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A GEOLOGIC RECONNAISSANCE
OF A PART OF THE
RAMPART QUADRANGLE
ALASKA

BY

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CONTENTS.

ILLUSTRATIONS.

PREFACE.

By Alfred H. Brooks.

This volume is one of a series of reports presenting accounts of the geology and mineral resources of the Yukon-Tanana region. The unit of publication is a quadrangle embracing 2° of latitude and 4° of longitude. Only that part of the Rampart quadrangle lying between Yukon and Tanana rivers has been mapped, but the report on it is here issued as one of the regular series. A report on the Circle quadrangle has been prepared, and reports on the Fortymile and Fairbanks quadrangles have been issued.[1]

These are reconnaissance reports, and the work on which they are based must be followed by more minute surveys before the details of stratigraphy and structure can be determined. It is believed, however, that they will serve a useful purpose both in outlining the general features of the geology and in affording information about the mineral resources of the region.

The publication of this series of reports will bring to a close the first stage in the investigation of the Yukon-Tanana region, which was begun in 1903 and has been continued every season until 1911. Most of these investigations were made by Mr. Prindle and his assistants, but as it was desirable to publish a report on the important gold placers of Rampart and Hot Springs at an early date and as Mr. Prindle was busy elsewhere the task was assigned to Mr. Eakin.

[1] Prindle, L. M., The Fortymile quadrangle, Yukon-Tanana region, Alaska: Bull. U. S. Geol. Survey No. 375, 1909. Prindle, L. M., A geologic reconnaissance of the Fairbanks quadrangle, Alaska, 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: Bull. U. S. Geol. Survey No. 525, 1913.

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By HENRY M. EAKIN.

FIELD WORK.

The Rampart and Hot Springs gold-placer districts, together with a narrow strip on the opposite side of the Yukon, had been topographically mapped prior to the summer of 1911, during which a geologic reconnaissance of the region was made by the writer. The party, consisting of the writer and R. A. Conkling, who rendered valuable assistance throughout the season, landed at Rampart June 24. The following five weeks was spent in studying the mining districts and adjacent territory between the rivers. On August 3 the party returned to Rampart, obtained a boat, and began the study of the rocks along the Yukon below this settlement. One week was spent in making an overland trip to the head of Squaw Creek, west of the Yukon, after which the work along the river was resumed. Tanana, at the west margin of the area mapped, was reached August 16. From this date until the latter part of August the work was carried westward along the Yukon beyond the Gold Hill district, approximately to longitude 154°. (See Pl. I, in pocket, and Pl. III, p. 16.) It would have been impossible to cover so large an area in this comparatively short time had it not been for the previous work of other geologists, and acknowledgment is due to those whose published records have been freely drawn upon in the preparation of the following pages. Special assistance has been given by Mr. L. M. Prindle, who has carried on a systematic study of the Yukon-Tanana region since 1903 and whose personal suggestions have aided in working out the geologic relations of these districts to the neighboring areas on the east.

PREVIOUS INVESTIGATIONS.

In 1866 Dall[1] ascended the Yukon to Fort Yukon with a survey party of the Western Union Telegraph Co. and took notes of the geology of this part of the Yukon basin. In 1889 Russell[2] ascended

[1] Dall, W. H., Exploration in Russian America: Am. Jour. Sci., 2d ser., vol. 45, 1868, pp. 97-98; Correlation papers—Neocene: Bull. U. S. Geol. Survey No. 84, 1892, p. 247.

[2] Russell, I. C., Notes on the surface geology of Alaska: Bull. Geol. Soc. America, vol. 1, 1889.

the full length of the Yukon and published valuable data on the geography and surface geology of the region. Much greater light was thrown on the geology about Rampart and along the Yukon by the more detailed studies of Spurr, Goodrich, and Schrader,[1] who in 1896 made a reconnaissance from Chilcoot Pass to Nulato. They attempted a systematic classification of the rocks along the Yukon based on their determination of the stratigraphic succession and correlated similar groups of rocks widely distributed along their route of travel; they also introduced a system of nomenclature, most of which has persisted to the present time. Their work was followed by that of Collier,[2] who in 1902 descended the Yukon, giving special attention to the coal-bearing formations, and by that of Brooks[3] and Prindle, who in the same year carried a reconnaissance from Cook Inlet to the Yukon at Rampart. Two years later Prindle and Hess[4] carried a reconnaissance from Eagle to Rampart and spent the latter part of the season in a study of the Rampart placer district. In 1907 Prindle[5] again touched the region about Rampart, and in the same year Atwood, descending the Yukon in the course of a general study of the coal-bearing terranes, spent a few days in the vicinity of Rampart.

The investigation of the water supply of the Rampart district was begun by Covert and Ellsworth[6] in 1908 and continued by Ellsworth in 1909. In addition to investigating the water supply, these engineers gathered data regarding the progress of mining in the Rampart and Hot Springs districts.[7]

GEOGRAPHY.

LOCATION AND EXTENT.

The Rampart and Hot Springs districts include most of the triangular area between Yukon and Tanana rivers west of longitude 150°, which marks the western boundary of the Fairbanks quadrangle.[8] This area, which embraces about 12,000 square miles, is part of the Rampart quadrangle, one of a system of uniform areas projected over the Territory of Alaska by the Survey to facilitate mapping

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[1] Spurr, J. E., Geology of the Yukon gold district, Alaska, with a chapter on the history and present condition of the district by H. B. Goodrich: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 87-392.

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

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

[4] Prindle, L. M., and Hess, F. L., The Rampart gold placer region, Alaska: Bull. U. S. Geol. Survey No. 280, 1906.

[5] Prindle, L. M., The Fairbanks and Rampart quadrangles, Yukon-Tanana region, Alaska: Bull. U. S. Geol. Survey No. 337, 1908.

[6] Covert, C. C., and Ellsworth, C. E., Water-supply investigations in the Yukon-Tanana region, Alaska, 1907 and 1908: Water-Supply Paper U. S. Geol. Survey No. 228, 1909, pp. 59-84, 96-98.

[7] Ellsworth, C. E., Water supply of the Yukon-Tanana region, 1909: Bull. U. S. Geol. Survey No. 442, 1910, pp. 270-281; Placer mining in the Yukon-Tanana region, 1909: Idem, pp. 239-243; Placer mining in the Yukon-Tanana region, 1910: Bull. U. S. Geol. Survey No. 480, 1911, pp. 166-168.

[8] Prindle, L. M., A geologic reconnaissance of the Fairbanks quadrangle, Alaska, with a detailed description of the Fairbanks district by L. M. Prindle and F. J. Katz: Bull. U. S. Geol. Survey No. 525, 1913.

and description. Each quadrangle embraces 2° of latitude and 4° of longitude. This report takes account not only of all the triangular area but also of a strip of territory lying along the opposite side of the Yukon and stretching westward beyond the Gold Mountain district, or nearly to longitude 154°.

DRAINAGE.

The entire drainage of the area studied is tributary to Yukon and Tanana rivers. From the divide, which trends east and west about midway between these rivers, many streams lead northward to the Yukon and many southward to the Tanana. The strip of territory north of the Yukon, through narrow, extends back as a rule from the river to the heads of the numerous small streams tributary to the Yukon. It does not, however, embrace the whole course of Tozitna River, which enters the Yukon about 12 miles below the mouth of the Tanana. This stream, which is about 100 miles long, heads in the hills a few miles northwest of Rampart and flows parallel with the Yukon for most of its length.

Several of the smaller tributaries should be especially noted. Minook Creek, about 25 miles long, heads in the Yukon-Tanana divide and flows northward in a remarkably straight course to the Yukon near the eastern limit of the area studied. Baker Creek drains the south side of the divide opposite the basin of Minook Creek and flows into the Tanana. Its system has a peculiar broad dendritic form, being made up of a large number of evenly balanced tributaries from the east, north, and west. Patterson Creek heads against the western tributaries of Baker Creek and flows south and west to the Tanana. American Creek, a much smaller stream, rises a few miles west of the head of Patterson Creek and flows into Fish Lake. Grant Creek enters the Yukon from the north, about 15 miles below Tozitna River. All these streams are relatively small, the largest being not more than about 20 miles long. They will be mentioned later in connection with the descriptions of placer gold deposits. Little Melozi River heads against some small tributaries of the Yukon west of Grant Creek and flows first northeastward and then northward, out of the special area under consideration, to its junction with Melozitna River, which enters the Yukon about a hundred miles farther west.

RELIEF.

The topographic province to which the area under consideration belongs is the central plateau region of Alaska, which lies between the Alaska Range, nearly 200 miles south of the Rampart area, and the Endicott Range, about the same distance north.[1] This central

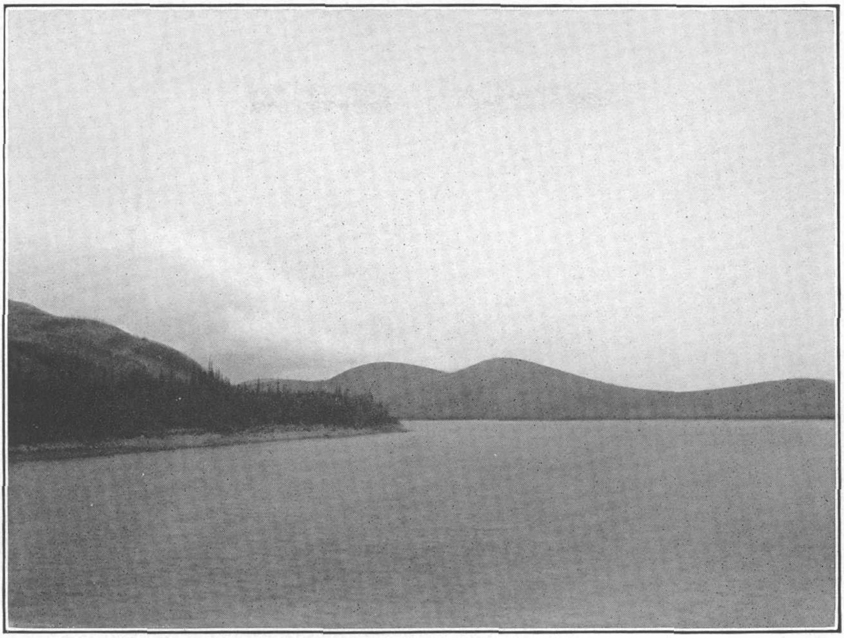
[1] Brooks, A. H., Geography and geology of Alaska: Prof. Paper U. S. Geol. Survey No. 45, 1906, pp. 27-46.

plateau, however, here lacks the remarkable uniformity of elevation that characterizes it farther east, where the Yukon plateau is typically developed. Its relief is not great; the larger part of the upland of the region ranges in height from 2,000 to 3,000 feet, but peaks here and there rise to a maximum elevation of about 4,000 feet. There are local ridges that resemble those of the Yukon plateau, but they are of various elevations and most of them are only a few miles long. A somewhat uneven ridge of this type is Bean Ridge, which stretches northeastward along the Tanana to the big bend of Baker Creek. It increases in elevation gradually from either extremity to a point near Hot Springs, where it culminates in a prominent dome 2,650 feet high. The Yukon-Tanana divide has a rather even crest line from a point near the junction of the two rivers eastward to Roughtop Mountain, which rises to an altitude of about 3,000 feet. The upland area broadens east of Roughtop Mountain and numerous more or less parallel northeast-southwest ridges occupy the area between Baker Flats and the Yukon at Rampart. Many of these ridges have an elevation of approximately 2,000 feet; others of similar form rise to about 3,000 feet, and Baldry Mountain and Elephant Dome to about 4,000 feet.

The area north of the Yukon shows even greater diversity of topographic form. On the headwaters of Tozitna River is a well-developed mountain range some of whose peaks reach altitudes of over 5,000 feet. Nearer the Yukon the elevations are lower and ridges like those between the Yukon and the Tanana occur, except in the lowlands adjacent to Tozitna River. This ridge topography extends westward along the Yukon to a point about 30 miles west of the Tozitna. Here begins another prominent range, which reaches altitudes above 4,000 feet and extends westward beyond the area studied.

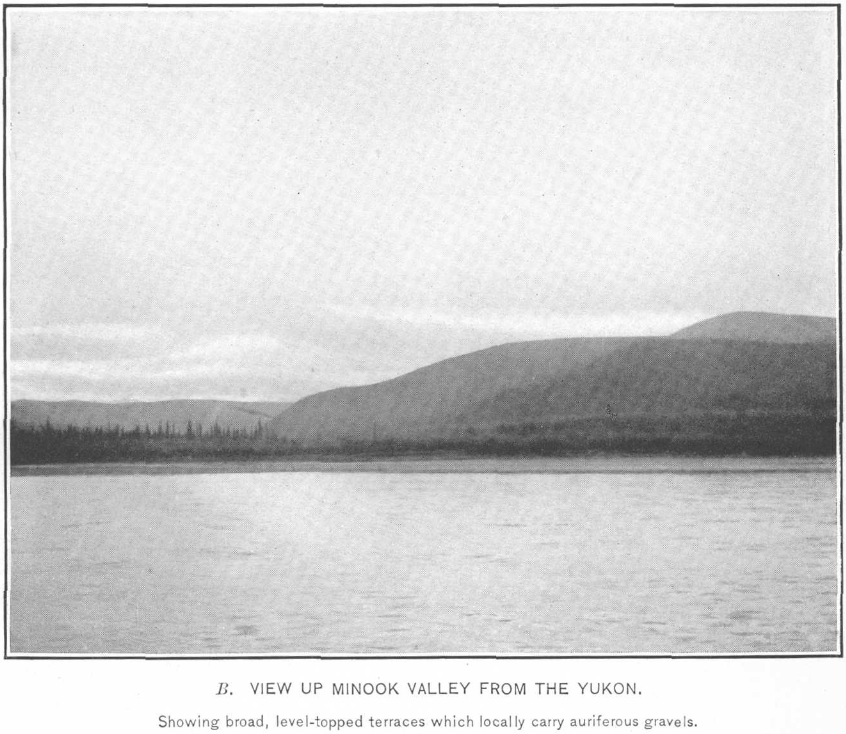
Extensive lowlands stretch along the Yukon and the Tanana and along the lower courses of some of the smaller streams, as on Baker, Patterson, American, and other southward-flowing creeks of the Tanana basin, and on Tozitna River, Grant Creek, and streams farther west, flowing into the Yukon from the north. East of the Ramparts of the Yukon and parallel with them is a depression several miles wide, which is crossed by a number of small streams that head in the Yukon-Tanana divide.

Much broader, however, are the lowlands lying south of the larger streams. Seeming to be a dead-level expanse of sparsely timbered tundra, they stretch away to a horizon of low, rounded hills perhaps 60 miles south from the Yukon, and on clear days the snowy masses of McKinley, Foraker, and a great array of lesser mountains can be seen looming up at still greater distances, emphasizing the flatness of the intervening wastes. These lowlands extend eastward along the Tanana to the end of Bean Ridge and westward along the Yukon 50 miles beyond the area studied, to the mouth of the Melozitna.



A. LOWER END OF THE RAMPARTS.

Showing edge of the lowlands to the right and the hills forming the left wall of the Ramparts in the center. The chief gorge of the Ramparts is opposite the most distant hill.



B. VIEW UP MINOOK VALLEY FROM THE YUKON.

Showing broad, level-topped terraces which locally carry auriferous gravels.

The Ramparts of the Yukon are about 15 miles long and lie midway between the mouth of Minook Creek and that of the Tanana. The valley of the Yukon is here steep sided and in places canyonlike, being little wider than the stream itself and having a depth of 1,000 feet or so below the bordering hills. Disconnected remnants of terraces occur at intervals to the top of the valley walls. The high land on the right side is continuous back from the river and rises to greater altitudes than that of the immediate valley wall. On the left the river is bordered by a narrow range of hills, more or less uniform in elevation, which separates the present valley of the Yukon from the broad depression on the east. (See Pl. II, *A*.)

Tributaries join the Yukon from both sides in the Rampart reach. The smaller streams from the right enter through narrow gorgelike valleys and the larger ones commonly have broader valleys with bottom lands. The streams from the left, after traversing the broad depression, break through the narrow range of hills, some through narrow V-shaped gaps and others through broader openings corresponding with the valleys of the larger streams from the right. (See Pl. I, in pocket.)

Terraces, some rock cut and others constructional, occur at a number of places along the Yukon Valley above the Ramparts. The highest noted are at an elevation of about 1,600 feet, according closely with the top of the Ramparts, and are in the form of horizontally truncated ridges. They become more noticeable farther upstream, and near Rampart they are broadly developed in the interstream ridges of Minook Creek and its tributaries. Plate II, *B*, shows these features near the mouth of Minook Creek.

CLIMATE.

The climate of the Rampart Hot Springs districts is the same that prevails over much of interior Alaska. The winters are long and cold; the summers are short and comparatively warm. The following table gives the recorded precipitation at Rampart for the years 1906 to 1910 inclusive:

Monthly precipitation, in inches, at Rampart, 1906–1910.[a]

[Rainfall or melted snow is given in the first line, snowfall in the second line.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1906	0.63	0.08	0.17	0.04	0.40	0.15	1.86	2.40	0.59	0.61	0.95	0.33	8.21
	7.2	2.0	1.8	.5	......	......	......	......	......	......	10.2	3.5	25.2
1907	1.17	.44	1.17	.02	.44	1.64	2.29	3.38	2.52	.65	.55	1.26	15.53
	12.0	4.5	12.8	2.5	......	......	......	......	......	......	6.3	......	......
1908	1.08	.52	.81	.58	.82	1.38	1.13	.46	1.56	.39	.73	1.14	10.60
	11.5	6.9	8.1	......	......	......	......	......	......	5.1	3.6	16.8	52.0
1909	.09	.10	.37	.51	1.04	.85	2.01	1.41	.36	1.14	.35	1.99	10.22
	1.4	1.2	6.2	5.6	......	......	......	......	1.5	14.4	3.6	20.2	54.1
1910	.84	.08	.36	.07	.20	.98	.71	.62	.43	.45	.26	.32	5.32
	11.1	.8	4.7	1.0	......	......	......	......	......	6.0	3.5	5.0	32.1

[a] Excerpt from table by C. E. Ellsworth, Water supply of the Yukon-Tanana region: Bull. U. S. Geol. Survey No. 480, 1911, pp. 176–177.

The average temperatures of interior Alaska are summarized by Brooks [1] as follows: "The average winter temperature in the province is 5° to 10° with a minimum of −65° to −76°; for the summer months of June, July, and August the mean is 50° to 60° and the recorded maximum 90°." A later record gives a maximum temperature of 92° on July 27, 1910, at Rampart.[2]

Concerning those phases of climate that affect transportation and mining in the interior provinces of Alaska Brooks [1] says:

> Ice usually begins to run on the Yukon between the first and middle of October, but the delta closes to navigation one or two weeks earlier. In the spring the ice breaks at the mouth of the Tanana about May 10 to 15. So far as the records show, the Tanana breaks a little sooner in the spring and closes a little later in the fall than the Yukon. * * * The sluicing season in the Fairbanks district usually extends from about May 10 to the middle or end of September. There are records of creeks opening as early as the middle of April, and in 1907 most of the waterways remained open until the end of October.

Except where unusual factors operate the ground below a slight depth is permanently frozen. It remains unfrozen about Hot Springs, because of the heat of the springs, and on some of the creeks where the gravels are unusually permeable to circulating ground waters.

Summer climate is a critical factor in determining the agricultural possibilities of a country. The length of the growing season is indicated by the following table of records made at the United States Agricultural Experiment Station at Rampart:[3]

Length of growing season at Rampart.

Year.	Last spring frost.		First autumn frost.		Days between frosts.
	Date.	Temperature (°F.).	Date.	Temperature (°F.).	
1906	May 20	23	Aug. 25	25	96
1907	May 21	25	Sept. 6	24	107
1908	May 19	30	Aug. 31	29	103
1909	May 29	30	Aug. 24	27	86
1910	May 28	28	Aug. 21	27	84

VEGETATION.

Prior to its occupation by white men the region was largely covered with timber, mostly of sparse growth but locally furnishing trees suitable for mine work and lumber. Spruce is the most widely distributed species and is also the largest of the trees, attaining a diameter of 2 feet or more in especially favorable places. Birch and cottonwood are also widely distributed but attain their best growth

[1] Brooks, A. H., The Mount McKinley region, Alaska: Prof. Paper U. S. Geol. Survey No. 70, 1911, p. 199.

[2] Gasser, G. W., Ann. Rept. Alaska Agr. Exper. Sta. for 1910, p. 44.

[3] Idem, p. 43.

only on the southward-facing slopes and on the unfrozen ground at and near Hot Springs. A few tamarack were noted on some of the tributaries of the Yukon, and willow and alder thrive on the higher slopes and along streams. Partly by use and partly by extensive forest fires the available timber has been materially reduced. It is estimated that fully four-fifths of the timbered areas have been burned over in the last decade, and during most of the summer of 1911 a number of fires were burning in different parts of the region.

Except in the densely timbered areas and natural meadows the ground is covered with the usual Alaskan carpet of mosses, grasses, herbs, low bushes, and creeping plants. Various edible berries flourish in their respective habitats. Red and black currants and raspberries are abundant in places more or less sheltered by timber; salmonberries and blueberries favor the open ground; and cranberries thrive on the sunny slopes above the timber line. In early summer the mountains are gay with lupine, gentian, wild poppy, and innumerable species of small flowering plants, the lower levels are clustered with bluebells and wild roses, and the warm hillsides, especially in burned-over areas, flame with the brilliant fireweed.

Native grasses are so generally distributed in the region that no trouble was experienced in selecting camp grounds where abundant forage was available. Redtop exceeds the other varieties in abundance and breadth of distribution. Native meadows of this grass on the Yukon bottom are annually mowed and furnish hay of good quality. A large herd of beef cattle and a number of horses were being pastured on the bottom land of the Tanana near Hot Springs, and at a number of other places horses were living on the native grasses exclusively, all keeping in excellent condition.

ANIMAL LIFE.

The largest animals native to the region are moose, caribou, and bear. Evidences of moose were observed at several places between the Yukon and Tanana, but none of the animals were seen. Caribou often range into the country during their winter migrations but are rarely seen in summer except in the mountainous areas north of the Yukon. Black and brown bear are very common, but keep mostly in the timber, and occasionally a grizzly is seen in the higher open country.

Wolves, wolverines, foxes, rabbits, marmots, martins, weasels, squirrels, and mice are among the smaller animals at home in the region, the wolves and martins being relatively scarce.

Ptarmigan and grouse are the principal game birds resident in the country the year round. Geese, ducks, cranes, and a number of smaller water fowl, shore birds, and other migrants spend the warmer months in the region.

No reptiles are known in the region. A single amphibian, a small green frog, is rather common.

Fish are abundant in all the streams that are not polluted by mining operations. The grayling and brook trout frequent even the smallest brooks. The king, silver, and dog salmon run up the larger streams annually. Pike and whitefish live in the Yukon and Tanana, and the pike is said to inhabit also some of the larger lakes.

POPULATION.

The inhabitants of the Rampart and Hot Springs districts have varied in number and have shifted from place to place with the changing fortunes of mining operations. The oldest settlements persisting at the present time are Rampart, near the mouth of Minook Creek, and Tanana, below the mouth of Tanana River. Hot Springs, on a slough of the Tanana; Glen, on a tributary of Baker Creek; and Tofty, on Sullivan Creek, have developed as supply points for the mines of the Hot Springs district. A small group of cabins and roadhouses on the bank of the Yukon near the mouth of Grant Creek is the only other white settlement in the region.

Rampart is said to have had a population of about 1,500 during its best days in 1898 and 1899.[1] Since then its population has dwindled to the present number—a little more than a score. The town of Tanana, independent of Fort Gibbon, a United States military post situated there, has a population probably fluctuating between 200 and 300. Tofty and the immediate neighborhood could number during the summer about 150 persons, but this figure would be greatly affected by any change in mining operations. The other settlements mentioned have only a few residents each—probably 50 all told.

The native population is said to be greatly reduced from its number two decades ago when few white men had visited the region. At present the principal native settlement is a mile above Tanana on the Yukon, where there are a mission and a school. There is another small village near the mouth of Tozitna River and a few natives live near Rampart.

MEANS OF COMMUNICATION.

Yukon and Tanana rivers give easy access to all parts of the region and they are navigated by a fleet of well-equipped steamboats. The freight rates from Seattle vary with the nature of the commodities and the route traversed, as indicated in the following table:

[1] Prindle, L. M., The Fairbanks and Rampart quadrangles, Yukon-Tanana region, Alaska: Bull. U. S. Geol. Survey No. 337, 1908, p. 60.

Freight and passenger rates from Seattle to towns in the Rampart and Hot Springs districts, based on tariffs of 1910–11.

Town and route.	General merchandise per ton.	Lumber per M.	Forage per ton.		Passengers.	
			Hay.	Grain.	First class.	Second class.
Rampart:						
Via Skagway	$82–$115	$77.50	$83	$77	$111	$80
Via St. Michael	58	87.00	58	58	115	90
Tanana:						
Via Skagway	84–117	79.50	85	79	115	81
Via St. Michael	50	75.00	50	50	111	85
Hot Springs:						
Via Skagway	89–125	84.50	90	84	125	90
Via St. Michael	55	82.50	55	55	115	90

Local freight rates from river points to the creeks vary according to the condition of the roads and the season of the year. In both the Rampart and the Hot Springs districts some excellent roads are maintained. The rapid development of the Sullivan Creek placers in the last two years has made necessary additional road improvements, which were being pushed during the summer of 1911. The summer rate on goods from Hot Springs to Tofty, a distance of 12 miles, was 5 cents a pound, and considering the difficulties of the present route this charge was not unreasonable. On the completion of the route under construction the rate will probably be reduced to about the present winter rate of 1½ cents a pound.

All the river communities are in touch with the United States military telegraph. Local telephone lines give service in the Rampart and Hot Springs districts. Regular United States mail service extends to all the settlements, both winter and summer.

INDUSTRIES.

The chief industry of the region is gold-placer mining. However, a considerable part of the population is engaged in mercantile pursuits, river transportation, and freighting. Fishing, woodcutting, lumbering, and agriculture receive considerable attention. The mining industry will be treated in this report in the section on economic geology. The mercantile business of the region is limited to a rather scant fur trade and to supplying the residents with necessary commodities. The steamboat traffic on the large rivers gives employment to a number of the inhabitants of the region, both native and white. Supplies are transported from river points to the inland towns and mining camps by team and pack train, outfits for this purpose being maintained in all the river settlements. The heavy demand for dried salmon to feed dogs with during the winter leads many persons to devote themselves to the fishing industry during the annual salmon runs. The fish are usually taken by means of fish wheels set in the margins of the larger streams. Supplying wood for fuel to the steamboats and to the towns and mining camps is a source of income for many persons. Considerable lumber is sawed in the town of Tanana, one plant being operated by the natives at their village and another at the military post. The logs are brought down Yukon and Tanana rivers in rafts and most of the lumber is used locally. The agriculture of the region is principally gardening. A small truck patch is connected with almost every establishment, whatever its nature, and at Rampart and several other places on the Yukon and at Hot Springs more extensive plots are under cultivation. At Rampart the Government maintains an agricultural experiment station under the efficient management of G. W. Gasser. This station has not only demonstrated the possibility of maturing a variety of grains and raising many kinds of vegetables but has originated a number of new varieties of these plants that are better adapted to this environment than those already existing.[1] At Hot Springs about 30 acres of unfrozen ground and about an equal area of the usual type having its subsoil permanently frozen are farmed annually. Here, in addition to the produce ordinarily grown in the region, sweet corn, cucumbers, melons, cantaloupes, and tomatoes are raised successfully, and all find a ready and profitable sale in the larger towns along the rivers. Milch cows and poultry are also kept and supply the table of the hotel, which is run in connection with the farm, with the unusual luxuries of fresh butter, milk, and eggs.

An unexpected phase of agriculture was met with at McCormick's ranch, about 12 miles below Rampart. Here potatoes are grown as food for swine. At the time of the writer's visit, August 7, the potatoes were well formed, promising a good yield, and several litters of healthy young pigs indicated the possibilities of success in the unique industry.

DESCRIPTIVE GEOLOGY.

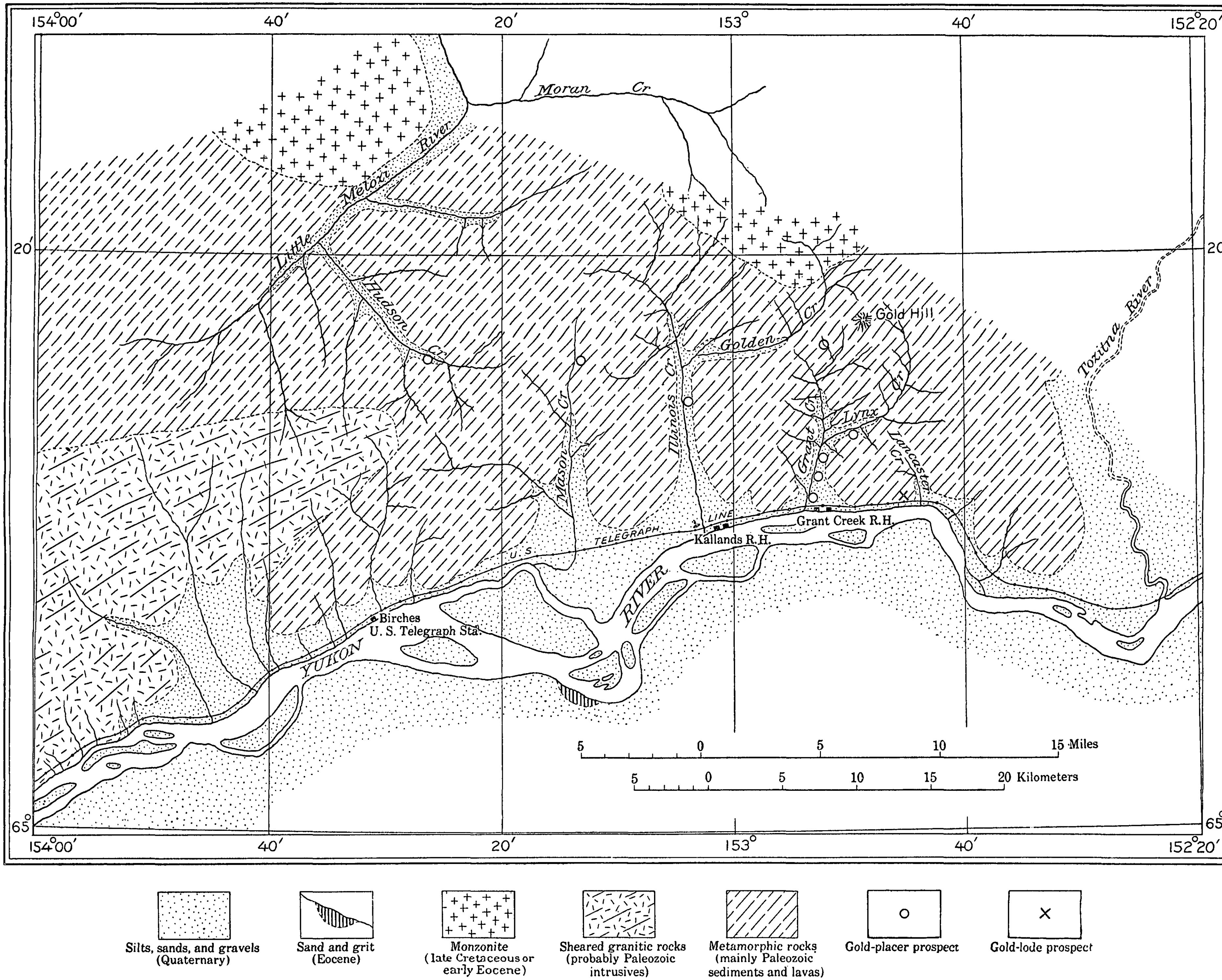
GENERAL SUCCESSION.

At the base of the geologic column in the Rampart and Hot Springs districts is a series of metamorphic rocks. They are overlain locally by Tertiary sediments and broadly by those of Quaternary age. Unaltered granitic intrusives are widely distributed in the pre-Tertiary rocks and are accompanied by a complex system of dikes, probably related to them genetically.

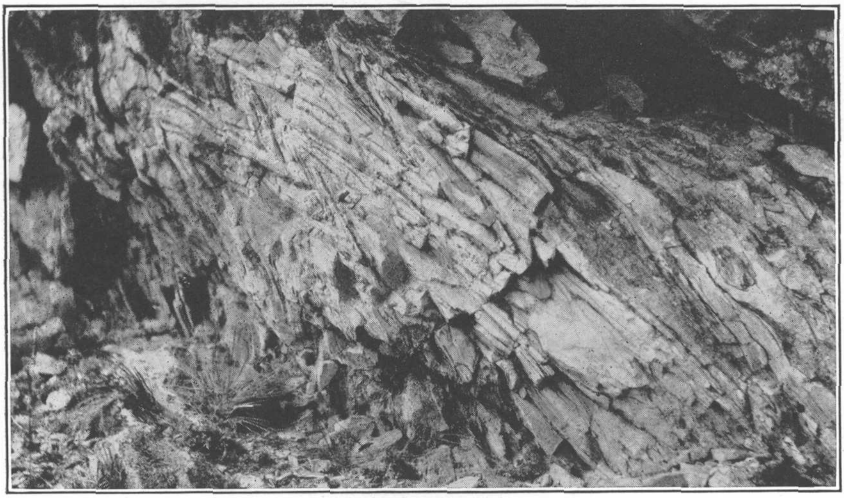
METAMORPHIC ROCKS.

Metamorphic rocks floor the greater part of the Rampart and Hot Springs districts and are conspicuous in all sections of the area studied. They are for the most part derivatives of original sediments but include igneous types.

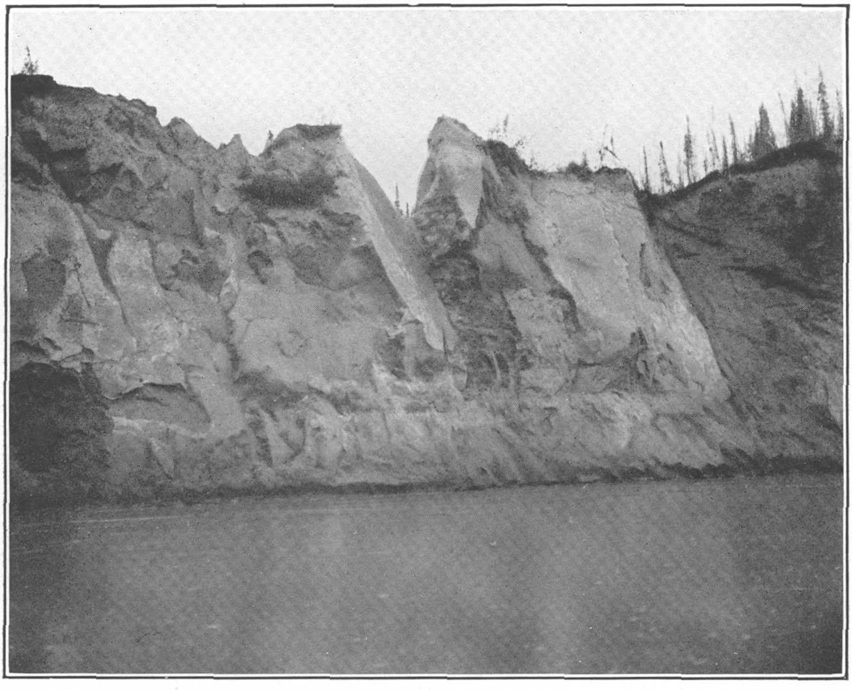
[1] Georgeson, C. C., Ann. Repts. Alaska Agr. Exper. Sta. 1899-1910, Office Exper. Sta. U. S. Dept. Agr.



GEOLOGIC SKETCH MAP OF THE GOLD MOUNTAIN DISTRICT, ALASKA.



A. CLOSE FOLDING IN LIMESTONE ON SPUR NORTH OF RUBY CREEK.



B. MASSIVE DEPOSIT OF SILT AT THE PALISADES OF THE YUKON, 25 MILES BELOW TANANA.

Differences in original constitution and in character of alteration have resulted in a wide divergence between the types of the metamorphic rocks. On account of their extremely complicated structure and their general lack of fossils, lithology is the principal basis on which they can be subdivided. Four general lithologic subdivisions are recognized, each including a different set of rock types that are constantly associated over a considerable area. (See geologic maps, Pls. III, p. 16, and IV, in pocket.) The subdivisions are (1) limestones and schists; (2) greenstones; (3) slates, sandstones, and conglomerates; and (4) slates, quartzites, and schists. The order in which these subdivisions are mentioned here is that of their apparent stratigraphic sequence. The first is probably Silurian and Devonian, the second late Paleozoic, the third early Mesozoic, and the fourth Cretaceous and older, probably mainly Lower Cretaceous. In Plate IV some of the larger limestone areas of the oldest groups are distinguished; in this plate also some rhyolites, flows, tuffs, and breccias that are closely related to the greenstones are shown separately.

LIMESTONES AND SCHISTS (SILURIAN AND DEVONIAN?).

Limestones and schists occupy a belt from 2 to 6 miles wide along the Yukon-Tanana divide from the eastern margin of the field nearly to the junction of Yukon and Tanana rivers. They occur also in the hills of the Ramparts and are the only metamorphic rocks represented in the Gold Hill region.

The chief areas of limestone in the eastern part of the region are shown on the geologic map (Pl. IV). All these beds have suffered intense deformation, and it is highly probable that the irregularity of the limestone areas is mainly due to the aggregation in certain places of beds that were once much more evenly distributed. Plate V, *A*, shows the characteristic closely folded limestone structure. That the deformation of these rocks took place under heavy cover is shown by the common occurrence of flow structure, which is especially evident in the wavy banding of the purer marbles.

Strong metamorphism is shown by many of the limestones, especially by those of impure types. Mica is the most common secondary mineral, but garnet, epidote, and scapolite also occur. The replacement of calcite by a chertlike form of quartz is a common phenomenon, which in many places has brought about a complete change in the chemical composition of the rocks. Many of the cherts and quartzose schists are believed to represent limestones that have suffered such substitution of minerals.

The limestones of the Yukon-Tanana divide are mostly nonmagnesian, are bluish or white in color, and incline strongly toward silicification. In addition to these types buff-colored dolomitic members occur at the Ramparts and near the head of Garnet Creek. No fossils were found in the limestones by the writer, but some were collected in 1907 by Prindle from the head of Little Minook Creek and from Quail Creek. These fossils, which were obtained from beds probably equivalent to some of those that occur along the Yukon-Tanana divide farther west, indicate Silurian and Devonian formations.

The schists include a wide variety of types. As already stated, the limestones grade into calcareous schists; quartzites and cherts grade into quartzitic and quartz-mica schists; and the slates grade into graphitic shists. Igneous rocks occurring with these schists are represented by greenstone schists, feldspathic schists, and granitic gneisses. Locally garnet and staurolite schists are developed. The metamorphism of the schistose rocks has probably been caused mainly by intense deformation of the original rocks under pressure sufficient to develop flow structure in many of the members. A complex crenulated structure in some of the schists indicates that more than one period of deformation occurred—probably most of these rocks have been affected by deformation many times.

The presence of garnet and staurolite in some of the schists is apparently due, at least in part, to the influence of the later granitic intrusives. The schists bearing these minerals are closely associated with the igneous rocks and some of them contain other minerals suggestive of contact metamorphism. The character of the schists, then, is not a fair criterion of their age. Greater weight should attach to the probable Silurian and Devonian age of the limestones, and it seems likely that in these periods most of the limestones and schists were originally deposited.

GREENSTONES (PROBABLY LATE PALEOZOIC).

In the northeastern part of the region is a large area whose predominant rocks are greenstones. This area flanks the Yukon-Tanana divide on the north, reaching from Minook Creek just above the mouth of Hoosier Creek southwestward to the Stevens Creek lowland. On the north the greenstones extend across the Yukon and beyond the head of Squaw Creek, which is the limit of the area observed.

The greenstones proper are altered basic igneous rocks, principally diabasic flows and tuffs. Associated with them in the vicinity of Rampart are minor beds of slate, chert, and limestone, besides other igneous types. Among the latter are rhyolitic lavas and flow breccias and dense aphanitic laminated rocks that apparently include glassy lavas and fine-grained tuffs. The rhyolitic rocks occupy considerable areas to the exclusion of other types, their white or buff color contrasting strongly with that of the greenstones. At the head of Squaw Creek the sedimentary rocks are absent and reddish andesitic flows are interbedded with the greenstones. Throughout the area of the greenstones basic igneous dikes are common, but in the Squaw Creek locality they are especially abundant. In stratigraphic position the greenstones are apparently above the limestones and schists. The nature of their relation to the underlying rocks is not clear, but they seem to record a continuance of the same activities with a marked increase in volcanism. The lowermost greenstones are interbedded with marine sediments and were probably submarine flows. The absence of such sediments among the higher members suggests that either the accumulation of the lower beds or uplift brought the area above sea level and afterward igneous activities alone were recorded. The rate of accumulation of an igneous series is capable of such wide variation that it is obviously unsafe to designate any age as that witnessing the formation of all the greenstones. It seems likely that the formation of the lower members closely followed the Devonian sedimentation. They may represent only late Devonian activities or possibly some late Devonian and more or less of the succeeding age.

SLATES, SANDSTONES, AND CONGLOMERATES (EARLY MESOZOIC).

The area lying between the Baker Creek flats and Tanana River in the southeastern part of the region is occupied by a sedimentary series. According to published descriptions [1] these rocks include red and green slates, sandstones, and fine conglomerates and although they have suffered much deformation they are but slightly metamorphosed. No fossils have been obtained from them, so their age and relations are in doubt. If they are to be correlated with a group of rocks that occurs along the north front of the Alaska Range, as suggested by Brooks,[2] they are older than Middle Devonian—probably older than the limestones and schists of the Rampart and Hot Springs districts. However, judged by their relative degree of metamorphism, they appear to be younger than the limestones and schists—younger even than the greenstones of the Rampart district. This would place them in the late Paleozoic or early Mesozoic—a view that is strengthened by the fact that the younger group next to be described, occurring in a contiguous area on the north, is largely Mesozoic and in part at least of Cretaceous age.

[1] 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, p. 472.

[2] Brooks, A. H., The Mount McKinley region, Alaska: Prof. Paper U. S. Geol. Survey No. 70, 1911, pp. 75-76.

SLATES, QUARTZITES, AND SCHISTS (CRETACEOUS AND OLDER).

Separating the area just described from that of the limestones and schists between the Yukon and Tanana is a belt of country several miles wide, occupied by the fourth subdivision of the metamorphic series, which is composed of slates, quartzites, and schists. On the northeast these rocks extend beyond the limit of the field investigated and on the southwest they disappear beneath the alluvial lowlands of the Tanana basin. The quartzites are confined rather closely to the northern part of the belt, the slates and schists occupying much of the belt alone.

Most of the slates are dark colored, many being notably graphitic. Remarkably fine, even cleavage was noted in many places and in some of these the lines followed the configuration of closely compressed folds. Locally a higher degree of alteration has produced phyllites, and again cleavage is but poorly developed or absent, the rock being an indurated shale.

The quartzites occur in massive beds from 10 to 50 feet thick interbedded with the slates and schists. They are most abundant in the northern part of the area, probably being among the lowest members. They are typically developed in the ridge between the main forks of Boulder Creek, in Eureka Dome and vicinity, and in the Little Minook-Quail Creek divide. In each locality heavy beds of hard, vitreous quartzites occur; most of them are dark gray but part are of lighter shades, some being almost milk white. The original quartz grains are plainly evident in many of the specimens and exhibit well-rounded boundaries and regrowth of crystals. In some places thin parallel but widely spaced leaves of muscovite have been developed. The more impure types show a greater degree of metamorphism; they grade in both composition and structure into the schists.

The schists of this age have been produced evidently by the alteration of impure quartzose sedimentary rocks. Some are almost pure quartz and differ from the quartzites only in the development of a schistose structure. However, most of them contain more or less ferruginous matter and secondary femic minerals. Rarely feldspars are included, indicating a derivation from an original arkose. The schists are for the most part light gray, becoming iron stained on weathering.

The assemblage of slates, quartzites, and schists just described is largely if not entirely of Mesozoic age. From one of the quartzites, which are regarded as among its lowest members, a collection of fossil shells was obtained on the Little Minook and Quail Creek divide. These fossils were submitted to T. W. Stanton for determination and the following is quoted from his report:

7241, No. 11 AE5. Little Minook-Quail Creek divide, one-half mile below trail crossing, Rampart quadrangle, Alaska:

Aucella? sp. apparently belonging to the group of *A. crassicollis* Keyserling.

Many fragments of pelecypods, probably Lower Cretaceous or Jurassic.

The collection is far from satisfactory and the determination is given only provisionally. If it is correct, the horizon is either Lower Cretaceous or uppermost Jurassic.

Prindle[1] found Upper Cretaceous fossils in "black, rather massive carbonaceous sandy shales" on Wolverine Mountain. Similar rocks extend southwestward from Wolverine Mountain, and it is probable that the Upper Cretaceous epoch is represented also by some of the dark shales associated with the quartzites and schists. Although the evidence is not as full as might be desired, a considerable range in age seems to be represented in this assemblage. In view of the great thickness of Mesozoic strata in adjacent regions, these rocks may belong entirely to this era—perhaps to only its later epochs.

TERTIARY SHALES, SANDSTONES, AND CONGLOMERATES.

Several small isolated areas of Tertiary sediments occur in the region adjacent to the Yukon. They include clays, shales, sandstones, conglomerates, and thin lignitic seams, and are apparently of fluviatile origin, the coal beds representing vegetal accumulation in the lateral basins of ancient aggrading streams. The beds have suffered considerable deformation, their dips ranging from practically zero to almost vertical. Extensive faulting has also occurred. The Tertiary beds still remaining are probably remnants of deposits that originally extended over the entire region, their preservation being due to a protected position among the older rocks given to them by downfolding or faulting. Owing to the extensive erosion to which the Tertiary strata have been subjected, it is impossible to estimate their original thickness. The present outcrops exhibit beds aggregating hundreds if not thousands of feet.

The exposures along the left bank of the Yukon above the town of Rampart have furnished fossils, both plants and invertebrates, of Eocene age. Concerning the shells W. H. Dall, who examined them, says, "These are *Unio althlios* Meyer, a species first described from the leaf-bearing beds of the Kenai formation of Cook Inlet, Alaska." The plants from this locality were examined by Arthur Hollick, who gave the following report:

Collection 11 AE1. Bluff, left bank of Yukon, 1½ miles above Rampart (Lot No. 6094). This collection consists of four specimens in a friable sandy clay matrix. Apparently only a single species is represented.

Rhus n. sp.

Collection 11 AE2. Bluff, left bank of Yukon, 1½ miles above Rampart, 300 feet higher than 11 AE1 (Lot No. 6095). This collection contains two kinds of matrix.

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[1] Prindle, L. M., The Fairbanks and Rampart quardangles, Yukon-Tanana region, Alaska: Bull. U. S. Geol. Survey No. 337, 1908, pp. 23–24.

One is apparently the same as that of collection 11 AE1; the other is a hard clay ironstone, which may, however, be merely an indurated phase of the former. The following identifications were made:

In sandy clay matrix:
- Ulmus braunii Heer.
- Betula prisca Ettingsh.
- Hicoria magnifica Knowlton.
- Acer arcticum Heer?

In clay ironstone matrix:
- Populus glandulifera Heer.
- Corylus macquarrii (Forbes) Heer.
- Hicoria magnifica Knowlton.
- Grewia crenata (Ung.) Heer.
- Platanus haydenii Newb.?

Age: Eocene.

There can be no doubt that sediments of similar composition and condition in other areas are of approximately the same age as the beds at the locality above Rampart and that all represent the notable period of fluviatile deposition in Eocene time, evidence of which is widespread in Alaska.

QUATERNARY SILTS, SANDS, AND GRAVELS.

Much of the area under discussion is mantled by silt, sand, and gravel deposits of Quaternary age. Although extensive erosion has greatly reduced the amount of these deposits, they still persist as a filling hundreds of feet thick in the lowland areas and occur as remnants up to an elevation of 1,500 feet above the sea, a level to which they evidently at one time filled the older topographic depressions. Plate V, *B*, shows the massive character of the silts at the Palisades of the Yukon.

Deposits of gravel and bowlder usually constitute the base of the series and fine sand and silts make up the greater part of its mass. Some of the bowlders are large, several that measured 5 or 6 feet in their longest dimension being noted. Although most of the bowlders occur in the beds next to bedrock, isolated ones are found well up in the silts, their position indicating an unusual mode of transportation. The silts are fine and light colored and are composed of finely comminuted angular mineral fragments, chiefly quartz, and a little clay. The beds are practically undeformed and only locally are they appreciably consolidated.

Pleistocene mammal remains are plentiful in the lowermost bowlder beds and land shells of species still living in the same region are found in the silts. As silts of like character are a common product of glacial action, it is presumable that those of this series may be of glacial origin. Whether the time of the principal glaciation in this region coincided with that of the Pleistocene ice extensions in lower latitudes is uncertain, and the age of the silts must be regarded as correspondingly in doubt. The extent to which they have been eroded would indicate a great lapse of time and favor the presumption of early rather than late Quaternary age. The conditions attending the deposition of the silts are discussed more fully in the section on geologic history (p. 27) and special types of the deposits are described in the section on the auriferous gravels (pp. 30–34).

IGNEOUS ROCKS.

The older, metamorphosed igneous rocks have been described in connection with the rest of the metamorphic rocks. Besides these the region contains a number of areas of monzonites and a complex system of dikes composed of rocks that differ greatly in composition.

The monzonites have the forms of batholiths and immense sills, the latter assuming the dip and trend of the principal structure of the region. In the eastern part of the region they occur at the Ramparts of the Yukon, in Roughtop and Hot Springs mountains, and in Elephant Dome. In the Gold Hill district they occupy areas between the heads of Golden and Illinois creeks and north of Little Melozi River. As a rule these areas are manifest topographically, the superior resistance of the monzonite to weathering resulting in prominent rugged mountains.

The typical monzonite is a coarse-grained grayish rock, in hand specimens of which large tabular feldspars, biotite, and a pyroxene can be distinguished. In many specimens border phases show finer grain and a relatively greater abundance of femic minerals. The usual type includes both alkalic and calcic feldspars, augite, biotite, and hornblende, with accessory apatite, titanite, and zircon. In ordinary phases the alkali feldspars predominate and in the more basic differentiations the calcic varieties are more abundant. Feldspars having a wide range in composition are present in most specimens. In one both orthoclase and anorthite are associated with feldspars of intermediate composition. Augite is the most important of the femic minerals. It is pink and pleochroic, probably being titaniferous. Titanite is very abundant in many specimens and should certainly be regarded as an esssential constituent of some. Biotite occurs in small idiomorphic crystals in all the monzonites, and in some of the differentiation phases it is the dominant femic mineral.

Dikes cut the pre-Tertiary rocks in many parts of the region. Some of them are essentially like the monzonites in composition, others are granite and acidic pegmatite. Many pegmatite dikes have a center of practically pure milky quartz containing a few scattered leaves of muscovite and borders of quartz, orthoclase, plagioclase, biotite, aud muscovite, with accessory garnet, tourmaline, and apatite. In many places the border phases of the pegmatites are but poorly developed and the dike consists almost entirely of quartz. Numerous quartz veins in the same region may have resulted from a complete transition from dikes to veins.

GEOLOGIC HISTORY.

PRE-TERTIARY TIME.

The legible geologic record of the Rampart and Hot Springs districts begins with the deposition of the oldest of the metamorphic rocks, which probably occurred in Silurian and Devonian time. The history of these periods can not be traced in detail, but certain generalizations may be drawn. That the earlier sediments were deposited beneath the sea is shown by the abundance of limestone and by the fossils that have been found in them. Volcanism began early in the period represented by the older sediments, but was a subordinate factor until near the close of that period. It then prevailed over all other activities and superimposed a great thickness of igneous rock upon the earlier sediments. The earlier volcanic rocks were submarine flows and tuffs and were accompanied by a minor amount of sediments. Later the land was raised or built above sea level, and an exclusively igneous series was formed.

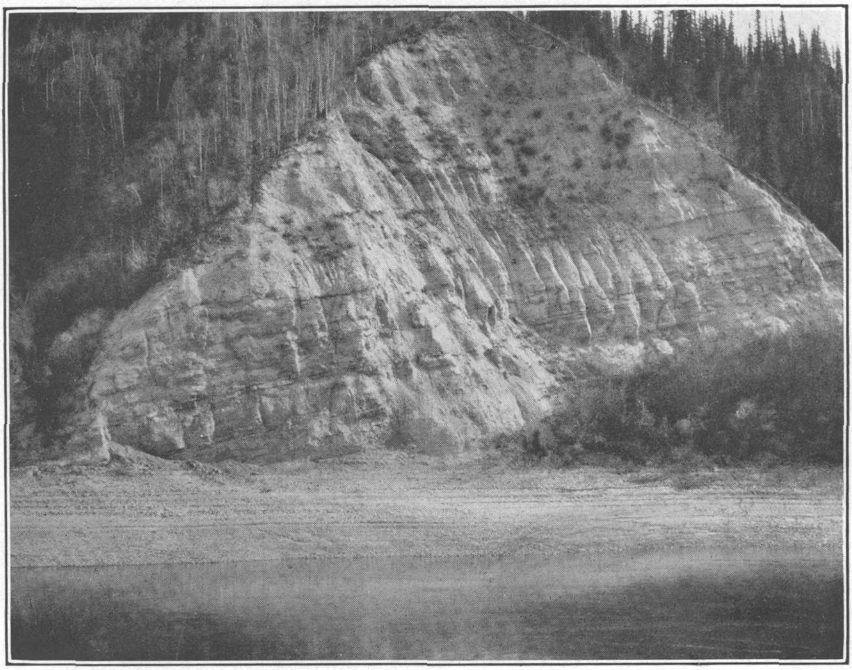
Late Paleozoic and perhaps early Mesozoic time is unrepresented by any lithologic record, unless the slate, sandstone, and conglomerate assemblage is of one of these ages. If it is, the relatively slight alteration of these beds indicates a possible period of diastrophism before their deposition and after that of the older groups.

At some early period the older groups of stratified rocks were intruded by immense granitic masses that have since been deformed and altered with the rocks that they invaded.

As already noted, the rocks of later Mesozoic age—the slate, quartzite, and schist assemblage—are in evident unconformity with the underlying rocks; also they are less altered. The Lower Cretaceous sediments were evidently deformed under heavy cover, and an extended period of erosion ensued before the Upper Cretaceous beds were laid down, for the base of the latter is a conglomerate of quartzite bowlders apparently derived from the Lower Cretaceous quartzites.[1] Both Lower and Upper Cretaceous sedimentation was marine in large part, if not entirely.

After the Upper Cretaceous sedimentation igneous activities were renewed with the intrusion of the monzonites and of various dikes. The area became elevated above sea level, probably with additional folding and faulting of the Cretaceous and older rocks. A long period of erosion followed, during which the Crêtaceous beds were removed from large areas, later occupied by younger sediments.

[1] Prindle, L. M., oral communication.



A. EOCENE BEDS ON LEFT BANK OF THE YUKON $1\frac{1}{2}$ MILES ABOVE RAMPART.

The beds in this locality are composed chiefly of fine sands and clayey shales.

B. EOCENE BEDS OVERLAIN UNCONFORMABLY BY SILTS IN THE PALISADES OF THE YUKON.

Composed principally of sands and fine conglomerates but contain abundant kaolin, as is shown by their white color.

TERTIARY TIME.

To account for the absence of Cretaceous beds beneath the Eocene in certain areas and for the gradation from clays and fine sediments in the lower part of the Eocene to sands and conglomerates higher in the series, a succession of periods differing greatly in erosional activity is required, the differences being due probably to orographic changes.

Between the Cretaceous and the Eocene sedimentation there must have been a long period of active erosion, in which the Cretaceous beds were removed from the areas noted above. Erosion then subsided, probably keeping pace with a general reduction of grades by the streams. Then followed a long period when weathering was the dominant process and when a mantle of the products of rock decay was formed over much of the country.

Next came orographic changes that quickened erosion over certain areas, the materials probably being redeposited at no great distance from their sources. It is reasonable to suppose that the axes along which uplift started these changes were already determined by prior movements and that they probably coincided with the principal divides of the drainage systems. The uplift, then, first affected the headward portions of the streams most strongly. With their energy thus increased the streams easily attacked the surface deposits and delivered large volumes of fine débris to the trunk channels, whose capacity was at first probably little affected by the crustal movements. Deposition in the valleys of the larger streams followed. This resulted in a steepening of grades farther and farther from the seat of uplift. The longer the streams the greater would be the thickness of strata required for the establishment of competent grades to the sea. As aggradation lifted the streams out of their valleys their flood plains coalesced, permitting the continuous deposition of similar materials over wide areas. During this period the interstream areas were probably at times heavily vegetated swamps, in which were accumulated the materials now comprising the lignite beds. Shifting of the streams to new courses as their channels became aggraded above the level of the interstream swamps occurred at intervals, giving in each section an alternation of lignite beds and clastic deposits.

Continued uplift, whether steady or intermittent, permitted the streams, after the removal of the decomposed mantle from the area of strongest uplift, to attack bedrock, and during an intermediate period the products of both decomposition and comminution entered into the Eocene formations, the latter products tending to predominate more and more. (See Pl. VI, *A* and *B*.) In the sequence from the clays and lignites at the base to the sands and conglomerates at the top of the series is recorded the growth of the mountains and the evolution from the placid streams of the early part of the period to the mountain torrents that at last probably determined the gradient and character of the streams for the entire distance to the sea.

There is some doubt as to the age of certain heavy gravel deposits overlying the beds of known Eocene age south of Tanana River. In some places they are apparently conformable with the Eocene beds, but in others they show evidence of erosional unconformity. These deposits probably record a period in which erosion was greatly stimulated by a marked uplift of the mountain provinces. This uplift might have followed the Eocene deposition either closely or more remotely, for if the intervening period was one of relative stability of the land, the rivers would have reached adjustment and no sedimentary record would have been formed except near the sea. At any rate both the known Eocene beds and the overlying gravels had been laid down before the next notable period began.

After the Tertiary beds were deposited the whole region over which they were spread was affected by diastrophism resulting in a general uplift of the land and the deformation of the beds. General erosion was renewed by these movements, and the later Tertiary history of the region is a record of the stages of land degradation. There is strong evidence in many parts of interior Alaska to show that the late Tertiary uplift was not continuous, but halted in at least one stage long enough for the reduction of large areas approximately to base-level. This stage was recorded in the Yukon Plateau, a peneplain which was later dissected and whose remnants have been widely recognized. In this stage the Tertiary beds were completely removed from large areas but remained wherever they were flexed or faulted below the level of the peneplain. After the period of base-leveling degradational agencies were again brought into play by further elevation of the land and the areas of less resistant Tertiary beds became the object of selective erosion. In this stage, principally by the removal of Tertiary beds, the areas of relative depression in post-Eocene time received topographic expression in valleys and lowlands, outlining the orographic features that were to persist to the present day.

QUATERNARY TIME.

Erosion subsequent to the elevation of the Yukon Plateau had progressed for a long time prior to the beginning of the Quaternary period and had produced the well-developed system of valleys of a mature topography. Interstream areas were small, many of the lower ones being in the form of sharp ridges. Either the land was standing at a higher elevation or the streams had lower gradients than those of to-day, for in many depressions that then existed the present streams have their courses laid over a great thickness of Quaternary filling.

During earlier Quaternary time an important group of sediments was laid down, rock-cut terraces were formed on the sides of the pre-Quaternary valleys, interstream ridges at certain elevations were horizontally truncated, and the Yukon, assuming a course at variance with the pre-Quaternary depressions, excavated its canyon-like valley through the Ramparts.

The Quaternary sediments filled the older valleys in the vicinity of the Ramparts to a height which is now about 1,500 feet above sea level. This altitude also closely approximates that of the top of the Ramparts, the higher rock-cut terraces, and the truncated ridges. It is apparent that the level of these features must have been reached at the time when the Yukon assumed its present course at the Ramparts by a body of water in which the silts were deposited and whose shore lines are marked by rock-cut terraces and truncated ridges. The elevation of the Yukon at the Ramparts during the period of their development exercised a controlling influence on the erosion in the upstream portion of its basin. Many terraces below the highest may represent the activities of the river or of ponded waters during periods of relatively slow lowering of the Ramparts barrier.

In the Tanana basin Quaternary silts and gravels were deposited and rock-cut terraces were developed, but neither stand at as great an elevation as the corresponding features in the Yukon basin, the highest being about 1,200 feet above sea level. The lower terraces apparently represent the beach erosion of a body of water whose surface was rising by successive stages, not falling, for the deposits of each successive terrace overlap those of the terraces below it.

The Quaternary inundation was followed by the withdrawal of the waters and the establishment of the drainage systems in their present forms. Later erosion has left only remnants of the earlier Quaternary deposits, having redeposited or completely removed from the region their larger part.

The area here under consideration is unglaciated itself, but to the influence of glaciation in adjacent parts of Alaska are probably due the special activities noted as having affected it during the earlier part of the Quaternary age.

Many of the auriferous gravels lie beneath thick deposits of gravel and silt and probably represent concentrations incident to the erosion of the pre-Quaternary valleys. Others developed on the terraces are probably early Quaternary concentrations. Certain streams have developed courses across Quaternary terrace deposits and their gravels represent a still later period of concentration, which is still in progress.

ECONOMIC GEOLOGY.

GENERAL FEATURES.

Gold is the only mineral whose occurrence in the Rampart quadrangle has proved to be of economic importance. It has been mined profitably in both the Rampart and Hot Springs districts, and is known to occur at a number of other localities. The known distribution of auriferous gravels is shown on Plate VII.

Tin occurs with the gold in the placers of Sullivan Creek, and small quantities have been recovered incidentally to the gold mining. So far, however, no serious attempt has been made to recover any large part of the tin ore and no profitable disposal has been made of that saved.

Lignitic coal occurs in the Eocene beds near Rampart, but no seams thick enough to be mined profitably have been found.

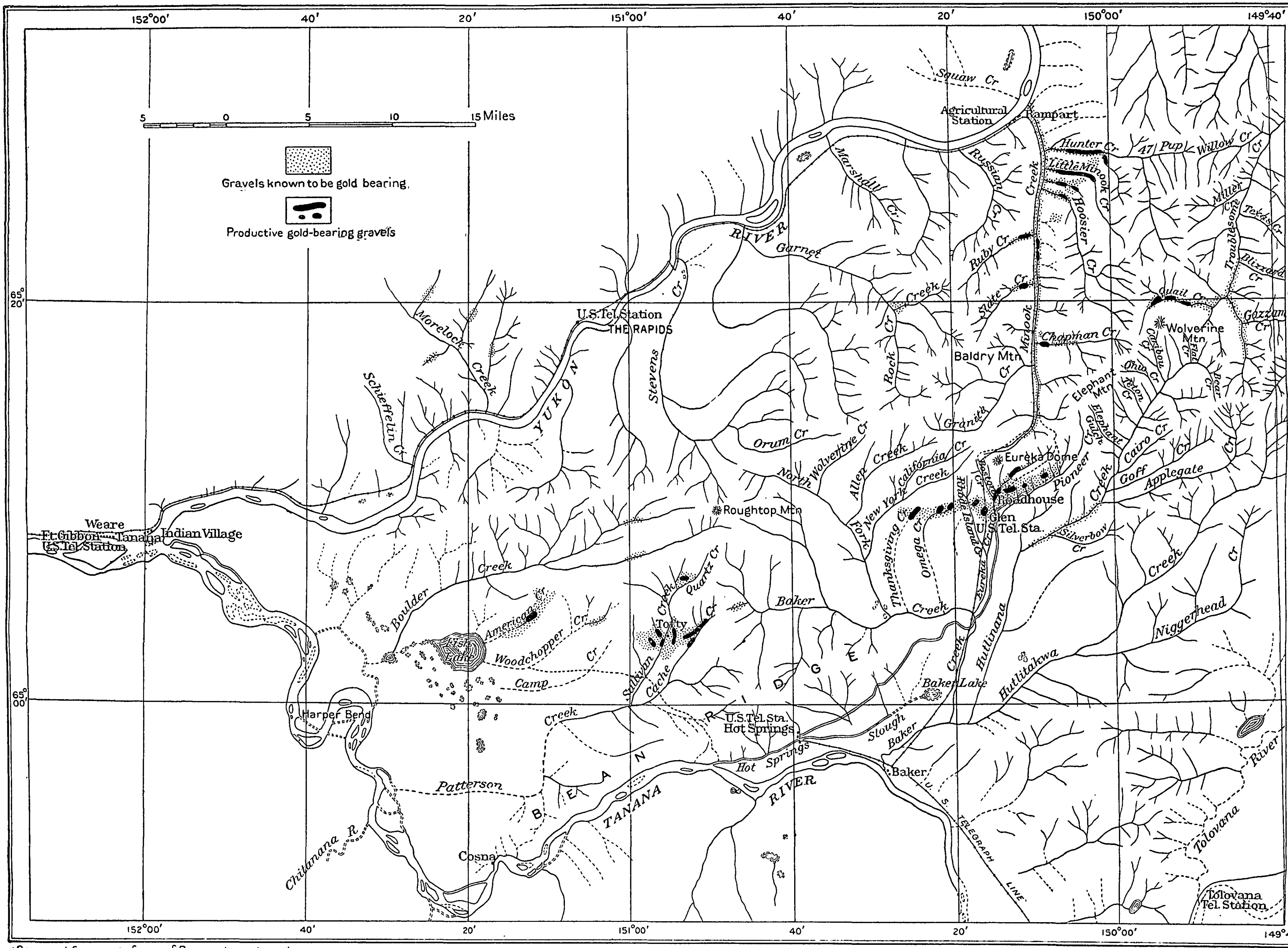
GOLD.

HISTORY OF DEVELOPMENT.

Placer gold was discovered in the Rampart district probably as early as 1893. The first discoveries were made on Minook Creek and its tributaries, and since 1896 systematic mining has been carried on in this district, the first claim worked being on Little Minook Creek. (See Pl. VIII, *B*, p. 34.) Later, as the area being prospected increased, placers were located and mines developed on the tributaries of Baker Creek along the northern border of the flats, and still later on Sullivan Creek and neighboring streams tributary to Patterson Creek.

Prospecting on the tributaries of the Yukon and Tanana west of the productive areas has revealed the presence of gold in a number of localities, as shown on Plate IV (in pocket). Although much ground is held on some of these streams, especially in the Gold Hill district, the presence of gold in commercial quantities has not been demonstrated. In the Gold Hill district this may be due in great part to the facts that very little besides annual assessment work is being done and that what is done is largely futile.

The scene of greatest activity in mining in the Rampart and Hot Springs districts has shifted to the south as successive discoveries have been made. The Rampart district yielded its greatest output in 1906 and 1907. The placers along the north margin of Baker Flats reached their maximum production about the same time but have not fallen off so rapidly as the Rampart district. The Patterson Creek locality has steadily increased its production since operations were begun, the season of 1911 recording the largest output in its history.



Prepared from part of map of Rampart quadrangle

MAP OF RAMPART AND HOT SPRINGS DISTRICTS, ALASKA, SHOWING DISTRIBUTION OF PLACER GOLD.

Gold and silver produced in Rampart district.

Year.	Gold.		Silver.	
	Fine ounces.	Value.	Fine ounces.	Value.
1896 to 1903, inclusive	29,799.00	$616,000	4,440	$2,664
1904	4,353.75	90,000	649	376
1905	3,870.00	80,000	576	351
1906	5,805.00	120,000	865	588
1907	6,046.87	125,000	901	595
1908	3,628.13	75,000	540	286
1909	4,837.50	100,000	721	375
1910	2,080.12	43,000	310	167
1911	1,548.00	32,000	231	125
Total	61,968.37	1,281,000	9,233	5,527

Gold and silver produced in Hot Springs district.

Year.	Gold.		Silver.	
	Fine ounces.	Value.	Fine ounces.	Value.
1902 and 1903	12,717.79	$262,900	1,818	$964
1904	7,038.56	145,500	1,007	584
1905	5,805.00	120,000	831	507
1906	8,707.50	180,000	1,245	843
1907	8,465.63	175,000	1,210	798
1908	7,256.25	150,000	1,038	550
1909	15,721.87	325,000	2,248	1,169
1910	15,721.88	325,000	2,248	1,169
1911	37,974.37	785,000	5,430	2,932
Total	119,408.85	2,468,400	17,075	9,516

SOURCE OF THE GOLD.

The distribution of the gold in the Rampart and Hot Springs districts is definitely related to the metamorphic rocks. The bedrock in the Rampart district is mainly greenstone, which is accompanied by a variety of slates, cherts, and impure limestones, all more or less altered. The Hot Springs district, from American Creek to the Baker Creek placers, lies within the slate, quartzite, and schist area, and the placer ground of Quail Creek, which heads against Little Minook Creek, is a continuation of the same area.

Quartz veins are so plentifully distributed in the older rocks of the entire region that a greater abundance in the areas containing the placers can hardly be asserted. Although as a rule the quartz veins are barren of visible mineralization, there is some evidence that in the placer districts they are gold bearing. On Little Minook Creek a vein 6 feet wide is said to yield gold on being crushed and panned. In the Sullivan Creek placers the richer ground is thought by the operators to be marked by an unusual abundance of quartz veins. In both districts nuggets composed partly of quartz are common. In the Gold Hill district is a quartz vein known to be auriferous, but an unsuccessful attempt has proved that it is not of sufficient extent or richness to be mined profitably.

Although these facts indicate that much of the placer gold comes from quartz veins, another source is suggested for at least a part of it in the Hot Springs district. Nuggets from What Cheer Bar, near Glen, contain fragments of black slate. In the tailings of one of the Sullivan Creek mines was found a piece of quartzite having tiny stringers of gold along its cleavage planes. It would appear that on these creeks the gold was deposited in the available spaces in the country rock, wholly without gangue minerals. The formations comprising the country rock in all the placer districts contain members that are very rich in carbonaceous material. Carbon is thought to influence the precipitation of gold under certain conditions, and it seems possible that the distribution of gold in the region may be in some degree related to that of the carbonaceous beds.

Still another source of gold may be the hematite deposits in the neighborhood of the monzonite areas near Hot Springs and Roughtop Mountain. Brecciated zones of the country rock ranging from a few inches to several feet in width have received deposits of hematite. Samples taken from these deposits, both in the Roughtop Mountain locality and near Hot Springs, are said to yield steady assay returns of several dollars a ton in gold. Although such an occurrence of gold is unusual, it is far from impossible, but further sampling, including entire crosscuts of minable bodies of the ore, will be required to establish the economic value of the hematite.

AURIFEROUS GRAVELS.

The auriferous gravels of the Rampart and Hot Springs districts, considered in their relation to modern topography, are of two types—stream gravels, forming the beds and flood plains of modern streams, and terrace gravels, situated above the present valley floors. Some deposits of the latter type cover benches that undoubtedly were formed by the present streams; others do not clearly indicate this origin.

The stream gravels have furnished the greater part of the gold output of the Rampart district, the operations on all the creeks except Hunter being confined to these gravels. On Hunter Creek only a small part of the gold produced has come from this source. The stream gravels of the district are shallow, as a rule; on Minook they range in thickness from a few feet to 15 or 20 feet, and on the smaller streams the range is even less, the usual thickness being from 6 to 8 feet. The gravels lie under a cover of muck and silt, which generally thickens toward the sides of the valley. It appears that the valleys were at one time more or less completely filled with silt, a large part of which has been removed. Where the removal has been most complete, near the courses of the streams, open-cut mining is employed, but nearer the valley walls, where the overburden is very heavy, drifting is necessary.

In the Hot Springs district a large part of the gold taken from the streams tributary to Baker Creek has come from the stream gravels. The deposits of this type are similar to those of the Rampart district except that generally they are overlain by a much thinner overburden of silt or muck. The stream gravels of the Patterson Creek group carry gold in small quantities, but are nowhere rich enough to be mined profitably.

Terrace gravels occur in both the Rampart and Hot Springs districts. In the Rampart district well-defined benches occur on Minook and Hunter creeks. Those on Hunter Creek lie along the valley walls and may represent stages in the down cutting of the stream. The lowest bench on Hunter Creek, lying as a rule only 15 or 20 feet above the stream, has been the principal source of the Hunter Creek gold. The bedrock floor of this bench is irregular, in some places sloping downward away from the stream, toward the valley wall. The actual surface of the bench slopes upward toward the margin of the valley, especially in the vicinity of lateral streams. The upper part of this bench deposit seems to be composed largely of materials delivered to the main valley by its tributaries in the form of alluvial fans of varying steepness. The deposits of the lower terrace of Hunter Creek are minable by open cuts along their streamward margins, being made up, as a rule, of 3 to 6 feet of gravel with an overburden of a few feet of muck. The notable thickening of the overburden toward the margins of the valley limits the width of ground to which open-cut mining is applicable.

Ill-defined remnants of terraces occur at various elevations along the sides of Minook Valley, but only the lower bench, which resembles that of Hunter Creek, has been productive.

The ridges between the eastern tributaries of Minook Creek are peculiarly flat-topped and rise eastward in a succession of broad steps standing from 600 to 800 feet above the level of Minook Creek. Some carry gravel deposits that have proved, locally at least, to be gold bearing. Prospecting has revealed deposits of various depths, the thickest being more than 100 feet deep. Their materials in the main consist of more or less worn fragments of the local country rock, yellow clays or silts, and scattered quartzite bowlders, many of great size, which are foreign to the immediate neighborhood. Only very low contents of gold have been reported from these deposits, and their elevated position, even if they should prove to contain larger amounts of gold, would render their exploitation very difficult.

In the Hot Springs district bench gravels have been productive on most of the gold-bearing streams tributary to Baker Creek, and in practically all the Patterson Creek placers the deposits have no evident relation to the present streams.

The peculiar type of bench deposits characteristic of the Hot Springs district is illustrated by What Cheer Bar. This deposit skirts the point between Eureka and Pioneer creeks, lying at a level about 250 feet vertically above the latter stream and 2,000 feet above it up the side of the valley. A space 2,000 feet long and from 150 to 200 feet wide has been mined and the resulting cut reveals the general character of the deposit. What Cheer Bar is a flattened space on a gently sloping valley side, which formerly bore auriferous gravels ranging in depth from 3 to 10 feet. The gravels range in size from fine material up to bowlders several feet in diameter. The bench has no perceptible grade the long way, but crosswise toward Pioneer Creek, it slopes at a grade which was found suitable for the sluice boxes but which is less than the general slope of the hillside. At the uphill side of the bench the bedrock rises at a steeper angle than elsewhere, coming nearly to the surface, and then flattens to the general slope of the hillside. Most of the bowlders found in the deposit are quartzite, but some are conglomerate. Rocks of these types occur in place in the basin of Pioneer Creek and perhaps in the hill on which the bench is developed. Other benches that carry a little gold occur on the hillside above What Cheer Bar, and farther up the valley of Pioneer Creek, on the same hillside, similar deposits have been productive.

A heavy deposit of gravel occurring along the north side of Baker flats west of Eureka Creek is apparently unrelated in origin to the present streams, which flow transversely across it. Although in general this deposit has proved to be of too low a tenor to be worked, it carries some gold and probably has been the source of much of the gold found in the gravels of the streams where they cross it.

In the Patterson Creek locality shallow gravels are worked by open cuts on Quartz Creek and Tofty Gulch. The deposit on Quartz Creek, known as Homestake Bar, is about a quarter of a mile from the creek, on a slightly sloping hillside. It consists of 3 or 4 feet of gravel overlain by 3 feet of yellow silt. The gravels are little worn except in a thickness of about 1 foot next to bedrock. The entire hillside is covered with deposits similar to those being worked except that they carry less gold. The workable deposit extends horizontally along the hillside and no surface indications suggest its extent. However, the bedrock slopes toward the creek at a lower angle than the surface of the ground, and at the uphill margin it rises more sharply, forming a so-called rim. The rim seems to mark the limit of the richer deposit. The ground is worked by ground sluicing and with pick and shovel.

On Tofty Gulch a considerable open cut has been made on a bench on the hillside about 1,000 feet from Sullivan Creek. The deposit consisted of 4 to 6 feet of gravel covered by several feet of yellow silt and black muck. Large bowlders were very common in the top layers of the gravel and some were found in the lower part of the silt. The black muck contained a great many remnants of trees, which added considerably to the difficulty and expense of mining. In working the deposit the top layers of muck and silt were ground-sluiced off, dynamite being employed to break up the tangle of wood débris in places, after which the gravels were carried to the sluice boxes with a steam scraper.

The other placers of Sullivan Creek and those of Cache Creek lie deeper—from 30 to 75 feet below the surface. They are worked by drifting. Machinery is employed to hoist the gravel to the surface. The thickness of the gravel deposits ranges from 10 to 35 feet, the remaining depth below the surface being made up by an overburden of silt. It is reported that 90 feet of silt was penetrated in sinking an unsuccessful prospecting shaft at a place between Cache and Sullivan creeks.

The gravels include some well-worn materials but are made up mostly of angular fragments of the country rock. In fact, it is often difficult to distinguish the surface of the bedrock, so closely does it resemble the fragmental deposits. One prospect hole was abandoned where it reached a lens of this material, but when deeper holes near by had revealed rich gravels the shaft was sunk through the lens, and when it reached the true bedrock workable gravels were found.

The more worn materials are usually of the most resistant types, a hard vitreous quartzite being common. Many bowlders of this rock too large to handle are encountered in all the drifts; in some 5-foot drifts all the vertical space is taken up by a single bowlder. However, as these bowlders are generally more or less isolated they offer no serious difficulty to mining.

Most of the bedrock surface is much weathered, being brecciated and carrying gold to a depth of a foot or more. The configuration of the bedrock surface in all the deeper mines is that of a succession of flat benches, which rise one after another toward the higher ground. The richest gravels are commonly found near the uphill margin of the benches.

The auriferous gravels of American Creek are somewhat similar to the bench gravels of the Patterson Creek locality. It is reported that more of the later discoveries have been made on bench ground than in the stream gravels. The depths range from 10 to 20 feet. The gravels are worked by drifting and so far no steam machinery has been used in hoisting.

On Grant Creek and some of its tributaries and on Illinois Creek, in the Gold Mountain district, good prospects are reported, but so far the presence of valuable deposits has not been demonstrated. Prospecting is seriously hindered by the great depths to the gravels in much of the district and by live water where they are unfrozen. On Illinois Creek a hole is said to have been sunk 133 feet and then abandoned on account of live water, so that it did not reach bedrock. This shaft passed through several beds containing fine gold.

On Grant Creek the results have been much the same, live water having caused the abandonment of holes when they had been sunk from 30 to 135 feet. The only holes sunk to bedrock on Grant Creek are about 2½ miles above its mouth and have a depth of about 30 feet. A few holes on Lynx Creek, the principal eastern tributary of Grant Creek, have reached bedrock at a depth of about 20 feet, discovering on bedrock a foot of gravel said to yield at the rate of $10 or $12 a yard. After a small amount of drifting had been done the works were abandoned. On American Gulch, a small tributary of Grant Creek, near its head, the gravels are said to yield the best prospects found in the region, some estimates putting the values as high as $1 a square foot of bedrock. The gravels are 10 to 12 feet deep and are not frozen. The construction of a bedrock drain, which has been unsuccessfully attempted, would probably afford more definite knowledge of the deposit.

WATER SUPPLY.

With the exception of Minook Creek and two of its tributaries, Hunter and Hoosier creeks, the streams of the Rampart and Hot Springs districts furnish a very scanty supply of water for mining. Hunter Creek usually has a discharge sufficient for two 3-inch nozzles under a 150-foot head, and in time of freshets, of course, its discharge is much greater. Its recorded minimum flow[1] is 3.7 second-feet, or about 150 miner's inches, and its maximum is 27 second-feet, or more than 1,000 miner's inches. Hoosier Creek is of very nearly the same size. Little Minook Creek carries less than a sluicehead during much of the drier part of the season.

Eureka Creek at its mouth has a discharge similar to that of Hunter Creek. About half of this is contributed by Pioneer Creek and about a fourth by the main head of Eureka Creek above Pioneer Creek. None of the tributaries of Patterson Creek at the locality of the mines furnishes sufficient water for constant sluicing during much of the summer, and pumping is practiced at most of the plants.

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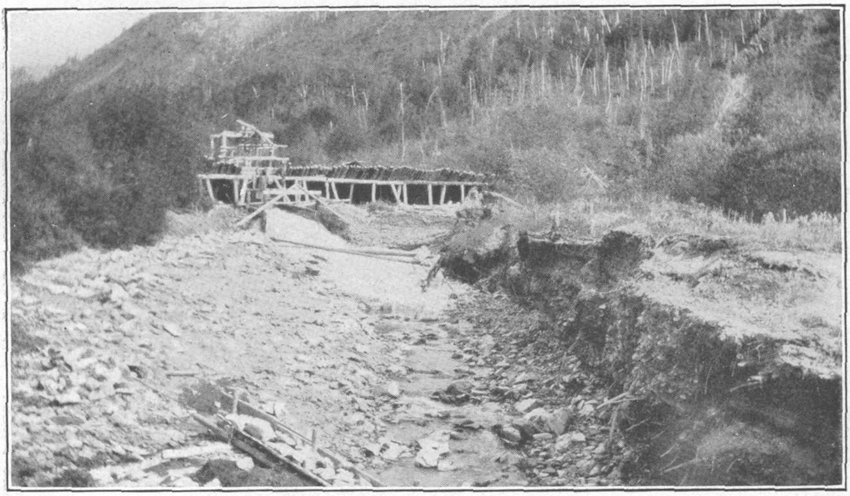
[1] Ellsworth, C. E., Water-supply investigations, Yukon-Tanana region, Alaska: Water-Supply Paper U. S. Geol. Survey No. 228, 1909, p. 68.



A. SPLASH DAM ON LITTLE MINOOK CREEK.

B. LITTLE MINOOK CREEK, SEEN FROM IDAHO BAR.

MINING IN 1911.

RAMPART DISTRICT.

General conditions.—Active mining in the Rampart district during 1911 was limited to Hunter and Little Minook creeks, of the Big Minook basin, and to Quail Creek, a tributary of Troublesome Creek. Gravels that were generally of lower tenor than those mined in former years were encountered and the difficulties of mining were greater, owing to an increase of the overburden as the valley walls were approached and to the obstruction caused by tailings of former operations.

Hunter Creek.—On Hunter Creek two hydraulic plants were operated during the summer of 1911. A steam hoist was installed on Dawson Creek, a tributary of Hunter Creek, but owing to an accident was abandoned for the summer. A single claim was worked to a small extent by pick and shovel. About 12 men were employed on four claims during a part of the summer.

Little Minook Creek.—On Little Minook Creek five claims were worked to some extent during the year. The operations included winter drifting on two claims and during the summer the use of two splash dams, employing about seven men. (See Pl. VIII, *A*.)

Quail Creek.—Quail Creek was not visited by the writer. It was learned, however, from the miners near Rampart that four splash dams were operated most of the summer, employing from 8 to 12 men at different times.

HOT SPRINGS DISTRICT.

General conditions.—The year 1911 witnessed a marked decrease in mining operations in the part of the Hot Springs district tributary to Baker Creek, contrasting with an increased activity in the Patterson Creek camp. In the former locality Thanksgiving, Omega, Pioneer, Eureka, and Hutlinana creeks were active. In the latter mining was in progress on Sullivan, Cache, Quartz, and American creeks.

Thanksgiving Creek.—In the early summer about 20 men were sluicing and shoveling in on Thanksgiving Creek. Later in the season operations were at a standstill, owing to lack of water.

Omega Creek.—A single claim is reported to have been worked on Omega Creek in 1911; it was being drifted, the gravel being hoisted by hand. The ground was about 16 feet deep and the results were said to be satisfactory.

Eureka Creek.—A steam scraper was employed in open-cut work on Eureka Creek near the mouth of Boston Creek. On the upper part of Eureka Creek a claim was worked by means of a splash dam. Eight or ten men were employed on this creek.

Pioneer Creek.—Four men were employed in sluicing on the bench ground of What Cheer Bar, on the right bank of Pioneer Creek, a little above its mouth. Two or three claims were being worked higher up on Pioneer Creek but were not visited. About 15 men were said to be employed in the summer workings.

Hutlinana Creek.—Four men operated two splash-dam outfits on the upper part of Hutlinana Creek during the summer. Nothing definite was learned of their success.

Sullivan Creek.—The greatest activity in the whole region was in the Sullivan Creek locality. Six steam hoists, employing about 150 men, were in operation most of the summer. In depth to bedrock the claims range from 30 to 70 feet. Most of the overburden is yellow silt, the rest being gravel and black muck.

The gold is usually in the lowest 2 or 3 feet of gravel and in the shattered bedrock. According to the reports of operators the tenor of the gravels, expressed in terms of the area of bedrock uncovered, ran from about 50 cents to more than $20 a square foot, and selected pans from the pay streak of the richest claim carried $10 to $15 in gold. The tenor of the gravels actually removed ranged from about $3.50 a yard to very much higher figures.

The costs of mining vary with conditions on the different claims and the methods employed. Many of the plants were compelled to pump water for sluicing, which adds considerably to the expense for fuel and cost of upkeep. The lowest estimate of the cost of operation was 35 cents a square foot of bedrock, which is equivalent to about $2.50 a yard of gravel. On some claims the costs were probably more than double this amount.

In the summer valuable gravels were discovered on a claim adjacent to those being worked, and further prospecting will very likely disclose a still wider distribution of pay gravel in this locality.

Cache Creek.—Three steam hoists were operated on Cache Creek in the early part of the summer, but at the time of the writer's visit two had shut down. The third plant was employing about 25 men but had only a small amount of ground remaining to be worked. The general mining conditions are similar to those on Sullivan Creek, the pay gravel lying at a depth of 50 feet and the water supply requiring the use of the pump for sluicing.

Quartz Creek.—A single plant was operating on Quartz Creek. The ground is on a bench on the right bank of the creek and is shallow, permitting the use of open-cut methods. A large area had been stripped by groundsluicing off a covering of tundra and about 3 feet of muck, and two men were shoveling in. The gravel deposit is from 1 to 2 feet deep and consists mostly of angular, little-worn material except in the part very near bedrock. Although the entire waters of the creek were diverted into the ditch, the supply was sufficient for sluicing less than half the time. There is said to be much ground along this bench which could be profitably worked if sufficient water could be had for hydraulic mining, but which can not be exploited by the more expensive hand methods.

American Creek.—A discovery of placer gold on American Creek, a small stream flowing into Fish Lake about 15 miles west of the Patterson Creek mines, was reported early in 1911. Active prospecting during the summer revealed pay gravel on at least four claims, from one of which a considerable production is reported. A hand windlass was used in hoisting the pay dirt, the ground on most of the claims being only 12 or 15 feet deep. From 30 to 50 men were on the creek during most of the summer, and preparation was being made for extensive work in both prospecting and mining during the winter.

TIN.

Smoothly rounded pebbles of cassiterite, the oxide of tin, occur with the gold in the Sullivan Creek placers. The neighboring placers on Cache and Quartz creeks are barren of this mineral, so that the area in which it occurs is small, being less than a mile in its longest direction. The tinstone or stream tin, as it is commonly called, varies in amount with the gold, the placers commonly being rich or lean in both minerals. In the richest spots as much as half a pound of tin to the pan is reported, which at the present price of the ore would give the gravels a value, not allowing for costs of mining or transportation, of $18 to $20 a yard, according to assay.

Gravels that contain as little as 9 pounds of cassiterite to the yard are being mined profitably in the York region, Alaska. There can be little doubt that a great part of the gravels mined on Sullivan Creek carry as high a content of tin as this and that some may run much higher. However, on account of the inconvenience that the tin ore occasions in the extraction of gold, the tin is regarded as a nuisance by the miners of the district rather than as a possibly valuable product.

The bedrock source of the tin has been the subject of a great deal of speculation, and considerable effort has been made to locate it. This effort, however, has been expended in the region about Roughtop Mountain rather than in the neighborhood of the placers, under the impression that only an area of igneous rock could furnish the mineral. Although in its typical occurrence in bedrock tin ore is evidently closely related to some igneous rock from which the tin-bearing solutions probably emanated, cassiterite may occur also in quartz veins and small dikes at some distance from any large igneous mass. There is a strong likelihood that the tin of these placers has not been brought a great distance to its present position. Apparently it has been derived from the veins and dikes of the country rock that has been eroded from the area in which the tin-bearing placers are found. Bedrock prospecting in the vicinity of the mines is difficult, owing to the thick covering of gravel and silt. Nevertheless, it would be desirable to make a closer scrutiny of the bedrock exposed in the mines and in the neighboring hills, especially of the quartz veins and micaceous dikes, which may possibly be tin bearing. Should any angular and little-worn cassiterite be found in the gravels, it would be good evidence of a bedrock deposit near at hand.

That the quartz veins of the Sullivan Creek area are probably the source of the tin as well as of a large part of the gold is indicated by the structure of the ore, which is a recemented breccia. The fragments of the breccia are vein quartz. The cementing material is principally cassiterite. Blue and brown tourmaline and small amounts of fluorite also fill spaces between the quartz fragments in some of the specimens. From this structure it is inferred that the quartz veins were originally formed without the other minerals, along the joint planes of the country rock. Subsequently dynamic stresses, possibly due to the injection of an igneous mass underneath the region, caused movement along these planes and the brecciation of the quartz veins. This igneous mass might also have furnished the tin-bearing emanations from which the ores were derived.