THE FAIRBANKS GOLD PLACER REGION.

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

INTRODUCTORY STATEMENT.

The Fairbanks region, notwithstanding strikes of the miners in 1907 and an unusually dry summer in 1908, produced during the year approximately $9,200,000 in placer gold. The importance of the region and the demand for accurate maps by miners, prospectors, and others operating or having interests in the region led to the mapping of the most productive area by the Geological Survey in the field season of 1907. The results of this work were published in the summer of 1908 as the Fairbanks special map. The area covered by this map lies in about the central part of Alaska. It is about 35 miles long from northeast to southwest and 16 miles wide. Most of it lies diagonally between parallels 64° 45′ and 65° 10′ and meridians 147° and 148° 15′. The map is on a scale of 1 to 62,500, or about 1 mile to the inch, and has a contour interval of 25 feet. Topographic data, such as the shape of the surface and the drainage areas and grades of the streams, are thus clearly visualized and rendered available for utilization by miners and engineers.

This map was used as a base during the summer of 1908 for the work of a Survey party that was engaged in studying the geology and mining developments. The results of this work will be embodied in a report that is now in preparation. The present preliminary statement includes only those facts which seem most appropriate for emphasis at the present time. To illustrate this statement the accompanying geologic sketch map (Pl. VIII), including the area covered by the Fairbanks special map, has been prepared.

GEOGRAPHIC SKETCH.

RELIEF.

The surface of this area is predominantly one of ridges alternating with valleys of corresponding size, limited on the southwest by the northern edge of the Tanana Flats. The main ridges trend northeast and southwest, but this general trend is obscured somewhat by numerous bulky lateral spurs, trending in various directions, that add to the uniformity of altitude so characteristic of the region. The ridges are crowned locally by flattened domelike prominences of somewhat greater height, and the greatest altitude above sea level is approximately 2,700 feet. The main valleys also trend northeast and southwest and are occupied by southwestward-flowing streams whose waters ultimately reach Tanana River. The numerous lateral tributaries flow in diverse directions corresponding to those of the lateral spurs. The valleys exhibit a uniformity of depth below the level of the even-topped ridges, and the northern edge of the Tanana Flats is about 500 feet above sea level.

DRAINAGE.

The distribution of surface drainage is shown on the accompanying geologic sketch map (Pl. VIII). With the exception of Tanana and Chatanika rivers, most of the drainage of the area is of local origin and the supply of water is dependent on local climatic conditions. The creeks where mining is in progress are small, their drainage areas are of moderate extent, the perennially frozen character of much of the material gives but scant capacity for what little water might otherwise be stored in it, the deforestation as a result of mining and the removal of moss by fires diminish still further the storage capacity of the surface, and the quantity of water in the streams is brought through the interaction of all these factors into very close dependence on the rainfall.

The large number of unsluiced dumps of pay dirt that accumulated during the summer of 1908 bore testimony to the unfavorable effect on mining operations of such conditions. A quantitative discussion of the water supply will be found in the paper by Mr. Covert (pp. 201–228).

CLIMATE AND VEGETATION.

The climate of the region, that of north latitude 65°, has naturally influenced its economic development.

No temperature records for Fairbanks are available, but the temperature at Tanana, in about the same latitude, 120 miles farther west, for the period from August, 1901, to December, 1902, ranged from −76° F. in January to 79° F. in August. The winter of 1907–8 was unusually mild, and December temperatures in that period, according to report, ranged from −36° F. to 20° F., with an average for the month of −3.4° F. Two critical periods for the region are the times of closing and opening of navigation. 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 dates reported 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 varying in different years from May 10 to May 15, and a few days later they are generally open to navigation.

The region being one of semiaridity, the snowfall is not excessive. The lakes and larger streams may freeze to a thickness of about 6 feet, but there is a considerable amount of water in circulation throughout the winter. Overflows are frequent and their repeated freezing, particularly in the smaller valleys, forms constantly accumulating deposits of ice known locally as "glaciers." Such overflows of the larger streams are a source of delay in travel, and such accumulations of ice in the headward portions of small valleys, where they may linger till late in summer, are a source of delay in mining. Under the operation of factors that are not clearly understood much of the superficial portion of the area is permanently frozen to depths that, so far as revealed by mining in the alluvial deposits, may exceed 300 feet. Differences in the material and in the position of the material with reference to drainage, however, have exerted a modifying action on the processes of freezing and there are considerable areas of deep deposits that are unfrozen.

The shortness of the summers is compensated by the length of the days. There are generally no killing frosts until about the first of September.

The mean annual precipitation, including both snow and rain, is not large. Observations taken at Tanana at intervals from 1882 to 1886 gave an annual average of 15.45 inches. The rainfall, therefore, although in some seasons more than sufficient for the needs of mining, is more likely to supply less than the amount required.

Vegetation increases in amount gradually toward the southern part of the region and is most abundant on the slopes adjacent to the Tanana. In this area there is a luxuriant growth of spruce, birch, and poplar on the valley slopes and lower ridges and of large spruce fringing the major streams and sloughs. A scrubby growth of small spruce with scattered larch covers the valley floors. The tops of the higher ridges throughout the region are covered only with a scanty growth of grass, moss, and low bushes. Inroads upon the fine growth of birch and spruce on the slopes of valleys where mining is in progress are resulting in a rapid deforestation of these slopes and the timber is being replaced by an abundant growth of grass and in places clumps of red-raspberry bushes. It has been demonstrated that vegetables can be grown successfully in this area. The lower slopes facing the Tanana Flats and adjacent portions of the flats are favorable for cultivation and such land is being taken up as ranches.

TRANSPORTATION.

The transportation of freight from points on the Pacific coast to the Fairbanks region is being accomplished as heretofore by way of Dawson and the upper Yukon and by way of St. Michael and the lower Yukon. Freight and passenger rates from Seattle remain about the same, averaging in 1908 about $75 a ton on ordinary supplies and for first-class passengers $125 to $140. Freight shipments to Fairbanks up to the close of navigation in 1908 approximated 15,000 tons. The supplies are brought by steamer to the towns of Chena and Fairbanks. The areas of greatest present importance are all within about 30 miles of these supply points, with which they are connected by wagon roads and the Tanana Valley Railway.

Through the agency of these means of transportation the high freight rates formerly prevalent on supplies from Fairbanks to the creeks, about 5 cents a pound in the winter and 25 cents a pound in the summer, have been reduced to a few cents a pound for summer freights to the most extreme points. Besides Fairbanks and Chena, which together have a population of several thousand, a number of small towns of a few hundred population each have developed on the creeks. The region has been in communication with the outside world by means of the government telegraph system for several years and during 1908 additional service was rendered available by the successful installation at Fairbanks of a wireless station operated by the Government.

GEOLOGIC SKETCH.

BED ROCK.

The Yukon-Tanana region lies in the intersectional area of the two dominant structural trends of Alaska—southeast - northwest and northeast-southwest—and includes a variety of formations possessing complicated structures. It has been a field of sedimentation, diastrophism, widespread metamorphism, abundant intrusion, and volcanic action. Mantling the products of all these processes are products of weathering and alluvium.

A formation composed predominantly of schists, mostly of sedimentary origin and regarded provisionally as pre-Ordovician, has a wide distribution throughout the central and eastern parts of the Yukon-Tanana region. Paleozoic rocks, including phyllites, limestone, etc., predominate in the western part of the region. The boundary line between these two groups extends northeast and southwest between Chatanika and Beaver rivers. The placers of the Birch Creek district, many of those of the Fortymile district, and those of greatest present importance in the Fairbanks district are located in areas occupied by rocks of the older group.

The rocks of this group, in the area covered by the Fairbanks special map, include rather massive quartzites, quartz-mica schists, carbonaceous schists, garnetiferous mica schists, lenticular bodies of crystalline limestone, and highly metamorphosed rocks derived partly, at least, from calcareous sediments. A few small bodies of granitic gneiss are present.

The most common types of rock are quartzitic and quartz-mica schists that occur in thin alternating beds. These schists form the predominant bed rock in the valleys where the placers are located and their varying resistance to the process of weathering results in alternating hard and soft bed rock that has an important influence on the distribution of the placer gold. The soft, decomposed bed rock is impermeable to placer gold, which may, on the other hand, sink to a depth of several feet along the cracks and crevices of the hard, blocky bed rock. The general structure has a northeast-southwest trend. Carbonaceous schists with associated calcareous beds, crystalline limestone, and hornblende schists are present, mostly in a zone extending northeast and southwest along the line of the Goldstream Valley. Garnetiferous altered calcareous rock occupies an interrupted zone along the northwest side of the main ridge and is there most common in lenticular masses in the schists of the upper parts of the valleys of Vault, Dome, Cleary, and Captain creeks. Chiastolite schists are limited to the northern portion of the area shown on the map, in the upper valleys of Captain and Alder creeks and the intervening ridges. A small patch of conglomerate and sandstone of comparatively recent date caps Fourth of July Hill, near the eastern limit of the area.

The region is one of close folding, and in some places the rocks have been folded so far upon themselves that the folds are in a recumbent position. The schists are jointed with two prominent sets nearly at right angles. Minor folding and crumpling are rather general, and there is a local development of cleavage and cleavage banding. Quartz veins are common, some of them having been folded with the schists and in places reduced to lenticular fragments and another system having crosscut the schists. Quartz veins up to 8 feet in thickness were observed. The schists and quartz veins have at many localities undergone intense brecciation and these brecciated zones have been recemented with quartz and ferruginous matter which has also penetrated the substance of the schists.

Igneous rocks have played an important part in the geologic history of the Yukon-Tanana region. These rocks are usually distinguishable from the rocks of sedimentary origin with which they are associated, and betray in the characteristics that render them distinguishable the different process to which they owe their origin. Differences in the composition of molten material have resulted in rocks of widely varying mineral composition. Differences also in the conditions under which consolidation has taken place cause great differences in the resultant products. Material that has been intruded into other rocks in a molten condition at great depths below the contemporaneous surface of the earth and has gradually consolidated there forms ultimately a completely crystalline rock which is entirely different in appearance, though having nearly the same composition, from the rock formed of the same kind of material that has been poured out over the surface of the earth as lava and then subjected to rapid cooling. Through the processes of metamorphism to which all rocks are subject the igneous rocks of deep-seated origin and those poured out at the surface may depart far in composition and structure from the original rock. The Yukon-Tanana region contains representatives of three different groups of igneous rocks—intrusive rocks of various kinds formed at various depths below the surface, extrusive rocks formed from igneous material that has welled out upon the surface, and metamorphic igneous rocks formed by the alteration of either of the other groups through the processes of metamorphism.

Igneous rocks may have a far-reaching influence in fracturing and altering the rocks into which they have come and introducing into them many products not originally present, among which are ores of metals or metals themselves. Igneous rocks are common in all the gold-placer areas of the Yukon-Tanana region, and the available evidence points to them as being, indirectly at least, the cause of the gold occurrences from which the placers have been derived. The distribution of igneous rocks, their delimitation from the sedimentary rocks, and detailed information as to their mode of origin and the part they have taken in the geologic history of the region are therefore of prime importance to those interested in mining. For these reasons the main areas of igneous rocks in the Fairbanks district have been roughly outlined on the accompanying sketch map (Pl. VIII). It is noticeable from the map that although there are no very large bodies of these rocks and they occupy but a small part of the total area they nevertheless have a wide distribution throughout the district and occur somewhere in all the valleys where productive placers have been found.

Most of the igneous rocks of the Fairbanks district are unmetamorphosed intrusives of the granodioritic group; they comprise quartz diorite, porphyritic biotite granite, and persilicic rocks. There are a few small areas of granite gneiss. Fresh basalt is found on Fourth of July Hill, where it occurs most probably as a small flow, and it is present also in the lower valley of Alder Creek. A few small, inconspicuous basic dikes occur in the district. The quartz diorite forms the main mass of Pedro Dome. It has intruded the schists, and in the surrounding area there are small dikes derived from the same magma. Small inclusions of quartzite schist are to be found in the marginal area of this rock, particularly on the northwest side of Pedro Dome. The quartz diorite shows but little alteration or mineralization, and the contact effect seems to have been limited to a slight alteration of the schists, expressed principally by the development of biotite.

Porphyritic biotite granite is more abundant than the quartz diorite and forms the largest intrusive mass in the district—that of the ridge between Gilmore and Smallwood creeks. A considerable mass of it occurs also on Twin Creek, in close relation with the quartz diorite of Pedro Dome, which is intruded by related dikes. There are numerous persilicic dikes throughout the district, and these seem on superficial study to be referable to the same magma. The biotite granite is in places heavily mineralized with iron pyrites, which is in some localities distributed along the joint planes of the granite and in others embedded in the mass of the granite itself and surrounded by rusty areas due to the alteration of the pyrites. Small rusty dikes so heavily charged with ferruginous matter that their original character is obscured are of common occurrence throughout the district. They are generally covered by a thick mantle of moss and muck, and their presence in a valley may be revealed only by a small proportion of this material in the heaps of tailings from the placers. One of the largest areas of these highly altered rocks is on the west side of Pedro Dome at the head of Dome Creek; here practically the only original mineral that has escaped alteration is quartz, whose distribution in the rock shows an original graphic relation to feldspar. The altered granitic dikes at this locality, as well as the schists in which they are found and the quartz veins in the schists, have been brecciated and impregnated with secondary quartz and ferruginous matter. In the narrow belt of schists separating the quartz diorite of Pedro Dome from the porphyritic biotite granite of Twin Creek auriferous quartz veins have been found along joint planes, and it seems highly probable that the intrusion of the granitic rocks has been accompanied or followed by the deposition of gold in the surrounding schists.

The extent of mineralization in the Fairbanks region is shown also by the common presence of stibnite (antimony sulphide), either intimately associated with granitic dikes in the schist, as at the head of Cleary Creek, or in quartz veins in the schist, as in the ridge at the head of Ready Bullion Creek, a tributary of Ester Creek. On Chatham Creek gold has been found in a quartz vein with stibnite, zinc blende (zinc sulphide), and iron pyrites.

Native bismuth has been found locally in the gravels, and some pieces are intergrown with gold. Concentrates from the placers are still under investigation and have been found to contain galena, arsenopyrite, wolframite, and cassiterite. Cassiterite is of rather common occurrence in the concentrates, notably in those from Cleary, Twin, and Eldorado creeks.

Neither the age of intrusion nor that of mineralization is known. The nearest similar intrusive rocks whose age is rather definitely determined are those of the Rampart region, 80 miles to the northwest, where Upper Cretaceous rocks have been intruded. The unaltered intrusives of the Fairbanks region may have been intruded at the same time as those of the Rampart region.

The greatest part of the auriferous material has probably been deposited subsequent to most of the intrusive masses, and the deposition may have accompanied an extensive shattering of the schists and a part of the intrusive rocks. This shattering would have furnished abundant avenues for widespread distribution through the schists of the materials resulting from intrusion.

Many of the nuggets found in the placers have quartz attached, and it seems probable, from the general occurrence of placer gold and the manner of its distribution in the valleys and from the fact that it has been found in place in quartz veins in the schist, either alone or in combination with sulphides, that the greatest part of the gold in the placers has been derived from quartz veins in the schists.

Although the distribution of gold is rather general, the fact that it is found on certain creeks while others in the immediate vicinity have up to the present time proved unproductive shows a localization of its occurrence. Moreover, although it has apparently been rather widely distributed in the bed rock of the valleys that have proved productive, as shown by the fact that gold can be detected so generally on the valley slopes, recent work of prospectors indicates that even in such valleys there has been a concentration of gold in the bed rock within narrow limits. If there are any localities in the area where the concentration of gold in the bed rock has been carried so far as to produce bodies of auriferous quartz of economic value such localities are most probably to be found in the vicinity of the igneous intrusives, especially in those valleys which have yielded placer gold.

During the later part of the season of 1908 there was considerable interest in quartz prospecting in this region, and auriferous quartz had been found in place at several localities. Surface material was taken for assay at many localities other than those where gold has been found in place in the quartz veins in such form as to be visible to the eye, and while the greatest part of the material assayed was found to contain only negligible quantities of gold the specimens from a few localities showed amounts of gold which, although small—$11.02, $1.24, and 83 cents to the ton being the highest—were yet sufficient to indicate a rather widespread mineralization. It may be stated in this preliminary discussion that the assays reaffirm the close association of gold and stibnite observable at some localities in hand specimens.

UNCONSOLIDATED DEPOSITS.

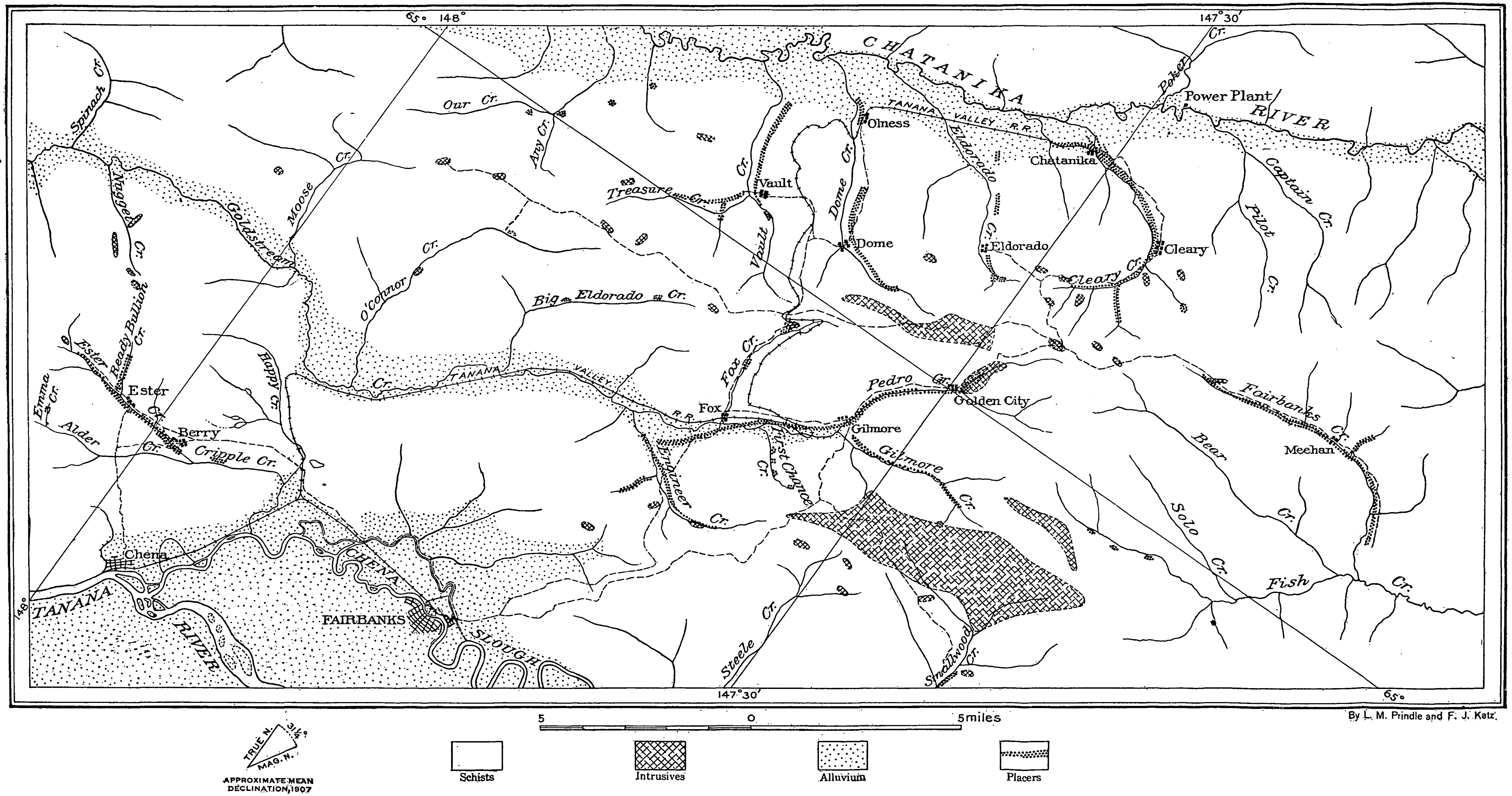
The bed rock of this region is for the most part covered with a deep mantle of residual and transported material. The evidence available indicates that this material has been deposited in an area where glaciation was absent under conditions predominantly fluviatile. The noteworthy characteristics of these deposits are their thickness and their consolidation by ice. The maximum thickness that has been revealed by mining operations is over 300 feet, and, so far as known, the greatest depth to which the ground may be found frozen has not yet been reached. Although most of the ground is frozen, in some localities unfrozen ground and circulating waters complicate the mining problem. The unconsolidated material includes slide rock, muck, sand, silt, clay, barren gravels, and the gravels in which the gold is found. These deposits are generally separable, in the vertical section from surface to bed rock, into three divisions, designated by the miners muck, barren gravels, and pay gravels or pay dirt. The term "muck" has been applied by the miners to all the fine material overlying the main body of gravels, with a thickness up to 100 feet, and it includes not only material derived from the decomposition of vegetation, but also clay and sand that occur either intimately mixed with the organic matter or in beds and lenticular masses. There are also intercalated beds of ice up to 40 feet in thickness.

Where the productive gravels are more or less continuous in a valley they form the "pay streak" of the miners. So far as has been determined the position of the productive gravels in the vertical section of the unconsolidated deposits is almost without exception next to bed rock. They include from a few inches to 6 or 8 feet of gravel and clay and a foot, or in some places several feet, of bed rock where this is of a blocky character. The gravels are composed predominantly of schist fragments, generally subangular, and the proportion of bowlders is small. The productive gravels as a rule contain a considerable proportion of fine material, termed by the miners "sediment," made up of minute rock fragments, quartz and other minerals resistant to alteration, and much clay derived from rock decomposition. There is in some places a sharp line of demarcation between these sediment-containing gravels and those above them, and this is further emphasized by difference in color. In other localities these gravels grade imperceptibly upward into gravels free from sediment. The productive gravels, under present costs, are mined to an average width for the entire region of about 200 feet, but in exceptional cases the width of gravel mined is much greater. The value of the gold recovered from the ground that is being mined ranges from less than $1 to $8 or more to the square foot of bed-rock surface. The average value, as estimated from a preliminary study of the available data, is about $1.25 to the square foot of bed rock, or about $5.25 to the cubic yard of pay gravels. Some of the gold is coarse and nuggets worth over $500 have been found; most of it, however, occurs in small flattish pieces. Assay values ranging from about $16 to more than $19 per ounce have been reported. The most common mineral associates of the gold are garnet, black sand, and rutile.

The total length of ground along which productive areas are scattered at the present time is approximately 75 miles, and the proportion of this distance where the depth to bed rock is less than 40 feet is probably not more than 20 per cent. The areas that have been productive of placer gold are indicated on Plate VIII. The valleys that have proved most productive during 1908 are those of Ester, Dome, Vault, Cleary (with the adjacent portion of the Chatanika Valley), Goldstream, Pedro, Engineer, and Fairbanks creeks. During the fall of 1908 promising discoveries were being made in the lower part of the Eldorado Valley and on the Chatanika Flats.

The valleys are narrowly V-shaped at the heads and gradually open out, the valley floors widening from 100 or 200 feet near the head to half a mile or more in the largest valleys. The grades range from 150 feet to the mile near the heads of the valleys to 25 feet to the mile in the wide, flat portions. The cross sections of the valleys are as a rule unsymmetrical, one side being steep and the other a gradual slope that merges into the base of the ridge slopes. The bed-rock surface on which the alluvial deposits have been laid down is in many places flatter than the present surface of the valleys. The course of the streams is generally close to the steeper slope. The location of the productive gravels is only in part coincident with that of the present streams. In many valleys they occupy a position far back from the stream on the side of the gradual slope and rest on a bed-rock surface at about the same level as the bed rock underlying the present stream bed.

The following tabular statement summarizes the entire thickness of the unconsolidated deposits, the thickness of the muck, and the width of the valley floors in the productive valleys:



GEOLOGIC MAP OF FAIRBANKS DISTRICT.

Depth to bed rock, thickness of muck, and width of valley floor at claims in Fairbanks region.

Claim.	Depth to bed rock.	Thickness of muck.	Width of valley floor.
	Feet.	*Feet.*	*Feet.*
Cleary Creek:			
8 above	35-65	16-40	300
3 above	52	40	450
Discovery	14-20	....	800
6 below	68-90	20-55	1,200
10 below	65	20	1,000
12 below	71-85	....	1,200
15 below	40-100	18-20	2,000+
18 below	125	10	....
Chatanika Flats:			
1 above	75	....	....
Discovery	80-125	18-25	....
Hope	65	40	....
Stier	105	72	....
Eldorado Creek:			
7 above	87	62	600
3 above	140	125	1,200
3 below	135	59	1,200
6 below	160	80	1,500
Idaho group	122	46	....
Dome Creek:			
6 above	50	27	400
3 above	100	60-70	600
Discovery	140-150	90	1,200
3 below	175	65-70	1,500
6 below	198	160	2,000
14 below	150	90	2,300
16 below	160	30	4,000+
20 below	175-180	15-20	....
Vault Creek:			
9 above	65	55	200
Hard Luck group	200	165	700
Isabella group	150	60	1,800
Victor group	175	90	1,800
Oregon group	180	150	2,000
Sierra group	202	102	3,000+
Treasure Creek:			
6 above	100	80	300
Tonaskate group	110	90	1,300
Do	171	164	1,600
Victoria group	200	135	1,500
Do	140	100	1,200
Our Creek:			
Georgia group	120	54	400
Junction of Any Creek	64	....	....
Washington group	75	58	....
Fairbanks Creek:			
9 above	12	3	300
6 above	15	3	350
3 above	18	4	400
Discovery	18	4	400
3 below	21	5	450
6 below	20	5	500
9 below	57-108	12-53	1,000
12 below	110	80-90	1,100
15 below	100	50	1,200
Fish Creek:			
10 above	25	15	500
4 above	24	12	800
Smallwood Creek:			
3 below	100	17	600
4 below	135	25	700
5 below	140	40	800
Goldstream:			
Discovery	45	33	1,000
4 below	33	....	1,200
8 below	22	9	1,400
12 below	51	....	2,500
16 below	80	55	3,000
21 below	70	....	3,000
Engineer Creek:			
Engineer Bench	103	78	1,000
Owl group	70-95	55-70	2,000
2 above	55-60	35	....
Discovery	50	15-25	....
Big Eldorado Creek:			
5 above	54	20	....
6 below	98	38	....
Fox Creek:			
11 above 10 above	10-19	3-11	300

Depth to bed rock, thickness of muck, and width of valley floor at claims in Fairbanks region—Continued.

Claim.	Depth to bed rock.	Thickness of muck.	Width of valley floor.
	Feet.	*Feet.*	*Feet.*
Pedro Creek:			
2 above	12	....	400
2 below	22-35	....	800
6 below	9	4	900
10 below	15	8	1,000
Twin Creek:			
2 above	8	4	250
Gilmore Creek:			
4 below Upper Discovery	4-8	....	400
8 above Lower Discovery	8	5	400
Lower Discovery	15-18	10	800
Ester Creek:			
7 above	20	6	150
6 above	22	7	250
4 above	20	12	350
2 above	34	14	350
Discovery	85	50	600
4 below	100	55	800
8 below	95	50	1,200

MINING DEVELOPMENT.

PRELIMINARY STATEMENT.

The mining operations in this region will not be described in detail in the present paper, but the development in mining methods which has taken place since the last report on the region[a] will be briefly summarized.

During the summer season of 1908 about 300 mining plants were in operation on the placers of the Fairbanks district, 85 per cent of these being used in drift mining and the remainder in various methods of open-cut work. Mining practice in this district has been determined largely by the great depths of the placer ground and operations have been facilitated by improvements in transportation from the supply towns, Fairbanks and Chena, to the producing creeks. The Tanana Valley Railway, a narrow-gage road about 50 miles long, was, in 1907, finished to Chatanika, at the mouth of Cleary Creek, and wagon-road improvement and construction had so far advanced by the close of the season of 1908 that large and heavy loads could be conveniently laid down at the workings on all the creeks of present importance except Treasure Creek, the lower few miles of Vault Creek, and Eldorado Creek. A large portion of the road building was made possible by the voluntary and substantial cooperation of the Fairbanks citizens with the Alaska road commission. The resulting system of public roads is highly creditable to so young a community. The development has been furthered also by the establishment in Fairbanks of foundries and machine shops, excellently equipped and

[a] Prindle, L. M., The Fairbanks and Rampart quadrangles, Yukon-Tanana region, Alaska: Bull. U. S. Geol. Survey, No. 337, 1908. See also Purington, C. W., Methods and costs of gravel and placer mining in Alaska: Bull. U. S. Geol. Survey No. 263, 1905.

under the direction of clever mechanics and foresighted business men. Much machinery that is especially adapted to the mining conditions of the district has been devised and entirely constructed in these local shops.

PROSPECTING.

The prospector, as a rule, still heavily taxes his funds and energies in sinking shafts to bed rock. A great advance over the hand-windlass method, which is barely practicable on ground approaching 200 feet in depth, is offered by an outfit now furnished in Fairbanks, consisting of a 4-horsepower boiler, hoisting engine, automatic self-dumping carrier and bucket, cable, pipe, steam points and fittings, etc., at a cost of about $600. This equipment is compact and light enough to be transported by dog team. The prospector is in the main still unable to cope with live water in his shaft. The method of prospecting by drilling promises, however, to increase in favor. A small-sized modification of the well-known churn drill was designed and built in Fairbanks to be supplied, with complete equipment, to prospectors for approximately $1,600. This machine is readily transportable and thus overcomes the chief obstacle to the use of the larger drills.

OPEN-CUT MINING.

Forty open-cut plants in actual operation were visited during the course of the present investigation. Of these, nine were working without mechanical or hydraulic equipment, on Pedro and Fox creeks. Hoisting by steam power appears to be the favorite method of handling gravels in open cuts, 23 such plants being in operation.

The cuts are generally opened by cutting off the vegetation and ground sluicing the muck and barren gravels in the spring or late fall. Occasionally, as on Discovery claim, Cleary Creek, steam scrapers are used for stripping; on "No. 5 below," Pedro Creek, horse plows and scrapers are used. In ground sluicing, the overburden is washed into a previously worked-out cut; in scraping, the material is carried to a waste pile. For draining the pits, bed-rock drains, pulsometers, centrifugal pumps, and ram pumps are in use, and on two claims China pumps were seen. On Pedro Creek, where most of the open-cut work is done, bed-rock drains are preferred when any considerable amount of water is to be removed. Cuts are opened on the lower end of the block of ground, claim, or series of claims to be mined, and are carried upstream as the work progresses, thus facilitating drainage and waste disposal. Artificial thawing is usually not necessary when stripping is far enough in advance of the handling of the auriferous gravels. At one plant, however, steam points were set vertically and 6 feet apart. On a few claims gravels are handled by hand shoveling from the cut directly to the sluice boxes, or are carried short distances in wheelbarrows to the sluice boxes. Much more commonly, however, the gravels are hoisted by steam power in buckets on self-dumping carriers. One such plant, using two buckets dumping to the same sluice box, had a capacity of nearly 1,000 square feet of bed-rock surface in twenty-four hours. The use of derricks and rock pumps has been abandoned in this district. The method of handling gravels with steam scrapers was employed with marked success on three claims during 1908. Where bed rock is not too hard, is not deeply creviced, and is not broken into heavy blocks this is probably the most advantageous system for open-cut mining. The auriferous gravels are scraped directly to the sluice boxes, where the scraper automatically trips and dumps itself. Where the gravels and bed rock are too firm to be scraped they are loosened up by a grading plow rigged in place of the scraper. Plowing was done at night on the one claim where it was found necessary. Plants thus equipped can handle as much as 135 cubic yards of pay gravels a day, employing 5 or 6 men—the equivalent of the duty of 15 to 20 men working with pick, shovel, and wheelbarrow. The greatest depth worked by open-cut methods is 20 feet, on "No. 7 above," Fairbanks Creek. This is in ground whose rich portions had been drifted out.

The cost of open-cut mining is materially less than that of drift mining. Even where work is exceptionally hindered by heavy, blocky, deeply creviced bed rock, rather thick overburden, and the necessity of artificial thawing, open-cut work costs no more than drifting. Operating expenses are reported on various claims to be 25, 28, 32, and 60 cents, and exceptionally $1, to the square foot of bed rock cleaned.

Conditions in the Fairbanks district are unfavorable for hydraulic mining. Only five hydraulic operations were seen. On First Chance Creek two small plants working with a scanty water supply under low head were practically ground sluicing into boxes set in bed-rock cuts. On Gilmore Creek, at the junction of Tom Creek, a small outfit was working with a monitor on the point between the creeks, where about a sluice head of water was available under a pressure of 45 feet. On Twin Creek a more efficient plant was installed during 1908, ditches, pipe line, and bed-rock cut being made ready for work in 1909.

DRIFT MINING.

The methods of drift mining have materially improved, with the result that plants are larger, capacity and efficiency are increased, and values are extracted from ground formerly regarded as unprofitable. During the last season not more than 20 outfits engaged in drift mining were equipped only with a hand-windlass hoist, and several of these outfits were either just opening ground or were taking out "pillars" left in the course of larger operations. Nearly all the productive mining is done with large steam-power plants averaging 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 outfit 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.

The average plant of this description employing 15 men will hoist about 80 cubic yards of pay streak or clean about 360 square feet of bed rock to the shift of ten hours. Several plants on Ester, Vault, Dome, Cleary, and Goldstream creeks have twice and some even three times that capacity. It is common practice in the larger plants to hoist from two shafts simultaneously, dumping to one string of sluice boxes erected between the two holes. One such plant on Ester Creek employed 45 men in two ten-hour shifts daily and could hoist 270 cubic yards (the equivalent of about 1,250 square feet on bed-rock surface) a day.

The operating expense of these plants is estimated by the operators at 50 cents to $1 for every square foot of bed rock mined. It would be difficult to strike a fair average, as conditions vary greatly, even from claim to claim on the same creek. Chief among the factors affecting the operating expenses are the character of the bed rock and the readiness with which the ground thaws and can be handled with pick and shovel—conditions which affect the duty per man per day—and the amount of live water in the ground.

Working shafts range in depth from 20 to 260 feet in this district, the more common depths being from 100 to 180 feet. The usual cross section is square, 6 by 6 feet in the clear, though many of the small operations in shallow ground use smaller shafts, and some of the larger plants in deep ground hoist through 7 by 7 feet openings. The cost of sinking and timbering a shaft 7 feet square in the clear is about $15 a foot. Shafts are cribbed with 4 to 6 inch spruce poles, dovetailed at the corners and chinked with moss, and a filling of gravel and moss is put in behind the cribbing. Heavy upright spruce posts are used as underpinning at the bottoms of the shafts. A small chamber is usually excavated and timbered at one side of the shaft and in it a pump is set up over a sump. Main tunnels, or runways, are driven upstream and downstream from the shaft along the pay streak. These runways are timbered with square sets of native spruce and lagged overhead and on the sides with spruce poles, the side lagging being carried from the ceiling preferably only halfway down the sides. The pay streak is crosscut at the ends of the tunnel, and sometimes also at a few places between the shaft and the ends of the main tunnel. In this way the ground is prospected and blocked out. From these end crosscuts the ground is breasted out, a face being worked back from each end toward the shaft. Where the distance from face to shaft does not much exceed 125 feet the shovelers carry the gravels in wheelbarrows to the shaft, where the bucket is lowered into a sump so that its rim is flush with the floor. Greater wheeling distances cut down the capacity, so that it becomes economical to install dump cars on rails in the tunnels. Some operators run the cars direct to the face; others wheel from the face to a platform at the end of the tunnel and there dump into cars. The face is carried back rapidly, so that there is usually no danger from caving of the unsupported roof. In unusually favorable ground, chambers 200 feet in diameter can be excavated without timbering. Sometimes unthawed pillars are left as supports, to be "pulled" as the face is carried far enough back, or cribs of birch poles filled with waste gravels and bowlders are built.

Thawing is done with steam points. The use of wood fires and of hot-water hydraulicking has been abandoned in the Fairbanks district. Points of 7, 8, 10, 12, and 16 feet length are used, and exceptionally 20-foot points in driving tunnels. Local manufacturers have designed and patented an improved connection for the steam supply hose and an implement to facilitate the "pulling" of the points after thawing. In the drifts the points are driven at about bed-rock surface and usually from 2½ to 3 feet apart, depending on the amount of moisture in the gravel, a factor that governs also the time required for a thaw—eight to forty hours. The usual duty of a steam point is to thaw about 3 to 3½ cubic yards. Water from the sump, heated by the exhaust from the pump, is forced through the points while they are being driven. Then dry steam at a pressure of about 25 pounds at the point is admitted. Where many points are set in a long face, it is a growing practice to withdraw the points after driving and replace them with light iron pipes termed "sweaters." Skillful operators carefully plug the holes around the points or sweaters with cotton waste or sand and always try to allow the ground to cool after thawing before they remove it, in order that the air in the drifts and tunnels may remain cold and dry and that in consequence the roof and walls of the working may not thaw and "slough," causing inconvenience and extra handling of waste. For this reason thawing and excavating are done on alternate days in the drift on each side of the shaft.

In some of the deeper workings it is difficult to maintain drainage and keep clearance for cars in the tunnels because the floors rise as the pressure on them is relieved by the removal of the gravel, 12-inch to 15-inch spruce timbers being bent inward and broken. This trouble is known as "swelling ground." It is mitigated somewhat by omitting the lagging from the lower half of the tunnel walls, thus relieving side pressure on the timbers. However, the difficulty can not be entirely avoided, and it is necessary to watch the timbers closely, replacing them when they show signs of failing. Fortunately, the timbers bend and break slowly and no sudden failures have been experienced. Trouble with the shaft cribbing is due primarily to thawing around the shaft and can be minimized only by careful packing of the steam supply pipes and the prevention of steam leakage in the workings.

The length of time tunnels and shaft will remain in working condition—that is, the ability of the ground to stand up—governs the size of the block of ground worked with one "set up" of the plant. The utmost limit thus far reached by the larger plants is about 700 feet along the pay streak worked from one shaft. Commonly 500 feet is the length of pay streak leased to individual operators.

Drift mining has recently been extended to the working of unfrozen ground containing live water on Ester Creek, with some promise of success. The cost of pumping is offset by the facts 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 tunnel was driven on the lower side of the pay streak, and the pay streak was crosscut at short intervals and on the upper side was to be drained by a drainage tunnel parallel with the main tunnel A sump 5 by 7 by 9 feet in bed rock 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 a square foot of bed rock, or twice the average cost in frozen ground.

In the recovery of gold from the gravels there has been no essential advance in the Fairbanks district. The miners have so far not considered it necessary to save a larger proportion of the gold than has been possible by the methods hitherto in use. With a few exceptions all the operators use nothing but a string of sluice boxes with riffles of rough peeled spruce poles. The head box into which the gravel is dumped (hence called the "dump box") is longer, broader, and deeper than the other boxes and provided with pole riffles. One man is stationed on the dump box, armed with a fork with which he removes large bowlders and pieces of bed rock, and thus keeps the gravel running freely through the boxes. At a few plants dressed poles with iron straps on the upper surface were seen in use, and on one claim an undercurrent was used which, though crudely constructed, was doing good service in saving fine gold. The 12-foot boxes are given a grade of 9 to 12 inches.

It is hardly necessary to point out the inefficiency of the gold-saving devices at present in use in comparison with the machinery employed on modern dredges. At plants of large capacity otherwise expensively equipped, the additional expense of gold-saving machinery would not be prohibitive and would probably be entirely offset by the saving of the expense involved in the maintenance of strings of sluice boxes and by the larger returns resulting from more thorough handling of the tailings and increased recovery of gold. Gold-saving machinery is especially to be commended for this region, where fine sticky sediment is abundant in the auriferous gravels and where the water is scanty in amount and, through repeated use, frequently overloaded with sediment.

When gravels are hoisted and piled in dumps in the winter or during droughts, the practice of carefully clearing shrubbery, moss, etc., from the ground and of setting strings of boxes under the dump in shallow cuts in the ground wherever feasible should be more widely adopted. By this procedure the bottom of the dump can be easily and completely taken up and the boxes will still hold their alignment and grade.

The hydraulicking of dumps into sluice boxes set beneath, by means of a pulsometer or centrifugal pump delivering water under pressure to a nozzle, has been successful and economical on several claims.

FUEL AND POWER.

Wood is still the only fuel and source of power of this district. Near the towns and mines the hills are consequently being rapidly stripped of their birch and spruce groves, so that the price is likely to rise with the distance fuel has to be hauled. In 1908 the average cost per cord delivered on the ground was $10. Not only is the fuel supply of Cleary Valley and nearly all of that in Dome and Ester and parts of other valleys almost exhausted, but through forest fires the covering of underbrush and moss also is being rapidly destroyed.

The power station in operation at the mouth of Poker Creek was designed as a hydro-electric plant, but on account of the insufficient water supply it is being run part of the time by steam power with wood fuel. Ten or twelve plants on Dome and Cleary creeks use power from this station for driving pumps and lighting. It has been suggested in a previous report[a] that the coals south of the Tanana might be used for the development of electric power for the Fairbanks district.

COSTS.

The data at hand on the cost of mining in the Fairbanks district are not as abundant as could be desired, but the following statements are believed to be warranted and conservative. The lower limit of the operating expense of drift mining under the usual present conditions is about 75 cents a square foot of bed rock, or about $3.50 a cubic yard of pay gravels; for open-cut mining, by means of steam scrapers, about 25 cents a square foot of bed rock, or about $1 to the cubic yard of pay gravels.

The common practice of the operators in the district is to lease from the owners portions of claims in blocks 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 by 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. Over 65 per cent of all the 1908 operations were on leases or "lays," the lessees or "laymen" paying royalties of 20 to 50 per cent of the gross production. On a "lay" of 200,000 square feet of workable drifting ground the operator would expend about $175,000 on plant, installation, blocking out ground, and extracting the auriferous gravels, so that a gold content of $1 to the square foot, the lowest limit of value of drifting ground under the conditions prevailing in 1908, would just permit him to pay his royalties. Wages in 1908 were $5 a day and board, and the usual length of a shift ten hours, but a small number of operators were paying $5 for eight hours, or $6 for ten hours.

LENGTH OF WORKING SEASON.

The weather at best permits ordinary sluicing from about the last week in April until the middle of September—at the most, 150 days. Open-cut operators can not get in as many days as this unless they adopt artificial methods of thawing during the early part of the season. Drift mining can, of course, be conducted continuously through the year. An attempt at winter sluicing was made in 1907–8 on Ester Creek, where a sluice head of water was running all winter. This water was warmed by the exhaust from the hoisting and pumping engines and pumped to the sluice boxes. Sluicing was continued into

---

[a] Prindle, L. M., The Bonnifield and Kantishna regions: Bull. U. S. Geol. Survey, No. 314, 1906, p. 226.

January. That this experiment was satisfactory is indicated by the fact that several operators were preparing for winter sluicing during 1909.

PRODUCTION.

The total and annual production of gold from the Fairbanks district for the years 1903 to 1908, inclusive, is approximately as given in the following table:

Production of gold from Fairbanks district.

1903	$40,000
1904	600,000
1905	4,000,000
1906	9,000,000
1907	8,000,000
1908	9,200,000
	30,840,000

WATER SUPPLY OF THE YUKON-TANANA REGION, 1907–1908.

By C. C. Covert and C. E. Ellsworth.

INTRODUCTION.

It is the purpose of this report to summarize the water-supply investigations of the Yukon-Tanana region during 1907 and 1908. The work in this region was started in 1907,[a] when streams in the Fairbanks district were gaged and general conditions affecting the water supply and its development were considered, the investigations covering a field season from June 20 to September 15. In March, 1908, in order to procure data concerning the spring break-up, C. C. Covert, of the Geological Survey, went to the field of operations and made such preparations as seemed practical for collecting data regarding the high-water flow. Records were kept in three drainage basins—those of Chatanika River, Little Chena River, and Washington Creek. In June the engineer in charge was joined by C. E. Ellsworth as assistant engineer, one field assistant, a cook, and a packer, with four pack horses, and the work was extended to the Circle and Rampart districts.

The records of 1908 covered the period from May 1 to October 21 and an area of about 4,200 square miles. The work was continued along lines similar to that of 1907. A few regular stations were established at convenient points in the different drainage basins, and daily records were kept at these stations, miscellaneous measurements being made in the surrounding country. This plan afforded the best opportunities for procuring comparative data. In this country, without storage, daily records are an important factor in determining the amount of water available, and it is difficult to obtain such records over an extended area. Outside of the gold-producing creeks the country is practically a wilderness, where it is almost impossible to get observations other than those made on the occasional visits of the engineer. In such localities no daily or even weekly records could have been assured, and the results obtained from occasional

[a] Henshaw, F. F., and Covert, C. C., Water-supply investigations in Alaska, 1906–1907: Water-Supply Paper, U. S. Geol. Survey, No. 218, 1908.

measurements furnish no comprehensive idea of the actual daily run-off of the stream throughout the open season.

Among the many who rendered valuable assistance in procuring the data given in the accompanying tables, acknowledgment is due to Mr. John Zug, superintendent of the Alaska roads commission; Mr. C. W. McConaughy, chief engineer of the Chatanika Ditch Company; Mr. Falcon Joslin, president of the Tanana Valley Railroad Company; Mr. Herman Wobber, Fairbanks Creek; Mr. Martin Harrais, of the Chena Lumber and Light Company, Chena; Mr. W. H. Parsons, general manager of the Washington-Alaska Bank; Mr. Frank G. Manley, Baker Hot Springs; Mr. A. V. Thorns, general manager of the Manley mines; Mr. M. E. Koonce, Rampart; and numerous miners who are personally interested in the work.

GAGING STATIONS.

Discharge measurements were made in 1907 at 45 points in the Fairbanks district, and in 1908 at 39 in the Fairbanks district, 33 in the Circle district, and 56 in the Rampart district. These gaging stations are given in the following lists:

Gaging stations in Fairbanks district, 1907–8.

Little Chena River above Elliott Creek.
Elliott Creek above Sorrels Creek.
Sorrels Creek near mouth.
Fish Creek above Fairbanks Creek.
Bear Creek below Tecumseh Creek.
Fairbanks Creek.
Miller Creek near mouth.
Miller Creek below Heim Creek.
Miller Creek above Heim Creek.
Charity Creek 1 mile above Hope Creek.
Hope Creek near Zephyr Creek.
Faith Creek near mouth.
McManus Creek above Montana Creek.
McManus Creek below Montana Creek.
McManus Creek 1 mile below Idaho Creek.
McManus Creek 500 feet above Smith Creek.
McManus Creek below Smith Creek.
McManus Creek at mouth.
Smith Creek below Pool Creek.
Smith Creek above Pool Creek.
Pool Creek at mouth.
McManus Creek near mouth.
Chatanika River near Faith Creek.
Boston Creek at elevation 800 feet.
McKay Creek at elevation 800 feet.
Belle Creek at elevation 800 feet.
Crooked Creek near mouth.
Kokomo Creek near mouth.

Poker Creek near mouth.
Poker Creek near elevation 800 feet.
Little Poker Creek at mouth.
Caribou Creek above Little Poker Creek.
Chatanika River below Poker Creek.
Cleary Creek near Cleary.
Eldorado Creek above trail to Dome Creek.
Dome Creek near Dome.
Goldstream Creek near Claim "No. 6 below."
Fox Creek near elevation 900 feet.
Beaver Creek above East Branch.
East Branch of Beaver Creek near mouth.
Nome Creek near mouth.
Bryan Creek at elevation 1,800 feet.
Trail Creek about 4 miles above mouth.
Brigham Creek near mouth.
Fossil Creek near mouth.
Little Chena River below Fish Creek.
Fish Creek below Miller Creek.
Fish Creek at mouth.
Pedro Creek at claim "No. 1 above."
Murphy Creek above McCloud Creek.
Washington Creek below Aggie Creek.
Washington Creek above Aggie Creek.
Aggie Creek at mouth.
Chatanika River below Murphy Creek.
Cleary Creek above Chatham Creek.
Chatham Creek at mouth.
Wolf Creek at mouth.
Belle Creek at elevation 1,200 feet.
Ophir Creek at mouth.
Nome Creek above Ophir Creek.
Beaver Creek above Nome Creek.
Flat Creek below 3d Pup.
Sourdough Creek 1 mile above mouth.
West Fork of Chena River at elevation 1,600 feet.

Gaging stations in Circle district, 1908.

Twelvemile Creek at elevation 2,500 feet.
Twelvemile Creek above East Fork.
Twelvemile Creek at mouth.
East Fork at Twelvemile Creek near mouth.
North Fork Birch Creek above Twelvemile Creek.
North Fork Birch Creek below Twelvemile Creek.
Tributary of North Fork Birch Creek from north.
Ptarmigan Creek at mouth.
Eagle Creek at mouth.
Eagle Creek below Cripple Creek.
Eagle Creek below Mastodon Fork.
Miller Fork of Eagle Creek above ditch intake.
Miller Fork ditch at intake.
Miller Fork ditch at outlet.
Mastodon Fork of Eagle Creek above storage dam.
Harrison Creek near elevation 2,200 feet.

North Fork of Harrison Creek near elevation 2,600 feet.
Mastodon Creek at claim "No. 21 above."
Mastodon Creek at claim "No. 1 above."
Flume on Mastodon Creek at Discovery claim.
Independence Creek near mouth.
Miller Creek near mouth.
Mammoth Creek at Miller House.
Bonanza Creek near elevation 2,200 feet.
Porcupine Creek near elevation 2,200 feet.
Porcupine Creek below Bonanza Creek.
Boulder Creek near mouth.
Crooked Creek at Central House.
Deadwood Creek above Switch Creek.
Switch Creek at mouth.
Albert Creek at trail crossing.
Quartz Creek at trail crossing.
Birch Creek at Fourteenmile House.

Gaging stations in Rampart district, 1908.

Minook Creek above Little Minook Creek.
Hunter Creek at claim "No. 14 above."
Hunter Creek at claim "No. 17 above."
Little Minook Creek at claim "No. 9 above."
Hoosier Creek at claim "No. 11 above."
Little Minook Junior Creek at mouth.
Russian Creek 3 miles above mouth.
Hoosier Creek below pipe intake.
Hoosier Creek above pipe intake.
Squaw Creek at mouth.
Ruby Creek at mouth.
Slate Creek at mouth.
Minook Creek below Chapman Creek.
Chapman Creek at mouth.
Granite Creek at road crossing.
Minook Creek 4½ miles above Chapman Creek.
Troublesome Creek below Quail Creek.
Troublesome Creek above Quail Creek.
Quail Creek above Nugget Gulch.
Quail Creek above South Fork.
South Fork of Quail Creek at mouth.
Buckeye Creek at mouth.
Goose Creek below Buckeye Creek.
Starvation Creek at mouth.
West Fork of Tolovana River below junction of Moose and Starvation Creeks.
Moose Creek at mouth.
Goose Creek 4 miles above mouth.
Hutlinana Creek below Caribou Creek.
Ohio Creek at trail crossing.
Elephant Gulch at mouth.
Hutlinana Creek below Cairo Creek.
Goff Creek one-half mile above mouth.
Applegate 1 mile above mouth.
Pioneer Creek at What Cheer Bar ditch intake.
What Cheer Bar ditch near Seattle Creek.

What Cheer Bar ditch below spillway.
Eureka Creek at claim "No. 14 above."
Eureka Creek at claim "No. 5 above."
Thanksgiving ditch 800 feet above outlet.
Thanksgiving ditch 30 feet below weir.
Thanksgiving ditch near outlet.
New York Creek at Thanksgiving ditch intake.
California Creek branch of Thanksgiving ditch near intake.
California Creek at Thanksgiving ditch intake.
New York Creek at trail crossing.
Allan Creek at trail crossing.
Allan Creek 5 miles above mouth.
Wolverine Creek 2 miles above mouth.
Wolverine Creek at mouth.
North Fork of Baker Creek below Wolverine Creek.
Eureka Creek at mouth.
Baker Creek at road crossing.
Quartz Creek one-half mile above mouth.
Sullivan Creek 3 miles above mouth.
Cache Creek at trail crossing.
Woodchopper Creek at trail crossing.

DISCHARGE AT REGULAR STATIONS.

Records of gage height have been kept for periods ranging from a few weeks to two seasons at 29 stations in the Yukon-Tanana region, including 16 in the Fairbanks district, 3 in the Birch Creek drainage basin, and 8 streams and 3 ditches in the Rampart district. The daily discharge has been computed for these stations, and the monthly maximum, minimum, and mean are given in Tables 1 to 8. Table 9 gives the minimum daily discharge in second-feet and second-feet per square mile. Tables 10 to 13 give the mean weekly discharge in second-feet, which can be reduced to miner's inches of 1.5 cubic feet per minute by multiplying by 40. Table 14 gives the mean weekly discharge in second-feet per square mile. Tables 15 to 17 are lists of miscellaneous measurements.

TABLE 1.—*Monthly discharge of streams in Little Chena River drainage basin, Fairbanks district, 1907-8.*

LITTLE CHENA RIVER ABOVE ELLIOTT CREEK.

[Drainage area, 79 square miles.]

Month.	Discharge in second-feet.				Run-off, depth in inches.
	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
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
99 days	405	28	103	1.30	4.80

ELLIOTT CREEK ABOVE SORRELS CREEK.

[Drainage area, 13.8 square miles.]

Month.	Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off, depth in inches.
1907.					
July 22-31	9	2.5	5.94	0.430	0.16
August	23	5.8	11	.797	.92
September 1-10	12.3	9	10	.724	.27
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
99 days	216	4.4	15.5	1.12	4.13

SORRELS CREEK NEAR MOUTH.

[Drainage area, 21 square miles.]

Month.	Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off, depth in inches.
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	.762	.28
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
99 days	131	10	31.3	1.49	5.50

TABLE 1.—*Monthly discharge of streams in Little Chena River drainage basin, Fairbanks district, 1907–8*—Continued.

FISH CREEK ABOVE FAIRBANKS CREEK.

[Drainage area, 39 square miles.]

Month.	Discharge in second-feet.				Run-off, depth in inches.
	Maximum.	Minimum.	Mean.	Mean per square mile.	
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
51 days	155	18	32.0	.820	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
98 days	227	12	41.1	1.05	3.84

FISH CREEK AT MOUTH.

[Drainage area, 90.2 square miles.]

Month.	Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off, depth in inches.
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
119 days	682	22	151	1.67	7.40

MILLER CREEK AT MOUTH.

[Drainage area, 16.7 square miles.]

Month.	Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off, depth in inches.
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	4.98	.298	.30
107 days	122	4	19.7	1.12	4.67

LITTLE CHENA RIVER BELOW FISH CREEK.

[Drainage area, 228 square miles.]

Month.	Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off, depth in inches.
1908.					
May	1,668	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
119 days	1,668	59	332	1.46	6.44

TABLE 2.—*Monthly discharge of streams in Chatanika River drainage basin, Fairbanks district, 1907–8.*

FAITH CREEK NEAR MOUTH.

[Drainage area, 51 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches.
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
73 days	87.4	19.2	38.5	.755	2.05

McMANUS CREEK NEAR MOUTH.

[Drainage area, 80 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches.
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
73 days	114	15.0	41.5	.510	1.42

CHATANIKA RIVER NEAR FAITH CREEK.

[Drainage area, 132 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches.
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
76 days	1,770	54	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
89 days	1,340	82	241	1.82	5.51

KOKOMO CREEK NEAR MOUTH

[Drainage area, 26 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches.
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
37 days	112	7.9	23.8	.916	1.30

TABLE 2.—*Monthly discharge of streams in Chatanika River drainage basin, Fairbanks district, 1907–8*—Continued.

CHATANIKA RIVER BELOW POKER CREEK.

[Drainage area, 456 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches.
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
117 days	3,160	167	496	1.08	4.61
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
159 days	4,120	179	699	1.53	9.05

GOLDSTREAM CREEK NEAR CLAIM "NO. 6 BELOW."

[Drainage area, 28.6 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches.
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
110 days	41	2.2	18.5	.649	2.66

TABLE 3.—*Monthly discharge of streams in Washington Creek drainage basin, Fairbanks district, 1908.*

WASHINGTON CREEK BELOW AGGIE CREEK.

[Drainage area, 147 square miles.]

Month.	Discharge in second-feet.				Run-off, depth in inches.
	Maximum.	Minimum.	Mean.	Per square mile.	
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
123 days	1,400	24	234	1.53	7.28

WASHINGTON CREEK ABOVE AGGIE CREEK.

[Drainage area, 117 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Run-off, depth in inches.
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
105 days	557	18	89.1	.762	2.98

AGGIE CREEK AT MOUTH.

[Drainage area, 35.8 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Run-off, depth in inches.
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
105 days	125	4.5	18.8	.525	2.04

TABLE 4.—*Monthly discharge of streams in Birch Creek drainage basin, Circle district, 1908.*

MAMMOTH CREEK AT MILLER HOUSE.

[Drainage area, 37.1 square miles.]

Month.	Discharge in second-feet.				Run-off, depth in inches.
	Maximum.	Minimum.	Mean.	Per square mile.	
September 8-30	36	14.4	22.6	0.609	0.52
October 1-13	14.4	13	14	.376	.18
36 days	36	13	19.5	.525	.70

PORCUPINE CREEK BELOW BONANZA CREEK.

[Drainage area, 39.9 square miles.]

July 4-31	147	17.8	40	1.00	1.04
August 1-10	21.7	15.5	17.1	.429	.16
38 days	147	15.5	34.0	.852	1.20

BIRCH CREEK AT FOURTEEN MILE HOUSE.

[Drainage area, 2,150 square miles.]

June 26-30	1,190	1,020	1,090	0.507	0.09
July	2,630	847	1,140	.530	.61
August	1,620	825	1,080	.502	.58
September 1-29	6,070	900	2,150	1.00	1.08
96 days	6,070	825	1,423	1.48	2.36

TABLE 5.—*Monthly discharge of streams in Minook Creek drainage basin, Rampart, district, 1908.*

MINOOK CREEK ABOVE LITTLE MINOOK CREEK.

[Drainage area, 130 square miles.]

Month.	Discharge in second-feet.				Run-off, depth in inches.
	Maximum.	Minimum.	Mean.	Per square mile.	
June 7-30	200	77	134.0	1.03	0.92
July	110	34	56	.431	.50
August	38	30	34	.262	.30
September 1-22	128	38	70.4	.542	.44
109 days	200	30	69.2	.532	2.16

HUNTER CREEK AT CLAIM "NO. 17 ABOVE."

[Drainage area, 33.4 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Run-off, depth in inches.
August 11-31	5.5	3.7	4.6	0.138	0.11
September 1-12	27.7	6.6	15.8	.473	.14
33 days	27.7	3.7	8.68	.260	.25

HOOSIER CREEK AT CLAIM "NO. 11 ABOVE."

[Drainage area, 25.7 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Run-off, depth in inches.
August 16-31	4.7	4.7	4.7	0.183	0.10
September 1-21	42	4.7	13.6	.529	.41
37 days	42	4.7	9.73	.379	.51

LITTLE MINOOK CREEK AT CLAIM "NO. 9 ABOVE."

[Drainage area, 5.9 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Run-off, depth in inches.
June 21-30	6.8	1.60	2.48	0.420	0.16
July	26.4	.62	3.78	.641	.74
August	.87	.62	.80	.136	.16
September 1-15	10.1	1.4	3.60	.610	.34
87 days	26.4	.62	2.54	.431	1.40

TABLE 6.—*Monthly discharge of streams in Hess Creek drainage basin, Rampart district, 1908.*

TROUBLESOME CREEK BELOW QUAIL CREEK.

[Drainage area, 43.2 square miles.]

Month.	Discharge in second-feet.				Run-off, depth in inches.
	Maximum.	Minimum.	Mean.	Per square mile.	
August 12-31	9.4	6.2	7.48	0.173	0.13
September 1-25	48	4	22.2	.518	.48
45 days	48	4	15.7	.363	.61

TABLE 7.—*Monthly discharge of streams in Baker Creek drainage basin, Rampart district, 1908.*

HUTLINANA CREEK, BELOW CAIRO CREEK.

[Drainage area, 44.2 square miles.]

Month.	Discharge in second-feet.				Run-off, depth in inches.
	Maximum.	Minimum.	Mean.	Per square mile.	
June 9-30	122	24	69.6	1.57	1.28
July	32	12.8	22	.498	.58
August 1-21	12.8	10.5	11.7	.265	.20
74 days	122	10.5	33.3	.753	2.06

PIONEER CREEK, NEAR WHAT CHEER BAR DITCH INTAKE.

[Drainage area, 8.1 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Run-off, depth in inches.
June 7-30	10.8	2.9	5.44	0.672	0.60
August	4.1	2.6	2.52	.311	.36
September 1-20	6.6	2.6	4.18	.516	.39
75 days	10.8	2.6	3.90	.481	1.35

NEW YORK CREEK AT THANKSGIVING DITCH INTAKE.

[Drainage area, 4.7 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Run-off, depth in inches.
June 6-30	8.2	0.7	3.15	0.670	0.62
July 1-14	1.7	.7	.843	.179	.09
August 8-31	3.0	.7	1.29	.275	.25
September 1-20	8.2	2.3	4.10	.873	.65
83 days	8.2	.7	2.45	.521	1.61

CALIFORNIA CREEK AT THANKSGIVING DITCH INTAKE.

[Drainage area, 6.7 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Run-off, depth in inches.
August 8-30	3.2	2.4	2.45	0.366	0.31
September 1-20	8.7	3.2	5.07	.757	.56
43 days	8.7	2.4	3.67	.548	.87

TABLE 8.—*Monthly discharge of ditches in Baker Creek drainage basin, Rampart district, 1908.*

THANKSGIVING DITCH NEAR OUTLET.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
June 6-30	12.0	2.4	6.84
July 1-14	3.3	2.1	2.37
August 8-31	3.9	1.6	2.25
September 1-20	12	3.3	6.46
83 days	12.0	1.6	4.67

CALIFORNIA BRANCH OF THANKSGIVING DITCH NEAR INTAKE.

Month.	Maximum.	Minimum.	Mean.
June 6-30	17.0	2.1	4.68
July 1-14	2.5	1.8	2.08
August 8-31	3	2.1	2.20
September 1-20	7.9	3	4.67
83 days	17.0	1.8	3.52

TABLE 9.—*Minimum daily flow of streams in Yukon-Tanana region, 1907–8.*

FAIRBANKS DISTRICT.

Point of measurement.	Elevation.	Date.	Minimum flow.	Drainage area.	Minimum discharge per square mile.	Duration of record. From—	Duration of record. To—
1907.	*Feet.*		*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*		
Little Chena River above Elliott Creek.	800	July 22–25, 29–31	42	79	0.532	July 22	Sept. 10
Elliott Creek above Sorrels.	800	July 31	2.5	13.8	.181	...do.....	Do.
Sorrels Creek above mouth.	800	.....do	6	21	.286	...do.....	Do.
Fish Creek above Fairbanks Creek.	925	July 30–31	18	39	.462	...do.....	Do.
Faith Creek at mouth	1,400	July 10	19.2	51	.376	June 20	Sept. 4
McManus Creek at mouth	1,400	July 10–12	15	80	.188	...do.....	Do.
Chatanika River below Faith Creek.	1,350	July 31	54	132	.409	July 17	Sept. 30
Kokomo Creek near mouth	750	July 23, 30–31	7.9	26	.304	July 9	Aug. 14
Chatanika River below Poker Creek.	700	July 4–7, 10	167	456	.366	June 20	Oct. 14
1908.							
Little Chena River above Elliott Creek.	800	Aug. 11	82	79	.354	May 20	Aug. 26
Elliott Creek above Sorrels Creek.	800	Aug. 4–7, 9–13	4.4	13.8	.319	...do.....	Do.
Sorrels Creek near mouth	800	Aug. 3–14	10	21	.476	...do.....	Do.
Fish Creek above Fairbanks Creek.	925	Aug. 21, Sept. 12-13	12	39	.308	May 22	Aug. 27
Fish Creek at mouth	700	July 17–18, 31, Aug. 6, 12–13.	22	90.2	.244	May 1	Do.
Miller Creek near mouth	750	Aug. 12–13	4.0	15	.267	May 13	Do.
Little Chena River below Fish Creek.	700	.....do	59	228	.259	May 1	Do.
Chatanika River near Faith Creek.	1,350	July 21–22	82	132	.621	July 13	Sept. 30
Chatanika River below Poker Creek.	700	Oct. 15–16, 21	179	456	.386	May 16	Oct. 21
Washington Creek below Aggie Creek.	600	July 23	24	153	.157	May 5	Sept. 4
Washington Creek above Aggie Creek.	600	.....do	18	117	.154	May 23	Do.
Aggie Creek above mouth	600	July 31	4.5	35.8	.126	...do....	Do.
CIRCLE DISTRICT.							
1908.							
Mammoth Creek at Miller House.	1,700	Oct. 10–13	13.0	37.1	0.350	Sept. 8	Oct. 13
Porcupine Creek below Bonanza Creek.	1,900	Aug. 7	15.5	39.9	.388	July 4	Aug. 10
Birch Creek at Fourteen-mile House.	700	Aug. 8	825	2,150	.384	June 26	Sept. 29

TABLE 9.—*Minimum daily flow of streams in Yukon-Tanana region, 1907-8*—Continued.

RAMPART DISTRICT.

Point of measurement.	Elevation.	Date.	Minimum flow.	Drainage area.	Minimum discharge per square mile.	Duration of record. From—	To—
1908.	*Feet.*		*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*		
Minook Creek above Little Minook Creek.	425	Aug. 15	30	130	0.231	June 7	Sept. 22
Hunter Creek at claim "No. 17 above."	600	Aug. 23	3.7	33.4	.111	Aug. 11	Sept. 12
Hoosier Creek at claim "No. 11 above."	600	Aug. 16-31, Sept. 21.	4.7	25.7	.183	Aug. 16	Sept. 2
Little Minook Creek at claim "No. 9 above."	1,000	July 17-Aug. 1	.62	5.9	.105	June 21	Sept. 15
Troublesome Creek below Quail Creek.	1,750	Sept. 25	4.0	43.2	.093	Aug. 12	Sept. 25
Hutlinana Creek below Cairo Creek.	1,050	Aug. 19-21	10.5	44.2	.238	June 9	Aug. 21
Pioneer Creek at What Cheer Bar ditch intake.	900	Aug. 8-13, 25-28, Sept. 13.	2.6	8.1	.321	June 7	Sept. 20
New York Creek at Thanksgiving ditch intake.	800	June 30-July 14, Aug. 9-17.	.7	4.7	.149	June 6	Do.
Thanksgiving ditch ¼ mile above outlet.	800	Aug. 12-16	1.6			...do...	Do.
California branch Thanksgiving ditch near intake.	800	July 2, 8	1.8			...do...	Do.

TABLE 10.—*Mean weekly water supply, in second-feet, from Little Chena and Chatanika River basins, Fairbanks district, 1907.*

Date.	Available for use by diversion at elevation 1,350 feet. Chatanika River near Faith Creek.	Available for use by pumping at elevation 700 feet. Chatanika River below mouth of Poker Creek.	Available for use by diversion at elevation 800 to 900 feet. Little Chena River above Elliot Creek.	Elliott Creek above Sorrels Creek.	Sorrels Creek above mouth.	Fish Creek above Fairbanks Creek.	Total, Little Chena drainage area.
June 17-23	86						
June 24-30	64	216					
July 1-7	44	178					
July 8-14	36	190					
July 15-21	64	250					
July 22-28	67	224	52	7	12	24	95
July 29-August 4	84	540	80	12	18	55	165
August 5-11	138	516	110	12	24	42	188
August 12-18	85	313	73	10	16	26	125
August 19-25	110	260	56	6	10	24	96
August 26-September 1	180	413	90	11	18	26	145
September 2-8	130	324	82	9	15	26	132
September 9-15	592	1,360					
September 16-22	451	1,480					
September 23-29	238	737					
September 30-October 6		655					
October 7-13		415					
Mean	158	504	78	10	16	32	136
Maximum	592	1,480	110	12	24	55	188
Minimum	36	190	52	6	10	24	95

TABLE 11.—*Mean weekly water supply, in second-feet, from Little Chena River, Chatanika River, and Washington Creek basins, Fairbanks district, 1908.*

Date.	Available for use by diversion at elevation 1,350 feet.	Available for use by pumping at elevation 700 feet.	Available for use by diversion at elevation 800 to 925 feet.					Available for use by diversion at elevation 600 feet.
	Chatanika River near Faith Creek.	Chatanika River below mouth of Poker Creek.	Little Chena River above Elliott Creek.	Elliott Creek above Sorrels Creek.	Sorrels Creek above mouth.	Fish Creek above Fairbanks Creek.	Total in Little Chena drainage basin.	Washington Creek below Aggie Creek.
May 16-19	....	3,220	....	....	....	....	....	a 1,200
May 20-26	....	3,020	339	93	87	b 162	681	546
May 27-June 2	....	1,980	227	30	55	98	410	360
June 3-9	....	1,360	181	15	31	79	306	198
June 10-16	....	1,160	172	25	34	50	281	200
June 17-23	....	775	118	9.3	54	44	225	226
June 24-30	....	331	77	8.9	48	42	176	68
July 1-7	....	394	59	6.8	33	30	129	52
July 8-14	c 150	468	48	5.3	24	23	100	56
July 15-21	110	278	38	4.6	15	16	74	35
July 22-28	127	207	33	4.5	11	13.5	62	29
July 29-August 4	151	271	32	4.5	11	13.5	61	31
August 5-11	101	211	31	4.4	10	13.5	59	29
August 12-18	112	236	36	4.5	12	14	66	29
August 19-25	202	402	d 59	d 4.6	d 16	17	97	32
August 26-September 1	157	306	....	....	....	....	....	35
September 2-8	351	743	....	....	....	....	....	e 85
September 9-15	176	407	....	....	....	....	....	....
September 16-22	153	423	....	....	....	....	....	....
September 23-29	f 152	313	....	....	....	....	....	....
September 30-October 6	....	284	....	....	....	....	....	....
October 7-13	....	228	....	....	....	....	....	....
October 14-21	....	205	....	....	....	....	....	....
Mean	162	749	104	15.7	31.5	44.0	195	225
Maximum	351	3,220	339	93	87	162	681	1,200
Minimum	101	205	31	4.4	10	13.5	59	29

a May 13-19. b May 22-26. c July 13-14. d August 19-26. e September 2-4. f September 23-30.

TABLE 12.—*Mean weekly water supply, in second-feet, of various streams in the Circle district, 1908.*

Date.	Birch Creek at Fourteenmile House.	Porcupine Creek below mouth of Bonanza Creek.	Mammoth Creek at Miller Roadhouse.	Date.	Birch Creek at Fourteenmile House.	Porcupine Creek below mouth of Bonanza Creek.	Mammoth Creek at Miller House.
June 26-July 3	1,240	....	....	September 5-11	4,090	....	b 32.5
July 4-10	1,600	73.5	....	September 12-18	1,510	....	21.9
July 11-17	1,160	45.3	....	September 19-25	1,290	....	23.3
July 18-24	936	21.5	....	September 26-October 2	c 942	....	14.6
July 25-31	870	19.7	....	October 3-9	....	....	14.4
August 1-7	850	16.0	....	October 10-13	....	....	13.0
August 8-14	1,060	a 19.5	....				
August 15-21	964	....	....	Mean	1,420	32.6	17.1
August 22-28	1,280	....	....	Maximum	4,090	73.5	32.5
August 29-September 4	2,110	....	....	Minimum	850	16.0	13.0

a August 8-10. b September 8-11. c September 26-29.

TABLE 13.—*Mean weekly water supply, in second-feet, of various streams in the Rampart district, 1908.*

Date.	Minook Creek above Little Minook Creek.	Little Minook Creek at claim "No. 9 above."	Hunter Creek at claim "No. 17 above."	Hoosier Creek at claim "No. 11 above."	Troublesome Creek below Quail Creek.	Hutlinana Creek below Cairo Creek.	Pioneer Creek at What Cheer Bar ditch intake.	Thanksgiving ditch near outlet.	New York Creek at Thanksgiving ditch intake.	California branch Thanksgiving ditch near intake.
June 6-12	[a] 136	....	....	....	....	[b] 82.6	[c] 7.2	8.4	4.4	4.6
June 13-19	164	....	....	....	....	103	7.0	8.7	3.4	4.6
June 20-26	136	[d] 3.1	....	....	....	51.4	3.8	6.0	2.8	7.2
June 27-July 3	75	1.6	....	....	....	31.1	3.0	2.7	1.0	2.3
July 4-10	77	9.9	....	....	....	27.0	....	2.3	.8	2.1
July 11-17	63	5.0	....	....	....	23.8	....	[e] 2.2	[e] .8	[e] 2.1
July 18-24	41	.62	....	....	....	18.5	....	....	....	....
July 25-31	35	.62	....	....	....	14.8	....	....	....	....
August 1-7	36	.78	....	....	....	12.5	2.9	....	....	....
August 8-14	32	.71	[f] 4.8	....	[g] 6.7	11.8	2.6	1.7	.8	2.1
August 15-21	33	.82	4.6	[h] 4.7	6.6	10.8	2.9	2.5	1.5	2.4
August 22-28	34	.87	4.4	4.7	7.5	....	2.7	2.4	1.4	2.2
August 29-Sept. 4	62	4.4	12.2	16.4	20.9	....	4.6	5.6	3.9	3.9
September 5-11	83	2.8	[i] 14.9	14.8	37.6	....	3.6	6.0	3.8	4.3
September 12-18	58	[j] 1.6	....	8.5	16.1	....	3.8	5.1	3.3	4.7
September 19-25	[k] 33	....	....	[l] 7.3	8.5	....	[m] 6.1	[n] 10.4	[n] 6.8	[n] 4.8
Mean	68.6	2.53	8.18	9.40	14.8	35.2	4.18	4.92	2.67	3.64
Maximum	164	9.9	14.9	16.4	37.6	103	7.2	10.4	6.8	7.2
Minimum	32	.62	4.4	4.7	6.6	10.8	2.6	1.7	.8	2.1

[a] June 7-12.
[b] June 9-12.
[c] June 7-12.
[d] June 21-26.
[e] July 11-14.
[f] August 11-14.
[g] August 12-14.
[h] August 16-21.
[i] September 5-12.
[j] September 12-15.
[k] September 18-22.
[l] September 18-21.
[m] August 19-20.
[n] September 19-20.

TABLE 14.—*Mean weekly discharge, in second-feet per square mile, at regular stations in the Yukon-Tanana region, 1908.*

	Chatanika River below Poker Creek.	Little Chena River below Fish Creek.	Washington Creek below Aggie Creek.	Hutlinana Creek below Cairo Creek.	Minook Creek above Little Minook Creek.	Birch Creek at Fourteenmile House.	Mean.	Chatanika River near Faith Creek.	Little Chena River above Elliott Creek.	Mean.
Drainage area, in square miles	456	228	147	44.2	130	2,150	......	132	79	......
May 1-5	......	3.84	......	......	......	......	......	......	......	......
May 6-12	......	3.53	5.51	......	......	......	4.52	......	......	......
May 13-19	7.03	5.10	7.84	......	......	......	6.66	......	......	......
May 20-26	6.61	3.44	3.57	......	......	......	4.54	......	4.29	......
May 27-June 2	4.34	1.92	2.35	......	......	......	2.87	......	2.87	......
June 3-9	2.98	1.69	1.29	1.67	1.18	......	1.76	......	2.29	......
June 10-16	2.52	1.14	1.31	2.32	1.05	......	1.67	......	2.18	......
June 17-23	1.70	1.10	1.48	1.57	1.30	......	1.43	......	1.49	......
June 24-30	.72	.83	.44	.82	.68	0.51	.67	......	.98	......
July 1-7	.86	.62	.34	.68	.51	.50	.58	......	.75	......
July 8-14	1.02	.45	.37	.55	.61	.80	.63	0.97	.61	0.79
July 15-21	.61	.33	.23	.48	.38	.46	.42	.83	.48	.66
July 22-28	.45	.31	.19	.38	.28	.40	.35	.96	.42	.69
July 29-August 4	.59	.32	.20	.28	.27	.40	.36	1.15	.41	.78
August 5-11	.46	.29	.19	.27	.26	.45	.32	.76	.39	.58
August 12-18	.52	.31	.19	.25	.24	.46	.33	.85	.46	.66
August 19-25	.88	.43	.21	.24	.26	.54	.43	1.55	.75	1.15
August 26-September 1	.67	......	.23	......	.28	.64	.46	1.19	......	......
September 2-8	1.63	......	.55	......	.73	1.93	1.21	2.66	......	......
September 9-15	.89	......	......	......	.44	.99	.77	1.33	......	......
September 16-22	.92	......	......	......	.48	.66	.69	1.16	......	......
September 23-29	.68	......	......	......	......	.47	.58	1.15	......	......
September 30-October 6	.62	......	......	......	......	......	......	......	......	......
October 7-13	.45	......	......	......	......	......	......	......	......	......
October 14-21	.45	......	......	......	......	......	......	......	......	......

NOTE.—In comparing the various records it was found that the rate of run-off from the upper portions of the drainage areas was greater per square mile than from those farther down.

MISCELLANEOUS MEASUREMENTS.

Miscellaneous measurements were made at points where no regular gage readings could be obtained. They show the discharge at these points for only a few days, but an approximate idea of the seasonal average can be obtained by comparing the discharge on the date of measurement with that at some regular station on the same or an adjoining stream. The miscellaneous measurements made in 1908 are given in the following tables:

TABLE 15.—*Miscellaneous measurements in Fairbanks district, 1908.*

LITTLE CHENA RIVER DRAINAGE BASIN.

Date.	Locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
July 13	West fork of Chena River at elevation 1,600 feet	24.7	9.2	0.372
July 19	Bear Creek below Tecumseh Creek	12.0	5.4	.450
July 21	Miller Creek above Heim Creek	6.0	2.5	.416
August 1	.....do	6.0	2.2	.367
July 21	Miller Creek below Heim Creek	10.0	3.1	.310
August 1	.....do	10.0	2.4	.240

CHATANIKA RIVER DRAINAGE BASIN.

Date.	Locality.	Drainage area.	Discharge.	Discharge per square mile.
July 12	Pool Creek at mouth	14	15.4	1.10
July 13	.....do	14	11.0	.786
July 14	.....do	14	12.3	.879
July 13	Smith Creek above Pool Creek	17	11	.647
July 14	.....do	17	9.3	.547
August 30	.....do	17	14.2	.835
September 1	.....do	17	20.5	1.21
July 12	Smith Creek at mouth	34	33.8	.995
July 13	.....do	34	27.4	.806
July 14	.....do	34	22.7	.668
Do	McManus Creek at mouth	80	59	.738
Do	McManus Creek above Smith Creek	42	36	.858
July 12	Faith Creek at mouth	51	66.9	1.31
July 13	.....do	51	77.7	1.52
July 14	.....do	51	67.7	1.33
July 13	Sourdough Creek 1 mile above mouth	15.9	22.5	1.42
July 15	Flat Creek below 3d Pup	7	2.8	.400
August 29	.....do	7	3.7	.529
August 9	Belle Creek at elevation 1,200 feet	....	1.4	....
August 14	Poker Creek at ditch intake	18.1	9.3	.514
Do	Little Poker, and Caribou Creek ditch	....	6.2	....
July 23	Wolf Creek at mouth	3.8	.91	.239
Do	Cleary Creek above Wolf Creek	2.7	1.6	.593
Do	Chatham Creek at mouth	3.0	1.3	.434
July 26	Murphy Creek above McCloud Creek	17	1.7	.100
August 20	.....do	17	1.3	.076
July 26	Chatanika River below Murphy Creek	677	263	.388

GOLDSTREAM CREEK DRAINAGE BASIN.

Date.	Locality.	Drainage area.	Discharge.	Discharge per square mile.
July 23	Pedro Creek at claim "No. 1 above"	6.3	3.2	0.508
August 24	Fox Creek at elevation 900 feet	3.4	.43	.127

BEAVER CREEK DRAINAGE BASIN.

Date.	Locality.	Drainage area.	Discharge.	Discharge per square mile.
August 12	Ophir Creek at mouth	33	2.0	0.066
August 11	Beaver Creek above East Branch	122	80.3	.658
August 12	Beaver Creek above Nome Creek	226	108	.478
August 11	East Branch of Beaver Creek at mouth	67	44.3	.661
August 12	Nome Creek at mouth	120	33.6	.280
Do	Nome Creek above Ophir Creek	87	26.0	.298

TABLE 16.—*Miscellaneous measurements in Circle district, 1908.*

BIRCH CREEK DRAINAGE BASIN.

Date.	Locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
July 10	Twelvemile Creek at mouth	44.5	38.0	0.854
Do	Twelvemile Creek above East Fork	18.9	15.6	.826
Do	Twelvemile Creek at elevation 2,500 feet		6.3	
September 4	Twelvemile Creek at mouth	44.5	73.3	1.64
July 11	Twelvemile Creek at elevation 2,500 feet		6.0	
July 10	East Fork of Twelvemile Creek near mouth	22.9	24.4	1.07
September 4	do	22.9	23.9	1.04
July 9	North Fork of Birch Creek below Twelvemile Creek	132	125	.947
July 10	do	132	129	.977
Do	North Fork of Birch Creek above Twelvemile Creek	87	87	1.00
September 4	do	87	191	2.20
July 9	Tributary of North Fork of Birch Creek from north, at mouth	11.6	20.3	1.75
Do	Ptarmigan Creek at mouth	19.0	26.2	1.38
September 5	do	19.0	24.7	1.30
July 7	Eagle Creek below Cripple Creek	12.4	10.5	.847
July 9	Eagle Creek at mouth	15.5	15.4	.994
September 5	do	15.5	24.7	1.59
September 6	Eagle Creek below Mastodon Fork	8.4	[a]4.2	.50
Do	Miller Fork ditch at intake		2.8	
Do	Miller Fork ditch at outlet		1.4	
Do	Miller Fork of Eagle Creek above ditch intake	2.6	2.1	.808
July 7	Mastodon Fork of Eagle Creek above storage dam	4.1	1.1	.269
September 6	do	4.1	1.3	.317
July 8	Harrison Creek at elevation 2,200 feet	17.9	4.9	.274
Do	North Fork of Harrison Creek at elevation 2,600 feet	6.2	7.1	1.15
July 5	Mastodon Creek at claim "No. 1 above"	10.4	7.7	.740
July 7	Mastodon Creek at claim "No. 21 above"	6.9	9.1	1.32
September 6	do	6.9	3.9	.565
September 7	Mastodon Creek at mouth		11.5	
July 5	Flume on Mastodon Creek at Discovery claim		7.3	
Do	Independence Creek at mouth	13.2	4.6	.348
September 7	do	13.2	11.9	.902
July 6	Miller Creek at mouth	10.5	5.9	.562
September 7	do	10.5	11.2	1.07
July 4	Bonanza Creek at ditch intake	7.9	12.4	1.56
July 6	do	7.9	13	1.64
September 7	do	7.9	12.3	1.56
July 6	Porcupine Creek at elevation 2,200 feet	17.8	12.6	.708
July 1	Boulder Creek at mouth	38.8	8.0	.206
July 2	do	38.8	5.8	.150
June 30	Crooked Creek at Central House	161	57.7	.358
July 1	do	161	52.0	.323
September 9	do	161	86.4	.536
July 1	Deadwood Creek above Switch Creek	21.3	9.1	.427
Do	Switch Creek at mouth	5.8	.72	.124
Do	Albert Creek at trail crossing	92.7	9.1	.098
June 29	Quartz Creek at trail crossing	8.4	2.7	.322

[a] Does not include diversion for hydraulicking by ditch about 2 miles below.

TABLE 17.—*Miscellaneous measurements in Rampart district, 1908.*

HESS CREEK DRAINAGE BASIN.

Date.	Locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
August 12	Quail Creek above Nugget Gulch	17.6	4.3	0.244
Do	Quail Creek above South Fork	13.3	2.8	.210
Do	South Fork Quail Creek at mouth	3.7	1.4	.378
Do	Troublesome Creek above Quail Creek	21.4	2.5	.117

TABLE 17.—*Miscellaneous measurements in Rampart district, 1908*—Continued.

MINOOK CREEK DRAINAGE BASIN.

Date.	Locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
August 8	Minook Creek 4 miles above Chapman Creek	9.2	2.9	0.315
Do	Minook Creek below Chapman Creek	58.3	7.1	.122
Do	Granite Creek at road crossing	26.9	5.7	.212
Do	Chapman Creek at mouth	14.8	2.9	.196
Do	Slate Creek at mouth	7.9	2.2	.278
Do	Ruby Creek at mouth	10.6	1.7	.160
August 10	Hoosier Creek above pipe intake	21.2	4.8	.226
September 9	do	21.2	11.1	.523
Do	Hoosier Creek below pipe intake		1.2	
August 10	Hunter Creek at claim "No. 14 above"		2.3	
September 5	Little Minook Junior Creek at mouth	1.3	.32	.246

MINOR YUKON RIVER DRAINAGE.

September 11	Squaw Creek at mouth		27.7	
September 18	Russian Creek 3 miles above mouth	9.9	1.91	0.193

BAKER CREEK DRAINAGE BASIN.

June 6	Thanksgiving ditch near outlet		11.1	
June 7	What Cheer Bar ditch below spillway		4.0	
August 6	Eureka Creek at mouth	37.7	4.8	0.127
August 20	Hutlinana Creek below Caribou Creek	16.1	1.9	.118
September 2	do	16.1	3.1	.192
August 20	Ohio Creek at trail crossing	3.2	.93	.290
Do	Elephant Gulch at mouth	3.3	1.1	.334
Do	Goff Creek ½ mile above mouth	11.4	2.4	.210
Do	Applegate Creek 1 mile above mouth	18.9	2.8	.148
August 21	Eureka Creek at claim "No. 14 above"	2.8	.77	.275
Do	Eureka Creek at claim "No. 5 above"	5.8	1.3	.224
August 22	New York Creek at trail crossing		1.4	
Do	Allen Creek at trail crossing	15.3	4.9	.320
Do	Allen Creek 5 miles above mouth	5.9	2.7	.458
August 29	Thanksgiving ditch 30 feet below weir		1.7	
August 30	North Fork of Baker Creek below Wolverine Creek	19.7	5.2	.264
Do	Wolverine Creek at mouth	8.2	2.6	.317
Do	Wolverine Creek 2 miles above mouth	6.2	2.1	.339

PATTERSON CREEK DRAINAGE BASIN.

August 4	Cache Creek at trail crossing	22.7	3.2	0.141
August 25	Woodchopper Creek at trail crossing	19.7	4.4	.223
August 26	Quartz Creek ½ mile above mouth	8.0	2.8	.333
August 4	Sullivan Creek 3 miles above mouth	20.7	5.7	.275
August 24	do	20.7	4.5	.217

TOLOVANA RIVER DRAINAGE BASIN.

August 13	Goose Creek 4 miles above mouth	41	3.2	0.078
August 14	Goose Creek below Buckeye Creek	20.8	1.6	.077
August 13	Starvation Creek at mouth	23.8	2.2	.092
Do	Moose Creek at mouth	19.8	1.9	.096
Do	West Fork Tolovana River at junction of Moose and Starvation creeks	43.8	4.0	.091
August 14	Buckeye Creek at mouth	10.6	.20	.019

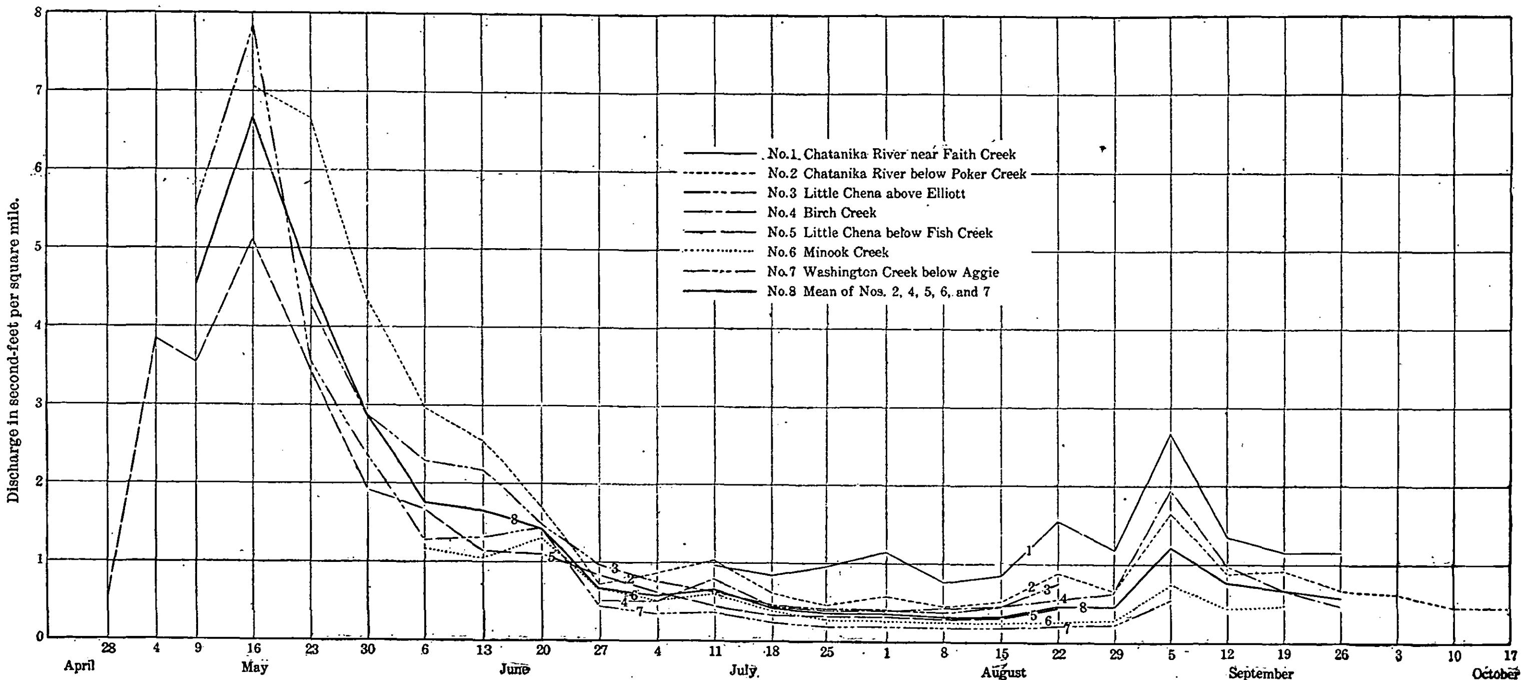


FIGURE 17.—Diagram illustrating relative discharge, in second-feet per square mile, of various streams in Yukon-Tanana region, 1908.

COMPARATIVE DISCHARGE.

Figure 17 shows the mean weekly discharge, in second-feet per square mile, of various streams in the Yukon-Tanana region on which records have been kept. This diagram is intended to illustrate graphically the relative discharge per square mile of streams in this section of Alaska, and may be used with some degree of accuracy in connection with the following table of drainage areas. Although the data represent weekly periods, they are far more comprehensive than was expected, and when used in connection with precipitation records will give the engineer sufficient information to determine whether a project is worthy of detailed study.

TABLE 18.—*Drainage areas of streams in Yukon-Tanana region outside of district covered by records in 1907 and 1908.*

Stream and location.	Elevation above sea level.	Drainage area.	Approximate fall below point.
Salcha River basin:	*Feet.*	*Sq. miles.*	
East Fork of Salcha River	1,975	475	200 feet in 9 miles.
Salcha River at the splits	1,400	1,290	200 feet in 8 miles.
Charley River	2,200	449	400 feet in 9 miles.
Do	1,000	1,470	200 feet in 5 miles.
Fortymile River 3 miles below Fortymile telegraph station	1,300	1,620	100 feet in 4 miles.

NOTE.—Areas and elevations were obtained from the reconnaissance topographic maps of the Fortymile and Circle quadrangles.

RAINFALL.

In connection with these investigations the following rainfall stations were established:

Summit road house near Pedro Summit; elevation 2,310 feet.
Cleary City; elevation 1,000 feet.
Chatanika River near mouth of Poker Creek; elevation 730 feet.
Chatanika River near mouth of Faith Creek; elevation 1,400 feet.
Charity Creek; elevation 2,800 feet.
Eagle Creek; elevation 2,590 feet.
Baker Hot Springs; elevation 370 feet.

The results of the observations taken at these stations and at Fairbanks, Circle, and Rampart in 1906 to 1908, together with a summary of records for stations in the Yukon-Tanana region, are given in the following tables:

TABLE 19.—*Monthly precipitation, in inches, at stations in Yukon-Tanana region, 1907-8.*

Station.	Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Baker Hot Springs	1908										0.41	.20		
											4.1	2.0		
Circle	1907	1.02	0.57	0.28	0.15	0.29		1.36	2.79	1.73			0.63	
		8.5	7.8	3.25									8.2	
Do	1908	1.23	.25	.76	1.45	.29	0.20	.87	1.08	2.21	.40	.75		
		9.2	2.5	6.75	8.0						3.0	8.5		
Charity Creek	1908				.11	.27	1.33	2.80	2.33	2.28	.20			
											3.0			
Cleary	1907						.84	2.55	2.88	3.82				
Eagle Creek	1908								2.99					
Fairbanks	1907	3.30	.86	2.42	.03	.35	1.47	1.51	1.81	3.58	2.44	.35	.59	18.71
		33.0	8.6	24.2	.3						24.4	3.5	5.9	99.9
Do	1908	.42	.21	1.1	.11	.52	.96	.73	.71	.15	.47	.51		
		4.2	2.1	11.0	.8					1.53		4.0		
Faith Creek	1907							1.87	3.00	2.97				
Fort Egbert	1907	1.45	.21	.75	.25	.40	1.89	1.48	1.98	1.45	1.12	.40		
		2.0	2.0	7.5	.15	.55					13.0	4.0		
Do	1908	.12	.25	.75	.10		2.16	2 47	1.02	1.48	.18	.82		
		3.0	2.5	7.5	1.0						6.0	7.0		
Fort Gibbon	1907	1.26		.53	0	.30		2.58	2.31	2.32	1.22	.03		
		12.6		5.0						4.00	12.0	1.5		
Do	1908	.23	.26	.90	0	1.16		.96	1.13	1.60	.45			
		4.0	6.0	17.0	0					2.25	6.0			
Kechumstuk	1907	.12	.20	.27	Tr.	1.30	2.30	1.60	2.14	.49	.72	.40		
		2.0	3.0	4.0		12.0					9.0	4.0		
Do	1908	0	0	.41	.40	1.78	1.77	2.30	2.22	1.35				
				5.0	4.0									
North Fork	1907	.69	.28	.27	Tr.	1.34	1.92	1.57	3.19	2.00	1.40	.20		
		15.5	3.0	3.0		4.0				5.0	12.0	2.0		
Do	1908	.50												
		5.0	Tr.											
Poker Creek	1907								1.40	3.70	1.70	.25	1.07	
											24.0	3.3	6.8	
Do	1908		1.32		.42	.58	1.80	2.02	.99	2.45	.75			
			10.5		5.0					4.5	6.9			
Rampart	1907	1.17	.44	1.17	.02	.44	1.64	2.29	3.38	2.52	.65	.55		
		12.0	4.5	12.8	2.5							6.3		
Do	1908	1.08	.52	.81	.58	.82	1.38	1.13	.46	1.56	.39			
		11.5	6.9	8.1							5.10			
Summit road house	1907							2.71	3.27	[a]3.33				

[a] September 1-22.

NOTE.—Where there are two lines rainfall or melted snow is given in the first line; snowfall in the second line.

TABLE 20.—*Summary of precipitation records, May to August, inclusive, at stations in Yukon-Tanana region.*

Station.	Maximum.		Minimum.		Mean, inches.	Duration of records.
	Inches.	Year.	Inches.	Year.		
Fairbanks	5.73	1906	2.92	1908	4.60	1906–1908.
Circle	4.15	1907	2.44	1908	3.30	1907–8.
Rampart	7.75	1907	3.79	1908	5.58	1905–1908.
Fort Egbert	6.31	1908	4.87	1906	5.75	1903–4 and 1905–1908.
Fort Gibbon	10.26	1905	3.30	1904	5.76	1903–1908.
Kechumstuk	9.06	1906	3.66	1905	6.73	1904–1908.

Table 20 shows that a total precipitation as high as 10.26 inches or as low as 2.44 inches may be expected during the mining season. In general, the season of 1908 was one of low precipitation in the Fairbanks, Circle, and Rampart districts. Kechumstuk, Fort Egbert, and the Dawson country had perhaps more than a normal amount. The precipitation was above the normal also in a small area at the head of Chatanika, Twelvemile, and Preacher creeks, the records at Charity Creek, tributary to the Chatanika, showing 6.73 inches, which accounts for the fact that the run-off of Chatanika River was higher at the station near Faith Creek than at the Poker Creek station, and higher at these two stations than at those on other streams studied.

HYDRAULIC DEVELOPMENTS.

FAIRBANKS DISTRICT.

Little work has been done in the Fairbanks district toward constructing ditch lines from larger drainage areas to obtain additional water, present developments being confined to small ditches which convey water to mines in their immediate vicinity on the creeks from which they draw their supply.

The district lies in three drainage basins, separated by high dividing ridges, and in order to supply the producing creeks in one basin with water by ditch line from another the ditch must have a high elevation, which throws its intake so far into the headwaters that the ditch has only a small drainage area from which to draw and consequently carries but little water. The records kept during the season of 1907 prove conclusively that had the proposed high-line ditch from the upper Chatanika basin to the mining camp been built it would have had, instead of a daily supply of 125 second-feet as was estimated, less than half that amount during the greater part of the open season.

In the spring of 1908 water began to run in the mining creeks and the more open country from the 20th to the 25th of April, and by the 1st of May the larger streams were breaking up. If the run-off of 3 to 5 second-feet per square mile incident to the break-up during the month of May and part of June could have been distributed through July and August an adequate supply would have been at hand for any reasonable development. Could storage be provided for this period of excessive run-off, a number of projects which have been considered in the Fairbanks district would have a brighter aspect; in fact, they could rightly be considered as commercial possibilities.

The development of water power for electric transmission in the Fairbanks district seems worthy of consideration. Records relating to such development have been kept in the Little Chena drainage basin for two seasons, and in the spring of 1908 similar records were started on Washington Creek.

CIRCLE DISTRICT.

GENERAL CONDITIONS.

The situation in part of the Circle district is more favorable for hydraulicking than that in the Fairbanks or Rampart regions. The camps on Mammoth and Eagle creeks lie on streams of relatively high gradients and consequently the water supply, though small, can be delivered to the mining property by comparatively short ditch lines, which give high heads for operating.

Up to 1906 practically the only hydraulic development in this district was a small plant on North Fork of Harrison Creek, but owing to miscalculations the project proved a failure. However, considerable construction work was done during 1908.

EAGLE CREEK.

The ditch that taps Miller Fork of Eagle Creek about 1 mile above its mouth, started by Berry & Lamb in 1907, was finished in 1908. It carries the water to a storage reservoir on Mastodon Fork. From this reservoir a small ditch conveys the water for about 2 miles along the left bank of Eagle Creek, to a point where a 200-foot head is obtained for hydraulicking. This ditch was not completed until early in July and consequently could not utilize the water from the spring break-up. The storage reservoir was not finished until the end of the season, and very little hydraulicking was done.

The method employed at the Eagle Creek plant is somewhat different from the usual hydraulic methods practiced in Alaska. A channel was first ground sluiced along the bed of the creek, and the sluice boxes were set in it. On the side of the sluice box opposite the pipe line an iron back stop was erected. The plan is to elevate the auriferous gravels by the use of water direct from the nozzles. This method requires at least two nozzles in operation at the same time—one for washing gravel against the back stop, from which it falls into the sluice boxes, and the other for furnishing at the head of the boxes water sufficient for sluicing.

PORCUPINE CREEK.

About 6 miles of ditch were built in 1908 along the right bank of Porcupine Creek. The ditch taps Bonanza Creek about 2 miles above its mouth and leads the water to ground on Mammoth Creek near the mouth of Miller Creek, where a head of about 500 feet is obtained. The water will be used for hydraulicking the Mammoth Creek flats.

RAMPART DISTRICT.

GENERAL CONDITIONS.

The situation concerning water supply in the Rampart district is similar to that in the Fairbanks district. The topography is most unfavorable to an outside supply by gravity, and it seems that water will have to be obtained by pumping unless some extensive system of storage can be devised. The producing creeks are all small and supply a very meager amount of water during the greater part of the mining season. Present data fail to show where any extensive system of ditch construction for carrying water to the mines is warranted.

MINOOK CREEK GROUP.

Very little if any new work was done on the Minook Creek side of the Rampart placer region in 1908. The hydraulic elevator on Hoosier Creek was operated for a short period in June and September. The work on Little Minook Creek was carried on as usual by the operation of splash dams. On Hunter Creek some hydraulicking was done, but in this section, as elsewhere in the Yukon-Tanana region, the work was very much hampered by lack of water, and during July and August was practically at a standstill.

BAKER CREEK GROUP.

The Baker Creek diggings are situated on the north or right bank of Tanana River, about 150 miles below Fairbanks. In 1907 Frank G. Manley, of Baker Hot Springs, completed several small ditches to convey water for mining the bench gravels on Thanksgiving and Pioneer creeks. The ditch for work on Thanksgiving Creek taps New York and California creeks a short distance above their confluence. It is about 4 miles long, is 5 feet wide, and has a grade of about $6\frac{2}{3}$ feet to the mile. The water is used for ground stripping and for washing gravels that are shoveled into the sluice boxes. The What Cheer Bar ditch taps Pioneer Creek well toward its headwaters and carries the water along the right bank for use on Seattle Bar and What Cheer Bar. The water is used principally in the same way as on Thanksgiving Creek.

During 1908 Jerome Chute built a small ditch for operations on Eureka Creek above Pioneer Creek. There are several other small ditches that carry water for use on Glen, Gold Run, and Chicago creeks. Owing to the scarcity of water, very little work was accomplished during the last summer, except the stripping of ground to get mining property in shape for shoveling in.

SULLIVAN CREEK.

During the summer of 1908 a short ditch line was constructed along Sullivan Creek for working ground near the mouth of Tufty Gulch. Several other small ditches were in process of construction.

CONCLUSIONS.

Throughout the Yukon-Tanana region mining in general has been carried on by means of the meager water supply from individual creeks, with very little consideration for methods or economy. Fortunately, most of the ground that has been worked has been wonderfully rich, and the miner has been able to follow haphazard methods and still reap a substantial harvest. The time is rapidly approaching when cheaper ground will have to be worked, and the miner of the future will be forced to give careful consideration to the water supply. The camps have already attained a stage of development that demands a greater amount of water than the local creeks can furnish.

The topographic relation of the mining camps to the surrounding country is not favorable to the procurement of an outside water supply by gravity, ditch lines from the larger drainage areas being not altogether practical. The region lies in a semiarid belt, having an annual precipitation of only 10 to 18 inches. Consequently it is necessary to look to streams of considerable drainage area to obtain a supply commensurate with any reasonable development. This necessity usually places the supply at too great a distance, or at too low an elevation for use on the auriferous gravels.

There are several streams in this region, however, so situated that their development for transmission of electric power to the mining camps seems practical. Table 18 indicates the most desirable of these streams. Unfortunately, however, the data are insufficient to show what these streams are actually doing, and on account of a lack of development in their drainage areas it is very difficult to procure the desired information. The diagram (fig. 17) shows that the streams that have been studied exhibit a considerable degree of similarity in run-off per square mile of drainage area, and the diagram and the accompanying table of drainage areas may be used as a guide to the localities most favorable for electric development.

The small miner can not be expected to investigate possible water-power developments, but the capitalist looking for an investment could well afford to consider them. There is little doubt that an era of what is termed low-grade mining has a future in this country. The coming of better transportation facilities, modern machinery, and up-to-date methods is bound to create a demand for power that can not be supplied by the moderate growth of timber which is used at present for fuel to generate steam. Modern methods in electric transmission make hydro-electric development seem the most feasible solution of the water-supply and power problems of the Yukon-Tanana region. This method of utilizing the available water supply would dispense with many miles of ditch construction and would furnish the camp not only with water but also with power for running the hoist, elevating the tailings, pumping water from the mines, lighting the underground work, pumping water to the sluice box, and, in some localities, running dredges.

GOLD PLACERS OF THE RUBY CREEK DISTRICT.

By A. G. Maddren.

INTRODUCTION.

Late in the summer of 1907 a report was circulated that prospects of placer gold had been discovered on Ruby Creek, a small stream about 3 miles long that flows into Yukon River on its south side, opposite the mouth of the Melozitna. (See map, Pl. IX.) The discovery was made at the mouth of the creek, in some fine gravel at the level of the spring high-water mark of the Yukon. As this locality is very accessible, especially from the settlements of Tanana, Rampart, and Fairbanks, a good many men went to Ruby Creek during the latter part of 1907, and extensive tracts of land on a number of the streams were located as placer-mining ground. About 30 men remained in the vicinity of Ruby Creek during the winter of 1907–8, prospecting on the various creeks in this district. A number of shafts were sunk during the winter, largely with the aid of three small steam boilers, but the results of these operations do not appear to have been very encouraging, for by July, 1908, most of the men had left the district, and Discovery claim, on Ruby Creek, was the only property that was being actively worked. The writer spent seven days in this locality in July, 1908, and made a hasty examination of the general geology.

GEOGRAPHIC SKETCH.

LOCATION.

The locality known as the Ruby Creek district—from the name of the small stream on which gold was first discovered in the area—is situated along the south bank of Yukon River, directly south of and opposite the mouth of Melozitna River, about 175 miles below the town of Tanana or 110 miles above Nulato, the two nearest large settlements on the Yukon.

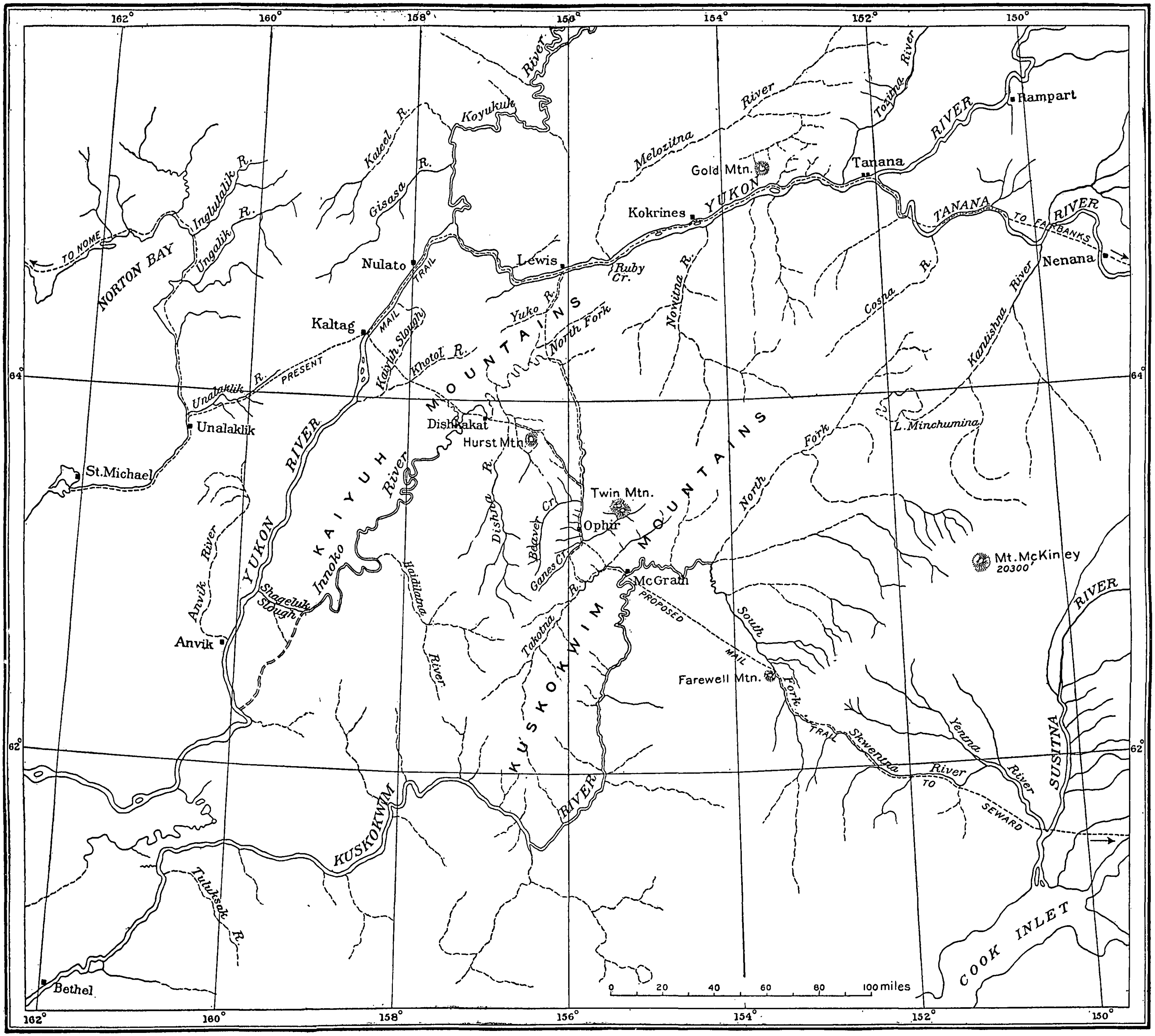
The district is within the St. Michael recording precinct, as it is now defined by the court for the second judicial division of Alaska. The nearest points where supplies may be obtained are at the village of Kokrines, 24 miles up the Yukon, and at Lewis's store, 23 miles down the Yukon. The United States military telegraph station called Melozi is on the north bank of the Yukon 8 miles below Ruby Creek. The region is easily reached throughout the year by way of Yukon River.

RELIEF.

For a distance of 10 miles along the south bank of the Yukon the Ruby Creek area presents rolling hills from 400 to 500 feet high that overlook the river with rock bluffs 200 to 300 feet high. These hills may be considered to form the northeast end of the Kaiyuh Mountains, which extend for about 175 miles toward the southwest to lower Innoko River. The Ruby Creek hill country is noteworthy as being the only place along the south side of Yukon River between Tanana River and Bering Sea, a distance of over 800 miles, where the highland is made up of the older rocks, and bluffs of consolidated bed rock form the immediate bank of the Yukon. The south bank of the Yukon throughout all the rest of this distance is made up of low bluffs of unconsolidated, alluvial silt, which covers the older hard-rock formations for distances of 5 to 20 miles or more back from the stream. The rolling hills near the Yukon gradually rise to low, dome-shaped mountains 1,200 to 1,500 feet in height 10 miles south of the stream, and these low mountains continue southward and southwestward to the Innoko Valley.

DRAINAGE.

The drainage of this area is of the kind that may be expected to characterize a low, rolling region. None of the streams carry much water and their grades are not steep. Nowitna River discharges into the Yukon from the south about 36 miles above Ruby Creek, after meandering across extensive flats that extend southward from the Yukon for 20 miles or more. Along the wide valleys of the larger tributaries of the Nowitna broad strips of flat bottom land extend far back into the hills, and the Ruby Creek hills descend eastward to these flat lands of the lower part of the Nowitna Valley. A large western tributary of the Nowitna called the Solatna rises southeast of the northeast end of the Kaiyuh Range, which is formed by the low-domed mountains southwest of the Ruby Hills. The largest streams whose sources are in the Ruby Creek district flow toward the east into the Nowitna Flats. These streams, named in order from north to south, are Big, Independence, and Eureka creeks and the headwater tributaries of the Solatna—Wolf, Joe, New York, Beaver, and Dome creeks. There are also several large creeks that rise in the Ruby Hills and drain toward the west, across the wide flats that are occupied by sloughs, small lakes, and the meandering lower course of Yuko River, which discharges into the Yukon about 23 miles below Ruby Creek. Only two of these streams have been named—Ora and



SKETCH MAP OF LOWER YUKON AND KUSKOKWIM VALLEYS.

Main creeks; both empty into a slough that leaves the Yukon just below the bluffs along the main river.

Big and Ora creeks run east and west, respectively, 3 or 4 miles south of the Yukon and somewhat parallel to it. The divide that separates these creeks from the Yukon is the southern boundary of the strip of hilly country, from 2 to 3 miles wide and about 10 miles long, that extends along the south bank of the Yukon with the bluffs already mentioned overlooking the river. The bluffs are separated by small valleys, at right angles to the Yukon, that are occupied by creeks from 1 to 3 miles in length. Named from east to west these streams, which drain directly into Yukon River, are as follows: Flat, Center, Melozi, Ruby, Short, and Hannah creeks. They are all small streams with a very scanty supply of water. Thus, the Ruby Creek hills and the low dome-shaped mountains that rise to the southwest of them form a divide between waters that flow eastward into the Nowitna and westward to the Yuko Flats, and thence into Yukon River.

VEGETATION.

The vegetation of the Ruby Creek district is that typical of this part of the Yukon Valley. The white spruce is the only tree of importance, and it grows to a good size only on the flats, being small and scrubby on the hills.

GEOLOGIC SKETCH.

The bed rock of the hills and low mountains of the Ruby Creek district comprises a variety of old altered sedimentary rocks—crystalline limestones, garnet-mica schists, and mica-quartz schists with so fine a grain that they may well be called coarse slates. These rocks occur in the bluffs along the Yukon. The bluff exposures show local zones of shearing, with quartz stringers deposited along the fractures. Near Flat Creek the results of shearing in the schists are somewhat pronounced and large quartz lenses and stringers occupy the openings thus produced. On the surface these quartz deposits are of the lens or bunch type, with no particularly uniform trend or thickness for any considerable distance. Two principal exposures of quartz were seen, one about 100 yards below the mouth of Flat Creek that shows a maximum thickness of 4 or 5 feet on its face, and another about 100 feet downstream that is several feet in thickness but of no marked linear extent. Assays of samples of quartz from these exposures are said to have shown good values in gold. In 1906 a tunnel, now caved in, was run in on the largest of these quartz deposits, it is said for a distance of 150 feet, with the object of following the quartz that shows on the surface of the bluff. After the work had progressed for a few feet it was found impracticable to follow the irregularities of the quartz stringers with a straight tunnel, and most of the tunnel was run through the slaty schist country rock, as is shown by the material on the dumps. In brief, the bodies of quartz were found to be too irregular and uncertain in extent to be mined by tunnels, and what has been demonstrated at this place will probably be found to be true of any other quartz deposits in this region.

Farther inland, quartzite schists, mica-quartz schists, cherty limestone, and cherts make up the low mountains. All these rocks have been considerably changed from their original form by metamorphism, but not to a degree that noticeably obliterates their sedimentary origin and arrangement. They are similar to and are presumably to be correlated with formations that occupy large areas of the mineral belt between Yukon and Tanana rivers, 200 miles to the east.

The rocks of the district have been intruded to some extent by dikes of igneous rock. These dikes are of diabasic and granitic types.

The alluvial deposits that fill the bottoms of the valleys are moderate in amount and thickness, and appear to be the gradual accumulations produced by a meager drainage such as now prevails. The rounded forms of the hills and mountains suggest that the present aspect of the country is the result of a long period of uniform erosion.

GOLD.

Colors of placer gold are reported to have been found in the alluvial deposits of nearly all the streams that rise in the Ruby Creek district, but no rich gold-bearing gravels have yet been found.

In the fall of 1907 a number of men, following the usual practice adopted when a new placer district first attracts attention, located practically all of the alluvial bottom lands along the streams of this district as placer-mining ground. These locations comprised both association placer groups containing 160 acres and single 20-acre tracts. Large areas of the valley slopes were also located as so-called "bench claims."

During the winter of 1907–8 about 30 men prospected for placer gold in the alluvial deposits of the creeks by sinking a number of holes to bed rock. Most of this work was done on Ruby and Big creeks, but a few holes were sunk on Boston Creek and two of its headwater tributaries, Logger and Boston gulches. Some prospecting was also done on the headwaters of the Solatna—Beaver and Dome creeks. One hole that did not reach bed rock was sunk on Melozi Gulch.

On Big Creek about 15 holes from 15 to 60 feet deep were dug to bed rock. The deeper holes are on the upper part of the creek. Farther downstream the unconsolidated deposits are not so thick. Washed gravel of schist rocks lies on bed rock in a layer from 1 to 7 feet thick and is overlain by sandy clay and muck. Bowlders of igneous rocks and quartz up to 1 foot in diameter are also present. It is reported that colors of gold were found in all the holes on Big Creek. A good deal of iron pyrite is included in the gravel, both as washed grains and inclosed or attached to the larger fragments of slaty bed-rock material.

The unconsolidated valley deposits on Ruby Creek probably average about 15 feet in depth. They are composed of muck, loamy sands, patchy layers of flat schist and slate pebbles, and a good many water-rounded bowlders of igneous rock. The bed rock is schist, slate, and limestone in the form of rectangular blocks and slabs.

The results that had been obtained by the close of the winter prospecting season do not appear to have been of sufficient promise to encourage the prosecution of summer work, except at the mouth of Ruby Creek. In July, 1908, two men were carrying on open-cut work on Discovery claim, the first above the Yukon. They were working about one-eighth of a mile back from the river on the east side of Ruby Creek, in a bank of muck, silt, gravel, and bowlders. A small ditch had been built with an intake about 400 yards above to bring a sluice head of water to the open cut. The bed rock in this cut is a blocky, impure, banded crystalline limestone similar to that exposed on the Yukon in the "lime bluff" just below the mouth of Ruby Creek. It is in the shape of sharp-cornered rectangular blocks and bricklike slabs that have not been rounded by erosion. It is all in a shattered condition, so that it has to be handled in working.

The material handled consists of this loose blocky limestone, flat pieces of coarse mica slate similar to that seen above and below Ruby Creek on the Yukon, close-grained cobbles of diabase, and large, heavy bowlders of medium-grained diorite, similar to that seen in a large dike on the Yukon. These bowlders are from 12 to 18 inches in diameter and are well rounded. The large, heavy bowlders do not lie on bed rock, as might be expected, but for the most part several feet above it in the muck. The finer wash is below the muck, on bed rock, and is made up mostly of flattish slate pebbles mixed with loamy sand. This sand also fills the spaces between the blocky limestone fragments of the bed rock. Mixed with the sand and in patchy layers within it and on top of the blocky limestone are finer waterworn gravels consisting of slate pebbles, mostly flat. These layers of fine washed material do not appear to be continuous for any great extent, nor are they very thick. They carry most of the placer gold, which is in the form of fine, flaky, light particles, not as large as bird shot. Owing to this fineness, it is hard to save all of the gold in the sluice boxes.

Up to July, 1908, about $1,000 worth of this fine gold had been produced from the open cut on Discovery claim on Ruby Creek.

PLACERS OF THE GOLD HILL DISTRICT.

By A. G. Maddren.

INTRODUCTION.

In 1907 deposits of placer gold were found on several small streams that flow into the Yukon from the north about 25 miles below the town of Tanana. Further prospecting showed that placer gold occurs also in streams that lie across the divide and flow northward into the upper course of Melozitna River. This district may be easily reached by way of Yukon River, and as soon as the news spread that placer gold had been found on these creeks, all of the alluvial ground on them was located for placer-mining purposes. Most of the locations were made by association groups, covering 160 acres each, a plan which enables a few persons present on the ground, provided with the powers of attorney of a number of absent persons, to tie up completely many thousands of acres of alluvial gold-bearing deposits. As the healthy growth of the placer-mining industry depends largely on individual effort, there has not been as much prospecting in the Gold Hill district as its accessible situation and other favorable conditions appear to warrant. About 25 men spent the winter of 1907–8 in this locality prospecting on the various creeks. The writer made a hasty examination of the district from June 25 to July 4, 1908.

GEOGRAPHIC SKETCH.

The name Gold Hill district is loosely applied to an area in the central Yukon Valley, about 25 miles below the mouth of Tanana River, that lies along the north side of the Yukon and extends westward from the western slopes of the valley of Tozitna River to the higher mountains north of the United States military telegraph station called Birches. The Yukon forms the southern boundary of this district, and its northerly extent is limited in a general way by the headwater drainage of Melozitna River. Roughly, the district embraces an area extending 30 miles east and west and 20 miles north and south, covering about 600 square miles. Most of this area consists of mountains that form a divide extending east and west about midway between the main courses of the Yukon and the headwaters of the Melozitna.

This divide separates the region into two areas that are drained to the north and south by creeks of moderate length and volume. The principal southward-flowing streams on which placer locations have been made, named from east to west as they join the Yukon, are Grant, Illinois, and Mason creeks and their tributaries; those flowing northward into the Melozitna, named in the same order, are Moran, Eureka, Hudson, Langford, and Tiffany creeks and their tributaries. All these streams are of moderate length and volume. The topography is one of comparatively low, rolling mountains with wide, moderately sloping valleys that appear to be the result of a long period of rather uniform downcutting and wearing away of the country rock by a drainage system similar to that of the present day. With the exception of the silts along the immediate banks of the Yukon, there are no detrital deposits that occupy elevated positions with reference to the present drainage in the sense in which this distinction is usually made; that is, all the alluvial deposits of the streams now lie in the bottoms of the valleys and may be properly classed as stream deposits or creek gravels, none of them being sufficiently above the present stream grades to place them in the class usually called bench gravels.

The mountains of the district have an average altitude of about 3,000 feet above sea level. For the most part they form wide undulating ridges, but a few of the mountains rise to heights of 4,000 feet and have more rugged forms. Yukon River cuts into the southern slopes of these mountains and exposes bed-rock bluffs where the ridges between the creeks come down to the main river. The tributary valley spaces between the ridges show low banks of recent alluvium about 10 feet high and also a few benches of the older silt deposits that stand in places from 20 to 50 feet above the river level.

The Yukon has an elevation of about 300 feet above the sea at Gold Hill. Owing to this low level, the tributary valleys along the south side of these mountains have been eroded more deeply than those on the north side, and they all have considerable grades, especially in their upper portions. These valleys are in the form of wide basins extending from 5 to 10 miles back into the mountains and opening out into the Yukon Valley with widths of one-half mile to 3 miles.

The valleys on the north side of the mountains lie from 600 to 1,000 feet above the level of the Yukon, and for this reason the headwater streams corresponding in length to those flowing into the Yukon have lower grades and their valleys have not been eroded so deeply into the country rock as those on the south side of the divide.

GEOLOGIC SKETCH.

The low, rolling mountains of the Gold Hill district appear to be made up entirely of a typical development of an assemblage of metamorphic rocks that have been given the general name Birch Creek schist. This name was first used by Spurr for the bed-rock formations in the Birch Creek gold-placer district, and he considered the rocks of Gold Hill to belong to the same group because of their similarity. These schist rocks make up a general group of formations that have been recognized as a characteristic part of the bed rock in all the better-known placer-mining districts of the Yukon Valley. In the Gold Hill area the predominating rocks are quartzite schists and micaceous quartz schists. More or less vein quartz occurs in the schists, mostly in the form of small and nonpersistent stringers and lens-shaped bodies. Many of these quartz fillings appear to have been shredded and faulted by movements in the rocks that have occurred since most of the quartz was deposited, so that they can not be traced very far. Much of the quartz is recemented by iron mineral matter, and some of it is known to carry gold.

ECONOMIC DEVELOPMENTS.

Probably the first attempt to open a lode mine in the interior of Alaska was made about 1890 at the locality since known as Gold Hill. The prospect on which work was done is situated on the river slope of a ridge that comes down to the north bank of the Yukon 20 miles below Tanana. A tunnel 110 feet long was run in on a vein of sheared and broken rusty quartz that outcrops on the surface with a width of 2 or 3 feet. The tunnel is now abandoned and caved. It is said that the vein became more and more broken away from the surface and that at the breast only a few streaks of it remained in a decomposed schist, between talcose schist walls, in a country rock of micaceous quartz schist. The quartz taken from this tunnel is known to be gold bearing, but the prospect has not been developed into a mine. This occurrence of gold-bearing quartz is similar to that seen in the Ruby Creek district.

Placer gold is reported to occur in the creek gravels of all the streams that have been named, but, although many thousands of acres of ground have been located, only a very small amount of prospecting work has been done, because there have not been many men in the district.

About 20 holes were dug in the stream deposits during the winter of 1907–8. All of this work was done with the aid of wood fires for thawing the frozen ground, as there are no steam prospecting plants in the district. Some of these holes reached bed rock and showed prospects of gold; others tapped live water in thawed ground and did not reach bed rock.

Open-cut ground-sluicing operations have been begun at several localities in the Gold Hill district, but owing to the scarcity of water, due to the unusual dryness of the summer of 1908, very little gold has yet been produced. Some gold found on the head of Mason Creek is mostly in the form of small rounded pellets about the size of bird shot.

GOLD PLACERS OF THE INNOKO DISTRICT.

By A. G. Maddren.

INTRODUCTION.

Since the discovery of placer gold in paying quantities on some of the headwaters of Innoko River, in 1906, that part of Alaska has received more attention from prospectors looking for new fields than any other district in the Yukon Valley. During the last three years probably as many as 1,500 men have visited the Innoko country and remained there for the whole or part of a season. Although it is reported that prospectors visited the Innoko in 1898, during the earlier days of the gold excitement in Alaska, they do not appear to have been much encouraged by what they found, for they did not remain in the valley. The real discovery of placer gold in commercial quantities was made during the summer of 1906 by a party of prospectors consisting of Thomas Gane, F. C. H. Spencer, Mike Roke, and John Maki. These men came into the headwater country of the Innoko Valley from the Kuskokwim and found a few colors of gold on the bars of the main Innoko a short distance below the mouth of its principal headwater tributary, now named Ganes Creek. Later in the season of 1906 they ascended Ganes Creek with the hope of finding the source from which these colors of gold were derived, and during August or September they located Discovery claim on Ganes Creek about 10 miles above its mouth. At this time, their provisions having become exhausted, the party returned to the Kuskokwim for a new outfit of supplies; but these they failed to find there, so they again crossed to the headwaters of the Innoko and descended that river to the settlements on the lower Yukon. They returned to Ganes Creek during the winter of 1906–7, hauling supplies with them on sleds. In the meantime news of the discovery had spread to prospectors who were scattered in various parts of the upper Kuskokwim Valley, so that during February and March, 1907, stampeders from the Kuskokwim arrived on Ganes Creek. The news also reached Nulato, on the Yukon, and others rushed to the Innoko from that place and the settlements near by. By early spring encouraging reports of the discovery had reached Nome and Fairbanks, so that as soon as summer navigation of the rivers was possible a great many people were ready to go to the new placer district. It is estimated that during 1907 about 800 or 900 people went to the Innoko from Fairbanks, and several hundred from Nome.

Up to the time of the 1907 summer arrivals attention had been devoted to locating claims on Ganes Creek. Over 50 claims were located on this stream below Discovery claim, and over 80 claims above it. These claims covered all the ground on Ganes Creek from its mouth to its source. Besides the creek claims along the present valley floor, all of the promising bench ground within the valley was located, though more as a last resort by those who had arrived too late to get creek claims than from any particular knowledge as to where the values were to be found, for most of the locating on Ganes Creek was done before the winter snows had left the ground.

Many of those who flocked into the Innoko district in the summer of 1907, finding Ganes Creek completely located, became discouraged and left the country. Others, however, remained and devoted their energies toward prospecting other streams. As a result of this search prospects were found on Little, Spruce, and Ophir creeks, which drain into the Innoko to the northwest of Ganes Creek. These streams were thoroughly covered by locations during the summer of 1907, although gold in paying quantities had not been demonstrated to exist on them at that time. In fact, with the exception of a small production of gold on one or two of the bench claims on Ganes Creek, little was done during the summer of 1907 but to locate a great many claims on nearly every water course within the mountainous part of the upper Innoko Valley. As a result most of those who had come to the region during the summer had by early fall so exhausted their means that they could not remain during the winter, and so left for Fairbanks and Nome.

The recording office for the precinct was established in September, 1907, on Ganes Creek at the mouth of Last Chance Gulch, opposite claim No. 6 above Discovery. It was named Moore City and consisted of about 20 log cabins. This place was the center of settlement at the diggings during the winter of 1907–8.

It is estimated that about 150 men spent the winter of 1907–8 in the Innoko precinct. The greater part of the time of these men was taken up with the task of providing themselves with food from rather distant points on Yukon and Kuskokwim rivers, for entirely inadequate amounts of supplies had been brought to the region during the previous summer. However, some winter prospecting was carried on, notwithstanding the discouraging conditions. Most of the prospect holes were sunk on Ganes Creek, but a few were put down to bed rock on Little and Ophir creeks. In the latter part of January, 1908, rich auriferous gravels were discovered by different parties at several separate localities on Ophir Creek within one week. As a result of the finds, all but three or four men stampeded from Ganes Creek to Ophir Creek in February, 1908. From the meager facts at hand very optimistic surmises were hastily made concerning the width, length, and richness of the pay streak that was presumed to extend along the whole course of Ophir Creek. Without further investigation, enthusiastic reports were at once dispatched to Fairbanks and Nome, and had the effect of restoring a keen interest in the Innoko country. As a result half a dozen small stern-wheel river steamboats went from Fairbanks to the Innoko on the opening of river navigation early in June. These boats carried about 500 persons and several hundred tons of miscellaneous cargo, and landed them at the upper limit of navigation for such boats on the banks of the Innoko at points from 75 to 100 miles below Ophir Creek.

In the meantime a new settlement had been established on upper Innoko River at the mouth of Ophir Creek, and this place was the objective point for most of those bound for the diggings. Attempts were made to form settlements at the points where the various steamboats landed their passengers and freight, but these settlements were maintained for only a short time.

The United States commissioner removed the recording office for the precinct from Moore City to Ophir early in the summer of 1908. At the present time Ophir, with a population of about 150 whites, and Dishkakat, with a population of about 25 whites, are the only two settlements of a substantial character within the Innoko Valley. Ophir is in the mining area, and Dishkakat serves as a halfway station between the diggings and the settlements of Anvik and Kaltag, on the lower Yukon.

During August and September, 1908, the writer made a hasty examination of the region drained by Innoko River, more especially of the area of its southern headwater tributaries.

CLIMATE.

The temperature, precipitation, and seasons of the Innoko Valley are those which prevail throughout the lower Yukon country. The streams usually freeze over in October and thaw out in May. Early in September killing frosts make the grass practically worthless for forage. Locally, in the narrow valleys and gulches where the drainage is feeble, much of the alluvial material remains permanently frozen, but in the wider bottoms of the larger streams and the main river the alluvial deposits probably carry live water in some quantity throughout the year.

In temperate climates the superficial winter freezing temporarily consolidates only a small part of the detrital cover, but in most of

Alaska the effects of the longer cold period are such that unfrozen detrital ground, even in summer, is the least common kind. The final result of the annual superficial freezing in Alaska tends to add to the amount of detrital material that remains permanently consolidated by the frost.

The alluvial covering of the bed-rock floor is in general permanently frozen over most of that part of Alaska lying north of the area that drains into the Pacific Ocean, though there are local variations of this condition. The extent and development of the ground frost depend on the extent, position, thickness, and proportions of the gravel, sand, clay, and humus members that compose the alluvium and the amount of underground and surface water present. Generally the alluvial deposits are permanently frozen where they are not well drained by an abundant supply of surface water and where the circulation of underground water is feeble. There is, however, no uniformity of condition even within small areas, either vertically or horizontally, for often while shafts are being sunk in ground that appears to be solidly frozen layers charged with live water are encountered and flood the workings in such quantity that the workers are "drowned out."

In general the climate of Alaska tends to retard the processes of stream erosion and transportation. The almost universal frost binder, together with the widespread humus and muck insulation it fosters and the consequent arrested condition of the available supply of running water for the greater part of the year, prevents the streams from moving and reworking the otherwise loose-textured detrital deposits and adding new material to them as rapidly as they would if the material were wholly unfrozen and the flow of water continuous. Probably the concentration of the placer gold in this country is a slower process than it would be under the conditions of a more temperate climate, where the alluvium would be moved more frequently, the lighter materials carried farther, and consequently the heavier gold concentrated more rapidly.

VEGETATION.

The valley floors and the lower slopes of the mountains in the Innoko country are mostly covered by the characteristic blanket-like accumulation of sphagnum mosses. This moss covering, with low bushes, is thickest in the lowlands, and gradually becomes thinner as the hillsides are ascended, except in favorably moist places and on cool sheltered slopes. The highest ridges are generally well covered by mosses, heathers, stunted bushes, and grasses. The highest mountain tops of this region are the only places where a ground-covering vegetation is sparse or absent.

Several kinds of grasses suitable for summer forage for horses and cattle grow in the rather meager meadow areas in the valleys and in open places, many of them old burnt areas, on the ridges. In the meadows and along the banks of the streams where they are free from brush a moderate amount of grass may be cut and cured into hay of fair quality if the season is not too rainy and advantage is taken of the sunny days.

Timber suitable for fuel grows in moderate abundance throughout the larger valleys, up the gulches, and locally well up the slopes of the lower ridges. On the evenly undulating tops of the ridges timber is usually scarce. White spruce is practically the only tree that reaches a size suitable for cabin logs or sluice-box lumber, and even this is not plentiful in desirable sizes except in small patches along the valleys of the main river and its larger tributaries. The more scrubby black spruce, together with stunted white spruce, grows in scattered clumps on the slopes of the ridges.

In swampy areas in the middle Innoko Valley there are considerable groves of larch, or tamarack. In these localities it reaches a diameter of 8 to 10 inches and a height of 30 feet. Smaller larch saplings are scattered in the smaller valleys and on their lower slopes.

Birch grows here and there throughout the region and also in thick groves of considerable extent on the drier banks of the lower Innoko, where it has been cut as cord wood for the small river steamboats.

GEOGRAPHIC SKETCH.

LOCATION AND EXTENT.

The Innoko is the lowest noteworthy tributary of the Yukon entering from the left. It is about 500 miles long and with its tributaries drains the largest part of an extensive area that lies between the central lower courses of Yukon and Kuskokwim rivers and is approximately bounded by the meridians of 156° and 160° west longitude and the parallels of 62° and 64° north latitude. (See Pl. IX.)

RELIEF.

This extensive area as a whole is primarily one of moderately mountainous character. It is mostly occupied by broad, undulating, rather even-topped ridges separated by deep, relatively narrow valleys. The average height of the ridges above the stream beds is from 800 to 1,200 feet. Isolated mountain masses rise above the general level of the ridges, more especially in the headwater region of Innoko.

The Innoko Valley is separated from the Yukon basin to the northwest by the Kaiyuh Mountains, which extend from the south side of the Yukon, opposite the mouth of Melozitna River, in a southwesterly direction to the lower course of the Innoko, at the point where it is joined by Shageluk Slough, a distance of about 175 miles. These mountains are comparatively low, being little more than high hills at their northeast and southwest extremities. They are crossed by several low, flat passes, especially where the north fork of the Innoko lies opposite Yuko River, which drains into the Yukon, and also where Kluklaklatna River, a lower tributary of the Innoko, heads against a branch of the Khotol on the Yukon side. The higher parts of the Kaiyuh Range between these low passes rise to a maximum height of about 2,000 feet above sea level. Throughout their extent they present rather smooth, evenly rounded, and undulating outlines with no sharp peaks.

To the southeast the valley of the Innoko is divided from that of Kuskokwim River by a range of the Kuskokwim Mountains, which, although not uniformly high, form a definite belt that trends northeast and southwest. These mountains are higher and more rugged than the Kaiyuh Mountains, and the passes across them are not so low and flat as those through that range. In the Kuskokwim Mountains isolated mountainous masses of greater or less extent rise to over 4,000 feet above sea level, and at least one area, lying between the heads of Ganes and Beaver creeks and Dishna River, is occupied by a comparatively high, rugged group that was formerly the center of extensive local glaciation. This group stands up in rugged contrast above the more flat-topped, gently rolling forms presented by the surrounding mountains. It presents a thoroughly glaciated appearance, with ample and well-developed cirque basins and U-shaped valleys within the mountains themselves, extensive deposits of morainal material spread out as broad lobe-shaped ridges, and piedmont benches extending from them into the wide valleys around the group.

DRAINAGE.

The Innoko Valley presents two kinds of drainage that naturally divide it into two large and distinct provinces, corresponding approximately with the upper and lower halves of the valley. The upper province is characterized by hills and low mountains and is drained by clear streams that flow with currents of moderate strength in valleys whose flood plains are well developed to a width commensurate with the amount of water carried by the main river and its tributaries. In this province the streams flow for the most part over flat valley floors composed mostly of well-washed gravels, but also locally to some extent through small areas of sands, and here and there through deposits of silt. Toward the headwaters there are a few localities where the streams run directly upon bare bed rock. The upper province is one where erosion and transportation by the streams have been going on for a long time and are still in progress.

On the other hand, the lower half of the Innoko Valley is an area characterized by stream deposition. The main river and its principal tributaries in this province meander widely over a great extent of low, flat country made up of silt and clay deposits. The channels and banks are for the most part cut in these fine-grained water-laid sediments, although here and there in its lower course the Innoko touches low rock bluffs on its right-hand side as it passes around the southwest end of the Kaiyuh Range and makes its tortuous way toward the Yukon. These low, flat, swampy plains occupy all of the wide belt of country lying between the Kaiyuh and Kuskokwim ranges. They are more than 20 miles wide from east to west and extend from the hilly country of the upper Innoko on the northeast to the great Yukon-Kuskokwim delta on the southwest. In fact, the lower half of the Innoko Valley is merely a tonguelike extension inland between two low mountain ranges of the vast coalescent coastal delta plains of the Kuskokwim and Yukon.

Where the Innoko emerges from its upper valley, its banks are on an average from 10 to 15 feet above the normal stage of the river. Here and there the river cuts banks of silt that are 20 to 25 feet high, but its banks gradually decrease in height downstream, and on the lower river they are in many places only 3 or 4 feet above the usual water level. During the spring freshets the whole lower valley is inundated, and after the floods have subsided large areas of swamps, shallow ponds, and lakes remain over its surface. Good examples of natural levees are built up along the banks of the main course of the lower Innoko as a result of floods and subsequent run-off. Dishkakat and some of the other settlements are located on the higher silt banks, to avoid the spring floods.

The group of mountains between Dishna River and Ganes Creek that now rise to heights of about 4,500 feet were during Pleistocene time occupied by snow and ice fields of considerable local extent. The former glaciers eroded this mountain group strongly and laid down extensive moraines of unassorted angular rock blocks and bowlders about the base of the group and out into the wide surrounding valleys for considerable distances; while the large volumes of water from the melting snow and ice carried considerable quantities of cobbles, gravel, sand, and silt still farther down the valleys and laid them down with some degree of assortment.

The higher silt banks cut by the lower Innoko are considered to have been formed during the glacial period and therefore to be of Pleistocene age. The present course of the lower Innoko cuts through some of these high silt deposits, and no doubt a number of areas of similar old silts are present in the wide expanse of flat country forming the lower province of the Innoko Valley. Nearer the mountains deposits of Pleistocene age appear to be represented here and there by banks of gravel that stand from 20 to 30 feet above the present stream grades.

Except on Ganes Creek, this local glaciation does not appear to have effected any widespread changes in the relative positions or character of the drainage of the southern headwaters of the Innoko, outside of the area surrounding the mountains that was occupied by the ice streams and the débris they carried. This area is now deeply covered by morainal deposits of angular rock fragments and bowlders. Within the area occupied by these moraines, especially on the north side of the mountains, where the glaciers appear to have been most strongly developed and consequently where the glacial deposits are most widespread, the present drainage is all relatively young, for it inherits its arrangement from the land forms eroded by the ice and left after the glaciers had melted.

Outside of the area now occupied by morainal deposits there is, however, one marked exception where the preglacial drainage has been strongly modified as a direct result of the glacial activity. Ganes Creek, one of the streams on which placer gold is found, is at least twice as long as it was before the glacial period, and its volume of water has greatly increased owing to an enlargement of its drainage basin, which is three or four times greater than formerly. Before the glacial period Ganes Creek was little longer or larger than Ophir Creek is to-day, and its valley was confined to the slate formation that occupies the lower half of its present course. Previous to the development of glaciers on the group of mountains situated between the upper valleys of Beaver Creek and Dishna River, the area that now makes up the upper part of the Ganes Creek drainage basin was part of the Beaver Creek valley. One of the marked results of glacial activity was to fill the upper part of the wide Beaver Creek valley deeply with deposits of morainal material. In addition to this morainal filling, the ice streams themselves, when at their maximum extent, appear to have occupied the whole, or at least a large part of this basin, completely covering the previous land surface. When the ice melted, it left the upper Beaver basin clogged with a thick filling of morainal dumps. Although the detailed features of this glacial filling and damming of the upper Beaver Valley are not well known, it is very evident that the former drainage channels were so disarranged that a large volume of the water produced by the melting snow and ice could not find an outlet into the Innoko, toward the northwest, by way of the lower Beaver Valley. As a result, it backed up and found an outlet across the lowest divide to the northeast, into what was then the head of Ganes Creek. The large supply of water that was thus diverted down Ganes Creek rapidly cut a canyon down through the slate bed rock of the former divide. This canyon, which is several hundred feet deep and 5 or 6 miles long, is situated about midway between the present source of the stream and its mouth. The rapidity of the downcutting is shown not only by the typical box-canyon features, but also by the rock-cut bluffs, with bench gravels on top of them, that rise on either side of the valley at intervals below the canyon for a distance of about 8 miles, to the point where its flood plain widens out to coalesce with that of the Innoko.

TRANSPORTATION TO INNOKO VALLEY.

SUMMER ROUTES.

There are two principal summer routes available by which the Innoko placer district may be approached. These are determined by the geographic position of the Innoko Valley between the easily navigable portions of the two largest rivers in Alaska—the Yukon and the Kuskokwim.

YUKON RIVER.

By way of Yukon and Innoko rivers it is about 244 miles from Anvik to Dishkakat, and about 190 miles farther upstream to Ophir, or 434 miles by the summer water route from Anvik to the diggings. As already stated, small river steamboats can deliver freight as far up the Innoko as Dishkakat throughout the season of navigation, from June to October. In early June and at other uncertain times of high water, these boats can occasionally ascend the main river to points within 55 to 75 miles of Ophir.

As the summer of 1907 was one of much rainfall and a consequent high stage of water in the streams, and that of 1908 was one of very scanty rainfall with a low stage of water, a comparison of the navigation limits reached in these two years probably represents the maximum and minimum availability of the Innoko as a route for transporting supplies into the country with steamboats of the size and type now employed. In 1907, during a period of high water, a steamboat with a draft of about 22 inches when loaded reached a point on the upper Innoko about 55 miles below the present town of Ophir. A cargo of 50 or 60 tons of freight might be landed at this distance below Ophir under such conditions of high water. It will probably always be necessary to transport freight from this point to Ophir in small lots of 3 or 4 tons by light-draft flat-bottomed scows, or in 1 to 2 ton lots by still smaller poling boats. In 1908 conditions were not so favorable. Even at the time of the early summer high water the same steamboat could get only within 70 miles of Ophir, and during July and August this boat found it difficult to ascend the Innoko to the village of Dishkakat and was obliged to discharge its freight there, being unable to go farther upstream.

Most of the freight shipped into the Innoko has been brought from Fairbanks, the largest town in the Yukon Valley, situated on Tanana River, 770 miles above Anvik and about 1,014 miles from Dishkakat by the rivers. The freight charge from Fairbanks to Dishkakat has been $80 a ton. The transportation companies operating large steamboats on the Yukon from St. Michael, where they connect with ocean steamers, have quoted a rate of $38 a ton from Seattle or San Francisco to Anvik or near-by points on the Yukon. One of these companies has also published a through rate of $70 a ton to Dishkakat from Seattle or San Francisco, and a local rate of $35 a ton to Dishkakat from Anvik, but the company did not offer a regular service on Innoko River and reserved the right to operate steamers thereon only when business warranted. These rates expired on September 1, 1908. No attempt has yet been made to ship freight direct from the United States to the Innoko. The ocean distance from San Francisco to St. Michael is 2,846 miles, and from Seattle to St. Michael 2,487 miles. If the traffic should amount to much, probably a lower freight charge would be quoted over this route, and another advantage it has over shipping from Fairbanks is that the original cost of supplies is much lower in the United States.

A few individual outfits have been purchased at Nome and shipped a distance of 115 miles by ocean vessels to St. Michael, there reshipped on Yukon River boats to Anvik, 405 miles from St. Michael, and there again transferred to the smaller boats which ascend the Innoko. The distance from Nome to Dishkakat by this route is about 764 miles, and it appears that if a reliable line of transportation was established between Nome and Dishkakat by way of the lower Yukon the merchants of Nome, enjoying a comparatively low freight tariff afforded by direct ocean communication with the Pacific ports of the United States, should be able to bid successfully for the Innoko trade in competition with the merchants of Fairbanks. It is doubtful, however, whether the Innoko route is as good as that by way of Kuskokwim River if an equally reliable line of communication should be established from Nome to Bethel.

KUSKOKWIM RIVER.

The Kuskokwim is the second largest stream in Alaska, and is perhaps the best river for steamboating in that country, with the possible exception of the Yukon. Steamboats of large size can ascend the river about 633 miles, to the confluence of its two principal headwater branches, the North and South forks, and smaller steamboats have been up the South Fork about 40 miles above this junction, and no doubt could also ascend the North Fork for some distance. Boats with a draft of 2 feet have ascended Takotna River, a large tributary of the Kuskokwim that heads against the sources of the Innoko, for a distance of about 60 miles to a point within 25 miles of Ganes Creek, whence supplies may be forwarded 30 miles farther up the Takotna to the mouth of Big Creek, which is only about 12 miles from Ganes Creek.

The Kuskokwim has not been used to any great extent as a route for the transportation of supplies, because the country within its drainage basin has not been prospected or developed, as has the territory within the Yukon basin. Another reason is that Kuskokwim Bay and the estuary or tidal portion of the river's mouth has been considered a hazardous locality in which to navigate ocean vessels, but this opinion appears to be due rather to the fact that this part of the Alaskan coast is mapped only in rough outline and is not known in detail, even by the very few who have some personal knowledge of these waters, than to the presence of any real dangers to navigation other than those caused by lack of acquaintance and proper charts for guidance. When accurate surveys of Kuskokwim Bay and the mouth of the river are made and the good channels that run through its extensive shoals are properly marked, ocean vessels with a draft of 12 feet may enter and ascend it to Bethel with safety and dispatch.

The Kuskokwim route was traveled by many of the people who went to the Innoko from Nome in 1907. The passengers and their supplies were taken across Bering Sea from Nome to the mouth of the Kuskokwim, a distance of 480 miles, by various small unseaworthy craft. Thence they were taken up the river on several steamboats to Takotna River and up the very winding course of that stream to points 12 to 20 miles from Ganes Creek, which may be reached by several trails across a low mountain range over which supplies can be packed by men or horses during the summer or hauled on sleds during the winter.

In the spring of 1908 a company with trading interests on Kuskokwim River brought several hundred tons of freight direct from San Francisco to Bethel on a large two-masted ocean schooner equipped with auxiliary gasoline power. During the summer this company sent about 40 tons of supplies up the Kuskokwim and Takotna to the mouth of Big Creek, a point about 90 miles above McGrath, which is on the Kuskokwim at the mouth of the Takotna. This freight was taken up the Takotna about 60 miles by a small stern-wheel boat which could go no farther owing to the unusually low water. From this point the goods were taken in scows and poling boats the remaining 30 miles to the mouth of Big Creek. Here a log store has been built and the place is known as Joaquin. From Joaquin it is about 12½ miles to the settlement called Moore City, on Ganes Creek, half a mile below Glacier Gulch. A trail that may be used by pack horses in summer and sleds during winter follows Big Creek for 9 miles to its head with an ascent of about 900 feet, all of which is gradual except in the upper quarter of a mile, where the trail rises more steeply for 200 feet. This trail passes over a saddle divide to the head of Glacier Gulch, down which it goes for 3 miles to Ganes Creek with an even descent of 600 feet. This route offers no particular difficulties to the construction of a wagon road. If a wagon road or permanent winter trail is to be built from the Kuskokwim drainage area to the Innoko Valley, however, it appears best to select a somewhat longer route which would connect a point on the lower Takotna more directly with the Innoko at the mouth of Ganes Creek, 10 miles below Moore City. This point on the Innoko side is more central to the placer-gold area, as it is now known; the advantage on the Kuskokwim side lies in the fact that some point on the lower Takotna can be reached at all stages of water by steamboats plying direct from Bethel, where direct connection can be made with ocean vessels from Seattle or San Francisco. By such a route it may be possible to deliver freight at a centrally located distributing point in the mining region with fewer transfers, and consequently a lower transportation charge, than is possible by any other route into the headwater portion of the Innoko Valley. A wagon road, or at least a good winter sled trail, could be built from a point on Takotna River 15 to 25 miles above its confluence with the Kuskokwim to the upper Innoko Valley near the mouth of Ganes Creek, or about 5 miles farther to the town of Ophir. Such a road would not be over 30 or 35 miles long, and the divide to be crossed from the Kuskokwim to the Innoko is not high or rugged. The road would probably not be as high or present as steep grades as the Big Creek-Glacier Gulch trail does, and it would lead more directly to a suitable central distributing point for the placer region. In the fall of 1908 an auxiliary gasoline schooner of about 15 tons burden, with a draft of 4 feet, made a continuous trip from Nome to a point on the Takotna, 30 miles above its mouth, without any difficulty. This trip shows the advantages of this route, for the same boat could not have proceeded farther than Dishkakat by the Yukon-Innoko route, and even if successful in reaching that place it would still be 55 miles by the winter trail from Ophir. The distance from Nome by way of the Kuskokwim to a point on the Takotna 25 miles above its mouth and within 35 miles of the Innoko diggings is 1,170 miles. The distance over the Yukon-Innoko route from Nome to Dishkakat, 55 miles from Ophir by winter trail, is about 764 miles.

The difference in favor of the Kuskokwim route is not only in the shorter distance of its terminus from the diggings, but also in the smaller number of transfers of freight necessary. At St. Michael, which is a more or less shallow, open roadstead rather than a protected harbor, it is necessary to lighter all cargo from ocean vessels to the shore and then reload the freight into the river boats at the docks or warehouses. Moreover, it is often necessary for the river boats to wait several days or even a week, after being loaded, for calm weather on Norton Sound during which to make the passage of 60 miles around the shoal coast to the mouth of the Yukon. This passage is hazardous for the small steamboats that can ascend the Innoko. Consequently, safety will make it advisable to send freight from St. Michael to Anvik on large steamboats and to transfer it again at Anvik to smaller boats for the trip up the Innoko. Thus three transfers are necessary between starting point and destination. By the Kuskokwim route, on the other hand, only one transfer is necessary, that at Bethel, and it can be made directly from the ocean vessel to the river boat in a safe port.

During 1907–8 supplies have been transported to the Innoko gold diggings in a rather unsatisfactory manner by means of small river steamboats to the head of navigation and thence by small scows towed by horses and poling boats propelled by men to Ophir. This settlement has never been a well-stocked distributing point, however. In fact, many of the necessities have often been entirely lacking, and a shortage of provisions in the whole Innoko Valley has prevailed throughout the last two years. During the winter of 1907–8 it became necessary for many of those who wished to remain in the country to journey over difficult winter trails to Anvik, Kaltag, and Nulato, on the lower Yukon, and haul back with them on hand and dog sleds the bare necessities for existence, thus expending much time in unprofitable labor.

The cost of transporting freight from points where the steamboats may be able to land it on Innoko River to Ophir, by means of man-propelled boats, varies from 10 to 20 cents per pound, according to the distance it must be carried. At present it costs from $280 to $480 a ton for freight charges alone to have supplies brought to the Innoko diggings from the larger centers of supply on the Yukon. Besides this heavy freight toll, the initial cost of provisions in Fairbanks is much higher than at the ocean ports of Nome or St. Michael. By establishing reliable communication with St. Michael, the freight charge from Seattle may probably be reduced to about $70 a ton for goods delivered at Dishkakat, but the difficulty of carrying them from that place to Ophir will still remain. The writer was told that the charge for hauling freight with horses and sleds over the 55 miles of winter trail from Dishkakat to Ophir was about 7 or 8 cents a pound, so that the lowest estimate it is now possible to make with the figures at hand is a freight cost of $210 a ton for delivering supplies at Ophir from Seattle by way of St. Michael and the Yukon. This figure is based on the current freight tariffs, but there appears to be no reason why this cost might not be materially reduced by an organized and well-regulated effort.

There is no doubt that freight can be brought from San Francisco or Seattle to Bethel fully as cheaply as to St. Michael. At Bethel the river boats can be loaded directly from the ocean vessel, only one handling being necessary. The river boats can ascend the Kuskokwim and the Takotna to its forks without any difficulty, and from this vicinity the overland haul of about 35 miles to Ophir can easily be made by summer wagon road or winter sled trail, or by a light railroad if developments should warrant. There appears to be no question that the Kuskokwim route to the Innoko placer camp affords the most expeditious and satisfactory solution of the transportation problem; that even under present conditions there is no reason why supplies from Seattle may not be delivered at Ophir for $100 a ton; and that with good management the actual freight cost over this route may be reduced considerably below that figure.

WINTER ROUTES.

Distances by the winter routes from the lower Yukon to the Innoko are much shorter than by the summer water routes. The wide extent of flat, swampy country of the lower Innoko Valley is then frozen over, so that more direct courses may be followed from one place to another. It is about 57 miles by sled trail from Kaltag to Dishkakat, and about 55 miles from Dishkakat to Ophir, or 112 miles altogether. This trail is for the most part over flat-lying country, but between Dishna and upper Innoko rivers it crosses a low mountain range at an elevation of about 1,300 feet above sea level by way of a low, wide pass, with easy grades approaching it from either side. Kaltag is a military telegraph station and a regular post-office on the winter mail route from Fairbanks to Nome. During the winter of 1907–8 a moderate amount of freight was hauled over this trail by dog teams from Kaltag and Nulato to Ophir for 50 cents a pound. A number of personal outfits were hauled over it by means of hand sleds, and some new arrivals even hauled their provisions from Nome. A herd of reindeer of about 30 head was driven from Unalaklik to the Innoko and sold for the meat.

Another winter route to the Innoko leaves Yukon River at a small trading station called Lewis's, which is located on the north bank of the Yukon, about 15 miles below the United States military telegraph station called Melozi. The trail goes south from the Yukon up the valley of Yuko River, crosses the wide, flat pass at its head into the valley of the North Fork of the Innoko, and continues southward down this valley to a point on the Innoko 65 miles below Ophir. The route then follows Innoko River to its headwaters. Several parties traveled over this route during the winter of 1907–8, and a few dog-team loads of freight were hauled over it. The distance is estimated to be about 100 miles, and it is by far the shortest winter route for those who wish to go from Ophir to upper central Yukon points such as Tanana, Rampart, or Fairbanks. Under present conditions this route would be the shortest and most direct for a winter mail service to Ophir, as all the winter mail for western Alaska now passes down the Yukon from Fairbanks, but no service to Ophir has yet been established.

EFFECT OF HIGH TRANSPORTATION RATES.

It may be seen that the transportation of supplies to the Innoko placer district for a reasonable cost has not been accomplished and that the exorbitant operating expenses in this district are the direct result of poor and inadequate transportation. For this reason the present conditions and possibilities have been described in detail, as the transportation problem is of vital importance and its solution as soon as possible is imperative to the success of the Innoko placer district as a mining community.

During 1907-8 the prices of staple provisions at Ophir were as follows:

Flour	per pound	$0.30	Bacon	per pound	$0.65
Corn meal	do	.50	Ham	do	.65
Rice	do	.50	Butter	do	1.00
Rolled oats	do	.45	Cheese	do	.75
Beans	do	.50	Dried fruit	do	.55
Coffee	do	1.00	Canned fruit	per can	1.00
Tea	do	1.00	Canned vegetables	do	.75
Sugar	do	.50	Canned milk	do	.50

GEOLOGIC SKETCH OF THE INNOKO REGION.

The bed rock of the Innoko region is for the most part primarily of sedimentary origin, although the original condition of the older rocks has been greatly changed by metamorphic alterations, so that now they are mostly in the form of schists and slates, with some cherts and crystalline limestones. Associated with these metamorphosed sediments, more particularly with the slates, and making up considerable areas of the bed rock, are large masses of basic volcanic rock, principally diabase, that may be related with part of the slates as one or more extensive original effusive stratigraphic members, or may be distinct from the slates in a stratigraphic sense. In addition to this large amount of apparently extrusive igneous rock, in the form of diabase, both the schists and slates contain locally intrusive dikes of more acidic igneous rocks. These dikes may be considerably younger than either the schists or the slates into which they are intruded, and they have no purely stratigraphic relation with those rocks such as the diabases may have with the slates. All the rocks above mentioned, with the possible exception of the acidic igneous intrusives, are considered to be of Paleozoic age because of their lithologic and stratigraphic similarity to the Paleozoic rocks of the upper Yukon Valley.

Lying unconformably above the Paleozoic rocks are a series of unaltered sedimentary formations of Mesozoic age that consist principally of limy sandstones and shales. Along the Kuskokwim Mountains between the southern headwaters of the Innoko and Kuskokwim River there is a belt that shows past igneous activity of both extrusive and intrusive character. The effusive rocks appear to be lavas, for the most part of basic type, that were poured out over restricted areas during Mesozoic time, for they are interstratified with arkoses, shales, and other sedimentary rocks that show ripple marks with plant remains, giving evidence of formation along a shore. On Kuskokwim River, where it cuts through the low ranges of the Kuskokwim Mountains from Kolmakof to Kalchagamut, Spurr[a] noted a number of occurrences of old-appearing volcanic rocks that appear to be flows of lava contemporaneous with the Mesozoic sedimentary rocks which form most of the mountains in this vicinity. Spurr considers these interbedded effusives to be of Cretaceous age. Dikes are also of common occurrence in this range of mountains. In general they are of siliceous varieties, and most of them have a porphyritic texture. These dikes are considered to be of Tertiary age because they cut sedimentary rocks thought to be Cretaceous.

With the exception of a very small area of slightly consolidated clays and sands containing some lignite, seen on the lower Innoko, the writer knows of no sedimentary rocks within this area that he considers to be of Tertiary age, although there is little doubt that rocks of this age may occur. Besides the igneous rocks associated with the Paleozoic and Mesozoic formations, there are some fresh, young-looking volcanic rocks of andesitic and rhyolitic types and effusive aspect on the lower Innoko at the southwest end of the Kaiyuh Range. These rocks are probably late Tertiary in age and may be considered, through similarity and proximity, to be closely related to the Tertiary volcanic rocks that appear at intervals along the lower Yukon from Nulato to St. Michael.

Thus there appears to be evidence that this region has been the scene of volcanic activity, in the form of lava flows, during three distinct periods—the Paleozoic, Mesozoic, and Tertiary.

ECONOMIC GEOLOGY.

The only mineral of commercial value known to occur in the Innoko region is gold, in placer deposits and possibly in lodes. Up to the present time the only production has been from the placers. The principal gold lode discovered is being actively prospected, however, and its owners hope to prove it to be of commercial value.

[a] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 159-163.

KINDS OF PLACERS AND METHODS OF WORKING.

The placer-gold deposits of Alaska may be classed as shallow or deep. Each of these classes may be subdivided into those in a solidly frozen, partly frozen and thawed, or unfrozen state. The unfrozen deposits may be still further subdivided into those that are unfrozen throughout the year and those that are only superficially thawed during the summer. A permanently frozen condition of the alluvium is the normal state of most of these deposits throughout the greater part of Alaska.

No particular limit can be arbitrarily set to the depth in feet of shallow placer ground. In a broad, general way, shallow placer ground may be defined as that which can be most economically worked for its gold content by some kind of surface opening and the removal of all the dirt lying on the bed-rock floor. The methods of moving the dirt may be various—hand shoveling, ground sluicing, hydraulicking, horse or steam scraping, steam shoveling, derricking. and dredging, singly or in various combinations. Placer deposits 40 feet or less in depth may perhaps be called shallow, because this depth may be considered the average limit for dredging operations.

Deep placers may be considered to be those in which the valuable strata are so deeply buried under barren material that they can not be mined successfully by any kind of open surface works. The universal method of mining deep placers is by shafts and drifts, with or without thawing and timbering. In Alaska such works have been carried to depths of 200 to 300 feet.

The Innoko region affords no exception to the conditions found elsewhere in Alaska. All the gold-bearing deposits now known there are comparatively shallow, being not more than 35 feet in depth. They occur in a mixture of humus, muck, clay, sand, and gravel, in the various characteristic conditions as to frost already named. On their depth and condition depend the methods of working them that should be practiced. Most of the work that has been done in the region so far may be classed as that of merely prospecting the ground. This has included both the sinking of shafts to bed rock and the digging of open cuts, the methods usually employed in a new camp, by pick and shovel labor, aided by the use of a few small steam boilers for thawing frozen ground. The sinking and drifting method may be carried on throughout the year, providing the ground does not contain too much live water. Open-cut work is confined to the summer season.

WORKING SEASONS.

The climate of Alaska is such that it divides the year, both for transportation and for mining operations, into two working seasons—summer and winter. The summer season is the period of surface flowing water, and this directly governs cheap transportation (by water routes) and cheap mining (by hydraulic methods). During the winter season, from October to early May, practically all the streams are frozen over. So far as mining operations are concerned, the effects of the summer and winter seasons are not marked except where the gold-bearing gravels are of the class that can be worked only to the best advantage by open-cut or hydraulic methods. Many gold placers in Alaska can be mined throughout the year, but the local conditions vary in the different districts, and in some places may be so different on two adjacent creeks, or even at two localities on the same creek, that entirely different methods of working are used.

The average season during which hydraulicking operations may be conducted, providing there is a sufficient supply of water available for this method of working the gravels, extends from about the first of June to the middle of September. As a rule, sluicing may be commenced the middle of May and continued two or three weeks later than hydraulicking, because it does not require so large a quantity of water.

THE ECONOMIC AREA AND ITS BED ROCK.

The area of known economic importance lies near the headwaters of the Innoko, in a region of low mountains. It extends from a point about 5 miles north of Ophir up the Innoko to the divide between Ganes Creek and Takotna River and is about 20 miles north and south by about 10 miles east and west. It embraces that part of the slate formation that has been most intensely altered and in addition intruded to a moderate extent by siliceous dike rocks. Some of these siliceous dikes are altered and mineralized with pyrite. Secondary quartz deposited along the walls of one of these dikes is known to carry free gold. This locality is well up on the southeast side of the Ganes Creek valley, at the head of Carter Gulch, near the divide on the trail that runs from Ganes Creek to the Takotna. The residual quartz found on the surface along the outcrop of the dike carries good values in free gold. A shaft sunk 30 feet on the dike did not reach below the zone of surface weathering and disintegration, and up to this depth the lode is not very well exposed. At the time of visit the lower 10 feet of this shaft was filled with ice, so that little could be seen. The association of free gold in quartz with this siliceous dike is a good indication of the probable existence of lode gold deposits worth prospecting for and also of the probable original source of the placer gold of the district.

How far these slates extend to the northeast of the Innoko is not known. The writer did not visit that part of the valley, and few prospectors have been far in that direction. To the southwest the slates extend up Ganes Creek for about 15 miles, or throughout the lower half of its valley. The entire drainage basins of Little, Spruce, and Ophir creeks, which each average about 10 miles in length, are within the slate bed-rock formation.

Up to the present time paying quantities of placer gold have been found only at isolated places on Ganes, Little, and Ophir creeks. This gold occurs in the present stream gravels and in bench gravels.

TOPOGRAPHIC AND DRAINAGE CONDITIONS.

The topographic conditions of the placer-gold area and its immediate vicinity are those of relatively even-topped mountain ridges, whose highest parts stand at an elevation of about 1,200 feet above the Innoko Valley floor. These ridges occupy all the major interstream areas and appear to express the former existence of an old land surface that had a much less pronounced relief than the surface of to-day. The present drainage system appears to be directly inherited from a former one in which the streams occupied the same relative horizontal positions that they now occupy. There has merely been a change in vertical position with reference to the older surface, brought about by a gradual downcutting into the older, more shallow valleys to a depth of at least several hundred feet, followed during Quaternary time by a much more rapid downcutting by Ganes Creek and Innoko River of at least 75 feet.

The first, longer, and more gradual downcutting period of erosion was mainly preglacial in age. It is apparently indicated by the level tops of the major interstream ridges and divides and by the moderately sloping upper sides of the larger valleys where they descend from the divides and continue down on the secondary ridges and spurs between the minor gulches, to break off abruptly into the present valley troughs as bluffs of bed rock from 50 to 100 feet in height. Many of the present streams are now cutting along the bases of these bluffs.

The second period of stream erosion, in which the downcutting has been more rapid, has taken place since the glacial activity that has been already described. It is expressed on Ganes Creek and Innoko River by canyon and rock-cut bluff topography, and on the secondary streams by gulch topography. These secondary gulches are deeply eroded well back toward the major divides. During this period the erosion has been so rapid that on the larger streams considerable areas of the preglacial valley-floor filling of gravels have been left perched on the present valley sides as bench deposits. In places these bench gravels occupy positions 100 feet or more above the present streams, but on the gold-producing creeks the benches are on an average about 60 feet above the stream grades. About the mouths of Little, Spruce, and Ophir creeks, where they merge with the much wider valley of the main Innoko, there are also some elevated bench deposits. These are not creek benches, but benches of the Innoko Valley.

The three producing creeks now known fall into two classes as a result of the topographic development of the country they drain. Ganes Creek is a large stream with an extensive drainage area, carries a good volume of water, and is in a class by itself when compared with the other streams of the district. Its topography is in strong contrast to that of the other two gold-producing streams—Little and Ophir creeks—for these are relatively small streams, whose valleys are small in area and whose water supply is scanty. Little, Spruce, and Ophir creeks do not show any canyon topography due to a large and sudden increase in their water supply with its attendant rapid downcutting. Their valleys are deeply eroded for their size and length, but are of the form that indicates a long period of more uniform erosion.

STREAM GRADES AND WATER SUPPLY.

The valleys of Little, Spruce, and Ophir creeks have an average cross section of the broad, open V form, and although the streams are not large and their grades are not steep, they appear to have had sufficient transporting power throughout their history to carry the detrital materials produced by their erosion out into the wide Innoko Valley without any marked clogging or accumulation of material within their own valleys. As a result, these valleys are comparatively clean.

On the other hand, the volume of water in Ganes Creek is large, and the stream has cut the bottom of its valley down to a rather low grade, especially below the canyon. This condition of low-stream grade on the gold-producing part of Ganes Creek appears to be shown by the wide, uniformly flat bed-rock cross section of the valley from the canyon to the mouth. The plan of this cross section is that of a wide, shallow rectangular trench cut down into the bed rock of an older, broadly V-shaped bed-rock floor. From the canyon down to the Innoko the present floor of Ganes Creek is covered throughout its width and length by alluvium, over which the stream meanders with a current of irregular velocity. At one place the stream is obstructed by a large beaver dam which causes a riffle, and there are other irregularities that accelerate the current for short distances and give it a velocity in some places of 4 or 5 miles an hour. In other places the stream runs more slowly, at a rate of only 2 miles an hour. Probably its average velocity is 3 miles per hour.

To sum up the situation so far as stream grades and water supply are concerned, it appears that on Ganes Creek there is ample water with enough head for hydraulicking if the supply is obtained at the upper end of the canyon and brought around to its lower end, but that the grade of the bed rock below the canyon, upon which lie the deposits that are supposed to carry paying quantities of gold, is not sufficient to afford a good dumping ground for hydraulic tailings, which would have to be elevated or disposed of by some other mechanical means that would add to the cost of operation. On Little and Ophir creeks the valley grades are not quite so flat and appear to be sufficient to afford dumping ground for the tailings, but the water supply that may be obtained within these valleys themselves does not appear to be adequate for conducting hydraulicking operations on an efficient scale. There may also be doubt as to the presence of enough pay gravel within these valleys to justify bringing water for hydraulicking from a considerable distance. In 1908, which was a dry year, the amount of water in Little and Ophir creeks did not appear to be more than enough for sluicing purposes.

Of course, final statements of this kind can not be made without thoroughly prospecting the gravels by determining their quantity and average value, actually measuring the average water supply, and carefully investigating the whole problem from an engineer's standpoint.

THE PRODUCING STREAMS AND THEIR PLACERS.

GANES CREEK VALLEY.

General description.—Ganes Creek may be considered the head of Innoko River, although it shares this distinction about equally with the unnamed headwater fork that is generally spoken of as the upper Innoko, which flows from the northeast and joins Ganes Creek to form the main river. The volumes of water in these two streams are about equal. Both streams can be ascended 10 miles or more in light poling boats.

Ganes Creek, which is about 33 miles long, heads in a large, strongly glaciated cirque that is surrounded by sharply irregular mountains 4,500 feet above sea level. It flows for about 5 miles in this mountain basin over and through a mass of large glacial bowlders composed of the hard igneous rocks that make up the mountains. A large percentage of these bowlders are varieties of porphyry. Near the lower end of this cirque Ganes Creek is joined by a stream called Idaho Creek, of about the same size and character and flowing from a similar cirque.

From the mountains Ganes Creek flows for about 12 miles in a northerly direction out across a wide basin that is now largely filled by morainal bowlders. Topographically this basin appears to have been a part of the head of Beaver Creek valley before glacial time. About 3 miles southwest of this part of Ganes Creek is another large stream parallel to it, called Last Chance Creek. This stream is of about the same length and volume as upper Ganes Creek, heads in the same mountains in a similar cirque farther south, and flows across the basin in the same manner. Ganes and Last Chance creeks are separated by a ridge which appears to have been a medial moraine during the period of maximum glaciation. This ridge, on its surface at least, is formed of morainal deposits, except near the middle of its length, where a large dome-shaped mass of cherty limestone bed rock outcrops. This dome is called Knob Hill. Last Chance and Ganes creeks join at the northern edge of the basin, at the head of the canyon that has already been described as occupying the middle course of Ganes Creek. Throughout the basin both of these creeks flow over deposits of morainal bowlders which, like those in the cirques, consist mostly of igneous rocks, derived from the glaciated mountains. From a point near the source of Ganes Creek to the head of Ganes Canyon, a distance of about 15 miles, the descent of the stream is about 500 feet.

In its middle course Ganes Creek now runs for about 6 miles in a box canyon across a low range of mountains, made up of slate, that form the divide between the Beaver Valley and that of the Innoko. This canyon is not much wider than the present stream, which here flows on bed rock.

Below the canyon the stream has cut a wide, shallow trench of rectangular cross section with rock-cut bluff walls in the slate formation. This rock-cut trench is about one-eighth of a mile wide at the lower end of the canyon and broadens out to a width of about a mile at the point where the Ganes Valley joins the Innoko Valley, about 10 miles below. The perpendicular rock-bluff sides of this trench rise nearly 100 feet above its rock floor at the mouth of the canyon, and these bluffs bound the valley for considerable distances at intervals below the canyon. The heights of these bluffs decrease gradually from the canyon downstream, their average height being probably about 60 feet. Their continuity as a rock wall is interrupted by the numerous short tributaries that come in through steep side gulches, most of which are cut down to the level of the main valley. The presence on the tops of these rock bluffs of remnants of the old stream gravel filling of the former valley shows that the latest period of downcutting was rapid. It is evident that to produce this wide, trenchlike valley Ganes Creek has performed considerable lateral cutting, while the grade of the stream has remained at practically the same level. The rock floor is covered to a depth of 5 to 30 feet with stream deposits of fine to medium-sized gravels, which are made up chiefly of slate, with some clay and a few bowlders 1 to 2 feet in diameter. The larger cobbles and bowlders consist of igneous rock derived from dikes in the slates to some extent but mostly from the morainal wash from the area above the canyon. Nearly everywhere the gravel deposits are covered by humus muck 10 to 20 feet thick, upon which is a thick growth of willows, alders, and other brush, with here and there a clump of spruce trees of fair size. Probably most of these valley-floor deposits are frozen, but the large percentage of porous gravel beds and the good water supply cause a considerable amount of live water to be present. This tends to keep a considerable proportion of the material in an unfrozen condition, at least for part of the year. The deposits have not been prospected thoroughly enough to determine the distribution either of the ground frost or of the gold values.

Stream deposits.—Locally the present stream deposits are loosely divided into "creek claims" and "creek flat bench claims." The creek claims embrace the lowest ground; the creek flat bench claims lie a few feet higher and are mostly situated along the bases of the low rock bluffs. The creek flat bench claims are essentially of the same character as the rest of the valley-floor detrital covering, but to some extent they may contain more of the detrital material that has sloughed down from the higher benches lying on top of the rock bluffs.

All the ground along Ganes Creek, from the morainal rock piles in the cirque at its source to the alluvial flats at its mouth, has been located as placer-mining ground. In the wider part of the valley, from the canyon to its mouth, besides the claims immediately along the creek, the valley bottom on either side that is not embraced within the creek claims is located as far back as the bluffs on the right and left. These side claims are the "creek flat bench claims."

The numbers that designate these claims run from about 58 below Discovery claim, which is 10 miles above the stream's mouth, to about 83 above Discovery. The ground along all the tributaries of Ganes Creek has been located, on most of them for their entire length. From claim "No. 40 above," on Ganes Creek, which is just above the head of the canyon, to the head of the creek, the ground located embraces nothing but glacial deposits. These upper claims were located in the winter, when covered by snow, under the supposition that the placer gold on the lower part of the stream had been brought down from its headwaters.

No work has been performed above claim "No. 40 above," on which several holes have been started. These holes are in coarse morainal material and, as might be expected, have yielded no encouragement. From this claim down through the canyon to claim "No. 13 above" no work of any consequence has been done. It is reported that on claim "No. 37 above" the bench rim gravel is about 10 feet thick, and that it contains coarse gold. There is not much gravel at this place, however. From "No. 13 above" down to "No. 29 below" prospecting along the creek has been carried on in a desultory way at different places. During the summer of 1908 there were only a few men working in the Ganes Creek bottom, and they were engaged in prospecting and in doing assessment work. Prospects of gold are reported at irregularly distributed localities from "No. 13 above," which is at the mouth of Spaulding Creek, a short distance below the lower end of the canyon, to "No. 2 below." Some open-cut pick and shovel work has been done on "No. 11 above," but no profitable returns are reported. On "No. 10 above," or on a fraction between Nos. 9 and 10, a shaft has been put down from which values are reported. During the winter of 1907–8, 26 holes were sunk on the boundary line between "No. 20 below" and "No. 21 below," 16 holes on "No. 21 below," and 9 holes on "No. 29 below," all with no results. "Nos. 22 and 23 below" have also been prospected unsuccessfully. The holes sunk in the creek deposits are from 18 to 30 feet deep, and the alluvium is found to be made up of 15 to 22 feet of humus muck on top of 3 to 6 or 8 feet of gravel.

A little work was done on several of the tributaries of Ganes Creek during 1908. Glacier Gulch, which is 3 miles long and is staked from its mouth to its source, comes into Ganes Creek about half a mile above Moore City, on the east side of the valley. A little open-cut work has been done on the lower end of claim No. 1, at the mouth of the gulch. Here the deposit is coarse washed gravel about 4 feet deep, in which a little gold was found. Above, on claim No. 2, an open cut was started, and here the alluvium is much deeper than at the mouth of the gulch. This cut penetrated about 20 feet of muck and sandy clay with a little gravel, but did not reach bed rock.

Carter Gulch is the next tributary of Ganes Creek on the east side below Glacier Gulch. On this stream just above its mouth one man was ground sluicing a trench down to bed rock with the aid of an automatic dam, in August, 1908. The cut was put down to a depth of 23 feet, in ground composed mostly of tenacious clay, without exposing gravel, bed rock, or a pay streak.

On Last Chance Gulch, the next tributary below, on the same side of Ganes Creek, another man was making an open-cut trench with the aid of an automatic dam similar to that used on Carter Gulch. This trench reached a depth of about 10 feet, mostly in tenacious clay, and a few colors of gold were found.

Work was done on these three gulches because they are thought to be favorably situated for the presence of gold. The reason for this supposition is that these gulches all head on the divide southeast of the Ganes Valley, in an area of slates that have been intruded by mineralized dikes with which quartz carrying free gold is associated.

Bench deposits.—The occurrence of bench deposits of stream-worn gravel upon the tops of the rock-cut bluffs of the Ganes Valley appears to show that before Ganes Creek acquired its large increase in length and drainage area as a result of the glaciation above its canyon it was a stream of the same character as Little, Spruce, and Ophir creeks are to-day. The preglacial valley of Ganes Creek was then wholly within the slate belt, which extends to the head of its present canyon, and there was a divide across the site of this canyon that separated the drainage of the Ganes Valley from that of the basin above, now glaciated. Apparently the gravels now found in the benches are what is left of the preglacial alluvial deposits that occupied the Ganes Valley before the invasion of the glacial waters. When the waters that had accumulated above the canyon first burst across the divide and flowed rapidly down Ganes Creek, they no doubt rewashed most of the preglacial valley gravels now found on top of the bluffs, and thus introduced some bowlders and cobbles of the igneous rocks from the glaciated mountains. But this condition did not last long, for the enlarged stream of water that came down the valley soon cut a trench valley below the grade of the older deposits and with its rapidly lowering level carried the largest part of them downstream, so that they now make up a considerable portion of the present stream deposits. It does not appear that any large amount of the glacial wash was transported through the canyon from the basin above, and therefore most of the present valley filling is made up of detrital material that has originated within the slate belt.

The placer gold in the present valley gravels of Ganes Creek is no doubt derived from that which may have been contained in the gravels of its preglacial valley, but this gold is probably not concentrated to the degree it was in the older valley gravels, because the new stream, having a very much larger volume of water, has performed more erosion and transported a large amount of loose material out into the Innoko Valley. The power of the present Ganes Creek is shown by the deep canyon it has cut down through the slates and also by the fact that only very small remnants of the preglacial valley floor now exist. These remnants consist of disconnected strips along the valley that have an average height of about 60 feet above the present stream and extend back from the edges of the bluffs for a few hundred feet. They are cut in the slate and this rock makes up the valley sides above them.

The alluvial deposits on top of these rock benches are essentially the same in composition as the present valley deposits. They extend along the right side of the valley from a point near Spaulding Creek, opposite claim "No. 13 above," down to about No. 5 below Discovery. On the left side of the valley some bench ground is found on "No. 16 below" and again on "Nos. 19 and 20 below." Thus it is evident that the high bench ground is very meager in extent. However, the production of placer gold on Ganes Creek in commercial quantities is practically confined to several of these bench claims. The Pelky and Discovery bench claims have given the largest production. Under present conditions it is hard to work these bench claims because of a scarcity of water. Barely enough water for sluicing can be obtained from the small streams that flow in the short gulches which have been cut down through the bench deposits at intervals. Two ditches were being dug in 1908 to bring water upon some of the bench claims, but neither had been used at the time of the writer's visit. One was to take water from Last Chance Gulch to the bench opposite "No. 6 above." The other was intended to bring water from Yankee Creek over a divide into Mica Gulch and upon bench claim "No. 3 above." The Pelky bench claim is on the east side of Ganes Creek opposite creek claim "No. 4 above." Here there is 6 feet of gravel covered by 10 feet of muck at a distance of 72 feet back from the edge of the bluffs. All of the muck and gravel is frozen. Three "laymen" worked this claim on a 40 per cent basis during the summer of 1908. They worked an area of seven cuts 20 feet wide and six sluice-box lengths, from 60 to 80 feet back from the edge of the bluff; in all about 11,200 square feet of bed-rock surface was uncovered. The tailings were dumped over the bluff. The gold is coarse and not flattened. It has considerable quartz attached to it. The largest nugget weighed 16 ounces, 7 pennyweights, and 8 grains. Discovery bench claim was worked during 1908 by four "laymen" on a 50 per cent basis, but the production was not as large as in 1907.

LITTLE, SPRUCE, AND OPHIR CREEKS.

Little Creek is a comparatively small stream about 10 miles long. It lies to the northwest of and in a general way parallel to lower Ganes Creek, into which it flows about one-half mile from the Innoko, in the river valley flat. All of the alluvial ground in the valley of Little Creek, from its mouth to its source, was located for placer-mining purposes in 1907. The claims next above and below Discovery claim are located in the form of association groups of 160 acres each, and are the equivalents in area of eight ordinary single placer claims. The ownership of Discovery claim on this creek was in dispute in 1908. Work was being carried on by means of shafts and drifts on the Fathergill association group, below Discovery, and about eight men were employed on open-cut pick and shovel operations at the lower end of the Gold Run association group, where it joins Discovery claim. In August there was hardly enough water in Little Creek for sluicing. Both of these association groups had a gold output during 1908. Several other camps of prospectors were located at intervals on this creek above the Gold Run association tract, and prospects are reported to have been found at several separated localities up as far as claim "No. 14 above."

Spruce Creek is the next stream northwest of Little Creek. It is of about the same character and length as Little and Ophir creeks, and all of its alluvial ground has been located. Little work has been done within its basin, and it has not produced gold in commercial quantity.

To the northwest of Spruce Creek is Ophir Creek, which is about 10 miles long and empties into the Innoko about 5 miles in a direct line below the mouth of Ganes Creek. Like every other stream in the region, Ophir Creek has been completely staked from its mouth to its source. There are two discovery claims on this creek, a lower and an upper. Eight claims are located below Lower Discovery claim, and they extend upstream to No. 12 above Lower Discovery. "No. 12 above" is the same as Upper Discovery, and upstream from this claim the numbers begin again with 1 and extend up to No. 23 above Upper Discovery. Thus there are 43 claims staked along the course of Ophir Creek. Besides the creek claims, there are also some side or low bench claims, but no work has been done on ground of this class. From claim "No. 8 below" up to No. 2 above Lower Discovery, no substantial development has taken place, only the assessment work having been performed. From No. 2 above Lower Discovery up to No. 3 above Upper Discovery, a length of 14 claims along the creek, more or less work has been performed upon every claim. On No. 4 above Lower Discovery 5,000 buckets of dirt are said to have been raised. The largest production, however, is reported from Nos. 8 and 9 above Lower Discovery.

Ophir, Spruce, and Little creeks are all of about the same length. They are parallel to one another and to Ganes Creek, in a general way. Their valleys are of about the same depth and grade and are separated by ridges of about the same width and height. The whole area drained by them is made up of the same slaty bed rock. They all flow into the Innoko from the southwest and have their sources on a low mountain ridge about 1,200 feet above the Innoko. This ridge extends in a southeast-northwest direction from the canyon of Ganes Creek to the lower course of Beaver Creek, a distance of about 15 miles, and lies between the upper Innoko Valley and the glaciated basin of Beaver Creek to the southwest.

The alluvial deposits in the valleys of Little and Ophir creeks are all of the same general character and are not very thick or wide. The depth to bed rock is from 15 to 24 feet, the lower 4 to 7 feet being gravel and the upper part silt and muck. The width of 600 feet that is embraced by an ordinary placer claim includes the larger part of the alluvial deposits along these creeks, although in many places so-called bench claims have been located to cover the more gently sloping portions of the valley sides. Practically no work was done on these side locations in the summer of 1908, and little is known of their real character. All of the alluvial ground is covered by a heavy accumulation of moss. There is also a thick overgrowth of brush and considerable scrub spruce in the valleys.

The gold from Little and Ophir creeks is, like that from Ganes Creek, coarse and rounded, with a good many nuggets.

SUMMARY.

The creek deposits of the Innoko are all shallow and are composed of muck, clay, and gravel, which are for the most part frozen. The gravel and gold lie mostly on bed rock, and so far as experience indicates there are no well-defined pay streaks—that is, the distribution of the values is irregular both horizontally and vertically.

The opportunities for profitable drift mining on these creeks do not appear to be so favorable as the possibilities for a comprehensive scheme of hydraulic mining, by which all of the alluvial material may be worked in a systematic manner and all the values in the whole body of gold-bearing material may be recovered, regardless of its condition of distribution. Such a method of working means an entirely different community of interests than now exists, and probably there is at present little hope of bringing this about. To work these deposits with the greatest possible profit would involve the thorough prospecting of all the gold-bearing ground under expert supervision, the bringing of water from a considerable distance, and the consolidating of all property interests.

AMOUNT OF GROUND LOCATED IN THE PRECINCT.

About 1,600 instruments have been recorded in the official books of the Innoko precinct. About 1,200 of these cover placer-mining claims, which are located on nearly every watercourse within the Innoko Valley, many of them being on streams far removed from the known gold-bearing area. In other words, there has been a maximum of locating and a minimum of prospecting done by those who have visited the region. Of all the ground located only that on Ganes, Little, and Ophir creeks may be considered to have been prospected.

GOLD PRODUCTION.

On Ganes, Little, and Ophir creeks about 25 claims have produced placer gold. The production of about four claims has exceeded $10,000 each in a single season, but none of the claims has reached a production of $20,000.

An estimate of the total production for the Innoko precinct for 1907–8, based on the most reliable information the writer has been able to obtain, gives a total of $85,200, of which the season of 1907 is credited with $13,100 and that of 1908 with $72,100.

The placer gold thus far found in the Innoko country is very pure, its fineness being about 0.915. The average refined value is about $18.50 an ounce, and at Ophir the unrefined gold passes in commercial exchange at $17 an ounce.

SOURCE OF THE PLACER GOLD.

The chief source of the placer gold is probably in the belt of slates that have been strongly metamorphosed and intruded to some extent by siliceous dikes. The slates occupy the lower half of the Ganes Valley and all of the area drained by Little, Spruce, and Ophir creeks. It is thought that all the gold comes from points within the slate area. The writer saw dikes cutting the slates in the Ganes Valley and on Little Creek, and other dikes are reported to occur within the basins of Spruce and Ophir creeks. Some of these dikes are known to be mineralized with pyrite, and it is presumed that more of them may be so mineralized. Vein quartz is found along the walls of some of the dikes and some of this quartz is known to carry free gold. Thus it appears from the evidence in hand that the placer gold now found in the stream gravels of Ganes, Little, and Ophir valleys has originated from the mineralizing activities brought about by the siliceous dikes that are known to cut the slates.

The placer gold appears to have been formed by slow concentration as a result of the long period of erosion to which this mineralized slate belt has been subjected by the streams that drain its area. The gold now found in the bench deposits of Ganes Creek was probably all formed before the canyon was cut across the former divide by glacial water, and the placer gold in the present stream gravels on Ganes Creek is undoubtedly derived from the former valley filling of which the benches are small remnants. Probably almost all of the placer gold in this district is of pre-Pleistocene age.