteness of the limestone serves to emphasize the relation of the two where the limestone of the crest arches over the darker rocks that form the core of the ridge. The rocks are closely folded and are nearly vertical in the main portion of the ridge, except where the limestone extends over the older rocks. (See fig. 3.)

Fossils found in the conglomerate beds of the Tatalina group just below the massive limestone and in the limestone a short distance above the base proved to be Ordovician. Other fossils, found along the eastern base of the main ridge close to Fossil Creek, in a gray magnesian portion of the limestone stratigraphically considerably above the base, proved to be Silurian. Still other fossils, found farther southwest, in the top of the ridge close to the point where Fossil Creek cuts it, were determined mostly as Middle Devonian. Although the White Mountains have been studied at but a few points, it seems fairly well established, therefore, that the underlying volcanic rocks, conglomerates, and slates are in part at least of Ordovician age, and that the overlying massive limestones form a continuous mass, including Ordovician, Silurian, and Middle Devonian.

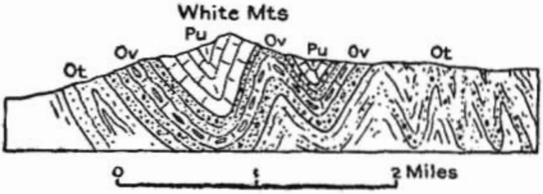
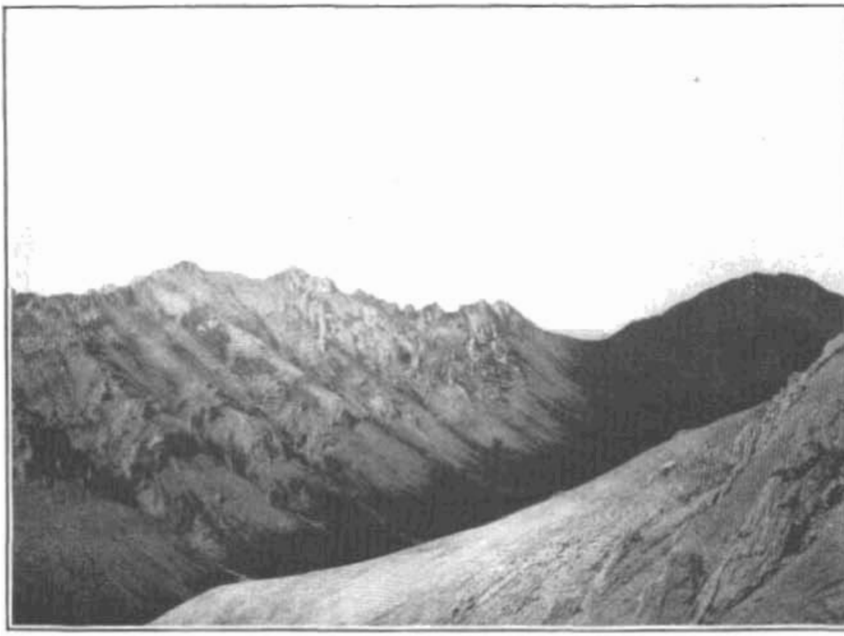


FIGURE 3.—Diagrammatic section of White Mountains near Fossil Creek. Pu, Paleozoic, undifferentiated = Ordovician, Silurian, and Devonian limestones; Ov, Ordovician volcanic rocks (lavas, tuffs, and breccias) of Tatalina group, with some cherts, conglomerates, and limestones; Ot, Ordovician sedimentary rocks of Tatalina group (conglomerates, sandstones, quartzites, etc.).

Northwest of the White Mountains across Beaver Creek another ridge, formed of greenstone, some limestone, and dark shales, probably represents the same sequence as that of the White Mountains. Although no fossils have been found in this ridge, it is believed that the rocks form the extension of the dark shales with some limestone, which in the western part of the quadrangle have furnished Silurian and Devonian fossils. Still farther northwest, in the ridge close to the southern edge of the Yukon Flats, occurs another belt of limestone, with which is associated a little volcanic material, a considerable amount of interbedded greenish quartzite, and some greenish and reddish shales correlated with the Tonzona. The limestones should probably also be correlated with those of the White Mountains.

The massive limestone of the White Mountains, as shown on the geologic map (Pl. VIII, in pocket), persists to the southwest for a considerable distance but narrows very rapidly, suggesting that the conditions of deposition were comparatively local. This phenomenon may, however, be due to close folding or faulting. No Ordovician or



A. TYPICAL EXPOSURES OF PALEOZOIC LIMESTONES IN THE WHITE MOUNTAINS.

B. RESIDUAL GRANITE BOSSES ON DISSECTED PENEPLAIN.

Silurian fossils have been found in the southwestern extension of this limestone. In the small area of limestone lying between Tolovana and Tatalina rivers a few Devonian fossils have been found. The limestone also shows a rapid change in character laterally and toward the northwest is interbedded with argillaceous and quartzose sediments. The volcanic materials also become less abundant to the southwest along the strike. They appear in the middle belt to a less extent than in the White Mountains and are present only sparsely in the northern belt.

Ordovician limestone.—The Ordovician limestone is a heavily bedded siliceous blue and white crystalline rock. It has been definitely recognized only in the White Mountains, where it forms the lower portion of the main mass of the upper part of the range, occurring as a closely folded syncline, which rests on the conglomerate and greenstone member of the Tatalina group. Stone has noted similar limestones north of the lower valley of Beaver Creek, but positive proof of the identity of the two is lacking. Some greenstones occur with this limestone, but volcanic activity seems to have died out at the close of the Tatalina, to recur in Devonian time. The Ordovician portion of the limestone probably does not exceed a few hundred feet in thickness.

Silurian limestone.—Silurian limestones have been recognized only in the White Mountains, where they succeed the Ordovician limestones. The typical rock is a blue, rather heavily bedded magnesian limestone. No measure of thickness was obtained, but it is probable that the formation does not exceed 100 feet.

In addition to the above some limestones in the western part of the quadrangle have been found to contain doubtfully Silurian fossils. Descriptions of these fossils are included in the account of the Devonian limestone below.

Devonian limestone.—The Devonian limestone is typically a blue, rather massive rock, commonly containing only subordinate amounts of silica. Where it has been recognized within the quadrangle it is commonly associated with slates and in many places with various types of greenstones.

The Devonian limestone is known to occur at the top of the section in the White Mountain region in the ridge between Tatalina and Tolovana rivers as well as in small areas in the west-central part of the quadrangle. It also occurs in small scattered areas within the region mapped as undifferentiated greenstone. The Devonian limestone may rest unconformably on the older formations, but this has not been verified by direct field observation.

Most of the fossils found in the limestone are of Middle Devonian age, and the rock seems to belong to the Middle Devonian series, which is widely distributed in Alaska.

Paleozoic fossils.—From the fact that the Ordovician, Silurian, and Devonian limestones have not been differentiated, and that so far as the present field evidence indicates they form one body of limestones in the White Mountains, their fossils are here listed together.

The following report on fossils collected in 1909 is by Edwin Kirk:

The material on the whole is very poorly preserved, so that exact determination of the fossils is extremely difficult, and many of those that are determinable represent new species. Hence any conclusion regarding the age of the deposits must be reached mainly through a consideration of the general aspect of the faunas and the genetic affinities of their constituent species. It is thought however, that the stratigraphic assignment of the several lots is fairly accurate.

Richmond fossils (late Ordovician).

Lot 9AJ 70. Fossils in limestone of White Mountains, 56 miles N. 10° E. of Fairbanks, Alaska.

Halysites gracilis Hall var.
Columnaria? sp.
Streptelasma sp.
Cyathophylloides thomii (Hall).
Rhombotrypa sp.
Triplesia sp.
Plectambonites sericeus (Sow.) var.
Plectambonites n. sp. (same as at 9AP 87).
Rhynchotrema increbescens H. and C. var.
Rhaphistomina sp.
Maclurea?
Cyclonema sp.
Liospira cf. progne (Bill.).
Isotelus (fragments).

The above fossils will be discussed with lot 9AP 87, next to be considered, which is essentially identical.

Lot 9AP 87. Fossils from limestone of White Mountains, from near contact of limestone and conglomerate, 56 miles N. 10° E. of Fairbanks, Alaska.

Streptelasma rusticum Bill.
Rhombotrypa.
Plectambonites n. sp. (same as at 9AJ 70).
Rhynchotrema increbescens H. and C. var.
Rafinesquina sp.
Dinorthis sp.
Dyeria (?).
Isotelus (fragments).

Lots 9AJ 70 and 9AP 87 are certainly referable to the Richmond. Some discordant elements, however, seem to indicate a late Black River or early Trenton age. If these fossils were collected on a talus slope they may well have been slightly mixed. Otherwise the earlier fossils might have occurred in pebbles embedded in the sediments of Richmond age. There is really but one specimen that, if correctly identified, indicates an age earlier than Richmond. This is a badly weathered and very imperfect gastropod, doubtfully referred to *Maclurea* under lot 9AJ 70, and not very much importance should be attached to it. I should, then, consider these beds as of Richmond age, an admixture of Black River and Trenton types being possibly found in included limestone fragments.

Silurian fossils.

Lot 9AJ 82. Fossils in limestone of White Mountains; Brachiopod Gulch, 53 miles N. 9½° E. of Fairbanks, Alaska.

Pentamerus sp.

This *Pentamerus* is unquestionably of Silurian age, but as it was not found in a standardized section the exact stratigraphic equivalence of the beds carrying it has not been definitely established. It will no doubt prove to be of approximately Niagaran age. The same species ranges as far south as New Mexico.

Lot 9AP 94. Fossils in limestone of White Mountains, N. 25° W. of Cache Mountain; Brachiopod Gulch, 53 miles N. 9½° E. of Fairbanks, Alaska.

This collection is identical with that of lot 9AJ 82.

Lot 9AJ 84. Corals in limestone of White Mountains at SW. end of Long Gulch (Limestone Creek, flowing northeastward), 48 miles N. 6° E. of Fairbanks, Alaska.

Favosites (2 species).

Lot 9AP 99. Fossil corals from Limestone Creek, White Mountains, 48 miles N. 6° E. of Fairbanks, Alaska.

Favosites sp.

The corals in the two lots listed above are probably referable to Favosites, but the material is very poorly preserved, owing to replacement by dolomite. A number of thin sections made of the specimens failed to give even approximately satisfactory results.

It seems fairly safe to refer the containing beds to the Silurian, but it is impossible to place them within narrower limits.

The following report on fossils collected in 1904 is by E. M. Kindle:

Fossils from the White Mountains.

Lot 4 AP 240. This lot contains two corals, a *Michelina* and a *Zaphrentis*, neither of which is specifically determinable. Probably Devonian.

Lot 4 AP 241. *Favosites* near *epidermatus* occurs in this collection, indicating Middle Devonian age.

Lot 4 AP 242. Specimens of a coral comparable with *Favosites winchelli* comprise the collection from this locality. Probably Middle Devonian.

Lot 4 AP 243, 245, and 246. These lots represent the same horizon. The fauna represented in the collection comprises a single species of brachiopod *Gypidula* cf. *pseudogaleatus*. Late Silurian or early Devonian, probably the latter.

Lot 4 AH 186. Includes only poorly preserved specimens of *Cladopora*. Probably Middle Devonian.

Lot 4 AH 193. The fossils represented are *Cytherella* sp., *Cladopora* sp., and *Ptilodictya?* cf. *frondosa*. Probably Silurian.

Lot 4 AH 194. *Favosites* near *limitaris* occurs in this lot, indicating a horizon probably near Middle Devonian.

Lot 4 AH 195. Contains an undetermined *Stromatopora*. Probably Devonian.

Fossils from the Rampart region.

Lot 4 AP 303. Two poorly preserved specimens of *Aulacophyllum* comprise this lot. May be either Devonian or Silurian.

Lot 4 AP 317. Minute fragments of small corals in a breccia. Too fragmentary for determination of age.

Additional material from the Rampart region collected during 1907 was also referred to Mr. Kindle, and the following is taken from his report:

Lot 7 AP 277 (Quail Creek). This lot contains several species of corals and fragmentary representatives of a large lamellibranch and a gastropod. They are referred provisionally to the following genera:

Cladopora?
Syringopora.
Amplexus?
Streptelasma?
Diphyphyllum.
Megalomus??
Pleurotomaria?

The minute characters used for specific limitation in corals are not well enough preserved in this material to justify any attempt at specific determination. Since the genera noted are all common to both the Devonian and the Silurian, they afford no definite evidence as to which the corals represent. The chief interest of the collection lies in the lamellibranch fragments, which represent a very large, thick-shelled form that appears almost certainly to be specifically identical with a shell occurring in the limestones of Glacier Bay and similar beds at Freshwater Bay in southeastern Alaska. This southeastern Alaska shell has been referred to the genus *Megalomus* and is considered to belong to a late Silurian fauna.

Lot 7 AP 318 and 7 AP 320 (Head of Little Minook Creek). This material has yielded four or five species of brachiopods, represented by very poor fragments, so that even approximate determination is difficult. They may be tentatively referred to the following genera:

Chonetes?
Stropheodonta.
Delthyris?
Amphigenia?
Rhipidomella?

The determination of *Stropheodonta* is based on a fragment of a single valve, but the distinctly denticulated hinge line leaves but little doubt of its correctness. This genus is unknown in the Carboniferous "and is emphatically characteristic of the Devonian." *Amphigenia*, which is believed to be represented by a fragmentary mold of a pedicle valve, is also limited to the Devonian. The specimen referred to *Delthyris?* is unique in its ornamentation and may possibly belong to another genus. There are also two other doubtfully determined genera of brachiopods, represented by fragments. The small gastropods, which are represented by molds belonging to two or three species, contribute no evidence as to the age of the fauna. Although more and better material is needed to determine the horizon with certainty, it is believed that the forms determined as *Stropheodonta* and *Amphigenia?* necessitate placing the fauna in the Devonian, at least provisionally.

The occurrence of this fauna in conglomerates interbedded with black shales leads me to believe that it belongs near the top of the Devonian of the Yukon section, in beds corresponding to the black shales of the Calico Bluff section.

The fauna is quite unlike any other Alaskan fauna which has come under my observation, but for the reasons already stated it should, in my judgment, be placed provisionally in the Devonian.

TONZONA GROUP (DEVONIAN AND SILURIAN?).

A series of red, green, and black argillites, conglomerate, and sandstone, including some chert, is here correlated with the Tonzona[1]

[1] Brooks, Alfred H., The Mount McKinley region: Prof. Paper U. S. Geol. Survey No. 70, 1911, pp. 73–76.

group. Locally some limestones are included in the Tonzona as mapped. The information gained in regard to these rocks is far from being conclusive in regard to their stratigraphic position. In some places they have been found in such close association with the Tatalina group that they might be regarded as a member of it. On the other hand, Brooks[1] obtained what seemed to be fairly conclusive evidence that they are younger. He also maintained that they were older than the Devonian limestone, but of this there is no direct evidence within the Fairbanks quadrangle. As these rocks have already been mapped as a separate stratigraphic unit it has seemed best, in the absence of evidence to the contrary in the area here under discussion, to maintain this classification. In the area mapped by Stone in the northeastern part of the quadrangle the rocks correlated with Tonzona are made up of rather coarse conglomerates with sandstones and slates of various colors. On the Tanana the group is represented by fine quartz conglomerates, sandstones, and red and green slates. Stone's evidence[2] goes to show that these rocks rest unconformably upon a heavy limestone which is probably Ordovician or Silurian. Brooks's evidence on Tanana River indicated that the Tonzona group had an unconformable relation to rocks now correlated with the Tatalina group. In the intermediate area the exposures of these rocks are poor and but little evidence was obtained as to their stratigraphic relations.

The Tonzona group as thus defined stretches through the central part of the quadrangle in several belts. As it is believed to bear an unconformable relation to the older rocks it is likely to be found in juxtaposition to any of these. The rocks along the western boundary have been included provisionally with the Tonzona.

The Tonzona group in the areas where originally described has thus far yielded no fossils. Its stratigraphic relations as above indicated are obscure, but it is believed to be younger than the Ordovician and Silurian limestones of the region, and the rocks along the western boundary, which have here been mapped with the Tonzona, have yielded Devonian fossils. It will, therefore, here be provisionally assigned to the Devonian, with the warning that it may be in part Silurian.

CARBONIFEROUS ROCKS.

Character and distribution.—The recognized Carboniferous within the quadrangle includes gray and black shale, siliceous slate, some chert, and probably some limestone. These rocks form a belt lying adjacent to rocks of the Tonzona group in the headwater region of Hess Creek near the northern boundary of the quadrangle. The

[1] Op. cit., p. 75.

[2] Unpublished notes.

western limit of these rocks has not been mapped, but it seems probable that they occur in a syncline. As the strata along the southern boundary of the group appear to dip to the southeast under the Tonzona rocks, which are believed to be older, it is evident that the fold must be overturned. It seems probable that the Carboniferous may be extensively developed within the unmapped northern margin of the quadrangle. It is also not impossible that Carboniferous rocks which have not been recognized may be folded in the older formations of other parts of the quadrangle.

Age and correlation.—The fossils collected from this formation have been studied by George H. Girty, whose report, already published,[1] is as follows:

Fossils from near Yukon Flats and from Hess Creek, Alaska.

4 AH 213.

Stenopora 2 sp.	Rhombopora sp.
Fenestella sp.	Productus? sp.
Rhombopora sp.	Lima? sp.

4 AP 270.

Fistulipora sp.	Rhombopora sp.
Stromatopora? sp.	Rhombopora sp.
Coral sp.	Spirifer n. sp.?
Fistulipora sp.	Hustedia cf. H. compressa Meek.
Fistulipora? sp.	

4 AP 277.

Coral? sp.	Polypora? sp.
Lithostrotion? sp.	Archimedes? sp.
Fistulipora 3 sp.	Productus sp.
Rhombopora sp.	Euomphalus sp.

The presence of the form identified as *Hustedia compressa* seems to show that lot 270 belongs in the Pennsylvanian, perhaps in the "Permo-Carboniferous." The ages of the other lots, although without much doubt being Carboniferous, are less certain. While probably no species is common to all three collections, yet in a general way the facies is much the same, and it is quite possible that all represent the same fauna.

It will be observed that the forms in only one collection have been identified specifically In many collections the material is too imperfectly preserved to admit of more than the genus being determined. In others the species are distinct from those of the Mississippi Valley sections and are entirely new unless some of them have been described in European and Asiatic publications not included in my bibliography and therefore difficult of reference.

I have consulted freely with Mr. Bassler wherever the Bryozoa were concerned.

The above determinations indicate a horizon not recognized in the Carboniferous of the upper Yukon, where the Carboniferous sequence

[1] Prindle, L. M., The Fairbanks and Rampart quadrangles: Bull. U. S. Geol. Survey No. 337, 1908, p. 23.

has been determined in some detail by Brooks and Kindle.[1] Their stratigraphic sequence is shown in the following table:

Carboniferous section, upper Yukon River.

Series.	Lithologic character.	Locality.
Upper Carboniferous.	Heavy limestone (invertebrate fossils).	Yukon River near mouth of Nation River, upper White River valley.
Lower Carboniferous.	*Unconformity?* Nation River formation, conglomerates, sandstones, and shales (plant fragments).	Yukon River at mouth of Nation River.
	Unconformity? Calico Bluff formation; thin-bedded limestone, slates, and shales; some igneous rocks (invertebrate fossils). *Conformity.*	Calico Bluff and other points on upper Yukon River, also on Porcupine River.

The upper and lower Carboniferous of the above section carry invertebrate fossils which have been determined by Girty.

The middle formation (Nation River) yielded a few plant fragments provisionally assigned to the Pennsylvanian by David White. It has been shown that the Carboniferous of the Fairbanks quadrangle has yielded only Pennsylvanian fossils, and it can therefore be represented in the above section only by the Nation River formation. This, however, is made up of coarse clastic material and bears but little resemblance to the Carboniferous rocks here under discussion. Two interpretations of these facts are possible. First, the Nation River, whose typical exposures are about 200 miles east of those of the Carboniferous here under discussion, may change its lithologic character and grade into finer sediments. Second, the Carboniferous of the Fairbanks quadrangle may represent a formation which belongs between the Nation River and the Calico Bluff, but which was eroded before the deposition of the former. On the whole this latter explanation seems the more probable. It should also be noted that the Nation River formation may be represented within the Fairbanks quadrangle by some of the conglomerates and slates which may have been erroneously assigned to an older formation.

MESOZOIC ROCKS.

CRETACEOUS ROCKS.

An area of rather massive black sandy shales, fine-grained black shales, and conglomerates composed of quartzite and black slate pebbles occurs near the western limit of the quadrangle. These rocks are especially well developed along the eastern or northeastern flanks of the Wolverine Mountains. The conglomeratic portion where observed had a thickness of about 10 feet and forms a basal conglom-

[1] Brooks, Alfred H., and Kindle, E. M., Paleozoic and associated rocks of the upper Yukon, Alaska: Bull. Geol. Soc. America, vol. 19, 1908, pp. 262, 291–304.

erate resting on quartzites and shales regarded as Paleozoic. The rocks are folded, have been intruded by granitic rocks, and contain many quartz veins. The thickness is not determined but is probably not more than a few hundred feet. Fragments of dicotyledonous leaves and a part of an indeterminable bivalve were collected from these rocks in 1905. Partly on that basis and partly on their lithologic character they were assigned to the Cretaceous. In 1907 additional material was obtained. The following statement is taken from the report of T. W. Stanton on this material:

While the fossils are fairly well preserved, they have been considerably distorted, so that it is not practicable to make specific determination. The better preserved forms appear to be undescribed. The following list will show the forms recognized in each lot.

4278. 7 AP 271 (Spur of Wolverine Mountain).

Hemiaster? sp.	Lucina sp.
Pecten sp.	Pleuromya sp.
Inoceramus cf. labiatus Schloth.	Pachydiscus sp.
Cucullæa sp.	Pachydiscus? sp.

4279. 7 AP 278 (Ridge on left limit south fork of Quail Creek).

Hemiaster? sp.	Pachydiscus sp.
Cucullæa sp.	Pachydiscus? sp.

4280. 7 AP 279 (Right limit south fork of Quail Creek).

Pachydiscus sp.

These fossils evidently all belong to practically a single horizon, which is confidently referred to the Upper Cretaceous. * * * The species of *Inoceramus* is very likely one that has been previously found on the Yukon, but the specimens in the present collection are too imperfect to serve as the basis for a positive identification. The most important forms are ammonites, which make up the bulk of the collection and which I have referred, in some cases doubtfully, to the genus *Pachydiscus*. These are unquestionably Upper Cretaceous types.

Further work may show that a portion of the area mapped as Paleozoic in the western part of the quadrangle is made up of Mesozoic rocks.

CENOZOIC ROCKS.

TERTIARY ROCKS.

Tertiary rocks, probably chiefly of Eocene age, have a wide distribution south of the Yukon between Eagle and Circle. In the Fairbanks quadrangle, however, only two localities of rocks regarded as Tertiary have been noted north of Tanana River, one of them on the Yukon opposite the mouth of Hess Creek and the other in the northwestern part of the area covered by the special map of the Fairbanks district. (See Pl. XI, in pocket.) At the former locality the rocks include conglomerate containing many chert pebbles, sandstone, shale, clay, and lignitic coal beds. They dip at high angles. They strike across the Yukon toward the Hess Creek valley and to judge from fragments of conglomerate found within this valley extend to the eastward. The coal deposits associated with them are described later. (See pp. 151–152.) The rocks of the Fairbanks district regarded as Tertiary consist of brown micaceous sandstone and conglomerate composed principally of schist fragments, vein quartz, and some granitic material. The sandstones contain carbonized plant remains but no coal beds. The Tertiary coal-bearing rocks are abundantly developed south of the Tanana in the Bonnifield region.[1]

The Tertiary plant remains of the Hess Creek locality on the Yukon have been definitely assigned by F. H. Knowlton and Arthur Hollick[2] to the Kenai formation. The other areas of Tertiary rocks have not received a definite age assignment. Some of them may be younger than the Kenai.

QUATERNARY DEPOSITS.

The unconsolidated materials, comprising mainly silt, sand, gravel, slope wash, and talus, present a succession of deposits, the oldest of which is probably Pleistocene and the youngest Recent. They are separable into those that have been deposited under conditions somewhat different from the present and those deposited under present conditions. To emphasize the presence of the older deposits grouped under the general term Pleistocene, they are separately indicated on the geologic map. The areas indicated, however, are by no means expressive of their actual distribution, but indicate only such as have been under some degree of observation or are evident from the character of the contouring. Furthermore, the older deposits are mostly covered with a mantle of slope wash or other material formed under present conditions. All of these deposits are alike in having kept their original position of horizontality, but members of the older group are found at elevated positions with reference to the present drainage, and it is their elevated position that has been utilized in demarcating them on the map.

Pleistocene deposits.—The changes in elevation with reference to sea level which the Yukon region has undergone have left rock-cut benches at various levels, some of which are independent of present drainage lines. Alluvial deposits have been left on some of the lower benches, and at one locality just off the western edge of the quadrangle such deposits occur at a height of 500 feet above the present

[1] Capps, S. R., The Bonnifield region: Bull. U. S. Geol. Survey No. 501, 1912, pp. 26–29.
[2] Chiefly in unpublished notes, but Knowlton's determination is referred to in "Coal resources of the Yukon," by Arthur J. Collier: Bull. U. S. Geol. Survey No. 218, 1903, pp. 17 and 42.

drainage, and consist of nearly 100 feet of gravel, both coarse and fine, well waterworn, and composed of material found in place elsewhere in the same drainage system. Similar deposits occur also in the valley of Troublesome Creek near the western edge of the quadrangle, and these are in all probability to be correlated with those farther west. Other bench gravels have been observed at numerous other localities, though not at so high an elevation, within the quadrangle north of the Tanana. In the vicinity of the Tanana, however, notably in the Fairbanks district, the deposits at elevations above the present drainage comprise a large proportion of fine silt composed largely of angular and rounded minute quartz grains and clay. These silts in places overlie a bed of bench gravels, and in places gravels are interbedded with them. Elsewhere there are beds of comparatively pure ice up to 40 feet in thickness. (See pp. 93 and 108.)

The gravels are everywhere well waterworn, well stratified, and are those characteristic of deposition by stream action. The silts are probably largely of lacustrine origin, conditions in the interior of Alaska having been preeminently favorable for the development of flat valleys. On many streams thick accumulations of ice persist throughout a large part of the summer, forcing the streams out of their channels and compelling them to work largely against the valley sides. The tendency is thus to widen rather than to deepen the valleys. The stream becomes distributed in many channels over flats of considerable extent, the drainage of the abandoned portions becomes so poor that lacustrine conditions prevail, and lakes become characteristic of the larger valleys. Moreover, the development of the Yukon system was at one time retarded, probably by the slowness with which the river cut through the hard granitic intrusive rocks at what are now the rapids on the Yukon, about 35 miles above the mouth of the Tanana, and the retardation naturally operated to produce lacustrine conditions, of which silt deposits are characteristic. Conditions have thus been favorable for the accumulation of extensive silt deposits throughout a large portion of the Yukon and Tanana drainage systems.

The terrace deposits have yielded no fossils and are here referred to the Pleistocene. They should probably be correlated with the other terrace deposits of the Yukon, including the White Channel gravel of the Klondike, the terrace deposits of Fortymile, of the upper Yukon, and of Minook Creek. They are not to be confused with the extensive gravel sheet which mantles the southern margin of the Tanana Valley. These, termed the Nenana gravel, are regarded by Capps[1] as of Tertiary age.

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[1] Capps, S. R., The Bonnifield region, Alaska: Bull. U. S. Geol. Survey No. 501, 1912, pp. 30–34.

Recent deposits.—The deposits of the present streams include silt, sand, and gravel. In most valley deposits the gravels lie next to bedrock and are overlain by silt, intermixed toward the surface with considerable vegetable material, the mixed product being termed "muck" by the miners. The gravels of the smaller valleys consist of subangular fragments of bedrock intermixed with much fine material of the same nature. The proportion of bowlders is small. The gravels of the larger valleys are well rounded and embrace a considerable variety of lithologic types. The maximum thickness of the alluvial deposits, so far as shown by the operations of mining, is over 300 feet, most of which is permanently frozen. Lenticular masses of ice occur in places intercalated in these deposits and veins of ice have been observed cutting them. More detailed descriptions of the alluvial deposits are to be found in the description of the placers.

IGNEOUS ROCKS.

ROCK TYPES.

Most of the igneous rocks of the quadrangle fall into five groups, namely, (1) greenstones of effusive origin and probably chiefly of Devonian age; (2) older gneissoid granites, probably of pre-Ordovician age; (3) massive diorites, granites, etc., probably intruded chiefly in Mesozoic times; (4) diabase and other basic dikes, probably of Mesozoic or Tertiary age; and (5) basalt flows, probably of Tertiary age. Of these, the greenstones are mapped as a separate cartographic unit; the two granitic types are not differentiated, but are mapped together as intrusives; and the diabase dikes are not shown on the map at all. The basalt occurs within the area covered by the detailed map of the vicinity of Fairbanks and will be described in the account of that region. (See p. 74.)

EFFUSIVE ROCKS.

CHARACTER AND DISTRIBUTION.

The undifferentiated greenstones are made up of diabasic and basaltic flows, tuffs, and breccias. They are characterized by a general green color and though folded are usually rather massive. They include principally ordinary diabase with ophitic structure (which also occurs in many places as dikes), serpentine, basalt carrying augite phenocrysts in an augitic and glassy groundmass with a little labradorite, basalt with biotite and a larger proportion of plagioclase, and olivine basalt. Some limestones, some cherts, and a less quantity of argillites are so intimately intermingled with these igneous rocks that they probably could never be differentiated even with the most detailed mapping.

The largest area of these greenstones, a complex of igneous rocks with some intermingled sediments, lies in the northwestern part of the quadrangle along the Yukon and southward to Hess Creek. Similar greenstones occur in the valley of the Tolovana and in the Chena River basin in the southeastern part of the quadrangle. These areas are less well known but seem to include few sedimentary rocks. Greenstones occur also along both flanks of the White Mountains, but these are regarded as belonging to the Tatalina group and hence are older than most of those here described, which, as will be shown, are probably chiefly Devonian.

AGE AND CORRELATION.

Spurr,[1] who first described this great complex of igneous rocks, termed them the Rampart series, applying this name especially to their igneous portions, though he included also under this term some associated limestone. He provisionally referred the Rampart "series" to the Silurian. It has been shown that there are some greenstones in the Tatalina group (Ordovician?), and to this some of those described above may belong.

Brooks and Kindle[2] collected fossils which show that the limestones associated with the greenstones of the upper Yukon are of Middle Devonian age, and this age determination will probably be found to hold for most of the greenstones of the Fairbanks quadrangle. The volcanic outbursts which furnished these rocks seem to have been comparatively localized, for though these greenstones are very abundant on the Yukon above Hess Creek they do not occur in association with the Devonian limestones of the White Mountains,[3] but are found again 100 miles to the east.

INTRUSIVE ROCKS.

ROCK TYPES.

The intrusive rocks are with few exceptions representatives of the granito-dioritic group, and by far the largest part of them are granites. A small proportion of the granitic rocks was intruded at a period antedating the metamorphism of the schists and was metamorphosed along with the latter into granite gneisses. Most of the granitic rocks and those of intermediate composition were probably intruded during the same general period of intrusion in the Mesozoic. From the close relationship of all the intrusive rocks they are represented on the geologic map by the same color. A glance at the

[1] Spurr, J. E., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 155–169.

[2] Brooks, A. H., and Kindle, E. M., The Paleozoic and associated rocks of the upper Yukon basin: Bull. Geol. Soc. America, vol. 19, 1908, pp. 281–284.

[3] The greenstones of this region are believed to be of Ordovician age.

map shows the widespread distribution of these rocks and the comparatively small size of individual areas. Many of the domes consist mostly of granite. (See Pl. X, *B*.)

GRANITIC AND RELATED ROCKS.

Biotite granite is the most common type of granitic rock. Most of it is porphyritic, with feldspar phenocrysts measuring up to an inch or more at some localities, as in the ridge south of Gilmore Creek in the Fairbanks district, and in other localities averaging about a half inch, as in much of the granitic mass at the head of Hope Creek. The mineral composition is fairly uniform over the entire area, quartz, orthoclase, microcline, and biotite being the predominant constituents, accompanied in many places by considerable oligoclase or albite. Small dikes composed mainly of irregular grains of quartz and feldspar are rather common in the biotite granite. Some of these are somewhat coarsely pegmatitic in character. They are described in more detail in connection with the Fairbanks district (pp. 68–74).

At the head of Hope Creek the biotite granite is in places so impregnated with tourmaline as to form a tourmaline granite, in which the tourmaline occurs in irregular grains and spongy masses, replacing in part the feldspar. At this locality fluorite also is abundant as veins, along with quartz and iron pyrites, in the schist adjacent to the intrusive mass. Small grains of fluorite were observed in the intrusive rock itself.

A light-colored dike of tourmaline granite was observed cutting the massive limestones of the White Mountains, and this small area is represented upon the geologic map. The only contact effect observed was the alteration of the limestone to a white, finely crystalline marble.

Sills and dikes of granite porphyry occur in the schists at the heads of Bachelor and Faith creeks, in the northeastern part of the quadrangle. The rocks are composed of quartz and feldspar phenocrysts in a groundmass of quartz and feldspar and a little mica. The groundmass, though in most places clearly granular, is very fine grained and aphanitic near the margins of the masses. These rocks appear as knobs on the ridges. Some of them have been reddened by iron and some have been considerably mineralized; on Homestake Creek gold has been found in the immediate contact area of these rocks with the schists.

SYENITIC ROCKS.

The only syenitic rocks observed in the Yukon-Tanana region occur in a small area east of Cache Mountain on Bear Creek. The most common type is a porphyritic rock with trachytic structure, composed chiefly of tabular orthoclase and pyroxene with a little biotite.

HORNBLENDE GRANITE.

Hornblende granite occurs at a few localities. It is similar to the biotite granite, except that it contains hornblende, more plagioclase, and less biotite, being transitional on the one hand to monzonitic rocks and on the other hand to quartz diorites. A mass of this rock about 1,000 feet wide forms part of the summit of Wolverine Mountain, in the western part of the quadrangle. It is a porphyritic gray rock composed chiefly of quartz, phenocrysts of orthoclase a half inch or more in diameter, considerable plagioclase, biotite, hornblende, and a little diopsidic pyroxene. A similar rock occurs west of the mountain with coarser feldspars, some of them an inch or more in diameter, with tabular development. It contains less quartz and more pyroxene. The rock is transitional to the monzonitic type.

MONZONITIC ROCKS.

Closely associated with these pyroxene granitic rocks in the western part of the quadrangle are monzonitic rocks ranging in color from dark brown to black. The rock is composed of about equal proportions of orthoclase and plagioclase, embedded in the orthoclase, abundant pale-green diopsidic pyroxene, conspicuous reddish-brown biotite, and some olivine the grains of which are frequently fringed with hypersthene. There is some apatite and in some specimens much magnetite.

Numerous dikes up to a few feet in thickness in this portion of the quadrangle are composed predominantly of prominent plates of bleached biotite and much pyroxene. These rocks are generally much altered, are minette-like in character, and are related to the monzonitic rocks.

QUARTZ DIORITIC ROCKS.

Quartz dioritic rocks are typically developed in the Fairbanks district. Those of Pedro Dome are dark gray to light gray, evenly medium grained, and are composed of plagioclase, a small amount of orthoclase, biotite, hornblende, pyroxene, and accessory titanite, ilmenite, zircon, and apatite. Related dikes, which are common in the Fairbanks district, are generally porphyritic, and some of them contain a considerable amount of sulphides.

The igneous rocks of the region adjacent to Fairbanks include some of the above as well as other types. (See pp. 68–74.)

CONTACT METAMORPHISM AND MINERALIZATION.

Most of the granitic rocks are surrounded by zones of more or less altered rock. In some of these contact zones appreciable alterations have taken place over widths of about 1,000 feet. The most common alteration is to a hornfels containing abundant new biotite and andalusite. In some places the granite itself seemed to have become more charged with ferruginous matter marginally for 100 feet or more; one granitic mass, west of Bear Creek, assayed 80 cents in gold per ton, a fact which, though of no economic interest, is of importance as showing the existence of gold in the marginal portion of the granite. The presence of gold at the margin of granite porphyry on Homestake Creek has already been mentioned (p. 53), and the presence of gold, cassiterite, and sulphides in the Fairbanks district in close relation to igneous rocks is considered in more detail in the description of the gold-quartz veins (pp. 87–92). It suffices here to state that more or less contact metamorphism and mineralization have taken place around most of the granito-dioritic rocks.

STRUCTURE.

The main structural trends of the quadrangle are northeast and southwest. The prevalent strike of the Birch Creek schist appears to be somewhat more to the northeast than that of the Paleozoic rocks, but this can be determined only by more detailed observations. In the Troublesome Creek region, in the western part of the quadrangle, the dominant structural lines are about east and west. This may be either a purely local phenomenon or may mark the beginning of decided variance from the general trends of the quadrangle. Folding has been more intense in the schists, and their type of structure is closely appressed, overturned folds simulating undulating horizontal structure. Similar close folding and overturning were also noted locally in the Paleozoic rocks and may form the dominant type, but on the whole this type seems to be exceptional. An example of this is found in the Carboniferous area (see section C–D, Pl. VIII, in pocket), where Carboniferous rocks appear to dip under the older Tonzona rocks. Stone's investigations in the northern part of the quadrangle (see section A–B, Pl. VIII) indicate rather open folds. It appears that the Tonzona group and the Carboniferous are less folded than the older Paleozoic rocks. The Tertiary of Hess Creek is closely folded, and that near Fairbanks is but little disturbed.

A line stretching northeast from the Fairbanks placer district is regarded as representing the axis of an anticlinorium, the belt of Birch Creek schist exposed along this line being limited on either side by Paleozoic rocks. The position of the Fairbanks and the Birch Creek district and the intermediate Faith Creek area, which has also been proved auriferous, would then take on significance as being located along this axis.

Northwest of this main anticlinorium the Paleozoic rocks are thrown up into a series of folds. (See sections A–B and C–D, Pl. VIII.) The crests of the White Mountains and the two ridges beyond are formed by closed synclines separated by anticlines. Figure 3 (p. 40) is a diagrammatic representation of the structure of the White Mountains near Fossil Creek. The more open folding to the north is shown by figure 4, which is drawn across the granite boss northwest of Beaver Creek and through to the Yukon Flats. Similar types of structure are shown in the exposures of the Tonzona group on Tanana River below the mouth of the Tolovana. (See fig. 5.)

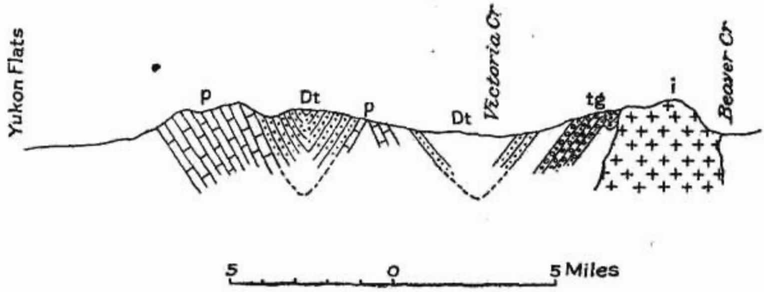


FIGURE 4.—Diagrammatic section from Beaver Creek near mouth of Mascot Creek to Yukon Flats. i, Intrusive rock; Dt, Devonian, Tonzona group (quartzite and red and green slate); P, Paleozoic limestone; tg, Tatalina group (Ordovician), consisting of quartzite, conglomerate, and black slate.

The linear arrangement of intrusive bodies shown in the northern part of the quadrangle in the divide separating the Yukon and Tanana drainage is rather striking and suggests a structure at about right angles to the prevalent direction.

Cleavage is very generally developed throughout the schists and the Paleozoic rocks. In the latter some true slates are present. A shattering of the rocks is very prevalent and characteristic in the Fairbanks district, where it is believed to be the result of the intrusions.

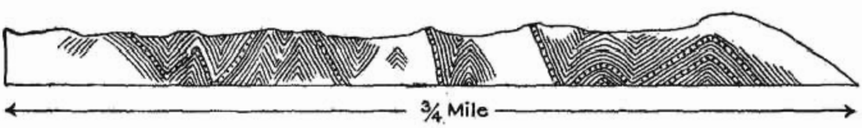


FIGURE 5.—Section along Tanana River below mouth of the Tolovana.

Minor faults are common throughout the region and large displacements are suspected. As there was no direct evidence of large faults, however, the structure sections have been drawn without indicating any. Some of the relations indicated as overturned folds may be complicated by thrust faults.

The Birch Creek schist was undoubtedly folded before the deposition of the Tatalina group, and another period of deformation probably took place before the Tonzona group was deposited. Disturbances also took place after the intrusion of the granite believed to be of Mesozoic age; these, however, may have been part of the same diastrophism that folded the Tertiary sediments.

GEOLOGIC HISTORY.

No geologic history worthy of the name can be written without profound familiarity with the lithology, stratigraphy, structure, and organic remains of the region discussed. Reconnaissance work permits only tentative conclusions, and the following statements are to be regarded as such.

The material of the Birch Creek schist indicates conditions favorable for the formation of a considerable thickness, perhaps several thousand feet, of alternating sandy and argillaceous sediments over large areas, with local conditions favorable for the deposition of calcareous material. The structure of these schists, their degree of metamorphism, and their relation to succeeding formations suggest an age antedating the Ordovician.

Subsequent to the consolidation of the Birch Creek deposits, their folding, the intrusion of granitic material, and other events of what was undoubtedly a long and complex history, the sediments (Tatalina group) regarded provisionally as Ordovician were deposited. The relation of these later rocks to the Birch Creek schist is one of unconformity, and their feldspathic material is regarded as derived in part at least from the old granitic intrusives that now appear as gneisses. These older Ordovician rocks reflect in their composition the character of the formation from which they have been derived and like the latter consist of alternations of argillaceous and siliceous sediments.

In the White Mountains and possibly elsewhere the deposition of the Tatalina was ended by volcanic disturbance, during which flows of diabase and basalt took place, accompanied by tuffs, volcanic breccias, and conglomerates, apparently in part of submarine origin. These were followed by the deposition of heavy limestones during late Ordovician and Silurian time. Sedimentation was probably interrupted by a period of folding, followed by another period of deposition of argillaceous sediment with interbedded gravels and sands and some limestone.

During Middle Devonian time limestone and chert were deposited, accompanied locally by extensive volcanic outbursts. It seems probable that an erosional interval intervened between the deposition of the Tonzona group and the Carboniferous, but of this no direct evidence has been obtained. Deposition in Carboniferous time, so far as known, was only of fine sediments and cherts.

The Mesozoic is represented by the Upper Cretaceous, and it is possible that other divisions of the Mesozoic may be included in the areas mapped as Paleozoic. The small area in the western part of the quadrangle is the only one definitely recognized as Cretaceous, and this has most probably been preserved from erosion by the intrusive granitic rocks that have penetrated it. The presence in these rocks of dicotyledonous leaves and ammonites in close association with the Cretaceous sandy sediments indicates deposition in waters not far removed from land. Volcanic activity was dominant during the Paleozoic, but the Mesozoic was a period of widespread intrusion; and in the western part of the quadrangle the Upper Cretaceous rocks were invaded by porphyritic rocks of granitic character.

The Tertiary was a period of abundant deposition, most probably in part lacustrine and in part fluviatile, as shown by deposits of clay, sand, and gravel loosely consolidated in some places and completely consolidated at others into massive conglomerates. The vertical position of these beds in many places bears witness to the continuance of diastrophic movements.

The geologic history would not be complete without a brief reference to the development of the present surface. The uniformity of the upland, which is very striking throughout the Yukon-Tanana region, is the product of complex processes, each of which has taken part in giving it final form. It is regarded, nevertheless, as resulting mainly from weathering and stream action. The tendency of streams in this region to form extensive flats has already been noted (p. 22). That this process was effective before the present deposits were formed is proved by the fact that the bedrock surface beneath the deposits of the present streams, so far as exposed by the operations of mining, is flatter than the present surface of the valleys. (See Pl. XIII.) The section from Ester to Cripple Valley (fig. 6, p. 104) is especially noteworthy in this respect, the bedrock between the two valleys rising only about 40 feet, whereas the present surface rises over 100 feet. These facts are regarded as of great importance in tracing the history of the present surface.

GEOLOGY OF THE FAIRBANKS DISTRICT.

By L. M. Prindle and F. J. Katz.

DESCRIPTIVE GEOLOGY.

GENERAL FEATURES.

It has already been stated that an area of approximately 300 square miles (see Pl. II, in pocket) lying north of and adjacent to the town of Fairbanks, here designated the Fairbanks district, was studied and mapped in considerable detail. The geologic results of this work will here be set forth, the description of the general geology of the quadrangle already presented serving as an introduction.

The Fairbanks district lies entirely within the area of the Birch Creek schist, as shown on the geologic reconnaissance map of the quadrangle (Pl. VIII, in pocket), and its rocks therefore belong essentially to the metamorphic Birch Creek schist, and are regarded as probably of pre-Ordovician age. It is possible, however, that small areas of Paleozoic rocks may be present. One small area of sandstone and conglomerate is assigned to the Tertiary on account of its lithologic character and stratigraphic position. Closely associated with this conglomerate is some unaltered basalt, probably also of Tertiary age. Unconsolidated deposits, including both terrace and modern alluvium, cover about one-third of the area. The main problems to be considered are those relating to the lithology and metamorphism of the schist; to the distribution and character of the intrusive rocks and their relation to the schist; to the mineralization of the region, which is most probably due more or less directly to the igneous rocks; and to the distribution and character of the alluvial deposits, which are of particular importance, from the fact that they have proved so abundantly auriferous.

GEOLOGIC MAP.

The geologic map (Pl. XI, in pocket) on a scale of about a mile to the inch shows the distribution of the more important geologic units. Two types of the Birch Creek schist are mapped, one including the schist proper and the other the crystalline limestone. A number of lithologic varieties of schist described in the text are not differentiated on the map. The unmetamorphosed sedimentary rocks shown include Quaternary and some Tertiary beds, the former being represented by terrace and present stream deposits. The igneous rocks mapped are (1) augen gneiss, probably of pre-Ordovician age, (2) quartz diorite intrusives, (3) porphyritic granite intrusives, (4) altered dike rocks, (5) basalts.

STRATIGRAPHY.

PRE-ORDOVICIAN (?) ROCKS.

BIRCH CREEK SCHIST.

GENERAL CHARACTER.

The metamorphic rocks classed as Birch Creek schist form by far the greatest part of the visible bedrock of the district, and have been found to underlie practically all gold placers. Their distribution on the geologic map shows that they form the predominant bedrock of the district. This formation includes several kinds of rock, but these, although distinct, form parts of one unit rather than independent units capable of individual separation. Whatever their origin, they have been so highly altered and welded by processes of metamorphism and diastrophism that their original relations are more or less obliterated, and their present composition and structure are predominantly those resulting from metamorphism. They include rather massive quartzites, quartzite schists, quartz-mica schists, hornblende schists in part amphibolitic, carbonaceous schists, crystalline limestone, altered calcareous rocks, with associated eclogitic rocks, andalusite hornfels, and a small amount of granitic gneiss derived from intrusive porphyritic granite. It is not improbable that small areas of younger Paleozoic rocks occur infolded in the older formations, but in the absence of any definite criteria for their separation, it has not been deemed advisable to attempt to differentiate them.

QUARTZITE AND QUARTZ-MICA SCHIST.

Occurrence.—The most common bedrock in the area is thin-bedded quartzitic schist and quartz-mica schist. Its most common mode of occurrence is in alternating beds from an inch or less up to a foot or more in thickness, composed of more or less blocky quartzite schist in which quartz is the predominant mineral. These beds are separated by beds of schist in which mica is the predominant mineral. At some localities the rock is made up almost entirely of the blocky quartzitic variety, most of which, however, contains sufficient mica to render it definitely schistose; at other localities the rock consists only of the soft micaceous schist. The planes and crevices between the alternating beds of blocky quartzitic schist and schist containing a large proportion of mica, where occurring beneath placer ground, permit the gold to penetrate to various depths, in some places to several feet, whereas the clayey surface formed by the more easily decomposed micaceous schist, being practically impermeable to gold, retains it at a fairly constant level.

Petrography.—Minerals observed entering into the composition of the quartzite and quartz-mica schists are quartz, sericite, biotite, orthoclase, albite, epidote, zoisite, garnet, staurolite, chlorite, zircon, rutile, titanite, amphibole, tourmaline, magnetite, iron pyrites, and limonite. The most common types are composed of quartz, sericite, and biotite, some having sericite so abundant as to form a quartz-sericite schist and others having biotite so abundant as to form a quartz-biotite schist. In some occurrences grains and irregular masses of albite are so common as to form a distinctive type. Garnet is very commonly developed, most generally in sharply defined crystals, but in some places as spongy masses. Staurolite was observed in only one specimen, and tourmaline is not common.

Some of the rocks that are distinctly quartzitic in character exhibit the detrital origin of the quartz grains, but most of them contain the quartz in the form of an interlocking, evenly granular aggregate, with unoriented flakes of mica. In the more micaceous schists the parallel arrangement of the constituents is very pronounced.

The rocks are jointed, closely folded, and exhibit in some cases cleavage and cleavage banding. Folding has been so intense that recumbent folds in a position approaching horizontality are common. Quartz veins were observed as much as 15 feet in thickness. Some quartz veins were introduced sufficiently early to be folded along with the schist; others cut the earlier structure or are present along joint planes.

HORNBLENDE SCHIST AND AMPHIBOLITE.

Hornblende schist.—Hornblende schist occurs in the quartzite schist at several localities in the Goldstream Valley, on the ridge northeast of Pedro Dome, and sparsely at several other localities. Minerals observed in this rock are hornblende, biotite, quartz, albite, garnet, epidote, zoisite, rutile, titanite, calcite, apatite, iron pyrites, and magnetite. A common type is composed essentially of green hornblende, biotite, quartz, and calcite. Through the parallel orientation of the prismatic hornblende and the biotite there is generally a well-developed schistose structure. In some places the amphibole is developed in tufts of acicular crystals independent of the schistosity. Garnet is common. The titanium minerals are present in nearly all occurrences and in some are very abundant.

Amphibolite.—Amphibolitic rocks occur, with albite or acidic soda-lime feldspar as essential constituents and composition otherwise similar to that of the hornblende schist. These may be altered igneous material or may be of sedimentary origin. No evidence bearing upon this point except that of association is available. In one place they are associated with crystalline limestone, a fact that suggests a sedimentary origin but is by no means conclusive, as Paleozoic limestones with interbedded volcanic rocks are common in the Yukon-Tanana region, and the metamorphism of such rocks would produce rocks like those under consideration.

CARBONACEOUS SCHIST.

In the Goldstream Valley some carbonaceous schist is associated with the crystalline limestone. Some occurs also on the northwest side of the main ridge, in association with calcareous beds and green garnetiferous rocks, and again in the ridge near the town of Fairbanks. Interbedded with it are thin beds of black and greenish micaceous quartzite. The rock is composed of a finely granular mass of quartz grains with some sericite, much carbonaceous matter, and some ferruginous material.

CRYSTALLINE LIMESTONE.

Limestones are associated with the hornblende schists and occur also with the quartzite schists. They occur in the Goldstream Valley below and above Moose Creek, on O'Connor Creek near the mouth, along the railroad below the mouth of Fox Creek, on Fox Creek about one-half mile above the mouth, on Goldstream above Fox beneath the placer ground, near the mouth of Bear Creek, on a spur of Fourth of July Hill near Deep Creek, and south of Fish Creek near the eastern limit of the area mapped. Nearly all of these localities lie along one general line, and although the limestone probably occurs not as a continuous belt but rather as disconnected lenticular masses, these occurrences serve to indicate a zone in which calcareous material predominates. The fact that so many of the localities are on spurs limiting the Goldstream Valley would indicate that Goldstream followed this calcareous zone in the cutting of its valley. The limestone is in general thin bedded, occuring as thin calcareous bands in schist, and ranging in color from white to rather dark bluish gray. At Fox it is closely crumpled and contains considerable tremolite.

SILICATED LIMESTONE AND ECLOGITE.

Occurrence and character.—In parts of the valleys of Vault, Dome, Eldorado, Cleary, and Fish creeks and trending northeast-southwest parallel with the main ridge of the district are massive and schistose rocks in part calcareous that contain abundant garnet, pyroxene, and amphibole. Some of them are composed essentially of garnet and pyroxene and form a massive eclogitic rock. Titanium minerals are abundant in all these rocks. The rocks range in color from dark green to grass green and almost all the weathered surfaces are studded with garnets. The more schistose varieties contain abundant mica and show apparent transitions to quartz-mica schist. In some places bands of bluish limestone an inch or more thick were observed, alternating with bands composed of garnet, amphibole, and pyroxene.

The massive varieties are dense, tough, heavy rocks. In early days, on account of their resistance to heat, they were used by the miners for thawing ground, being heated in a fire at the surface and when hot thrown into the shaft to remain there until cool, when they were hoisted out with the gravel that had been thawed. This rock forms the most blocky variety of bedrock underlying the placers, and the placer gold is found to depths of several feet within it. In mining operations on some of the creeks, notably on Dome Creek, it has been necessary to take up large quantities of this rock to recover the gold, and the difficulty of handling it adds considerably to the cost of mining. The high gold tenor of this ground, however, has proved more than sufficient to offset the extra expense.

The rocks occur apparently as lenticular masses in the quartzite and quartz-mica schist conformable to the structure of the schist. They are found in place as massive outcrops along the bases of ridges alternating with bands of quartz-mica schist or in some places with limestone. Fragments several feet across occur in decomposed schist on the slopes of ridges, and numerous small fragments that have weathered from the inclosing schists seem to have been derived from narrow bands or lenticular masses in the schist.

Petrography.—The minerals observed as constituents of these rocks are calcite, garnet, monoclinic amphibole and pyroxene, rutile, titanite, muscovite, biotite, epidote, zoisite, quartz, feldspar, chloritic material, and iron minerals, among which pyrrhotite is most common. Quartz and feldspars are not abundant.

For purposes of description the rocks formed of these minerals may be divided into three varieties, which are apparently connected by many intermediate forms. A specimen illustrative of the first variety is composed of a large proportion of calcite, with pale-green slender prisms of pyroxene, a little amphibole, garnet, abundant titanite, some colorless mica, and a little iron ore. The calcite grains are arranged partly in bands separated by narrower bands composed of pyroxene grains and prisms. The garnet is usually without regular boundaries, is spongy in character, and is in places crossed by rows of grains parallel with the banding of the calcite and pyroxene, forming a helicitic structure. Titanite is scattered abundantly through the rock as irregular grains and in places forms granular groups several millimeters in diameter. There is a small amount of pale-green amphibole. A massive rock of similar composition contains a larger proportion of the pale-green amphibole, more titanite, some biotite, and pale-pink garnet, much of which is without definite boundaries, though some occurs sharply outlined in the midst of the other constituents; in places it shows alteration to fibrous amphibole.

A second variety is a massive rock composed almost entirely of amphibole, garnet, and titanite. The amphibole is present as closely crowded, irregular grains, slightly elongated parallel to the vertical axis, and showing pleochroism from nearly colorless to bluish green. Garnets are scattered in irregular masses and form but a small proportion of the rock. Small, irregular grains of titanite are abundant and evenly distributed, and a small amount of rutile rimmed with titanite is present.

A third variety is a massive, dark-green, tough rock composed essentially of pyroxene and garnet and considerable rutile. The pyroxene is nearly colorless; extinction angles on 010 as high as 45° were noted, and it occurs as anhedrons somewhat lengthened parallel to the vertical axis. The garnets are pale pink in color, have crystal outlines, and are rimmed with a narrow zone of deep-green amphibole. Rutile is abundant, not only as grains of considerable size (one piece measured 6 by 2 millimeters) but also as thin veins an inch or more in length. A particularly coarse and beautiful variety of this rock contains thickly crowded garnets up to 5 millimeters in diameter, pyroxene dark green in hand specimens, but nearly colorless in thin section, deep-green rims of amphibole about the garnets, and abundant titanite.

Origin.—The origin of these rocks is by no means clear. At one extreme are bands of the silicates interbanded with crystalline limestone on the small scale of a hand specimen; at the other extreme are massive eclogitic rocks. The most probable tentative explanation is that these rocks were impure calcareous sedimentary rocks containing basic or interbedded tuffaceous material and that they were metamorphosed while they were deeply buried.

HORNFELS.

Occurrence.—In the northeastern part of the district in parts of the valleys of Alder and Captain creeks and on the adjacent ridges are rather massive quartzites and quartzitic schists, some of which are tough and fine grained, with weathered surfaces studded with lumps of harder material.

Petrography.—At the termination of the spur between the forks of Alder Creek the talus, which alone is exposed, contains blocks of rather massive, slightly schistose quartzite, some of which shows bands of coal-black carbonaceous schist partly coated with slender crystals of andalusite; blocks of coarse quartz-mica schist, with abundant pinkish garnets up to a centimeter in diameter; fine-grained gray rocks with many garnets; and dark-colored blocks of compact fine-grained rock, thickly crowded with altered andalusite crystals. The fine-grained gray rocks are composed of finely granular quartz and sericite. The garnets are small, up to about 2 millimeters in diameter, are without distinct crystal outline, and have a tendency to spherical development. They are rimmed with brownish biotite. The andalusite rocks contain quartz, biotite, a small amount of feldspar, garnet, sericite, chloritic material, a little rutile and tourmaline, and aggregates of micaceous matter in the characteristic forms of andalusite. The main body of the rock is composed of a fine-grained aggregate of quartz and biotite, in which the other minerals are embedded. The garnets are small and rounded. The biotite is reddish brown and in part forms rims about the garnets.

A fragment of dark medium-grained rock, found in the float near the head of Steamboat Creek, is composed largely of fresh andalusite in forms up to several millimeters across, quartz, biotite, abundant magnetite, and some iron pyrites. This is not far from the intrusive granite that outcrops on the ridge at the head of Steamboat Creek and indicates most probably the presence of a zone in the schists that has been metamorphosed by the intrusive rock. Schist with pleochroic andalusite and reddish-brown biotite, which are apparently products of contact metamorphism, occurs also in Skoogy Gulch close to a granitic dike only half an inch thick.

GRANITE GNEISS.

Occurrence.—Gneiss forms a component part of the Birch Creek metamorphic assemblage of rocks at a few localities. It occurs in the upper part of Pedro Valley from a short distance below the mouth of Twin Creek to a short distance above the mouth of Deadwood Creek and may extend into the covered country beyond these points. It was found also on Solo Creek, Bear Creek, and is well exposed on Fairbanks Creek above the mouth of Sixteen to One Creek, all these points being in a single line of strike parallel to the general strike of the schists. The extreme width observed is at most a few hundred feet.

Petrography.—The rock is in part composed of bands of quartz and feldspar separated by micaceous layers. Feldspar augen are rather evenly distributed and attain a width of about one-half inch in the coarser varieties. The average variety contains feldspars measuring up to about a quarter inch in a medium to fine grained groundmass. Bands of lighter rock, composed essentially of quartz and feldspar, traverse the average type, generally running parallel with the structure of the latter, but some of these show crumpling within the limits of a hand specimen.

The usual type contains augen of microcline in a granular mass of quartz, feldspar, sericite, biotite, epidote, titanite, and orthite. The feldspar of the groundmass includes alkali feldspar and soda-lime feldspar; albite is the most common variety. Although but a few thin sections were studied, orthite is present in most of them, and generally grains of epidote are grouped about this conspicuous isolated mineral. The minerals of which these rocks are composed have been shattered and recrystallization has taken place.

A rather coarsely porphyritic gneiss, with feldspars up to an inch or more in diameter, occurs in the spur between Pilot and Captain creeks. It is composed of quartz, feldspars, and muscovite. In some portions of the rock the feldspars have retained their crystal forms, and the rock is a somewhat gneissoid porphyritic granite. Other portions have become schistose, with the feldspars reduced to augen. This rock occurs apparently as a dike, a few hundred feet thick, cutting the schists.

TERTIARY (?) ROCKS.

Occurrence.—Brown micaceous sandstone and conglomerate, composed predominantly of schist fragments with vein quartz, in a small area on Fourth of July Hill, are unlike any other rocks of the district. Near the highest point of the hill where these deposits are found there is much detrital granitic material, partly bowlders, and there are also serpentinous rocks unlike the rocks of the district but similar to rocks found to the northeast in the Chena Valley. The granitic material also more closely resembles the granitic rocks of the Chena Valley than those of the Fairbanks district. These rocks rest partly upon the metamorphic schist and partly upon the basalt that forms the point of the hill. Indeterminable plant remains and ferruginous nodules were observed in the brownish sandstone. The rocks are but loosely consolidated and the coarser material is strewn along the slopes below the outcrop and has the appearance of bench gravels related to the present stream.

Correlation.—The brown sandstone with ferruginous nodules and remnants of plant remains is very similar to rocks of the Kenai formation and has about the same degree of consolidation. Coal has been reported from the north side of the Tanana, in the valley of the Little Salchaket, and it is probably of Kenai age. If so, the coal-bearing deposits, so abundantly present south of the Tanana Flats, are also represented at least by remnants north of the river. In view of their lithologic resemblance to similar rocks of the Kenai, the rocks of the little area of Fourth of July Hill are correlated with that formation. It should be stated, however, that no evidences of coal except the carbonized branchlets of some forms of plant life were observed in this occurrence, and it is most probable that only sandstone and conglomeratic members are present. There has been considerable prospecting for gold, however, in these deposits, as is usual wherever conglomerates of Kenai age have been found in the Yukon-Tanana region. In other areas there is evidence that some conglomerates referred to the Kenai are auriferous, containing placer gold that was deposited as such with the waterworn gravels of which they are composed, but it has been only by a secondary concentration from the weathered products of the conglomerate by the present streams that such gold has been made available.

QUATERNARY DEPOSITS.

The varying elevation at which the Yukon-Tanana region has stood has produced rock benches which now stand at different heights above sea level. Some of these have been so extensively developed as to be independent of present drainage areas, but others are related to them. Alluvial deposits have been left on some of the lower benches, and in some portions of the Yukon-Tanana region, notably the Fairbanks district, extensive amounts have accumulated in the valleys of the present streams. These deposits include silt, sand, and gravel, deposited in part on benches and in part on valley floors. They were laid down partly under the action of lacustrine conditions and partly under the interaction of lacustrine and fluviatile conditions, though it is probable that fluviatile conditions prevailed. Deposition most probably began in the Pleistocene or earlier and continued to the present time, the most active period probably being during the time when the glaciation of the areas about the Upper Yukon made so large an amount of silt available, and when the retention of this abundance was assured by a period of sluggish drainage in the Yukon. Since their deposition in the Fairbanks district, the alluvial deposits have been carved into terraces having steep silt banks 20 feet or more in height, bordering valleys with comparatively narrow floors over which flow the present streams.

IGNEOUS ROCKS.

OCCURRENCE AND CHARACTER.

Igneous rocks are common in all the gold-placer areas of the Yukon-Tanana region (pp. 30–32), and the evidence available points to them as being at least the indirect cause of the presence of gold in the rocks from which the placer gold has been derived. Their distribution, the delimitation of their areas from those of the sedimentary rocks, their relation to the inclosing rocks, their origin, and the part they have played in the geologic history of the region are therefore of importance to miners.

The distribution of the main occurrences of igneous rocks is indicated on the geologic map. (See Pl. XI, in pocket.) It is noticeable that although there are no very large areas of these rocks, and that although they do not form a large proportion of the total area, they have, nevertheless, a wide distribution throughout the district; even where not found in place they are shown to be present by igneous material in the gravels. It must be remembered that so large a part of the area is covered with vegetation that the areas indicated are probably by no means as extensive as those actually occupied.

The igneous rocks of the Fairbanks district include several varieties of intrusive granular rocks and a small amount of igneous material regarded as extrusive. Intrusive granular rocks that penetrated the schist at such depths below the contemporary surface of the earth as to have cooled with sufficient slowness to become entirely crystalline are separable into quartz diorite, porphyritic biotite granite, light-colored persilicic granitic dikes, and altered porphyritic dikes related to granitic and dioritic rocks. Besides these intrusive rocks, which form the greatest part of the igneous material present in the district, small masses of basalt outcrop on Fourth of July Hill and near the mouth of Alder Creek. The relations of these occurrences are not entirely clear, but that on Fourth of July Hill is believed to be of extrusive origin—that is, to have been poured out upon the earth's surface.

INTRUSIVE ROCKS.

QUARTZ DIORITE.

Occurrence.—An elongated mass of quartz diorite forms the main body of Pedro Dome and extends southwestward along the ridge. Dikes of related rock occur also in the spur between Twin and Pedro creeks. That this rock occurs elsewhere is shown by its presence in stream gravels.

Petrography.—The quartz diorite ranges from dark gray to light gray in color, from medium to fine in grain, is evenly grained, and is composed of light and dark constituents. The minerals observed in different varieties are quartz, soda-lime feldspar, alkali feldspar, biotite, hornblende, pyroxene, titanite, ilmenite and other iron minerals, zircon, and apatite. In the hand specimen quartz is recognizable by its grayish color and lack of cleavage, feldspar by its whiter color and its cleavage, biotite by its splitting easily into elastic laminæ, and hornblende by its black shining luster of cleavage surfaces and by its cleaving into thick brittle masses rather than into leaves like mica.

The most common variety is composed essentially of automorphic crystals of plagioclase, quartz, a very little orthoclase, biotite, and hornblende. The plagioclase is zoned and in the different zones ranges in composition from basic labradorite to acidic oligoclase. It has the crystal form developed and is embedded most generally in the irregular grains of quartz. Only a very small amount of orthoclase is present, the plagioclase being most generally in direct contact with the quartz. The brown biotite and green hornblende are rather evenly distributed.

In one variety a segregation was observed, composed of augite, hornblende, and biotite, the augite forming the central portion of the aggregate. Augite occurs as an essential constituent in a specimen taken from a marginal portion of the mass. A dike in the spur between Twin and Pedro creeks contains, in addition to the other minerals, some interstitial orthoclase and a few grains of orthoclase in which plagioclase individuals are embedded. This variety approaches granodiorite in composition.

Several porphyritic dikes of the same material were observed in the vicinity of the main intrusive mass, but most of them are too small to be shown on the scale of the map. One of these porphyritic rocks near the head of Cleary Creek near what is known as the Mother Lode claim is composed of amphibole and quartz in a finely granular groundmass of quartz and feldspar. The feldspar phenocrysts grade into the automorphic feldspars of the groundmass, which form centers of crystallization for spherical masses of quartz-feldspar aggregates. Iron pyrites is abundant.

Relations.—The quartz diorite has intruded the schist and shows small inclusions of quartzite schist in its marginal portion on the northwest side of Pedro Dome. It does not seem to have been much changed through contact with the schist, and the quartzite schist in immediate contact shows but little alteration, but where the composition of the schists was somewhat different biotite has been developed rather commonly as a contact mineral, as has also the fresh andalusite rock of Steamboat Creek and Skoogy Gulch above described (p. 65). The quartz diorite as well as the schists which it has intruded have undergone fracturing. The fracturing in the quartz diorite is most evident in the quartz, nearly all the grains of which in some specimens have been more or less broken. Some of the fractures were observed to have been healed with plagioclase.

BIOTITE GRANITE.

Occurrence.—Porphyritic biotite granite is more common than quartz diorite. It forms a large part of the ridge southeast of Gilmore Creek and extends southwestward to the headwaters of Engineer Creek, where the rock is found in the gravels and where dikes related to it form part of the bedrock beneath the gravels. Another mass of the same kind of granite is found on Twin Creek, where it forms the bedrock on some of the claims and extends to the northwest above the wagon road. In the vicinity of this last intrusive mass are small related dikes in the schist and in the quartz diorite, which at this locality is in close association with the biotite granite.

Petrography.—The minerals observed as constituents of this rock are quartz, microcline, biotite, muscovite, amphibole, zircon, titanite, and orthite.

Microcline is the most conspicuous mineral in these rocks, occurring as automorphic individuals up to 2 inches in diameter in a more or less evenly granular mass of quartz, feldspar, and biotite. The quartz is easily distinguishable by its dark-gray glassy appearance in the midst of the whitish feldspar. The quartz grains average about a quarter inch in diameter. Microscopic examination shows much wider variation in the size of grain than is apparent in the hand specimen. The feldspar of the groundmass includes both alkali feldspar (microcline and orthoclase) and soda-lime feldspar, the latter ranging from oligoclase to andesine in composition. Toward the extreme northeastern limit of the mass a little hornblende was observed as a minor constituent. Orthite was observed as a small automorphic form embedded in microcline. There is some sericitization of the feldspar and chloritization of the biotite, but otherwise the rock at most localities is fresh.

In places the biotite granite contains a considerable proportion of iron pyrites. Outcrops on Rose Creek, a tributary of Gilmore Creek, show scattered crystals of iron pyrites, about which are spherical stained areas in which the rock has been colored by the alteration of the iron pyrites. At one locality on the road from Skoogy Gulch to Golden City a large amount of iron pyrites is present, both in the rock itself and on the joint planes, where it occurs as pyritohedrons largely altered to limonite. In the upper valley of Hill Creek also iron pyrites highly impregnates the rock and by alteration has reduced large amounts of the granite to loose masses of granitic sand.

Through the contact action of the biotite granite the schists close to the contact have become gneissoid and have come to contain a considerable proportion of feldspar.

PERSILICIC ROCKS.

A granitic dike outcropping near the head of Fox Gulch is composed of a light-colored, fine, and more or less even grained rock consisting of quartz, perthitic alkali feldspar, soda-lime feldspar mostly oligoclase, and sporadic fragments of muscovite. The constituents are all xenomorphic. The rock shows cataclastic action, some of the plagioclase grains being bent and broken and some larger grains being surrounded by finely granular quartz-feldspar fragments. This rock is cut in places by veins of coarser material of similar nature, the feldspars of which attain a length of half an inch or more. These veins, so far as observed, are from a fraction of an inch to several inches in width, and very commonly the feldspar individuals are arranged more or less at right angles to the walls of the vein cavity which they fill. In some cases the medial portion of the veins is filled with quartz. This granitic material has also penetrated the schist as thin independent anastomosing dikes of granitic material.

On Melba Creek also the porphyritic granitic type is cut by light-colored quartz-feldspar rocks composed of a granular mass of plagioclase feldspar, orthoclase, and some muscovite.

The porphyritic biotite granite of the ridge between Smallwood and Gilmore creeks is also traversed by persilicic dikes of similar nature to those described. Some of these in the valley of Engineer Creek contain scattered grains of orthoclase up to a quarter inch in diameter, mostly kaolinized, in a finely granular xenomorphic mass of quartz and feldspar, the latter being almost entirely altered. They contain also limonitic material, so distributed as to give the rock a yellowish color, and also numerous sharply outlined crystals of iron pyrites, largely altered to limonite. Scattered through the rock or partly filling cavities are masses of very fine crystalline quartz, some of which show traces of concentric structure, the layers being composed of somewhat fibrous silica. These masses of apparently secondary quartz contain more ferruginous matter than the rest of the rocks and, together with the limonitic areas derived from the alteration of the iron pyrites, give to the rock a spotted appearance.

Dikes formed of rock composed essentially of quartz and feldspar and similar to the different varieties above described are common in and adjacent to the intrusive porphyritic granite of Twin Creek. At this locality, as already mentioned (p. 70), dikes of similar material cut the quartz diorite. Associated with these persilicic dikes are masses of quartz, some of which are directly associated with masses of feldspar, some of which form veins, apparently, in fine-grained masses of quartz-feldspar and some of which are penetrated by veins or dikes of the finely granular quartz-feldspar material. These are all observable on the small scale of a hand specimen. They are found also penetrating the quartz-biotite schist and along joint planes in the schist. Some quartz veins in this schist contain isolated areas of orthoclase feldspar, some of which are crystals. Furthermore, these quartz veins are in part auriferous; one hand specimen of vein quartz contains gold, embedded directly in the quartz, feldspar, and crystals of iron pyrites largely altered to limonite; in another specimen gold is embedded in iron pyrites. All that it is desired to emphasize in this connection is that at this locality there is a close association of persilicic dikes and quartz veins. The relation of this association to the occurrence of the gold will be considered in a discussion of the mineralization.

GRANITIC AND DIORITIC PORPHYRIES.

Small dikes that are so heavily charged with ferruginous matter or other alteration products that their original composition is obscured are common throughout the district. Their presence in a valley is generally indicated only by a small proportion of their pebbles or bowlders in the tailing piles of the placers. In some places material is present showing less alteration, and from this some information is obtainable regarding the original nature of the rock; and at several localities these rocks have been found in place, making it possible to study not only their composition but also their association. Where the composition is observable they are found to be porphyries of intermediate constitution referable to the igneous material from which have been derived the intrusive granite and quartz diorite already described.

These porphyritic rocks, where they are sufficiently unaltered, show quartz and feldspar phenocrysts in a microgranitic and granophyric groundmass. The quartz phenocrysts are generally corroded, the feldspar phenocrysts are mostly altered, and many of both are surrounded by spherical masses of granophyric quartz and feldspar. Some quartz phenocrysts are surrounded by spongy quartz with the same orientation as the phenocrysts. Plates of biotite are present, and in one specimen a rounded fractured garnet was observed. Sericite is abundantly developed in some areas, so much so that the identity of the feldspathic constituents is recognizable only by outlines and by twinning striations, which maintain their position although the original material is no longer present.

At what is called the Mother Lode claim, situated on the wagon road near the head of Cleary Creek, one of these altered porphyries occurs as a thin dike in quartzite schist, closely associated with stibnite. The rock is light gray, fine grained, and pitted with numerous cavities formerly occupied by crystals of iron pyrites. Under the microscope it is observed to be composed mostly of sericite. Sericitic masses with sharp outlines indicate the forms of feldspars and stand out faintly from the base of fine quartz and sericite. Bands and bunches of ferruginous minerals indicate the former presence of biotite or possibly hornblende, and finely divided ferruginous material is scattered generally through the rock. Sharply outlined forms of iron pyrites are present, but their substance has been replaced by iron carbonate—small glistening pyritohedrons of carbonate, pseudomorphic after iron pyrites, which are visible in the hand specimen.

A more highly altered rock occurs at the west end of Pedro Dome, where there is an irregular mass of this rock in close association with the quartz diorite of Pedro Dome and with the highly altered schists. This is a whitish friable rock, in some places resembling fragments of unslaked lime. Much of it is stained yellowish or reddish by ferruginous matter. The rock is composed of clear colorless quartz, patches of dark ferruginous matter made up of bands of ferruginous grains, areas of sericite, and areas of minutely granular quartz embedded in clear colorless quartz with rectangular outlines suggesting those of feldspar individuals. In transmitted light these aggregates of quartz are transparent, yellow, and apparently uniform in composition; they are in strong contrast with the colorless quartz. The latter occurs as grains and areas, irregular in outline, like those of granitic quartz; some of the areas show uniform orientation. The rock is minutely fractured, and the clear quartz areas show minute veins of the yellowish silica. In this vicinity are siliceous breccias with much secondary quartz and ferruginous matter. Dikes of these altered granites, as well as the rocks in which these granites occur, have been penetrated by brown ferruginous veins that are very common in this main ridge of the district. (See pp. 52–55.)

AGE RELATIONS OF THE INTRUSIVE ROCKS.

The greater part of the intrusive rocks of the Fairbanks district belong to the granito-dioritic group. The quartz diorite of Pedro Dome and the porphyritic biotite granite of the Smallwood-Gilmore ridge are distinct types, but there are several intermediate types. Although the coarse porphyritic biotite granite was nowhere observed cutting the quartz diorite, fine-grained dikes like those which cut the biotite granite and which are closely related to the latter in composition and were only shortly subsequent to it in time of intrusion were observed to cut also the quartz diorite. It is believed that both of the main types are products of the same general period of intrusion, that the sericitized dikes of granite porphyry and quartz diorite porphyry are referable in their origin to the main intrusive masses, that these dikes have been altered in part by hydrothermal action, and that passageway for various afterproducts of intrusion was afforded by an extensive shattering that took place in part at least subsequent to intrusion.

No formation is known to mark the time of these intrusions. Conglomerates regarded as Tertiary contain numerous granite bowlders, the origin of which is not definitely known, but it is very probable, from what is known of the Tertiary deposits in other portions of the

Yukon-Tanana region, that these conglomerates are of Kenai age, which would make the period of granitic intrusion previous to the Kenai epoch. The nearest similar intrusive rocks whose age of intrusion is rather definitely determined are those of the Rampart region, 90 miles to the northwest, which have intruded upper Cretaceous rocks.

The unmetamorphosed intrusions of the Fairbanks district were most probably intruded during the same general period as those of the Rampart region—a period of widespread intrusion throughout Alaska.

EXTRUSIVE ROCKS.

A rock entirely different in appearance from any of the igneous rocks hitherto considered is the olivine basalt that forms the end of Fourth of July Hill facing Fish Creek. The rock forms a steep bluff overlooking the Fish Creek valley and has a thickness of probably 250 feet. At several points around the base of the hill it was found resting upon schist, the main structural planes of which dip about 30° toward the hill. The rock is brownish black, weathers into spherical masses that might be mistaken for waterworn bowlders, and in places along the face of the hill is roughly prismatic. It is composed of plagioclase laths, pinkish augite, olivine grains, partly altered brownish glass, and abundant plates and grains of iron ore.

The basalt underlies sandstone and conglomerate at points over a mile apart, making it probable that it has a considerable distribution beneath the area of sandstone and conglomerate. No definite evidence was available regarding its mode of occurrence. It lies horizontally on the schist and is probably a flow

The same kind of rock was found outcropping on the west side and about a mile above the mouth of Alder Creek valley, where it forms the termination of a small ridge. Its contacts and extent are hidden by vegetation.

SEQUENCE OF IGNEOUS PHENOMENA.

Although knowledge as to igneous activity in the district is very fragmentary, it is possible to state what seem to have been the main igneous events

That there was an older period of intrusion is indicated by the presence of what are regarded as metamorphosed porphyritic granites. The period of their intrusion antedates the metamorphism of the region and was probably more or less synchronous with that of similar intrusive gneisses that are common in the eastern part of the Yukon-Tanana region. The unmetamorphosed igneous intrusions are assigned to the close of the Mesozoic. The sequence of this almost synchronous material seems to have been as follows: Quartz diorite, porphyritic biotite granite, persilicic dikes. The time relations of the altered granitic and quartz dioritic porphyries are not clear, as they were not observed cutting the main intrusive masses. It is probable, however, that they are synchronous with these masses and are their peripheral portions. The olivine basalt is the latest expression of igneous activity.

CONTACT METAMORPHISM AND MINERALIZATION.

The contact effects of the intrusive rocks seem to have resulted principally in the production of biotite and andalusite, to which reference has already been made. A large part at least of the mineralization of the region is intimately connected with these rocks. In relation to them the mineralization may be regarded as manifesting itself in the peripheral parts of the main masses, especially in the porphyritic granite, in the dikes, and in the surrounding schists. In time the mineralization was at least partly subsequent to the intrusive masses, for these have been partly shattered and then mineralized. The extensive shattering to which both igneous rocks and schists have been subjected is regarded as a most important factor in the distribution of mineralization. The shattering, though very general, is most extreme in the main ridge of the district in the vicinity of intrusive rocks and is probably due to the process of intrusion.

STRUCTURE.

The attempt to bring the different groups of material found in the Fairbanks district into a systematic relation approximately expressive of their true relations and geologic history must not be considered as definitive. The data are too meager to permit more than a general statement.

The strike of the rocks is northeast-southwest, parallel with that of the main contact line between the pre-Ordovician (?) schists and the overlying Paleozoic rocks found to the northwest outside of the Fairbanks district.

The rocks are closely folded. Recumbent minor folds are common and, so far as observed, the strata are overturned toward the northwest. In places the folding is so close that the limbs are nearly parallel, and cleavage and bedding planes become also parallel. The dips taken therefore indicate rather the dip of the predominant structural planes, which may or may not be the true dip.

It is believed that the surface presented by erosion in the Fairbanks district is not far removed vertically from what was originally the contact plane of the pre-Ordovician (?) schists and the known Paleozoic rocks. That contact plane has been regarded as one of unconformity, but the exact relations of the rocks involved have not been observed. The presence of Paleozoic rocks to the northwest and of similar rocks regarded as Paleozoic in the Chena Valley suggests in a broad way an anticlinal structure for the area between the Beaver and Chena rivers. The presence of a calcareous zone in the Goldstream Valley and the existence of another zone, partly calcareous, parallel with it on the northwest side of the main ridge suggest a lithologic relationship between the two. In the Goldstream zone, associated with the calcareous rocks, there is some carbonaceous schist and schist characterized by amphibole; in the zone northwest of the main ridge, associated with the calcareous rocks, is some carbonaceous schist and rocks characterized by pyroxene, amphibole, and garnet. Along the strike of the latter zone to the northeast, near the edge of the area, hornfels occurs and still farther off are fine and coarse quartzites that show but little metamorphism. The structure suggested by the lithology and by the degree of metamorphism and borne out by the dips so far as these are available is that of two synclinal areas—one located in the Goldstream Valley and one in the area between the Chatanika Valley and the main ridge. These parallel, partly calcareous zones, both of them interbedded partly in the schists, are regarded as the upper portion of the schists. The different development of ferromagnesian minerals in the two zones may have been due partly to differences in the original material and partly to deeper conditions of metamorphism imposed by an overthrusting of folds from the southeast suggested by the minor recumbent folds. The occurrence of less metamorphosed rocks to the northeast in the zone along the northwest side of the ridge suggests a pitch in that direction, with successive younger, less deeply buried strata coming into view. (See Pl. XI.)

SUMMARY OF GEOLOGY.

The Fairbanks district is predominantly an area of metamorphic schists of sedimentary origin. Their age has not been definitely determined and is provisionally fixed as pre-Ordovician. The area lies between areas of rocks regarded as Paleozoic. One small area of sandstone and conglomerate is assigned to the Tertiary.

The area has been one of intrusion, and the greatest part of the intrusive rocks are unmetamorphosed. These rocks include quartz diorite, porphyritic biotite granite, fine-grained porphyries related to both types, and persilicic dikes. The peripheral portion of the biotite granite shows in places much mineralization with iron pyrites, and the porphyries exhibit alteration to sericite (sericitization) and mineralization with iron pyrites and other sulphides. All of these rocks are believed to have been intruded during the same general period—a period, however, of sufficient length for the prolonged action of heated waters both upon part of the igneous material itself and upon the surrounding schists. The intrusion of these rocks was probably at the end of the Mesozoic. The mineralization is regarded as due to their influence and to have been facilitated and rendered available largely through an extensive shattering, probably caused by their intrusion.

ECONOMIC GEOLOGY.

MINERAL RESOURCES.

The only mineral resources of the Fairbanks quadrangle that have been developed on a large scale are the gold placers. Auriferous lode deposits have been exploited near Fairbanks, as have also some lodes carrying silver, lead, or antimony. A little stream tin has been found in some of the placers but not in commercial quantities. A little lignitic coal has been mined on Yukon River near the western margin of the quadrangle, and other deposits have been reported at several localities north of the Tanana, but these are probably of no commercial importance at the present time. Peat deposits are not uncommon, but in view of the extensive coal deposits in the Nenana field, which skirts the southern margin of the quadrangle, the peat is not likely to become of commercial importance. Some of the Paleozoic slates and probably some of the granites would be of commercial value if the deposits were situated in a more accessible region. Two hot springs are known, one on the west fork of Chena River, and one between Tolovana River and Montana Creek (see Pl. I), and further exploration is likely to find others.

But all of the developed mineral resources are insignificant compared with the gold placers of the Fairbanks district, by which is meant the region tributary to the town of Fairbanks. The following table presents a summary of the placer gold and silver production of this, the most productive area of placer gold in the interior of Alaska. The silver occurs as an impurity in the placer gold and the production of this metal is based on an estimate of its percentage.

Placer gold and silver production from the Fairbanks district, 1903 to 1912, inclusive.

Year.	Gold.		Silver.	
	Fine ounces.	Value.	Fine ounces.	Value.
1903	1,935.00	$40,000	348	$188
1904	29,025.00	600,000	5,225	2,821
1905	290,250.00	6,000,000	52,245	28,212
1906	435,375.00	9,000,000	78,367	42,318
1907	387,000.00	8,000,000	69,660	37,616
1908	445,050.00	9,200,000	79,909	43,151
1909	466,818.75	9,650,000	84,027	45,375
1910	295,087.50	6,100,000	53,116	28,683
1911	217,687.50	4,500,000	52,245	27,690
1912 [a]	211,398.75	4,370,000	50,736	31,203
	2,779,627.50	57,460,000	525,878	287,257

[a] Preliminary estimate.

To obtain the estimated total value of the gold production of the Fairbanks quadrangle the output of the Tenderfoot, upper Preacher Creek, and Troublesome Creek regions should be added to the above totals. Detailed information regarding the production of these smaller districts is not available, but the value of their total gold output up to the close of 1912 is probably about $1,200,000.

GOLD IN THE YUKON-TANANA REGION.

It has been shown that much similarity in geologic conditions obtains throughout the Yukon-Tanana region, of which the Fairbanks quadrangle forms a part. Therefore it seems desirable to outline briefly the occurrence of the auriferous deposits of the larger province before describing those of the Fairbanks quadrangle. This account will be largely extracted from an article already published by the senior writer.[1] The bedrock geology has already been presented (pp. 32–76 and Pl. VIII), but the surficial deposits will be considered in somewhat greater detail than has been previously done.

ALLUVIAL DEPOSITS.

GENERAL CHARACTER.

The alluvial deposits comprise partly auriferous silts, sands, and gravels of Pleistocene and Recent age. The Fortymile, Birch Creek, Fairbanks, and Rampart districts have up to the present time produced most of the placer gold, but intervening areas have also proved somewhat productive, and the causes of mineralization have evidently been in operation over a large part of the region. Though the alluvial deposits have furnished practically all the gold that has been produced, gold occurs in the bedrock in the Fairbanks district and in a few other localities.

The alluvial deposits containing gold include chiefly the present stream gravels and the bench gravels related to the valleys of these streams. Most of these deposits are frozen throughout the year. It is possible, also, that some of the Tertiary conglomerates have contributed a small part of the alluvial gold.

STREAM GRAVELS.

The extent and thickness of the stream deposits vary greatly in different valleys. Narrow valleys, like those of Franklin Creek in the Fortymile district or the upper part of Deadwood Creek in the Birch Creek district, have a narrow deposit of gravels sufficiently shallow to be worked almost entirely by open cuts. Wider valleys, like those of Wade and Mastodon creeks, have wider and thicker deposits that are still, however, largely workable by the open-cut

[1] Prindle, L. M., Occurrence of gold in the Yukon-Tanana region: Bull. U. S. Geol. Survey No. 345, 1908, pp. 179–180.

method. Open valleys, like that of Chicken Creek in the Fortymile district or those of the Fairbanks district, have a great extent of alluvial deposits that reach in parts of the Fairbanks district a thickness of more than 300 feet.

The alluvial deposits containing gold are, in general, separable into an overlying bed of muck, an intermediate bed of barren gravels, and an underlying bed of gravels containing the gold. These beds are in some places well defined; in others they grade into one another. The three are not everywhere present, and some of the stream deposits have been invaded by slide rock from the valley sides. The auriferous gravels may have a thickness of several feet, or the gold may be confined mostly to the surface of the bedrock. Where the bedrock is blocky the gold is generally found also to a depth of a few feet in its cracks and crevices. The width over which gold is found differs greatly in different valleys; in some it is several hundred feet. In some valleys the pay streak is well defined and continuous; in others the distribution of the gold is very local and irregular.

The source of the stream deposits, in the absence of general glaciation in the Yukon-Tanana region, is referable to the bedrock in which the valleys of the streams have been cut.

BENCH GRAVELS.

Bench deposits at different levels from a few feet to several hundred feet above the present streams are common in many of the larger drainage areas. In the Fortymile district they occur on the high benches of Fortymile Creek and some of its tributaries to a level at least 300 feet above that of the present streams. In the Rampart region there are bench gravels 500 feet above the valleys. The bench gravels occupy positions in the old valleys corresponding to those of the stream gravels in the present valleys. They are the remnants of the old valley deposits left behind in the downward cutting of the streams to their present level, and the gravels at different levels mark the pauses, with attendant deposition, in this process. Like the stream gravels, they reflect in their composition the character of the bedrock in the valleys to which they belong. They are of widely differing thickness in different areas, and at some localities, notably in the Chicken Creek area and in the Rampart district, they have been found rich in gold.

AURIFEROUS CONGLOMERATES.

The conglomerates regarded as Tertiary that occur in the Yukon-Tanana region are so much older than the stream and bench gravels that the conditions of their formation are obscure. The gravels forming them, however, were probably deposited under fluviatile conditions associated with or subsequent to lacustrine conditions and were afterward consolidated and folded. These rocks form a well-defined belt in the area between the Seventymile and the Yukon and westward toward Circle. The gravels of several creeks draining this area contain gold and have been mined for several years. Their gold content is regarded by Brooks[1] as evidence of the presence of alluvial gold in the conglomerates.

ORIGIN OF THE GOLD.

All the available evidence regarding the origin of the placer gold in the Yukon-Tanana region indicates that it has not been deposited in the placers from solution, but has been derived with the other constituents of the gravels by mechanical separation from the bedrock. Inasmuch as the material forming stream and bench gravels is definitely referable to the bedrock of the respective valleys, those auriferous valleys where there is the least variety of bedrock should throw some light indirectly on the origin of the gold. Furthermore, the immediate associates of the gold, or, better still, adherent pieces of other mineral or rock, bear definitely on this problem. If in addition to these indirect sources of information, localities can be cited where gold occurs in place in the bedrock, a considerable body of material will have been assembled that should prove illuminative of at least some phases of the origin of the placer gold.

On but few creeks in the Yukon-Tanana region are the geologic conditions simple. The variety of bedrock of sedimentary origin is further complicated by the intrusive rocks that are locally present in all the important placer-mining areas. Under what are apparently some of the simplest conditions, however (such as those on Wolf Creek in the Fairbanks district, where the bedrock observed in the amphitheatral area at the head of the creek is quartzitic schist and quartz-mica schist with small quartz veins and where the gravels so far as observed are of the same material), the rough, gritty gold, some of it with quartz attached, must have been derived from the schist and most likely from quartz stringers cutting it. The conditions of origin are apparently the same on Fairbanks Creek, heading on the opposite side of the same ridge. On Harrison Creek, in the Birch Creek region, where the same bedrock prevails, a slab of similar schist was found in the gravels containing a gold-bearing quartz seam. This occurrence was described by Spurr.[2] A similar association has been observed on Davis Creek, in the Fortymile region. The fact seems definitely established that in some of the most productive regions a part of the gold, at least, has been derived from the quartz veins in

[1] Brooks, A. H., Report on progress of investigations of mineral resources of Alaska in 1906: Bull. U. S. Geol. Survey No. 314, 1907, pp. 198–200.

[2] Spurr, J. E., and Goodrich, H. B., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 353–354.

the schists, and as these schists are the most common rocks in the Fortymile, Birch Creek, and Fairbanks districts, it is probable that a large proportion of the gold has had this origin. That the mineralization of the schists has not been confined to the deposition of gold is shown by the facts that in the Fairbanks district stibnite (sulphide of antimony), cassiterite (oxide of tin), and bismuth have been found in association with the gold in the placer deposits and that veins of stibnite have been found in the schists.

Rocks regarded as Paleozoic are present in the Fortymile district, and some of the gold occurrences are referable to these rocks. The same is probably true of the Rampart district, where the rocks are predominantly Paleozoic but where there are also pre-Ordovician schists and a few Mesozoic rocks of Upper Cretaceous age. In the Rampart region native silver is a common associate of the gold on some of the creeks, and native copper is found.

The metals and minerals associated with gold in the placers of the Yukon-Tanana region include lead, silver, copper, bismuth, argentite (silver sulphide), stibnite (antimony sulphide), galena (lead sulphide), cinnabar (mercury sulphide), iron pyrites, copper pyrites, barite, cassiterite (tin oxide), rutile, garnet, magnetite, hematite, and limonite.

On creeks tributary to the Yukon a close relation has been observed by Brooks between the alluvial gold and Lower Cretaceous slates, and the following is quoted from his report:[1]

> The rocks exposed along the Yukon between Eagle and Circle do not anywhere include any of the older schists, such as are associated with the Birch Creek placers. In fact, over much of this belt the formations are slightly altered limestones, shales, slates, and conglomerates, which do not bear evidence of mineralization and will not attract the placer miner. Locally, however, some of these rocks are mineralized and contain more or less gold. Thus on Nugget Gulch, a tributary of Washington Creek, slates of Cretaceous age are found which are permeated with quartz veins, some of which must yield gold, as the associated alluvium is auriferous. The writer was not able to study this locality, but it appears that the coarse gold occurs in small patches on the bed rock. This occurrence, though probably of small commercial import, has a far-reaching significance, as it indicates that there has been an intrusion of mineralized veins since these younger rocks were deposited. The writer is, however, of the opinion that this mineralization is not general enough to encourage the search for placers where these Cretaceous slates form the country rock.

Gold has been found in place at several localities in the Fortymile district. On Mosquito Fork about 2½ miles from Chicken Creek gold occurs in a brecciated mineralized zone in a quartz diorite. There has been considerable silicification and an abundant introduction of iron pyrites. Near the head of Chicken Creek gold occurs

[1] Brooks, A. H., Report on progress of investigations of mineral resources of Alaska in 1906: Bull. U. S. Geol. Survey No. 314, 1907, pp. 198–199.

in thin calcite veins that are associated with pyritiferous quartz veins in black phyllites regarded as Paleozoic. These rocks are in contact with quartz diorite porphyry, the marginal facies of a rock like that on Mosquito Fork. The placer gold of Chicken Creek is derived in part, at least, from a deposit of this form. At Canyon Creek a very ferruginous brecciated mass of vein quartz and quartzitic schist yields fragments containing specks of gold that are visible to the eye. On Flume Creek numerous small auriferous quartz veins penetrate a serpentinous igneous rock that is intruded by basic dikes. The metalliferous veins of the Fairbanks district are described on pages 89–92. Other occurrences of gold in bedrock are reported, but have not been studied by the writer.

So far as definitely known, then, at the present time, the placer gold of the Yukon-Tanana region is traceable to quartz veins in the pre-Ordovician schists, apparently also to those in the Paleozoic phyllites, and possibly to those in the Cretaceous slates; to calcite veins in rocks regarded as Paleozoic in close contact with igneous rocks; and to quartz veins and silicified areas of secondary origin in igneous rocks.

A consideration of the map shows that igneous intrusives are widely distributed over the entire region and are present in all the chief placer-mining districts. They are also of widely differing age. The Upper Cretaceous rocks in the vicinity of Rampart have been intruded by them and mark, so far as known, the last period of intrusion of plutonic rocks in the Yukon-Tanana region. Mesozoic rocks have not been found in other areas of intrusion, and it is not known how many of the areas of fresh igneous rocks of granitic and intermediate compositon are of Mesozoic age. It is probable, however, that a large proportion of them were intruded at this time. Some of the granitic rocks and schists are cut by fresh basaltic dikes, and the areas of fresh volcanic rocks attest the continuation of igneous activity. The question whether these volcanic rocks have taken part in the mineralization of the region has not been answered.

There are several hot springs in the region, and at least two of them are near the contact of granitic rocks with schists and with carbonaceous phyllites. The temperature of these waters is probably due to the residual heat of the igneous masses and indicates the long-continued operation of one of the factors influential in mineralization.

This region is regarded as one of large batholithic masses of intrusive rocks, now mantled by a comparatively thin shell of sedimentary rocks. Intrusions have taken place at different periods. Numerous acidic dikes and sills were formed, probably at times when the depth of intrusion was so great as to favor, through increased pressure and temperature, a wide dissemination of the final products of the crystallizing magma through the surrounding rocks not only as dikes and sills, but as intrusive quartz veins, and finally as the ordinary quartz veins so common in the schists. Where the intrusives have penetrated to higher levels, as in the Upper Cretaceous rocks of the Rampart region, no opportunity for long-continued differentiation and distribution of the magma in such attenuated form was afforded, and the action under such conditions was confined to contact metamorphism and the release of the waters of intrusion to act as solvents, to mingle ultimately with meteoric waters, and to deposit the quartz or calcite or other substances they carried in solution.

The acidic dikes and sills are very common in the Fortymile district. They have in places been crumpled and reduced to augen and exhibit generally cataclastic action. They are apparently most characteristic of the older intrusions. The occurrence of gold in the Fortymile district has not been traced directly to them, and they are not common in the Birch Creek, Fairbanks, and Rampart regions.

The intrusives of the Birch Creek, Fairbanks, and Rampart districts are comparatively fresh, and similar fresh intrusives are common in the Fortymile district. Many of these masses are surrounded by shatter zones of rock containing numerous dikes of the same material as the main mass, or a more basic marginal phase. The period of intrusion was one of great disturbance. The gold in the Chicken Creek area is in close relation with such intrusives, and it is believed that in this locality at least they mark a period of mineralization accompanied by the deposition of gold derived primarily from the igneous rocks. The age of this period of mineralization is not known. The quartz veins in the Lower Cretaceous slates of Washington Creek, regarded as auriferous by Brooks, and the ferruginous quartz veins in the Upper Cretaceous rocks of the Rampart region that have been intruded by granitic rocks both indicate a period of mineralization that is probably to be referred to such intrusions. Those of Chicken Creek may belong to the same period; there is as yet no direct evidence bearing on this point. The influence of igneous intrusion is far-reaching, especially in areas of such permeable rocks as siliceous schists, and in view of the widespread distribution of igneous rocks in the Yukon-Tanana region, both in space and time, and their relation to the known facts, it seems justifiable to ascribe to them the widespread mineralization of the region and to refer a part, at least, of this mineralization to the close of the Mesozoic. In this connection it is important to note the relation of mineralization to Mesozoic intrusion traced by Wright in southeastern Alaska.[1]

It might be inferred, perhaps, that if the igneous intrusives supplied the gold, the most productive areas would be found in the

[1] Wright, C. W., Bull. U. S. Geol. Survey No. 314, 1907, pp. 49–51.

vicinity of the most abundant intrusives. Little, however, is known regarding the laws governing the occurrence of the gold in the bed-rock. The composition of the intruding rock, the conditions of intrusion, and the character and physical structure of the intruded rock are among the factors in the problem. It is probable that extensive deformation at the time of intrusion, by rendering the surrounding rocks more permeable, facilitates the transportation of material from the igneous magma. It is perhaps true that in the vicinity of a cooling intrusive mass conditions favorable for solution may be maintained so long that gold derived from this source is carried in solution far into the surrounding rocks before reaching areas where conditions favorable for deposition prevail.

Some of the most productive placer areas lie within the pre-Ordovician schists and some within the Paleozoic rocks. Even in the Rampart region, where the Paleozoic rocks are abundantly developed, the older rocks are present, and the Birch Creek, Fairbanks, and Fortymile areas are not far removed from the present contact of the two groups. It seems probable, therefore, that these areas of gold deposition were adjacent to what before erosion was the contact plane of the two groups, and this plane may have afforded a favorable zone for circulating waters at the time mineralization was in progress.

SUMMARY.

From present knowledge it appears that intrusion has been very widespread in the Yukon-Tanana region, especially in the areas occupied by the pre-Ordovician (?) schists (Birch Creek schist); also that the auriferous deposits have a close genetic relation to the intrusive rocks. The distribution of the developed gold placers and lodes appears to indicate that the conditions for the formation of auriferous deposits are more commonly met in the Birch Creek schist than in the later Paleozoic rocks. That the Paleozoic sediments have, however, been subjected to auriferous mineralization is evident from the occurrence of placer gold in the Rampart, Hot Springs, and other districts, where so far as known there are no pre-Ordovician schists. The most important practical deduction from the above is that the gold seeker should pay special attention to those areas which have been invaded by granite and other intrusives. Furthermore, he should remember that the auriferous mineralization may not be confined to the contact, but may occur a mile or more from it.

GOLD IN THE FAIRBANKS QUADRANGLE.

HISTORICAL SKETCH.

Placer gold was first found on the Tanana in the early seventies (see p. 13), and this was in fact the first discovery of placer gold in inland Alaska. In 1886 the Fortymile placers were found, followed in 1893 and 1894 by the Rampart and Birch Creek placers. In the succeeding years some of the Birch Creek prospectors made their way across the divides into the Chatanika basin and found some gold though not enough to encourage further prospecting. The first reported discoveries of placer gold were those on Faith, Hope, and Charity creeks, which were probably first staked about 1898.

In 1898 a party of gold seekers made their way in two small steamers up the Tanana and the Chena Slough, passed the present site of Fairbanks, and established a winter camp on Chena River, probably not far from the mouth of the Little Chena River.[1] From this camp members of the party made excursions into the headwaters of the Chena, visited the Chatanika Valley, and traversed much of what now constitutes the Fairbanks placer district. The gold placers of this field lie under a heavy cover of muck and gravel and the party was but ill equipped for deep mining; therefore they obtained no definite knowledge of the presence of workable placers, though they found gold in the alluvium.

In the same year Brooks studied the geology of the Tanana Valley, but had no opportunity to examine anything except the banks of the river. The formations were found to be similar to those of the better-known regions, and it is interesting, in the light of recent developments in the Tanana Valley, to read again the following extract from Brooks's report regarding the possibilities of the region:

In this description of the gold resources an attempt has been made to state the bare facts, clearly shorn of all speculations and wild rumors. We have seen that traces of gold have been found throughout the region examined by our party, and that the conditions for its occurrence are in many respects favorable; also that the little prospecting which has been done up to the present time has been too hurried and too superficial to be regarded as a fair test of the region. Our best information leads us to believe that the same horizons which carry the gold in the Fortymile and Birch Creek districts are represented in the White and Tanana river basins. I believe, therefore, in spite of the adverse results which have been obtained so far, which are purely negative, that the White and Tanana river basins still offer a favorable field for the intelligent prospector. I am inclined to think that the upper basins of these rivers are occupied chiefly by the younger nongold-bearing rocks. I should advise prospectors to carefully investigate the small tributary streams of the lower White and of the Tanana from Mirror Creek to the mouth. The headwaters of the streams lying to the north of the Tanana ought to offer favorable returns, situated, as they are, opposite the headwaters of Fortymile and Birch creeks, streams which are more or less gold bearing.[2]

The discoveries of placer gold in the Fortymile, Birch Creek, and Rampart country led to the rapid development of these three areas, and they became producers of placer gold. The regions adjacent to these centers of production were investigated by prospectors under

[1] Information obtained from Alfred H. Brooks.

[2] Brooks, A. H., A reconnaissance in the Tanana and White river basins, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 488.

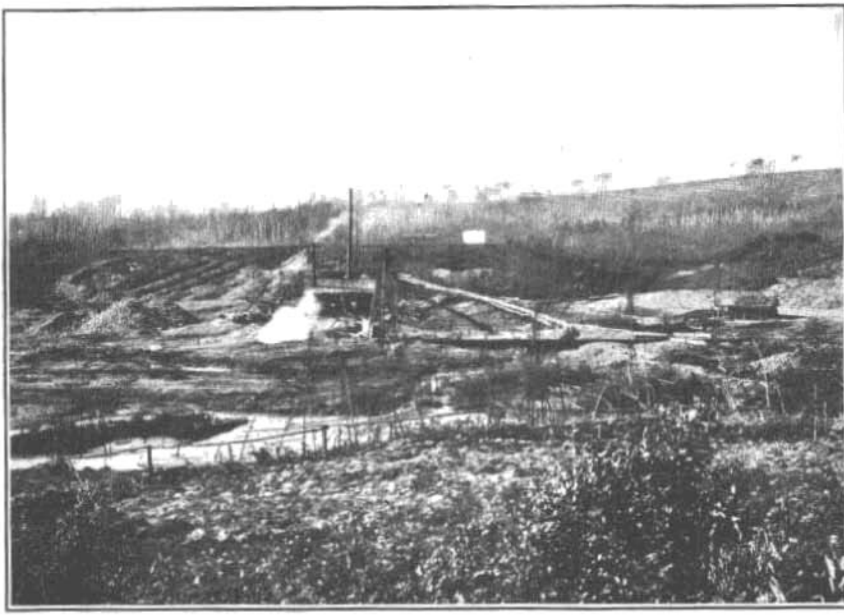
the primitive conditions of transportation then prevailing. Through the energizing impulse of the discoveries in the Klondike region in 1896, the valleys of streams tributary to the Tanana came within the sphere of investigation. The first men who undertook this work had only small supplies of food. They were obliged to travel rapidly. They had few opportunities to more than glimpse the country traversed and fewer still to prospect with sufficient thoroughness, especially in valleys where the depths to bedrock in most places far exceeded the depths obtaining in other regions and those attainable by the limited facilities at their disposal. So, apart from sporadic trips by miners from the Fortymile and Birch Creek regions or from the temporary halts of those who traveled down the Tanana, this rich region was neglected.

A trading station named Fairbanks was established in 1901 on a slough of the Tanana about 260 miles above the point where Tanana and Yukon rivers join. Felix Pedro, while prospecting north of the Tanana in July, 1902, about 12 miles from the trading station, in the valley of a small creek, since called Pedro Creek, discovered gold. The few prospectors in the region staked out the neighboring valleys, among which were those of Fairbanks and Cleary, and these and the Pedro Valley became the first productive areas.

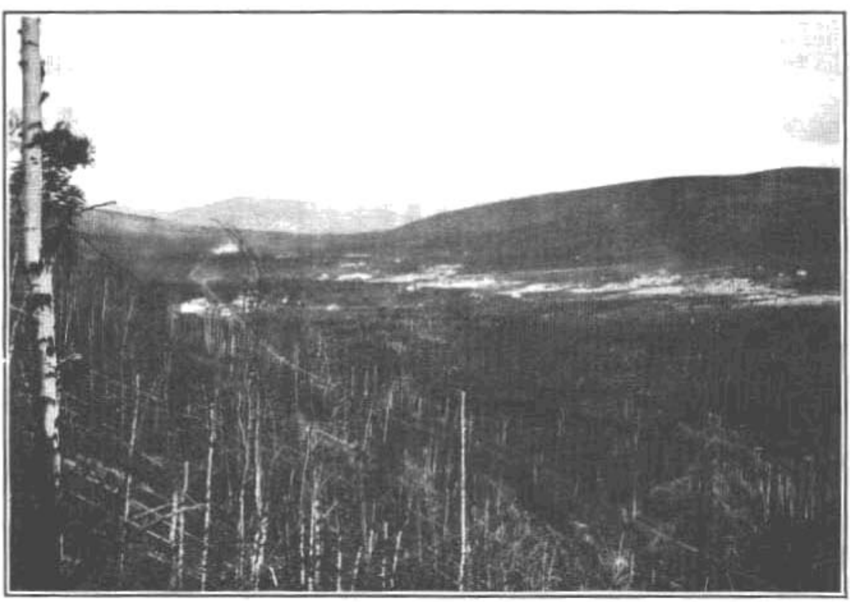
The news of the discovery naturally spread to neighboring regions and to Dawson, and during the winter of 1902–3 there took place the inevitable rush of miners to the new placers. The contrast between the phenomenally rich and comparatively accessible placers of the Dawson region and the lower grade, deeply buried placers of the Fairbanks region was unfavorable to the latter, and the stampede was an incident without appreciable results in the commercial advancement of the region.

During the summer of 1903 the region developed slowly, but as the results obtained by the persistence of the miners became apparent through an output for that year of about $40,000, the attitude of indifference gave place to one of confidence, and a period of rapid development began in 1904 and has continued up to the present time.

It was soon found that the comparatively shallow gravels where the first discoveries were made were of small extent and that by far the greatest part of the productive gravels were buried beneath a thick, barren, mostly frozen overburden. The problem of mining, therefore, necessitated the employment of powerful hoisting machinery and the development of suitable transportation facilities from the navigable waters to the areas to be mined (Pl. XII, *B*). The pack trails gave place to wagon roads of a temporary nature and these in turn to a narrow-gage railroad and the permanent system of wagon roads now being elaborated through the cooperation of the Alaska Road Commission and the miners.



A. PLACER-MINING PLANT ON ESTER CREEK.



B. VIEW UP GOLDSTREAM VALLEY.

The development of the local supply points, Fairbanks and Chena, has kept pace with the development in mining. These communities have already become of relative importance as centers of distribution for supplies coming from Pacific coast points, and minor supply points have come into existence on the most important creeks.

The development of the region has taken place under conditions of very high costs—conditions that could only be successfully overcome by the fact that the portions of the auriferous gravels that have hitherto been mined were sufficiently rich to grant a degree of prosperity even under adverse conditions. That this degree is close to the limit possible with the present facilities for transportation is shown by the financial sensitiveness of the region at the time of the miners' strikes of 1907, when few operators could bear any increased costs whatever, and again in 1908, when the long-continued drought prevented the miners from washing out their gold and caused much temporary financial stringency.

As an incident in the development of this community is to be noted the change in character of the mining population. The prospectors of the early years were men who had worked long under northern conditions, and many of them had made worthy reputations as pioneers. With the advent of large operations the prospectors gave place to men skilled in the methods of drift mining prevalent in the Dawson region. Under their leadership haphazard methods of gophering for immediate returns gave place to more systematic work, and rapid handling of material by large plants became the standard of mining practice.

METALLIFEROUS LODES.

QUARTZ VEINS.

The quartz veins in the Yukon-Tanana region range in age from pre-Ordovician to Upper Cretaceous. A particular area, therefore, like the Fairbanks district, probably contains quartz veins formed at widely separated periods, and, although it may be possible to fix the age of some of them with more or less certainty as previous to the general folding of the region and to regard others as being related to a period of intrusion, a considerable proportion show no recognizable evidence of their period of formation.

The quartz veins after their formation have not been exempt from the deformational processes to which the inclosing rocks have been subjected, but, according to their age, have undergone more or less folding, minor faulting, or brecciation. Slickensided surfaces attest the motion that has taken place, and the fact that gold has been observed rubbed into slickensided surfaces of quartz in a direction parallel with that of movement shows that some of the motion has been subsequent to its deposition. The amount of local faulting to which the veins have been subjected has apparently been considerable and has rendered some of the auriferous quartz veins discontinuous. Where the recovery of such veins is sought the dip of the slickensided surfaces and the grooves upon them should be carefully scrutinized, as their direction and angle may indicate in what direction the continuation of the vein should be sought.

Besides the changes already noted there has been in some places a reintroduction of quartz, so that the present quartz veins embody the results of a sequence of events, one of which, at least for some of the veins, has involved the introduction of gold and sulphides. The portions of the veins at present visible have undergone weathering and erosion, whose effects have extended to considerable depths and have gone deeper as the upper portions of the veins have been eroded.

Besides the simple fissure veins crosscutting the schists there are in places shear zones of country rock containing parallel or anastomosing veinlets of quartz in many places surrounding brecciated portions of the schist, and there are other areas in which irregular masses of altered and brecciated igneous rock have become permeated with secondary quartz that occurs not as well-defined veins but rather as spongy masses.

Up to the present the greatest number of auriferous veins have been found adjacent to the main ridge running northeast from Pedro Dome for about 10 miles in the drainage areas of Pedro, Cleary, and Fairbanks creeks. The veins range in thickness from small stringers to veins 12 to 15 feet thick. Their general strike is northeast and southwest, or about parallel with the general strike of the country rock. The dips are mainly vertical. The veins in places run parallel to the structure of the schists, and in places they crosscut the schists. The deposition of quartz, in some places auriferous, has been common along the joint planes of the schists. In the productive veins the vein quartz is as a rule of a milky, opaque, white color, but the latest deposits are locally transparent and are present partly as crystals, some of which project into masses of compact granular stibnite deposited subsequently to the quartz. There is a considerable quantity of the gray glassy barren quartz referred to commonly by miners as kidney quartz or bull quartz.

Quartz is by far the most abundant vein material. A little orthoclase is found in some of the veins, mostly kaolinized, however, and a little micaceous mineral, probably sericite. At one locality small stringers of quartz containing fresh albite were observed. Calcite veins are not common, and those observed are small stringers in calcareous bands in the schist, along with associated sulphides.

The proportion of tourmaline in the Fairbanks district is small. It has been observed in the mica schist and andalusite schist at a few localities. At one locality it occurs in the schist at the margin of an auriferous quartz vein, where it is embedded in colorless mica associated with iron pyrites and arsenopyrite.

METALLIZATION.

The metallic compounds and metals thus far observed in the bedrock are iron pyrites, limonite, stibnite, arsenopyrite, galena, sphalerite, and gold. Minerals present in the stream gravels that have apparently been derived from similar veins are cassiterite (which is rather abundant), wolframite, and bismuth, small pieces of the last having been found intergrown with gold.

Iron pyrites is perhaps more abundant than any other sulphide. It occurs in granitic rocks, in quartz veins, and in schists. In the marginal portion of the coarse porphyritic biotite granite of Twin Creek it is in places particularly abundant, occurring as crusts of crystals of pyritohedral habit along the joint planes of the granite and embedded in the granite. The pyrite is almost entirely altered to limonite, and the superficial portion of the granite has become a mass of loose material. Similar conditions prevail on Hill Creek, a small tributary of Gilmore Creek. A small amount of placer gold found at the head of Hill Creek has been derived apparently from such pyritized granite. Dikes composed almost entirely of quartz and feldspar, which occur near the head of Engineer Creek, contain crystals of altered pyrite. Small pyritohedrons of altered iron pyrites occur also in and marginal to dikes of sericitized granite porphyry, in close association with stibnite. Here the alteration has been to iron carbonate. Small crystalline masses of fresh iron pyrites have been found in association with galena and sphalerite and calcite stringers.

Although the pyritized granite assayed for the Survey failed to reveal more than traces of gold, the conditions on Hill Creek are such that the gold found there must have been derived from the granite. The limonitized pyrite of quartz veins in Skoogy Gulch has been found to contain visible gold embedded in the limonite.

Besides the altered pyrite of the veins above mentioned, there is in the brecciated schists, in quartz veins throughout the district, and in some of the altered igneous dikes a large proportion of limonite, whose pronounced discoloration renders conspicuous the minutest fractures. The wide extent of this discoloration in the Fairbanks district is an index of the large amount of ferruginous matter involved.

Stibnite (bisulphide of antimony) was common in the concentrates from the placers in the early days of mining in the Fairbanks district, and was afterward found in place in the bedrock at several localities in widely separated parts of the district. It occurs in place here and there in the drainage area of Cleary Creek, and together with arsenopyrite accompanies the gold in the richest of the quartz veins. It has been found as narrow stringers composed almost entirely of massive stibnite crosscutting quartzite schist, or forming a network of stibnite veins between fragments of brecciated schist; in veins of quartz and stibnite, where the massive stibnite occupies the spaces left between quartz crystals; and as fine needle-like crystals or small crystalline groups along with some fresh, clear quartz areas in more or less fractured quartz veins. At one locality stibnite was found in close association with a sericitized dike of granite porphyry. The schist had not only been intruded by the dike but had apparently been fractured by it. Stibnite has been deposited on the surface of the dike and occurs as small veins and lenticular masses up to several pounds in weight in the schist; at this locality it is apparently in close genetic association with the granite porphyry. Assays of the stibnite have not shown a gold content of over $1 to the ton.

Arsenopyrite occurs massive in veins a few inches thick in the schist, associated with quartz; as crystals in some of the altered granite porphyry dikes; and as crystals and crystalline groups in some of the rich gold-quartz veins, associated with stibnite and gold. At one locality massive arsenopyrite was found associated with massive stibnite, galena, and quartz. The arsenopyrite is easily distinguishable from the stibnite by the lighter-gray color and greater hardness.

Galena is less common than the other sulphides but has been found in the bedrock in association with sphalerite and calcite veins at one place and with stibnite and arsenopyrite at another. A small amount of sphalerite is present with arsenopyrite, stibnite, and gold in the richest quartz veins. It has been found rather abundantly also at two localities in calcareous bands in the schist, associated with iron pyrites and stibnite.

The occurrence of bismuth intergrown with gold has been noted. Small grains composed of these two metals have been found in the concentrates from the placers on Gilmore Creek and in the upper valley of Fish Creek, in areas of both schist and granitic intrusive rocks.

Cassiterite is a constituent of the concentrates from the placers of several creeks, where its most common associates are garnet and rutile. Wolframite has been observed in the concentrates from two localities.

Much of the gold of the quartz veins is free and visible, occurring as small flakes and grains. It has been observed embedded in limonitized crystals of iron pyrites and also in the midst of clear quartz with no admixture of ferruginous matter. Its most common associates in the richest veins are stibnite and arsenopyrite, with a little iron pyrites and sphalerite. Tellurium ores have been reported, but material tested in the laboratory of the Survey from several localities showed no trace of tellurium. Where the gold occurs in the quartz with sulphide there is a rather even distribution of these minerals throughout the portion of the vein containing them. In places a foot or more of wall rock each side of a vein has been found to be auriferous. Although the richest ore is that in which abundant stibnite and arsenopyrite are associated with the quartz, veins composed of the sulphides alone have been found to carry but little gold. The rock showing specks of free gold is naturally of high value and helps to raise the average values over a width of several feet, some portions yielding about $50 a ton. A specimen assayed for the Survey contained $1,033.50 in gold and 11.50 ounces of silver to the ton. The value of the vein gold has been reported to be $17.50 an ounce.

Gold has been deposited in quartz veins from solution. The process of deposition is one in which many factors have been involved. The recognition of the factors involved, the apportionment to each of its appropriate share in the process, and the determination of the relative period of deposition are problems that are difficult and only partly understood. The process and the sequence of events have to be inferred from the kinds and relations to each other of the products now found in the veins.

That the introduction of the sulphides was, to some extent at least, independent of the introduction of quartz is shown by the presence of small veins of stibnite crosscutting the schists or cementing fragments of brecciated schist. The introduction of the sulphides was probably one of the last events in the history of vein deposition, an event during which some quartz, a little mica, gold, and sulphides were deposited, partly in quartz veins already formed and partly in new veins, some of which were veins of solid stibnite. The deposition in the veins already formed seems to have been either conformable to the preexisting quartz or unconformable to such quartz in spaces resulting from more or less shattering before the deposition of the gold and sulphides. The facts seem to point to the latter supposition as being more expressive of the truth.

The sequence of events may have been somewhat as follows: At about the close of intrusive activity, after the intrusion of dikes of granite porphyry and of persilicic granitic dikes with related quartz veins containing a small proportion of alkali feldspar like that of the persilicic granitic dikes, there was an introduction of further products of intrusive activity in the form of solutions, in part auriferous. Through the activity of these solutions some of the dikes were sericitized, with a little alteration of iron pyrite to iron carbonate, and gold and sulphides were deposited. The occurrence of tourmaline in close association with iron pyrite and arsenopyrite at one locality seems to show one phase of the process.

The facts indicate a close relation between the gold and the sulphides and the reference of both to a genetic relationship with the igneous rocks. The metallization probably occurred near the end of the Mesozoic era.

The Fairbanks region was last visited by the writers in 1909, at which time few lodes had been developed. Lode mining has increased so much since that date that it was specially investigated in 1912 by Philip S. Smith. Mr. Smith's report is presented as a separate chapter of this bulletin (pp. 153–216), and as it sets forth all the available facts regarding the lodes further description of them here is omitted.

GOLD PLACERS OF THE FAIRBANKS DISTRICT.

MATERIAL OF THE PLACERS.

GENERAL CHARACTER.

The unconsolidated material derived from solid bedrock varies in character according to the time it has been exposed to weathering and the distance over which it has been transported. Outcrops of bedrock in the Fairbanks district are confined mostly to the summits of the ridges and to the steeper slopes of the valleys, the more gentle slopes and the valley floors (Pls. V, *B*, and XII, *B*) being formed of unconsolidated material.

The deep mantle of residual and transported material that covers so large a part of the area includes broken bedrock, rock slide, and all the fine products washed down the slopes toward the valleys from the bedrock ridges, as well as silt, sand, and gravel that have been under the more active influence of water. On the map (Pl. XI) the latter deposits, including slope wash and stream gravels, have been termed terrace deposits. The slope wash or waste from the hills is particularly worthy of recognition because in these northern latitudes a large amount of material slips down the slopes and mingles with the products of stream action. Ripples of waste sending out tonguelike processes are characteristic minor features of the surface throughout the timberless areas of the Yukon-Tanana region, and even on gentle slopes covered with moss and small spruce frequent slides of material to the valleys strip areas acres in extent.

This process seems to have been favored partly by the decrease of friction due to a frozen under surface and partly by increased mobility due to a large water content. The ability of finely divided rock material to retain a large percentage of cold water and thus to become very mobile has been noted in other northern regions and is familiar to every prospector who has thawed his way through what is known to him as "muck."

The evidence available indicates that the gravel, sand, and silt of the valleys have been deposited under conditions predominantly fluviatile, but that lacustrine conditions have also been present. The district has not been exposed to the direct effects of glaciation. The noteworthy characteristics of the deposits are their thickness (the maximum thickness revealed by mining operations is over 300 feet) and their consolidation by ice, the greatest part of the alluvial deposits being perpetually frozen. Deposits have been found frozen to the greatest depths attained in mining. There is a considerable proportion of unfrozen ground, however, in which water is generally circulating. The material exposed by the mining operations includes slide rock, muck, sand, silt, clay, barren gravels, and gravels in which gold is found, all of which are generally collectable into three divisions designated respectively by the miners muck, barren gravels, and "pay gravels" or "pay streak."

MUCK.

Under the term muck have been included generally very diverse materials, the term being applied to all the fine material, with a thickness up to about 100 feet, overlying the main body of gravels. The term was originally applied in the Fairbanks district to designate the uppermost black deposit derived from the decomposition of moss and other vegetation, with a considerable percentage of clay and sand either intimately mixed or distributed as thin layers or lenticules throughout the mass. As thicker deposits were worked the term came to include the extensive fine grayish beds that occurred beneath the black deposits in many places, especially on benches. This material is composed predominantly of very fine, partly rounded angular grains of quartz, with grains of other minerals resistant to decomposition. Farther up on the slopes fine particles of schist and other bedrock become mixed with these fine materials. Exceptionally the black beds containing vegetable material are found beneath the gravels. Beds or lenticular masses of nearly pure ice up to 40 feet thick are found interbedded with the muck. In one shaft on Dome Creek, where the depth to bedrock is 117 feet, the distribution of muck, ice, and gravels is as follows:

Record of shaft on Dome Creek.

	Feet.
Muck	6
Ice	9
Muck	12
Ice	11
Muck	44
Gravel	35

GRAVEL.

The gravels underlying the muck, from which they are generally separated by a rather definite plane, have a thickness that in places exceeds 150 feet. They are not coarse, the proportion of material exceeding a foot in diameter being small, and few of the bowlders being sufficiently large to cause difficulty in handling. The gravels are composed of the bedrock found in the respective drainage areas; and as quartzite schist and quartz-mica schist are the most common varieties of bedrock the gravels are composed predominantly of these rocks; further, as the quartzite schist is the harder and more resistant to weathering, it forms the largest proportion of coarse material in the gravels. The gravels also include carbonaceous schist, green garnetiferous rocks, vein quartz, and igneous material. Teeth and fragments of the tusks of the mammoth and bones and horns of other extinct animals are frequently found. The coarse material, being mostly schistose, occurs as more or less flattened angular pieces but slightly waterworn. The fine material is composed partly of smaller pieces of the more resistant rocks and partly of clay derived from the decomposition of the more micaceous schists. There is also a small percentage of individual minerals released by the processes of weathering. The proportion of clay in the nonproductive or barren gravels is small. All the material, both coarse and fine, is irregularly intermingled, the flat pieces having a rough horizontal arrangement. Colors of gold are found frequently in the upper gravels, but normally they do not carry sufficient gold to make them of importance to the miner.

The productive gravels almost without exception lie next to bedrock. They resemble the gravels above them but generally contain a considerable proportion of very fine material, termed "sediment" by the miners, which adheres to the gravel and to the blocky fragments of bedrock. The presence of this fine material, which is made up of minute rock fragments, quartz and other resistant minerals, and clay derived from rock decomposition, generally renders the productive gravels easily distinguishable from the overlying gravels. In places also the gray, red, or brown color of the productive is in strong contrast to the blackish color of the nonproductive gravels. In other places, however, the two grade imperceptibly into each other.

The thickness of the productive ground ranges from a few inches to 6, 8, or more feet of gravels and from a foot to several feet of bedrock. The average thickness for the district is about 6 feet. The lateral extent of gravels productive under present costs is different in the different valleys and in different parts of the same valley but is much less than the width of most of the valleys. The average width mined in 1908 for the entire district was about 200 feet, but exceptionally it is much greater. The value of the gold recovered ranged from less than $1 to $8 or more per square foot of bedrock mined, which, for depths of 6 and 10 feet, respectively, of productive gravels, gives values of about $4.50 and $20 per cubic yard. An estimate of the gold obtained in 1908 is $1.25 per square foot of bedrock or (with 6 feet of productive ground) about $5.60 per cubic yard.

The total length of ground along which productive areas were scattered in 1908 was approximately 75 miles and the proportion of this distance where the depth to bedrock is under 40 feet is probably not over 20 per cent.

The gold is either evenly distributed throughout the productive gravels or lies mostly near the bedrock or in a few places is found within the bedrock. The great bulk of it is composed of flattish pieces up to a quarter inch in diameter, of granular pieces, some of which are minute, and of considerable very fine gold. The proportion of nuggets is small; those worth a few dollars are common, and a few of considerable value have been found. Some of the largest were worth, respectively, $145, $160, $190, $233, and $529. Assay values have ranged from about $16 to over $19 of gold per ounce. The common associates of the gold in the placers are garnet, rutile, and black sand, partly magnetite and partly ilmenite.

TERRACE DEPOSITS.

Terrace deposits are well developed along a large part of the southwest side of the Goldstream Valley, in part of the Chatanika Valley, and are observed at many other localities. One terrace seems to have had an extensive development throughout a large part of the region. At one place the front of this terrace is 65 feet above the level of the present valley floors and the material of which it is composed consists of about 25 feet of gravel overlaid by 40 feet of silt. These deposits deepen toward the southwest and for the most part become thinner toward the northeast as the valleys narrow and grade upward toward the heads of the streams.

Bedrock benches are not common. A low bench mantled with gravel was observed near the head of Fairbanks Creek, and similar benches have been observed on Gilmore and Ester creeks. The predominant characteristic of the bedrock surface is its flatness as compared with the present surface of the ground. These terrace deposits are not, therefore, deposits upon a high bedrock surface but are rather portions of unconsolidated deposits that extend down to a bedrock surface not essentially higher than that underlying the present streams. Since these deposits were laid down (probably in part in lakes, a few small ponds being present even to the present day) the valley floors of the present streams have been formed, and within them are minor terraces.

The conditions that brought about the terrace deposits are not local to the region. Similar deposits on the Yukon side of the Yukon-Tanana region most probably result from the same conditions in the same general period of sluggish drainage and abundant fine sediments, as shown by the tremendous body of silts in the upper Yukon Valley.

The relations of the bedrock surface to the alluvial deposits, the position of the productive gravels in the valleys, and the position of the present streams in the valleys are shown in the cross sections (Pl. XIII).

FORMATION OF PLACERS.

Although the processes involved in the deposition of the auriferous gravels are but imperfectly understood and any explanation therefore must be considered only tentative, it is nevertheless useful to make such an attempt.

The earth's surface is known to undergo periodical elevations and depressions, which, although inappreciable with reference to the earth's radius, may, nevertheless, be very marked on the surface of the particular portion of the earth undergoing movement. The inland of Alaska has been subject to such movements, and the productive gravels seem to have been deposited under conditions connected therewith—conditions somewhat different from those now prevailing. The general uniformity of ridge level suggests a former more or less continuous surface of low relief—a surface formed by erosion of the land nearly to sea level. The later elevation of such a region above sea level would give an opportunity for the streams to develop the present valleys by downcutting toward sea level and by lateral widening.

Through successive changes in elevation the history of the surface of a region may become very complex, and such has been the history of the Yukon-Tanana region. In general terms, however, the successive stages in the history of the region may have been as follows: (1) Elevation of a surface laden with unassorted weathered material and older stream deposits; (2) a period of active erosion by the streams during which the valleys were partly cut and the older stream deposits and weathered material were partly removed; (3) a period of deposition when the streams were nearly down to grade and when the portion of the heavier weathered material and of the older deposits that had thus far escaped removal was laid down to form the future productive gravels; (4) a period of abundant deposition, stream shifting, and valley widening, with the gradual development of the unsymmetrical type of the valley of the present day. That there have been minor changes of elevation is shown by terrace deposits, and the erosion of these by the cutting of the present streams gives to the surface of these valleys a relief greater than that of the underlying bedrock.

It seems very probable that at the time the main bodies of productive gravels were deposited the streams had access to the products of long-continued weathering and that the weathering had released from the bedrock a much larger amount of auriferous material than is accessible to the streams of the present day. But the occurrence of gold in the shallow deposits near the heads of the present streams, where cutting of the bedrock is still in progress, indicates that gold is still in process of deposition. In these portions of the valleys the deeply buried, more or less permanently frozen productive gravels merge into the auriferous material due to the present stream activity; in other portions the present streams bear but little relation to the productive gravels.

The extent to which the gold is found near and in bedrock results primarily from its high specific weight. In the often interrupted progress of material down a valley this material is subjected to gravitational selection, the pieces of higher specific weight tending to lag behind the other pieces and to find a lower position in the mass or a position in the crevices of the bedrock. Such pieces will be most sensitive to any weakening of the force that carries them forward and will be the first to be deposited.

In the valleys of the Fairbanks district, as elsewhere, there is an upper portion with a steep grade where the bedrock is being cut and a lower portion with a more gentle grade where material is being deposited. Somewhere in the transition between these two portions there is an area where the tendency passes from cutting to deposition, and it is in this area, close to bedrock, that the conditions are most favorable for the deposition of any gold that is being carried forward. As valleys develop backward toward their heads this area will migrate upstream, and the deposits formed in it will become in the course of time more or less continuous and, if sufficient auriferous material is present, will form a body of productive gravels—the "pay streak" of the miners. The deposits formed in the earlier stages become covered with a constantly thickening overburden until they are no longer subject to change, the active portions being above the place where the deeply buried nonactive portions emerge from beneath their thick overburden into the area of the streams' activity in the headward portions of the valleys.

The extent of the consolidation of alluvial deposits by ice, although dependent primarily on the climate, is greatly modified by local conditions. Though most of the deposits that are being mined are frozen, there is a considerable circulation of underground waters, and in nearly every valley some workings have been flooded. The "live" water is very frequently encountered just above the productive gravels, the common clay content of the latter forming an impervious stratum. It is probable that where deposits are of such a character and so located as to be easily drained they will not be subject to permanent consolidation by ice.

It does not seem that climatic conditions essentially different from those of the present time would be necessary to account for these deposits. That there has been a period of more abundant precipitation is suggested by the much greater former extension of the glaciers of the Alaska Range.

GOLD-PLACER AREAS.

PRODUCTIVE AREAS.

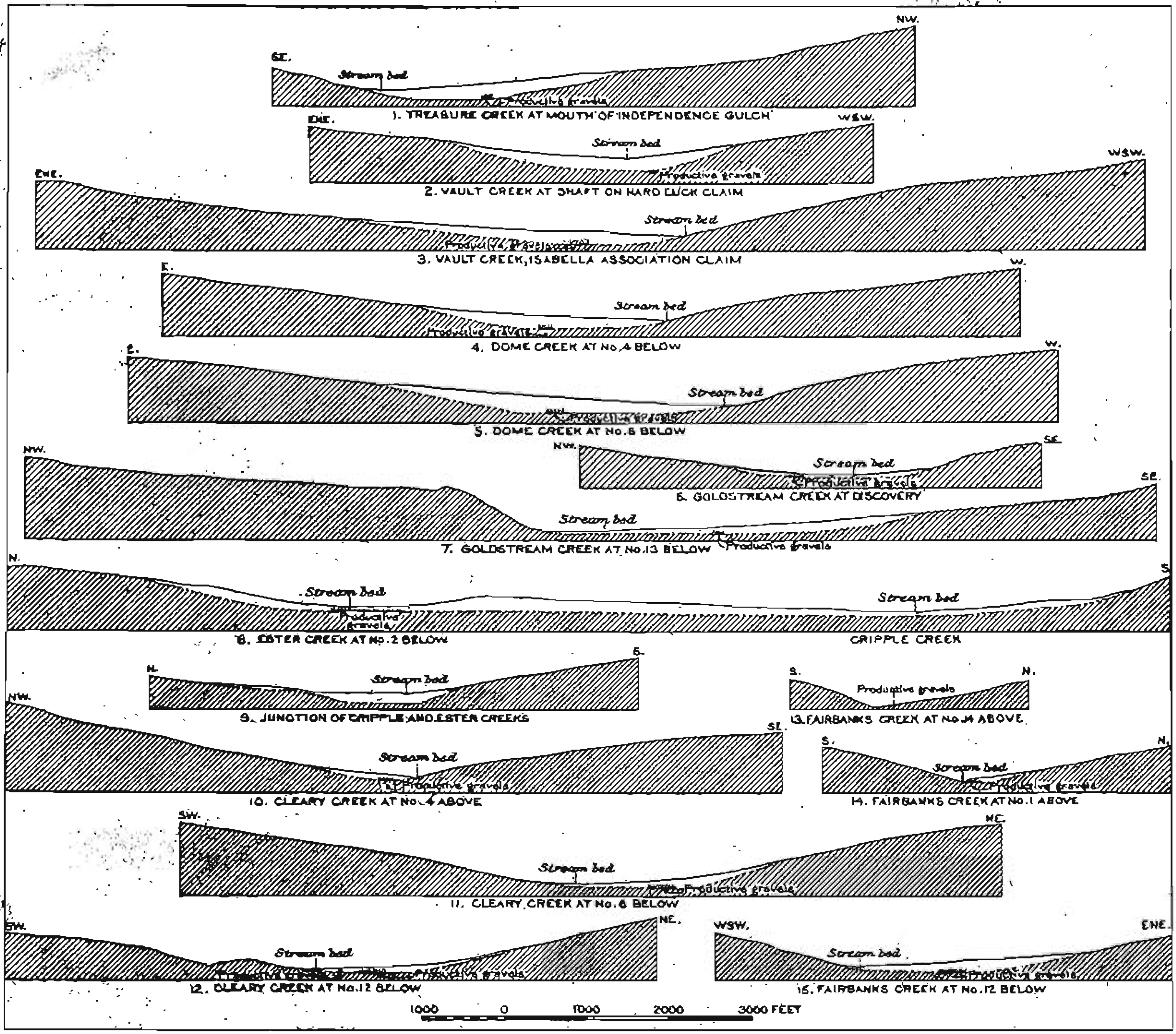
The gold-placer areas are marked on the map (Pl. VIII), and statistical data regarding the placer deposits are given on pages 107–110. Pedro, Fairbanks, and Cleary creeks became productive in 1903 and furnished the bulk of the production in 1904. During 1905 Dome (Pl. V, *B*, p. 21) and Ester creeks were added to the list, and in 1906–7 Vault, Goldstream (Pl. XII, *B*), Engineer, Eldorado, Our, and Smallwood valleys were found to be auriferous. The valleys that proved most productive during 1908 were Ester, Dome, Vault, Cleary with the adjacent portion of the Chatanika Valley, Goldstream with its tributary valleys (Pedro and Engineer), and the Fairbanks Valley. During the fall of 1908 promising discoveries were being made in the lower part of Eldorado Valley and on the Chatanika Flats. During 1909 the season was a successful one in the region of the Chatanika Flats at the mouth of Cleary. The Engineer Valley also proved increasingly productive. The season of 1910 witnessed a marked decrease in the amount of placer gold produced

The cross sections of the valleys and the ground plans and columnar sections illustrate the relation of the deposits to the underlying bedrock and the dimensions of the deposits.

CLEARY CREEK AND CHATANIKA FLATS.

In 1908 some work was being done on Cleary Creek about the mouth of Chatham Creek, and a little mining was being done on Chatham Creek, but the upper portion of the Cleary Valley was strewn with piles of tailings from the ground that had been worked in the past, and most of the mining was confined to the portion of the valley extending from the mouth of Wolf Creek to the Chatanika Flats, and was concentrated in the area adjacent to the town of Chatanika.

The alluvial deposits of the Cleary Valley have been found to range in thickness from a few feet to 135 feet. The thickness of the productive gravels averages about 5 feet, and widths that have been mined have in places reached several hundred feet. The productive gravels (Pl. XIV) were found to be very continuous in the Cleary



CROSS-SECTIONS OF VALLEYS, SHOWING ALLUVIAL DEPOSITS AND BEDROCK FLOOR.

Valley and to maintain their persistence out into the Chatanika Flats, where they partly diverge and partly swerve round to the left, mingling with the gravels of the Chatanika.

So much work has been done in the Cleary Valley that the course of its deposits is very definitely outlined. Their position above the bend of Cleary Creek is beneath the gently sloping side of the valley. They cross at the bend, where they are particularly wide, and below the bend they are again beneath the gently sloping side, which is here the opposite side. Their position both above and below the bend is such as to suggest equidistance from the inclosing ridges, and prospectors have made use of this relation in prospecting other unsymmetrical valleys where no data are available to determine the best areas to prospect.

The relation of the deposits of the Cleary Valley to those of the Chatanika Flats has been the subject of much speculation. The gravels of Cleary Valley are easily distinguishable from the finer, more rounded gravels of the Chatanika Valley. As is usual where one stream joins another, there is a mixture of material, which is shown in some of the ground mined in the flats. It is very probable that at the time the productive gravels were being laid down the stream shifted from side to side as it entered the larger valley and consequently distributed its auriferous material over a considerable area. The distribution would not necessarily be uniform, however, and the probabilities are that the deposits would be reworked in the larger valley and carried in part beyond the mouth of Cleary Valley. Old meanders close to the southern limit of the Chatanika Valley attest the recent presence of Chatanika River on the southern side of its valley, and similar conditions were as likely to occur when the productive gravels were deposited. The continuation of the productive gravels from the mouth of the Cleary Valley across the railroad nearly to the mouth of Ruby Creek, where the workings have shown the gravels to be of the same type as those of the Chatanika Valley, is what would be expected. The discovery of auriferous ground far out in the flats opposite the mouth of Cleary was taken by some to indicate the presence of productive gravels belonging independently to the Chatanika Valley, and reports during the winter of 1908 indicated that a Chatanika "pay streak" had been found. This may be so, but the complex way in which the deposits of one stream may become mingled with those of another into which it flows makes it difficult to settle the problem by the study of any deposits within the area of possible mutual influence of the streams that deposited the auriferous material, and it can only be said that so far no gravels that belong definitely to the Chatanika Valley have been found to carry gold sufficient to pay for working.

ELDORADO CREEK.

Eldorado Creek heads in the quartz diorite mass of Pedro Dome, and its gravels, which are composed predominantly of schist, carry quartz diorite as a characteristic constituent. A very heavy body of terrace deposits and slope wash on the eastern side of the valley has made prospecting difficult. The productive gravels have not been found to be continuous. Noteworthy discoveries were made in 1908 below Marshall Creek and again far out near the edge of the Chatanika Flats. Coarse gold has been found in this lower portion of the valley, a $90 piece having been found below Marshall Creek, and a nugget worth $54 at the edge of the flats. The depth to bedrock at the latter locality is 122 feet. The section from surface to bedrock was reported as follows:

Section on Eldorado Creek at edge of Chatanika Flats.

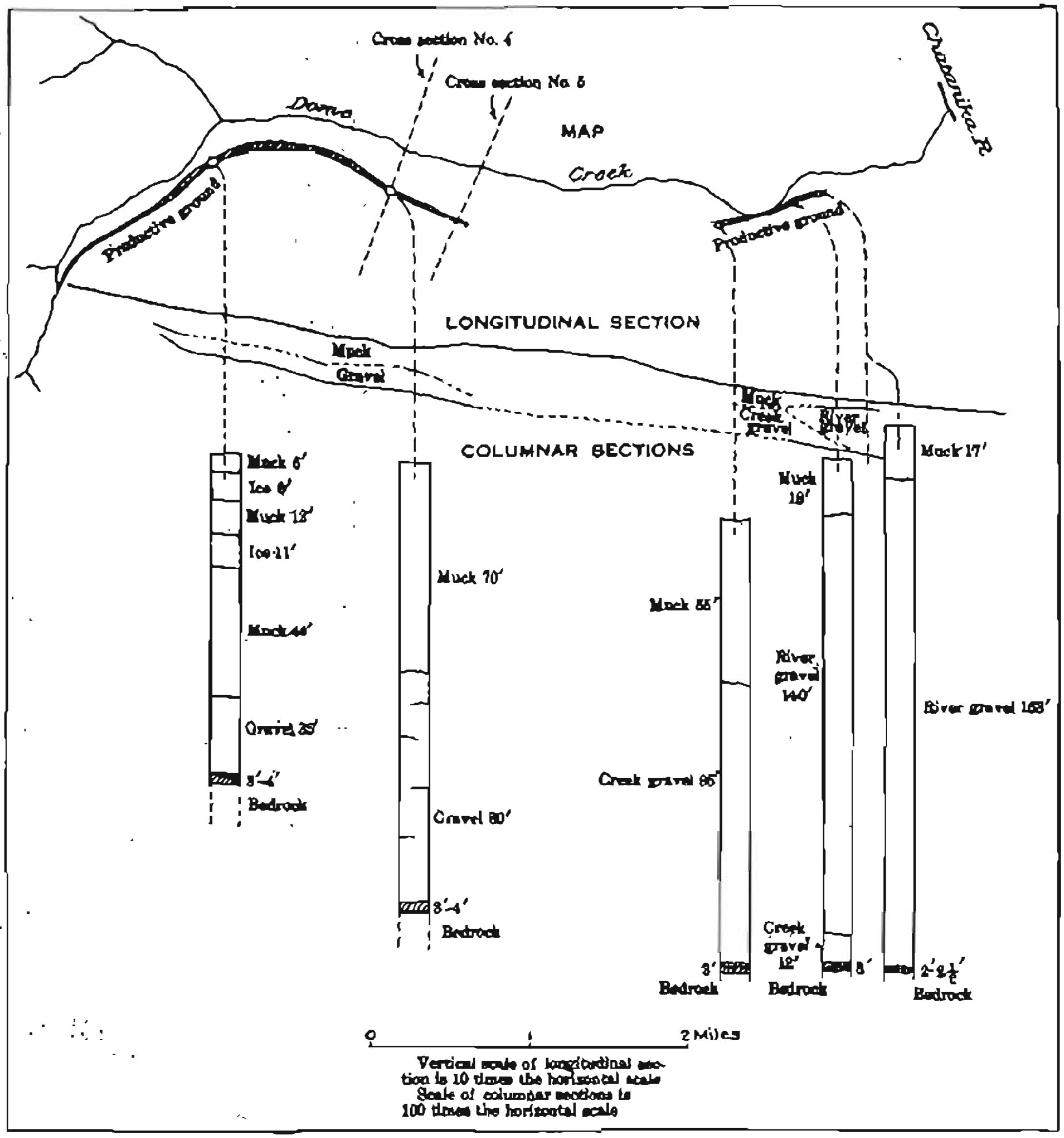
	Feet.
Muck	46
Gravel (Chatanika wash)	15
Muck	7
Sand and gravel	24
Gravel (Eldorado wash)	30

The section of deposits was not observed, but both Chatanika wash and Eldorado wash were observed on the dump. The muck was composed largely of vegetable material. The presence of gravels from Chatanika River overlying muck-covered gravels from Eldorado Creek is suggestive of the complexity of the mutual relations of the two streams and may be found of significance with reference to the drainage history of the region when other facts become available.

DOME CREEK.

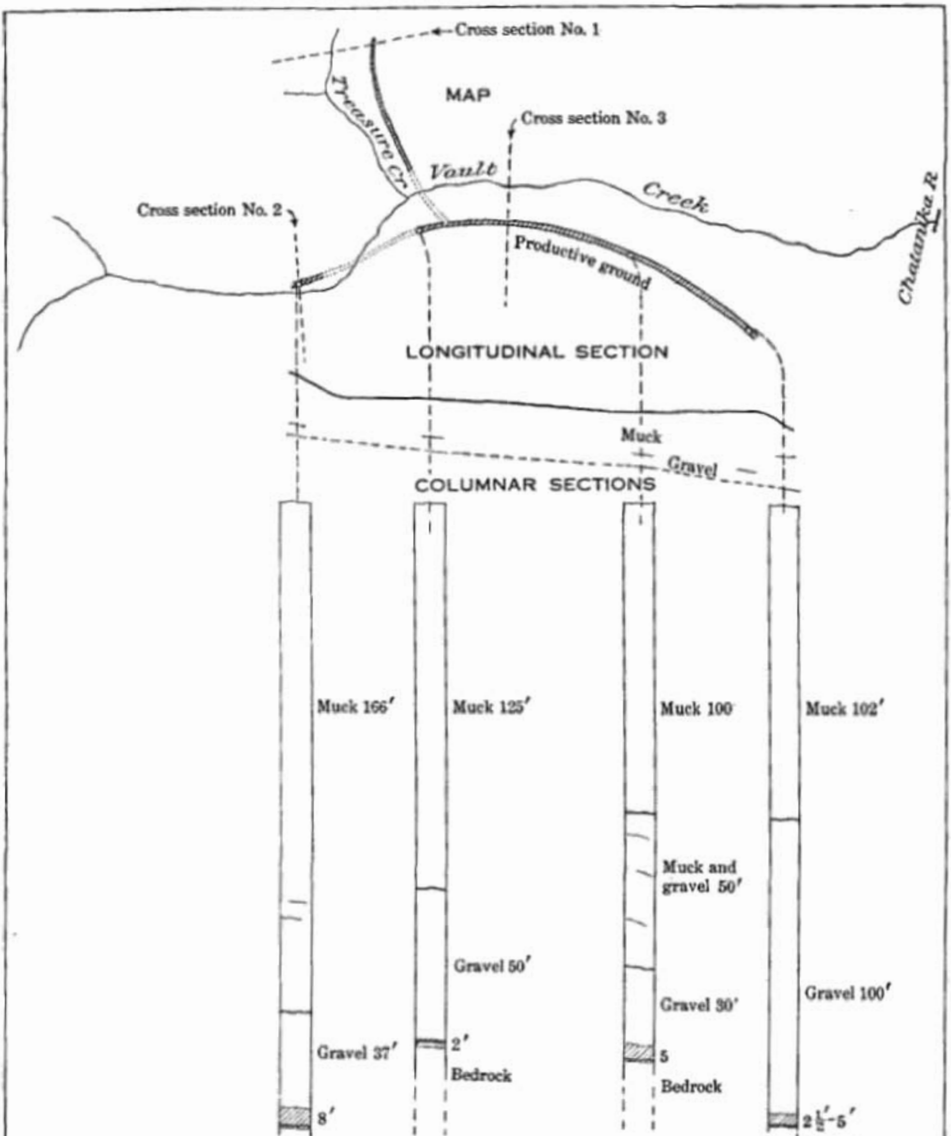
The valley of Dome Creek (Pl. V, *B*) is heavily burdened with terrace deposits and slope wash, and its development as a producer was retarded on that account. The productive gravels of the Dome Valley terminate at the entrance of the last small tributary from the east and are not found again until near the exit to the Chatanika Flats, whence they have been traced into the flats in the line of the valley.

The mining ground is deep, ranging from 50 to 200 feet. The thickness of the productive gravels (Pl. XV) ranges from a foot to over 8 feet, and the average width of ground worked is about 160 feet. Values as high as $6 or more to the square foot have been found, rendering Dome Creek one of the best producers of the district. A noteworthy feature is the abundance of the green garnetiferous rock in the Dome Valley. It forms the bedrock on many claims, alternating with the schists, and its blocky character has afforded



PRODUCTIVE GROUND EXPLOITED ON DOME CREEK.

Dashed lines crossing the creek show locations of cross sections given on Plate XIII, longitudinal section shows grade and thickness of muck and gravel, and columnar sections show beds at points indicated.



PRODUCTIVE GROUND EXPLOITED ON VAULT CREEK.

Dashed lines crossing the creek show locations of cross sections given on Plate XIII, longitudinal section shows grade and thickness of muck and gravel, and columnar sections show beds at points indicated.

favorable catchment areas for the gold, which is found in it to depths of several feet. The extra expense involved in obtaining it has been met by the high values in the ground. The absence of this rock in the lower valley of Dome Creek and the failure of the schists to retain the placer gold is probably one reason for the nonproductivity of that portion of the valley. The portion of the productive area that extends into the flats is mingled at its lower end with gravels from Chatanika River.

VAULT CREEK.

Vault and Treasure valleys are of the customary asymmetric type. Their gradual slopes are deeply covered by alluvial deposits and slope wash, which extend a mile back from the creeks in places, and which attain depths of over 200 feet in some of the ground worked. On Treasure Creek, opposite the mouth of Independence Creek, the cross section of the valley, as developed by eleven prospect holes, is shown in Plate XIII, page 96.

The auriferous deposits on Vault Creek (Pl. XVI) extend from No. 9 claim above Discovery to the mouth of the valley, a distance of 6 miles; on Treasure Creek to a point 3 miles above the mouth; on Wildcat Creek for about one-half mile above its mouth. On Vault Creek above Treasure Creek, however, productive gravels have been found at only one locality, and on Wildcat Creek the deposits so far developed are of low grade. The work on Treasure Creek also indicates interruption of gold deposition. The productive gravels have widths ranging from 25 to 225 feet, a maximum thickness of about 7 feet, and values ranging from 50 cents to $7 to the square foot of bedrock. Probably the average value of the gravels worked in 1908 was about $1.50 per square foot. The gold is in general coarse, very little flour or flaky gold being found. Pieces worth from a few cents to a dollar are common. A nugget worth $60 was found on upper Vault Creek, where one-third of the gold is in pieces worth $1 or more.

OUR CREEK.

In the Our Creek valley values have been found at a few scattering localities, which are indicated on the map. The discovery was made in 1906, and efforts have been made by miners to establish a continuity of productive gravels, but so far without avail. The alluvial deposits are irregularly distributed. Although the valley is wide and flat, bedrock is just beneath the surface far down toward the stream on the gradual slope. At the locality where most work has been done, the depth to bedrock is 75 feet, including 58 feet of muck and 12 feet of gravel. A nugget worth $12 was the coarsest found here in 1908. The bedrock of Our Creek valley is predominantly schist, but includes a small amount of rusty granitic rock.

In the lower part of Our Creek valley, about a mile south of the Chatanika, is a prospect hole, reported to have been originally 317 feet deep. It had been partly refilled with barren gravel, however, and no work on it was being done. The dump contains many rounded quartz bowlders, mingled with gravels of fine-grained brownish-weathering granite, carbonaceous schist, blackish quartzite schist, and quartz-mica schist.

On the banks of the Chatanika a hole is reported to have been sunk 218 feet to bedrock and to have been entirely in frozen ground.

FAIRBANKS CREEK.

The productive area of the Fairbanks Valley (Pl. XVII) begins about 2 miles below the source of the creek and extends for about 4 miles downstream. The productive gravel ranges from 4 to 8 feet in thickness, with an average of about 6 feet, and is mined to widths of from 40 to 200 feet. During 1908 an extension of the productive ground was found below Deep Creek. Walnut Creek, a small tributary, has been producing for about two years from shallow ground; coarse gold is found, one nugget being valued at $45. The bedrock of the Fairbanks Valley is predominantly schist; some gneiss occurs in the lower part of the valley and a little rusty granitic material in the upper part. Fairbanks Creek has been a good producer, the total production to date being approximately $5,250,000.

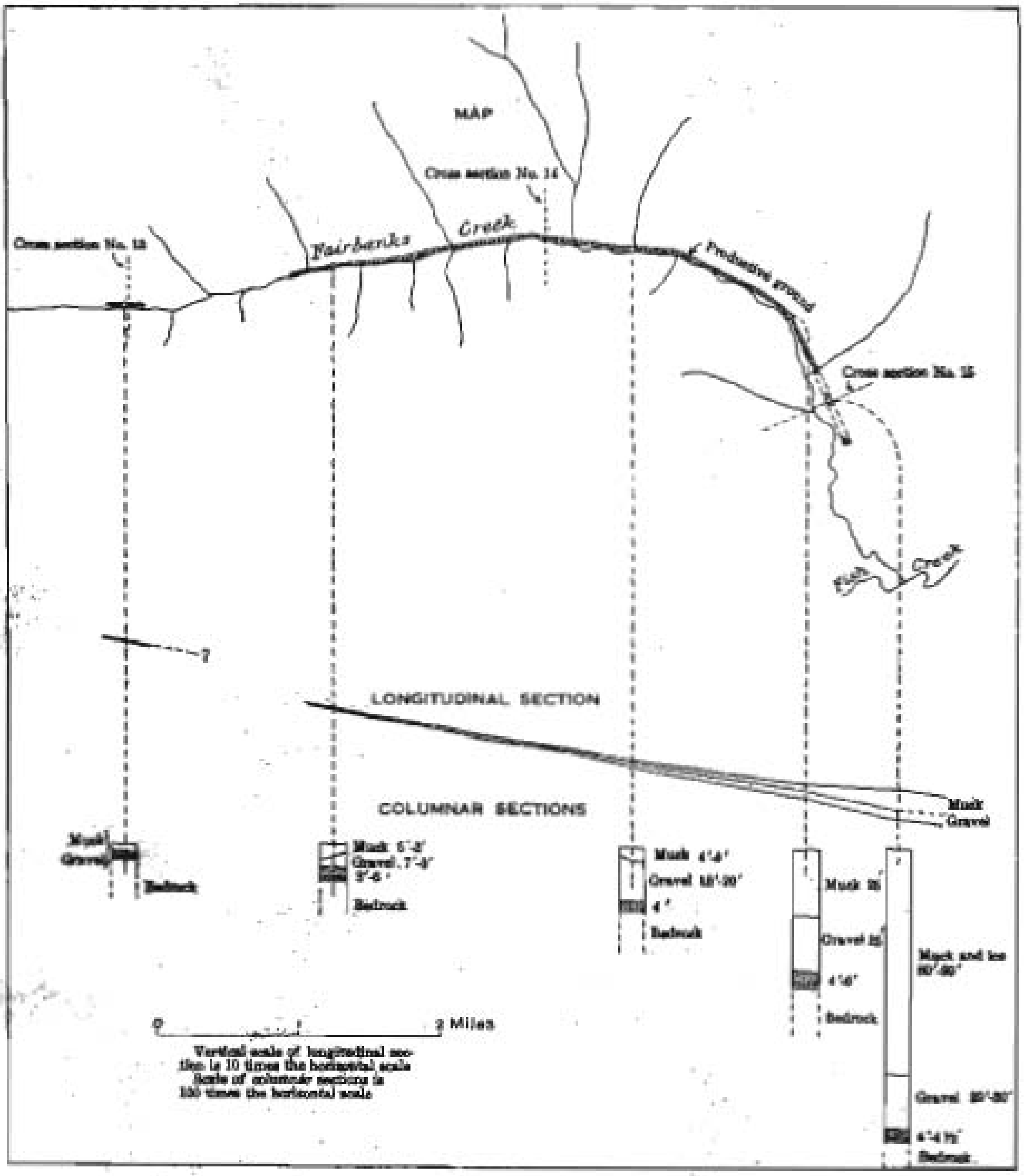
FISH CREEK.

Up to 1908 gold had been found on Fish Creek at a few rather widely separated localities, in a few feet of gravel underlying about 20 feet of overburden. Nuggets worth $2 to $3 have been found. The valley floor is 700 feet or more wide, and the deposits are shallower than most of those above described. The valley is comparatively well watered. A small area of granite outcrops on Melba Creek and is represented to some extent in the gravels. Bismuth has been found as an associate of the gold.

In 1909 and 1910 operations on Fish Creek were more successful than at any previous time. They have been described by Ellsworth and Parker as follows:[1]

A decided increase in mining operations has taken place on Fish Creek during the past year, and developments this summer seem to indicate that it will remain on the productive list for some years to come. A number of operators on the upper part of the creek who took out winter dumps were very greatly surprised when their clean-ups netted more than they were expecting. This was due largely to the presence of coarse gold, which had not been found to any great extent in prospecting. It is reported that a $43 nugget was found in the

[1] Ellsworth, C. E., and Parker, G. L., Placer mining in the Yukon-Tanana region: Bull. U. S. Geol. Survey No. 480, 1911, p. 159.



PRODUCTIVE GROUND EXPLOITED ON FAIRBANKS CREEK.

Dashed lines crossing the creek show locations of cross sections given on Plate XIII, longitudinal section shows grade and thickness of muck and gravel, and columnar sections show beds at points indicated.

spring clean-up of "No. 5 above," and later in the season the operators on "No. 2 above" are said to have taken out a nugget valued at $84.25. Previous to this spring it was thought that Fish Creek would produce chiefly fine gold.

Mining was being done on almost every claim from "No. 10 above" to "No. 2 above" by both open-cut and drifting methods. "Nos. 2 and 3 above" yielded the best returns for the summer season. Below "No. 2 above" there was some prospecting done, without success, in trying to locate a pay streak between this claim and "No. 8 below," where one outfit, employing 4 men, was occupied in drifting in gravel carrying fine gold. About 35 men were employed on eight claims during the winter, and it is probable that about 50 men were employed during the open season.

SMALLWOOD CREEK.

The tributaries of Smallwood Creek head in the large mass of granite that forms the ridge between Smallwood and Gilmore, and granite, therefore, is a common constituent of their gravels. The only ground mined in 1908 is in the portion of the valley just within the area shown on the map (Pl. II). The ground is deep and there is only a narrow valley floor in the thick mass of terrace deposits, which are a half mile or more in width. Productive gravels, reported to have a width of 120 feet, are composed of 3 to 4 feet of gravel and the upper portion of bedrock. Nuggets valued at $2.75 and $11.50 have been reported. As in other valleys filled with deep deposits, prospecting is slow and expensive, and although the creek was staked in 1904 little work was done before 1906, and as yet no large bodies of productive gravels have been discovered.

ESTER CREEK.

Ester Creek was staked in 1903, but was neglected by most of the miners, and not till after persistent work by a few prospectors were its possibilities recognized. It became productive in 1905, and since that time has been one of the largest producers of the district. (See Pl. XII, *A*, p. 86). Many mines are being operated there and new methods are being tried out. In the winter of 1907–8 winter sluicing was begun, and during the summer of 1908 unfrozen ground was being worked successfully.

The alluvial deposits are deep and, from the neighborhood of the Ester Valley to the Tanana, exhibit drainage phenomena that have been but faintly impressed on more distant areas. The cross section of the Ester and Cripple valleys (fig. 6, p. 104) shows clearly the flatness of the bedrock floor upon which the alluvial deposits have been laid down. The hill between Ester and Cripple is made up principally of unconsolidated deposits, which in the section shown are 174 feet deep. The material from surface to bedrock includes 134 feet of muck, 5 feet of quicksand, and 35 feet of gravel, all of this material being unfrozen.

The deposits of the Ester Valley (Pl. XVIII) are mostly less than 100 feet deep. The productive gravels range from 30 to 600 feet in width and average about 300 feet; in the widest portion mining operations extend across the entire width of the valley floor. The maximum thickness of the productive ground is about 8 feet. Values range from less than $1 to over $4.50 per square foot of bedrock, the average for the creek being about $1.50 per square foot. Some of

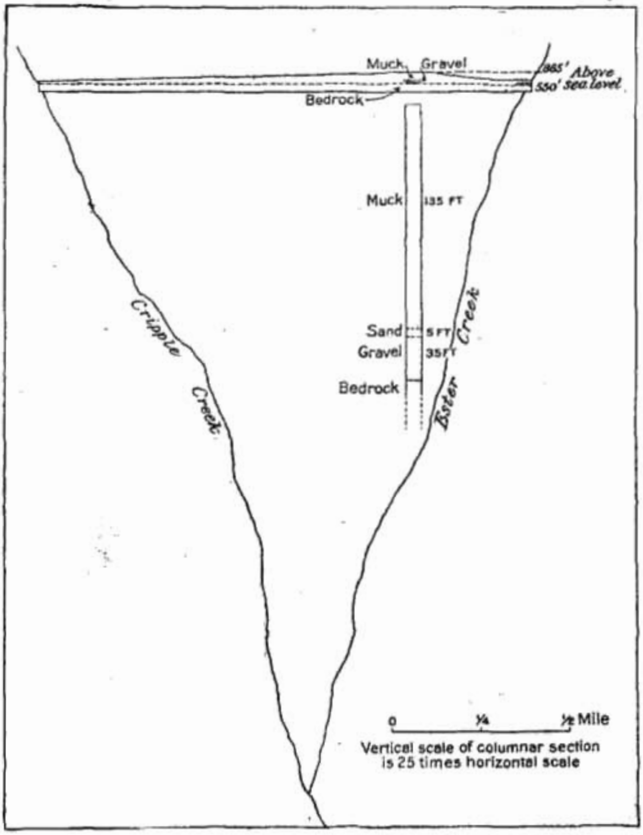
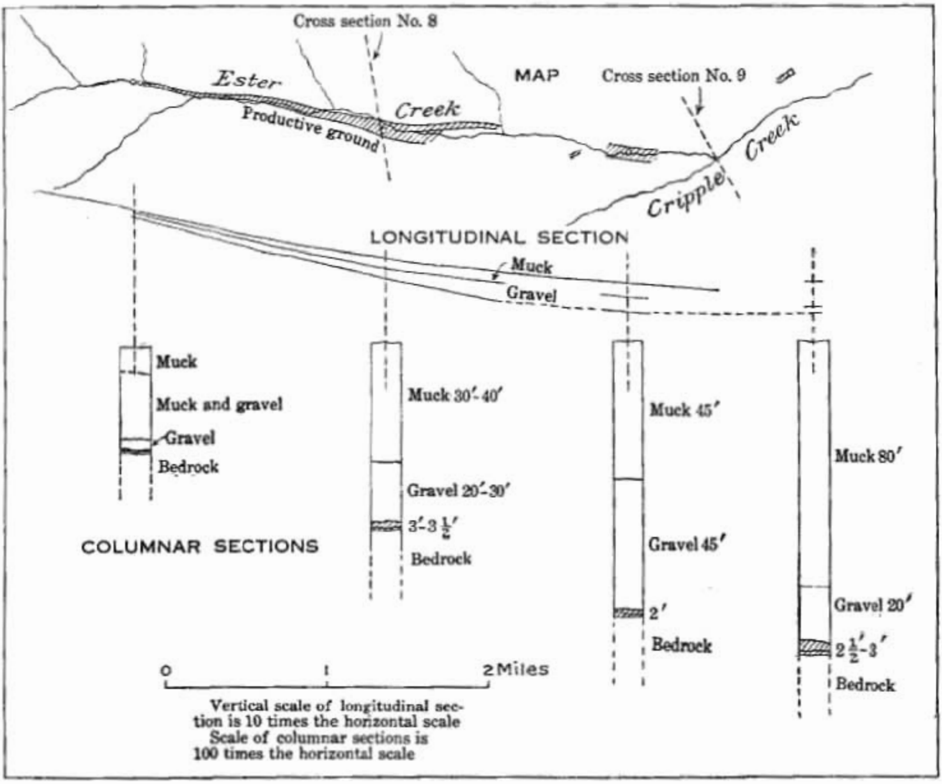


FIGURE 6.—Cross section from Cripple Creek to Ester Creek, with columnar section of alluvial deposits.

the mines contain both red and black auriferous gravels; the red gravels apparently form an older terrace deposit, which has been partly reworked and partly covered by the black gravels, which contain considerable material of vegetable origin. In places the contact plane of the two gravels is particularly rich in placer gold. Gravels resting on a bedrock bench were found in the area between the Ready Bullion and Ester creeks, and these have also been found to be auriferous.



PRODUCTIVE GROUND EXPLOITED ON ESTER CREEK.

Dashed lines crossing the creek show locations of cross sections given on Plate XIII, longitudinal section shows grade and thickness of muck and gravel, and columnar sections show beds at points indicated.

The distribution of the productive gravels in the Ester Valley presents some puzzling features. Although found over nearly the entire width of the valley opposite the town of Ester, a short distance below that place they apparently become confined to the north side of the valley, along which they have been traced as far as Eva Creek, where they are lost. On No. 6 they are again found, and on Nos. 7 and 8 and 8A they are present over a wide area. Insufficient development work has as yet been done to decide definitely the many questions regarding the distribution of gold in the Ester Valley below the point where the upper main body of productive gravel narrows. The flatness of the underlying bedrock in a large part of the valley combined with the presence in other parts of the valley of rock-cut benches, all concealed beneath an overburden, brings into the problem too many unknown factors. It is the belief of some that Goldstream at one time flowed to the Tanana by way of the valley of St. Patrick Creek, and that Ester left its valley a short distance below the Eva Creek valley and flowed to the St. Patrick Valley. Such suppositions are reasonable, but too few facts are available at present to permit their intelligent discussion. The earlier drainage courses may have been far different from the present ones. Lateral stream shifting under the conditions that then prevailed was to be expected, and hidden as the deposits are beneath an overburden their location is not ascertainable. Coarse gold is common in the vicinity of Discovery claim, and a run of coarse gold is picked up again in the lower part of the valley, but no evidence is available as to whether these are different portions of the same body of gravels or are entirely separate.

GOLDSTREAM BASIN.

In 1908 the productive areas of the Goldstream basin (Pl. XII, *B*) included Goldstream itself, and Pedro, Gilmore, Engineer, and Fox creeks.

The work on Goldstream itself extended from the confluence of Pedro and Gilmore to claim No. 17 below Discovery. The lower portion of the productive ground diverges markedly from the course of the present stream and although the surface overlying much of the productive ground is considerably higher than the valley floor near the creek the bedrock rises but little. (See Pl. XIII, secs. 6 and 7, and Pl. XIX.) The average thickness of the productive ground is about 6 feet, and the average width mined in 1908 about 225 feet, with values averaging approximately $1 per square foot of bedrock.

The productive area in the Pedro Creek drainage includes a portion of the tributary Twin Creek valley and the Pedro Creek valley itself from the mouth of Twin Creek to that of Gilmore Creek. In places gold has been found through 8 feet of gravel and 4 feet of bedrock; in other places it is confined mostly to the bedrock.

The deposits of the Gilmore Valley are comparatively shallow. The productive area is about 2 miles long and the average width regarded as productive is about 50 feet. Native bismuth intergrown with gold has been found in Gilmore Valley

The open valley of Engineer Creek is rather deeply filled with deposits, and the work of prospecting has been slow. Productive ground has been located at several points. The depth to bedrock in ground that is being worked ranges from about 50 to 100 feet. Values have been found through 4 to 7 feet of gravel over widths of 30 to 100 feet, ranging in values from $1 to $6 to the square foot of bedrock. Granite, partly mineralized with iron pyrites, occurs in considerable quantity in the valley of Engineer Creek, and granitic sand forms a good proportion of the alluvial deposits near bedrock, coloring the productive gravels whitish and rendering them clearly distinguishable from the darker overlying gravels.

In the Fox Valley only a small amount of work was being done. Granite outcrops near the head of the creek contribute material to the gravels. At one locality near the head, 500 feet back from the creek, where a shallow deposit was being worked, the section of deposits showed 6 feet slide rock, clay, sand, fine gravel, and next to bedrock 1 foot of coarse gravel. The gold ranged from fine gold to nuggets worth $2.50.

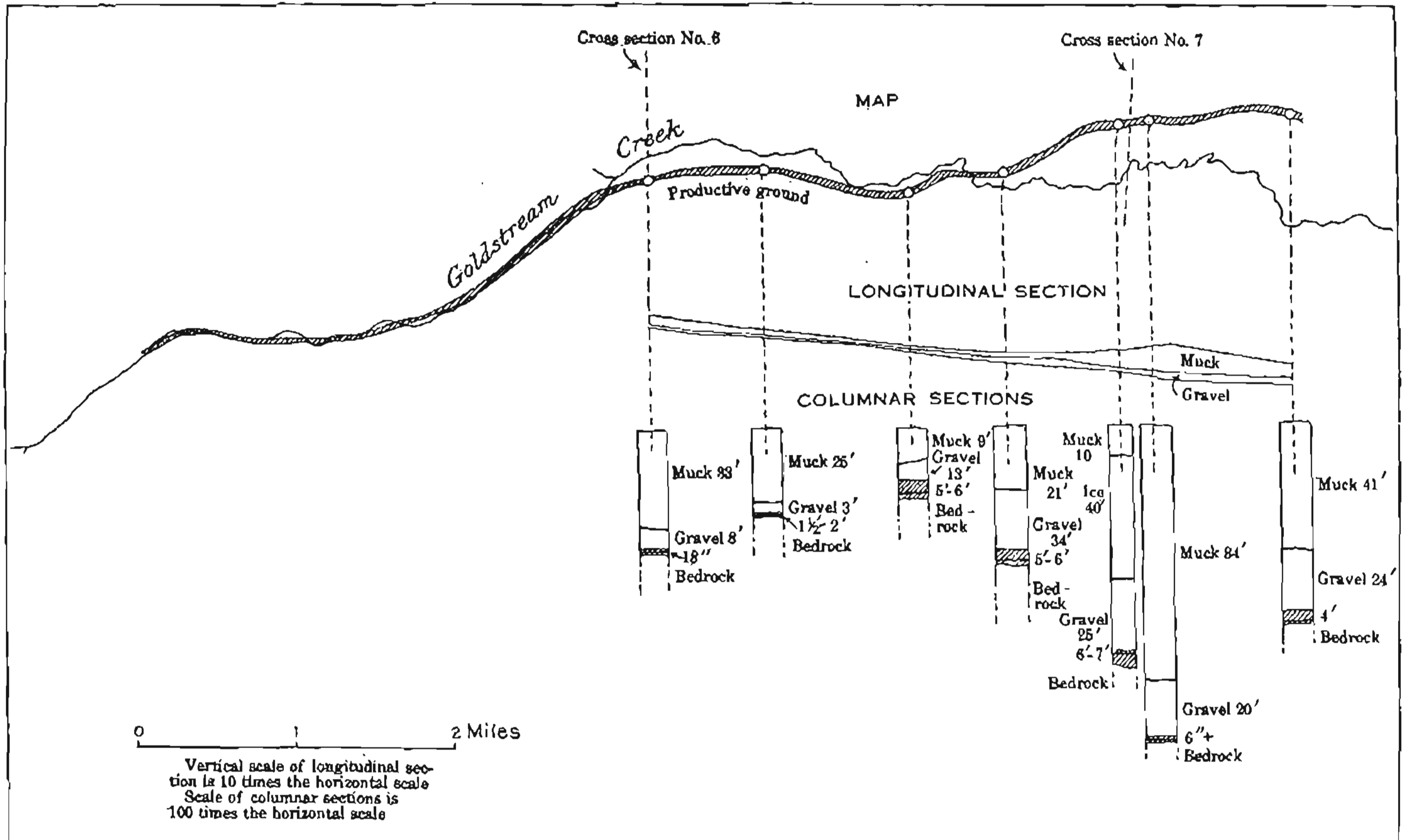
Eldorado Creek valley has a thick mass of terrace deposits on the gentle slope, which has rendered prospecting very difficult. Gold has been found in the upper part of the valley in gravel 50 feet deep, and a width of 30 feet of productive gravels has been reported. The bedrock is schist partly shattered and impregnated with ferruginous material. Some granite is found in the gravels.

O'Connor Creek is similar to Eldorado Creek, its valley being burdened with a great mass of the terrace and slope deposits. A small amount of gold is reported to have been taken from its upper part. The bedrock is schist. A few pieces of granite in the gravels betray the presence of granitic dikes toward its head.

Both Eldorado and O'Connor valleys are strikingly unsymmetrical. The valley floor is narrow, and the creeks flow close to the steep slope on the southeast. The thick terrace deposits extend close to the streams and are furrowed by the small tributaries. The upper portions of the long, gentler northwest slopes are covered with a beautiful growth of birch, which toward the streams gives place to small spruce.

SUMMARY.

The following data on depth to bedrock, dimensions of productive ground, etc., on the most important creeks have been tabulated for purposes of comparison.



PRODUCTIVE GROUND EXPLOITED ON GOLDSTREAM CREEK.

Dashed lines crossing the creek show locations of cross sections given on Plate XIII, longitudinal section shows grade and thickness of muck and gravel, and columnar sections show beds at points indicated.

Tabular statement by creeks of width, depth, and thickness of gold placers in the region adjacent to Fairbanks.

[In feet.]

Claim.[a]	Thickness of muck.	Thickness of gravel.	Depth to bedrock.	Thickness of productive ground.			Width of productive ground.	Width of valley floor.
				Bedrock.	Gravel.	Total.		
Cleary Creek:								
8a	15–45	20	35–65				100	300
5a		8–10	14–30	6			300	
3a, first tier left	40	12	50–52	¾–1		3–3½	150+	450
2a, first tier, left		10–16	45–50			av. 2½	200±	
Discovery			14–20	1	3½			800
D, first tier, right		5	38					
1b, first tier, right		20	40	1	3			
1b, first tier, right, upper half			14–17					
6b, first tier, right, upper half		35–40	68				500+	1,200 (6b, upper and lower half)
6b, first tier, right, lower half		33	87	[b] ⅔	3–5		300	
7b, first tier, right, upper half			84					
10b, first tier, right	20	45	65			6	225	1,000
11b, first tier, right		45	70	0–2		6–8	250–300	
12b, first tier, right, upper part		30	73	2	0–4		500	
12b, first tier, right, lower part	0	[c] 65	71–85		6–12		520+	1,200
12b	15	40	65		½	3	30	
13b, first tier, right	35 18	72 62	107 80		5	[d] av. 4½	700+	
14b, first tier, right	14–16		95 80				200	
15b	18–20	40–45	40 55 64	1–1½			200	
15b, Diamond fraction	18		75		3–4		175–200	2,000+
15b, first and second tiers, right	6	88	94	1½	3		450	
16b, fraction			40					
16b, first tier, left			135					
18b, first tier, right	10	115	125	1/12+	3–4		200	
Chatanika River:								
1a			75			3	275	
Discovery	18–25		80 110 *125*				180	
Hope claim	40	20–25	65	1½–2	1		70–100	
Hard Scramble claim		30	104				80+	
Stier claim	72	33	105					
Eldorado Creek:								
Fraction, 7a, first tier, right		25	87			1–4	14–60	
6a, first tier, right		10–12	110			3–4	50–100	
5a, first tier, right		10–12						
4a, second tier, right		0–15	140				30–140	
3a, second tier, right		15	122				75	
3b, first tier, right	59		135	1	2		130	1,200
4b, first tier, right	60		140	½	3			
5b, first tier, right	[e] 100		145	2–3	0		135–140	
Eldorado Association (6b)	80		160	2	4½		85	1,500(?)
Idaho Association	46	([f])	122		3½			
Treasure Creek:								
6			80–100				120	300
Tonaskate Association—								
Wilson & Strobel			97		½–¾			
Smith, Pearson & Ketchum		15	100	1–3	½–5		100	
Hallner, McGoway	30–60	20	110	1	2–3		100	1,300
Gallinati, etc.	Slide.	7	171		3		55	1,600
Victoria Association—								
Jonas & Brown		14	180–185	Few.	1½–3½		30–40	
Kobish & Dietz			185	⅓–1/12	1½–7			
Woodson & Stroup	[g] 135		200		0–10		50	1,500
Lemieux & Co.	140–165	25	165–190	2–5	2–5		60–120	
Martin & Boyd	*115*	25	140	3			50–35	
Dougherty & Carroll	100	40	140	½	*1–1½*		88–*150*	1,200

[a] In Alaska placer claims are designated, according to their position, 1, 2, 3, etc., above (a) or below (b) Discovery claim (D). Claims lying away from the creek are further located by their positions in the first, second, or third tiers to right or left (right limit or left limit).

[b] Rarely 3 to 4 feet.

[c] Includes 6 to 20 feet of sand.

[d] Maximum, 5 to 6 feet.

[e] Fifty feet muck and ice; 50 feet muck and sand.

[f] Fifteen feet gravel (Chatanika type); 7 feet muck; 30 feet gravel (Eldorado type).

[g] Twenty-five feet slide; 40 feet gravel.

Tabular statement by creeks of width, depth, and thickness of gold placers in the region adjacent to Fairbanks—Continued.

[In feet.]

Claim.	Thickness of muck.	Thickness of gravel.	Depth to bedrock.	Thickness of productive ground.			Width of productive ground.	Width of valley floor.
				Bedrock.	Gravel.	Total.		
Vault Creek:								
9a	55		65					200
Hard Luck Association		35	200-203	1	7		25	700
Nevada Association							130	
Bank Association		50	175				12-30	
Isabella Association	60	80-90	150	½	2		80	1,800
Victor Association—								
First 500 feet		90-100	163		to 4	av. 1	av. 60	
Fifth 500 feet	[a] 80	100	180	1	2-3		100	
Sixth 500 feet		70	186	0-1	½		60-90	
Seventh 500 feet	[b] 90	85	175	0-few.	2			
Eighth 500 feet			182				90-100	
Oregon Association—								
Robertson	(c)	(c)	182			1½-2½	80-120	
Stone & Brand	(d)	(d)	180	½+	4½-5	5	—to 225	2,000
Sierra Association—								
Bates		40	200±					
Riley & Shaw		40	200					
Gatty		135	208	2				
Morino	[e] 102	100	202		2½-5		120-145	3,000+
Dome Creek:								
7a			38			2½	30	
6a, upper end	27		50					400
6a, lower end	27		42	½-2	1½		30-40	
6a, first tier, right	26-30		65		7			
5a, lower end			45			4-5		
3a	60-70		100				125-130	600
2a		35	117			2½	174	
1a	62	42	104			½-4½	180	
Discovery	85		140	1-5	3		280	
D, first tier, right	90		150			[f] 1-8	295	
D, second tier, right	90		130-145				150	
1b, first tier, right	100		160			8	200	
2b, first tier, right, upper end	82		150			3-8	150-185	
2b, first tier, right, lower end	98 85		160 180			5-6	190	
3b, first tier, right	65-70		175			6-7	115	1,200
4b, second tier, right	70		150			3-4	110-125	
5b, second tier, right	130	40-45	173+			4	160-175	
Upper 6b, second tier, right	160		185		2-3		200+	
Lower 6b, second tier right	160		198		1½-7		150-175	2,000
Upper 7b, second tier, right	1	10-6	160			1-1½	200	
14b	50-90		150		½-2			2,300
15b	(g)	(g)	162		¾-2		120-200	
Shakespeare group—								
16b	40		162	½-1	1-1½		100	
16b	30		160				120	2,300
17b	28-30		165	(h)	1½-3		140	
18b	32		175		1½		120-170	
19b	10		170		2-3?			
Niggerhead group, 20b	15-20		175-180	½-3	1		100-230	3,000+
Our Creek:								
Georgia Association	54							
Washington Association	58	12	75		4		70	
Fairbanks Creek:								
9a	3	9	12					300
8a	2	8	10					
7a, upper half	2-11	6-9	12?	0-6				
7a, lower half	2	9						
6a	3	12	15					350
5a	3	14	17					
4a	4	13	17					
3a	4	14	18					400

[a] Includes 40 feet of ice.
[b] Includes 30 feet of ice.
[c] Eighty feet muck and ice; gravel bed; 60 feet muck and gravel; 30 feet clear gravel.
[d] One hundred feet muck; 50 feet mixed muck and gravel streaks; 30 feet clear gravel.
[e] Muck and ice.
[f] Average, 5 feet.
[g] Forty feet muck; 100 feet gravel, slide, and muck; 20 feet clear gravel.
[h] A few inches.

Tabular statement by creeks of width, depth, and thickness of gold placers in the region adjacent to Fairbanks—Continued.

[In feet.]

Claim.	Thickness of muck.	Thickness of gravel.	Depth to bed-rock.	Thickness of productive ground: Bed-rock.	Thickness of productive ground: Gravel.	Thickness of productive ground: Total.	Width of productive ground.	Width of valley floor.
Fairbanks Creek—Continued.								
2a	4	12	16					
1a, upper half	3	9	12					
1a, lower half	3	8	11					
D, upper half	4	14	18					400
D, lower half	4	14	18					
1b	4	14		½	0-7		175	
2b	7-8		19-30		3-9		500-600	
3b, upper half	4-6		24		4-9		200	
3b, lower half	5	16	21					450
3b, first tier, left	4		35				100-160	
4b, first tier, left			40				100	
4b	5	16		1-4	2-6			
5b			20	2	0-9			
5b, lower half	4	14						
6b	5	15	20					500
7b, side	12	30						
7b		20	35-40		7-12		270	
8b fraction	6	35						
8b	25	25	50		4-6		150-200	
9b fraction	15	35	50	1-1½	3		200	
9b and 10b fraction							100	
9b, first tier, left	53	55	108			6	100+	1,000
12b, first tier, left, upper half	80-90	20-30	110	1-1½	3		175-200	
12b, first tier, left, lower half							300	1,100
Twin Creek:								
2a, "2 Fraction" (upper half of 1a)	4	4	8				60?	250
Pedro Creek:								
2a			12	0-4	2½		120-150	400
1a, fraction	3-4	3-5					150	
1b, lower half	2-3	5±		0-4				800
2b, lower half		22-35					300	
2b, first tier, right		4-6						
3b	12-26	12	26-40				(a)	
4b	3-4	3-4	8					
5b, upper half	4-5	0-5	9	0-9			400	
5b, lower half	3½		12				150 / 275	
Fraction, 5b and 6b	4	5	9					
6b	4-5	4	9	3-5	1		500+	900
7b	5-6	5		4	3		400	
8b, right	12	8	20					
8b and fraction			10-12					
9b								
10b, upper fourth	7-8	6-7	15		6			1,000
Gilmore Creek:								
8a, bench	5	3	8			3-4		400
1a	10		12-15				30	
Lower discovery	10	5	15-18				60-80	800
4b		4-8						
8b						3-4		
Goldstream Creek:								
D, first tier, right	33	8-12	40-45		0-1½	1½	125	1,100
1b, first tier, right		12-15	33 / 40		Few.		250	1,200
2b, first tier, right		2-12	26				190+	1,200
3b, first tier, right	25	3	30 / 28				80	1,000
4b, first tier, right			29-33				150	
5b, first tier, right							60-75	1,100
5b	6	6-7					150+	
6b			14	Few.	½-1		60+	
Fraction 6b and 7b, first tier, right		13-14	14 / 20				130+	
7b	18+	7	25	1-1½	3½-4	5	175	1,400
8b	av. 9	av. 13	av. 22	2-2½	5-6		330+	1,400
8b, first tier, right	17	7-8	24-26		4-4½		150	
9b								
10b, first tier, left			23-37		0-6		350-400	1,200

a Eighty feet productive; 80 feet barren; 90 feet productive.

Tabular statement by creeks of width, depth, and thickness of gold placers in the region adjacent to Fairbanks—Continued.

[In feet.]

Claim.	Thickness of muck.	Thickness of gravel.	Depth to bed-rock.	Thickness of productive ground. Bed-rock.	Thickness of productive ground. Gravel.	Thickness of productive ground. Total.	Width of productive ground.	Width of valley floor.
Goldstream Creek—Continued.								
11b, first tier, left	20	15	35		4–5		200	} 1,500
11b, first tier, left	21		45		4$\frac{1}{2}$		70	
11b, second tier, left	30	15	45	$\frac{1}{2}$–3	3–6		175	
12b, second tier, left			51	1–1$\frac{1}{2}$	4		200	
Wagner fraction, 12b, second tier, and 12b, third tier, left		12–20	54	0–6	5		35–210	
12b, third tier, left	40	20	60				150–200	
13b, second tier, left	62	15–18	80	4–5	2–3		70–125	} 2,200
13b, third tier, left	50	25	75	6–7			75–150	
14b, second tier, and third tier, left	84	20	104		$\frac{1}{2}$		335(?)	
15b, first tier, left	80		110			1$\frac{1}{2}$–6	80	
15b, second tier, left	89		110	$\frac{3}{4}$–$\frac{1}{4}$			200–260	
Fraction, 15b, 16b	76		96	4				
16b	55	25	80				150	3,000
17b	35	25	60		4		80	
17b		24	65		4		250	
18b	25–30		60					
21b			70					3,000
26b	25		50					
Engineer Creek:								
Engineer Bench Association	78		103			6–7	65	1,000
Owl Association, lower end			55					
2a, upper half			55	1	2			
2a, lower half	35		60	0–1	2–4		260	
1a, first tier, left		20–25	{63 75}				30	
D, upper end		25	50		4		100	
D, lower end		30–35	49	0–4		0–4	4$\frac{1}{2}$	
Smallwood Creek:								
1a	10		50					
2a			50					
3b			108					
4b	25		130					
5b			135					
7b	45		145					
17b	60–100		317					
Ester Creek:								
7a	6		18–20			4	30	150
6a, upper half		3–4	22–24				35	
6a, lower half	7		18				50	
5a	8–9		25	2$\frac{1}{2}$		4	75	
4a, upper half	36	8	45					
4a, lower half	10–12	8	18–20			4		350
3a			39			4	200	
Fraction	53	12	65			4–6		
2a	14	20	34			5$\frac{1}{2}$	150	350
Discovery	40–50	30–40	85			?–$\frac{3}{4}$	175	600
Fraction, D, 1b	36		78					
1b	28		71					
2b, upper half	30	20–30	60			4+	600+	
2b, first tier, right, upper half							300	
2b, lower half	35	40	75			2–4		
3b	46	18	64			4–5	} 650	
3b, first tier, right	100	70	170			6–7		
3b, first tier, left	57	45	102			4–6$\frac{1}{2}$		
4b	55	45	100			4	125	800
4b, first tier, left	60	40	96–100	2	4–5		90	
5b	30	70	100	1$\frac{1}{2}$	5		80	
5b, first tier, left			107			4		
6b, first tier, right	60	40	100			4	40	
7b, 8b, 8Ab		40–45	80–95			7$\frac{1}{2}$	600	1,200
Ready Bullion Creek:								
1, bench		36	80			3		
Cripple Creek:								
Berton claim	53	23	76					
Do	68	20	88	}		2$\frac{1}{2}$–3	150	
Do	80	20	100					

DISTRIBUTION OF GOLD PRODUCTION.

The total gold production of the Fairbanks district has been given by years on page 77. In the following table all available data relating to the distribution of gold output gathered by the Survey from mining operators, banks, and other sources have been assembled by creeks. The results are necessarily incomplete and only approximate. It is believed, however, that they represent with a fair degree of

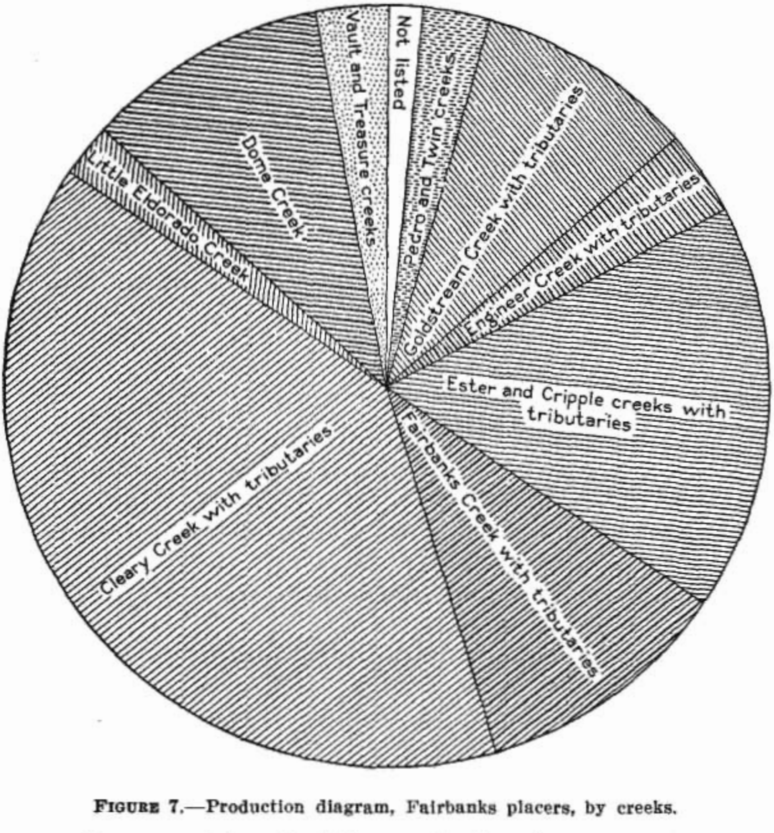


FIGURE 7.—Production diagram, Fairbanks placers, by creeks.

accuracy the general trend of the production from year to year and that they are worthy of consideration. The results are expressed more graphically in figures 7 and 8.

Estimated value of gold production, Fairbanks district, 1903–1910, and its distribution by creeks.

Stream.	1903	1904	1905	1906	1907	1908	1909	1910	Total.
Pedro	$20,000	$73,000	$60,000	$150,000	$130,000	$300,000	$317,000	$200,000	$1,250,000
Twin	1,500	21,000	....	1,600	21,000	18,000	30,000	27,000	120,100
Goldstream	1,500	60,000	50,000	200,000	625,000	1,225,000	1,488,000	600,000	4,249,500
Gilmore	....	....	3,800	4,500	40,000	10,000	48,900	14,000	121,200
Fox	....	....	10,000	2,000	5,000	....	14,000	....	31,000
Big Eldorado	....	....	....	5,000	10,000	....	8,000	27,000	50,000
O'Connor	....	....	....	....	1,000	....	....	....	1,000
Engineer and tributaries	....	....	....	....	5,000	250,000	1,145,000	400,000	1,800,000

Estimated value of gold production, Fairbanks district, etc.—Continued.

Stream.	1903	1904	1905	1906	1907	1908	1909	1910	Total.
Cripple						$24,000	$14,000	$12,000	$50,000
St. Patrick								17,000	17,000
Ester		$1,000	$60,000	$1,200,000	$1,750,000	2,000,000	1,659,000	1,130,000	7,800,000
Ready Bullion					13,000	50,000	237,000	200,000	500,000
Fairbanks		250,000	1,400,000	1,500,000	550,000	500,000	550,000	500,000	5,250,000
Crane						30,000			30,000
Walnut				1,200	5,000	2,500			8,700
Fish								200,000	200,000
Smallwood						12,000			12,000
Cleary	$14,000	150,000	4,312,000	5,383,000	3,000,000	2,000,000	1,441,000	1,200,000	17,500,000
Chatanika					285,000	170,000	500,000	290,000	1,245,000
Wolf	1,000					500	1,500	30,000	33,000
Chatham	2,000	45,000	90,000	103,000	30,000	19,000	8,000	3,000	300,000
Little Eldorado					50,000	60,000	500,000	490,000	1,100,000
Dome				500,000	1,200,000	1,750,000	1,000,000	600,000	5,050,000
Vault					250,000	700,000	220,000	80,000	1,250,000
Treasure					35,000	77,000	90,000	48,090	250,000
Our						5,000			5,000
Miscellaneous			14,200		5,000		378,600	32,000	429,800
	40,000	600,000	6,000,000	9,050,300	8,010,000	9,203,000	9,650,000	6,100,000	48,653,300

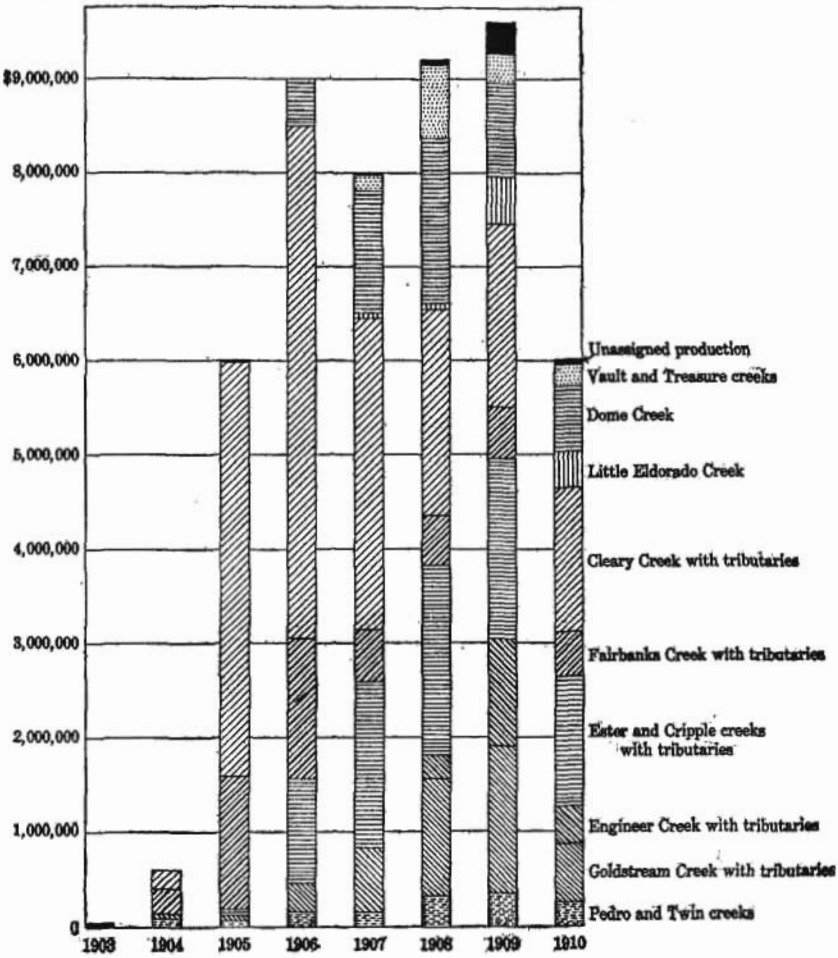


FIGURE 8.—Production diagram, Fairbanks placers, by years.

VALUE AND FINENESS OF THE PLACER GOLD.

The following table, compiled by B. L. Johnson, presents the available information on the value of the placer gold of the Fairbanks district, together with the value of gold from a few creeks in other parts of the quadrangle. The sources of this information are reports from the miners, either verbal reports obtained in the field or yearly schedules of placer production submitted by the miners to the Geological Survey. A few statements are backed by bank or Mint assay-office returns. The large majority report the net price paid by the bank for the gold dust; that is, the true value minus assay and exchange charges, which amount to about 2½ per cent; some give the price per ounce of crude "dust" and others the price per ounce after melting, which eliminates quartz and other impurities. The differences between values before and after melting are exceedingly variable. A few reports give the trade value price, which is considerably below the true value. Because of these discrepancies in the appended figures, no attempt has been made to reduce the reported values per ounce to a uniform base or to state the fineness, as is usual, in parts per thousand.

Approximate value of placer gold of Fairbanks quadrangle.

Stream.	Number of reports.	Value per ounce.	
		Range.	Average.
Big Eldorado	4	$18.75 - $19.65	$19.38
Chatanika River (below Cleary Creek)	6	17.40 - 18.11	17.62
Chatham	14	16.15 - 17.60	16.90
Cleary	63	16.00 - 18.09	17.06
Crane Gulch	2	....	17.00
Cripple	3	17.15 - 17.25	17.18
Dome	34	16.65 - 18.77	17.43
Eldorado	4	16.75 - 17.27	17.03
Engineer	11	18.35 - 19.18	18.70
Ester	53	15.82(?)- 18.00	16.56
Fairbanks	34	17.00 - 18.00	17.26
First Chance	1	....	18.25
Fish	4	18.25 - 18.75	18.48
Fox	1	....	17.50
Gilmore	10	18.25 - 19.31	18.85
Goldhill (Cripple Creek)	1	....	17.00
Goldstream (Discovery to 21 below)	40	18.00 - 19.21	18.33
Iowa	1	....	19.00
Little Eldorado	2	....	17.00
O'Connor	1	....	18.00
Our	2	17.80 - 19.06	18.43
Pedro	24	17.10 - 18.50	17.68
Ready Bullion	8	15.99 - 17.00	16.38
Rose	1	....	18.00
St. Patrick	1	....	17.50
Steamboat Pup	1	....	18.00
Treasure	4	17.75 - 17.80	17.77
Twin	6	17.11 - 18.40	17.66
Smallwood	1	....	18.11
Vault	14	17.25 - 18.25	17.75
Walnut	1	....	17.00
Wolf	1	....	17.85
Banner	2	14.56 - 15.68	15.12
Buckeye	3	15.15 - 15.68	15.38
Democrat	3	15.50 - 15.80	15.63
Tenderfoot	6	12.40 - 14.18	13.15
Platt	2	17.49 - 17.69	17.59
Rex	1	....	16.20
Touchet	1	....	18.40

The extreme values reported from the Fairbanks district are $15.82 and $19.65, and the average of all the values listed is $17.73. From the Tenderfoot district the values are $12.40 to $15.80. The range of values reported from each of the several creeks and the distribution of the values along the creek is not even satisfactorily approximate because the discrepancies of individual reports, noted above, have undue prominence. The Fairbanks banks pay off-hand a higher price for gold dust from the lower claims of some creeks than for gold dust from the claims farther up the same creeks. As their assays are for the most part unavailable, it is not known to what extent this rule is based on their determination of fineness. It is, however, quite general in the district that the upper claims produce rougher and coarser gold, which contains more quartz, iron rust, and other impurities than gold from the lower claims, and these differences may be sufficient to account for the difference in prices received by different miners for gold from the same pay streak.

Within the Fairbanks district proper the gold shows some areally distributed differences in value. The creeks in the central portion—Fish, Smallwood, Gilmore, Goldstream, Engineer, and Big Eldorado creeks—produce gold worth from $18 to $19.65 an ounce. On Fairbanks, Twin, Pedro, Cleary, Eldorado, Dome, and Vault creeks and their tributaries the gold is worth between $17 and $18.50. Ester Creek gold has the lowest value—$16 to $18—in the district.

The silver content of the placer gold is known only from seven assays, in which it ranges from 82 to 172 parts per thousand. Other metals and impurities (copper, iron, etc.) amount to 5 to 10 parts per thousand.

PLACER-GOLD RESERVES.

Any attempt to value the unproved ground can be little more than guesswork. It seems desirable, however, to present a summary of the data given in the foregoing pages and to attempt an estimate of the gold reserves. The gold reserves are, of course, determined by the cost of mining. The cheaper the cost the larger the reserves, for reduction in cost makes available auriferous gravels which under present conditions are valueless. As no information about the future cost of mining is available, it seems necessary to consider here only the auriferous gravels which can be profitably worked by methods now in use in the district. The following table presents a summary of the data in regard to the gold recovery and reserves in quantitative form.

Summary of information in regard to gold placers adjacent to Fairbanks region.

Total estimated length of productive ground[1] ....miles..	75
Total estimated width of productive ground (based on average of available data) ....feet..	200
Total estimated thickness of productive ground (based on thickness handled in mining) ....feet..	6
Average tenor per mile of pay streak	$1,312,733
Average tenor per bedrock square foot	$1.23
Average tenor per cubic yard of productive ground (shallow ground less than 40 feet deep)	$7.70
Average tenor per cubic yard of all pay dirt	$5.53
Total estimated value of productive ground (based on yield per square foot)	$73,841,000
Total estimated value of productive ground plus one-third for ground not productive under present conditions	$98,455,000
Production to 1910 inclusive	$48,653,000
Reserve	$49,802,000

It is therefore estimated that in round numbers about $50,000,000 worth of gold is still present in the ground of the region adjacent to Fairbanks. This takes into account in part a large bulk of auriferous gravels whose values are so low that they can not be profitably exploited by any methods now in use. For example, there are about 12 or 13 miles of the gold-bearing area which is under 40 feet in depth. If it prove feasible to dredge this ground, gold would undoubtedly be recovered from the overburden and from much greater widths of gravel than are now classed as productive. This might add very much to the ultimate gold reserves, but no data are at hand permitting the increase to be estimated quantitatively.

METHODS OF PLACER MINING IN FAIRBANKS DISTRICT.

By F. J. Katz.

GENERAL FEATURES.

The factors determinative of local mining methods are the depth of the gravels beneath the surface, the topographic position of the placer, the condition of the auriferous alluvial deposits, and the amount of water available. In the Fairbanks area not less than 80 per cent of the productive deposits lie at depths of 40 to 260 feet, all are in valley bottoms with low grade, most of them are solidly frozen, and the water supply[2] of all the individual creeks where mining is carried on is exceedingly meager and conditions are not favorable to obtaining outside supplies by gravity. Hence development has been chiefly by drift-mining methods of a kind and on a scale compatible with high costs and adverse conditions.

[1] About 17 per cent of the total length of productive ground is shallower than 40 feet.

[2] For full treatment see Bulls. U. S. Geol. Survey Nos. 345, 379, and 442, and Water-Supply Papers Nos. 218 and 228.

During the summer of 1908 about 300 mining plants were in operation on the placers of the Fairbanks district. About 85 per cent of these were used in drift mining in deep ground and the rest in different forms of open-cut work in shallow ground. Hydraulic mining has been attempted in a small way but has little applicability in the district. Dredging has not yet been employed, though several dredging projects are under advisement.

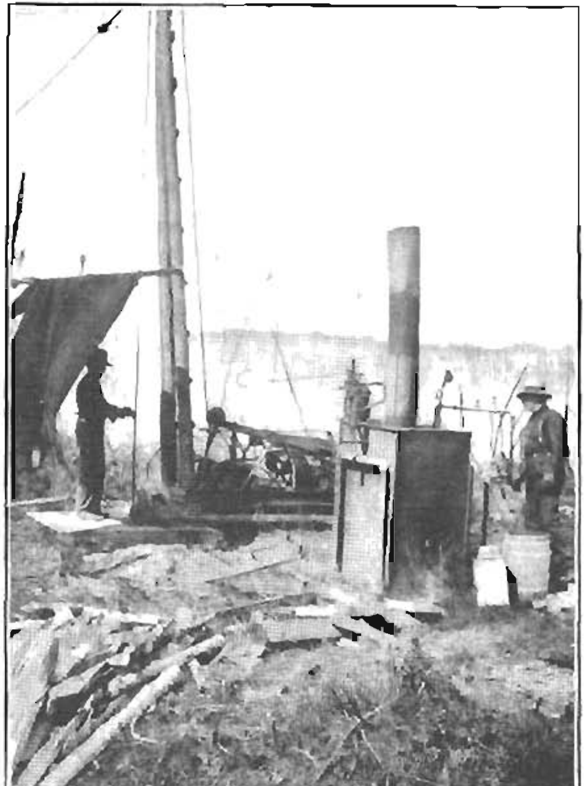
Specific data on the capital invested in mining in the district are not available. An approximation based on the number of plants operated and the average cost of plants yields a rough estimate of four or five million dollars invested in equipment. As to the investment in mining properties for "assessment," purchase price, and rentals of mining claims, no data are available. The magnitude of the Fairbanks gravel-mining operations is indicated by the fact that during the season of 1908 approximately 2,500 laborers were employed and that the boilers used developed in the aggregate more than 8,000 horsepower.

Mining practice has been facilitated by improvements in transportation from the supply towns, Fairbanks and Chena, to the producing creeks. In 1907 the Tanana Mines Railway was completed to Chatanika, at the mouth of Cleary Creek, making its total length about 45 miles. By the extension of the Tanana Mines Railway and an excellent system of wagon roads heavy and bulky loads can be conveniently laid down at most of the important workings.

PROSPECTING.

In prospecting all efforts are directed to uncovering the bedrock, so as to estimate the gold content of the lower part of the gravels and upper part of bedrock. The usual procedure is to sink shafts to bedrock and then to drift along it. The shafts are generally only large enough in cross section to permit one man to work and are cribbed for only a short distance downward through the peaty vegetable accumulation to the line of permanent frost and upward to 4 or 5 feet above ground to a platform upon which the windlass is set and from which the excavated material is dumped. Drifting on the bedrock surface is done by tunnels at right angles to the course of the stream or the supposed run of auriferous gravels and, in some mines, also up and down stream. These tunnels are only large enough for the men to work in.

The common prospecting equipment consists of a small boiler for steam thawing, with requisite pipe, hose, points, and steam fittings; a hand-power windlass, perhaps constructed on the spot; a cable, and wooden buckets of 1 to 2 cubic feet capacity. In the drifts these buckets are skidded on peeled poles to the shaft. In the Fairbanks district boilers are easily obtained and readily transported, so that recourse to the earlier tedious methods of thawing by wood fires, hot



A. PROSPECTING BY DRILLING.

B. DUMP OF AURIFEROUS GRAVELS ON GOLDSTREAM CREEK.

water, or hot rocks is not necessary. In more elaborate equipments small hoisting engines and not infrequently self-dumping buckets, with gin pole, blocks, and cable, are used; and wheelbarrows are employed under ground. Such equipment is a necessity rather than an extravagance in prospecting deep ground, as hand-windlass methods are barely practicable on ground 200 feet in depth. Fairbanks manufacturers now offer an outfit consisting of 4-horsepower boiler, hoisting engine, automatic self-dumping carrier, and bucket, cable, pipe, steam points, and fittings for $600. This outfit is compact and light enough to be transported by dog team.

The testing of the ground is most often done by panning the bottom gravels and the top of the bedrock but sometimes by sluicing the material from the bottom of the shafts and from the tunnels. As far as could be learned, however, sampling methods are as a rule very crude and inaccurate. Many mines have been opened with expensively installed equipment, only to find that the results of sampling were very misleading, the prospector having lost sight of the fact that actual mining required handling of much more material than the portion of the ground tested. "Prospecting for bedrock" permits the sampling of only the richest portion of the deposits and leads to many failures when the handling of lean or barren higher gravels and deeper bedrock is necessitated by larger mining operations.

Unfortunately, little prospecting with drills has been attempted. One miner who has tried drilling and has every confidence in the methods employed reports that several holes can be put down for the price of one shaft. No definite figures showing cost are available, but from experience elsewhere there can be no question as to the economy in time and money if the drill is intelligently and skillfully directed. The chief obstacle to the use of drills in this district has been the difficulty of transportation. This is now obviated by a small-sized churn drill designed and built in Fairbanks, to be supplied with complete equipment for approximately $1,600. (See Pl. XX, *A*.)

OPEN-CUT MINING.

Open-cut methods of mining are applied where the ground is not more than 20 feet in depth. Open-cut work has one great advantage over drift mining in that artificial thawing is for the most part unnecessary, and where conditions are particularly favorable for the use of mechanical excavators it permits much more expeditious and efficient removal of the pay dirt at greatly reduced cost. Of the numerous modes of operation which may be grouped under this head four are practiced in the Fairbanks district; they differ in means by which the pay gravels are conveyed from the banks to the sluices—whether by direct shoveling or wheeling in barrows by hand, by groundsluicing, by hoisting with buckets on trolley carriers, or by steam scrapers. (See fig. 9.)

The first operation is always to clear the ground and strip off the barren overburden. This is accomplished (1) by groundsluicing in the early spring or preferably in the late fall, the material removed by groundsluicing being washed into the stream, or into a previously worked cut; (2) by scraping with horse scrapers, the material being

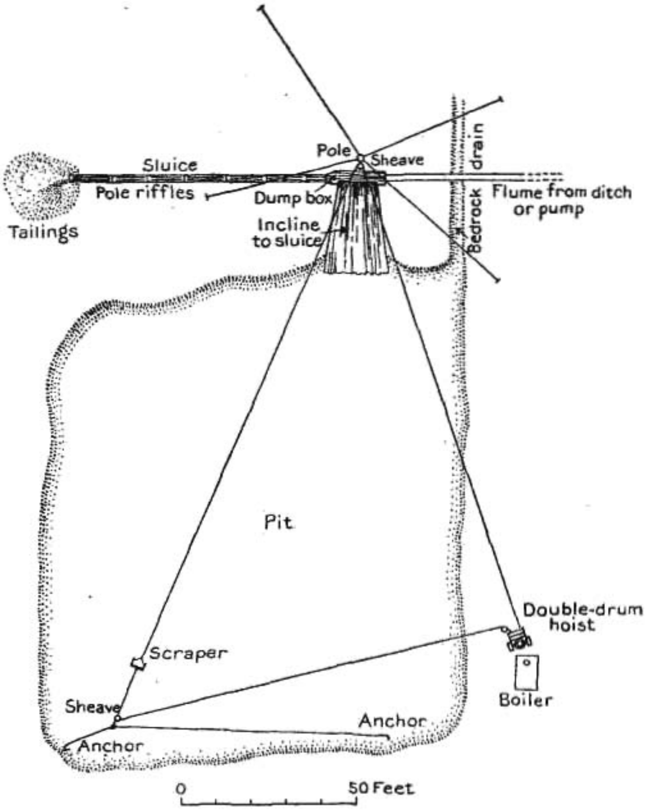


FIGURE 9.—Diagram showing arrangement of an open-cut mine.

carried to a spoil bank or dumped in an old cut; (3) by steam scraping. Some stripping is done by pick and wheelbarrow, but this is rather too expensive for general practice. Groundsluicing is always preferable where there is water and room for tailings. At several plants a combination of methods is employed.

On Pedro Creek a company has taken over a block of productive gravels about 820 feet long and 450 feet wide, or containing nearly 350,000 square feet. The equipment installed consists of a large boiler (about 60 horsepower), a double-drum hoisting engine, a heavy grading plow, scrapers of one-half to two-thirds yard capacity, cables, blocks, gin pole, and other apparatus for operating plow and scrapers, a 6-inch centrifugal pump for elevating sluice water, a dump box and sluice boxes mounted on a trestle, and an inclined approach, built of poles, to the dump box. The plant also includes the usual carpentry and blacksmithing outfits. The plant employs not over 10 men all told, there being generally 6 on the day shift and 3 on the night shift operating the plow.

Operations began with clearing the ground of brush and then plowing and scraping the overburden to a waste heap at the side of the pit. No artificial thawing is required. The natural thaw keeps pace downward with the progress of stripping. Cables for working the plow and scraper are fastened to them fore and aft and led through anchored blocks and thence to the drums of the hoisting engine. By proper disposition of the anchored blocks the excavators can be made to travel over any portion of the cut in the desired direction. Change in direction is accomplished by shifting the block on the drawback cable. A thickness of about 3½ feet is scraped to the waste heap, then the productive gravels are plowed at night and during the following day scraped to the dump box. For this operation the pulling cable is led through a block on a gin pole set up back of the dump box, opposite the pole incline. When the scraper reaches the dump box its teeth encounter a log and are held so that further pulling trips the pan and throws the load into the sluice. A man is not needed on the sluice to dump the scraper. The hoist man watches the scraper and after it is dumped draws it back into the pit. Here two men guide the scraper as it refills. At least two men are required also to guide the plow. Alternate plowing and scraping back and forth across the pit are continued until all the productive gravels and bedrock, together about 8½ feet, are removed. The plant is then moved upstream to the next cut. During a working season of about 120 days this plant was installed on virgin ground and two cuts, together measuring 135 feet by 275 feet, were made. From about 37,000 square feet of bedrock approximately 5,000 cubic yards of overburden and 11,500 cubic yards of productive ground were removed.

Water for sluicing was obtained through ditch and flume from Pedro Creek and an adjacent tributary, but had to be elevated about 15 feet with a centrifugal pump. Good fuel from neighboring hills costs $8 a cord, cut and laid down at the plant. About a cord a day was consumed. The operators stated that the cost of handling the gravels averaged 30 cents per bedrock square foot.[1] The total cost of operating, exclusive of costs and installation of plant and amortization charges, would be about 42 to 45 cents per bedrock square foot.

[1] The "bedrock square foot" is the unit in general use in the Yukon-Tanana region for measuring the amount of material handled; values of pay ground and costs of operating are expressed as so much gold or so many dollars per bedrock square foot.

On Cleary Creek another large open-cut operation has been conducted for several years. This plant is equipped for removal of overburden by steam scraping and for hoisting the pay gravels. The hoisting apparatus comprises two gin poles set up one on either side of a dump box at one side of the cut. From the gin poles, cables on which a self-dumping bucket carrier travels are stretched across the cut. The ground is cleared and stripped of about 11 feet of muck and barren gravel by steam scraping, leaving about 3½ feet of productive gravel, through which pits are sunk into bedrock. The buckets are lowered into the pits and filled with auriferous gravel and with about 1½ feet of the bedrock broken out with pick and shovel. As the buckets can be lowered into any desired portion of the pit by shifting the trolley cable and the block on it which arrests the carrier, little time need be given to wheeling from bank to bucket. Tailings are run into an old cut so that their disposal presents no difficulty. In ordinary seasons the gravity water supply is adequate; in 1908, however, about half of the water had to be raised with a pump. The ground required thawing by steam points, which were set vertically in the pay gravels at intervals of 6 feet. Forty-five men were employed in two 10-hour shifts. This plant in 1908 worked out 75,000 square feet of bedrock in two cuts, an average of nearly 1,000 square feet per day, at a total estimated cost of $1 per square foot.

On Pedro Creek the common practice is to groundsluice off the overburden of muck and barren gravels, and then to hoist pay dirt from the cut with dumping buckets to elevated sluices. There is not sufficient grade to the valley to permit direct shoveling to the boxes.

A few claims on low benches of First Chance and Gilmore creeks are worked in a small way by groundsluicing to bedrock and cleaning up bedrock with pick and shovel and by hand. On Twin Creek a bedrock flume has been installed and ditches built to tap Twin and Pedro creeks to give a water supply at an elevation of about 100 feet. It is intended to hydraulic the creek bed at a cost of about 35 cents per square foot.

Altogether there were 40 open-cut placer mines in the district in 1908. Three employed steam scrapers for handling the pay gravels, 5 were hydraulicked in a small way, 9 were worked by hand with pick, shovel, and wheelbarrow, and 23 hoisted pay dirt with self-dumpers.

At the time of this investigation of mining methods no attempt had been made to use the dredge in exploiting gold placers of the Fairbanks district, in spite of the fact that gold dredges had for a number of years been successfully operated in the Klondike and Fortymile districts of the Yukon basin. In 1911 a dredge was installed on "No. 8 above" on Fairbanks Creek.[1] This machine has 3½-cubic-foot close-connected buckets and a 40-foot ladder. The motive power is steam, wood being used for fuel. The alluvium where the dredge is operated is unfrozen and is 10 to 12 feet deep. This dredge was also operated during the open season of 1912.

DRIFT MINING.[2]

Processes.—The process of gold extraction and recovery by the drifting method includes in general the following operations: (1) Sinking a shaft to bedrock; (2) timbering the shaft and the portion of the drifts near the shaft; (3) opening up the ground by drifts either parallel to or across the productive gravels and driving crosscuts; (4) thawing and extracting the productive gravels, beginning at the farther limits of the drifts and working toward the shaft; (5) hoisting the auriferous material with as little barren material as possible to the surface; (6) recovering the gold by sluicing.

Equipment.—As stated by the author in a previous report:[3]

> Nearly all the productive drift mining is done with large steam-power plants of about 40 boiler horsepower. The usual mine equipment comprises boiler, hoist, steel bucket, automatic carrier, trolley cables, poles, blocks, etc., a small ram pump, steam points with pipe hose and fittings, and blacksmith's, carpenter's, steam fitter's, and machinist's outfits and tools. Such an equipment costs about $7,000. To it must be added the gold-washing apparatus, consisting generally of a dump box and string of sluice boxes on a light trestle 10 or 15 feet high and a ditch or flume for bringing water to the plant. Each plant is also generally provided with housing and mess for 15 or more men. The initial investment further includes the cost of transportation to the claim and installation of the plant, together with that of sinking a working shaft and blocking out the ground by prospect tunnels. The total first cost to the operator of a modern drift-mining plant amounts to about $12,000. This sum is in some plants further increased by the installation of a pumping plant for sluicing (about $1,000) and of an underground car system (about $1,000). Where the latter is used there is usually a corresponding increase in size and cost of boiler and hoist capacity.

Workings.—The following description of a plant on Vault Creek is typical of such operations in the Fairbanks district. (See figs. 10, 11, and 12.)

The shaft is sunk in the middle of a 500-foot block of pay streak averaging 100 feet in width. The shaft is 6 feet square in the clear and is cribbed with spruce poles chinked with moss. It is sunk 182 feet to bedrock and several feet more into rock, so as to serve as a sump for drainage and to afford gradient for easy movement of

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[1] Ellsworth, C. E., Placer mining in the Fairbanks and Circle districts: Bull. U. S. Geol. Survey No. 520, pp. 242–243.

[2] For a recent description of drift-mining methods in the Fairbanks district see article by T. A. Rickard, Min. and Sci. Press, vol. 98, 1909, pp. 382 et seq.

[3] Mineral resources of Alaska in 1908: Bull. U. S. Geol. Survey No. 379, p. 195.

the cars. Up and down stream from the base of the shaft, and approximately in the center of the pay streak, a main level or gangway is opened and timbered with sets of undressed spruce posts and caps, mostly set in bedrock without sills. Top and sides are lagged with round spruce poles. At the end of the gangway crosscuts were extended to the limits of the pay, and from these the ground is stoped out. The face of the stope at the outer limit is kept somewhat in advance of the face at the main gangway, so that at the close of operations the shaft is protected by a rhomboidal block of virgin ground. The procedure is very like the long-wall system of coal mining. The auriferous material lies on or in bedrock and in the lowest few inches of gravel; it has a total thickness of about 30 inches. The bedrock surface is very uneven, so that in places much of it has to be taken up to preserve drainage gradient. Altogether

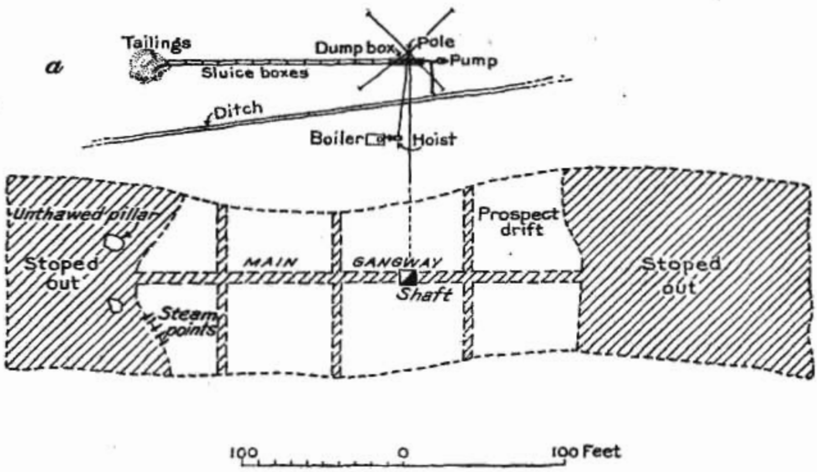


FIGURE 10.—Diagram showing arrangement of a drift mine. *a*, Plan on surface; *b*, plan on bedrock.

the drifts are kept 5½ feet high to give ample working space to the miners.

The ground is all solidly frozen and is thawed with steam points,[1] which, in the stopes, are driven just above the bedrock surface, from 2½ to 3 feet apart, or rarely at greater or lesser distances, depending on the amount of moisture in the gravel. The thawing and removal of gravels take place on alternate days; the face of the chamber at one end of the main gangway is thawed while the gravels thawed the day before in the chamber at the opposite end are being extracted. In this way the ground is given time to cool before it is broken down. It is shoveled into wheelbarrows and wheeled to platforms at the ends of the gangway and there dumped into cars, which are

[1] For details of the steam points, see Purington, C. W., Methods and costs of gravel and placer mining in Alaska: Bull. U. S. Geol. Survey No. 263, 1905, pp. 88–94.

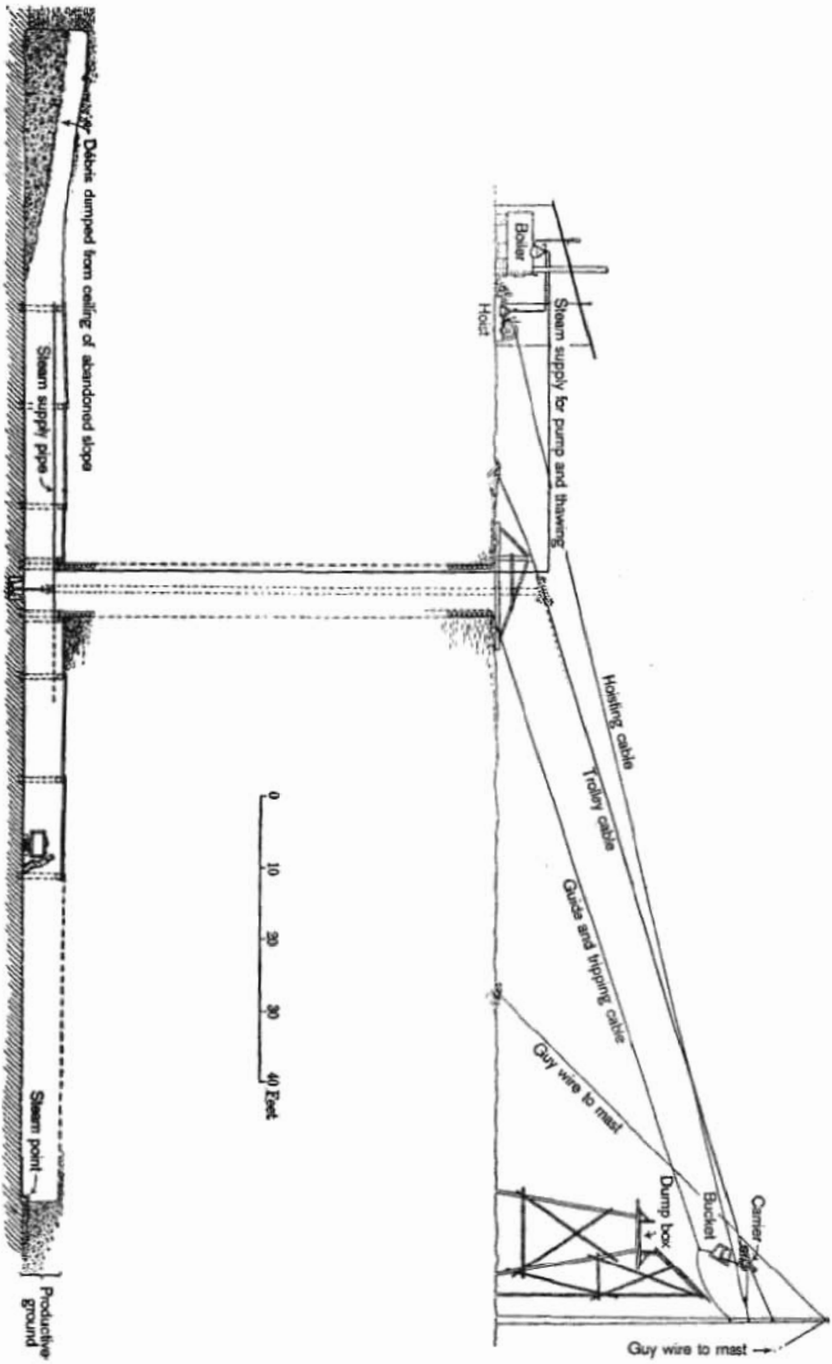


FIGURE 11.—Section of a drift mine.

trammed to the shaft, where it is discharged into the bucket, which has been let down into the sump so that its rim is flush with the floor. Each man picks, shovels, and wheels his own share of gravel. The men work in gangs of five or six, five or six wheelbarrows being the capacity of the car and the bucket. The shoveling and trundling are so timed that a loaded car is ready to dump into the bucket as soon as it has been lowered. The hoisting capacity thus determines the number of employees and the scale of operation. At the time of the visit this plant was working two 10-hour shifts a day, and was employing about 17 men, comprising a foreman, engineer, and pointman, besides a gang of shovelers on each shift, and was hoisting 250 bucket loads (about 80 cubic yards of gravel)

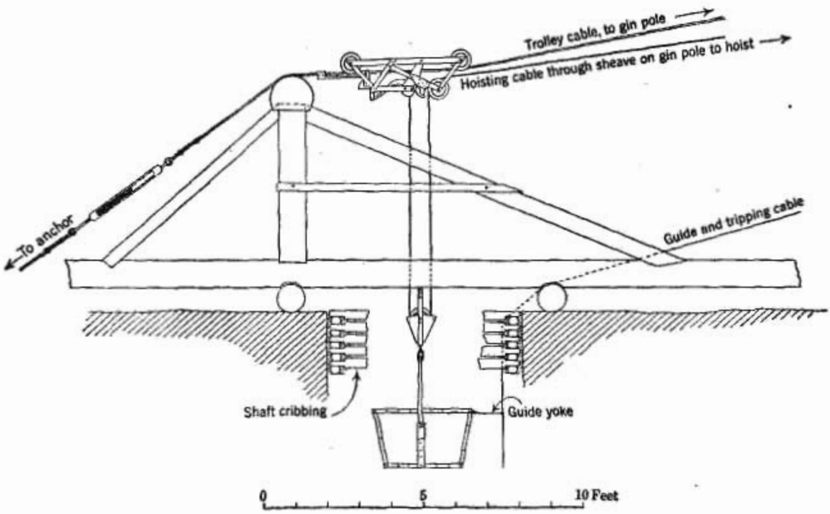


FIGURE 12.—Fairbanks type of head frame, automatic carrier, and bucket.

per day, or as more commonly measured in the district, was cleaning about 400 square feet of bedrock.

The bucket is provided with a guide yoke of wire cable or chain which travels on a guide wire made fast to the gin pole and to the bottom of the shaft. This serves to keep the bucket from "spinning" and also to trip it when it has arrived over the dump box.

The gravel-washing and gold-saving apparatus consists, as in all other placer mines in the district, of a dump box and a string of sluice boxes. Water for sluicing is led through a ditch from a point on the creek about a mile above the plant and is elevated to the dump box by a centrifugal pump.

A 40-horsepower boiler furnishes steam for thawing, for a double-drum (one drum only is used), two-cylinder hoist, and the pumping engine.

The cost of purchase and installation of this plant and of cleaning up the gold on the ground was reported to be $50,000. The net cost of operating after all the dead work of erecting plant, building ditches, driving tunnels, etc., was done was said to be 50 cents per bedrock square foot cleaned. The total time of the operation was about 10 months. It will be readily seen that an operation so short lived as this one would not be profitable unless the tenor of the ground were $1.50 or better per square foot, or about $7.50 per cubic yard of material handled.

The majority of the 250 drift-mining plants of the Fairbanks district in 1908 were of about the capacity of the one described and were worked in the same general way. A number, however, attacked the ground less systematically, especially on claims which had been worked for several years and by cruder methods in the early days of the camp. In many, too, the gravel is trundled direct to the bucket instead of to cars, especially where shorter blocks of ground are worked at a single set-up of the plant. This is particularly the case where shallower ground reduces the expense of sinking shafts.

The largest mines in the district, on Ester Creek, are entered by two shafts, half way between which the dump box is set up. One set of boilers supplies the whole system with steam, and one double-drum engine is used to raise both buckets. These are generally brought up alternately, so that the dump box receives an even supply of gravel. The largest of these plants was working a block 640 by 400 feet and was hoisting about 270 cubic yards a day, or clearing about 1,200 square feet of bedrock. The equipment included a 100-horsepower boiler. Forty-five men were employed in two 10-hour shifts. It was estimated by the operators that $1.25 would cover the total cost of mining per bedrock square foot.

Drift mining has recently been extended with some promise of success to the working of unfrozen ground containing live water on Ester Creek. The cost of pumping is offset by the fact that the water so raised is used for sluicing and that thawing is mostly or entirely obviated. On one claim the shaft was sunk in frozen ground, the main gangway was driven on one side of the pay streak, which was crosscut at short intervals and which was to be drained on the other side by a drainage tunnel parallel with the main gangway. A sump 5 by 7 by 9 feet in bedrock collected the water, and two 3-inch pumps raised it over 100 feet to the surface. The operating expense of the plant was about $2 per bedrock square foot, or twice the average cost in frozen ground.

Thawing.—It is regretted that quantitative data on the problem of thawing are not available. In the underground workings where points 8, 10, or 12 and sometimes 16 feet long are driven horizontally, parallel, and about 2½ to 3 feet apart the time required for thawing is from 8 to 40 hours. The amount of ice in the alluvium and bed-rock is the chief factor influencing thawing. It chiefly determines the time required for "a thaw" and the volume thawed. Furthermore, if the material is loose the steam is not retained (the miners say it "blows back") and thawing is retarded. The points are driven or set with hot water pumped from the boiler or from the mine sump where it is warmed by exhaust steam. After they are driven the ground is "sweated" by admitting dry steam at about 25 pounds pressure at the point.

Some pointmen withdraw the points after driving and replace them with light iron pipes, called by them "sweaters." This is done to keep down the number of points used in the mine, but as no other

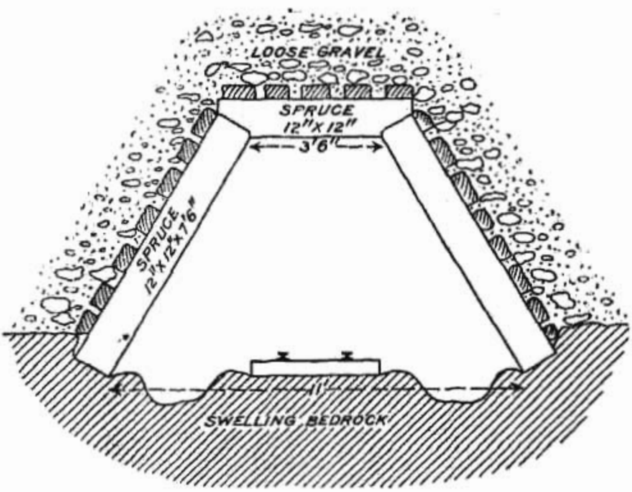


FIGURE 13.—Method of timbering in swelling ground.

advantage is evident the economy is doubtful, inasmuch as the life of the point is curtailed by the greater number of times it is driven. Care in packing the holes about the points with waste or sand is rewarded, both by better retention of the steam and hence by quicker thawing and by keeping the rooms of the mine dry and cool so that the ceiling does not thaw and "slough." The duty of a point is to thaw a block from the face to a foot or so beyond the end of the point and about 10 square feet in cross section.

Openings.—Shafts are generally lined with pole cribbing, chinked with moss; a filling of moss or sand or both is placed between the cribbing and the walls of the shaft. Heavy spruce post sets support the shaft cribbing. The main levels are timbered with sets of posts and caps, generally without sills, and are lagged top and sides with poles. In many places in deep ground the swelling of the bedrock when relieved from pressure by uncovering bends or breaks 12 and 15 inch posts, compelling their frequent replacement. Omission of the side lagging from the floor halfway to the roof lessens the evil by reducing the side pressure on the posts, but the difficulty can not be completely overcome. Relief from similar troubles in a California placer mine[1] was found by timbering as shown in figure 13.

The rooms or stopes are not timbered, as the frozen roof stands up long enough if the face is carried rapidly forward. (See fig. 14.) As the ceiling thaws sand and gravel drop in a continuous shower and pile up in mounds, partly filling the old workings. In some mines, especially where muck streaks are intercalated in the overhead gravels, huge slabs spall off, beginning to break away at the back and dropping lower and lower as the break extends forward until the weight of the slab causes it to break off. The slabs come down so slowly that they cause little danger to the men and consequently are not shored up unless they threaten to bury the face when they

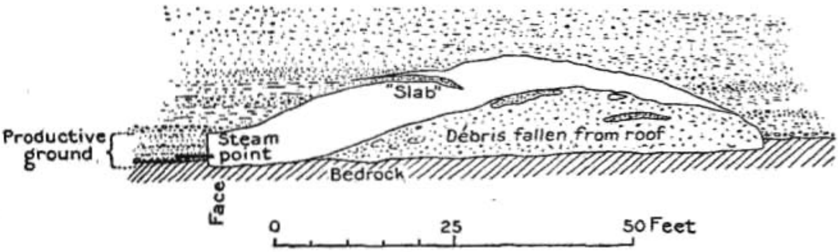


FIGURE 14.—Section of a stope.

fall. Where this is likely pillars of unthawed blocks may be left as supports until the face has been brought well forward. Then, if possible, the pillars are thawed and the auriferous material removed from them. Some miners support the ceiling with birch-pole cribs filled with waste gravels and bowlders.

Gold recovery.—Gold from the gravels and the auriferous portions of the extracted bedrock is recovered by washing the material through strings of sluice boxes provided most generally with riffles of rough peeled spruce poles placed lengthwise.

The material as hoisted from the shaft is delivered to a dump box that is provided with an apron. (See Pl. XXI, *A*, *B*.) The dump box is about 20 feet long, 40 inches or more in width, and is set customarily with a grade of 1 inch to 1 foot. The sluice boxes are generally 14 by 12 inches in cross section and 12 feet long and are set at grades of from 9 to 12 inches to the box. Most of the gold is caught in the dump box, as high as 90 per cent of the total product having

[1] Browne, R. E., Ancient river beds of the Forest Hill divide: Tenth Ann. Rept. State Mineralogist, California Bur. Mines, 1890, p. 452.

frequently been recovered there. The greatest portion of the remainder is caught in the next few boxes.

In the dump box the large bowlders and pieces of bedrock are washed and then forked out by a dump-box tender. The mud and sticky cement of the gravels are also loosened to some extent, though very inefficiently.

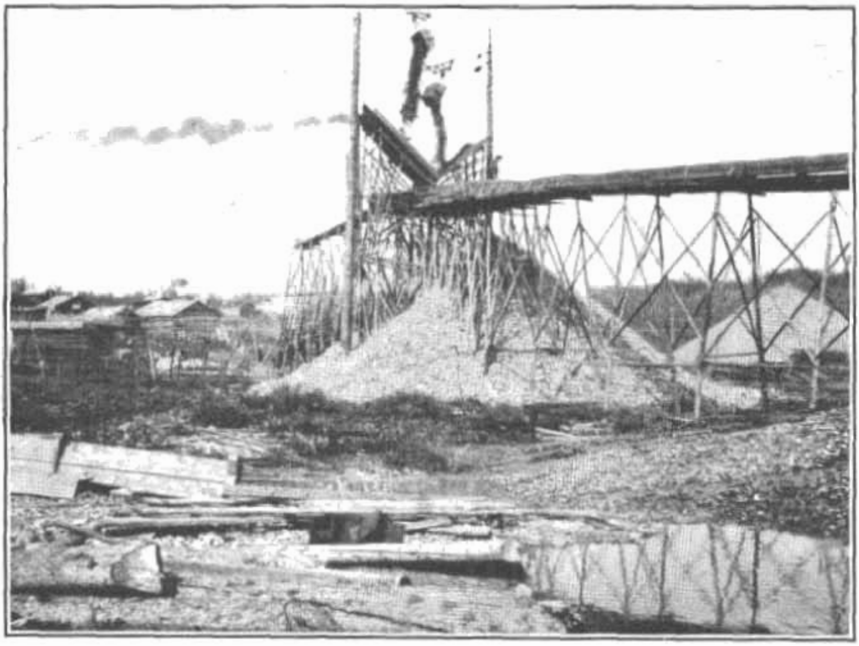
On a few claims dressed poles with iron straps on their upper surface are used as riffles, and on one claim block riffles in the dump box and an undercurrent were seen. The latter, though crudely constructed, was doing good service in saving fine gold

As a rule sluices are cleaned up weekly. The riffles are removed (to be renewed, if necessary), and the material caught by them is washed with a small stream of water and swept together with whisk brooms. It is then panned to remove the bulk of the heavy materials concentrated with the gold. These are saved and the season's product treated by amalgamation. The gold is dried, screened, and then cleaned with a magnet, but chiefly by "blowing," as in this district garnet, rutile, and ilmenite, nonmagnetic heavy minerals, are abundant. To "blow" gold is to repeatedly toss it in a specially shaped metal scoop or "blower," at the same time so blowing it with the breath as to remove all the heavy minerals but the gold. This process requires practice. The cleaned "dust" is sold to the local banks, who charge about 2½ per cent of the gross value for smelting, assaying, and shipping it to the outside.

It is hardly necessary to point out the inefficiency of the gold-saving devices at present in use in the Fairbanks district in comparison with the gold-saving machinery employed on modern dredges. In the case of otherwise expensively equipped plants of large capacity, the additional expense of gold-saving machinery would not be prohibitive and would probably be entirely offset by the saving of costs and maintenance of strings of sluice boxes, by more thorough washing of tailings, and by increased saving of gold. Gold-saving machinery, such as revolving or shaking screens upon which the gravels are washed and disintegrated by jets of water, and broad riffle tables over which to pass the fines, especially commends itself in this region where fine sticky sediment is abundant in the auriferous gravels and where the water supply is limited and, through repeated use, frequently overloaded with sediment.

Water for sluicing is most generally derived from short ditches and small board flumes carried from the creeks on which operations are conducted. In 1908 there were in the area about 40 of these ditches, all under 3 miles in length. Few of these deliver water direct to the sluice boxes by gravity, the majority bringing it to a place where it can be conveniently lifted by pump to the sluice boxes.

A. BUCKET DUMPER, SHOWING APRON AND DUMP BOX.



B. DOUBLE DUMPER.

Even during seasons of normal precipitation, probably a majority of the mining plants have had to elevate sluice water with pumps. It has been held by some of the operators that the cost of pumping is no greater than that of constructing and maintaining the longer ditches and flumes required for a gravity water supply. The capacities of the smaller ditches are, roughly, between ½ second-foot and 3 second-feet; that is, from 20 to 120 standard miner's inches. In a few places water has been pumped directly from the creeks and at one plant on Goldstream Creek from a pond on the claim. The one ditch of considerable size in the district is in the valley of the Chatanika, its intake being about 6 miles above the town of that name. It follows the south bank of the river, picks up Pilot Creek, is 7 miles long, and delivers 30 to 35 second-feet of water at Chatanika. During 1910 three plants pumped water from this ditch to their sluice boxes and five were low enough to receive this water by gravity.

During 1908 a large majority of plants had to elevate sluice water with pumps. The tailings piles were surrounded at many mines by dikes to impound the water from the sluices. This water was led back to the pump and repeatedly put through the boxes, and as only small additions of clean water were available, the gravels were very imperfectly washed.

The seasons influence drift mining in so far as sluicing is concerned. In the most favorable years weather permits ordinary sluicing from about the last of April until nearly the 1st of October. An average season is about 120 days. Extreme dates noted for sluicing without artificial aid are April 17 and October 16. In general during the winter and seasons of protracted drought the auriferous material is stored for subsequent sluicing in piles or "dumps" or in cribs and hoppers built of poles.

Dumps (Pl. XX, *B*) are so placed that their contents can be put through the sluice boxes with the least labor and with advantageous disposal of tailings. Generally the operator clears the ground of shrubbery and moss and sets strings of sluice boxes in shallow trenches in the ground and then lays poles across them. Over these the dump is deposited without disturbing the alignment and grade of the boxes and can be readily and completely cleaned up from the cleared ground.

Winter dumps require thawing in the spring either with steam points or with a jet of water. The latter serves the further purpose of breaking down the gravel which would otherwise have to be broken down with picks. At one plant visited, where the sluice boxes had been set up alongside of the dump, the gravels were being steam scraped to the boxes as in open-cut mining.

The crib hoppers seen were of small capacity and were built to tide the operations over drought. In them the pole floor on which the gravel was thrown was placed sufficiently high to provide grade and tailings room for the sluices which led from them.

The low gradients of the creeks of the district are an obstacle to the disposal of tailings on many claims. On some creeks, however, the position of the pay streaks, well up on the long-slope side of the valley and not in its center, affords grade toward the creek and obviates the difficulty. On many claims the difficulty is met by elevating the sluice boxes on trestles and pumping the water to them if it can not be led there by gravity. Some miners keep the sluiceways cleared by removing tailings with horse scrapers.

Winter sluicing has been tested on Ester Creek, where a small amount of water was running all winter. One plant used this during the winter 1907–8 by warming it with the exhaust from hoisting and pumping engines and pumping it to the sluice boxes. The water from the boxes was impounded, returned to the pump, and used repeatedly. That this experiment was successful is indicated by the fact that several operators were prepared for similar sluicing during the winter of 1908–9. Any additional expense of winter sluicing over summer sluicing is of small consideration in comparison with the heavy interest account on sums tied up in winter operations without sluicing. Reports received in March, 1909, are to the effect that an Ester Creek plant continued sluicing all winter.

COSTS.

The average plant in the Fairbanks district employing a 40-horsepower boiler costs for machinery and supplies about $7,000, exclusive of car system and pumping installation for sluicing, each of which costs about $1,000; transportation and erection of the plant would add about $3,000; sinking and timbering shafts costs about $12 to $15 a foot for 6 by 6 to 7 by 7 feet in clear; opening up and timbering main levels and crosscuts adds from $2,000 to $5,000. All this preliminary expense for equipment and on "dead work" will amount to at least $15,000, these figures being based on costs in 1908.

Wages during 1908 were board and $5 a day of 10 hours for common mine labor, $6 or $7 for pointmen, and $7 for hoistmen; at a few mines $5 for 8 hours or $6 for 10 hours was paid. Board, estimated at $2.50 per man per day, is always included. Fuel (wood) costs from $4 to $12 (generally about $10) per cord cut and delivered at the mines. Wood for timbers was considerably more expensive, but the exact prices were not learned. Gin poles cost $50. Water for sluicing was sold generally at $20 per "sluicehead" per day. The cost of pumping water for sluicing on one of the larger plants was reported as $30 per day. Twenty-five estimates by operators of the cost of drift mining range from 50 cents to $2 per bedrock square foot mined. The average cost is about $1.

The common practice of the operators in the district to-day is to lease from owners portions of claims in blocks of 500 to 1,000 feet in length measured along the pay streak, or from 50,000 to 200,000 square feet of workable ground. Individual 20-acre claims 1,000 to 1,320 feet long are usually worked by two and sometimes three independent plants, and on group claims of 160 acres extending 1 mile along the pay streak as many as eight leases have been let at one time. Over 65 per cent of all the 1908 operations were on leases or lays, the lessees or laymen paying royalties of from 25 to 50 per cent of the gross production.

With present capacities of 75,000 to 25,000 square feet of bedrock cleaned per year, the life of a mine is limited to from less than one year to three years.

WATER SUPPLY OF THE FAIRBANKS DISTRICT.

By G. L. Parker.

GENERAL CONDITIONS.[1]

Precipitation in the form of rain or snow is primarily the source of all water supply. In the Yukon-Tanana region the chief factor influencing the distribution of this supply is the imperviousness of the frozen ground, which prevents any considerable underground storage and consequently makes impossible a uniform distribution of the total run-off. In warmer climates the main source of supply for most of the streams during the low-water periods is derived from that portion of the rainfall and melting snow which has seeped into the ground in wet months and has slowly percolated through it to a belated junction with the surface watercourses at a lower elevation. This source of supply, however, is relatively insignificant in Alaska.

In drift mining the winter accumulations of snow and ice are of great value. The winter dumps are so placed as to be handled rapidly, and the few weeks of abundant spring flow are in most places sufficient to wash the gold-bearing gravels hoisted during the entire winter. In open-cut mining, however, the progress is directly dependent on the water supply from day to day, and the spring flow is of little value, work being prevented by the very fact that the ground is then covered with ice and snow. Of course many of the open-cut mines lie in the lower valleys, where the ice disappears before the winter accumulations in the upper valleys and hills are exhausted, but even here the spring floods are generally of such short duration that they are not usually considered a very valuable asset.

[1] Adapted from Ellsworth, C. E., Bull. U. S. Geol. Survey No. 442, 1910, pp. 252–253.

An additional supply of water is that derived from the thawing of frozen ground during the summer, but this source is of minor importance.

In the *open-cut region*, therefore, where artificial storage of any magnitude has been so far considered economically impossible, the water supply available for mining is the daily flow of the stream at the point of diversion, and the determining factors of this supply are the summer rains and their distribution.

The local distribution of this supply is affected not only by the frozen condition of the soil but also to a large extent by the topography. The summer low-water flow of the streams that rise in high, rugged mountains is kept up by the melting of large bodies of ice and snow in the sun-protected gulches and rock crevices. The rainfall, however, is not so well conserved in these streams as in gently sloping valleys and pondage areas, where the run-off, in percentage of the rainfall, even though less than in higher regions, may be so distributed as to furnish the better supply.

The prevailing moss covering is the one great natural storage agent, and to its preservation should be given more thought than it evidently has received in the past. The writer has frequently observed while traveling over the country that those areas which were heavily covered with moss distributed the run-off from summer rains in a more uniform manner than those with a lighter moss covering.

LOCAL CONDITIONS.

The absence of mountains that might furnish water at a high level renders rather difficult the task of obtaining a water supply. The low grade of the valleys nearly to their heads and the fact that nearly all of them lie at about the same elevation above sea level preclude the successful application on any large scale of the hydraulic method. Ditches must intake at places sufficiently high to furnish an efficient head, and such places are generally so near the headwaters that the supply is liable to be insufficient for mining purposes. Any undertaking, therefore, involving water supply requires most careful preliminary measurements of available water and grades. The creeks where mining is in progress are small, their drainage areas are narrow, the perennially frozen character of much of the ground gives scant opportunity for storage, and the quantity of water in the streams is thus brought into very close dependence on the rainfall.

STREAM-FLOW DATA.

In the consideration of industrial or mining enterprises which use the water of streams it is necessary to know the total amount of water flowing in the stream, the daily distribution of the flow, and the conditions affecting the flow. Several terms, such as second-foot, miner's inch, gallons per minute, are used to describe the quantity of water flowing in a stream, the one selected depending on the use to be made of the data.

"Second-foot" is in most general use in all classes of work. It is an abbreviation of cubic foot per second and may be defined as the unit for the quantity of water flowing per second in a stream 1 foot wide and 1 foot deep at the rate of 1 foot per second. It should be noted that it is a *rate* of flow, and to obtain the actual quantity of water it is necessary to multiply it by the time.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly, as regards both time and area.

"Run-off in inches" is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is expressed in depth in inches.

The "miner's inch," the unit used in connection with placer mining, expresses a rate of flow and is the quantity of water flowing through an orifice of a given size with a given head. The head and size of the orifice differ in different localities, thus making the miner's inch a most indefinite and unsatisfactory unit. Owing to the confusion arising from its use it has been defined by law in several States. The California miner's inch, which is in most common use in the United States, was defined by an act approved March 23, 1901, as a flow of 1½ cubic feet of water per minute, measured through any aperture or orifice. This miner's inch corresponds to the so-called "6-inch pressure," and is one-fortieth of a second-foot.

Monthly discharge of streams in the Chena River drainage basin for 1907–1910.

Chena River above Little Chena River.

[Drainage area, 1,440 square miles.]

Period.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1910.					
May 17-31	4,550	1,330	2,850	1.98	1.10
June	8,850	915	2,290	1.59	1.77
July	1,390	495	834	.579	.67
August	4,700	578	1,600	1.11	1.28
September	3,280	1,450	2,100	1.46	1.63
October 1-28	1,390	550	814	.565	.59
The period (165 days)	8,850	495	1,650	1.15	7.04

Monthly discharge of streams in the Chena River drainage basin for 1907–1910—Continued.

Little Chena River above Elliot Creek.

[Drainage area, 79 square miles.]

Period.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1907.					
July 22-31	80	42	49.3	0.625	0.23
August	157	53	85.4	1.08	1.24
September 1-10	95	66	86.2	1.09	.40
The period (51 days)	157	42	78.4	.993	1.87
1908.					
May 20-31	405	210	296	3.75	1.67
June	223	65	142	1.80	2.01
July	65	33	43.2	.547	.63
August 1-26	79	28	41.1	.520	.49
The period (99 days)	405	28	103	1.30	4.80
1910.					
July	166	22	37.0	.468	.54
August	350	22	74.5	.943	1.09
The period (62 days)	350	22	55.8	.706	1.63

Little Chena River below Fish Creek.

[Drainage area, 228 square miles.]

Period.	Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off (depth in inches on drainage area).
1908.					
May	1,670	265	832	3.65	4.21
June	651	161	284	1.25	1.40
July	161	64	94.9	.416	.48
August 1-27	122	59	79.2	.347	.35
The period (119 days)	1,670	59	332	1.46	6.44
1910.					
July	232	38	67.3	.295	.34
August	460	36	109	.478	.55
The period (62 days)	460	36	88.2	.386	.89

Elliot Creek above Sorrels Creek.

[Drainage area, 13.8 square miles.]

Period.	Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off (depth in inches on drainage area).
1907.					
July 22-31	9.0	2.5	5.94	0.430	0.16
August	23	5.8	11.0	.797	.92
September 1-10	12.3	9.0	10.1	.724	.27
The period (51 days)	23	2.5	9.82	.711	1.35
1908.					
May 20-31	216	11	67.8	4.91	2.19
June	32	8.6	14.8	1.07	1.19
July	7.5	4.5	5.22	.378	.44
August 1-26	4.6	4.4	4.48	.324	.31
The period (99 days)	216	4.4	15.5	1.12	4.13
1910.					
July	10.6	2.3	3.50	.254	.29
August	15.1	2.3	5.60	.405	.47
The period (62 days)	15.1	2.3	4.55	.330	.76

Monthly discharge of streams in the Chena River drainage basin for 1907–1910—Continued.

Sorrels Creek near mouth.

[Drainage area, 21 square miles.]

Period.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1907.					
July 22–31	14.7	6.0	10.5	0.500	0.19
August	32.1	10.3	18.2	.867	1.00
September 1–10	19	14.7	16.0	.762	.28
The period (51 days)	32.1	6.0	16.3	.777	1.47
1908.					
May 20–31	131	36	73.0	3.48	1.55
June	72	27	42.8	2.04	2.28
July	38	11	19.9	.948	1.09
August 1–26	18	10	12.5	.595	.58
The period (99 days)	131	10	31.3	1.49	5.50
1910.					
July	46	3.6	7.53	.359	.41
August	36	3.6	12.2	.581	.67
The period (62 days)	46	3.6	9.86	.470	1.08

Fish Creek below Solo Creek.

[Drainage area, 21.5 square miles.]

1910.					
June 14–30	22	7.1	12.0	0.558	0.35
July	20	5.4	8.47	.394	.45
August	38	4.8	12.3	.572	.66
September	50	9.0	20.5	.953	1.06
The period (109 days)	50	4.8	13.4	.623	2.52

Fish Creek above Fairbanks Creek.

[Drainage area, 39 square miles.]

1907.					
July 22–31	24	18	22.5	0.577	0.21
August	155	24	36.8	.944	1.09
September 1–10	35	24	26.6	.682	.25
The period (51 days)	155	18	32.0	.821	1.55
1908.					
May 22–31	227	90	132	3.38	1.26
June	137	36	56.7	1.45	1.61
July	33	12	19.9	.510	.59
August 1–27	17.7	12	14.8	.380	.38
The period (98 days)	227	12	41.1	1.05	3.84

Fish Creek at mouth.

[Drainage area, 90.2 square miles.]

1908.					
May	682	105	404	4.48	5.16
June	327	69	125	1.39	1.55
July	65	22	32.2	.356	.41
August 1–27	31	22	25.9	.287	.28
The period (119 days)	682	22	151	1.67	7.40
1910.					
July	42	13.8	19.9	.221	.25
August	119	12.4	29.4	.326	.38
The period (62 days)	119	12.4	24.6	.274	.63

Monthly discharge of streams in the Chena River drainage basin for 1907–1910—Continued.

Miller Creek at mouth.

[Drainage area, 16.7 square miles.]

Period.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1908.					
May 13-31	122	13.8	62.7	3.77	2.65
June	55	10.6	18.2	1.08	1.20
July	11.1	4.3	7.50	.449	.52
August 1-27	6.4	4.0	4.98	.298	.30
The period (107 days)	122	4.0	19.7	1.12	4.67
1910.					
July	5.2	2.3	3.33	1.99	.23
August	13.5	2.0	4.56	2.73	.31
The period (62 days)	13.5	2.0	3.94	2.36	.54

Monthly discharge of streams in the Chatanika River drainage basin for 1907–1910.

Chatanika River below Faith Creek.

[Drainage area, 132 square miles.]

Period.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1907.					
July 17-31	96	55	67.8	0.514	0.28
August	205	72	125	.947	1.09
September	1,990	119	342	2.59	2.89
The period (76 days)	1,990	55	178	1.31	4.26
1908.					
May 12-20	1,340	320	598	4.53	1.85
July 13-31	200	82	131	.992	.70
August	270	95	137	1.04	1.20
September	530	102	208	1.58	1.76
The period (89 days)	1,340	82	241	1.82	5.51
1910.					
May 25-31	683	320	473	3.58	.93
June	2,000	118	377	2.86	3.19
July	293	48	86.1	.652	.75
August	1,010	49	197	1.49	1.72
September 1-25	430	141	233	1.77	1.65
The period (124 days)	2,000	48	235	1.78	8.24

Chatanika River below Poker Creek.

[Drainage area, 456 square miles.]

1907.					
June 20-30	250	192	228	0.500	0.20
July	283	167	211	.463	.53
August	1,160	216	428	.939	1.08
September	3,160	300	954	2.09	2.33
October 1-14	860	232	506	1.11	.47
The period (117 days)	3,160	167	496	1.08	4.61

Monthly discharge of streams in the Chatanika River drainage basin for 1907–1910—Con.

Chatanika River below Poker Creek—Continued.

Period.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1908.					
May 16-31	4,120	1,730	2,730	5.99	3.56
June	2,280	283	984	2.16	2.41
July	942	204	332	.728	.84
August	455	192	284	.623	.72
September	1,160	266	461	1.01	1.12
October 1-21	342	179	234	.513	.40
The period (159 days)	4,120	179	699	1.53	9.05
1909.					
May 9-31	3,620	474	1,870	4.10	3.51
June	1,220	152	416	.912	1.02
July	833	219	414	.910	1.05
August	1,740	179	530	1.16	1.34
September	219	130	151	.331	.37
October 1-5	110	92	103	.226	.04
The period (150 days)	3,620	92	598	1.31	7.33
1910.					
May 17-31	1,900	600	944	2.07	1.16
June	3,260	248	686	1.50	1.67
July	822	104	196	.430	.50
August	2,720	95	481	1.05	1.21
September	1,410	298	553	1.21	1.35
October 1-29	852	123	208	.456	.49
The period (166 days)	3,260	95	472	1.04	6.38

McManus Creek at mouth.

[Drainage area, 80 square miles.]

Period.	Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off (depth in inches on drainage area).
1907.					
June 20-30	34.8	21.7	28.5	0.356	0.15
July	40	15.0	21.4	.268	.31
August	114	32.2	66.4	.830	.96
The period (73 days)	114	15.0	41.5	.510	1.42
1910.					
May 25-31	359	160	236	2.95	.77
June	760	30	155	1.94	2.16
July	110	17	29	.362	.42
August	387	13	75	.938	1.08
September 1-25	282	59	131	1.64	1.52
The period (124 days)	760	13	103	1.29	5.95

Faith Creek at mouth.

[Drainage area, 51 square miles.]

Period.	Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off (depth in inches on drainage area).
1907.					
June 20-30	45.9	34.4	40.5	0.795	0.32
July	62.5	19.2	29.2	.572	.66
August	87.4	26.9	47.5	.932	1.07
The period (73 days)	87.4	19.2	38.5	.755	2.05
1910.					
May 25-31	333	146	237	4.65	1.21
June	1,240	60	222	4.35	4.85
July	244	31	57.1	1.12	1.29
August	733	36	122	2.39	2.76
September 1-25	169	74	102	2.00	1.86
The period (124 days)	1,240	31	132	2.59	11.97

Monthly discharge of streams in the Chatanika River drainage basin for 1907–1910—Con.

Homestake Creek near mouth.

[Drainage area, 5.6 square miles.]

Period.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1910.					
May 26-31	50	29	37.6	6.71	1.50
June	56	4.2	18.2	3.25	3.63
July 1-11	3.0	2.0	2.68	.479	.20
The period (47 days)	56	2.0	17.0	3.04	5.33

Kokomo Creek near mouth.

[Drainage area, 26 square miles.]

Period.	Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off.
1907.					
July 9-31	25.8	7.9	14.2	0.546	0.47
August 1-14	112	22.7	41.6	1.60	.83
The period (37 days)	112	7.9	23.8	.916	1.30

Goldstream Creek near claim "No. 6 below."

[Drainage area, 28.6 square miles.]

Period.	Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off.
1907.					
June 20-30	30.2	4.9	13.4	0.469	0.19
July	34.4	2.2	13.1	.458	.53
August	32.2	10.8	20	.699	.81
September	41	15.4	24	.839	.94
October 1-7	24.4	17.1	20.7	.724	.19
The period (110 days)	41	2.2	18.5	.649	2.66

Monthly discharge of streams in the upper Tanana drainage basin for 1909–10.

Banner Creek near mouth.

[Drainage area, 21.5 square miles.]

Period.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1910.					
June 20-30	13.5	4.0	6.30	0.293	0.12
July	26	2.0	5.63	.262	.30
August	19.3	2.7	7.63	.355	.41
September	17.5	7.2	11.4	.530	.59
The period (103 days)	26	2.0	7.97	.371	1.42

Monthly discharge of streams in the upper Tanana drainage basin for 1909–10—Contd.

Salcha River at mouth.

[Drainage area, 2,170 square miles.]

Period.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1909.					
July 4–31	9,130	1,630	3,830	1.76	1.83
August	7,460	1,750	3,690	1.70	1.96
September	1,730	1,350	1,460	.67	.75
The period (89 days)	9,130	1,350	2,980	1.37	4.54
1910.					
May 12–31	6,640	2,180	3,040	1.40	1.04
June	8,220	1,740	3,560	1.64	1.83
July	6,120	1,120	2,000	.920	1.06
August 1–19	5,590	930	1,880	.866	.61
The period (100 days)	8,220	930	2,990	1.38	4.54

Junction Creek above Moose Lake outlet.

[Drainage area, 23.6 square miles.]

Period.	Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off (depth in inches on drainage area).
1909.					
July 7–31	53	4.0	13.8	0.585	0.54
August	145	5.8	25.4	1.08	1.24
September 1–23	12.2	5.3	8.2	.347	.30
The period (79 days)	145	4.0	16.8	.712	2.08
1910.					
June 8–30	269	4.0	31.1	1.32	1.13
July	34	3.0	6.62	.281	.32
August	30	3.8	7.04	.298	.34
September 1–21	34	4.6	13.1	.555	.43
The period (106 days)	269	3.0	13.3	.564	2.22

Monthly discharge of streams in the Washington Creek drainage basin for 1908.

Washington Creek above Aggie Creek.

[Drainage area, 117 square miles.]

Period.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
May 23–31	408	183	282	2.41	0.81
June	557	45	159	1.36	1.52
July	63	18	33.2	.284	.33
August	30	22	24.6	.210	.24
September 1–4	104	30	59.8	.512	.08
The period (105 days)	557	18	89.1	.762	2.98

Monthly discharge of streams in the Washington Creek drainage basin for 1908—Contd.

Washington Creek below Aggie Creek.

[Drainage area, 153 square miles.]

Period.	Discharge in second-feet. Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off (depth in inches on drainage area).
May 5-31	1,400	234	774	5.26	5.28
June	600	52	182	1.23	1.37
July	88	24	41.3	.281	.32
August	37	28	30.8	.210	.24
September 1-4	124	38	73.1	.498	.07
The period (123 days)	1,400	24	234	1.53	7.28

Aggie Creek at mouth.

[Drainage area, 36 square miles.]

May 23-31	125	50	91.2	2.55	0.85
June	79	7.8	22.5	.629	.70
July	14	4.5	7.58	.211	.24
August	7.5	6.0	6.26	.174	.20
September 1-4	16	8.5	12.2	.341	.05
The period (105 days)	125	4.5	18.8	.525	2.04

GOLD IN THE TENDERFOOT REGION.

By L. M. Prindle.

GOLD PLACERS.

The gold-placer area commonly known as the Tenderfoot district lies about 60 miles southeast of Fairbanks and embraces the drainage basins of several streams tributary to Tanana River from the north. Richardson, a small settlement located on the bank of the Tanana at the mouth of Banner Creek, the supply point and telegraph station for the region, can be reached by the railroad from Fairbanks or by the small steamers which occasionally ascend the Tanana. Most of the supplies are brought to these creeks from Fairbanks in winter.

The Tanana at Richardson meanders by many channels through a broad flood plain bounded on the north by an upland having a rather uniform summit level 1,800 to 2,000 feet in altitude, above which stand some rounded domes and below which long flat-topped spurs digitate from the main divides. Both Banner and Tenderfoot Creeks occupy broad alluvium-filled valleys whose lower courses merge with the Tanana flood plain and whose slopes are gentle. All the main streams have low gradients and none are cut to bedrock.

So far as known, all the bedrock of the district belongs to the Birch Creek schist, but to the west, near Birch Lake, are some large intrusive masses of granite. All of the bedrock observed is mica schist, which decomposes readily. The hard quartzitic type of schists, so characteristic of the Birch Creek formation in other parts of the quadrangle, appear to be entirely lacking in the Tenderfoot region. The alluvium consists essentially of a heavy overburden of humus and silt resting upon a rather thin bed of gravel, which lies on bedrock. On the south side of Tenderfoot Creek a silt terrace, whose ill-defined upper surface merges with the talus slope, stands probably about 100 feet above the present stream level.

Small quartz veins and stringers are common in the schists of the region. Some of these are metallized and in the absence of any other probable source can be regarded as the source of the gold. Some gold-bearing galena ore has been found on Tenderfoot Creek, but its bedrock source has not been seen.

Gold was first found on Tenderfoot Creek in 1905, and in the following four years the value of the annual gold production was probably $300,000 or $400,000 annually.

Only a few fragmentary notes are available regarding the occurrence of the gold. The alluvial deposits range from 30 feet in thickness near the head of the creek to 155 feet near the mouth. Of this deposit the upper 35 to 80 feet is silt and humus, the rest being gravel. The gravel layer mined ranges from 3 to 5 feet in thickness. The highest values are said to occur where the gravels are thinnest. The following table is based on observations made in 1905; since that date there has been much mining on the creek, but no data concerning it are at hand. Gold has been found for about 4 miles along the creek:

Thickness of placer deposits of lower part of Tenderfoot Creek.

[In feet.]

Claim (below Discovery).	Total depth to bedrock.	Thickness of muck.	Thickness of gravel.	Thickness of pay streak.
No. 13	108	60	48	....
No. 12	92	....	....	....
No. 11	120	80	40	4
No. 6	80	40	40	....
No. 5	70	40	30	3
No. 1	48	36	14	4

The Tenderfoot placer gold is the lowest grade of any in the Yukon region. No assays of it are at hand, but it is reported to average from $12.25 to $13.50 an ounce, the highest-grade gold being found on the lowest workings of the creek.

The general occurrence of placer gold on Banner Creek is probably similar to that on Tenderfoot Creek, but detailed notes are lacking.

In 1909 but little work was done in this district, but in 1910 activities were resumed on Tenderfoot, where a new pay streak was located, which appears to be a bench deposit and which was traced for about a mile and a half. Two tributaries of Banner Creek, Buckeye and Democrat, were productive in 1910. On both creeks the gravels are shallow.

WATER SUPPLY.

The following account of the water supply of the Salchaket district, by Ellsworth and Parker,[1] includes information about the available water for the Tenderfoot district:

TANANA RIVER DRAINAGE BASIN.

The Tanana precinct, which includes the Salchaket district, embraces the area drained by the Tanana and its tributaries from and including Salcha River to a point on Tanana River south of Lake Mansfield. The larger streams included in this area are Salcha, Goodpaster, Volkmar, and Healy rivers from the north and Delta River from the south.

Tanana River rises near the international boundary line and flows in a general northwesterly direction for about 440 miles to its junction with Yukon River at Fort Gibbon.

The river in general follows the north side of the valley and is one maze of channels and islands. At McCartys, just above the mouth of Delta River, which is 95 miles from Fairbanks by the Government road, it flows in three channels except at extreme low water, when the middle one is dry. During the summer of 1909 the Alaska Road Commission installed ferries on the right and left channels and bridged the center one.

Tenderfoot and Banner creeks, which have been the largest gold producers in the district, are tributary to the Tanana about 75 miles northeast of Fairbanks, at a point about halfway between Goodpaster and Salcha rivers and from the same side. Canyon Creek is a small stream which flows into the main stream from the north about 5 miles below Richardson.

Salcha River rises opposite the head of the South Fork of Birch Creek, about 25 miles from the Yukon. The average fall of the river from the Splits to the mouth is 10 feet to the mile, and from a point about 2 miles from the summit of the divide at the headwaters it averages 19 feet to the mile. At the mouth, which is 40 miles from Fairbanks, a ferry, post office, store, and roadhouse are located, and good accommodations are at hand for the traveler. Redmond Creek enters the Salcha from the south about 15 miles above the mouth. Junction and Mosquito creeks, which join to form Redmond Creek, drain an area 6 to 8 miles north of the Tanana and parallel to it.

Little Salcha River, which is tributary to the Tanana from the east, enters the river at a point midway between the town of Salchaket and the Salcha telegraph station.

[1] Ellsworth, C. E., and Parker, G. L., Water supply of the Yukon-Tanana regi[on], 1910: Bull. U. S. Geol. Survey No. 480, 1911, pp. 192–194.

GAGING STATIONS AND MEASURING POINTS.

The following list gives the locations at which gaging stations were maintained or discharge measurements made in 1910 in the Salchaket district:

Gaging stations and measuring points in Salchaket district, 1910.

Tanana River drainage basin:
- Banner Creek at mouth.
- Canyon Creek near mouth.
- Salcha River at mouth.
  - Junction Creek above Moose Lake outlet.
- Little Salcha River at road crossing.

Monthly discharge of Salcha River at mouth for 1909–10.

[Drainage area, 2,170 square miles.

Month.	Discharge in second-feet.				Run-off (depth in inches on drainage area).
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1909.					
July 4-31	9,130	1,630	3,830	1.76	1.83
August	7,460	1,750	3,690	1.70	1.96
September	1,730	1,350	1,460	.67	.75
The period (89 days)	9,130	1,350	2,980	1.37	4.54
1910.					
May 12-31	6,640	2,180	3,040	1.40	1.04
June	8,220	1,740	3,560	1.64	1.83
July	6,120	1,120	2,000	.920	1.06
August 1-19	5,590	930	1,880	.866	.61
The period (100 days)	8,220	930	2,990	1.38	4.54

MEASUREMENTS.[1]

The following measurements were made during 1909 in the Salchaket district:

Daily discharge, in second-feet, of Banner Creek, Salcha River, and Redmond Creek, 1909.

Day.	Banner Creek near mouth (drainage area, 21.5 square miles).			Salcha River at Salchaket (drainage area, 2,170 square miles).			Redmond Creek above Mosquito Creek (drainage area, 24.7 square miles).		
	July.	Aug.	Sept.	July.	Aug.	Sept.	July.	Aug.	Sept.
1	....	....	7.8	....	7,460	1,730	....	28	5.8
2	....	....	6.6	....	5,700	1,630	....	69	5.3
3	....	....	6.6	....	6,300	1,530	....	145	5.3
4	....	....	6.6	1,730	5,590	1,630	....	65	5.3
5	....	....	6.6	1,710	5,260	1,630	....	38	6.2
6	10.6	....	6.6	1,630	4,060	1,630	....	17.3	7.5
7	6.6	....	6.6	1,630	4,250	1,630	5.0	12.2	8.8
8	10.6	....	5.4	1,800	4,540	1,630	6.7	13.4	10.2
9	5.4	....	5.4	2,840	5,480	1,530	5.5	22	7.2
10	6.6	....	7.8	2,840	5,940	1,530	8.3	36	6.7

[1] Ellsworth, C. E., Water supply of the Yukon-Tanana region, 1909: Bull. U. S. Geol. Survey No. 442, 1910, p. 283.

Daily discharge, in second-feet, of Banner Creek, Salcha River, and Redmond Creek, 1909—Continued.

Day.	Banner Creek near mouth (drainage area, 21.5 square miles).			Salcha River at Salchaket (drainage area, 2,170 square miles).			Redmond Creek above Mosquito Creek (drainage area, 24.7 square miles).		
	July.	Aug.	Sept.	July.	Aug.	Sept.	July.	Aug.	Sept.
11	5.4	....	6.6	2,840	4,940	1,530	10.2	24	7.2
12	5.4	....	6.6	3,380	4,440	1,480	8.6	28	6.7
13	10.6	....	5.4	3,220	4,160	1,480	27	14.5	6.2
14	10.6	....	6.6	4,640	3,540	1,480	22	10.2	8.6
15	9.2	....	6.6	7,300	3,060	1,480	36	9.4	12.2
16	7.8	....	6.6	9,130	2,760	1,480	12.2	9.4	12.2
17	7.8	....	12.2	6,860	2,410	1,350	6.7	8.6	11.2
18	7.8	....	9.2	3,960	2,340	1,350	5.3	7.2	7.9
19	5.4	....	7.8	4,740	2,340	1,350	5.2	6.2	8.7
20	4.3	....	6.6	4,440	2,480	1,350	4.6	73	9.5
21	3.3	....	6.6	4,160	2,910	1,350	4.3	45	10.2
22	3.3	....	6.6	2,840	3,060	1,350	4.0	32	10.2
23	5.4	....	6.6	2,690	3,060	1,350	4.3	17.3	10.2
24	5.4	....	7.8	2,690	2,910	1,350	7.2	12.2	....
25	5.0	....	4.3	3,220	2,690	1,350	6.7	7.9	....
26	4.3	....	4.3	2,910	2,480	1,350	4.6	7.2	....
27	5.4	9.2	....	2,480	2,340	1,350	4.5	6.7	....
28	10.6	9.2	....	2,410	2,200	1,350	6.7	6.2	....
29	17.2	9.2	....	4,740	2,010	1,350	40	6.2	....
30	29	7.8	....	6,580	1,780	1,350	53	5.8	....
31	....	7.8	....	7,800	1,750	....	47	5.8	....
Mean	8.1	8.6	6.8	3,830	3,690	1,460	13.8	25	8.2
Mean per square mile	.38	.40	.32	1.76	1.70	.67	.56	1.03	.33
Run-off, depth in inches	.35	.07	.31	1.83	1.96	.75	.52	1.19	.28

Miscellaneous measurements in Salchaket district, 1909.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
July 9	Tanana River at McCartys	13,900	27,600	1.99
August 28	do	13,900	21,300	1.53
July 11	Banner Creek above Buckeye Creek	13.8	3.3	.24
August 27	do	13.8	2.4	.17
July 6	Buckeye Creek at mouth	6.0	5.2	.87
July 11	do	6.0	1.8	.30
August 27	do	6.0	4.3	.72
July 4	Little Salcha River at road crossing	70	45	.64
July 13	do	70	62	.89
August 25	do	70	33	.47
August 30	do	70	27	.39

Daily discharge, in second-feet, of Banner Creek, Salcha River, and Junction Creek for 1910.

Day.	Banner Creek near mouth[a] (drainage area, 21.5 square miles).				Salcha River at mouth[b] (drainage area, 2,170 square miles).				Junction Creek above Moose Lake outlet[a] (drainage area, 23.6 square miles).			
	June.	July.	Aug.	Sept.	May.	June.	July.	Aug.	June.	July.	Aug.	Sept.
1	......	6.1	19.3	7.2	....	4,390	4,150	3,090	......	5.3	30	4.6
2	......	4.0	14.0	7.8	....	4,050	3,360	2,660	......	4.6	20	6.7
3	......	3.1	12.2	8.8	....	3,360	2,740	2,180	......	4.3	14.5	6.2
4	......	3.1	8.8	10.5	....	3,090	2,040	1,640	......	4.3	8.6	6.2
5	......	7.8	7.2	11.2	....	2,520	1,760	1,620	......	5.8	5.8	25
6	......	7.8	5.6	10.5	....	2,660	2,260	1,310	......	6.2	4.6	22
7	......	7.8	5.6	10.5	....	2,300	2,040	1,310	......	5.8	4.3	14.5
8	......	6.1	5.0	9.8	....	1,740	1,580	1,310	8.6	4.6	4.3	10.2
9	......	4.6	5.0	8.8	....	3,000	1,310	1,260	7.2	4.6	4.3	8.6
10	......	4.6	5.0	7.8	....	6,010	1,160	1,120	269	4.3	4.0	8.6
11	......	3.1	5.0	7.8	....	7,480	1,120	1,120	193	3.8	4.0	7.9
12	......	3.1	4.2	8.8	4,130	8,220	1,120	1,120	85	5.3	3.8	7.2
13	......	3.1	4.2	12.2	5,780	7,060	1,420	1,120	41	4.6	3.8	7.2
14	......	2.5	2.7	11.2	6,320	5,170	2,040	1,000	17.3	4.3	4.0	9.4
15	......	2.5	2.7	11.2	6,180	3,360	1,970	930	11.2	3.8	4.3	12.2
16	......	2.0	5.6	17.5	6,640	2,660	1,760	930	9.4	3.8	4.3	20
17	......	2.5	5.0	15.7	5,000	3,270	1,420	2,480	7.9	3.8	4.6	34
18	......	2.5	5.6	8.8	6,010	2,920	1,120	4,030	6.2	3.8	5.0	27
19	......	2.5	9.6	12.2	4,650	2,580	1,120	5,590	5.8	3.8	7.2	14.5
20	4.6	2.5	12.9	10.5	4,350	2,480	1,310	....	5.3	4.3	10.2	11.2
21	4.0	2.5	10.5	8.8	4,710	2,380	1,210	....	5.0	3.0	12.2	11.2
22	4.0	3.1	9.6	10.5	3,750	2,270	1,120	....	4.6	4.0	7.9	......
23	4.0	11.1	8.8	12.2	3,180	2,550	1,120	....	4.6	10.2	6.2	......
24	4.0	11.1	8.8	14.0	3,910	2,830	2,830	....	4.3	10.2	5.8	......
25	4.0	4.6	8.2	15.7	5,480	2,830	6,120	....	4.0	17.3	5.8	......
26	13.5	3.1	8.2	15.0	5,550	2,830	2,740	....	4.6	12.2	5.3	......
27	7.8	3.1	7.8	14.0	4,050	3,950	2,410	....	5.3	8.6	5.3	......
28	7.8	2.5	7.8	15.7	3,750	3,180	2,110	....	5.3	6.2	5.0	......
29	7.8	3.1	7.2	14.0	3,750	3,000	1,520	....	5.0	4.6	4.6	......
30	7.8	23	7.2	12.2	2,180	2,740	1,520	....	5.3	3.8	4.3	......
31	......	26	7.2	......	4,750	....	2,490	....	......	34	4.3	......
Mean	6.30	5.63	7.63	11.4	3,040	3,560	2,000	1,880	3.11	6.62	7.04	13.1
Mean per square mile	0.293	0.262	0.355	0.530	1.40	1.64	0.920	0.866	1.32	0.281	0.298	0.555
Run-off (depth in inches on drainage area)	0.12	0.30	0.41	0.59	1.04	1.83	1.06	0.61	1.13	0.32	0.34	0.43

[a] The discharges of Banner and Junction creeks are only approximate on account of shifting channels and insufficient measurements.

[b] The discharges of Salcha River at mouth are based on a rating curve that is well defined throughout.

Miscellaneous measurements in Salchaket district in 1910.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-feet.*	*Sec.-feet.*
June 21	Canyon Creek near mouth	4.7	0.45	0.091
June 22	Little Salcha River at road crossing	70	28	.40
August 15	....do	70	21	.30

GOLD IN THE TROUBLESOME CREEK REGION.

By L. M. Prindle.

GOLD PLACERS.

Some placer gold has been found near the western margin of the Fairbanks quadrangle in what is properly a part of the Rampart district. As these placers, however, fall within the area here under discussion they will be briefly described. Quail Creek, a tributary of Troublesome Creek, is the only stream which has produced gold in any considerable quantity in this region. Placer gold has, however, been found on Troublesome Creek itself and on some of its other tributaries. There has also been considerable prospecting in the headwater region of Hutlinana Creek, whose basin lies adjacent to and southwest of that of Troublesome Creek. This region is one of comparative ruggedness; its highest peak, Wolverine Mountain, stands at an altitude of 4,600 feet, below which are interstream ridges and spurs with an altitude of 3,000 to 4,000 feet and valley bottoms with an altitude of about 2,000 feet above the sea. Most of the valley walls rise steeply from comparatively narrow flood plains.

The country rock is chiefly graywacke and slate of the Tatalina group, with some narrow belts of the younger Devonian limestone. Forming part of the summit of Wolverine Mountain is a granite mass intruded in a small area of Cretaceous sediments. To the east of Troublesome Creek are the rugged Sawtooth Mountains, 4,800 feet in height, whose summits also are formed in part of intrusive granite. The alluvium includes the gravels of the present stream and also some terrace deposits which occur in the upper Troublesome Creek basin.

Quail Creek, which was staked in 1898 but on which no productive work was done until 1904, heads opposite Hoosier Creek, a tributary of Minook Creek, and flows eastward a distance of about 5 miles to Troublesome Creek. A large branch of this creek, known as South Fork, joins Quail Creek about a mile above Troublesome Creek. Between the two branches is a gravel-covered bench about 400 feet high, upon which colors of gold have been found. Remnants of a corresponding bench have been found upstream on Quail Creek. Another gravel terrace occurs on the north side of Quail Creek about 50 feet above the stream, and this, too, carries some fine gold. A prospect hole to bedrock on this bench showed 10 feet of gravel covered by 19 feet of muck.

Some mineralized dikes have been found cutting the sediments on the lower part of Quail Creek. One of these was assayed and was found to carry no gold but 52 ounces of silver.

So far as known the gravels on Quail Creek are shallow, 8 feet being the maximum thickness recorded. It is reported that the gold is rather evenly distributed along the creek, but that the total auriferous content is in most places not great enough to warrant mining by manual methods. Nevertheless, some gold has been recovered from about half a dozen claims. Operations were particularly successful in 1910, and the creek may yet become a regular producer of placer gold.

WATER SUPPLY.[1]

Troublesome Creek rises southeast of Wolverine Mountain, between the headwaters of Hutlinana Creek and the West Fork of Tolovana River, and flows northeastward for about 40 miles, entering Hess Creek 10 miles from the Yukon.

No study of this creek was made below the mouth of Quail Creek, but it is said to follow a winding course, meandering from one side of the valley to the other through soft, mucky soil abounding with "niggerheads" and a thick growth of small trees, which make travel slow and tedious. It also has steep, high slopes, which make it very difficult of approach.

The main and tributary valleys at the head are almost canyon-like in appearance, being shut in by rocky, barren ridges, which are high and precipitous.

Troublesome Creek seems to be the only one near enough to the Rampart mines with sufficient run-off and gradient to be worthy of consideration as a possible water supply for the development of hydroelectric power to be transmitted to that region. The approximate grade of the stream below the mouth of Quail Creek averages 45 feet to the mile, ranging from 150 feet at the upper limit to 18 feet at the mouth.

About 7 miles from the head Troublesome Creek receives Quail Creek, its first important tributary. Quail Creek heads opposite Hoosier Creek and flows eastward, draining the north slope of Wolverine Mountain. It is about 5 miles long and drains an area of 20.6 square miles. The south slope of its basin is rocky and barren, rising precipitously to the summit of Wolverine Mountain. On the north the valley has a very gentle approach and is covered with a heavy growth of wild grass, which furnishes excellent forage for pack animals. The stream is lined with a dense growth of willows in the upper portion, and near the mouth is a growth of spruce suitable for cabin and fuel purposes.

The South Fork joins Quail Creek about a mile above Troublesome Creek and is its largest tributary.

[1] Ellsworth, C. E., Water supply of the Yukon-Tanana region, 1909: Bull. U. S. Geol. Survey No. 442, 1910, pp. 275–276.

Daily discharge, in second-feet, of Troublesome Creek and tributaries, 1909.

Day.	Troublesome Creek below Quail Creek[a] (drainage area, 43.2 square miles).				Quail Creek at claim "No. 7 above"[b] (drainage area, 8.5 square miles).				Quail Creek at claim "No. 9 below" (drainage area, 20.2 square miles).			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	......	32	158	22	......	16.0	5.0	3.5	......	20	37	21
2	......	40	153	20.0	......	17.0	13.5	3.0	......	21	84	18.3
3	......	58	132	17.0	......	24	15.0	2.0	......	31	88	8.4
4	......	48	191	15.0	......	24	50	1.7	......	32	147	7.8
5	252	34	600	13.0	103	18.0	152	1.6	......	24	323	7.3
6	250	28	271	12.2	96	15.0	74	1.6	......	2.0	151	7.1
7	248	100	139	11.8	88	28	50	......	128	36	94	7.1
8	276	83	167	11.4	82	29	40	......	134	38	88	6.8
9	246	83	573	11.4	74	24	188	......	120	30	394	6.8
10	115	60	325	11.0	66	21	43	......	74	26	151	6.5
11	110	73	225	10.6	63	13.5	24	......	71	36	113	6.2
12	325	58	167	10.6	61	11.0	25	......	118	34	80	5.8
13	276	38	97	......	58	8.5	26	......	132	25	60	......
14	240	28	73	......	56	6.5	27	......	104	19.5	44	......
15	276	24	63	......	54	6.0	28	......	128	18.3	39	......
16	300	20	48	......	52	5.0	28	......	94	13.5	33	......
17	305	40	60	......	50	5.0	22	......	120	12.7	33	......
18	290	60	63	......	48	9.0	16.0	......	116	28	33	......
19	270	44	56	......	46	8.0	10.0	......	96	28	30	......
20	255	28	48	......	43	6.0	5.9	......	116	21	26	......
21	220	22	46	......	37	4.0	5.1	......	100	13.1	26	......
22	218	18.6	44	......	40	3.5	4.4	......	109	11.9	24	......
23	300	394	36	......	77	161	3.7	......	137	179	18.9	......
24	524	238	28	......	188	43	3.2	......	238	108	17.1	......
25	438	63	25	......	150	10.0	2.6	......	199	37	15.3	......
26	260	63	23	......	76	10.0	2.1	......	118	37	14.1	......
27	250	70	22	......	72	12.6	2.0	......	113	47	12.7	......
28	95	97	20	......	36	20	1.8	......	43	69	11.1	......
29	68	88	17.2	......	33	14.0	1.7	......	31	44	9.5	......
30	66	80	16.5	......	30	9.0	1.7	......	30	74	9.5	......
31	......	163	15.8	......	......	7.0	1.7	......	......	52	9.5	......
Mean	249	73	126	13.8	68	19.0	28	2.2	111	38	71	9.1
Mean per square mile	5.76	1.69	2.92	.32	8.00	2.24	3.29	.26	5.50	1.88	3.51	.45
Run-off, depth in inches	5.57	1.95	3.37	.14	7.74	2.58	3.79	.06	4.91	2.17	4.05	.21

[a] These values are only approximate because of insufficient measurements and shifting channel.
[b] These values are based on gage readings taken about every four days.

Miscellaneous measurements in Troublesome Creek drainage basin, 1909.

Date.	Stream and locality.	Drainage area.	Dis-charge.	Discharge per square mile.
		Sq. mi.	*Sec.-ft.*	*Sec.-ft.*
September 6	Troublesome Creek above Quail Creek	21.4	6.8	0.32
July 27	South Fork of Quail Creek at mouth	3.7	9.6	2.59
Do	Nugget Gulch at mouth	2.7	2.7	1.00

GOLD IN THE UPPER CHATANIKA RIVER, BEAVER CREEK, AND PREACHER CREEK REGION.

By L. M. Prindle.

GOLD PLACERS.

An ill-defined region in the northeastern part of the Fairbanks quadrangle, in which some placer gold has been found, is drained by the Chatanika, flowing southwest; by tributaries of Preacher Creek, flowing northeast; and by Beaver Creek, flowing southwest. The region is one of rather strong relief, the general upland surface standing nearly 4,000 feet above sea level, with some masses rising to over 5,000 feet and the larger valley floors sinking to about 2,000 feet. The valleys are steep-walled and all except the larger streams have only narrow alluvial floors. Schists of several types, but predominantly quartz-mica schist, form the major part of the country, but some large intrusive stocks also appear. The Birch Creek schist is closely folded and the beds are generally veined with quartz. Some of the quartz veins carry metals and a few have been staked as auriferous lodes. The placer gold has probably been derived from these lodes, but it remains to be determined whether any of them are of economic value.

Faith, Hope, and Charity creeks were staked for placer gold many years ago, and since 1907 some work has also been done on Bachelor Creek and on several tributaries of Beaver Creek. Up to the present no high values have been found in the placers, though some gold has been produced. The geologic conditions seem favorable to the occurrence of gold placers in this region and further prospecting is certainly justified.

Bachelor Creek.—In 1909 work was being done on Bachelor Creek,[1] a tributary of Preacher Creek, where plans were under way for working ground by the hydraulic method. A ditch was being constructed and part of the equipment was already on the ground. The bedrock at this locality is principally schist, including quartz-mica, quartzitic, and carbonaceous schists. An intrusive mass of granite porphyry 75 feet thick was observed traversing the schist in a direction parallel to its structure (N. 60° E.), and the same kind of rock occurs on the west slope and also at the head of the valley. The gravels are composed predominantly of schist, with a considerable proportion of vein quartz and some granite porphyry. They are reported to average 7 to 8 feet in thickness and to be unfrozen in the bed of the stream. Bench gravels about 20 feet thick lie on a low bench on the east side of the valley.

In 1910 the only mining done in the Preacher Creek drainage basin[2] consisted of installing and operating an automatic dam on

[1] Prindle, L. M., Bull. U. S. Geol. Survey No. 442, 1911, pp. 208–209.

[2] Ellsworth, C. E., and Parker, G. L., Bull. U. S. Geol. Survey No. 480, 1911, pp. 164–165.

Bachelor Creek just below Costa Fork in the later part of the season. The scheme to work the Bachelor Creek gravels by the use of hydraulic lifts, which led to expending considerable money in partly constructing a ditch in 1909, has apparently been abandoned. It is reported that large bodies of low-grade gravel exist in the Preacher Creek valley below the mouth of Bachelor Creek, which could be conveniently worked by some system of hydraulicking. A low-water measurement of 45 second-feet (1,800 miner's inches) above the mouth of Bachelor Creek seems to indicate that there is sufficient water for this purpose.

Homestake Creek.[1]—The shallow gravels of the tributaries at the head of Chatanika River are suited to the method of hydraulicking in vogue in the Circle district. The small hydraulic plant installed on Homestake Creek in 1910 was in readiness for "piping in" early in July, and a good showing was made, considering the drawback that was experienced through low water. The water was diverted from Homestake Creek near its head and conducted by ditch and hydraulic pipe for about 3 miles along the right side of the creek to a point near the mouth, where mining operations were begun. The head attained is 160 feet and the depth of gravel to be worked averages about 8 feet.

Ophir Creek.[2]—During May, 1910, some good values were found on Ophir Creek, a tributary to Nome Creek, which resulted in starting a small stampede about the middle of July. All of the ground in the Nome and Trail Creek drainage basins was staked, as well as that on several other creeks near by. Systematic prospecting followed in the wake of the stampede, and if reports are to be relied upon pay streaks have been located on Nome Creek above Ophir and on Ophir Creek near its mouth. Bedrock drains were being established on upper Nome Creek during the summer by an outfit which proposes to operate a bottomless steam scraper next season. The ground is all shallow, averaging about 15 feet deep, with 2 to 4 feet of pay gravel, so that open-cut methods will no doubt prove to be the cheapest means of recovering the gold. Ophir Creek, which flows into Nome Creek about 2 miles from its mouth, was the scene of the liveliest excitement during the stampede. On Discovery claim a 50-foot crosscut was run to determine the width of the pay streak, and it is stated that this was traced for a length of five claims before the close of the open season. The gravel carries coarse gold valued at about $17 an ounce and is reported to run from $1.25 to $1.75 to the square foot. The largest nugget found was valued at $4.30. Some very encouraging deposits were found on Trail Creek, which heads opposite Poker Creek, flows for about 15 miles in a northeasterly direction,

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[1] Ellsworth, C. E., and Parker, G. L., op. cit., p. 157.
[2] Idem, p. 165.

and joins Beaver Creek about 6 miles below Nome Creek. Prospects were also found on several newly named creeks, such as Dominion Creek, Gold Mountain Creek, and Hoosier Creek, the location of which was not learned by the writers.

Much complaint was made about the laws that make it possible for one man, with a power of attorney from others, to stake association claims. It is said that 12 miles of creek was staked by one man in this manner.

WATER SUPPLY.

The following data on the water supply of the Preacher Creek basin in 1910 are extracted from a report by Ellsworth and Parker:[1]

Preacher Creek rises near the headwaters of Chatanika River and Beaver Creek and flows generally northeastward for about 65 miles, entering Birch Creek about 50 miles from the Yukon. It drains an area of 1,090 square miles, ranging in elevation from over 5,000 feet at the head to about 700 feet at the Birch Creek flats.

The main tributaries are the North Fork from the north and Loper and Rock creeks from the south. Bachelor Creek is a small but economically important branch from the south near the head.

Daily discharge, in second-feet, of Bachelor Creek below Costa Fork for 1910.[2]

[Drainage area, 11.4 square miles.]

July 11	6.6	July 18	8.5	July 28	7.1
July 12	6.4	July 19	8.2	July 29	7.0
July 13	5.9	July 20	7.8	July 30	8.5
July 14	5.3	July 21	7.6		
July 15	5.2	July 25	8.1	Mean	6.93
July 16	5.0	July 26	7.6		
July 17	5.6	July 27	7.4		

Miscellaneous measurements in Preacher Creek drainage basin in 1910.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
July 29	Preacher Creek above Bachelor Creek	94.7	45	0.48
Do	Bachelor Creek at mouth	26.4	7.6	29
July 11	Costa Fork at mouth	4.5	2.1	.47

COAL.

By L. M. PRINDLE.

The most extensive coal deposits of the Fairbanks quadrangle are those of the Nenana field, the nearest part of which lies 50 to 60 miles south of the town of Fairbanks. These deposits, which include

[1] Ellsworth, C. E., and Parker, G. L., op. cit., p. 201.

[2] The discharges are only approximate on account of shifting channel.

good grades of lignitic coal in beds of from 3 to 25 feet thick, are very extensive but lie outside of the Fairbanks district.[1] They may, however, be eventually drawn on to furnish power for the Fairbanks and other mining districts.

Coal has been reported on lower Salchaket River, but the locality of its occurrence has not been visited by any Survey geologist. It is not impossible that a part of the Tanana lowland may be underlain by lignitic coal-bearing rocks, but the depth of the alluvial valley filling is unknown and the coal beds, if present, may be so far below the surface as to have no value for mining.

The only coal mining which has been carried on within the quadrangle is in an area of 2 to 3 square miles lying on the west bank of the Yukon opposite the mouth of Hess Creek. The country rocks are steeply dipping sandstones (Eocene?) with some conglomerate and shale, aggregating some 5,000 feet in thickness.[2] According to Collier there are probably seven coal beds at this locality distributed through a thousand feet of sediment. The only opening is on two beds aggregating 38 inches of clear coal in about 19 feet of coaly material.

Analyses by E. T. Allen of the Geological Survey of samples of clear coal from each of these two beds are as follows:[3]

Analysis of coal (No. 137) from 13-inch seam, Drew mine.

Water	9.58
Volatile combustible matter	36.87
Fixed carbon	39.83
Ash	13.72
	100.00
Sulphur	0.33

Analysis of coal (No. 138) from upper (25-inch) seam, Drew mine.

Water	9.54
Volatile combustible matter	40.09
Fixed carbon	37.35
Ash	13.02
	100.00

The Drew coal mine at this locality was first opened in 1897 and has produced probably 1,500 tons of coal. For a time the coal was used by some of the river steamers, but the property has been closed for many years.

[1] Capps, S. R., The Bonnifield region: Bull. U. S. Geol. Survey No. 501, 1912, pp. 54–62.

[2] Collier, A. J., The coal resources of the Yukon, Alaska: Bull. U. S. Geol. Survey No. 218, 1903, pp. 37–41.

[3] Idem, p. 39.

LODE MINING NEAR FAIRBANKS.

By Philip S. Smith.

INTRODUCTION.

The inevitable depletion of easily mined placer deposits near Fairbanks and the consequent availability of both men and money for other enterprises has given an impetus to prospecting for lode deposits which has resulted in the opening of some productive mines. The writer visited the lode-mining district late in the open season of 1912 to study the conditions under which the veins occurred, and the results of that study are set forth in the accompanying report. Work in the field began September 7 and closed September 25, 1912. In spite of this short season the studies by Mr. Prindle and Mr. Katz furnished geologic data so complete that the investigations here recorded were devoted exclusively to mining developments.

The writer is under deep obligations to both Mr. Prindle and Mr. Katz not only for their published data but also for the assistance they have given by consultation and advice. Grateful appreciation of the many courtesies and privileges received in the field is expressed to the various mine owners, operators, and residents of the Fairbanks region. Although specific mention is necessarily incomplete, thanks are especially due J. L. Sales, of Fairbanks; the Cook brothers, of Too Much Gold Creek; the members of the Rexall Mining Co., of Wolf Creek; Nels Giske and the Quemboe brothers, of Chatham Creek; Allan Cunningham and Antone Goessmann, of Bedrock Creek; C. S. Sargent, of Willow Creek; Sterling, Zimmerman, and Nightingale, of Twin Creek; W. L. Spaulding, of Dome Creek; and W. C. Harp, the Hudson brothers, and Louis Sagan, of Ester Creek.

PRESENT CONDITION OF LODE MINING.

GENERAL FEATURES.

In the region adjacent to Fairbanks 2,000 lode claims have been recorded and of these probably 50 are being more or less extensively prospected. Practically all the veins that are being developed are free milling gold lodes, as deposits of this or other metals requiring metallurgical treatment for extraction can not be mined under existing conditions. Six of the properties have been developed to the producing stage and maintain their own mills. Six other mills are being constructed and should be in operation before the end of 1912, and still others are contemplated.

The six mills now in operation have a total of 24 stamps, of which 22 are of the Joshua Hendy type (fourteen 1,000-pound stamps; five 500-pound stamps, and three 250-pound stamps) and two are Nissen stamps of 1,300 pounds each. These stamps have an estimated crushing capacity of 1 to 5 tons of ore a day. Of the mills being built two are to be equipped with seven stamps of the Hendy pattern, three with six Nissen stamps, and one with a Little Giant crusher having an estimated capacity of 6 to 15 tons of ore a day. According to these estimates the mills should be capable of crushing about 100 tons of rock a day.

According to Brooks[1] about $64,100 was produced by the lode mines in 1911 and about $60,000 had been produced previously. No reliable statements of the gold production from the lodes in 1912 have been received, but it is estimated to have been about $200,000. The discrepancy between this estimate and the amount that should have been produced as indicated by the theoretical capacity of the mills and the assumed tenor of the ore is due to three main causes, namely, many of the mills were built during the year and therefore lost more or less time on that account; few of the mines have been opened up sufficiently to yield a constant supply of mill rock; and many of the mills have been compelled to close down during the winter on account of the cold.

The trouble with cold is serious and is felt most acutely in its effect on the water supply. It is relatively easy to keep a mill so warm that water will not freeze in the mortars or on the tables, but the cutting off of practically all sources of surface water during the six or seven winter months presents an almost insuperable difficulty. The larger streams, of course, afford ample water throughout the year, but these are at some distance from the mines and selection of a mill site on them involves additional charges for the transportation of ore. Attempts to gain a sufficient permanent water supply by boring holes a hundred or more feet in depth have so far met with indifferent success. At a few places seepage water pumped from the mine has been used at the mill, but the supply has not been adequate. In fact, one mill where this was tried was forced to abandon the experiment and was moved near to a creek at a considerable distance from the mine.

On the whole the camp has shown a rather healthy development, with less exaggeration and wildcatting than has been customary

[1] Brooks, A. H., The mining industry in 1911: Bull. U. S. Geol. Survey No. 520, 1912, p. 30.

elsewhere. Most of the veins have been and are being opened by local men and capital, and some of the most productive have been made to pay from the start. In general this quiet, relatively inexpensive exploitation of the lodes has been beneficial, but the camp has had the disadvantage that many of the operators are not lode miners and consequently have made mistakes that might have been avoided. The need of proficient engineers and miners is already felt by the more enterprising operators and will become more urgent as mining increases. As a result of the absence of skilled management none of the mines employ the careful methods of sampling, investigation of mining costs, scrutiny of geologic data, and precise measurements that are necessary to reduce mining from a speculative venture to a more or less exact business enterprise.

LODE MINES AND PROSPECTS.

GENERAL DISTRIBUTION.

During the six or more years that prospecting for quartz has been in progress in the region a great number of prospect holes have been sunk. Many of these, for one reason or another, have been abandoned and their traces are no longer recognizable. In places, however, information about some of this old work was obtained from people living in the neighborhood, and such of this as appears reliable has been presented in this report. In the following descriptions many details concerning small and nonproducing properties have been given because they afford information as to the geologic history, mode of occurrence, and distribution of the veins. These descriptions, therefore, should be regarded not only as records of facts but also as clues to the character of deposits not yet exploited.

All parts of the area have not been treated with equal completeness, and some small prospect holes that were actually examined are undoubtedly described more fully than possibly extensive prospects that have been abandoned. Although there are many reasons for a good prospect lying idle, on the whole, other things being equal, the fact that no work is in progress on a certain property indicates that it is not so important as one on which work is in progress. Therefore the map (Pl. XI, in pocket) indicates, by the distribution of the prospect and mine symbols, the most developed lode area. This map shows that most of the prospects occur near the head of Fairbanks Creek, on many of the headwater branches of Cleary Creek, at the head of Dome Creek, on Twin and Skoogy creeks, and in the vicinity of Ester Dome, in the extreme western part of the district. The prospects in each of these areas will be described in the order of their geographic positions in the minor basins. Mineralization has been found and prospecting carried on not only in these main areas, of stibnite forms a lens, in places over 3 inches thick, of well-crystallized stibnite, practically unmixed with other sulphides. At an elevation of 2,050 feet another vein, trending about N. 15 E. and dipping west, has been traced northward for a short distance, but its gold tenor was so low that work on it was abandoned.

The vein material from the southern lead is mainly a light-colored, glassy quartz, somewhat crushed, but showing in places druses into which well-formed crystals of quartz project. On exposed surfaces the quartz has a brown iron stain, but more commonly it is characterized by a greenish-yellow color, due to the decomposition of stibnite. Here and there sulphides and visible gold occur in the quartz, but the amount of sulphides is small, on the average being much less than 5 per cent of the vein material. Although stibnite is the most abundant of the sulphides recognized at this place, argentiferous galena occurs sparingly and also some arsenopyrite, pyrite, and sphalerite. In many specimens the stibnite near the surface has been altered into the antimony oxide, senarmontite. This mineral is particularly abundant in the spaces between the quartz grains.

The gold appears to be entirely native but occurs in two main modes. In one it is closely associated with the sulphides and appears to have been essentially contemporaneous with their deposition; in the other it does not seem to have been formed with the sulphides but occurs instead in the midst of the earlier-formed quartz. Even in specimens of quartz containing no gold that is visible to the unaided eye and no sulphides, small colors of gold may be found by panning the finely crushed vein material. Although the gold content of some of the surficial portions of the veins may have been increased by secondary enrichment, the larger part of the auriferous content is probably original and is an integral part of the vein. These veins have not been accurately sampled, and estimates of the tenor of material carrying so much free gold are of little value. The ore, however, is reported to contain from $50 to $75 a ton in gold.

Surface prospecting has been the only work yet done on the property, but the owners propose driving an adit northwestward from a point near the vein outcrop on Moose Creek. As the valley walls are rather steep, a considerable back of ore would be obtained above the adit level; thus in a horizontal distance of 1,000 feet the back would be nearly 300 feet.

About 200 yards above the Crites and Feldman cabin two shallow prospect pits have been sunk by another prospector. The schist exposed in these pits is heavily iron-stained, but in the lower hole no distinct vein was disclosed. In the upper hole, however, some quartz in irregular stringers was found, and a good deal of arsenical pyrites mineralized not only the quartz but also the adjacent schist.

This material is said to yield gold on panning, but none was visible in the hand specimens examined. No ore from this property had been milled.

TOO MUCH GOLD CREEK.

At the head of Too Much Gold Creek, at an elevation of about 2,225 feet (see fig. 15, p. 157), Nars, Anderson & Gibbs have done considerable development work on a vein that appears to be the same as or parallel to that of Crites and Feldman, on Moose Creek. The main vein has been traced by surface pits eastward to the limits of the claims. A smaller vein parallel to the main lead has been found, but has not been so fully opened up. The main vein is from 6 inches to 2 feet wide, though in a few places, owing to mineralization of the wall rock, a width of probably as much as 6 feet can be profitably mined. The dip of the vein at the surface is about 65° N., but it is said to steepen in depth.

The ore is essentially the same as that of the Crites and Feldman veins, already described, but contains somewhat less stibnite. The contact of the vein with the country rock on the hanging wall is marked by a smooth fault plane. Where the vein and country rock come to this plane their surfaces are strongly slickensided and polished. Some of the sulphide mineralization was earlier than this faulting, for the sulphides have been spread out and striated by the movement. On the footwall the vein, in its surficial portion, is frozen to the country rock, and although the junction between the two is rather sharp, there is an intermingling of the ore and schist that differs notably from the abrupt transition on the hanging wall. The air in the shaft was too bad to permit the vein to be examined in depth, but the operators report that at 80 feet below the surface the footwall becomes smoother and the ore breaks away from the country rock better, which suggests that at depth the footwall may also mark a plane of movement.

The main underground development at this place has been the sinking of a 100-foot incline on the vein, from which short drifts, 15 and 25 feet, respectively, have been turned off at the 60-foot level. There has been no trouble with water, but the air has been so bad, possibly from the arsenical iron in the ore, that further sinking was abandoned until artificial ventilation could be provided. A small hoist and boiler have been installed at the shaft, and the owners plan to continue mining during the winter of 1912–13. Several mill tests of the ore made at Fairbanks are said to have yielded returns of about $60 a ton. Two and one-half tons were milled in the winter of 1911 and 4 tons in the spring of 1912, and about 2½ tons are sacked on the dump, ready for treatment.

On the ridge between Too Much Gold and Moose creeks, below the veins already described, there are several other prospect pits. At an elevation of 1,850 feet at a place nearly due north of the junction of the creek with Fairbanks Creek, on the Governor claim, a 70-foot shaft had been sunk on a vein trending N. 80° W. and dipping nearly vertical. The ore in general appeared similar to that from the veins already described, but in addition included a light-colored fine-grained rock, probably a fine-grained granite, that is said to carry from $10 to $15 a ton in gold. This rock contains many small vugs, which appear to have been formed by the leaching out of sulphides. Much of the ore has been strongly slickensided. At this shaft there is no permanent equipment, and no work has been done for some time.

At a point east of the Governor claim, at an elevation of about 1,600 feet, a ledge which may be the continuation of the Governor lead was reported to have been found, but at the time of the writer's visit it had not been opened up enough to allow adequate examination.

At an elevation of 25 feet above Cook's cabin, east of Too Much Gold Creek, some ore has been taken from a pit 18 feet deep. At the time of the writer's visit about half a ton of this ore had been sacked and was on the dump awaiting treatment. In the footwall at this place is a much-brecciated mass of rock of unknown extent, cemented together by iron, stibnite, and galena. This mineralized mass is believed to be entirely distinct from and younger than the auriferous vein near by, for it apparently contains fragments of the vein. The brecciation and mineralization at this place may have been produced by igneous intrusion, for an open cut at an elevation of 25 to 50 feet above the pit where this rock occurs contains float of a white porphyritic granite. So far as determined, however, the granite is not noticeably mineralized. The hill slopes near this place are too much covered with talus and turf to permit a determination of the direction or extent of the granite, but the men who have done most of the prospecting say that they have found several dikes here, one as much as 70 feet wide, which are more or less parallel with the larger quartz leads.

West of Too Much Gold Creek several claims have been prospected. (See fig. 15, p. 157.) On the Plumbum claim, which is the nearest to Fairbanks Creek, a quartz vein ranging in width from 3 inches to 2 feet has been exposed in a test pit 15 feet deep. The country rock is schist, striking nearly east and west, and dipping south at a low angle. The vein has nearly the same trend as the schist, but its dip is much steeper. The schist carries, in addition to the vein, which sharply cuts it, numerous quartz lenses, which are entirely distinct from the vein and are cut by it. The vein is composed mainly of a brownish-white, somewhat crushed quartz showing a few open spaces, practically barren of sulphides, and heavily iron stained on its upper surface. Some highly crystalline parts of the vein may, however, have been formed by later fracturing and infiltration. The well-formed quartz crystals in these crystalline parts are generally coated with iron oxide, which may have been derived from the decomposition of sulphides that were originally present in this more porous portion.

The westward continuation of this lead has been sought by sinking prospect holes along the ridge. Quartz veins have been exposed in many of these holes, so that the same or parallel leads have been found nearly to the limits of the claim. Several nearly vertical faults parallel to the vein were found in these pits, but the amount of displacement to which they gave rise was apparently slight. Faults transverse to the vein were not observed, but the failure to note them was due probably to the small extent of rock exposed, as the alignment of the pits suggests that the vein is not continuous. No production has been made from this claim, but about 1½ tons of ore are sacked on the dump awaiting shipment.

Farther up Too Much Gold Creek, on the Excelsior claim, at an elevation of about 1,625 feet, near the stream, two adits have been driven westward. The southern adit follows a small seam that dips steeply south. At a distance of 60 feet from the mouth of this adit a short drift has been turned off to the south on a small stringer that trends nearly north and south. The country rock is hard quartzitic schist that dips at a much lower angle than the vein. Near the mouth of the northern adit the same kind of schist occurs, but farther in the adit it is succeeded by soft black shiny graphitic schist which in places is said to yield high silver assays. Specimens of this ore examined in the laboratory showed a small amount of sulphides—galena, arsenopyrite, and stibnite—but the material does not appear to be much mineralized. This adit is about 60 feet long.

Near the Excelsior adit is an exposure of a light-gray fine-grained granitic rock containing small, irregularly distributed cavities surrounded by limonitic rings. This rock is considerably iron stained on its exposed surfaces but contains no visible metallic minerals. It has a fine-grained groundmass, mainly quartz and feldspar, through which quartz phenocrysts are scattered. This rock and the veins prospected on the Excelsior claim lie so close together at the surface as to suggest that they are genetically related, but the surface exposures are so small that such a relation can not be determined.

On the hillside above the Excelsior adit numerous pits have been sunk on a vein called the "cross vein," which trends about N. 30° E. and dips southeast at a high angle. Most of the pits have caved to such an extent that the character and width of the vein is not determinable. On the whole, however, this vein appears wider than the east-west veins already described and contains rather more sulphides. These veins are currently reported to carry considerable silver, but specimens collected by the writer have not yielded any of this metal. The dark mineral probably confused with silver is, in every specimen so far examined, galena, stibnite, or arsenopyrite.

The N. 30° E. vein just described intersects an east-west vein which has been opened up on the Mizpah claim on the ridge between Fairbanks and Too Much Gold creeks, at an elevation of about 1,700 feet. The contact between the two was not well exposed, but prospectors report that the two merged—that one did not cut the other.

WEST OF TOO MUCH GOLD CREEK.

The Mizpah vein, staked in 1910, is north of Fairbanks Creek about half a mile west of the mouth of Too Much Gold Creek, at an elevation of 1,800 feet. The vein strikes about east-west and dips more than 75° south. It has been developed by a shaft 120 feet deep, from which drifts have been turned off both to the east and to the west at the 80-foot level. No difficulty with water has yet been experienced. In the western drift numerous well-defined stringers composed mainly of quartz, with subordinate amounts of sulphides, carry free gold, apparently as an original constituent. The quartz has a sliced appearance, as if the vein had been subjected to considerable movement. In the eastern drift the vein made a slight roll, so that for a while it appeared faulted, but further work showed that it persisted in the hanging wall. On the foot-wall a gouge a few inches thick, said to prospect well, probably marks a zone of movement.

The minable rock at the Mizpah claim ranges in thickness from 12 inches to 3 feet, the average being about 2 feet. A test of about 3 tons of ore at the Fairbanks mill is reported to have given a return of $92 a ton. This, without doubt, was selected material, so the test only shows that some of the ore is of high tenor. Little work is now in progress at the property. Plans are said to be under way for building a mill, but it will probably not be constructed until the mine is further opened, and this delay is advisable not only to determine whether a mill is warranted but also to provide a sufficient reserve to keep it running.

Between the Mizpah shaft and Too Much Gold Creek are the Ohio and Mayflower claims of Connors & Stevens. The upper shaft, at an elevation of about 1,900 feet, is said to have been sunk about 45 feet. It opens up a vein that trends about northeast-southwest. The shaft was not accessible at the time of the writer's visit, but the country rock on opposite sides of the vein is reported to be dissimilar, which suggests that the vein occupies a fault plane. Specimens of the ore on the dump contain a large quantity of sulphides, notably galena and stibnite, associated with quartz. The quartz is sheared and many of the shearing planes exhibit sulphides or their oxidation products. In addition some quartz was apparently deposited contemporaneously with the sulphides and forms long hexagonal crystals in the midst of the galena.

The southern shaft on the Connors & Stevens property is near the road, at an elevation of about 1,675 feet. At this place there are two veins which are about 4 feet apart at the surface but more than 15 feet apart at the bottom of the shaft. The veins strike about northwest-southeast, but their direction is locally variable. The walls show strong slickensiding with striæ running practically vertical and the southern block relatively downthrown. The ore on the footwall merges into the schist, but that on the hanging wall abuts directly against the fault plane. No adequate measurement of the amount of displacement was obtained. About 15 feet above the bottom of the shaft a winze has been sunk to the northeast, at a low angle, on a stringer of ore which has been traced about 25 feet.

The tenor of the ore has not been tested by mill runs, and the few assays that have been made show a variation so great that they are of no service in estimating the average of the mine. The owners believe that the average value of the ore is at least $50 a ton, mostly gold, but partly silver.

On Fairbanks Creek, just below Connors & Stevens's prospect, is a short tunnel trending about north and south. At its mouth is a small amount of mineralized quartz, and beyond is graphitic quartzose schist which dips northward at a low angle. The schist is reported to have yielded 60 ounces of silver and $4 in gold to the ton, but no indications of a silver-bearing mineral were seen. The quartz stringers are said to carry about $4 a ton in gold and no silver, but this tenor is too low for profitable mining.

A short distance upstream from this tunnel is another, driven by M. A. Schaefer, about 150 feet long, trending N. 5° E. In the breast is a rather flat-lying quartz stringer. Its position is unusual, for in general the veins are steep and the country rock is fairly flat, whereas at this place the situation is exactly the reverse. The tunnel is so near the surface, even at its inner end, that the rock is greatly decomposed and strongly iron stained. No production has been made from this property and no reliable estimate has been made of the tenor of the ore.

Half a mile above M. A. Schaefer's, on Fairbanks Creek, is Kellen's property, which has been prospected by a shaft and tunnel. The tunnel has been driven 80 feet northward on blocky schistose quartzite that dips south at an angle of 60°. Some quartz stringers said to carry gold were intersected by the tunnel, but they are too small to be mined independently and their tenor is too low to permit much country rock to be mined with them. A reddish iron-stained seam at the face of the tunnel dips steeply to the north and suggests that the vein is near, but does not seem to be the lead encountered in the shaft above. The shaft was sunk just above the north end of the tunnel and uncovered a narrow lead of crushed and recemented quartz having somewhat the texture of a quartzite. Long cavities in the vein appear to have been formed by the leaching out of a striated bladed mineral, such as stibnite. Stibnite in irregular patches is fairly common throughout the quartz and shows the usual oxidation stages to senarmontite or has even been completely removed, if the cavities noted above were really formed by the leaching out of this mineral. No ore has been produced at this property and work has been carried on only at intervals.

At the extreme head of Fairbanks Creek are a number of leads, and the ground has been blanketed by rival claimants and tied up with lawsuits. In consequence the ownership of the several properties is uncertain, and until the courts act many of the claims have two or more names. Without expressing any opinion on the issues raised by the litigation, certain claim names have been adopted here solely for convenience in description.

Between the road and the head of Fairbanks Creek, at an elevation of 2,150 feet, is "El Toro 3" claim. It has been developed by a 65-foot inclined shaft sunk on the vein. Near the surface the dip of the vein is 72°, but lower down it flattens to 51°, and continues on this slope to the bottom of the shaft. The vein matter consists almost entirely of hard, rather glassy quartz, with a small amount of stibnite. The quartz is said to carry native gold, which is practically invisible until the ore is crushed and panned. No production has been made from this claim.

North of "El Toro 3," tending nearly east and west, five claims, named in order, from west to east, the War Eagle, the Leroy, the Pioneer, the Iron Mask, and the Black Warrior, extend between the road and the top of the ridge. The veins found on these claims have not yet been traced accurately, but they are all essentially contemporaneous and form a parallel series, having a nearly east-west strike and a dip of over 45° to the south. In physical appearance the vein matter from the different leads is practically indistinguishable, and, so far as determined, the gold tenor does not vary more in the different veins than it does in different parts of a single vein.

On the westernmost claim two leads have been found in five or six pits from 8 to 10 feet deep. The veins are 1 to 2 feet wide, and many pieces of the ore show free gold. On the next claim east two shafts have been sunk on a vein believed to be the continuation of one of the veins on the western claim. At this place the vein is about a foot wide. Little development work has been done on this lead.

Still farther east, on the Pioneer, the most extensive work on this group of claims has been done. Here a shaft 110 feet deep was sunk and the vein was drifted on both east and west for about 200 feet. East of the main shaft another, 75 feet deep, was put down and 50 feet of drift was driven eastward. About 75 feet east of this last shaft another, 38 feet deep, has been sunk. Still farther east pits 10 to 15 feet deep have been put down at intervals of 25 to 50 feet, and a lode has been uncovered. The vein is reported to have been proved in this manner for 800 feet, in which distance it shows an average width of about 18 inches. Gouge from 6 inches to a foot thick occurs on both walls.

A lode 3 feet wide has ben uncovered just east of the Pioneer, and is now being developed on a lease. On the hanging wall of the vein at this place is a white, thoroughly decomposed rock which appears originally to have been a fine-grained granular intrusive, but which is now a gritty gray mass of kaolin and quartz, the quartz occurring as irregular small particles in a groundmass of kaolin and finely crushed quartz. The underground workings at this place were inaccessible at the time of the writer's visit, owing to a cave-in, but this decomposed material is said to give place in depth to quartz-carrying gold, a condition that seems doubtful, as a faulted relation between the two is more probable.

Still farther east, on the last claim of this group, a vein is said to have been traced for 400 to 500 feet by test pits, 12 to 15 feet deep, sunk at intervals of about 50 feet. On this claim the vein averages from 8 to 10 inches in width.

In 1912 none of these properties were producing ore, but according to Angus McDougall, one of the owners, 107 tons have been mined and milled, mainly from the Pioneer property. Of this amount 22 tons is said to have yielded a return of $172 in gold to the ton, not including concentrates, and the rest carried from $125 to $150 a ton, also not including the concentrates. About 65 tons of ore are sacked on the dumps awaiting treatment. The owners estimate that this lot will yield about $65 in gold a ton. According to Frank W. Hawkins, formerly assayer for the Washington-Alaska Bank, the average fineness of the gold bullion so far received from this mine is 0.814½. All the ore has been milled at the Fairbanks custom mills, but the erection of a mill near the mine is contemplated.

PEARL CREEK VALLEY.

In the vicinity of the large mass of pegmatitic granite in the central part of the Pearl Creek valley many claims have been located by Michael Stepovitch and others, but the region has not been visited recently by members of the Survey, and no information concerning the results of the prospecting is available.

On the Smallwood-Pearl Creek divide Murphy and Perrault are reported to have been prospecting a vein on the American claim. A 50-foot shaft, the upper 8 feet of which was in talus, was sunk on this claim, and a vein from 18 inches to 4 feet in width, averaging 2 feet, is said to have been found. Several tons of ore were hauled to Fairbanks, and it is said yielded about $24 a ton in gold. On the adjoining claim to the south, the American Eagle claim, owned by the same men, is another vein, which the owners claim averages about 18 inches in width, and has a gold tenor of about $25 a ton. This vein has been opened up by a shaft 38 feet deep. According to report a dike cuts the lead, but its character was not learned, though the dike rock is said to have a gold content worth $15 a ton. Twenty tons of ore had been mined and was on the dump awaiting shipment in 1912.

TRIBUTARIES OF CHATANIKA RIVER.

WOLF CREEK VALLEY.

PENNSYLVANIA MINE AND VICINITY.

North of the War Eagle–Black Warrior group of claims, on the Wolf Creek side of the divide, are several other claims, on one of which, the Pennsylvania, at an elevation of 2,100 feet, the most development work has been done. The strike of the main vein on this property is N. 76° W. and the dip is 56° S. Gouge 3 to 4 inches wide occurs on the hanging wall and the striæ on the slickensided surface dip at low angles on the plane of the hanging wall to the east. The ore is essentially similar to that at the other properties described. In some specimens taken near the surface the gold occurs in cracks between fragments of fractured quartz in a yellowish decomposition product formed by the breaking down of an antimony mineral. In such occurrences the gold probably has been deposited later than the quartz and the vein secondarily enriched. This enriched zone, however, is reported not to extend more than a few feet below the surface. The width of the vein varies somewhat, but averages about a foot.

Underground developments at the Pennsylvania consist of a 92-foot shaft, from the 50-foot level of which drifts have been run east and west for 20 to 30 feet. In the western drift several upraises have been started, and one of these, near the end of the drift, connects with the surface, though, owing to surface caving, it does not afford a traversable passage. Little work was in progress at the time of the writer's visit, as the owners were awaiting the completion of the mill.

Several mill tests of selected ore from this mine, made at Fairbanks, yielded, it is said, very high returns. The owners, however, estimate that the average tenor of the ore is about $40. The ore will be milled in a Little Giant mill, which was being built on the south side of Fairbanks Creek, on the creek claim known as No. 17 above. (See fig. 15, p. 157.) A well-constructed road about half a mile long connects the mine and the mill, affording a down-hill haul for loaded teams. The ore will be dumped from the wagons into a bin at the mill, from which it passes over a grizzly and is fed by an automatic distributing device to the muller. The crushed material flows over plates below the mortar and is then carried through a launder to a Monarch table. The estimated capacity of the mill, as now constructed, is 8 to 20 tons of ore a day, but the building was planned so that, when necessary, two additional mullers could be installed without affecting the present equipment. The problem of obtaining sufficient water for the mill is believed to have been solved by damming Fairbanks Creek so as to form a small pond and by using seepage water. As the mill stands at an elevation of about 1,850 feet, the amount of water available is small and some doubt is felt as to its sufficiency during the winter. No special precautions have been taken to overcome the low winter temperature, with the exception of heating the mill by placing the boiler inside the mill building. The owners expect that this mode of construction will allow the mill to be run throughout the year.

Near the Pennsylvania claim, on the Wolf-Fairbanks Creek divide, are two other claims on which some work has been done. At the Dorothy claim, west of the Pennsylvania, a 95-foot shaft had been sunk on quartz stringers that appeared promising, but work had stopped and the shaft had caved and become inaccessible. Between the Dorothy and Pennsylvania is an abandoned tunnel, in which a quartz vein dipping steeply toward the south was found.

Prindle[1] notes:

> Near the head of Wolf Creek, on the Willie claim [see Pl. XXII], 4 to 5 feet of ferruginous quartz and mineralized schist have been exposed, from which gold can be panned. The strike is N. 50° E. and the dip 80° SE. It is reported that the deposit has been traced by float along this strike for about 1,000 feet.

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[1] Prindle, L. M., Auriferous quartz veins in the Fairbanks district: Bull. U. S. Geol. Survey No. 442, 1910, p. 227.

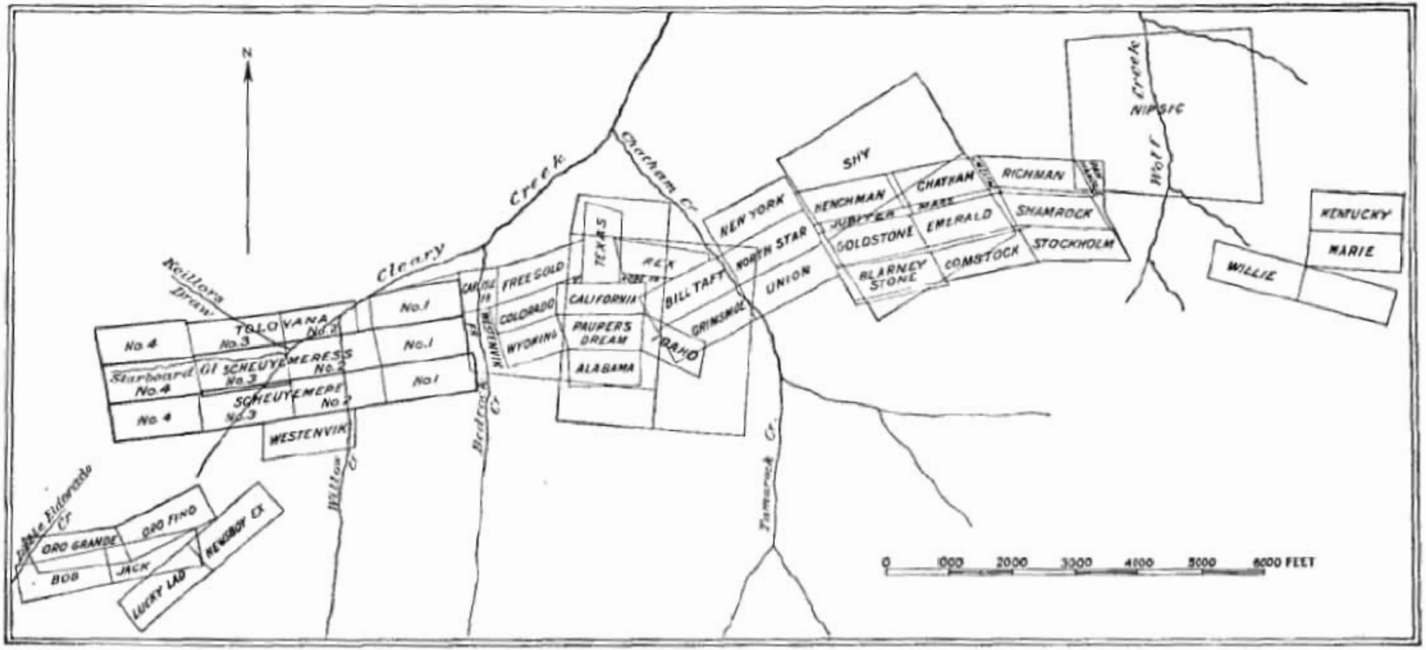
HOMESTAKE MINE.

At the head of Wolf Creek immediately south of the Nipsic claim (see Pl. XXII) the Homestake Mining Co. has been prospecting since 1908. In September, 1912, three men were at work on the property, which was being explored by means of a tunnel which at that time was over 650 feet long. At least five veins, which trend normal to the tunnel and which the tunnel is expected to intersect in depth, are known on the surface. These veins, like those on the Fairbanks-Wolf Creek divide, have a general east-west trend and dip southward at angles of 45° or more. Near the mouth of the tunnel is a small quartz stringer, which appears to dip steeply north, but this dip may be due to surface creep and may not be persistent in depth. A rich vein, on which 75 feet of drift to the east and 50 feet of drift to the west were driven, was found in the tunnel at a distance of about 320 feet from its mouth. This vein is from 3 inches to a foot wide and carries much gold, 1,300 pounds of selected ore yielding, as reported, $308 in free gold. In addition the concentrates are said to have contained considerable gold and silver. Their reported high content of silver is surprising, as no distinct silver mineral was recognized in the specimens collected by the writer. Sulphides of antimony, copper, and iron form a small amount of the vein matter, but galena was practically absent and no silver sulphide was detected. The quartz is rather crystalline, though shattered here and there with open spaces into which well-terminated quartz crystals extend.

Some water has been struck in driving the tunnel, but it seems to occur mainly along fracture zones. Except for the fact that the ground has not stood well near these fissures and the personal discomfort of working in the wet places, the water has caused little or no trouble, as it is carried away by the grade of the tunnel. When mining deeper than the tunnel level is attempted pumping may be necessary. By the time the main lead is reached, and drifts and stopes are turned off on the vein, sufficient information should be obtained to enable the owners to calculate closely the quantity of water to be handled, the cost of mining, and the tenor of the ore.

REXALL MINE.

A few hundred feet north of the Homestake Mining Co.'s tunnel is the Rexall claim (fig. 16), which was being actively worked by a crew of 5 to 10 men during 1912. This claim was staked in the summer of 1910 and more or less continuous work has been done on it ever since. Mining started on a large quartz vein, from 3 to 5 feet wide, trending N. 25° E. and dipping about 25° W. The vein mate-



LOCATION OF LODE CLAIMS IN UPPER PART OF CLEARY CREEK VALLEY.

From map by L. S. Robe, 1909.

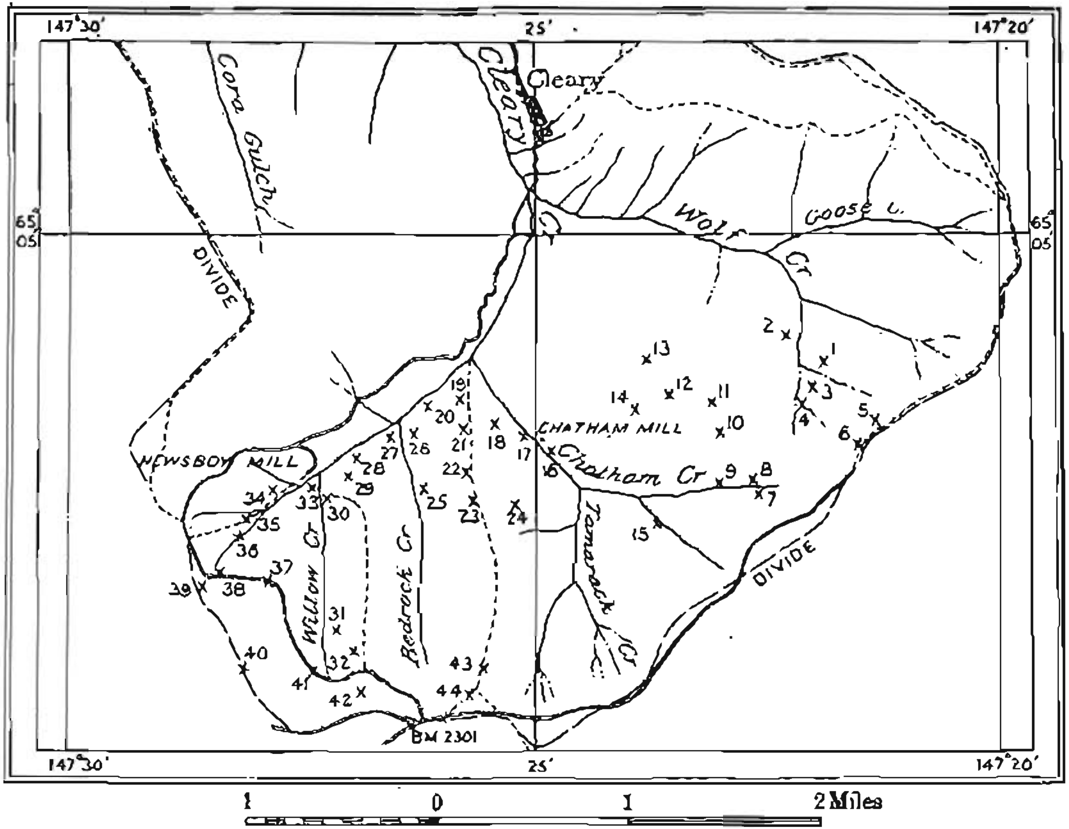


FIGURE 16.—Sketch map showing location of lode prospects in upper part of Cleary Creek valley.

1. Banner.
2. Solomon.
3. Rexall.
4. Homestake.
5. Pennsylvania.
6. Dorothy.
7–9. Chatham Mining Co.
10. Harris & Brown.
11. Quemboe Bros.
12. Furstenau.
13. Quemboe Bros.
14. Jupiter Mars.
15. Roughneck.
16. Pioneer.
17. Rex.
18. B.-P.
19. Cunningham.
20. Lyons.
21. California.
22. Pauper's Dream.
23. Alabama.
24. Bobbie.
25. Wyoming.
26. Rhoads-Hall.
27. Stepovitch.
28. Crosscut.
29. Tolovana Stibnite.
30. Tolovana.
31. Overgaard.
32. Emma.
33. Stibnite.
34. Scheuyemere.
35. Eldorado.
36. Stell.
37. ?
38. Newsboy Extension.
39. Newsboy.
40. ?
41. Cornell.
42. Cheyenne.
43, 44. Jackson.

rial consisted almost entirely of quartz, and its gold content is reported to be rather low. About 140 feet south of the mouth of the adit a small vein, trending nearly east and west and dipping 60° N., was struck and, being much the richer, was followed, work on the larger vein being temporarily abandoned. A winze was sunk to water level on the smaller vein.

Mining had so obscured the relations of the two veins that the contact could not be fully seen. The superintendent stated that the small vein was simply an offshoot from the large vein, an interpretation that seems questionable, for he also stated that the small vein offset against the large vein and that the large vein carried considerably higher values between the junction of the small veins. The condition is diagrammatically shown in figure 17, in which A and A′ are the offset small vein, and B and B′ the large vein, and the stippled area the richest portion of the veins. Such a condition suggests that AA′ had been faulted along a plane in general parallel to BB′ and that subsequent mineralization, by which the large vein BB′ was formed, took place along the fault. According to this interpretation the rich part of the vein between A and A′ may mark the dragged material formed by movement of the small vein on the old fault plane. A further bit of evidence suggesting that the smaller vein is older than the larger is the fact that the former is cut by faults, of small displacement, roughly parallel to the hypothetical fault, whereas the big vein, so far as traced, is not faulted.

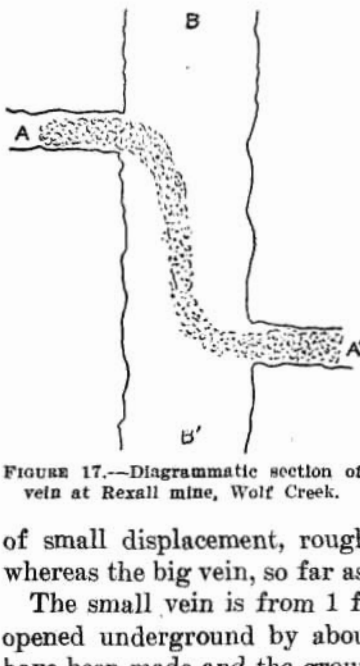


FIGURE 17.—Diagrammatic section of vein at Rexall mine, Wolf Creek.

The small vein is from 1 foot to 18 inches in width and has been opened underground by about 340 feet of drift. Several upraises have been made and the ground has been blocked out so that stoping can be begun when desired. The back of ore above the adit level in the present workings is estimated to be about 140 feet. Midway in the drift on the small vein a winze has been sunk to water level. At this place the vein is about 18 inches wide, and the hanging wall, which is much slickensided, carries 1 to 2 inches of gouge.

In addition to these two veins, small stringers of vein quartz that when panned yielded gold were discovered while excavations were being made for a mill site and a blacksmith's shop.

It is reported that 25 tons of ore from the small vein, milled at Fairbanks, yielded an average gold content of $112 a ton. It is also said that 10 tons of this ore yielded an average of $166 a ton, and that a 3-ton sample from the large vein gave a return of $37 in gold to the ton. All of these figures represent the values of the content of free gold, for the concentrates were not saved. A determination of the fineness of the gold from the Rexall, furnished by Frank W. Hawkins, of the Washington-Alaska Bank, gave 0.780½ and 0.785½, but the gold had not been thoroughly cleaned, so the true fineness is probably higher.

At the time of the writer's visit (September, 1912) the operators at the Rexall were preparing to build a mill. The site had already been graded, the lumber was beginning to arrive on the ground, and the machinery was in Chena, so it was expected that the plant would be in operation before the close of the year. The mill is a 2-stamp Joshua Hendy mill and will be operated by a gasoline engine. Water for this mill has been procured by sinking a 35-foot shaft within the space to be occupied by the mill. This water supply is said to be more than sufficient during the summer, but it may not be adequate after the surface water is frozen.

MISCELLANEOUS PROPERTIES.

Above the Rexall cabin, at an elevation of 1,450 feet, a shaft has been sunk on the Banner claim. Work at this place has been abandoned for some time and the shaft had caved and partly filled, but ore carrying free gold is reported to have been found.

On the western slope of Wolf Creek valley, northwest of the Banner claim, prospecting has disclosed a 3 to 4 inch vein of quartz carrying a large amount of stibnite. The general trend of this vein is said to be northeasterly, but the pit had caved, and therefore the ledge was not examined by the writer.

In the small draw at the head of Wolf Creek, above the Homestake Mining Co.'s tunnel, are several shallow open cuts. On the dumps is a considerable amount of quartz, but all the work done had been shallow prospecting, no underground development of the property having been attempted. No statements as to the results of this work were obtained, as the operator was absent at the time of the writer's visit.

On the Wolf Creek side of the Chatham-Wolf Creek divide, at an elevation of about 2,125 feet, the Quemboe brothers have discovered a vein trending N. 70° W. and dipping south. Development work at this place consists of a 60-foot shaft with a short drift to the east and another to the west. The dip of the vein and of the incline that follows it is steep near the surface, but flattens lower down. The ore shows some stringer banding and is much broken up. In parts of the vein the broken quartz fragments seem to have been cemented together by a subsequent infiltration of sulphides, the most abundant of which are stibnite, pyrite, and arsenopyrite. The country rock is a rather soft schist and the vein appears to have been subjected to faulting by which its contact with the country rock on the hanging wall is marked by a plane of movement. Samples taken by the owners across the entire face of the vein are reported to have assayed $22.50 and $32 in gold a ton.

A peculiar fact reported in connection with the sinking of the shaft on this claim was that in its lower part considerable trouble with water was experienced and the shaft was temporarily abandoned. Some time later the water disappeared and the mine is now dry except for a little surface-water seepage down the shaft. The walls are a good deal cracked, owing to settling, and this cracking may account for the sudden disappearance of the water.

CHATHAM CREEK VALLEY.

CHATHAM MINE.

The Chatham Mining Co. is developing a lead on the eastern slopes of the valley, at the extreme head of Chatham Creek, at an elevation of 1,825 feet. The vein was disclosed at the surface in 10 shallow pits, which are so spaced that the ore is traced for more than 500 feet. In order to avoid difficulty with water, a crosscut tunnel 200 feet long was driven to the vein and drifts were turned off both to the east and to the west. The trend of the vein is N. 60° W., and its dip is from 65° to 80° SW. The estimated difference in elevation between the tunnel level and the outcrop of the vein is 180 feet. The vein ranges in width from 6 to 18 inches and has physical aspects similar to the quartz veins of low sulphide content previously described. The hanging wall shows pronounced slickensiding, the striæ being practically horizontal on its steeply inclined surface. In addition to this strike fault, dip faults are by no means uncommon. The greatest displacement of the vein so far noted is 14 feet. Apparently the throw of all the faults is toward the southwest.

At the mine several hundred feet of drift have been driven along the vein and stopes have been started, so that the mine has reached a producing stage. The ore is broken down on canvas and stored in mill holes underground. It is then trammed to the surface and dumped into an ore bin, from which it is drawn as needed. About 10 men were employed underground in 1912 and each is estimated to be mining about a ton of ore a day. Precise figures as to the tenor of the ore are not available, but the average value of the free gold content is reported to be between $25 and $40 a ton.

Across the small stream at the head of Chatham Creek near an old cabin is an adit owned by the Chatham Mining Co. This adit is said to be about 60 feet long, but it has been abandoned and is now so caved as to be inaccessible. Little mineralization is said to have been found in the adit, and if a vein was discovered it must be south of the one which is being mined.

The ore of the Chatham Mining Co. is treated at the company's mill on the lower part of Chatham Creek about a mile from the mine and 700 feet lower. The mill consists of two batteries, each of two 1,000-pound stamps of the Joshua Hendy pattern, dropping from 100 to 105 times a minute. The ore is crushed to pass through 40-mesh screens and the pulp flows over amalgamated plates. The tailings from the plates are not saved, so that there is probably a considerable loss. Water for the mill is obtained from a small ditch that was formerly used by placer miners near the junction of Cleary and Chatham creeks. At the time the mill was visited an abundance of water was available, but whether this source will be ample throughout the year is questionable. The difficulty of milling with water in cold weather is shown by the fact that even as early as September 13 the mill was closed down for a while at night on account of ice. The mine and the mill are connected by a good wagon road, a little more than a mile in length, over which the ore is hauled by horses.

PIONEER MINE.

Near the claims now held by the Pioneer Mining Co. on Chatham Creek, less than a mile above the junction of Chatham and Cleary creeks, the first quartz claim in the Fairbanks region was located on August 28, 1903, and recorded on November 24 of the same year by John C. Rose as the Blue Bell lode. Not much work was done on the ground until 1908–1909. Prindle,[1] who visited the property in 1909, made the following report concerning it:

> The Pioneer Quartz Mining Co. has done considerable work at this locality on a claim known as the North Star. A shaft was sunk near the creek to a depth of 24 feet, when water was encountered. A second shaft was sunk about 100 feet farther up the east slope of the valley to a depth of about 85 feet on a vein about 3 feet thick, striking northeast and southwest. This vein was found to intersect the smaller vein at nearly right angles. At the intersection the smaller vein, it is reported, follows the main vein for a short distance and then penetrates the country rock. The smaller vein is said to range from 4 inches to 2 feet 6 inches in thickness. Both veins carry free gold, but in the smaller vein there is considerable stibnite and arsenopyrite, with some sphalerite and iron pyrite. The distribution of the sulphides is irregular, but in the portion of the vein where they occur they are for the most part rather evenly distributed through the quartz. They show a slight tendency in some places, however, to form small seams in the quartz.

At the time of the writer's visit in 1912 no mining was in progress, as the men were engaged in building a mill, but the new shaft, which

[1] Prindle, L. M., Auriferous quartz veins in the Fairbanks district: Bull. U. S. Geol. Survey No. 442, 1910, p. 226.

has been sunk 92 feet, starting about 20 feet above the level of the creek, was visited. Only a little water had been struck in the drifts turned off from the shaft, but the owners expect a stronger flow at a little greater depth. Drifts have been turned off both to the east and to the west of the shaft, the eastern one being much longer than the western; and stopes have been started, so that some ore is blocked out ready for mining as soon as the mill is completed. At the end of the eastern drift the vein is cut off by a fault, but the dislocation is slight, for the continuation of the lead has been picked up in surface pits beyond the fault with little offset.

A sample of the ore from the Pioneer Discovery claim was assayed by O. J. Tuschia, of the Monterey-Mexico smelter, with the following results, the gold and silver content being omitted:

Copper (Cu)	None.
Lead (Pb)	None.
Silica (SiO_2)	95.1
Iron (Fe)	2.5
Lime (CaO)	.9
Zinc (Zn)	None.
Sulphur (S)	.3
	98.8

This analysis shows the high silica content and the small amount of metals other than iron. The sulphur content is so low that only a small amount is available to combine with the iron to form pyrite. Unless the low figure for sulphur is due to an error in analysis, it is probably to be accounted for by the oxidation of sulphides that originally may have been present.

Several shipments of ore have been made from this property for mill tests at Fairbanks, and returns of $30 to $90 a ton in gold are reported. From these tests the owners have felt justified in putting in a battery of five 1,000-pound stamps. The latter part of the summer of 1912 was spent in building the mill, which will probably be in operation before the close of the year. Considerable difficulty in securing a suitable site for the mortar block was experienced, as at two places where excavations were started ground ice was found. Even at the place finally selected the foundation is none too good and a bed block 32 feet long containing more than 5,200 board feet of lumber was constructed to give sufficient support for the battery. Water for the mill will be obtained by pumping from the now abandoned shaft, over 100 feet deep, on the west side of Chatham Creek. No accurate estimates of the amount of water that can be obtained from this source have been made, but the fact that the earlier lode miners were unable to control the water is considered sufficient evidence that the supply will be adequate.

PROSPECTS ON EASTERN SLOPE.

On the hillside above the Pioneer Co.'s shaft and between that property and the Chatham Mining Co.'s ground a number of veins have been located and some work has been done, but none had reached a producing stage in 1912. The Jupiter-Mars Consolidated Mining Co. has seven or eight claims on the eastern hillside, and on the Gladstone claim, at an elevation of about 1,700 feet, it has driven two tunnels a short distance on a flat-lying lead. The vein trends about east and west and dips southward into the hill at a variable though low angle. Several faults intersect the vein, which does not appear at all regular. The miners believe that the part now being mined may be a large piece of slide and that farther up the hill the vein may be more regular. Not enough development work had yet been done to show the true condition, but in the northernmost tunnel the vein is abruptly cut off to the left by well-rounded gravels and wash. The gravel is similar to an ordinary river deposit and consists of pebbles of schist and quartz in a fine-grained, rather dirty matrix. The gravels are frozen, and therefore hold together well in the mine, but are not well consolidated. East of this place a 66-foot shaft has been sunk, and several other pits have been put down to prospect the ground. Shipments of a ton or so of ore from several of the veins have been tested at Fairbanks, and the average gold tenor of the ore is said to be about $30 a ton. Sulphides form but a small part of the vein material.

Farther north, on the ridge between Wolf and Chatham creeks, at an elevation of 1,850 feet, is a short tunnel of the Sky High claim. The lead at this place is a very much decomposed brown, iron-stained material, 3 to 6 inches wide, dissimilar from any of the other leads in the vicinity. Not enough development has been done to show the extent and character of the vein, but it appears to lie very nearly horizontal and suggests an iron capping rather than a vein. It is reported that the limonitic material affords gold on panning but that the amount is usually small. On the next adjacent claim a lead said to be 14 feet wide is rumored to have been opened by a short tunnel, but its gold content is small and little work has been done on it.

Southeast of the Sky High claim, at an elevation of 1,875 feet, in a now abandoned shaft, 60 feet deep, an east-west vein was discovered. No production, however, has been made from this place.

On the summit of the hill, between the two northernmost pinnacles of schist, at an elevation of about 2,050 feet, Harris & Brown have sunk a shaft 50 feet deep on a vein that trends N. 70° E. and dips at a high angle. The ore seems similar to that from the veins having a low sulphide content. One exceptional phase, however, was noted, in which the quartz was strongly brecciated and the fragments were cemented together by a matrix of crushed quartz. The cementation is so strong that the rock breaks across the large quartz fragments and the matrix appears like a quartzite. A somewhat similar rock, in which the matrix is formed of stibnite instead of quartz, was also seen. This rock shows that the sulphides were formed at a rather late stage in the vein filling. This phase is said to occur rather irregularly and forms but a small amount of the material cut by the shaft.

PROSPECTS ON WESTERN SLOPE.

Less than half a mile above the junction of Cleary and Chatham creeks, on the west side of the latter stream, is the B. P. claim, which has been more or less continuously prospected since 1908, though during 1912 the property was idle. Prindle, who visited the prospect in 1909, describes it as follows:[1]

> At a level of 150 feet above the creek a tunnel was driven southwest for about 90 feet. At 50 feet from the mouth of the tunnel a shear zone was encountered, about 6 feet thick, striking northwest nearly at right angles with the strike of the schists. The operators drifted northwest and then sunk on the shear zone, which was found to dip from 45° to 70° SW. to a depth of 150 feet, where the thickness was about the same as in the tunnel. Later a raise was put in above the winze, connecting it with the surface. The second level is about 100 feet below the first and extends along the vein for about 40 feet on each side of the shaft.
>
> The mica schist of the shear zone was found to be impregnated with sulphides, chiefly iron pyrites and arsenopyrite, with some galena, sphalerite, and stibnite. These sulphides also occur in the numerous quartz veins that penetrate the shear zone. Free gold is found in the upper, more oxidized portions of the mineralized zone, but it is reported that in the less decomposed lower portions of the lode the values are in the sulphides. A noteworthy feature is the occurrence of tourmaline needles in the mica schist close to the contact of schist and quartz veins and in close association with iron pyrites and arsenopyrite.

Difficulty with water caused the abandonment of mining for a while, but later an attempt was made to determine the quality of ore below the water level by sinking an inclined shaft. The venture was soon abandoned, however, and failed in its object. It is to be regretted that this particular lead was selected, for it does not appear to be typical of the majority of auriferous quartz veins. It is, instead, as Prindle describes it, a shear zone with an abnormally large amount of sulphides, even near the surface, and the free gold it carries is confined mainly to its weathered surficial portion, where the sulphides have been broken down and decomposed. As might have been expected, therefore, a short distance below the surface the ore became base and its value decreased.

[1] Prindle, L. M., Auriferous quartz veins in the Fairbanks district: Bull. U. S. Geol. Survey No. 442, 1910, p. 226.

Near the creek, between the B. P. and Pioneer claims, is the Rex Mining Co.'s claim. Owing to legal difficulties, little work has been done at this place. According to Brooks,[1] some work was done on the Rex during 1911, but when visited in 1912 no work was in progress and the place was deserted.

On the Bobbie claim, west of the junction of Tamarack and Chatham creeks, at an elevation of 1,650 feet, several shallow pits have been sunk and a tunnel has been driven on a lode striking nearly north and south and dipping westward into the hill. No work has been done at this place recently, and most of the pits are too much caved to allow examination. Specimens of the ore, however, indicate that the vein belongs to the group having a high sulphide content. The ore consists mostly of stibnite and galena with other sulphides in smaller quantities. In the midst of the sulphides are numerous well-formed quartz crystals with uncorroded surfaces and random orientation. Several of the quartz crystals are more than an inch in length and a quarter of an inch in diameter.

In the short incline from the open cut on this claim is a narrow stringer of nearly pure galena. This vein shows well-marked banded structure near the walls, the center of the vein being completely filled with large crystals of galena. The galena is reported to carry considerable silver, but the charges for treating this kind of ore are so high that the property can not be commercially developed in the near future, even if a much larger body of ore than has yet been found should be discovered.

BEDROCK CREEK VALLEY.

RHOADS-HALL MINE.

East of the lower part of Bedrock Creek (see fig. 16, p. 169), on the Free Gold claim, is the Rhoads and Hall mine, which was located in 1908 and is the largest in the region. It has been operated more or less continuously since its location and was practically the only producing mine up to 1911. The main vein is from 1 to 3 feet wide. The ore shows many different phases, but consists essentially of quartz with little or no sulphides. In places it is so much crushed that it is almost like sand. The vein includes schist horses a few feet long. It cuts the structure of the schists that form the country rock at the mine at rather high angles. The dip is fairly constant, the highest dip noted being 63° S. and the lowest dip about 55° S. Owing to faulting the trend of the vein is not constant, but averages about N. 75° W. Parallel to the main vein at a distance of about

[1] Brooks, A. H., The mining industry in 1911: Bull. U. S. Geol. Survey No. 520, 1912, p. 31.

25 feet in both the hanging and foot walls, are narrower quartz stringers composed of ore of the same kind, though of somewhat lower tenor.

The underground development of the property consists of a main adit over 975 feet long, started about 50 feet above the creek; an intermediate adit about 140 feet farther up; and an upper adit 50 feet still higher. The walls stand well, so that little timbering is necessary. This is fortunate, for a set of round-pole timbers costs at the mine about $3 and square timbers about $6. Little machinery has been used, as all drilling and tramming are done by hand and pumping is not necessary, for the adits drain the workings. A winze sunk to a depth of 20 feet at a point about 800 feet from the mouth of the adit encountered but little water and is to be carried lower. An electric pump is on the ground ready to be installed if water in troublesome amounts is found.

The dislocation of the vein by faulting makes the deposit difficult to open up and materially increases the cost of mining. A short distance from the mouth of the main adit, in an area at least 200 feet on a side, the rock is so thoroughly broken and sheared that the vein in it is practically unrecognizable. Slickensides are so numerous, diverge so greatly, and have formed at so many different times that they are of little service in determining the direction of movement at any particular place. In fact, many specimens of rock less than 3 inches cube show slickensides in three or four directions. Outside this highly shattered region the faults cutting the vein are of relatively small displacement. There are two distinct sets of these smaller faults. One set trends transverse to the vein and has a high inclination; the other trends nearly parallel to the vein and is practically flat. The usual effect of these faults is to throw the vein toward the footwall; that is, toward the north.

Much of the gold is irregularly distributed through the vein material in visible particles uncombined with other elements. In some places the vein is richest immediately adjacent to its walls; in other places it is richest in its center. The ore is in large part free from sulphides, but here and there includes stibnite, some galena, and arsenopyrite, as well as lesser amounts of pyrite, copper pyrites, and sphalerite. These sulphide-rich portions of the vein also contain gold, and Prindle[1] states that the gold sulphides and some quartz apparently have been introduced together at a period subsequent to that at which much of the quartz was formed. It therefore appears that the gold was introduced at two distinct times—first with the quartz and second with the sulphides. It is, however, by no means certain that the two events were separated by a long period.

[1] Prindle, L. M., op. cit.

According to the manager at the Rhoads-Hall mine, no material difference has yet been noticed in the tenor of the ore or in the amount of sulphides. In the highest level, near the surface, according to report, some sulphide enrichment was found, but none of the specimens seen indicated this process, although it may have taken place in the surficial portions of the deposit. Some oxidation of the sulphides has occurred to as great depths as have been reached by mining, but its amount is not great, as most of these minerals are hard and have the appearance and composition of unweathered material.

Three assays reported by F. W. Hawkins show that the gold from this property is 0.793, 0.820, and 0.830 fine and that the silver is 0.180, 0.164, and 0.164 fine. Silver is seldom actually determined by the Fairbanks assayers, and nine assays give only the fineness of the gold, namely: 0.802½, 0.810, 0.810½, 0.820, 0.822, 0.824½, 0.826, 0.827, 0.830. The average of these 12 determinations is nearly 0.818, which is equivalent to a gold value of about $16.89 an ounce. The fineness of the silver in the bullion, according to the usual method of estimating it as the difference between 0.990 and the fineness of the gold, is about 0.171½, which, with silver at 54 cents an ounce, would indicate a value of 9 cents.

No accurate figures as to the tenor of the ore are available. It is reported that 147 tons treated at the Chena mill in 1911 yielded $17,645, or an average of $120 a ton.[1] The conditions under which this ore was selected are not known, but the shipment was probably picked material.

For several years small shipments of ore were made from the Rhoads-Hall mine to the testing mills at Chena and Fairbanks, and it is reported that this mine furnished the first ore milled in the Tanana Valley. The development of the mine and the high charges for transporting the ore led the owners to put up a stamp mill on the property in 1911. After running about a month in 1911 the mill was closed on account of shortage of water until the spring of 1912. Since that time it has been in more or less continuous operation and the owners hope that they will not be forced to close it down during winter. The mill has a single battery of five 1,000-pound stamps of the Joshua Hendy pattern, operated at present by steam from a wood-burning boiler. The estimated capacity of the mill is about 17 tons of ore (about 3⅓ tons per stamp) in a day of 24 hours. Water for the mill is supplied during the summer by a short ditch and flume, but will be pumped during the winter from a well recently sunk.

[1] These figures, together with others given on later pages, were furnished to the Geological Survey, but as they have subsequently been published in the Fairbanks newspapers (Alaska Citizen, June 3, 1912) no confidence is violated by using them in this report.

The milling practice at this mine is relatively simple. The crushed ore flows through a 40-mesh screen and over the amalgamated plates, from which the tailings run over a canvas-covered table, and the material that is discharged from it is distributed by launders to a settling pond near the creek. Most of the free gold is caught in the batteries or on the plates. Some of the gold contained in the sulphides is recovered on the canvas-covered table, but a large amount of it is carried to the settling pond. The owners intend to install a vanner soon and believe it will effect a material saving. A table is necessary not only to recover the gold in the sulphides, but also to recover some of the free gold which, in an ore containing much stibnite or arsenopyrite, is likely to be carried off, owing to the sliming of the plates. When much of the stibnite ore is being milled it is necessary to dress the plates about once in three hours, or large losses of native gold result.

The concentrates are scraped off the canvas table from time to time and saved until enough have accumulated to pay for shipping. As they come from the table they are nearly black, but in about a week they oxidize to an iron-rust brown.

TANANA QUARTZ & HYDRAULIC MINING CO.'S CLAIMS.

A short distance south of the Rhoads-Hall mine are claims of the Tanana Quartz & Hydraulic Mining Co. and of men interested in that company. On this group of claims there are three leads, two trending about N. 75° W., and one trending nearly north and south.

The northernmost of the parallel veins, which has been prospected on the California and V claims, may be the continuation of the main lead at the Rhoads-Hall mine, with which it is nearly in line. The westernmost shaft on the vein starts from a point west of Bedrock Creek at an elevation of about 1,400 feet, with an inclination of 60° S., which about 20 feet below the surface decreases to 40° and continues at this angle for about 40 feet. A strong vein, from 1 to 3 feet wide, can be traced to a point near the bottom of the incline, where it is cut off by a fault. The ore appears similar to that of the richer veins of the region but is reported to be of low tenor, though little of it has been adequately tested.

Another shaft has been sunk somewhat farther east on the supposed continuation of this vein near the road on the Bedrock-Chatham divide, at an elevation of about 1,400 feet. Mining was not in progress at this place in 1912, and the underground workings were so full of water that they could not be examined. The material on the dump and descriptions given by those familiar with the place indicate that the vein is of the non sulphide-bearing type, and some tests showed it to carry gold. Fragments of a light-colored feldspar and quartz rock found on the dump and said to come from points close to the vein apparently belong to the granite family.

A number of shallow pits sunk on the same or parallel leads east of the old road have disclosed auriferous quartz. More than a thousand feet of prospecting with a Keystone drill has also been done in this region, but no rich veins have been discovered.

The southern east-west vein is on the Wyoming and Alabama claims, and has been most extensively opened up on the Wyoming claim by an adit 165 feet long, the mouth of which is on the eastern slope of the valley of Bedrock Creek, at an elevation of about 1,325 feet. A 50-foot winze, starting with an inclination of 60° but flattening to 49° near its bottom, has been sunk on the vein near the center of the adit. These openings have disclosed a vein 1 to 2 feet wide, the crushed rock from which yields considerable free gold on panning. Some ore has been shipped to the custom mills at Fairbanks and is said to have yielded high returns in gold. The vein cuts the country rock at a steep angle and seems in part to occupy a fault fracture. The country rock in this part of the area is greenish and less laminated than that to the north and in its physical features resembles a sheared and metamorphosed greenstone. The vein contains, just beyond the winze, several long, chimney-like vugs partly filled with crystals of quartz and calcite, the calcite being younger than and coating the quartz. The occurrence of calcite in the veins is rather unusual, and the vugs probably represent openings formed by late fracturing of the auriferous veins and the subsequent deposition of quartz and later of calcite. So far as could be learned these vugs carry no gold and do not affect the tenor of the vein. A peculiar feature noted in this mine was that though the surface of the main adit was heavily covered with ice crystals, some of them as much as 3 inches long, none occurred in the winze.

On the hillside above the adit, prospect pits have been sunk at intervals to a point on the crest of the divide at 1,825 feet, and in them quartz-vein material, some of which yields free gold, was discovered. According to Antone Goessmann, one of the prospectors most familiar with the property, a panful of surface material taken practically anywhere on the hillside yields particles of gold, many of good size and all sharp and angular, as though untransported.

The north-south vein is exposed at the surface on the lower part of the crest of the divide between Bedrock and Chatham creeks, on claims called the Pauper's Dream and the Texas—the former south of the latter—and crosses the California claim, already noted, which lies between the two. (See Pl. XXII, p. 168.) The southernmost opening on this vein is near the old ridge road at an elevation of 1,625 feet. The vein dips west at a high angle and is from 2 to 4 feet wide. Unlike the parallel east-west veins, this one carries a large amount of sulphides, mainly arsenopyrite, but it also contains free gold. Much coarse angular gold is reported to have been found in the weathered material overlying the vein. This vein appears to pass a little east of the shaft near the road on the California claim, previously described, but the relation of the two sets of veins is not determinable from the present exposures.

MISCELLANEOUS PROPERTIES.

On the divide between Bedrock and Chatham creeks, at an elevation of about 1,300 feet, and nearly in line with the north-south vein on the Texas and Pauper's Dream claims, a short tunnel has been driven into the hillside on a small vein carrying a large amount of arsenopyrite and some stibnite. From the tunnel a short winze has been sunk, but the property is now lying idle, and the workings are partly filled with water. The vein is well defined and has a smooth wall apparently due to faulting. Samples from this place are said to carry much gold, but no systematic sampling has been done, and no ore has been milled.

Near the rocky pinnacle at an elevation of 2,300 feet on the Bedrock-Chatham divide a small mass of quartz, galena, iron pyrite, arsenopyrite, and stibnite is interbedded in the schists. Nearly due south of this place, at an elevation of 2,400 feet, is a shallow shaft, now filled with water. On the dump is considerable galena. In a short tunnel driven into the hillside below the shaft similar ore has been found. It was reported that the deposit occurred in a blanket formation and that the vein in the tunnel and the one in the shaft were not the same but were parallel. The exposures afforded no ground for a definite conclusion, but the apparent flatness of the deposit seems to be due to surface creep, and does not represent the true altitude of the vein. Further prospecting is much needed to determine the extent and size of the ore body. The only other lode carrying large amounts of galena, the Bobbie (see p. 177), which strikes nearly north and south and dips westward, lies less than a mile N. 10° E. of this shaft. The similarity of the ores at the two places and their nearness suggests that the two lodes are probably genetically related. The fact that this galena occurs only about one-eighth mile from a small area of intrusive rock that is exposed near the 2,301-foot bench mark, at the crossroads, is also significant. The galena from this claim occurs both in large, well-crystallized cubes and in fine-grained masses, the latter usually lying close to the walls and the former being more remote. Strong evidences of faulting are recognizable throughout the vein material and country rock. The galena is reported to carry much more gold than silver, but the tenor of the vein has not been accurately determined.

On the ridge about a quarter of a mile west of the 2,301-foot bench mark, near the western end of the mapped area of igneous rock, several shallow pits have been sunk into the frost-riven talus in attempting to locate the lead that furnished much of the quartz lying on the surface. The direction and character of the lead can not be determined from the present exposures. Assays of samples from this lead are said to have shown a gold tenor of about $10 a ton.

WILLOW CREEK VALLEY.

TOLOVANA MINE.

At an elevation of 1,300 feet, or about 25 feet above Willow Creek, a little more than one-eighth mile upstream from its junction with Cleary Creek, is the Tolovana mine. The main development at this place consists of an adit that follows the vein for about 130 feet to a fault, which throws the vein northward about 30 feet. Beyond this offset the adit continues eastward for about 200 feet. Short crosscuts have been turned off here and there on small stringers, and some ground has been stoped above the level.

About a hundred feet from the mouth of the adit an inclined winze has been sunk, from which a drift has been turned off 50 feet below the adit. The fault discovered in the adit was found also in this drift and offsets the vein to the north. An inclined winze near the east end of this lower level, said to have been sunk on the vein, was full of water in 1912 and could not be examined. In the western part of the lower drift some ore has been stoped and hoisted up the winze to the adit level and thence trammed to the mill. At the time of the writer's visit, however, a shaft with an inclination of 60° S. had been sunk near the mouth of the adit, had intersected the 50-foot level, and was being driven deeper. This shaft will be used for hoisting ore from the lower levels.

Water has caused some difficulty in the sinking of the shaft. According to the superintendent, it accumulates in the bottom of the shaft at the rate of about 2 feet per hour, making continuous pumping necessary. As the bottom of the shaft is now more than 40 feet below the level of the creek and as it is probable that the most pervious part of the ground has been passed through, no excessive increase in the amount of water is expected.

The vein at the Tolovana trends nearly east and west and dips about 60° S. It differs from the other veins so far described in that the quartz forms small stringers, 1 to 3 inches wide, separated by considerable thicknesses of schist. The quartz is commonly frozen to the wall rocks so firmly that blasting does not separate them. In many places the country rock close to the vein is heavily impregnated with sulphides, mainly of iron. It is especially abundant where the wall rock is somewhat calcareous. In the vein, however, iron pyrite is practically absent, the common metallic minerals being stibnite and gold. The stibnite generally occurs in more or less well-formed crystals, many of which are small, isolated needles of nearly microscopic dimensions; no large masses have been found. In certain specimens stibnite lies along the granulation planes in the quartz, giving the rock a linear-parallel gneissic structure.

The gold is mainly native. Little or none is said to be contained in the stibnite, but some particles of gold are visibly in contact with the stibnite, and others bear all relations from close association to complete separation. In many specimens the gold occurs in crystalline aggregates in the midst of unfractured, somewhat glassy quartz and seems to have been introduced with the quartz and before the infiltration of the stibnite. It is reported, however, to be most abundant in ore containing some stibnite.

Determinations furnished by F. W. Hawkins show the gold to be 0.824, 0.821½, 0.819, 0.814, and 0.792 fine. The sample whose gold fineness is 0.792 contained 180 parts per thousand of silver.

The quartz is generally compact and rather milky. Here and there, however, small vugs occur in the vein, and these are usually coated with crystals of glassy quartz. Widespread shearing of the quartz has produced a structure resembling cleavage, causing glistening faces in parallel orientation to appear on fractured surfaces. A little feldspar is recognizable in some of the vein material; and Prindle[1] notes that a minute vein at this locality was found to be composed of quartz and fresh albite. In a few places a small amount of calcite is also associated with the quartz.

At two places on the Tolovana property veins carrying much stibnite have been found; one east of Willow Creek, at an elevation of about 1,325 feet; the other west of it, at about 1,300 feet. The eastern locality has been prospected by shallow pits, but the ledge has not been found in place. The stibnite occurs both in well-formed blades with characteristic pressure twinning and also in more or less massive form, intimately intermixed with other sulphides, notably those of iron. Red, yellow, and greenish-yellow oxidation products are common, but are more abundant on the well-bladed than on the massive ore. Below these pits a prospecting tunnel about 100 feet long has been run nearly due south, but has not yet reached the place where the stibnite vein is believed to occur. Possibly its course may be parallel rather than transverse to the vein, in which case it will yield no information concerning the vein. About 50 feet from the mouth of this tunnel a few small quartz stringers were found, but no well-defined lead was discovered. This method of prospecting appears to be much more expensive than surface trenching and sinking test pits on promising leads.

[1] Prindle, L. M., op. cit., p. 227.

A shaft at the locality west of Willow Creek is now filled with water and can not be examined. It is reported to have been sunk 16 feet on a small stringer carrying large amounts of stibnite. Several shallower holes were also put down, but disclosed no material that warranted development at that time, and further prospecting at this place in the near future seems unlikely.

A Huntington mill was in operation at the Tolovana mine in 1911, but was found not to be adapted to the work and was closed down early in the summer of 1912 to permit the installation of two Nissen stamps of 1,300 pounds each. Operations were resumed in September. The old mill was closed down during the winter of 1911–12, but if possible the new one will be kept running throughout the year. Seepage water pumped from the new shaft was used during the summer, and it is hoped that water from a well just sunk will supply all needs during the winter. The rock is difficult to crush, the estimated capacity of the mill being less than 8 tons a day of 24 hours. The ore is trammed from the mine, dumped over a grizzly, the larger pieces being put through a smaller power crusher, and is delivered to a storage bin, from which it is automatically fed to the stamps. The pulp, passing through 40-mesh screens, flows over the amalgamated plates. The tailings are discharged at the lower end of the plates onto an endless conveyor with a slope opposite to that of the plates and with the belt moving in an opposite direction to the slope. By this arrangement the heavier minerals are concentrated and carried to the head of the belt, where they are dumped into a receptacle, from which they are taken when enough have accumulated to warrant metallurgical treatment.

MISCELLANEOUS PROPERTIES.

At the head of Willow Creek some prospecting has been done on ground leased from the Newsboy Mining Co. by Dr. I. Overgaard. On the Emma claim, at an elevation of about 2,025 feet east of the creek, a shaft 60 feet deep has been sunk on a promising stringer 6 inches wide, and short drifts have been turned off at the bottom. The country rock differs on the two sides of the lead; on one side it seems to be a metamorphic igneous rock of the greenstone group. The dip of the vein at the surface is steep to the south, but in depth it decreases to about 45°. Particles of gold are recognizable in some of the ore that has been sacked for shipment. According to the operator, 10 tons of selected ore milled at Fairbanks yielded an average gold tenor of $38 a ton.

A short tunnel into the compact unmineralized rock has been started at an elevation of about 1,775 feet. No valuable minerals have been found in the tunnel, but a short distance below it a strong quartz lead is exposed. Unfortunately, however, assays of the quartz are said to show little gold.

An ingenious hand mill capable of treating about 100 pounds of ore in five or six hours has been built at this place. It consists of a heavy iron bar, expanded at the base, which is raised by means of a lever with the necessary tackle and is dropped into a mortar box which has a one-way discharge. The pulp flows over amalgamated plates, and the concentrates in the tailings are not saved. Water is derived from the near-by stream. The entire apparatus was manufactured on the ground, and though it can handle only a small amount of ore, it could be of service in testing vein material in places remote from capable assayers.

Near the road west of the Overgaard property, at an elevation of 2,075 feet, is the abandoned Cornell tunnel, which is reported to have been driven as a crosscut to prospect the region. Apparently no ore was discovered.

A shallow prospect pit has been sunk in an area showing some disseminated sulphide mineralization on the ridge between Willow Creek and the head of Cleary Creek, just above the road, at an elevation of 1,900 feet. This pit, which has been abandoned for several years, is near the western margin of a small area of intrusive rock, which has a mottled porphyritic appearance and which on weathered surfaces is heavily covered with limonite. Probably the sulphides noted in the schist were introduced through its agency. Apparently the deposit at this place has no economic value.

CLEARY CREEK VALLEY ABOVE WILLOW CREEK.

MISCELLANEOUS PROPERTIES.

About a quarter of a mile above Willow Creek, at an elevation of 1,325 feet north of Cleary Creek, a short shaft and tunnel have been driven on the Scheuyemere claim. The country rock is of the usual schistose type, and the material on the dump shows many pieces of rather glassy quartz. As mining had ceased for so long a time that the pits had caved and as there were no outcrops, exposures of the vein were not seen, and not even its direction or extent could be determined. No ore was milled from this property.

On the ridge between the two small headwater branches of Cleary Creek, at an elevation of 1,375 feet, is a 30-foot shaft of the Eldorado Mining Co. No work has been done here for two years, and the shaft is filled to the surface with water. The ore on the dump does not appear to be very promising. It is mainly quartz, though some stibnite occurs in the seams. The trend of the lead, as indicated by the direction of the shaft, is about north and south. Limestone apparently forms part of the country rock, for it makes up a considerable proportion of the dump. Pieces of brownish-gray, rather crystalline limestone and of blue compact crystalline limestone were fairly numerous, and some fragments of schistose limestone, with considerable mica and chlorite on the cleavage planes, were also found. These limestones probably belong to the general group mapped by Prindle and Katz as occurring along the road northeast of the shaft and on top of the hill to the north. In none of the other prospects was any considerable amount of limestone noted.

South of the Eldorado shaft, at an elevation of 1,475 feet, is the Steil tunnel. The tunnel was closed and the vein could not be examined in place. The vein material on the dump, however, indicated that it is more like that from the vein in the Tolovana mine than that from the more easterly veins. The quartz occurs in narrow veins that branch here and there through the country rock, which appears more compact and harder than the silvery schist and suggests relationships with the greenstones rather than with the sedimentary rocks. The veins are firmly frozen to the country rock and fracture with it. Some stibnite and less pyrite occur in the ore. A road has been built from the tunnel to the main road to the north, and small lots of ore will probably be hauled to one of the near-by mills for treatment. In 1912, however, the property had not reached the producing stage.

NEWSBOY MINE.

On the divide between Cleary and Last Chance creeks, at an elevation of about 1,875 feet, the inclined shaft of the Newsboy mine has been sunk nearly 350 feet and drifts turned off at the 60, 115, 215, and 315 foot levels. At the time of the writer's visit the mine had been closed down for some time, owing to alterations in the mill, and water that had collected in the bottom of the shaft made the lowest level inaccessible.

The Newsboy vein trends about N. 40° E. and dips about 73° NW. Its width ranges from less than 1 foot up to 9 feet, averaging between 2 and 3 feet. The ore is much sheared and consequently breaks down rather easily, leaving smooth walls; but the vein matter is tightly frozen to the country rock and therefore some ore is left in what are called the walls, or else some waste rock is mined with the vein material.

Large amounts of sulphides occur in the vein, but the ore differs from that seen at any of the mines so far described, though it is more closely akin to that of the Tolovana than to that of the more eastern veins. The sulphides are mainly pyrite and stibnite, though arsenopyrite, a little chalcopyrite, and sphalerite have been recognized. Quartz, although the most abundant mineral, forms a rather smaller proportion of the vein material than in most of the other mines. Most of the quartz simulates that in the quartzite rather than that in the normal veins and has a fine granular texture. Schist horses are fairly numerous in the vein and are not sharply separated from the vein material.

On the 215-foot level a drift has been run northeastward for about 200 feet, and midway in its length has been connected by an incline with the 115-foot level, thus blocking out a mass of ore for stoping. At the east end of this drift the vein is cut off by a transverse fault, and its eastward continuation has not yet been found. Most of the country rock is hard and very compact, suggesting affinity with the metamorphic greenstones, and throughout its extent is practically without any recognizable guide horizon. The fault plane is strongly slickensided; the direction of movement appears to have been sideways rather than vertical, but the rock does not preserve the scratches well enough to show toward which side the movement took place. Under these conditions the continuation of the vein can probably be found only by crosscutting beyond the fault.

Farther west on the same level a drift about 100 feet long, following the vein, cut another transverse fault similar to the eastern one, but dipping in the opposite direction.

On the 115-foot level a 40-foot drift has been turned off to the southwest and a 100-foot drift to the northeast. In the western drift the ore is said to be cut off by a fault, beyond which the vein has not been traced. In the eastern drift the vein is cut off by a transverse fault, which, if identical with that on the 215-foot level, may be expected to cut the vein on the 315-foot level about 300 feet from the shaft. It is doubtful, however, whether these two are the same fault, for if they are they should have displaced the vein above the 115-foot level, which apparently they have not done.

A raise has been driven from the 115-foot level to the 60-foot level. The 60-foot level runs northeastward for about 75 feet, and much of the ore above it has been stoped out. The ore has not been traced southwestward from the shaft, and this suggests that it is cut off by the southwestern fault.

The average tenor of the ore is not known, for considerable parts of the several large shipments made were hand picked. Sixty-six tons of ore treated in 1911 at the Chena mill are reported to have given an average free gold content of $81.50, and 7½ tons treated at the Garden Island mill, at Fairbanks, are said to have yielded $104 in gold per ton. According to another report, the ore is said to run about $40 a ton in gold.[1] The causes for these differences are not fully known, but, so far as could be learned, the controlling factor is not depth below the surface.

[1] Eng. and Min. Jour., vol. 93, No. 26, June 29, 1912, p. 1291.

For some time the ore from the Newsboy mine was shipped to the custom mills at Chena and Fairbanks, but late in the fall of 1911 a 5-stamp Hendy mill was built at the mine. Seepage water pumped from the mine was first used in the mill, but the supply was not entirely adequate, and in 1912 the mill was moved to a point on Cleary Creek near the mouth of Willow Creek, at an elevation of more than 600 feet below the mine. The work of removal had not been completed by the middle of September, but the mill was probably running again before the end of the year. The new site is over three-quarters of a mile from the mine, and it will be necessary to haul the ore in teams. Water will be supplied from a 6-inch drill hole 100 feet deep in amounts which the operators hope will be adequate throughout the year.

The mill is equipped with a battery of five 1,000-pound stamps, and a No. 2 Deister concentrator is used for saving the heavy minerals in the tailings. The mill superintendent estimates that 10 to 12 tons of ore can be milled a day, at a cost for both mining and milling of $7 a ton. If this estimate is correct, the cost will be much less than that at any of the other properties examined. Wood, costing about $15 a cord, is used for fuel.

NEWSBOY EXTENSION MINE.

About 500 feet northeast of the Newsboy is the so-called Newsboy Extension shaft. The faulting of the vein at the Newsboy makes it impossible to tell whether the same vein is really continued in the Newsboy Extension. Certainly the strike of the two veins is not the same, for that at the Newsboy strikes N. 40° E. and dips 73° NW., whereas that at the Newsboy Extension strikes N. 15° E. and dips 77° W.

The Newsboy Extension mine has not been worked for some time, and in 1912 the shaft was nearly full of water, which prevented examination of the underground workings. The operators report that the shaft is about 115 feet deep and that short drifts have been turned off both to the north and south at the 60-foot level. The country rock and ore, as seen on the dump and in the bins, is apparently much the same as that from the Newsboy, except that it contains even less quartz. No accurate determination of the gold tenor of the ore has been made, but it is said to be about $15 a ton.

Connected with the shaft house at the Newsboy Extension is a 5-stamp mill built by a Fairbanks company. The stamps weigh about 500 pounds, and it is reported that the mill can crush about 8 tons of ore a day. The machinery, however, is very light to treat rock so hard to crush as that from this mine, and its operation has been difficult. The mill stands so high on the ridge that little water is available, and the supply, which has been obtained by pumping from the shaft, has apparently not always been adequate. The mill has not been in operation recently.

ELDORADO CREEK VALLEY.

Little lode prospecting has been done in the Eldorado Creek basin, but the general geologic conditions there appear to be similar to those in regions that contain auriferous veins. On the Rose claim, which lies about a quarter of a mile south of the Newsboy mine, an adit 180 feet long has been driven on a quartz vein about 1 foot wide. Two tons of the ore, milled at one of the custom mills at Fairbanks, are said to have contained a large amount of concentrates, but no statement as to their average gold tenor has been published. The property, not being in operation at the time of the writer's visit, was not examined, so the direction and the character of the vein were not determined.

Prindle reported in 1909 that auriferous quartz had been found in a shallow prospect pit sunk at an elevation of 1,775 feet near the head of Last Chance Creek. No work has been done on this property recently. Farther west, at an elevation of 1,400 feet, near the forks of Little Eldorado Creek, Prindle noted in 1909 a short tunnel trending S. 15° E. Some work has been done at this place more recently, but the claim was not visited by the writer, and details concerning it are lacking. At an indefinitely located point near the head of Spruce Creek a lode said to carry about $12 a ton in gold is reported to have been opened up by a shaft 150 feet deep. This property was not seen by the writer, and no further information concerning it was obtained.

DOME CREEK VALLEY.

RELIANCE MINING CO.'S CLAIMS.

The northern slope at the head of Dome Creek valley is covered by claims belonging to the Reliance Mining Co. and to people interested in that company. These claims form two parallel series. The northern series, named from west to east, comprises the La Rose, Wild Rose, Soo, Waterbury, Carnation, and Inspiration claims; and the southern series, which extends from a point near the middle of the southern line of the Soo to the middle of the southern line of the Carnation, consists of the Waverly and Chief claims (fig. 18). Three main veins have been found on these properties, two trending nearly east and west and dipping north, and the third trending N. 50° E. and dipping 50° NW. The northern of the east-west veins is called the Soo vein and the southern the Wild Rose vein. The two converge toward the east, so that whereas near the west-end line of the Soo claim they are 135 feet apart, at the east-end line of that claim they are 60 feet apart, and at the end line between the Waterbury and Carnation claims they are said to be less than 20 feet apart.

Of these three veins the Wild Rose has been most developed and has yielded the greatest amount of gold. An inclined shaft on the end line between the Wild Rose and Soo claims has been sunk 100 feet and drifts have been turned off to the east at the 50-foot level and at the bottom. Much ore has been stoped from the upper level and milled. The vein followed by the drift at the bottom of the shaft is said to be a spur from the main vein, and the latter is supposed to be in the rock on the footwall side. Twenty-five feet east of the collar of the shaft an open cut has been made on the vein and the ore has been stoped out underhand.

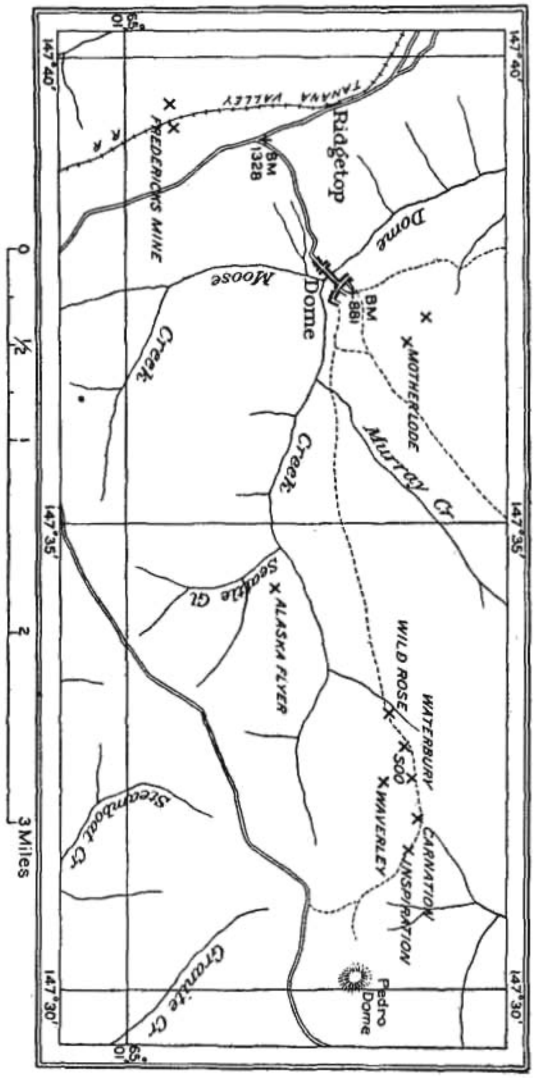


FIGURE 18.—Sketch map showing location of lode prospects in Dome Creek valley and near Ridgetop.

A little southeast of the open cut a tunnel was driven eastward for about 100 feet, to a point where it intersected the vein exposed in the shaft and open cut, and from that point a drift was turned back at an acute angle westward on the vein and the ore stoped out for about 35 feet. The drift was carried eastward from the intersection of the tunnel and the vein for about 100 feet to a cross vein trending about northeast-southwest and dipping 40° SE. Where it was first cut this cross vein was very narrow, but at the bottom of a winze 20 feet deep, sunk near the intersection of the veins, it was 3 feet wide. The east-west vein is sharply cut off by the cross vein, and its continuation in the rock on the hanging-wall side of the latter has not yet been found. The wall rocks of the cross vein are much slickensided, but the amount of movement can not be determined.

The main openings on the northern vein, the Soo, are on the end line between the Waterbury and Soo claims, near the center of the Soo. At the end line a shaft 100 feet deep has been sunk and a short drift turned off to the west. The vein dips about 68° N. In the center of the Soo claim a tunnel, now caved, crosscuts the northern vein. On the end line between the Waterbury and Carnation claims, near the 1,800-foot saddle on the ridge running west from Pedro Dome, several shallow surface pits have disclosed quartz float that is believed to have come from the vein, but no mining has been done at this place.

The so-called Chief vein, which trends N. 50° E., traverses parts of the Waterbury, Chief, and Carnation claims. It has been opened up at several places by shallow surface pits, but these have caved so badly that the vein could be seen in only one of them—a 20-foot shaft at an elevation of about 1,900 feet. This vein is nearly parallel to the cross vein in the eastern tunnel near the shaft on the line between the Wild Rose and Soo claims, but it dips northwest, whereas the cross vein dips southeast.

The specimens of ore taken from all these claims are strikingly alike, the ore from separate pits showing no greater differences than the ore from different parts of the same pit or drift. Much of the quartz has been subjected to shearing, so that it is "sliced" and its individual plates are elongated lenses. Crystalline quartz occurs in considerable amounts, not only in small drusy cavities, but also elsewhere in larger amounts, producing a typical "comb" structure. In one specimen, which was taken from the dump and whose location in place is consequently not known, a small stringer of crystalline quartz occurs between schist and a feldspar-quartz igneous rock.

Gold is practically the only valuable mineral in the ore. It is very bright and commonly occurs in crystalline aggregates, some of it in the midst of hard, glassy quartz, some in the more porous zones near the schist, some in the cracks and crevices between the fractured quartz grains, and some on quartz crystals that project into drusy cavities. It appears to have been introduced at different times, but there is little question that much of it was deposited contemporaneously with the rest of the vein material as free gold and was not leached from sulphides by surficial processes. At several places where faults occur the gold has been dragged out and forms thin metallic plates on the slickensided surface, showing plainly that it was in the vein prior to the faulting.

The richest gold ore is reported to occur in shoots that pitch eastward. This is the direction of dip of the cross vein in the tunnel noted on page 191, and it is by no means improbable that the shattering incident to the movement parallel to the fault occupied by this vein may have opened up the older vein and permitted the access of new gold-bearing solutions. Whether or not this interpretation is correct, the older vein is said to be much richer near its contact with the northeast-southwest vein. These shoots, of which at least two are known in the present workings on the Soo, are reported to be about 20 feet wide.

Several determinations by local assayers and by the Selby Smelting and Refining Co. of San Francisco show that the gold has a fineness ranging from 0.823 to 0.843. An assay made by the San Francisco firm of a 50-ounce sample of bullion gives 824½ parts of gold and 149 parts of silver. This indicates that the bullion is worth a little more than $17 an ounce.

Sulphides form but a small part of the vein material. A small amount of stibnite occurs in many places and some large masses are reported; none were seen, however, and their relations to the vein were not determined. In addition to the more usual sulphides, the vein contains small quantities of tetrahedrite (sulphide of silver, copper, and antimony), with which some gold is intimately mixed, the two having been deposited contemporaneously. Copper sulphides are extremely rare.

The gold tenor of the ore, estimated from the material now being mined, is very high. Much of the ore treated at the local mills has yielded $50 to $60 or even more to the ton, and mill runs on 8 to 10 tons of ore from the richest portions of the vein have given returns of over $250 a ton in gold.

The ore from this property was formerly treated at one of the custom mills, but in 1912 a small 3-stamp mill of local manufacture was installed. This mill, which is equipped with 250-pound stamps and has a capacity of only about 3 tons of ore a day, is situated near the Wild Rose-Soo shaft. Water is supplied mainly by pumping from a sump at the bottom of the shaft; and at that elevation so little is available that it has not been possible to run the mill more than a few hours a day. The ore as delivered from the mine is cobbed by hand before it is delivered to the hopper for automatic discharge to the battery. It is crushed in the stamps to 30 mesh and is then passed over the plates. No appliance is used for collecting the concentrates, the tailings being discharged directly from the lower end of the plates.

According to the manager, nearly 80 per cent of the gold recovered is caught in the mortar box, the remaining 20 per cent being found on the plates. All the gold amalgamates readily and little or no base material is present to contaminate the mercury. Though no determination of the amount of gold lost has been made, the amount of free gold lost in the tailings is probably small, for the lower end of the plates is very clean, but a good deal of the gold in the sulphides and other heavy minerals is probably lost

The present site of the mill is so disadvantageous that a new site has been chosen on Dome Creek below the mine, and a new mill, equipped with two Nissen stamps, is expected to be in operation by the close of 1912. Although this situation will necessitate tramming the ore for some distance, the advantage of a continuous supply of water should more than offset this charge.

MISCELLANEOUS PROPERTIES.

On the ridge between Dome Creek and the lower tributary of Seattle Gulch, at an elevation of about 1,200 feet, a 30-foot shaft has been put down on the Alaska Flyer claim. Not enough work has been done to indicate the nature of the ore, but it is reported that auriferous quartz has been found and that further prospecting will be done.

Half a mile northeast of Dome City, at an elevation of about 1,000 feet, some prospecting has been done at two shafts sunk on the Mother Lode and contiguous claims. The western shaft was 147 feet deep, and at its bottom a short crosscut was run eastward. The eastern shaft, 200 paces east of the western, was sunk 215 feet, the first 60 feet through muck and the rest through rock, no gravel intervening. In 1912 both shafts were almost filled with water, so that the underground workings were inaccessible, but the material on the dump indicates that no lodes similar to those now productive in the region have been found. The material is interesting, however, as it shows a somewhat graphitic limestone rather heavily impregnated with disseminated sulphides. The metallic mineral is mainly iron pyrite, but the rock also contains a little copper pyrite and some arsenopyrite. Some faulting has occurred subsequent to the deposition of the sulphides, for well-polished planes with mirror-like surfaces formed by both sulphides and country rock are by no means uncommon.

VAULT CREEK VALLEY.

FREDERICKS MINE

About a mile south of Ridgetop, on the eastern slope of Vault Creek valley, are claims forming what is locally known as the Fredericks mine. (See fig. 18, p. 191.) This property has been developed by two shafts—the western, at an elevation of about 1,225 feet, and the eastern, at an elevation of about 1,350 feet—both sunk on the same vein. The vein strikes approximately N. 70° W. and dips north at varying angles.

The western shaft is a little more than 300 feet deep. At the surface the dip of the vein is about 70° N., but at the bottom it is about 45°. On the 100-foot level a 50-foot drift has been turned off to the east. The vein in the face of the drift is about 3½ feet wide, but as the adjacent shattered schist is also mineralized, a somewhat greater thickness of rock may be profitably removed in mining. The junction between the vein and the schist on the hanging-wall side is a smooth fault plane. From the other side of the shaft, at the same level, in a 15-foot drift extending west, the width of the vein changes abruptly and much of the material mined seems to represent merely a shattered zone in the country rock. Some stibnite occurs in the ore and is apparently more abundant toward the foot than toward the hanging wall.

On the 200-foot level drifts have been run 120 feet east and 30 feet west. The vein appears rather weak and in places the quartz is merely of knife-blade thickness. The iron-stained shattered zone, however, continues with a width of several feet. A crosscut has been driven into the hanging wall and a granitic rock disclosed at a distance of about 50 feet from the shaft.

Below the 200-foot level the dip decreases greatly until, at the bottom of the shaft, as previously noted, it is about 45°. On the 300-foot level a short drift has been turned off to the west. A crosscut into the hanging wall, however, affords the best available information as to the geologic conditions. The wall of the lead, which was followed by the shaft, is, as in the upper levels, a smooth, slickensided plane developed on a hard quartizitic rock which appears to have been affected by contact metamorphism. A few feet north of this plane is a sharp break, marked by a much slickensided surface on which the striations are vertical, beyond which is a fine-grained granitic dike about 7 feet wide, bounded on the north by another fault plane. The granite is so much decomposed that it is almost impossible to pick up pieces of it. Most of it is light colored, but it weathers to a rusty yellow, small dark spots here and there representing the ferromagnesian minerals it originally contained. Beyond the northern fault is a dark, greasy, and somewhat graphitic schist showing innumerable small slip faults, which trend in all directions, but are broadly parallel with the dike. Though the underground workings do not show the deposit sufficiently to permit the solution of many of the problems, they give the impression that much of the material regarded as ore has been mineralized through its propinquity to the granite.

In the eastern shaft, which is 100 feet deep, the dip of the vein is about 80° at the surface and does not materially decrease in depth.

No granite was recognized underground or on the dump, but there is a hard compact rock that probably belongs to the group of greenstones. Mineralization seems to have taken place along a shattered zone and to have impregnated the rocks in the vicinity. This zone dips much more steeply than the country rock and consequently traverses different rocks in different parts of the mine. Most of the material penetrated by the shaft is a brown, heavily iron-stained quartzose rock. This rock is very different from the auriferous veins so far described and appears to be a brecciated and mineralized schist rather than a distinct vein. Here and there in this broken-up material are small vugs containing quartz crystals, many of which are coated with oxide of manganese.

MISCELLANEOUS PROPERTIES.

None of the other properties in the Vault Creek basin were examined by the writer during 1912. Brooks[1] writes:

> It is said that about 280 feet of shaft and 60 feet of drifting was done on a property near the divide between Wildcat and Vault creeks, owned by Hoel Bros., Johnson & Witmer. Current reports are to the effect that a 30-foot ledge carrying low gold values and a richer vein 8 inches to 2 feet in width have been found on this property.

Ore from a property near Ridgetop, owned by Charles Thrift, is reported to have been milled at Fairbanks and to have yielded $11 a ton in gold. No details of the manner of occurrence were learned. No active work appears to have been in progress during 1912.

In the basin of the first tributary of Treasure Creek from the south, west of Independence Creek, two lodes have been exploited, but according to available reports no considerable amount of development work has been done. Near the mouth of this creek, on the eastern slope of the valley, a gold lode is reported to have been located, and south of it, near the head of the basin, a lode carrying mainly stibnite was found. Specimens of the ore from both localities were seen and appeared to be of high grade. Some silver minerals are reported to occur in the lode, but their composition was not determined.

GOLDSTREAM VALLEY.

WEST OF TWIN CREEK.

Several lode prospects were examined in the Goldstream basin at the head of Sheep Creek, near the summit of Ester Dome. (See fig. 18, p. 191.) Interest in prospecting at this place was excited mainly by the finding at an elevation of about 1,950 feet, in the saddle nearly north of the triangulation signal on the summit of the

[1] Brooks, A. H., The mining industry in 1911: Bull. U. S. Geol. Survey No. 520, 1912, p. 32.

dome, of a large quartz bowlder liberally splotched with gold. This bowlder, which lay on the surface, measured about 3 by 2 by 1 to 1½ feet. Most of it is hard, white, glassy quartz, which, according to reports of prospectors who have sampled it, carries no gold. On one face, however, it is peppered with particles of gold, some of which are a quarter of an inch in diameter. It is suggested that the auriferous part may represent one wall of a vein formed subsequently to the main mass of the quartz.

When the bowlder was found the region was visited and staked, and several pits were put down. In the same saddle two claims, the Blue Bonanza and the Midnight Sun, were located, and an inclined shaft with a slope of 35° has been sunk near the end line between them. In the upper part of the shaft an 18-inch vein of quartz was discovered, but it gradually narrowed with depth until at the bottom it was less than a quarter of an inch wide. There are several fractures, however, which the owners intend to follow farther, in the hope that the ore body will again widen.

Two distinct periods of quartz-vein formation are apparent at this place. The older quartz is considerably crushed and contains cavities opened since the crushing. The younger quartz is most readily recognized by its well-formed glassy crystals and by its banded structure, parallel to the walls. The younger veins contain considerable deposits of sulphides, mainly galena, pyrite, and some stibnite, which occur predominantly along the walls parallel to the vein and in the interstices between the well-formed quartz crystals. Where weathering has broken down the sulphides in the younger quartz it is covered with a thick coating of iron oxide. Gold is here and there visible in the rock both near to and remote from the areas of sulphides. Without doubt, the gold seen in some specimens of the ore was introduced contemporaneously with the sulphides, but that seen in other specimens was probably introduced earlier.

Considerable silver occurs in the ore. One of the owners reported obtaining 3 grains of silver and 1 grain of gold from an ounce of rock. Tests in the laboratory of the Survey prove the silver mineral to be tetrahedrite, a sulphide of silver, copper, and antimony.

Half a mile south of the shaft just described, at an elevation of about 2,325 feet, an open cut and an inclined shaft about 12 feet deep exposes what seems to be a large body of mineralized quartz, the tenor of which is probably low, although samples have not been carefully tested. The vein trends about north and south and dips about 45° E. Not more than a quarter of a mile south of this place, near the 2,375-foot pinnacle, more or less lens-shaped masses of quartz, some of them over 6 feet in diameter, are exposed in a zone running north and south. The quartz is compact, little shattered, and glassy and does not look particularly promising. Little work has been done at this place, although a large amount of quartz has been broken down and scattered around.

Immediately west of the signal on the top of Ester Dome, at an elevation of about 2,425 feet, a vein known as the Farmer lode, trending north and south and dipping about 40° E., has been disclosed in an inclined shaft about 15 feet deep. The vein cuts the schists and is in turn cut by many small faults. It appears to be lens shaped, for it tapers out toward the bottom and toward the north wall of the cut. Sulphides, most commonly pyrites, are present, though not abundant. Gold is visible in the rock in a quantity which, though not accurately determined, is sufficient to warrant further prospecting and sampling.

A quartz vein reported to have been found on the southeastern slope of Sheep Creek valley at an elevation of about 1,500 feet was not visited by the writer, and no accurate data as to it were procured.

In the Goldstream basin between Big Eldorado and Twin creeks little lode mining has been done, and none of the several properties have been visited by the writer. In the Engineer Creek basin prospecting has been done near the divide between that stream and Columbia Creek and on Little Blanche Creek, a tributary of Engineer Creek. Near the head of Fox Creek Freeman & Sharf, it is reported, opened up a vein carrying considerable silver-bearing galena, as well as gold, and near the mouth of that stream a gold lode has been prospected. A lode has been located by Isaac Ogram on Rose Creek, a tributary of Gilmore Creek, and a lead carrying considerable galena and stibnite has been opened up by John Nightingale in Steamboat Creek valley. Near the head of Granite Creek, Busch & Anderson have been prospecting a vein from which 4½ tons of ore are said to have been tested at one of the customs mills. No statement as to its gold tenor was procured.

TWIN CREEK VALLEY.

Rainbow mine.—North of the junction of Skoogy and Twin creeks, at an elevation of 1,700 feet, a shaft has been sunk on the Rainbow claim (fig. 19) on a vein that trends nearly east and west and stands practically vertical, its dip being in most places more than 89° S. The lode has been prospected by means of shallow pits for several hundred feet, and in this distance it is apparently unfaulted and fairly uniform in character. Most of the country rock is schist, but in a pit 300 feet east of the shaft the vein clearly cuts fine-grained nonporphyritic granite with a sharply defined contact

The shaft is vertical and is 100 feet deep, and drifts 125 feet and 145 feet long, respectively, have been turned off from it to the east and to the west. In the eastern drift the vein is very regular in width, direction, and composition. It cuts across the country rock, which here consists of schists and quartzites. Both walls are well defined and are marked by fault planes. The rock stands well, so that no timbering is necessary in the drift.

In the western drift the conditions are more complex. A short distance from the shaft a narrow granite dike, dipping 40° E., appears in the footwall. This dike cuts across a small quartz stringer, which dips westward, but the dike is in turn cut by the main lode and has not been found on the hanging-wall side. Evidently it was faulted before the main vein was formed. On the walls of the dike is some quartz which marks the most acidic phase of the igneous

Figure 19.—Sketch map showing location of lode prospects in Twin and Skoogy Creek valleys.

rock. The granite is so badly decomposed that it falls to pieces when handled, and on account of its softness small slides have occurred at places where the ore rested on the granite as a footwall, leaving open spaces less than a foot wide and 2 to 3 feet long.

The country rock for a short distance west of the small granite dike is schist and quartzite, but for 40 feet farther west along the footwall it is a soft, greasy white gougelike material, which flows almost like clay. This material looks like a thoroughly decomposed granite, but tests show that most of it is a finely comminuted quartz and that only a small amount of it is aluminous. Still farther west the main lode is transected by a small fault which offsets it about a foot to the south. Beyond this fault, which is near the end of the drift, granite, apparently part of a considerable mass, is seen in the hanging wall and in the roof on the footwall. Near the margin of the granite on the hanging wall is a border phase of quartzitic material which has apparently been produced by contact metamorphism. This granite clearly was earlier than the ore and had cooled, consolidated, and been faulted before the vein filling was introduced.

The richest ore of the Rainbow mine is reported to occur in a shoot which dips about 45° E. Too little development work has been done to show whether this dip is general or is characteristic only of the single shoot that has been found. The parallelism of the shoot and the small granite dike noted in the west drift near the breast, however, suggests some genetic connection between the two.

The vein material carries, in addition to the more or less glassy quartz, a considerable amount of sulphides. Pyrite, arsenopyrite, galena, and sphalerite have been recognized in it, and possibly some others might be detected by chemical tests. The sulphides are almost entirely confined to the vein material, but in a few places they occur in the country rock. In such places the sulphide is generally pyrite in sharply crystalline unoxidized cubes. Visible gold is rather rare, though the owners of the mine report that the value of the ore lies in its free gold and that the sulphides do not carry much gold. The average tenor of the ore is not known with certainty. A mill run of a sample of 19 tons of ore is reported to have shown a gold content worth $38 a ton, but this was probably selected material. The fineness of the gold as determined in two assays reported by F. W. Hawkins is 0.838½ and 0.839½.

The machinery for a two-stamp Nissen mill was expected to arrive before the close of 1912. Much more underground development will be necessary before the veins can furnish a constant supply of ore for the mill.

Properties east of the Rainbow mine.—A short distance northeast of the Rainbow mine, at an elevation of about 1,825 feet, a 10-foot shaft has disclosed a 2-foot quartz vein which appears favorable for further exploitation. The vein strikes nearly east and west and dips steeply south. The ore is mainly shattered and sheared milky quartz containing only a small amount of sulphides.

Near the road a quarter of a mile east of this shaft, at an elevation of 1,975 feet, is a small pit which has been abandoned for some time. Coarse gold is reported to have been found in the slide rock near the surface, but at the time of visit the pit had caved so badly that it was impossible to determine whether there was at this locality a definite lead in place.

On the Moonlight claim, at an elevation of 1,900 feet on the southern slope of the valley, is a shaft about 50 feet deep from which has been turned off a 15-foot drift. The vein here rolls a little, but has a fairly steep dip to the north. It is about a foot wide and is said to carry considerable gold in some of the slip seams. The quartz is broken into wedge-shaped blocks, the thin edges of which overlap. No faults were seen in the small portion of the vein so far uncovered. The vein material is mainly quartz with a large amount of sulphides, and the country rock is quartzite schist. Prospect pits have been sunk at intervals west of the shaft, and vein material can be traced to the granite area above the junction of Twin and Skoogy creeks. East of the shaft, along this same trend, the Sunlight claim has been staked. Little work has been done on this claim, though, according to report, the vein has been located on it by means of shallow prospect pits.

North of the Moonlight lode a claim has been staked by Zimmerman and others on the supposed continuation of the Rainbow lode, and a short open cut has been run into the hillside south of Twin Creek at an elevation of about 1,700 feet. The strike of the lode is not constant, appearing to swing from east-west toward north-south, and the dip also changes from north to east. Assays of ore from the dump containing considerable sulphide-bearing material are said to have given returns of $12 in silver and $4 in gold to the ton. Under present conditions ore of this tenor can not be profitably treated in this region.

At the extreme head of Twin Creek W. Jackson and others have sunk a number of prospect holes. In a pit above the road, at an elevation of about 2,500 feet, a large amount of quartz cuts the greenstone-like schists that form the country rock. The quartz shows almost no sulphide mineralization. No trustworthy determinations of the extent or tenor of this lead have been made. It is probable, however, that its gold tenor is low, for the quartz differs decidedly in appearance from that in the rich lodes.

Properties west of the Rainbow mine.—The Apex claim, which lies adjacent to the Rainbow mine on the west, has been prospected by shallow pits that have revealed a vein having an eastward-dipping shoot of ore, apparently the extension of the Rainbow lead. No ore has been produced from this property, and not enough development work has been done to expose the vein satisfactorily. The proximity of the lead to the granite indicates that granite will probably be encountered in the underground workings a rather short distance below the surface.

In the granite area, near its northern contact with the schist, at the mouth of Skoogy Gulch, Peter Goepfert has driven a short adit on a nearly vertical 2-inch stringer of quartz which appears to cut the granite. No ore has been milled from this property, and although the material is said to carry some free gold, it looks barren.

A short distance up Skoogy Gulch, below the road crossing, a tunnel about 200 feet long has been driven N. 10° E. According to report, much of the material encountered in this tunnel is mineralized, but except for a few stringers and immediately at the face there is no distinct vein. The small stringers are transverse to the direction of the tunnel. At the end of the tunnel a strongly marked fault plane trends about east and west and dips steeply north. South of the fault there is from 6 to 8 inches of vein material, which, however, has not been tested for gold. Some gouge occurs along the fault.

Still farther up Skoogy Gulch, at an elevation of 1,750 feet, a short tunnel has been driven on a ledge said to carry considerable galena. This property was not examined in 1912, as no work was in progress. Another galena lode is said to have been found west of Skoogy Gulch at an elevation of about 1,725 feet, near the northern contact of the southern granite mass. The ore is reported to lie nearly flat, but this attitude is said to be due to downhill creep, and prospecting has not yet progressed far enough to disclose the real trend of the lead.

On the hillside west of Skoogy Gulch considerable prospecting has been done in the past, but during the summer of 1912 no mining was in progress on any of the claims. The shafts and tunnels were no longer accessible, and the following statements have been taken from reports by Prindle,[1] who visited the region in 1909, when some work was being done.

> The prospects in Skoogy Gulch, including the North Star, Center Star, S. S., and other locations, are all in schist close to intrusive rocks. * * * The rock in which the mining developments have been carried out is quartzite schist and quartz-mica schist striking northeast. The rock is somewhat metamorphosed by the contact influence of the intrusive rocks, an influence shown by the presence of a large amount of biotite and some andalusite. While some of the schist is very micaceous, much of it is a dense blocky quartzite schist. A small dike about half an inch thick in one of the tunnels shows the closeness of the igneous influence.
>
> Auriferous quartz veins are reported to have been traced on this [western] slope of Skoogy Gulch for 500 to 800 feet. At one locality, where surface prospecting in 1908 had discovered an auriferous stringer about 4 inches thick, together with several smaller auriferous stringers, some of them along the joint planes of the schist, a shaft about 65 feet deep and a tunnel about 200 feet long had revealed in 1909 a considerable number of stringers, some of them barren and some of them carrying high values.
>
> The vein regarded as the main lode strikes northwest and is said to average about 3 feet in thickness. Several hundred feet farther in the same direction a shaft has been sunk on a vein 10 to 12 feet thick, which carries values.

[1] Prindle, L. M., op. cit., pp. 223–224.

The marginal portion of the porphyritic granite contains in places a large amount of iron pyrites in the granite itself and along the joint planes. Iron pyrites occurs similarly along the joint planes of the schist at the locality of the auriferous quartz veins. The granite contains also some pegmatitic quartz and feldspar, occurring as feldspathic veins in quartz and quartz veins in feldspar. In some of these veins both margins are feldspar and the middle is quartz. The quartz present in these granitic products is gray and glassy. In the quartz veins that have been opened there is a similar gray, glassy quartz and this is apparently barren. The auriferous quartz is grayish white and opaque. The veins of both the barren quartz and the auriferous quartz contain a small amount of feldspar. This is mostly kaolinized, but so far as determined is like that of the pegmatitic granite dikes above mentioned. Cavities studded with quartz crystals are rather common in the quartz. The gold occurs partly in visible form embedded either with limonitized crystals of pyrite or in the quartz. The auriferous quartz contains a large number of microscopic liquid inclusions and so far as observed has been more or less shattered. Although it is possible that the auriferous pyrite and free gold were deposited synchronously with the quartz, it seems more probable that the deposition of gold was subsequent to a shattering of the quartz and synchronous with the deposition of pyrite along the joint planes in the schist and porphyritic granite.

TRIBUTARIES OF CRIPPLE CREEK.

ESTER CREEK VALLEY.

HUDSON MINE AND VICINITY.

In the Ester Creek valley (fig. 20) none of the prospects have yet been developed to a producing stage except the property locally known as the Hudson mine. This group of claims is on the ridge north of Ester Creek between Moose Gulch and Ready Bullion Creek, extending to an elevation of about 1,600 feet. The place where most of the mining has been done is at an elevation of about 1,500 feet. A shaft was sunk here, but in following the lead its course became so crooked that hoisting was difficult, so it was abandoned and a new shaft was sunk a short distance above. The new shaft is planned to intersect the old workings at a depth of 100 feet, but it will be continued below this depth and drifts will be turned off to open stoping ground. The new shaft, which is vertical, was sunk at the rate of about 3 feet a day.

Although the old shaft was no longer in use in 1912, it was still accessible and afforded the best insight into the character and mode of occurrence of the ore. To a depth of 40 feet the shaft is vertical, but from that depth downward the dip of the lead flattens, and an incline at an angle of 45°, turned off to the northwest, extends to a depth of about 94 feet. The lower part of the incline had caved a little and at the time of visit the ventilation was poor. Although all the rock is somewhat mineralized, there seems to be no well-defined lode. A fault plane on the east side of the shaft has apparently been taken as the footwall of the ore body, but so far as could be learned this plane is not a true footwall, for there is ore below it, and the only reason for considering it the footwall is that it forms a good surface to mine to. On this fault plane is a varying thickness of gouge which shows well-marked striations, as does also the fault plane. Movement in many directions is indicated by the grooves and scratches.

The country rock is mainly a thinly laminated dark greasy-looking chloritic schist, with the laminæ minutely crinkled. Numerous small

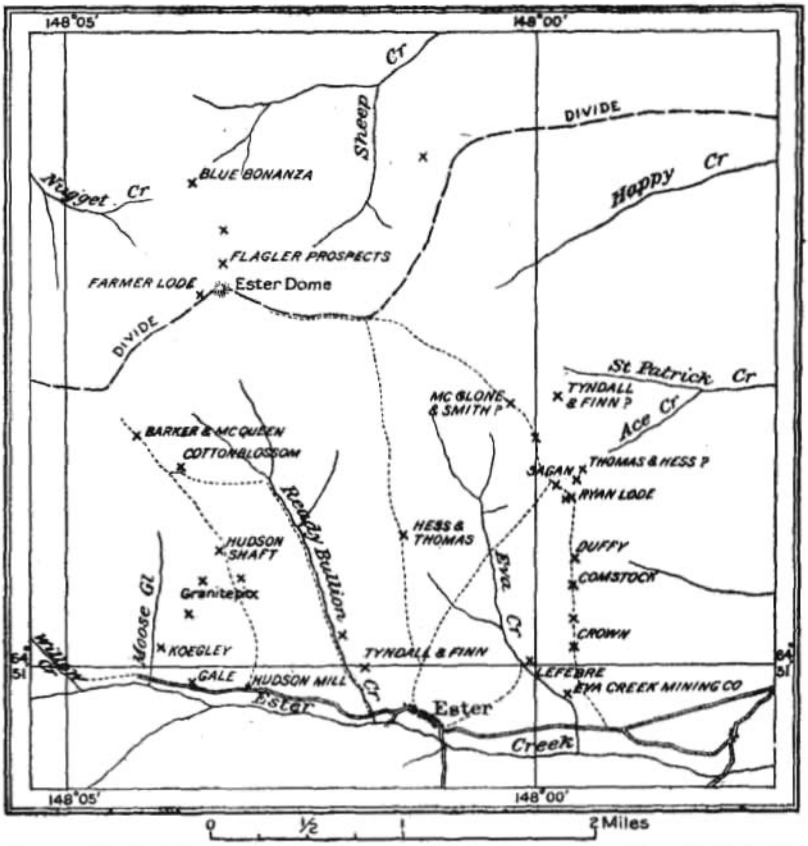


FIGURE 20.—Sketch map showing location of lode prospects in Ester Creek valley and vicinity.

quartz veins, ranging from mere films to stringers an inch or so thick, cut the schist at high angles. In addition to these narrow veins there are numerous larger masses of quartz having a more or less bowlder-like appearance. These masses are composed mainly of hard, glassy quartz, which is practically barren. Their surfaces are fairly smooth, are more or less completely enveloped in gouge, and are usually covered with slickensides. Probably many of these masses were formed by faulting, but some are probably old quartz lenses traversed by narrow younger veins.

At a few places quartzite forms the country rock. It is usually white or brownish and consists almost entirely of quartz. Silicification has apparently affected the rock at a late stage, for recently deposited quartz covers many of the joint planes and extends from them into the rock. The brown quartzite is stained with limonite, formed apparently by the decomposition of pyrite, which is sparsely disseminated through the rock. All the quartzites suggest proximity to an igneous intrusive, but the evidence is by no means conclusive.

The richest ore of this mine occurs in the narrow quartz stringers which intersect the country rock in all directions. These stringers usually adhere firmly to the country rock, so that the whole material must be mined and milled. The gold in the stringers is usually in small particles, but in places these are large enough to be recognized, even underground, at a distance of 3 or 4 feet. Sulphides are practically absent from these veins and the gold occurs free. It is bright yellow and seems to be more abundant near the walls than in the center of a vein. In the centers of the small veins at many places are cavities into which perfectly formed quartz crystals project.

Although the gold occurs mainly in the narrow veins, numerous particles of gold were found by panning a sample of the country schist from which nearly all pieces of quartz had been picked. This result shows that some of the schist is auriferous, but most of it that lies remote from the small veins is believed to be practically barren.

No estimate of the tenor or extent of the material to be mined has been made. Although very high gold assays have been obtained from pieces of the small quartz veins, they are of little value in showing what the average ore will yield, for a large amount of schist and rock of low gold content must be treated when the mine is opened commercially. Before an expensive mining and milling plant is installed the tenor of the rock for the width that must be mined should be accurately determined.

At intervals on the hillside below the Hudson shaft are numerous prospect pits and several large quartz bowlders, only partly buried in the moss. A prospect pit south and a little west of the main shaft, at an elevation of 1,400 feet, shows at its west end dark schist similar to that in the mine. East of this schist is a reddish-brown, much-decomposed granitic rock, and this is followed toward the east by a seam of gouge and a well-marked fault plane, beyond which is more granitic material. The width of the exposure is only about 5 feet, so that the extent of the granitic rock to the east is not known, but apparently it is not great. Slickensides have been abundantly developed along the fault. The granitic material strongly resembles that at the Fredericks mine near Ridgetop, already described (p. 194).

Although the underground workings have not yet been carried far enough to yield a constant supply of ore, a mill has been built on the north side of Ester Creek midway between Moose and Ready Bullion creeks. The construction work had been much delayed, but the mill was expected to be in running order soon after the 1st of October. The building is large enough for twice the present installation, which consists of a battery of two Nissen stamps. Space has been reserved for concentrating tables, but they will not be put in for some time, as it is believed that most of the gold in the ore will be recovered in the mortar on the plates. Water will be obtained from a well driven near the mill, which is believed by the owners to be capable of affording a sufficient supply throughout the year. The ore will be hauled by teams from the mine to the mill and stored in bins until required. The distance between the two places is about two-thirds of a mile and the difference in elevation is about 600 feet, the loaded wagons having a downhill haul.

On the north slope of Ester Creek valley, a fifth of a mile east of the mouth of Moose Gulch, a prospect pit 20 feet deep has been sunk on heavily iron-stained quartz and brown-weathering schist. The quartz is glassy and compact and appears to occur in small stringers in the schist, but many large pieces of quartz were seen on the dump. The material is reported to carry some gold.

A short distance above the ditch line on the eastern slope of Moose Creek valley, on the Koegley claim, a short tunnel has been driven in an area of mineralized schist cut by small quartz stringers. No strongly marked lead was followed, but here and there small quartz stringers and slips trending parallel with the tunnel have been found. According to men interested in the claim the small quartz stringers carry the most gold, but all the material traversed by the tunnel contains enough gold to warrant milling.

EVA CREEK BASIN.

Practically the whole of the Eva Creek basin is covered with quartz claim locations, and a great number of prospect pits have been sunk, particularly along the ridge, where the overburden is thinnest. Most of the holes have caved, however, and no longer afford exposures of the bedrock, and natural outcrops are practically absent. In the following notes only the more accessible prospects will be described.

Half a mile north of the mouth of Eva Creek a quartz vein which trends about N. 60° W. and dips 68° SW. has been prospected. The easternmost opening on this lead is an abandoned tunnel. A 75-foot shaft was sunk above this tunnel, and a narrow, well-defined vein was found. A little to the northwest, on the same vein, an open cut about 40 feet above the stream had exposed the vein for nearly 100 feet and the ore had been stoped out. Short tunnels near the creek level have been driven to cut the vein, and most of the ore that could be easily won has been removed. The walls stand well, even without timbering, but to continue mining it will be necessary to install a pump. The occurrence of the ore is more like that of the mines and prospects in the Chatanika basin than that of most of the other prospects in the Cripple Creek region.

A short distance farther up Eva Creek Hegan & Lefebre have driven a tunnel about 25 feet above the creek, on a vein which trends nearly north and south. In the breast of this tunnel are numerous flat-lying quartz lenses which are much crushed. About 8 feet from the face is a crosscutting fracture zone with some broken-up country rock and quartz. This seam is very narrow, and no statement of its gold tenor was obtained, but the owners are sinking on it.

Prospect pits are scattered all the way up the ridge east of Eva Creek, but only on the Ryan lode, at an elevation of about 1,325 feet, has any considerable work been done. Two shafts have been sunk on this property. The northern shaft is shallow and has been abandoned for some time. Practically all the material on the dump is quartz; there are almost no fragments of schist. The southern shaft is said to be over 90 feet deep, but in 1912 it had caved so much that the lower 30 feet was filled. The maximum width of the vein is about 16 inches. Near the bottom of the shaft the vein has been faulted, and it pinched out to the west. To judge from the direction in which the schists near the fault have been dragged, the continuation of the vein should probably be sought in the hanging wall above the point where the vein is cut off.

The rocks abutting on the fault are strongly slickensided, and although the grooves run in all directions, apparently the main movement was horizontal on the nearly vertical plane. Near the fault is considerable gouge, which seems to be ground-up material derived from the vein and the country rock. More or less parallel with the fault is a white, much-decomposed rock that resembles a thoroughly weathered granite. It consists mainly of quartz with subordinate amounts of feldspar, now altered to kaolin.

In the saddle northwest of the Ryan lode a shaft 30 feet deep disclosed auriferous material. At this place the whole rock seems to be mineralized, but no distinct vein with well-defined walls was found. The country rock is dark, much broken-up schist, containing numerous small quartz stringers. Although faults are common, they appear to have effected but a small amount of displacement. Sulphides are not abundant, although some of the ore is stained with limonite, probably derived from the decomposition of disseminated pyrite. A little of the vein matter, consisting of fine-grained quartz and feldspathic material, simulates a marginal phase of granite. The extent and distribution of rock of this kind, however, were not determined.

MISCELLANEOUS PROSPECTS.

As has been stated, undoubtedly many places where lode prospecting has been carried on have been omitted from the foregoing description. There are, however, some claims whose location, though more or less indefinite, places them outside of the drainage basins already described. None of these claims were visited in 1912, but in order to make this report as complete as possible the few available notes on these properties are given.

Between the headwater branches of the tributary of Columbia Creek, at an elevation of about 875 feet, an adit 100 feet long is reported to have been driven on a quartz lead. The ore is said to be of low grade but free milling. Above this place are the prospectors who have been working at the head of Engineer Creek, in the Goldstream basin. According to report, the whole region forming the Columbia-Steele-Engineer divide has been covered with lode claim locations, and at least four different parties have been more or less actively prospecting for veins, but so far apparently without notable success.

East of Steele Creek, on the ridge between that stream and Rex Creek, a tributary of Smallwood Creek, a little prospecting has been in progress. This work apparently was done mainly in the vicinity of the 1,825-foot hill. All the leads through this region are said to be wide, but the ore is of low grade and whether the properties can be profitably developed under present conditions is doubtful.

FUTURE OF LODE MINING.

In the earlier part of this report the mining developments in the vicinity of Fairbanks have been described with particular reference to the physical features of the veins and the extent and character of the work accomplished. There are, however, many other phases of the subject concerning which miners in the region or prospective investors wish to be informed. Many questions relating to these phases can not be satisfactorily answered, but it seems desirable at this place to set forth the inferences that may be drawn regarding the probable conditions, both geologic and commercial, to be expected in the future development of lodes in this region.

AREAL EXTENT OF MINERALIZATION.

Plate XI (in pocket) shows the places where gold-bearing lodes have been prospected and ore has been found. Whether this distribution of prospects truly represents the distribution of auriferous veins is a question of importance which can not yet be answered definitely. The two lines of available evidence lead to somewhat opposite conclusions. The rich placers are more or less closely confined to the streams that drain areas in which the most lode prospecting has been done, a fact which suggests that the auriferous lodes are more or less restricted to the prospected areas, though there are placers in parts of the Goldstream and other basins where lodes have not yet been discovered.

On the other hand, when deductions are based on the supposed origin of the auriferous lodes the conclusion is reached that the veins are much more widespread than the present lode prospecting. In order to explain why the origin of the veins throws light on the areal extent of mineralization, it is necessary to consider the theory advanced by Mr. Prindle (pp. 89–92). According to this theory, the mineralization was closely connected in time with the intrusion of the granitic igneous rocks. It was due not only to the mechanical effects of the intrusion, which fractured the rocks and provided open spaces in which the minerals were deposited, but also to the introduction of the minerals, which were derived from a deep-seated source. If this explanation is correct, it follows that the areas near the intrusive granitic rocks are the places where lodes are most likely to occur. Outcrops of these igneous rocks are widely distributed throughout the Fairbanks region, and in many places where these rocks are not exposed they probably occur a relatively short distance below the surface. In fact, the territory adjacent to Fairbanks may reasonably be regarded as occupied by schists underlain by a large granitic mass from which igneous material protrudes in irregular apophyses, some of which have been revealed at the surface by erosion. It is believed, therefore, that auriferous veins may reasonably be expected to occur at many places where their presence has not yet been proved by prospecting.

LOWER LIMIT OF MINERALIZATION.

Although the intrusion of granitic material was more or less closely associated with the mineralization, neither process was a single event, as there were several periods both of intrusion and of mineralization. Prindle[1] states that the sequence of intrusion was in general quartz diorite, porphyritic biotite granite, and persilicic dikes. From studies both by Prindle and by the writer it has been determined that mineralization of at least two types may be recognized—that producing a series of older auriferous quartz veins and that producing a later sulphide-bearing series. In addition there are veins of a much earlier period, with which the present investigations are not concerned, for so far as known they are not auriferous. The fact that all the veins and all the igneous rocks were not contemporaneous indi-

[1] Prindle, L. M., op. cit., p. 216.

cates that certain veins may cut certain of the igneous rocks. This conclusion is significant in determining the depth to which the veins may extend, for it suggests that they may persist into the areas occupied by the granite and are not necessarily limited to the country rock adjacent to the intrusive masses. This suggestion is in accord with the field observations, for at several of the mines veins were found occupying fissures along faults by which granite dikes have been offset. Therefore, although the veins probably did not extend as distinct veins to the zone where the rocks were in a state of flowage, there is no valid reason for placing the lower limit of vein formation above the surface of the granite, and some of the veins may reach a depth regarded by miners as considerable.

CHARACTER OF MINERALIZATION IN DEPTH.

The tenor of the ore and its physical character in the accessible surface portions can be examined and the commercial return that can be obtained by development of the deposit may be calculated with some degree of mathematical precision. It is important, however, to determine to what depth the several factors bearing on the problem, notably the chemical composition of the ore, are applicable. This is particularly true of auriferous quartz veins, which near the surface carry gold mainly in the native state. From such veins the gold can be recovered by simple processes of crushing and concentration. If, on the other hand, the gold in the unweathered ore is mainly in a state of chemical combination or mechanical suspension in particles so finely disseminated that its recovery necessitates metallurgical treatment, it may not warrant mining, even though it may be as abundant as in the free-milling ore.

It has already been stated that at least two distinct types of mineralization have been recognized in the shallow surface portions of the veins so far exploited. Each of these types requires separate description and the facts concerning one do not necessarily apply to the other. Failure to discriminate between the two has led to certain misconceptions. Not enough data have yet been gathered to determine with finality the character of the ore in depth, and the following statements are therefore tentative.

So far as determined the non sulphide-bearing auriferous quartz veins contain gold in a native state as an original constituent, and this is interpreted as indicating that to a moderate depth below the surface these veins are of approximately uniform composition. In other words, it is believed that to the depth which will probably be reached in mining in the near future the gold in the older auriferous quartz veins is free milling.

In the sulphide-bearing veins visible native gold was introduced contemporaneously with the sulphides and probably these minerals also carry a considerable amount of gold so finely divided as to be invisible. Under present milling practices the invisible gold is not recovered and its proportion to the visible gold is unknown. There are, therefore, no data as to the quantity of gold carried by the sulphides at different depths in the 300 feet to which mining has been carried below the surface, and deductions as to the conditions at still lower levels are therefore practically guesses. It should be realized that in veins of this type some of the gold in the surface portion is probably derived from broken-down sulphides and that this portion therefore contains more gold than can be recovered from unweathered ore from lower levels by milling without metallurgical processes, so that the average deep ore probably will not yield as much gold as that obtained nearer the surface.

In several of the mines examined veins of both types occur together. In some of these places the older vein had been fractured and later solutions of the sulphide-bearing type had been introduced. Where this happened the average gold content of the rock was increased and a rich shoot resulted. There is no reason why this condition should not occur also in the deeper parts of the deposit. In fact, it is possible that in the deeper parts the older quartz veins were more brittle than the other rocks and therefore were especially susceptible to fracturing, and allowed the later solutions to pass through. This suggestion, however, is based on so many rather indefinite assumptions that it is of little practical value and should serve only to indicate that to a moderate depth there is probably no marked decrease in the number of intersections of veins belonging to the two different periods.

TENOR OF THE ORE.

Statements of the value of the ore mined at the present time range all the way from a few dollars to over a thousand dollars a ton. Many of these statements are based on assays of small selected specimens and have no general application. None of the private mills have made returns of the tenor of the ore that are available for publication, so that the average value of the ore mined is not known. The records of the Fairbanks test mill show that the average tenor of the 64 tons of ore from 24 different properties milled in the first three months of 1912 was $69.87. (See p. 179.) It was reported that the 292 tons from five different properties milled at the Chena mill in 1911 yielded an average gold content worth $106.80 a ton. These results undoubtedly represent selected ore and consequently are higher than would be obtained in ordinary commercial practice if the mines were in constant operation. It seems certain, however, that the average vein material from many of the mines now in operation, if kept reasonably free from waste in mining, will run about $50 a ton. This estimate includes the free gold only, for, except at two or three mills, no concentrates are saved, though they undoubtedly contain additional gold.

Ore with these high gold values comes mainly from small quartz veins, many of which are only a foot or so in width. There are in the district, however, larger veins, some of which are as much as 15 feet wide. Some of these have been sampled and are said to yield from $10 to $15 a ton in gold. Under present mining costs ore of this low tenor can not be commercially developed in this region. With the reduction of expenses which may reasonably be expected, these low-grade deposits may possibly be developed profitably on a large scale.

It is undoubtedly true that at present only the richest parts of the veins are being mined. With the opening of the deposits on a large scale, undoubtedly the tenor of the ore milled will decrease. In large measure this will be due to improvements in milling practice through which lower-grade ore can be treated at a profit, but it will be due also to actual decrease in the tenor of the veins with increasing depth. The extent of this decrease is not known, though it now seems probable that, factors other than depth being eliminated, the veins should contain nearly as much gold at the depth which will be reached in the near future by mining as they do a few score feet below the surface.

MINING COSTS.

GENERAL EXPENSES.

At the present time, owing to the remote position of the district, its partial isolation during the winter, and its lack of productive occupations during the months when the surface water and the ground are frozen, the costs of supplies and wages are high. With the development of the region many of these disadvantages will be decreased or removed, so that a decided reduction in operating and living expenses is expected. Thus, when lode mining increases, many persons will find permanent employment throughout the year and will no longer be compelled to remain idle during the seven or eight months that the placer mines are closed. Moreover, if business increased, transportation facilities could be improved and charges could be reduced without affecting the profits. So many factors enter into the problem, and they interact so intricately, that the evaluation of the separate items which bear on the future mining costs in the district is impossible; but as a whole the costs will tend to decrease rather than increase.

COST OF POWER.

Although, on the whole, the general trend of costs will be downward, special expenses to which small mines are not subject will become more and more necessary as larger mines are developed. The most notable expense of this class is that for power. As long as the mines are shallow or are accessible from hillside tunnels little power other than that of man is necessary in mining, for underground drilling is done by hand drills, the ore and waste are removed by a man and windlass or by hand tramming, and water is kept away from the workings by allowing it to run off along the slope of the tunnel or by hoisting it with a windlass.

With increasing depth, however, power for pumping and hoisting becomes more and more necessary, not only on account of the larger amount of material that must be handled, but also of the longer distance the same amount of material must be moved. In the matter of pumping, which has given a number of operators concern, probably the greatest amount of water will be found in the surface zone. Proportionally more water will occur within the first few hundred feet than lower down, but with increased depth the water must be lifted a greater distance and will be more troublesome and more expensive to handle. Therefore, although existing conditions indicate that probably most of the mines will not be excessively wet, charges for pumping must be anticipated and provided for.

As the determination of the amount of water that may be expected in depth is a matter of considerable importance the following reasons for believing that under ordinary conditions the amount will not be excessive are given: First, the average mean annual precipitation at Fairbanks for the years 1906 to 1910, inclusive, was only 11.13 inches, and although precipitation is probably greater in the higher areas, it is nevertheless small; second, the frozen condition of the surficial parts of the deposits prevents much ground-water storage and increases the rapidity of run-off; third, except in the surficial portions the rocks are rather impervious and afford few channels for the passage of water underground; fourth, in practically all the underground work examined no considerable amount of water has been encountered.

At present power for various purposes at the mines and mills where machinery is used is produced from wood or gasoline as fuel. Timber near the mines is not abundant and is becoming scarcer, so that although in favorable places wood is sold for $5 a cord most of the mines pay about $15 a cord. All the gasoline used comes from the States and costs 60 cents or more a gallon at the mines. No coal is used as fuel, though there is a large amount of lignite 60 to 100 miles distant. Plans have been considered for utilizing this coal either by transporting it to Fairbanks or by transforming its latent power into electric power and transmitting it to places where it is needed, but uncertainty as to the Government's policy with regard to the coal lands has delayed this enterprise. Not enough water is available for use as a direct source of power at the mines and mills, and the projects that have been proposed to utilize the more distant supplies required so large an investment and presented so many difficulties that they have been abandoned. With increased transportation facilities some decrease in charges for wood and gasoline may be expected, but decided reduction in the cost of power probably depends on the development of the known coal resources.

MISCELLANEOUS SUPPLIES.

Increased development requires a more elaborate surface and underground equipment, and at those mines which are far from their mills cheap methods of intercommunication must be devised. All these matters demand careful consideration and can be most economically and satisfactorily determined through detailed examination by competent authorities. Ordinarily the looser methods practiced in many placer camps are not permissible in lode mining, and operators should obtain expert advice before undertaking the purchase of expensive machinery and similar equipment or laying out a system for future underground development.

In the shallower parts of the deposits visited little or no timber is now used. The walls stand well even down to 300 feet below the surface, and the few timbers seen were used more for lagging than for carrying weight. So little strength is required that most of the timber is merely 16-foot cordwood, much of which has been charred by forest fires. That not much support is necessary underground is fortunate, for a set of round pole timber (three pieces) costs $3 and a square set about $6, and very little good material for mine timbers can be found near at hand. The amount of timber used when more extensive openings are made underground will be much greater in proportion to the size of the openings than at present, and increasing difficulty and expense in getting a suitable supply should be expected.

INDEX.

RECENT SURVEY PUBLICATIONS ON ALASKA.

[Arranged geographically. A complete list can be had on application.]

All these publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained free of charge (except certain maps) on application.

2. A certain number are delivered to Senators and Representatives in Congress for distribution.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost. The publications marked with an asterisk (*) in this list are out of stock at the Survey but can be purchased from the Superintendent of Documents at the prices stated.

4. Copies of all Government publications are furnished to the principal public libraries throughout the United States, where they can be consulted by those interested.

GENERAL.

*The geography and geology of Alaska, a summary of existing knowledge, by A. H. Brooks, with a section on climate, by Cleveland Abbe, jr., and a topographic map and description thereof, by R. U. Goode. Professional Paper 45, 1906, 327 pp. $1.

*Placer mining in Alaska in 1904, by A. H. Brooks. In Bulletin 259, 1905, pp. 18–31. 15 cents.

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*The distribution of mineral resources in Alaska, by A. H. Brooks. In Bulletin 345, pp. 18–29. 45 cents.

Mineral resources of Alaska, by A. H. Brooks. In Bulletin 394, 1909, pp. 172–207.

*Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Bulletin 263, 1905, 362 pp. 35 cents. Abstract in *Bulletin 259, 1905, pp. 32–46. 15 cents.

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Map showing distribution of mineral resources in Alaska, by A. H. Brooks; scale, 1:5,000,000. Price 20 cents. Also included in * Bulletin 520. 50 cents.

SOUTHEASTERN ALASKA.

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*The Porcupine placer district, Alaska, by C. W. Wright. Bulletin 236, 1904, 35 pp. 15 cents.

*The Treadwell ore deposits, by A. C. Spencer. In Bulletin 259, 1905, pp. 69–87. 15 cents.

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*Lode mining in southeastern Alaska in 1907, by C. W. Wright. In Bulletin 345, 1908, pp. 78–97. 45 cents.

*The building stones and materials of southeastern Alaska, by C. W. Wright. In Bulletin 345, 1908, pp. 116–126. 45 cents.

*Copper deposits on Kasaan Peninsula, Prince of Wales Island, by C. W. Wright and Sidney Paige. In Bulletin 345, 1908, pp. 98–115. 45 cents.

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*Mining in southeastern Alaska, by C. W. Wright. In Bulletin 379, 1909, pp. 67–86. 50 cents.

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A water-power reconnaissance in southeastern Alaska, by J. C. Hoyt. In Bulletin 442, 1910, pp. 147–157.
Geology and mineral resources of the Berners Bay region, Alaska, by Adolph Knopf. Bulletin 446, 1911, 58 pp.
Mining in southeastern Alaska, by Adolph Knopf. In Bulletin 480, 1911, pp. 94–102.
The Eagle River region, by Adolph Knopf. In Bulletin 480, 1911, pp. 103–111.
The Eagle River region, southeastern Alaska, by Adolph Knopf, including detailed geologic and topographic maps. Bulletin 502, 1912, 61 pp.
The Sitka mining district, Alaska, by Adolph Knopf. Bulletin 504, 1912, 32 pp.
The earthquakes at Yakutat Bay, Alaska, in September, 1899, by R. S. Tarr and Lawrence Martin. Professional Paper 69, 1912, 135 pp.

Topographic maps.

Juneau special map; scale, 1: 62,500; by W. J. Peters. For sale at 10 cents each or $3 for 50.
Berners Bay special map; scale, 1 : 62,500; by R. B. Oliver. For sale at 10 cents each or $3 for 50.
Topographic map of the Juneau gold belt, Alaska. Contained in *Bulletin 287, Plate XXXVI, 1906. 75 cents. Not issued separately.
Kasaan Peninsula, Prince of Wales Island. No. 520–A; scale, 1 : 62,500; by R. H. Sargent, D. C. Witherspoon, and J. W. Bagley. For sale at 10 cents each or $3 for 50.
Copper Mountain and vicinity, Prince of Wales Island, scale, 1: 62,500; by R. H. Sargent. For sale at 10 cents each or $3 for 50.

CONTROLLER BAY, PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS.

*The mineral resources of the Mount Wrangell district, Alaska, by W. C. Mendenhall. Professional Paper 15, 1903, 71 pp. Contains map of Prince William Sound and Copper River region; scale, 12 miles=1 inch. 30 cents.
*Bering River coal field, by G. C. Martin. In Bulletin 259, 1905, pp. 140–150. 15 cents.
*Cape Yaktag placers, by G. C. Martin In Bulletin 259, 1905, pp. 88–89. 15 cents.
*Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin 259, 1905, pp. 128–139. 15 cents. (Abstract from Bulletin 250.)
The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.
Geology of the central Copper River region, Alaska, by W. C. Mendenhall. Professional Paper 41, 1905, 133 pp.
Copper and other mineral resources of Prince William Sound, by U. S. Grant. In Bulletin 284, 1906, pp. 78–87.
Distribution and character of the Bering River coal, by G. C. Martin. In Bulletin 284, 1906, pp. 65–76.
Petroleum at Controller Bay, by G. C. Martin. In Bulletin 314, 1907, pp. 89–103.
Geology and mineral resources of Controller Bay region, by G. C. Martin. Bulletin 335, 1908, 141 pp.
*Notes on copper prospects of Prince William Sound, by F. H. Moffit. In Bulletin 345, 1908, pp. 176–178. 45 cents.
*Mineral resources of the Kotsina and Chitina valleys, Copper River region, by F. H. Moffit and A. G. Maddren. In Bulletin 345, 1908, pp. 127-175. 45 cents.
Mineral resources of the Kotsina-Chitina region, by F. H. Moffit and A. G. Maddren. Bulletin 374, 1909, 103 pp.
*Copper mining and prospecting on Prince William Sound, by U. S. Grant and D. F. Higgins, jr. In Bulletin 379, 1909, pp. 87–96. 50 cents.
*Gold on Prince William Sound, by U. S. Grant. In Bulletin 379, 1909, p. 97. 50 cents.
*Mining in the Kotsina-Chitina, Chistochina, and Valdez Creek regions, by F. H. Moffit. In Bulletin 379, 1909, pp. 153–160. 50 cents.
*Mineral resources of the Nabesna-White River district, by F. H. Moffit and Adolph Knopf. In Bulletin 379, 1909, pp. 161–180. 50 cents.
Mineral resources of the Nabesna-White River district, by F. H. Moffit and Adolph Knopf; with a section on the Quaternary, by S. R. Capps. Bulletin 417, 1910, 64 pp.
Mining in the Chitina district, by F. H. Moffit. In Bulletin 442, 1910, pp. 158–163.
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Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska, by U. S. Grant and D. F. Higgins. Bulletin 443, 1910, 89 pp.
Geology and mineral resources of the Nizina district, Alaska, by F. H. Moffit and S. R. Capps. Bulletin 448, 1911, 111 pp.
Headwater regions of Gulkana and Susitna rivers, Alaska, with accounts of the Valdez Creek and Chistochina placer districts, by F. H. Moffit; including geologic and topographic reconnaissance maps. Bulletin 498, 1912, 82 pp.
The upper Susitna and Chistochina districts, by F. H. Moffit. In Bulletin 480, 1911, p. 127.
*The Taral and Bremner districts, by F. H. Moffit. In Bulletin 520, 1912, pp. 93–104. 50 cents.
*The Chitina district, by F. H. Moffit. In Bulletin 520, 1912, pp. 105–107. 50 cents.
*Gold deposits near Valdez, by A. H. Brooks. In Bulletin 520, 1912, pp. 108–130. 50 cents.
Coastal glaciers of Prince William Sound and Kenai Peninsula, Alaska, by U. S. Grant and D. F. Higgins. Bulletin 526, 1913, 84 pp.
The Hanagita-Bremner region, Alaska, by F. H. Moffit. Bulletin —. (In preparation.)

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Copper and upper Chistochina rivers; scale, 1:250,000; by T. G. Gerdine. Contained in Professional Paper 41. Not issued separately.
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Controller Bay region; No. 601 A; scale, 1:62,500; by E. G. Hamilton. Price 35 cents a copy or $21 per hundred.
Headwater regions of Gulkana and Susitna rivers; scale, 1:250,000; by D. C. Witherspoon and C. E. Giffin. Contained in Bulletin 498. Not published separately.

COOK INLET AND SUSITNA REGION.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.
*Coal resources of southwestern Alaska, by R. W. Stone. In Bulletin 259, 1905, pp. 151–171. 15 cents.
*Gold placers of Turnagain Arm, Cook Inlet, by F. H. Moffit. In Bulletin 259, 1905, pp. 90–99. 15 cents.
*Mineral resources of the Kenai Peninsula: Gold fields of the Turnagain Arm region, by F. H. Moffit, pp. 1–52; Coal fields of the Kachemak Bay region, by R. W. Stone, pp. 53–73. Bulletin 277, 1906, 80 pp. 25 cents.
Preliminary statement on the Matanuska coal field, by G. C. Martin. In Bulletin 284, 1906, pp. 88–100.
*A reconnaissance of the Matanuska coal field, Alaska, in 1905, by G. C. Martin. Bulletin 289, 1906, 36 pp.
Reconnaissance in the Matanuska and Talkeetna basins, by Sidney Paige and Adolph Knopf. In Bulletin 314, 1907, pp. 104–125.
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*Notes on geology and mineral prospects in the vicinity of Seward, Kenai Peninsula, by U. S. Grant. In Bulletin 379, 1909, pp. 98–107. 50 cents.
Preliminary report on the mineral resources of the southern part of Kenai Peninsula, by U. S. Grant and D. F. Higgins. In Bulletin 442, 1910, pp. 166–178.
Outline of the geology and mineral resources of the Iliamna and Clark lakes region, by G. C. Martin and F. J. Katz. In Bulletin 442, 1910, pp. 179–200.
Gold placers of the Mulchatna, by F. J. Katz. In Bulletin 442, 1910, pp. 201–202.
The Mount McKinley region, by A. H. Brooks, with descriptions of the igneous rocks and of the Bonnifield and Kantishna districts, by L. M. Prindle. Professional Paper 70, 1911, 234 pp.
A geologic reconnaissance of the Iliamna region, Alaska, by G. C. Martin and F. J. Katz. Bulletin 485, 1912, 138 pp.
Geology and coal fields of the lower Matanuska Valley, Alaska, by G. C. Martin and F. J. Katz; including detailed geologic and topographic maps. Bulletin 500, 1912, 98 pp.
*Gold deposits of the Seward-Sunrise region, Kenai Peninsula, by B. L. Johnson. In Bulletin 520, 1912, pp. 131–173. 50 cents.

*Gold placers of the Yentna district, by S. R. Capps. In Bulletin 520, 1912, pp. 174–200. 50 cents.
The Yentna district, Alaska, by S. R. Capps. Bulletin 534, 1913, 75 pp.
Preliminary report on a detailed survey of part of the Matanuska coal fields, by G. C. Martin. In Bulletin 480, 1911, p. 135.
A reconnaissance of the Willow Creek gold region, by F. J. Katz. In Bulletin 480, 1911, p. 152.

Topographic maps.

*Kenai Peninsula, northern portion; scale, 1:250,000; by E. G. Hamilton. Contained in Bulletin 277. 25 cents. Not published separately.
Reconnaissance map of Matanuska and Talkeetna region; scale, 1:250,000; by T. G. Gerdine and R. H. Sargent. Contained in Bulletin 327. Not published separately.
Mount McKinley region; scale, 1:625,000; by D. L. Reaburn. Contained in Professional Paper 70. Not published separately.
Lower Matanuska Valley; scale, 1:62,500; by R. H. Sargent. Contained in Bulletin 500. Not published separately.

SOUTHWESTERN ALASKA.

*Gold mine on Unalaska Island, by A. J. Collier. In Bulletin 259, 1905, pp. 102–103. 15 cents.
*Gold deposits of the Shumagin Islands, by G. C. Martin. In Bulletin 259, 1905. pp. 100–101. 15 cents.
*Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin 259, 1905, pp. 128–139. 15 cents. (Abstract from Bulletin 250.)
The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.
*Coal resources of southwestern Alaska, by R. W. Stone. In Bulletin 259, 1905, pp. 151–171. 15 cents.
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Geology and mineral resources of parts of Alaska Peninsula, by W. W. Atwood. Bulletin 467.
Outline of the geology and mineral resources of the Iliamna and Clark Lake region, by G. C. Martin and F. J. Katz. In Bulletin 442, 1910, pp. 179–200.
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The Balboa-Herendeen Bay and Unga Island region; scale, 1:250,000; by H. M. Eakin. Contained in Bulletin 467. Not issued separately.
The Iliamna region; scale, 1:250,000; by D. C. Witherspoon and C. E. Giffin. Contained in Bulletin 485. Not issued separately.

YUKON BASIN.

*The coal resources of the Yukon, Alaska, by A. J. Collier. Bulletin 218, 1903, 71 pp. 15 cents.
*The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, by L. M. Prindle. Bulletin 251, 1905, 89 pp. 35 cents.
Yukon placer fields, by L. M. Prindle. In Bulletin 284, 1906, pp. 109–131.
Reconnaissance from Circle to Fort Hamlin, by R. W. Stone. In Bulletin 284, 1906, pp. 128–131.
The Yukon-Tanana region, Alaska; description of the Circle quadrangle, by L. M. Prindle. Bulletin 295, 1906, 27 pp.
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The Circle precinct, Alaska, by A. H. Brooks. In Bulletin 314, 1907, pp. 187–204.
*The Yukon-Tanana region, Alaska; description of the Fairbanks and Rampart quadrangles, by L. M. Prindle, F. L. Hess, and C. C. Covert. Bulletin 337, 1908, 102 pp. 25 cents.
*Occurrence of gold in the Yukon-Tanana region, by L. M. Prindle. In Bulletin 345, 1908, pp. 179–186. 45 cents.
*The Fortymile gold-placer district, by L. M. Prindle. In Bulletin 345, 1908, pp. 187–197. 45 cents.

*Water-supply investigations in Alaska, 1906 and 1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper 218, 1908, 156 pp. 25 cents.

*Water supply of the Fairbanks district in 1907, by C. C. Covert. In Bulletin 345, 1908, pp. 198–205. 45 cents.

The Fortymile quadrangle, by L. M. Prindle. Bulletin 375, 1909, 52 pp.

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*The Fairbanks gold-placer region, by L. M. Prindle and F. J. Katz. In Bulletin 379, 1909, pp. 181–200. 50 cents.

*Water supply of the Yukon-Tanana region, 1907–8, by C. C. Covert and C. E. Ellsworth. In Bulletin 379, 1909, pp. 201–228. 50 cents.

*Gold placers of the Ruby Creek district, by A. G. Maddren. In Bulletin 379, 1909, pp. 229–233. 50 cents.

*Placers of the Gold Hill district, by A. G. Maddren. In Bulletin 379, 1909, pp. 234–237. 50 cents.

*Gold placers of the Innoko district, by A. G. Maddren. In Bulletin 379, 1909, pp. 238–266. 50 cents.

The Innoko gold-placer district, Alaska, with accounts of the central Kuskokwim Valley and the Ruby Creek and Gold Hill placers, by A. G. Maddren. Bulletin 410, 1910, 87 pp.

Sketch of the geology of the northeastern part of the Fairbanks quadrangle, by L. M. Prindle. In Bulletin 442, 1910, pp. 203–209.

The auriferous quartz veins of the Fairbanks district, by L. M. Prindle. In Bulletin 442, 1910, pp. 210–229.

Placer mining in the Yukon-Tanana region, by C. E. Ellsworth. In Bulletin 442, 1910, pp. 230–245.

Occurrence of wolframite and cassiterite in the gold placers of Deadwood Creek, Birch Creek district, by B. L. Johnson. In Bulletin 442, 1910, pp. 246–250.

Water supply of the Yukon-Tanana region, by C. E. Ellsworth. In Bulletin 442, 1910, pp. 251–283.

The Koyukuk-Chandalar gold region, by A. G. Maddren. In Bulletin 442, 1910, pp. 284–315.

Placer mining in the Yukon-Tanana region, by C. E. Ellsworth and G. L. Parker. In Bulletin 480, 1911, p. 172.

Water supply of the Yukon-Tanana region, 1910, by C. E. Ellsworth and G. L. Parker. In Bulletin 480, 1911, p. 217.

Mineral resources of the Bonnifield region, by S. R. Capps. In Bulletin 480, 1911, p. 235.

Gold placer mining developments in the Innoko-Iditarod region, by A. G. Maddren. In Bulletin 480, 1911, p. 270.

*Placer mining in the Fortymile and Seventymile river districts, by E. A. Porter. In Bulletin 520, 1912, pp. 211–218. 50 cents.

*Water supply of the Fortymile, Seventymile, and Eagle districts, by E. A. Porter. In Bulletin 520, 1912, pp. 219–239. 50 cents.

*Placer mining in the Fairbanks and Circle districts, by C. E. Ellsworth. In Bulletin 520, 1912, pp. 240–245. 50 cents.

*Water supply of the Fairbanks, Salchaket, and Circle districts, by C. E. Ellsworth. In Bulletin 520, 1912, pp. 246–270. 50 cents.

*The Rampart and Hot Springs regions, by H. M. Eakin. In Bulletin 520, 1912, pp. 271–286. 50 cents.

*The Ruby placer district, by A. G. Maddren. In Bulletin 520, 1912, pp. 287–296. 50 cents.

*Gold placers between Woodchopper and Fourth of July creeks, upper Yukon River, by L. M. Prindle and J. B. Mertie, jr. In Bulletin 520, 1912, pp. 201–210. 50 cents.

The Bonnifield region, Alaska, by S. R. Capps; including geologic and topographic reconnaissance maps. Bulletin 501, 1912, 162 pp.

A geologic reconnaissance of a part of the Rampart quadrangle, Alaska, by H. M. Eakin. Bulletin 535, 1913, 38 pp.

A geologic reconnaissance of the Fairbanks quadrangle, Alaska, by L. M. Prindle; with a detailed description of the Fairbanks district, by L. M. Prindle and F. J. Katz, and an account of lode mining near Fairbanks, by P. S. Smith. Bulletin 525, 1913, 220 pp.

The Koyukuk-Chandalar region, Alaska, by A. G. Maddren. Bulletin 532, 1913, 119 pp.

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The Iditarod-Ruby region, Alaska, by H. M. Eakin, with geologic and topographic reconnaissance maps. Bulletin ——. (In preparation.)

Topographic maps.

Fortymile quadrangle; No. 640; scale, 1: 250,000; by E. C. Barnard. Price, 10 cents a copy or $3 for 50.
Fairbanks quadrangle; No. 642; scale, 1: 250,000; by T. G. Gerdine, D. C. Witherspoon, and R. B. Oliver. Price, 20 cents a copy or $6 for 50.
Rampart quadrangle; No. 643; scale, 1: 250,000; by D. C. Witherspoon and R. B. Oliver. Price, 20 cents a copy or $6 for 50.
Fairbanks district; No. 642A; scale, 1: 62,500, by T. G. Gerdine and R. H. Sargent. Price, 20 cents a copy or $6 for 50.
*Yukon-Tanana region, reconnaissance map of; scale, 1: 625,000; by T. G. Gerdine. Contained in Bulletin 251, 1905. 35 cents. Not published separately.
*Fairbanks and Birch Creek districts, reconnaissance maps of; scale, 1: 250,000; by T. G. Gerdine. Contained in Bulletin 251, 1905. 35 cents. Not issued separately.
Circle quadrangle, Yukon-Tanana region; scale, 1: 250,000; by D. C. Witherspoon. Price 50 cents a copy. Also contained in Bulletin 295.

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*A reconnaissance of the Cape Nome and adjacent gold fields of Seward Peninsula, Alaska, in 1900, by A. H. Brooks, G. B. Richardson, and A. J. Collier. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900," 1901, 180 pp. 50 cents.
*A reconnaissance in the Norton Bay region, Alaska, in 1900, by W. C. Mendenhall. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900," 1901, 38 pp. 50 cents.
*A reconnaissance of the northwestern portion of Seward Peninsula, Alaska, by A. J. Collier. Professional Paper 2, 1902, 70 pp. 30 cents.
*The tin deposits of the York region, Alaska, by A. J. Collier. Bulletin 229, 1904, 61 pp. 15 cents.
*Recent developments of Alaskan tin deposits, by A. J. Collier. In Bulletin 259, 1905, pp. 120–127. 15 cents.
*The Fairhaven gold placers of Seward Peninsula, by F. H. Moffit. Bulletin 247, 1905, 85 pp. 40 cents.
The York tin region, by F. L. Hess. In Bulletin 284, 1906, pp. 145–157.
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The Kougarok region, by A. H. Brooks. In Bulletin 314, 1907, pp. 164–181.
*Water supply of Nome region, Seward Peninsula, Alaska, 1906, by J. C. Hoyt and F. F. Henshaw. Water-Supply Paper 196, 1907, 52 pp. 15 cents.
Water supply of the Nome region, Seward Peninsula, 1906, by J. C. Hoyt and F. F. Henshaw. In Bulletin 314, 1907, pp. 182–186.
The Nome region, by F. H. Moffit. In Bulletin 314, 1907, pp. 126–145.
Gold fields of the Solomon and Niukluk river basins, by P. S. Smith. In Bulletin 314, 1907, pp. 146–156.
Geology and mineral resources of Iron Creek, by P. S. Smith. In Bulletin 314, 1907, pp. 157–163.
The gold placers of parts of Seward Peninsula, Alaska, including the Nome, Council, Kougarok, Port Clarence, and Goodhope precincts, by A. J. Collier, F. L. Hess, P. S. Smith, and A. H. Brooks. Bulletin 328, 1908, 343 pp.
*Investigation of the mineral deposits of Seward Peninsula, by P. S. Smith. In Bulletin 345, 1908, pp. 206–250. 45 cents.
*The Seward Peninsula tin deposits, by Adolph Knopf. In Bulletin 345, 1908, pp. 251–267. 45 cents.
*Mineral deposits of the Lost River and Brooks Mountain regions, Seward Peninsula, by Adolph Knopf. In Bulletin 345, 1908, pp. 268–271. 45 cents.
*Water supply of the Nome and Kougarok regions, Seward Peninsula, in 1906–7, by F. F. Henshaw. In Bulletin 345, 1908, pp. 272–285. 45 cents.
*Water-supply investigations in Alaska, 1906 and 1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper 218, 1908, 156 pp. 25 cents.
Geology of the Seward Peninsula tin deposits, by Adolph Knopf. Bulletin 358, 1908, 72 pp.
*Recent developments in southern Seward Peninsula, by P. S. Smith. In Bulletin 379, 1909, pp. 267–301. 50 cents.
*The Iron Creek region, by P. S. Smith. In Bulletin 379, 1909, pp. 302–354. 50 cents.
*Mining in the Fairhaven precinct, by F. F. Henshaw. In Bulletin 379, 1909, pp. 355–369. 50 cents.
*Water-supply investigations in Seward Peninsula in 1908, by F. F Henshaw In Bulletin 379, 1909, pp. 370–401. 50 cents.

Geology and mineral resources of the Solomon and Casadepaga quadrangles, Seward Peninsula, by P. S. Smith. Bulletin 433, 1910, 227 pp.
Mineral resources of the Nulato-Council region, by P. S. Smith and H. M. Eakin. In Bulletin 442, 1910, pp. 316-352.
Mining in Seward Peninsula, by F. F. Henshaw. In Bulletin 442, 1910, pp. 353-371.
Water-supply investigations in Seward Peninsula in 1909, by F. F. Henshaw. In Bulletin 442, 1910, pp. 372-418.
A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, by P. S. Smith and H. M. Eakin. Bulletin 449, 1911, 146 pp.
*Notes on mining in Seward Peninsula, by P. S. Smith. In Bulletin 520, 1912, pp. 339-344.
Geology of the Nome and Grand Central quadrangles, Alaska, by F. H. Moffit. Bulletin 533, 1913, 140 pp.
Surface water supply of Seward Peninsula, Alaska, by F. F. Henshaw and G. L. Parker, with a sketch of the geography and geology, by P. S. Smith, and a description of methods of placer mining, by Alfred H. Brooks; including topographic reconnaissance map. Water-Supply Paper 314, 1913, 317 pp.

Topographic maps.

The following maps are for sale at 10 cents a copy or $3 for 50:

Casadepaga quadrangle, Seward Peninsula; No. 646 C; scale, 1:62,500; by T. G. Gerdine.
Grand Central quadrangle, Seward Peninsula; No. 646 A; scale, 1:62,500; by T. G. Gerdine.
Nome quadrangle, Seward Peninsula; No. 646 B; scale, 1:62,500; by T. G. Gerdine.
Solomon quadrangle, Seward Peninsula; No. 646 D; scale, 1:62,500; by T. G. Gerdine.

The three following maps are for sale at 50 cents a copy or $15 for 50:

Seward Peninsula, northeastern portion of, topographic reconnaissance of; scale, 1:250,000; by T. G. Gerdine.
Seward Peninsula, northwestern portion of, topographic reconnaissance of; scale, 1:250,000; by T. G. Gerdine.
Seward Peninsula, southern portion of, topographic reconnaissance of; scale, 1:250,000; by T. G. Gerdine.

Seward Peninsula, southeastern portion of, topographic reconnaissance of; scale, 1:250,000. Contained in Bulletin 449. Not published separately.

NORTHERN ALASKA.

*A reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska, by way of Dall, Kanuti, Allen, and Kowak rivers, by W. C. Mendenhall. Professional Paper 10, 1902, 68 pp. 30 cents.
*A reconnaissance in northern Alaska across the Rocky Mountains, along the Koyukuk, John, Anaktuvuk, and Colville rivers, and the Arctic coast to Cape Lisburne, in 1901, by F. C. Schrader and W. J. Peters. Professional Paper 20, 1904, 139 pp. 40 cents.
*Coal fields of the Cape Lisburne region, by A. J. Collier. In Bulletin 259, 1905, pp. 172-185. 15 cents.
*Geology and coal resources of Cape Lisburne region, Alaska, by A. J. Collier. Bulletin 278, 1906, 54 pp. 15 cents.
The Shungnak region, Kobuk Valley, by P. S. Smith and H. M. Eakin. In Bulletin 480, 1911, pp. 271-305.
The Squirrel River placers, by P. S. Smith. In Bulletin 480, 1911, pp. 306-319.
*Geologic investigations along the Canada-Alaska boundary, by A. G. Maddren. In Bulletin 520, 1912, pp. 297-314. 50 cents.
*The Alatna-Noatak region, by P. S. Smith. In Bulletin 520, 1912, pp. 315-338. 50 cents.
The Noatak-Kobuk region, by P. S. Smith. Bulletin 536. (In preparation.)

Topographic maps.

*Fort Yukon to Kotzebue Sound, reconnaissance map of; scale, 1:1,200,000; by D. L. Reaburn. Contained in Professional Paper 10. 30 cents. Not published separately.
*Koyukuk River to mouth of Colville River, including John River; scale, 1:1,200,000; by W. J. Peters. Contained in Professional Paper 20. 40 cents. Not published separately.

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