SKETCH OF THE GEOLOGY OF THE NORTHEASTERN PART OF THE FAIRBANKS QUADRANGLE.

By L. M. Prindle.[a]

INTRODUCTORY STATEMENT.

The area included in the Geological Survey's map of the Fairbanks quadrangle is delimited by meridians 146 and 150 and parallels 66 and 64. The Fairbanks gold-placer district is in the eastern part of this area. During the season of 1908 a Survey party was engaged in making a detailed geologic map of the Fairbanks district and during 1909 geologic investigations were carried north of the Fairbanks district and westward to Rampart. The results of these trips, together with those of previous trips, are being assembled for a geologic map of the entire quadrangle. A portion of the quadrangle, including the Fairbanks district and extensive areas to the north and west, is shown on the accompanying geologic sketch map (Pl. VI). From the presence of the Fairbanks district in the southeastern part of the area covered by this sketch map and of the Birch Creek district extending into the northeastern part of it the attention of prospectors has frequently been directed toward this area as a favorable one for prospecting. Although no other rich placers have yet been discovered than those of the Fairbanks and Birch Creek districts, there are outside of these well-known areas several widely separated localities at which auriferous gravels have been found and some attempts are being made to mine these deposits. There is also a small amount of quartz prospecting in progress.

The following preliminary report is designed to state briefly only what appear to be the main geographic and geologic facts regarding this area northwest of the Fairbanks district and west of the Birch Creek district, and to emphasize especially the contrast between the highly metamorphosed rocks of the eastern and southeastern portions of the area and the less metamorphosed rocks of the northwestern portion, and also the distribution of the granitic rocks.

These features are particularly worthy of attention from the viewpoint of the prospector from the fact that the gold-producing districts of Birch Creek and Fairbanks lie in the schists characterizing

[a] In both the field and the office work the writer has been assisted by B. L. Johnson.

the southeastern portion, while the quartzites, limestones, slates, and other rocks of the northwestern portion have proved up to the present time practically nonproductive.

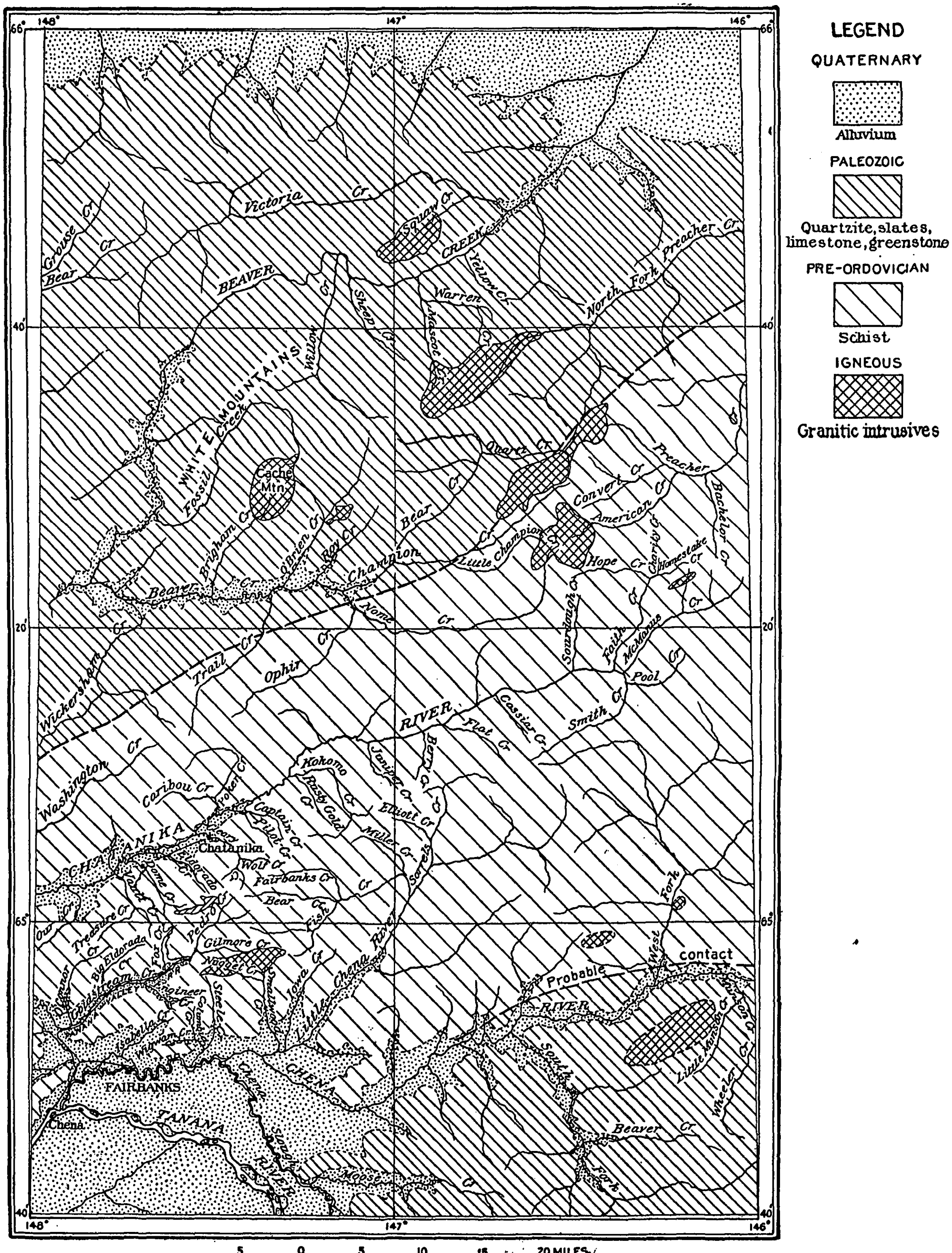
GEOGRAPHIC SKETCH.

There is a strong contrast between the type of topography characteristic of the Birch Creek and Fairbanks districts and intermediate areas and that toward the west. A few miles west of the headwaters of the Chatanika the country becomes of greater and more varied relief. A large part of the northeastern quarter of the Fairbanks quadrangle is made up of groups of bare rocky hills and ridges. The ridges in general trend northeast and southwest. The most conspicuous group of ridges and the one that dominates the area is the White Mountains. These limestone ridges for a distance of about 30 miles are conspicuous alike by color, angularity, and relief. Narrow, serrate ridge lines and steep slopes are characteristic. There are several isolated groups of hills east of the White Mountains that are likewise prominent features, and the position of these is indicated on the map by the areas represented as occupied by granite. This topographic diversity and the contrast with the areas to the east are due primarily to differences in the kind of bed rock.

The country southeast of the White Mountains, between them and the Chatanika, is made up of even-topped ridges with long, broad lateral spurs that separate wide, shallow valleys. Both ridges and valleys are largely covered with small spruce. Between the White Mountains and the Yukon Flats there is a space of about 20 miles occupied by bare, even-topped ridges trending northeast and southwest to east and west. The most prominent of the ridges in the area covered by the map are 4,000 to 5,000 feet above sea level and a few points in the area exceed 5,000 feet. The valleys are for the most part deeply cut and the bed of Beaver Creek in the northwestern part of the area is about 1,000 feet above sea level.

In general terms, then, the White Mountains, formed largely of limestone, and the group of hills formed of intrusive granite constitute the highest parts of the area and are surrounded by prevailingly even-topped ridges at altitudes of 2,500 to 3,000 feet above sea level.

The entire area has been closely dissected by numerous streams and the valleys are mostly narrow and deep. Chatanika and Beaver rivers are the most important streams. The Chatanika, in a part of its course, outlines roughly the western limit of the Fairbanks district. Beaver Creek drains most of the area and is the largest stream. It is easily fordable on foot in the portion of its course above the point where it loops round the southwestern portion of the White Mountains, but before leaving the hills to enter the Yukon Flats it becomes a stream several hundred feet in width.



GEOLOGIC SKETCH MAP OF NORTHEASTERN PART OF FAIRBANKS QUADRANGLE.

The timber resources of most of the area are meager. Most of the ridges are bare of timber and the timber line is approximately at 2,500 feet. Spruce, poplar, and birch, with some tamarack near the Tanana, are the kinds most common, and spruce is predominant. The proportion of timber increases toward the Tanana, and in some of the valleys near that river there is abundance. There is some timber suitable for mining purposes in parts of the stream flats of the larger streams throughout the area and spruce timber is available in most of the valleys, at least on the sunward-facing slopes. In many places in the smaller valleys the best and largest timber is to be found near the upper limit of growth, the conditions near the stream being less favorable. Small spruce suitable for fuel purposes is abundant.

GEOLOGIC SKETCH.

General statement.—The rocks of the area are separable into two general groups. One of these groups is composed predominantly of highly metamorphosed rocks of sedimentary origin, with some limestone and metamorphosed igneous rocks. These are all regarded provisionally as of pre-Ordovician age. The other group is composed of a heterogeneous complex of closely folded slates, cherts, conglomerates, greenstones, and limestones, in which, as determined on the basis of paleontologic evidence, there are rocks of Ordovician, Silurian, Devonian, and Carboniferous age. For the sake of brevity these two groups will be termed simply pre-Ordovician and Paleozoic, though the pre-Ordovician rocks may include some of Paleozoic age. There is a transition in metamorphism in passing from the pre-Ordovician rocks to the Paleozoic rocks and locally the latter also have become schistose. The general strike of both these groups is northeast and southwest and the contact line between them is approximately as shown on the map. There is a small area of slightly consolidated sandstone and conglomerate in the Fairbanks district which is probably of Tertiary age. The unconsolidated alluvial deposits include silt, sand, and gravel and are separable into bench deposits and deposits of the present streams. There is a considerable amount of igneous material in the Paleozoic rocks, largely of volcanic origin. Granitic intrusive rocks are common and the areas occupied by them are shown on the map.

Metamorphic rocks.—The contact line shown on the map as running northeast and southwest separates the predominantly highly metamorphosed rocks of the southeastern part of the area from rocks that are for the most part less metamorphosed. From the fact that the metamorphic rocks have proved more productive of placer gold in the Yukon-Tanana region than the others, this contact line possesses also an economic value, the quartzite, slate, and limestone areas being generally less favorable for prospecting.

The schists are predominantly quartzite schist and quartz-mica schist. There are some quartzites but slightly altered and there are some schists so extremely metamorphosed that their origin is in doubt. The group comprises also carbonaceous, garnetiferous, and hornblendic schists and crystalline limestone. The schists are mostly thin bedded and of rather uniform composition over wide areas. Along the trail from the Birch Creek district to the Fairbanks district these are the only rocks observable. They occupy also large areas eastward to the international boundary. The strike ranges from northeast-southwest to northwest-southeast. They are much folded and closely appressed recumbent folds are common. In many places the folds are in a nearly horizontal position and the beds in these areas present the appearance of horizontality. In places porphyritic granites have been so highly metamorphosed along with the schists that they are not easily separable from the schists, into which they were intruded before the metamorphism of the region took place.

Quartz veins are common in the schists, and in some areas, particularly in the Fairbanks district, the schists have suffered an extensive brecciation. As a result of this brecciation a large amount of quartz has been introduced. In that area also there is a considerable proportion of iron pyrites, which by its alteration discolors large areas of the schists.

Paleozoic rocks.—The rocks regarded as Paleozoic include many varieties of quartzite, mostly feldspathic, with gray, purple, and green slates, cherts, conglomerates, tuff, and volcanic rocks mostly altered to greenstone and limestone. Fossils found in the White Mountains have been determined as Ordovician, Silurian, and Devonian, and some found in the ridges overlooking the Yukon Flats have been determined as Carboniferous (Pennsylvanian). The Ordovician fossils of the White Mountains occur in a conglomerate at the base of the limestone and also in the limestone itself. Higher in the limestone Silurian and Devonian fossils have been found. The conglomerate underlying the limestone contains, along with abundant volcanic material, numerous chert pebbles and some beds of the conglomerate close to the limestone are composed of coarse feldspathic sandstone. The succession has apparently been approximately as follows: Feldspathic quartzites with interbedded gray, purple, green, and black slates and cherts; conglomerate; volcanic flows and breccias with Ordovician fossils near the top; limestone with Ordovician, Silurian, and Devonian fossils and interbedded greenstones and quartzites; gray, greenish, and black shaly slates with Pennsylvanian fossils. The relations between the Carboniferous and underlying beds have not been observed. The Paleozoic rocks southeast of the White Mountains are predominantly feldspathic quartzites, in some places with chert pebbles, and slates; in the White Mountains, cherts, conglomerate, greenstone, and limestone; northwest of these mountains fragmental rocks (partly volcanic, partly with chert pebbles), slates, quartzites, and limestones.

The Paleozoic rocks are at most localities very closely folded; they have in places become schistose and locally have been intensely sheared.

Tertiary(?) rocks.—There is a small patch of loosely consolidated sandstone and conglomerates in the Fairbanks district. The underlying rock of a portion of this deposit at least is a basaltic flow. Carbonized plant remains occur in the sandstone, but the material collected was indeterminable. These rocks resemble the Kenai formation of other areas and provisionally they have been referred to the Tertiary. There is some evidence also that Tertiary rocks are present in a portion of the northern part of the area east of the point where Beaver Creek enters the Yukon flats.

Quaternary deposits.—As a result of the shifting of the shore line which has taken place through changes either in the level of the land itself or in the sea level with reference to the land, benches have been formed in the drainage basins throughout most of the Yukon-Tanana region, and upon the lower benches, as high as 500 feet above the level of the present streams, alluvial deposits have been left. These unconsolidated deposits consist of silt, sand, and gravel, and are separable into bench deposits and those of the present streams.

Benching is prominently developed about the White Mountains up to a level of about 4,000 feet above the sea, and the lower benches, those more directly related to present drainage lines, are occupied by alluvial deposits. In the southwestern part of the area, in the Tolovana flats, there are extensive silt deposits and it is probable that these are due, in part at least, to lacustrine conditions. The deposits of the present valleys have been investigated in detail in the Fairbanks district and found to have a thickness in places of over 300 feet. These deposits are for the most part, under present climatic conditions, permanently frozen.

Granitic rocks.—The distribution of the intrusive granitic rocks (with the exception of dikes too small to appear) is shown on the map (Pl. VI). As a rule the larger masses are oriented with their longer diameters approximately parallel with the strike of the rocks into which they have been intruded. Most of the areas are topographically prominent. The most common type is porphyritic biotite granite, the coarsest of which has feldspars up to 2 inches in diameter. Quartz diorite occurs in the Fairbanks district and to a small extent basic types are present in the Beaver Creek areas. Small dikes are common in the Fairbanks district, some of them being composed only of quartz and feldspar, but most of them are granite porphyry or somewhat more basic in composition. Several small areas of granite porphyry occur near the head of Homestake Creek, and at one locality gold has been found in the bed rock in the contact region between this rock and the schist. Although tourmaline is uncommon in the Fairbanks district it is a very common constituent of the granites in the Beaver Creek area, particularly the mass at the head of Hope Creek. Fluorite is found also in the marginal portion of this mass and in the schist, where veins containing fluorite and iron pyrites occur; one of these veins is reported to carry values in gold.

All these granite areas in the Beaver Creek country, so far as observed, are surrounded by a zone up to about 1,000 feet or more wide, in which the schists show more or less contact effect of the intrusion. The schists have been indurated and have, from the alteration of iron pyrites, acquired a reddish color that renders the contact area visible at a distance. Here and there the development of andalusite was noted.

Iron pyrites, mostly limonitized, was observed also in the marginal portion of some of the granite masses, particularly the one at the head of Bear Creek. On the east side of the mass the decomposed granite contains a considerable portion of limonitized iron pyrites to a distance of several hundred feet from the margins. A sample of the decomposed granite taken for assay contained 83 cents to the ton in gold.

MINING DEVELOPMENT.

Outside of the territory covered by Plate VI, the areas where most work has been done on the auriferous gravels are the valleys of Washington Creek, of Faith Creek and its tributaries, of Preacher Creek and its tributaries, and of Victoria Creek. The conditions on Washington Creek are similar to those of the Fairbanks district. The creek is being more or less prospected and some pay has been reported. The upper part of the valley of Faith Creek has been investigated with the view of working the ground by the hydraulic method.

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

Gold is found in place in the valley of Homestake Creek along the contact of the intrusive granite porphyry with the schist, and such contacts probably form one source, at least, for the placer gold found in this area.

All the areas thus far considered are within the schist. The valley of Victoria Creek was the occasion of a stampede in 1905, but not sufficient gold was found to pay for working.

In view of the available information it seems that the localities in the vicinity of the granitic rocks are the most favorable localities for prospecting.

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AURIFEROUS QUARTZ VEINS IN THE FAIRBANKS DISTRICT.[a]

By L. M. PRINDLE.

INTRODUCTORY STATEMENT.

The geographic location of the Fairbanks district in central Alaska is now so well known as to require but little description. Its longitude is 148° west and its latitude (65° north) is such as to render the climatic factor important in the consideration of mining problems.

The most noteworthy feature in the economic development of the Fairbanks gold-placer district during 1908–9 has been the discovery of auriferous quartz veins. The discoveries of 1908 in the valley of Chatham Creek and in Skoogy Gulch were followed during 1909 by similar discoveries at several other localities. In view of the fact that quartz prospecting in the Fairbanks district is rendered unusually difficult by the moss, talus, and alluvial deposits that conceal the greatest part of the bed rock under a mantle most of which is permanently frozen, the results attained during the short period since quartz prospecting began are indicative of a rather widespread distribution of gold in quartz veins, particularly in the drainage areas of streams whose valleys have proved productive of placer gold.

As these ore deposits have been but recently discovered and as only a small amount of work has been done on them, this description is by no means a definitive statement of the occurrence of gold in bed rock in the Fairbanks district, but rather a brief summary of what seem to be the most important geologic facts involved in the occurrence of the gold-quartz veins and the bearing of these facts on the quantitative problems of the miner.

The expression of the geologic facts in their topographic relations was rendered possible by the completion of the Fairbanks special

[a] This description is based on the observations made by L. M. Prindle and F. J. Katz during detailed geologic work in the Fairbanks district in 1908; on the results obtained by L. M. Prindle and B. L. Johnson in the course of a brief visit to most of the localities during 1909, incidental to the mapping of the areal geology of the Fairbanks quadrangle; and on the work of A. H. Brooks, who also made a brief visit to these localities during 1909. In the field and office work and in the preparation of this report the writer has had the assistance of B. L. Johnson.

map by the Geological Survey in 1907 on a scale of 1:62,500, or about 1 mile to the inch, with a contour interval of 25 feet. This map was used as a base by the Survey party that was engaged in 1908 in a detailed study of the geology and mining developments of the district. The result of this work, together with a more detailed account of the gold-quartz discoveries, will be embodied in a report that is now in preparation. To illustrate the present paper the accompanying sketch map (fig. 4), embracing most of the localities in which gold-quartz veins have been found, has been prepared. The relation of this area to the larger area of which it forms a part is shown on the geologic sketch map of the northeastern part of the Fairbanks quadrangle (Pl. VI).

GEOGRAPHIC SKETCH.

The surface of the Fairbanks district is made up of ridges and valleys and a small portion of the extensive flats of Tanana River. The ridge and valley feature is a type that has a wide distribution throughout the Yukon-Tanana region. The main characteristic is one of uniformity, both of ridge and of valley. The relief in the Fairbanks district is not great, being embraced in the difference of altitude between the highest parts of the ridges, about 2,700 feet above sea level, and the Tanana Flats, about 500 feet above sea level. The ridge level breaks off rather abruptly to that of the Tanana Flats. The ridges are flat-topped, broad, bulky, and very uniform in height, and have an average elevation above sea level of about 2,500 feet. They slope unsymmetrically to the valleys on either side. In most of the ridges one slope is rather steep, with a grade up to about 20°. The other slope is gradual and merges into a gently sloping valley floor. The balance of ridge and valley development is such that the valleys are approximately counterparts of the ridges.

The valleys lie at levels of about 2,000 feet or more vertically below the ridges. They are narrowly V-shaped and symmetrically developed in cross section near their heads, but become open and increasingly unsymmetrical downstream until a valley floor is developed from a few hundred feet to a mile or more wide. The stream is as a rule close to the steeper side of the valley, where it occupies a comparatively narrow flat. From the edge of the stream flat opposite the steeper ridge slope the valley floor, although in some places nearly flat, in most places rises gradually to form a long sloping surface that becomes a dominant feature in this area. Owing to the fact that in such slopes, some of which are several hundred feet back from the stream flats, lie most of the gravels that have proved productive of placer gold, these portions of the valleys are characterized by the greatest amount of mining development.

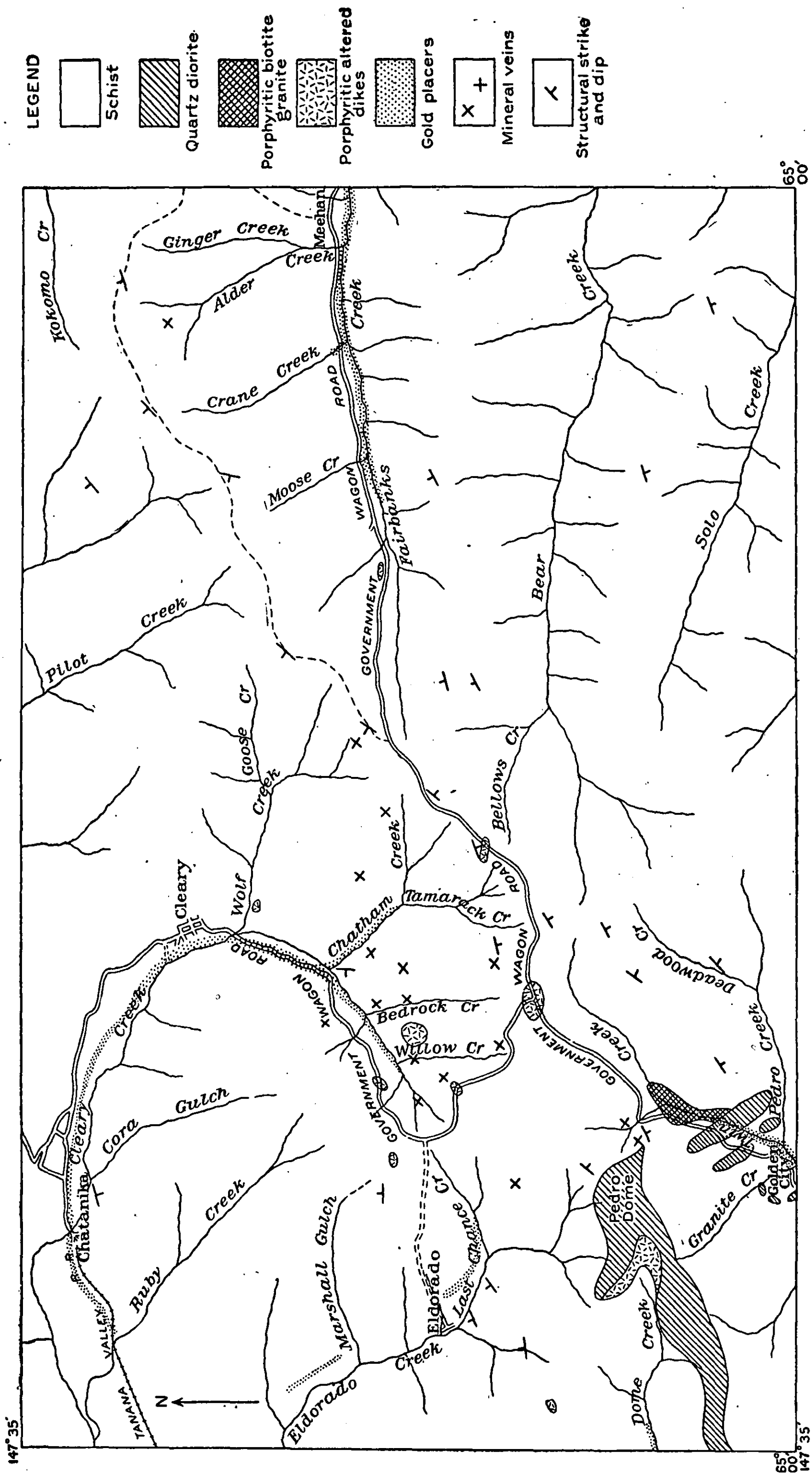

FIGURE 4.—Geologic sketch map of auriferous lodes in Fairbanks district.

The general trend of the ridges, although obscured by the absence of marked differences in relief and by the presence of numerous lateral spurs more or less equivalent in amplitude to the main ridges, is northeast and southwest, parallel with the main drainage lines. The most prominent ridge is that separating the Chatanika and Chena drainage basins, and in this ridge most of the streams that have proved productive of placer gold have their origin. Most of these streams are small and flow directly or indirectly to the Chatanika on the northwest, to the Chena on the southeast (both southwestward-flowing streams about 30 miles apart), and to the Tanana, which touches the southwestern edge of the ridge country.

The water supply, being to a great extent of local origin, is largely dependent on local topographic and climatic conditions. The topographic uniformity entails uniformity of process in the disposal of the rainfall. The streams head at about the same level, and at homologous positions in the valleys of equal streams there are approximately equivalent amounts of water. Inasmuch as the permanently frozen character of much of the ground to depths that probably exceed 300 feet is favorable to a rapid run-off, the dependence on rainfall is very direct, and in dry seasons the supply of water becomes much less than the amount required by the processes of mining that have hitherto been employed.

Although the prolonged low temperatures of winter leave conditions that prevail throughout the year, yet the long days of the short summers give opportunity for the growth of an abundant vegetation. Spruce and birch have proved sufficient up to the present time for the requirements of mining. The hillsides of the valleys that have proved productive of placer gold have been stripped bare, however, and the quantity of timber still available for the purposes of mining or for use as fuel is being rapidly depleted. Grass grows abundantly on the deforested areas, and there are areas along the larger streams and on the lower slopes facing the Tanana Valley and adjacent portions of the Tanana Flats that are suitable for the growth of the numerous agricultural products that can be raised in abundance.

Owing to the long winters, the working season during the summer is limited to a period of, at most, about one hundred and fifty days, from the latter part of April to the middle of September, although underground work may be carried on throughout the year; nearly all work dependent on water supply is confined to the open period, and with the frequent inadequacy of the water supply during this period the opportunity for summer work is still further abridged.

In the absence of a railroad to the coast the problem of transportation continues to be largely a function of the natural conditions. The region must still receive its supplies by the circuitous river route, either by way of Dawson and the upper river or by way of

St. Michael and the lower river. The opening of river navigation in the spring, about the middle of May, and its close in the fall, at dates ranging from about October 13 to as late, exceptionally, as November 23, are two factors that enter largely into the consideration of all business enterprises in this portion of Alaska. Even with the advantage of telegraphic communication with the port cities of the west coast of the United States and notwithstanding efforts by the transportation companies to forward all shipments to their destination before the freeze, supplies can frequently not be shipped in time to reach the district during the open season, so that their shipment is held up until the following season, or they may be delayed in the course of shipment by the freezing of the rivers. In either case extra expense is involved. Supplies for the Fairbanks district are brought by steamer to Chena and Fairbanks and transported by wagon road or railroad to the localities of present economic importance, all of which are within about 30 miles of Fairbanks. The freight rates on ordinary supplies from the coast ports of the States to Fairbanks are about $75 a ton.

The conditions of transportation, although permitting abundance of supplies during the summer, have up to the present time entailed a dearth of supplies during the latter part of the winter and the early spring. These communities are therefore in a condition of economic strain which will probably continue so long as they must depend on means of transportation that are available only during the short summers.

GEOLOGIC SKETCH.

The predominant bed rock of the area is schist like that of most of the eastern portion of the Yukon-Tanana region. There is a small amount of metamorphic intrusive granitic rock, a few small areas and rather abundant dikes of unmetamorphosed intrusive granitic rocks, and a small proportion of comparatively recent basalt, a part of which may be of volcanic origin.

A large proportion of the area is covered with alluvial deposits. The occurrence of abundant placer gold in these deposits has brought the district to a position of economic importance, and the extensive operations of placer mining have rendered available for observation and study a considerable body of these deposits. They have been found to have a thickness in places of over 300 feet and to be for the most part more or less permanently frozen. These deposits and the superficial covering of moss, timber, and other vegetation conceal so much of the underlying bed rock that only a small portion is accessible to study.

The rocks of the metamorphic formation are in general siliceous and characterized by their glistening appearance, due to the content of mica. While quartz-mica schist and quartzite schist are the most common members, there are also rather massive coarse and fine quartzites, carbonaceous schists and quartzites, lenticular masses of crystalline limestone interbedded with the schists, garnetiferous mica schists, amphibole schists, green eclogitic rocks containing a large proportion of garnets and rutile, a small amount of schist containing andalusite, and a little staurolite schist. A small amount of intrusive porphyritic granite has undergone metamorphism along with the schists and thus become a member of this metamorphic formation. These rocks, while differing in degree of metamorphism, have apparently all been subjected to the same metamorphic processes. The general strike of the structure is northeast and southwest. The rocks have been folded to a high degree, and in some places the folds have been overturned to a nearly horizontal position, and have been in part so closely crumpled or cleaved that the primary structures are obscured. These rocks have been intruded by a considerable quantity of igneous material, which has added to the metamorphism and to the complexity of structure. They have also undergone an extensive shattering and local brecciation which are in part most probably directly referable to the igneous intrusive rocks and in part indirectly referable to the interaction between the intrusive and the invaded rocks in the effort toward mutual adjustment under the action of general deformational processes subsequent to intrusion.

The rocks of sedimentary origin play in the main but a passive part in the geologic history of the region, but the igneous rocks, although occupying quantitatively but a small portion of the area, are of significant importance from the fact that they form an active element in the lithologic system involved. They have the power of exerting an influence both mechanical and chemical on rocks remote from their vicinity, and furthermore they may furnish avenues for the transmission in solution of deep-lying materials toward the earth's surface.

The study of the igneous phenomena, apart from its importance in the geologic history, derives special importance from the fact that the mineralization of the region is most probably to be referred more or less directly to the igneous rocks.

The granitic and related igneous rocks of the area intrude the schists. They were forced into the schists in a molten condition at a considerable depth below the contemporaneous surface of the earth, a depth measurable probably by at least several thousands of feet. Since their intrusion they have become part of the present surface by the wearing away and removal by erosion of the rocks under which they were formerly buried. The evidence of their intrusive character is found in the presence of dikes cutting the schists, of inclusions of schist in the marginal portion of the igneous rocks, and of some contact metamorphism. The evidence of consolidation under a considerable cover is found in the necessity of such a cover to give an opportunity under conditions of slow cooling for the igneous material to attain the degree of crystallinity that these rocks possess, some of them being comparatively coarse grained porphyritic granites.

The unmetamorphosed intrusive rocks occur as masses of a few square miles in area, most of them longer in a northeast-southwest direction, parallel with the general structure of the region, and as small dikes that have a rather wide distribution throughout the Fairbanks district. The material that forms these masses includes quartz diorite, the rock of Pedro Dome; porphyritic biotite granite, which is present on Twin Creek and forms the largest intrusive mass of the district outside of and east of the area shown on the map (fig. 4); altered dikes of granite porphry and quartz diorite porphyry; and persilicic dikes. From the facts available it appears that these intrusive masses are the product of one general period of intrusion; that they were not, however, contemporaneous, but closely sequent, and that the sequence has been in general quartz diorite, porphyritic biotite granite, and persilicic dikes.

The form of the intrusive masses available for study and the material composing them give but partial information as to the apparatus of intrusion and the products of intrusive activities. The materials constituting the rocks at the present time do not express the complete composition of the molten material from which they have crystallized, nor is the present composition necessarily the same as that immediately subsequent to crystallization. The present composition of the rocks, although predominantly that due to the original crystallization, is secondarily that resulting from a more or less complete adjustment to the long sequence of differing conditions that have since prevailed. The period immediately subsequent to intrusion is a critical period, as regards both the igneous rocks themselves and their environment. Besides the important mechanical effects of intrusion, a large amount of material is given off at the time of intrusion and subsequent thereto that is fraught with possibilities for fundamental changes both in the igneous rocks themselves and in the rocks into which they have been intruded. This material finally, as an aqueous solution more or less rich in dissolved substances, may invade not only the igneous rocks but a large volume of the rocks inclosing the intrusive masses and may introduce thus in many places a large amount of material that is more or less directly the product of the igneous action and take into solution minerals already present. The conditions pass from those that in general favor solution to those that in general favor deposition, and the end result in the rocks is the increase in the proportions of some of the minerals that were present before intrusion and the deposition of new minerals. One of the most common minerals added to the surrounding rocks through the action of granitic intrusives is quartz. Deposits of metallic compounds or of metals may also be formed.

The intrusive process under deep-lying conditions is a tremendous energizing influence. In the investigation of the intrusive rocks of an area, therefore, the problem is presented of evaluating, so far as possible, the igneous influence and assigning it to its appropriate position with reference to the general deformational and metamorphic forces to which an area like that under consideration has been subjected. If, in addition to the ordinary products of intrusion, ore deposits have been formed, the problem may become of economic importance. Although it may be comparatively easy to map the areas of the igneous rocks themselves, it is difficult to demarcate the areas that have been subject to the action of the influential concomitants and after-products of intrusion or to designate the materials resulting directly from the igneous process. While, therefore, an ore deposit may not be directly referable to the igneous rocks, the assemblage of facts may be sufficient to bring the possibility of such an origin well within the range of probability.

The rocks in the Fairbanks district exhibit structures due in part to sedimentation, in part to deformation, and in part most probably to intrusion. The mineral composition of the rocks is due in part to sedimentation, in part to metamorphism, and in part to the igneous intrusions. The problem, therefore, is complex, and the facts at present available are insufficient to permit definite statements as to the origin of structures or minerals.

Apart from the jointing; close folding, crumpling, minor faulting, and cleavage that the rocks have undergone, the schists, some of the quartz veins, and some of the igneous rocks have been more or less shattered and brecciated over areas of considerable extent. These phenomena are in places most intensified in the immediate vicinity of intrusive rocks, but are exhibited very commonly far beyond the limits of the visible igneous rocks. Although much more widespread in occurrence than the igneous rocks and due partly, perhaps, to general deformation, the largest part of the shattering and brecciation is regarded as having resulted more or less directly from intrusive action on a body of material predominantly so siliceous as to be particularly susceptible to such fracturing. Although the schists have probably been subject to this process at different periods, the largest part of the fracturing is believed to have been closely sequent upon the latest exhibition of intrusive action. The reason for this belief consists in the facts that the quartz diorite of Pedro Dome has undergone a small amount of fracturing and that the persilicic dikes, which were subsequent in origin to the intrusive mass of Pedro Dome and which belong apparently to the latest stage of the intrusion of plutonic rocks, have been in places intensely brecciated and then silicified and sericitized by the after-products of intrusive action. The shattering of the rocks is regarded as particularly important with reference to the occurrence of ore deposits, in that it has furthered and perhaps been largely the cause of the distribution of gold and metallic compounds within the range of accessibility.

QUARTZ VEINS.

Although only the northeastern part of the Fairbanks district is shown on the accompanying map (fig. 4), with the quartz prospects that had been found there up to the fall of 1909, auriferous quartz has been reported as far to the southwest as the valley of Ester Creek, and the distribution of gold in quartz veins, so far as it has been indicated by the discoveries of 1909, is roughly outlined by the distribution of the gold placers. The localities that have proved most productive of placer gold lie in a belt of country about 35 miles long from northeast to southwest and 15 miles wide. The placers are not uniformly distributed throughout this area, the most productive of them being confined to a few of the many valleys. The richest quartz veins that have been found are located near the heads of valleys that have proved large producers of placer gold. While this may be due in part to the fact that there has been more incentive to prospect such valleys for quartz veins, it is believed to represent more or less accurately the distribution of the most highly metallized areas.

The bed-rock gold of the Fairbanks district occurs predominantly in association with quartz veins, and therefore the geographic and geologic distribution of quartz veins, their dimensions, the minerals found in association with quartz, and the physical and chemical alteration of the quartz veins since their formation are all matters of significance.

As far back as 1905 considerable work was done in prospecting for auriferous quartz, especially in the vicinity of Pedro Dome, but no discoveries were made at that time of sufficient importance to stimulate interest in quartz prospecting. It was not till 1909 that, through the work of prospectors, the quartz veins were open to observation, and as yet only their superficial portions have become accessible.

Quartz veins are found throughout the Yukon-Tanana region, ranging in age from pre-Ordovician to Upper Cretaceous. In a particular area, therefore, like the Fairbanks district, there are quartz veins that have been formed most probably at widely separated periods, and, although it may be possible to fix the relative age of some of them with more or less certainty as previous to the general folding of the region and to regard others as being related to a period of intrusion, there may be present a considerable proportion of quartz veins showing no recognizable evidence of their period of formation.

The quartz veins after their formation have not been exempt from the deformational processes to which the inclosing rocks have been subjected, but, according to their age, have undergone more or less folding, minor faulting, or brecciation. Slickensided surfaces of the vein quartz attest the motion that has taken place, and that some of the motion has been subsequent to the deposition of gold is shown by the fact that gold has been observed rubbed into slickensided surfaces of quartz in a direction parallel with that of movement. The amount of local faulting to which the veins have been subjected has apparently been considerable. Through this process some of the auriferous quartz veins have in places become discontinuous. Where such has been the case and where the recovery of the vein is sought the direction and angle of the dip of the slickensided surfaces and the direction of the grooves upon them should be carefully scrutinized, as such facts may throw light on the direction in which work should be undertaken to find the continuation of the vein.

Besides the changes already noted there has been in some places a reintroduction of quartz, and the present quartz veins embody the results of a sequence of events, one of which, at least for some of the veins, has been the introduction of gold and sulphides. The portions of the veins at present visible have undergone the processes of weathering and erosion, which have brought about changes in the vein to considerable depths—changes that have gone progressively deeper as the upper portions of the veins have been removed by erosion.

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

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

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

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

METALLIZATION.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

DESCRIPTION OF LOCALITIES.

The localities where most of the quartz prospecting has been done are Skoogy Gulch, Bedrock Creek, the ridge between Bedrock and Chatham creeks, Chatham Creek, Willow Creek, the ridge at the head of Wolf Creek, and the ridge at the head of Alder Creek.

The prospects in Skoogy Gulch, including the North Star, Centre Star, S. S., and other locations, are all in schist close to intrusive rocks. The quartz diorite of Pedro Dome and the porphyritic biotite granite of Twin Creek are separated on the west side of Skoogy Gulch by only a few hundred feet of schist. The presence of fragments of the dioritic rock penetrated by small dikes of the granitic rock indicates the still closer relationship of the two intrusives. The rock in which the mining developments have been carried out is quartzite schist and quartz-mica schist, striking northeast. The rock is somewhat metamorphosed by the contact influence of the intrusive rocks, an influence shown by the presence of a large amount of biotite and some andalusite. While some of the schist is very micaceous, much of it is a dense blocky quartzite schist.

A small granitic dike about half an inch thick in one of the tunnels shows the closeness of the igneous influence.

Auriferous quartz veins are reported to have been traced on this slope of Skoogy Gulch for 500 to 800 feet. At one locality where surface prospecting in 1908 had discovered an auriferous stringer about 4 inches thick, together with several smaller auriferous stringers, some of them along the joint planes of the schist, a shaft about 65 feet deep and a tunnel about 200 feet long had revealed in 1909 a considerable number of stringers, some of them barren and some of them carrying high values.

The vein regarded as the main lode strikes northwest and is said to average about 3 feet in thickness. Several hundred feet farther in the same direction a shaft has been sunk on a vein 10 to 12 feet thick which carries values.

The marginal portion of the porphyritic granite contains in places a large amount of iron pyrites in the granite itself and along the joint planes. Iron pyrites occur similarly along the joint planes of the schist at the locality of the auriferous quartz veins. The granite contains also some pegmatitic quartz and feldspar, occurring as feldspathic veins in quartz and quartz veins in feldspar; in some of these veins both margins are feldspar and the middle is quartz. The quartz present in these granitic products is gray and glassy. In the quartz veins that have been opened there is a similar gray glassy quartz and this is apparently barren. The auriferous quartz is grayish white and opaque. The veins of both the barren quartz and the auriferous quartz contain a small amount of feldspar. This is mostly kaolinized, but so far as determinable is like that of the pegmatitic granite dikes above mentioned. Cavities studded with quartz crystals are rather common in the quartz. Limonitized crystals of iron pyrites are common in the auriferous is quartz. The gold occurs partly in visible form embedded either in the limonitized crystals of pyrite or in the quartz. The auriferous quartz contains a large number of microscopic liquid inclusions and so far as observed has been more or less shattered. Although it is possible that the auriferous pyrite and free gold were deposited synchronously with the quartz, it seems more probable that the deposition of gold was subsequent to a shattering of the quartz and synchronous with the deposition of pyrite along the joint planes in the schist and porphyritic granite.

Auriferous quartz has been reported also from the east side of Skoogy Gulch, where limonitized iron pyrites occurs along the joint planes of the schist and where there are also numerous small quartz stringers. High on the eastern slope of Skoogy Gulch a prospect has revealed stringers composed of quartz and arsenopyrite parallel to the structure of the schist.

At a location known as the Free Gold, on the east slope of the valley of Bedrock Creek near the mouth, rich ore has been discovered. The schist bed rock is traversed by quartz stringers and one main quartz vein from a few inches to nearly 3 feet in thickness, averaging about 20 inches. This vein is reported to have been traced for about 800 feet on the surface and to have been found auriferous throughout that distance. A tunnel had been driven along the vein for about 90 feet, and at a point along the strike of the vein about 800 feet uphill from the tunnel a shaft had been sunk on the vein to a depth of 50 feet. The portion of the vein exposed at the end of the tunnel is about 50 feet below the surface. The strike of the vein ranges from N. 75° W. to N. 65° E. It is in general northeast, with a dip of about 60° SE. The quartz has been more or less shattered and is slickensided and at one place in the tunnel the vein was lost for a short distance by local faulting. The quartz is grayish white and opaque. It is in part compact and in part of rather open texture, with quartz crystals partly individualized. There are a few grains of kaolinized feldspar and a little colorless mica scattered through the quartz. Much of the gold present is visible and is partly in close association with sulphides. The most abundant sulphides are stibnite and arsenopyrite, but iron pyrites and sphalerite are also present. The gold and sulphides, together with some quartz, have apparently been introduced together at a period subsequent to the formation of much of the quartz. The stibnite and arsenopyrite occur mostly as independent crystals or groups of crystals and the gold is partly granular. The portions of the vein rich in sulphides form an evenly granular fine-grained mass of quartz with the two predominant sulphides and free gold. These sulphide-rich portions are in places sharply demarcated from the rest of the vein but in other places grade into quartz with only a small proportion of sulphides. The proportion of gold is greater in the sulphide-rich portions of the vein. Part of the gold is so intimately associated with the sulphides that after the ore rich in sulphides is roasted gold appears on the surface as globules.

At two other localities on the east slope of the Bedrock Valley, one of them, the Wyoming Ledge, about 2,000 feet above the mouth of the creek, and the other, the Emma, near the head of the creek, similar auriferous quartz was being prospected. At the Emma the quartz vein had been exposed by a shaft about 40 feet deep. The strike, nearly east and west, and the dip, high to the southeast, show approximate parallelism with the vein at the Free Gold, already described. The vein ranges from a few inches to about 16 inches in thickness and is about parallel with the structure of the schist. The quartz and mineral association are similar to those of the vein already described. The schist at this locality has been much brecciated and the fragments have been cemented by quartz.

On the ridge between the head of Bedrock Creek and the head of Tamarack Creek there is a small mineralized mass interbedded in the schists, containing some quartz, galena, iron pyrites, arsenopyrite, and stibnite.

Chatham Creek was a good producer of placer gold for about 1 mile above its mouth. Gold quartz and sulphides have been found at several localities in the Chatham Valley either within or just above the portion of the valley where placer gold was found. A small quartz stringer carrying free gold was discovered at the upper end of the productive gravels in 1908. The Pioneer Quartz Mining Company has done considerable work at this locality. A shaft was sunk near the creek to a depth of 24 feet, when water was encountered. A second shaft was sunk about 100 feet farther up the east slope of the valley to a depth of about 85 feet on a vein about 3 feet thick, striking northeast and southwest. This vein was found to intersect the smaller vein at nearly right angles. At the intersection the smaller vein, it is reported, follows the main vein for a short distance and then penetrates the country rock. The smaller vein is said to range from 4 inches to 2 feet 6 inches in thickness. Both veins carry free gold, but in the smaller vein there is considerable stibnite and arsenopyrite, with some sphalerite and iron pyrites. The distribution of the sulphides is irregular, but in the portion of the vein where they occur they are for the most part rather evenly distributed through the quartz. They show a slight tendency in some places, however, to form small seams in the quartz. Pieces of free gold have been reported in the quartz, ranging in value up to 25 cents.

The Butler tunnel site was located on the west side of Chatham Creek opposite "3 a. Chatham," in October, 1908. At a level 150 feet above the creek a tunnel was driven southwest for about 90 feet. At 50 feet from the mouth of the tunnel a shear zone was encountered about 6 feet thick, striking northwest nearly at right angles with the strike of the schists. The operators drifted northwest and then sunk on the shear zone, which was found to dip from 45° to 70° SW., to a depth of 150 feet, where the thickness was about the same as in the tunnel. Later a raise was put in above the winze, connecting it with the surface. The second level is about 100 feet below the first and extends along the vein for about 40 feet on each side of the shaft. The mica schist of the shear zone was found to be impregnated with sulphides, chiefly iron pyrites and arsenopyrite, with some galena, sphalerite, and stibnite. These sulphides also occur in the numerous quartz veins that penetrate the shear zone. Free gold is found in the upper, more oxidized portions of the mineralized zone, but it is reported that in the less decomposed, lower portions of the lode the values are in the sulphides. A noteworthy feature is the occurrence of tourmaline needles in the mica schist close to the contact of schist and quartz veins and in close association with iron pyrites and arsenopyrite.

At several other localities in the Chatham Valley auriferous quartz has been found, as well as veins of stibnite, and more or less development work has been done.

On the old wagon road between Bedrock and Chatham creeks, in line with the rich ore occurrences near the mouth of Bedrock Creek and those just described, the shattered schist contains considerable stibnite and some gold. A Keystone drill was used for prospecting during the winter of 1908–9 and prospects were found over a width of about 200 feet. During the summer of 1909 the ground was being prospected by trenching.

On the east side of Willow Creek, about 1,000 feet above the mouth, work was just being commenced by the Willow Creek-Tolovana Mining Company on quartz stringers that had been found to be auriferous. The schist was traversed by a number of small parallel stringers striking N. 75° E. and ranging from less than 1 inch up to about 3 inches in thickness. Gold was visible in several of these stringers. One minute vein at this locality was found to be composed of quartz and fresh albite.

There are several other localities in the upper Cleary Valley where sulphides and some gold have been found.

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

At the head of Alder Creek, a tributary of Fairbanks Creek, at the McCarthy property, including the Lime, Lemon, and North Star claims, is a vertical quartz vein striking about N. 40° E. and 12 to 13 feet wide. A tunnel has been driven parallel to the vein for about 120 feet and the lode has been crosscut at a depth of 50 feet. Along the margin of the vein and along the horses of schist that are found in it there is considerable mineralization, and some values are reported. Two other similar large quartz ledges parallel the one described, but had not been opened in 1909. The vein quartz of these localities is much fractured and the mineral-bearing solutions have apparently been introduced subsequent to the fracturing.

There is apparently a zone in which auriferous quartz veins are particularly abundant, extending northeastward from the head of Cleary Creek across the Willow, Bedrock, and Chatham valleys and on into the ridge at the head of Wolf and Fairbanks creeks. Its extension to the southwest is indicated by the discovery of some auriferous quartz near the head of Big Eldorado Creek.

Besides the localities above described, others have been reported that are outside the areas visited, and throughout the Fairbanks district a large number of quartz and tunnel-site locations have been made.

METHODS OF PROSPECTING.

Prospecting for quartz in the Fairbanks district is rendered particularly difficult by the fact that the broken bed rock is for the most part deeply buried under a permanently frozen cover. The process of prospecting employed is that used so extensively in Oregon and California by the pocket hunters, and many of the auriferous veins in the Fairbanks district have been discovered by men conversant with this process. Prospect holes a few feet in depth at intervals up to 20 feet or more are dug along a hillside where auriferous quartz is suspected. When, by panning the material, colors are found, the same process is employed in tracing the colors up the slope to their origin in the bed rock. Proximity to the vein is indicated by increase in the size and number of colors and their deeper position in the overburden. Trenches are then dug until the vein is revealed. Subsequent operations in the Fairbanks district, where the veins are liable to change in direction and where they have in places become discontinuous by local faulting, should be confined to the vein. A practice particularly to be avoided is the driving of long tunnels to intercept the vein at points where its existence has not been demonstrated. In an area of schist like that of the Fairbanks district, where there has been extensive deformation at different periods and where some of the deformation has taken place subsequent to gold deposition, it is especially advisable to confine development to the vein itself, to trace its extent on the surface, and if the surface extent justifies further operations to sink upon it or to tunnel along it, according to conditions.

To facilitate the work of testing ore that was being discovered during 1908 and 1909 the business men of Fairbanks raised by subscription a sufficient sum for the construction of a stamp mill. A local firm built a 3-stamp gravity mill out of the material available, with stamps weighing 275 pounds each and working 80 to 90 drops a minute. The capacity of the mill ranges from 3 to 5 tons in twenty-four hours. The ore tested at the mill has run from $25 to $200 a ton of free gold, with an average of about $50 a ton. The cost of mining and milling combined, including freight from mine to mill, is about $50 a ton.

SUMMARY.

The bed rock of this district is predominantly schist, regarded as pre-Ordovician in age. The granitic rocks are intrusive and therefore later than the schists. The age of intrusion, although not definitely known, is believed to have been Mesozoic, approximately that of partly similar intrusives in the Rampart region which cut Paleozoic and Upper Cretaceous rocks. Quartz veins have been formed at different periods and a part of them have apparently resulted from the intrusions.

The deposition of gold and sulphides has been for the most part, at least, subsequent to the greatest part of the quartz of the quartz veins, and the ore-bearing solutions have been admitted in part after a fracturing of the veins. There is a close relation between the gold and the sulphides. The most common sulphides are stibnite, arsenopyrite, and iron pyrites. Small rich veins and larger veins with lower values have been found. Local faulting has taken place since the deposition of the gold, and this fact must be borne in mind in opening the veins. The deeply covered bed rock and local faulting render the process of prospecting expensive. In addition to the natural difficulties there are those imposed by the high transportation rates on all supplies, so that prospecting for quartz in the Fairbanks district is an undertaking requiring considerable capital.

The work accomplished in 1908 and 1909 was of the nature of prospecting. Small dumps of ore were accumulating at the openings of several tunnels and a few tons at each dump had been sacked awaiting shipment to the mill. Only the superficial portions of the ore had been exposed and insufficient work had been done to determine with definiteness changes in the character or value of ore with depth. In a few places a decrease in the amount of free gold had been noted. It is very probable that the eroded upper portions of these veins were much richer in free gold than the portions at present exposed and that these upper portions, enriched by long-continued weathering, furnished the bulk of the gold for the deeply buried productive gravels of the present valleys. It is probable also that the proportion of free gold diminishes with increasing depth. It has been demonstrated that there are many veins which carry gold. It is possible that the rich placers have had a multiple origin in the bed rock and that the gold has been distributed through a large number of small veins rather than concentrated locally into large bodies of ore, and the facts indicate that this is in part, at least, the case. It has been demonstrated further that there are veins worth the work hitherto expended on them—veins that possess such dimensions and values as to merit sufficient work to determine their possibilities.

PLACER MINING IN THE YUKON-TANANA REGION.

By C. E. Ellsworth.

INTRODUCTION.

During the mining season of 1909 the writer was engaged in an investigation of the water resources of the Fairbanks, Birch Creek, Rampart, Hot Springs, and Salchaket placer districts of the Yukon-Tanana region. (See p. 15.) Incidental to this work, some notes were made on the mining developments which came under his observation, but the data collected were more or less fragmentary, for only a small percentage of the plants in operation were actually visited. In the preparation of this report these data have been supplemented by information furnished by other members of the Survey, as well as by residents of the district, including United States commissioners, mine operators, and others too numerous to mention individually. The statistics of production are based on the reports furnished to the Survey by operators, supplemented by statements of banks, express companies, and deputy collectors. (See pp. 16–17.)

FAIRBANKS DISTRICT.

MINING CONDITIONS.

General statement.—Notwithstanding the fact that the richest pay streaks of many of the creeks in the Fairbanks district have been practically worked out, the value of the production for 1909, estimated at $9,650,000, was the largest since the discovery of gold in this district in 1902. Aside from the lode prospecting described in detail by L. M. Prindle (pp. 210–229), there were no new developments of importance. The large production was due mainly to the further tracing of the pay streaks already known, the most notable of which is that of Engineer Creek.

It has been estimated that over 100 steam-hoisting plants were operated in the Fairbanks district in 1909 and probably about 3,000 men were employed in mining. No marked improvements were made in the methods of mining, but a more careful supervision of work by mine owners is gradually leading to more economical exploitation. A noteworthy feature is the increased use of both steam and horse scrapers in handling the gravels and tailings. A shortage of staples before the opening of navigation in the spring of 1909 caused such excessively high prices that several operators were compelled to discontinue work. With few exceptions the wages continued at the same rates as in 1908, namely, $5 a day and board. Most of the plants worked two shifts daily, of ten hours each.

Owing to the limitations put on mining by the present operating costs only the richest pay streaks are mined, and many of these have been exhausted. It is probable that there are few open-cut operations in the Fairbanks district where the recovered values are less than $1 to the cubic yard, and the average cost of drift mining is about $3.50 a cubic yard. There is known to be a very large amount of gravel carrying lower values, but it can not be profitably mined until radical changes in mining methods are introduced. Relatively little attention has been given by operators to the problem of recovering these lower values. It is safe to say that the conditions are not favorable to hydraulic mining. This is largely due to the fact that in most places it will not be commercially possible to obtain water under sufficient head, but also to the depths of the deposits and the low stream gradients.

Although some of the ground may be too deep for dredging, much of it could probably be economically handled by such means if cheap enough power could be obtained; and if the overlying muck of the deep ground could be removed by water such ground might be made suitable for dredging, but the difficulty of obtaining water under pressure has already been mentioned and can not be too thoroughly emphasized. Cursory investigations have been made relative to the possibilities of developing electricity by water power for operating dredges, pumping water, etc., but no real advance has yet been made. The extensive coal deposits in the northern foothills of the Alaska Range have been described by Prindle [a] and a consideration of their possibilities as a means of developing electricity to be transmitted to the Fairbanks mines seems worthy of careful thought.

Dredging frozen ground is impracticable and the cost of thawing about doubles the expense. Thawing by the use of water under head has been introduced in the Klondike region, and this method is said to be cheaper than any other heretofore devised.[b] The strict application of this method would be impracticable in the Fairbanks district because of the large amount of water under pressure required, but a modification of such means might be practical.

Much of this field has reached the stage where further developments will require a large amount of capital. It appears as if the

[a] Prindle, L. M., The Bonnifield and Kantishna regions: Bull. U. S. Geol. Survey No. 314, 1906, pp. 221-226; see also Brooks, A. H., The mining industry in 1908: Bull. U. S. Geol. Survey No. 379, 1909, p. 47.

[b] Op. cit., p. 41.

quantity of gold-bearing gravels, the comparative accessibility of the creeks by railway and wagon roads, and the established commercial conditions justify investigation by engineers experienced in placer mining. Only on the results of such an investigation, probably supplemented by some preliminary experimentation, can the most economic methods of exploitation be determined.

Goldstream Creek and tributaries.—The productive area in the Goldstream basin has been largely increased and this area leads the Fairbanks district in output for the year 1909. Rich deposits have been located on the left bank of Goldstream Creek, and the chances of further discoveries in this valley are promising.

The main valley for about 4 miles below Gilmore Creek is thickly dotted with steam plants, many of which are of large capacity. The principal producing tributaries of Goldstream in 1909 were Engineer, Pedro, and Gilmore creeks. Several very rich claims were located on Engineer Creek during the year and it was probably the leading creek in the Fairbanks district for the season in gold output. Pedro and Gilmore creeks were mined extensively for nearly their entire length. A small amount of mining was also done above claim "No. 7 above," on Fox Creek.

Chatanika River and tributaries.—Dome Creek was probably the second in gold output for the season. The rich pay streaks of the upper part of the creek are about worked out, but prospecting along the lower course has met with success. The status of work on Vault Creek is similar to that on Dome Creek, in that the pay streak has been traced well into the Chatanika Flats.

Considerable mining was done on Treasure Creek, but much difficulty was experienced from underground water, and as a consequence mining on some very rich ground was abandoned.

While no doubt Cleary Creek has passed its prime as a gold producer, the extensive work now being done near the mouth in the flats of the Chatanika bears evidence that a considerable output for several years may be expected. The local water supply was found to be inadequate and during the early summer of 1909 a ditch was constructed which diverts water from Chatanika River above Pilot Creek. It follows the south side of the valley through the center of the town of Chatanika and passes beneath the railroad tracks near the depot. If in the future the demand for water for mining along lower Dome and Vault creeks should warrant the expense of construction, the ditch will probably be extended to those localities. An ample supply of water is available for such purposes. There was considerable winter mining on upper Cleary Creek in 1909, but only two mines were being operated above Discovery claim during the summer. It was reported that an underground reservoir which has handicapped work on claims Nos. 8, 9, and 10 below Discovery has been drained by a tunnel. Claims Nos. 4 and 5 below, which have been under litigation for several years, will probably be worked during 1910, and as they are known to be rich the production of the creek should be considerably augmented by their output. On Chatham Creek several mines were operated; on Wolf Creek work was confined to prospecting from which encouraging results were reported.

During the last two years there has been much mining in the Chatanika Valley along the extension of the pay streaks of the various tributary creeks. On the lower part of Cleary Creek, where its valley opens out into the flats of the Chatanika, the pay streak appears to split up and has been difficult to trace. This may also hold true of the gold-bearing gravels of the lower part of other streams, such as Dome and Vault creeks. These conditions make it difficult to prospect in these flats, for, in the absence of topographic relief, there is little to guide the search of the miner. A large amount of prospecting is therefore necessary. As the gravels average 100 feet in thickness and the cost of sinking shafts to this depth is estimated at $10 a foot, it will be seen that the initial expense in this part of the field before any returns can be expected may be very large.

The finding of some rich gravels on Little Eldorado Creek led to a large amount of expensive prospecting during the winter of 1908–9. No extensive pay streaks were traced, hence the miners who had done the prospecting suffered considerable loss. Several claims, however, were productive, but the output did not warrant the village of no small proportions which quickly sprang up near the railroad on this creek, and in consequence it was nearly deserted later in the season.

The considerable development work which has been done on Charity Creek during the last few years was not continued in 1909.

Fish Creek and tributaries.—Though Fairbanks Creek presented no very prosperous appearance in 1909 the value of the production was about $500,000. Most of the work was below Discovery claim. Several of the small tributaries of Fairbanks Creek from the north have been found to carry gold. Current reports indicate that a dredging enterprise on Fairbanks Creek was in contemplation. The gravels on the upper part of the creek are from 9 to 15 feet in depth, with 3 to 5 feet of overlying muck, and such an enterprise seems to be warranted.

Some gold was taken from the Fish Creek valley above the mouth of Fairbanks Creek and a little prospecting was done on Bear Creek.

Cripple Creek and tributaries.—Extensive operations have been conducted on Esther Creek in the past, but the close of the 1909 season marked the completion of work on several of the richer claims.

Ready Bullion Creek has contributed largely toward the production from this basin and some gold has been taken from Cripple Creek. A little work was also reported to have been done on St. Patrick's Creek. Winter sluicing by the use of warm water, which was commenced on Esther Creek in 1907–8, was not extensively practiced in 1909. Only two plants are known to have sluiced continuously during the winter in the Yukon-Tanana region, one on Esther Creek and one on Fairbanks Creek. Winter work is, however, said by some to be cheaper than to wait until spring and rehandle the gravel. The water is collected in the settling basin, where it is warmed by the exhaust from the engine. It is then pumped to the sluice and returned to be settled and used again.

Washington Creek.—Washington Creek, which has been staked for nearly its entire length, so far has not been productive. Very little has been done aside from the required assessment work.

PRODUCTION.

The estimated annual and total value of the gold production in this district since its discovery in 1903 is given below:

Value of production of gold from the Fairbanks district.

1903	$40,000	1908	$9,200,000
1904	600,000	1909	9,650,000
1905	4,000,000		
1906	9,000,000		40,490,000
1907	8,000,000		

CIRCLE DISTRICT.

MINING CONDITIONS.

General statement.—No new strikes were made in the Circle district during 1909. With the exception of hydraulicking on Eagle and Mammoth creeks the mines were worked in the same general manner as in the past, by drifting in the winter and open-cut methods in the summer. Sufficient data are not at hand to determine what proportion of the total production was due to winter or summer work, but there is no doubt that the summer output exceeded that of the winter.

The wireless station which was installed at Circle in 1908 has been found a great convenience as a means of communication with the "outside," as well as with the other mining sections of Alaska. A telephone line from Circle to the creeks is still under consideration. The need of it is never questioned, but the necessary initiative seems to be lacking. The government road was completed nearly to the Central House, which makes a total of about 34 miles already constructed. It was planned to build several miles more during the summer, but owing to a rather wet season, particularly during the early part, construction was greatly handicapped. There is a decided need for a good summer road as far as the Miller House, with a branch to Deadwood Creek. This would do much to reduce the cost of mining in this field. The value of the road already completed is shown by the fact that, although the season of 1909 was fully as unfavorable for travel as any other for several years, practically all the supplies taken to Deadwood Creek during the summer were moved on wagons, for this method was found cheaper, even with only the light loads that could be hauled, than to use pack horses, as has been done in the past. A few trips with wagons were also made as far as the Miller House.

Mastodon Creek.—Mastodon Creek still continues to be the largest producer of the district. The prevailing method of summer work is to remove the overburden by water and shovel the pay gravels into sluice boxes. There was some mining for nearly the entire length of the creek, but the most important operations were near the mouth.

An attempt has been made to work the ground on the creek more systematically by a combination of interests, but as yet little has been accomplished toward that end. While many of the richer deposits have been mined out, it is believed that the aggregate of the values left in the tailings and undeveloped portions is sufficient to warrant exploitation by dredges or large-scale methods.

Deadwood and Switch creeks.—Deadwood Creek, which comes second in production, was mined by methods similar to those used on Mastodon Creek.

During the winter of 1908–9 seventeen claims were being worked on Deadwood Creek and eight or nine on Switch Creek, and their output for that period is variously estimated from $25,000 to $60,000. Nuggets valued at $41, $31, and $23 were found, and several $8 to $10 nuggets were picked up. Most of the gold is much finer. The rougher and coarser gold is found near the heads of the creeks. The miners receive $16 an ounce for the gold.

The lower part of the creek, after it merges into the Crooked Creek flats, has been under consideration as suitable dredging ground for several years and has been prospected with that object in view, but the results are not known. There has also been some talk of hydraulicking below Switch Creek. Daily records of stream flow were kept on Deadwood Creek just above Switch Creek during the last season. (See p. 269.) They show that possibly during the period covered by the records sufficient water was available, but in order to obtain a working head it might be necessary to divert the water so far above as to make the supply insufficient during periods of drought. Nevertheless it does not seem improbable that such an enterprise might be successful, and it is recommended that an effort be made to obtain as complete records of stream flow as possible. If capital is to be interested, these records will be the first information called for and they will require the most time to obtain satisfactorily.

Mammoth Creek.—Mammoth Creek, which is formed by the junction of Mastodon and Independence creeks, meanders through a broad gravelly flood plain. Fine gold is said to be distributed rather uniformly throughout the gravel, which is, however, of too low a tenor to pay to work by the usual hand methods. A steam shovel was installed on the creek in 1903, but does not seem to have proved a paying enterprise. During the summer of 1908 a ditch was constructed from a point on Bonanza Creek about 3 miles above the mouth along the right banks of Bonanza and Porcupine creeks to a point on the left side of Mammoth Creek a short distance below the Miller House. The length of this part is 6 miles, the grade 5 feet to the mile, and the bottom width 7 feet. In 1909 this ditch was being extended around the spur between Bonanza and Porcupine creeks for 4 miles, with an intake on Porcupine Creek at an elevation of 2,350 feet, about 4 miles above the mouth of Bonanza Creek.

Considerable difficulty was experienced during the season with the ditch constructed in 1908, owing to the thawing of ground ice and seepage through the loose rock soil. The ditch was built along the hillside, and as the ice in the bottom thawed the water followed the line of thaw until often it finally escaped to the surface below the lower bank. Unless these underground channels were soon discovered and moss was tamped into the openings in the bottom of the ditch, they rapidly wore larger and frequently only a few hours were required before the whole outside bank of the ditch near the break was ground-sluiced away. In many places where the bottom of the ditch was impervious the outer bank, which is mostly in fill, settled and slid, and if allowed to fall below the water level the overflowing water did considerable damage if not immediately stopped. Moss sod was generally used for repair work. In repairing the large breaks the bottom and sides were built up with soil and then lined with sod. Moss was thoroughly tamped into all holes and crevices in the bottom and then puddled with clay. In repairing the settling bank the sod was cut in rectangular strips and successive layers were placed and tamped as the settling proceeded. In some places this settling and rebuilding continued to such an extent that very little, if any, of the original fill could be seen. At the end of the season the ditch presented an excellent example of construction and will probably be cheaply maintained in the future. The plan is to extend the ditch eventually to a point opposite Mastodon Creek.

The water supplied by this system will be used to hydraulic Mammoth Creek valley for its entire length from Mastodon to Porcupine

Creek. A working head of 500 feet will be available, although at present only about 300 feet is utilized. The water is taken from a ditch in a flume down the hillside to a point about 200 feet below, where it is dumped into a pressure box at the pipe intake.

Mammoth Creek has a very low grade, and in order to overcome this difficulty a plant was installed which is novel in Alaska, but is identical in principle to the one installed on Eagle Creek in 1908. The general plan of operation is as follows: First, a bed-rock drain is excavated to dispose of the water in the cut and to carry away the overlying muck, which is hydraulicked off from the gravels to be handled by the first set-up. A channel is then ground-sluiced back of and above the cut and opposite the hydraulic giants. In this channel substantially constructed sluice boxes (with block riffles), similar in design to those ordinarily used in hydraulicking, are set up with a grade depending on the character of the gravels to be washed. A sheet-iron back stop about 10 feet high is then erected back of and against the boxes. The auriferous gravels are driven directly by the water from the nozzles of the giants against the back stop, from which they drop into the sluice boxes. A gravel incline is formed in front of the boxes by the stream of water as soon as operations are begun, and for this reason the force of the moving gravel is not expended against the sides of the boxes. The water for transporting and washing the gravel, after it is dropped into the boxes, is diverted from the creek about 1 mile above and carried in a ditch to the head of the sluice and after passing through is carried away in the bed-rock drain. The tailings which accumulate at the end of the sluice are "piped" back out of the way by a separate giant set up at any convenient place. It is not ordinarily necessary to operate this giant continuously. The frequency with which the tailings have to be moved depends on the dumping room at the end of the boxes and the rate at which the gravel is being moved. This process does, however, require a quantity of water which should be taken into account in considering the supply necessary for such a system.

This method is especially adapted to working creek deposits with medium depths of gravel, where the slope of the bed rock is insufficient to permit the removal of the tailings by gravity. It has several advantages over elevators. The initial expense is less and the water required is less. No such heavy parts are required, which is an important item, especially in the more remote districts, where transportation is always expensive and often uncertain. The cost of set-ups is not as great and the chances of delay incident to repairs and replacement of parts are no greater than in ordinary hydraulicking.

Eagle Creek.—Eagle Creek, which is formed by the two forks, Mastodon and Miller, rises opposite the headwaters of Mammoth

Creek. It is the extreme head tributary of the North Fork of Birch Creek, and with the exception of its southern fork, Mastodon, is the only tributary of this fork of Birch Creek on which gold has been discovered in sufficient quantities to pay to work by the methods now in vogue. It has been a large producer in the past and has been worked mainly by drifting in winter, but this method has been displaced by others that are more economical. A hydraulic plant, similar to the one on Mammoth Creek, already described, was in operation during practically the entire season of 1909. The operators were favored with more than the average rainfall and its distribution was such that the water supply was kept fairly constant. This system of elevating gravels which is the first of its kind to be installed in Alaska, is said to be an entire success.

In addition to the above operations on Eagle Creek one claim was worked on Mastodon Fork throughout the season by open-cut and pick and shovel methods.

Miller and Independence creeks.—Mining on Miller and Independence creeks during 1909 was of about the same extent as in previous years. Four or five claims on each creek were mined by open-cut methods by two or three men to the claim.

Harrison Creek and tributaries.—Several claims were prospected on the North Fork of Harrison Creek during the summer, and it was reported that some profits were made by open-cut and sluice-box methods. Considerable bodies of auriferous gravel are known to occur on the main creek as well as on the north and south forks, and they are reported to be suitable for hydraulicking. A recent attempt has been made to procure an option on a large number of claims on the creek with a view of installing machinery, and it was rumored that active work was commenced during the latter part of the summer of 1909, but nothing definite is known concerning the project. The first hydraulic plant of the Circle district was installed on the North Fork of Harrison Creek in 1905 and an elevator was used to raise the gravel, but the design did not prove to be suited to the conditions and the water supply was inadequate the greater part of the time. Below the junction of the two forks, however, the location seems to be favorable for obtaining a good water supply under an ample working head by a relatively short ditch line. It is possible that the methods now in use on Mammoth and Eagle creeks could be advantageoulsy used here.

Preacher Creek and tributaries.—Bachelor Creek, which is tributary to Preacher Creek from the south about 10 miles from the head, was the scene of considerable mining activity during the summer of 1909. A ditch was in process of construction along the left bank with the intake a short distance below Costa Fork. The grade of the creek was found to be about 70 feet to the mile, and a hydraulic elevator will be installed to raise the gravels. The gravel deposits are shallow and bed rock is exposed at many places along the creek bottom.

Preacher Creek is said to carry considerable bodies of low-grade gravel near the mouth of Bachelor Creek and they may eventually be worked on a large scale. Loper Creek, which joins Preacher Creek about 20 miles below Bachelor Creek, from the same side, is also known to carry gold and has been prospected for several years in a small way.

Woodchopper Creek.—No information is available concerning the details of mining on Woodchopper Creek, but the total value of the gold output for 1909 was reported at approximately $20,000.

PRODUCTION.

From the scattered reports received, the total value of production in the Circle district for 1909 is estimated at $225,000, which shows an increase of $50,000 over that of 1908, probably due chiefly to a better water supply, although a general trend toward working ground in a more economical and expeditious manner is noticeably in progress in this district.

The estimated annual and total value of gold production in this district since its discovery in 1894 is given in the following table:

Value of production of gold from Circle district.

1894	$10,000	1903	200,000
1895	150,000	1904	200,000
1896	700,000	1905	200,000
1897	500,000	1906	300,000
1898	400,000	1907	200,000
1899	250,000	1908	175,000
1900	250,000	1909	225,000
1901	200,000		
1902	200,000		4,160,000

RAMPART DISTRICT.

MINING CONDITIONS.

General statement.—The Minook-Baker Creek divide roughly separates the Rampart and Hot Springs districts. Until the last two or three years the term Rampart district signified the area now included in both sections, but the rapid increase in production on the south side of the divide warrants the distinction now generally made.

No new enterprises were begun in the Rampart district in 1909. The considerable prospecting which was carried on during the winter of 1908–9 failed to show any new placer areas of importance.

Little Minook Creek.—Little Minook Creek, which still leads in production, has now reached the point where cheaper and more systematic methods of mining will have to be adopted. There is said to be some very rich ground to be worked, which is too deep for open cutting with the present water supply as now used and which can not be worked by drifting because of thawed gravel and underground water channels, which on being tapped soon flood the drift. That part of the creek bed lying below claim "No. 9 above" will no doubt eventually come under the control of one company and be systematically open cut. Some desultory investigations have been made as to the possibilities of obtaining an auxiliary water supply, but the problem is difficult of solution and it would not be surprising if it had to be abandoned and the local supply be made to do as well as possible. It seems proper to remark here that the feasibility of the various plans which have been suggested could be definitely decided once for all by a small expense in surveys, provided the aggregate value of the gold to be obtained thereby is as accurately known as is stated. From 20 to 30 men were mining on the creek during the winter. The gravel was hoisted by windlass. During the summer of 1909 the number of men employed was considerably less. Three automatic dams were operated, when the water supply would permit, to remove the overburden and concentrate the values, which were then shoveled into sluice boxes. During the periods of extreme low water they were very unsatisfactory, the seepage through and about them being about equal to the discharge of the stream. A good wagon road, connecting with the government road at the mouth of the creek, was built by the miners along the right bank as far as "No. 9 above."

Hunter Creek and tributaries.—On Hunter Creek several small dumps were taken out during the winter and some prospecting was done. Two hydraulic plants, one on "No. 18 above" and another on Discovery, were in operation throughout the summer. Both of these plants have been in operation for several years. A rock conveyer to be operated by a Pelton water wheel was shipped to the creek in the summer, but was not set up. Some work was also done on Dawson Creek, a tributary of Hunter Creek from the south, and values were reported. Favorable reports were also current from Miller Creek, a tributary from the north near the mouth.

Hoosier Creek.—On Hoosier Creek one hydraulic plant with an elevator was operated during most of the summer on claim "No. 14 above." The gold was reported to be irregularly distributed, and thorough prospecting was necessary to estimate with any accuracy the value of the ground. Some prospecting was done in the winter, but the results are reported to be not very encouraging.

Little Minook Junior Creek.—Little Minook Junior Creek is known to contain some very rich gravel, but the lack of water or of any economical method of obtaining it prohibits summer work, except such as may be done with a rocker. The melting of the winter accumulation of ice and snow permits the washing of winter dumps for a few days. The work of the last season was of about the same extent as in previous years.

Quail Creek.—Gold was first discovered on Quail Creek in 1898, and nearly every winter since then considerable prospecting has been done, but the gravels have, as a rule, been found to be of too low a tenor to pay to work by hand methods. The last season's work, however, has been exceptionally fruitful in demonstrating what can be done by hand methods. Claims "Nos. 8 and 9 below" and "No. 7 above" were worked by six men by shoveling into sluice boxes. The bench on the left bank opposite claim "No. 9 below" was crosscut and good prospects were reported. The creek promises to become an important producer if capital can be procured for development.

Other creeks.—Some mining was done on Ruby and Slate creeks during the summer. Chapman Creek also shows values sufficient to attract an occasional prospector, and one or two claims which were said to contain values were being developed during the summer. Seven or eight men were seen along the bars of Minook Creek shoveling into boxes or rocking where the bed rock was exposed at the rims. They are reported to have made good wages. Moose Creek and its small tributary, Buckeye Creek, have been generally staked, and while prospecting has shown gold, no values were reported.

PRODUCTION.

Lack of information prevents anything but a very rough estimate of the production of the district for 1909, which is placed at $100,000 and is somewhat in excess of that of 1908, owing to the better water supply.

The estimated value of the gold production in this district previous to 1904 and the annual value since and including 1904 are given in the following table:

Value of production of gold from Rampart district.

Previous to 1904	$616,000	1908	$75,000
1904	90,000	1909	100,000
1905	80,000		
1906	120,000		1,206,000
1907	125,000		

HOT SPRINGS DISTRICT.

MINING CONDITIONS.

General statement.—The value of the gold production from the Hot Springs district in 1909 is estimated at approximately $325,000, which is more than double the estimated output in 1908. The water supply was slightly better, but the increase in production was due mainly to the development of the mines on Sullivan Creek. As there are large bodies of gravel in this district known to contain values, and as prospecting is continually developing new ground, the outlook for the future of the camp is good.

Thanksgiving Creek.—On Thanksgiving Creek the bed-rock flume which was excavated in 1908 was found to have too small a grade to remove the tailings with the small amount of water available and was abandoned this season in favor of an elevated flume. A pole incline to the flume was built opposite the cut and the dirt was hoisted up the incline by a steam scraper, operated by a double-drum hoist. This system gave entire satisfaction when the water was sufficient and required less water than the bed-rock flume. Considerable gold was found in the muck overlying the gravel and a very vigorous washing was necessary to remove it.

Pioneer Creek.—The summer mining on Pioneer Creek was confined mainly to What Cheer Bar and open-cut methods were used. The muck was ground-sluiced off and the gravels were carried to the sluice boxes by a steam shovel supplemented by some pick-and-shovel work. Several winter dumps were taken out by hand methods on the creek and its tributaries.

Eureka Creek.—Extensive open-cut work was in progress on Eureka Creek near the mouth of Boston Creek during the summer of 1909, but the output was greatly curtailed by lack of water. A ditch was constructed in the early summer, which diverts water from Pioneer Creek above Boothby Creek, with the outlet on Eureka Creek a short distance above Boston Creek. The length is 2½ miles, the bottom width 5 feet, and the grade 5 feet to the mile. A few men were sluicing during a part of the summer near claim "No. 14 above." An attempt was made during the winter to obtain artesian water by a churn drill, but after a depth of about 200 feet was reached lack of casing necessitated the suspension of work for the season. It was planned to continue drilling during the winter of 1909–10.

Patterson Creek basin.—Values were located in the Patterson Creek basin on Sullivan Creek just below Tofty Gulch by Messrs. Snyder and Kempter January 1, 1907. Since then pay has been found at several different localities, and by the spring of 1909 a thriving camp was established. The business center, called Tofty, is situated about 1½ miles above Tofty Gulch on the east side of the valley, at the crossing of the Hot Springs-Tanana winter mail trail. Three road houses and several stores are located there and a post-office has been recently established.

The open-cut work on Tofty Gulch was continued during the summer of 1909 and, although progress was frequently retarded by lack of water, about 75,000 square feet of bed rock has been uncovered. The 5 or 6 feet of muck which overlies the gravel was so thoroughly intermixed with small trees and driftwood that great difficulty was experienced in disintegrating the mixture of frozen muck and wood. Dynamite was used to break down the banks and to give a greater area for attack by the sun's rays and water. Steam points were used to pierce the banks for the insertion of dynamite.

Discovery claim and "No. 1 below" have been worked more or less continuously for nearly two years. Considerable excitement was occasioned by the finding of gold on the so-called left-limit bench during the winter of 1908–9 and several steam hoisting plants were installed there. A large number of men were employed and work was actively carried on until the extreme low water of midsummer necessitated its suspension. The Midnight Sun, Abe Lincoln, and Dakota Bar were the principal producing claims. The depth to bed rock varies from 40 to 60 feet. In some places as much as 10 feet of the overlying gravel carries values. The gold, however, appears to be irregularly distributed and no very definite pay streak has yet been traced.

Cache Creek, which unites with Sullivan Creek to form Patterson Creek, has been prospected more or less for several years, but values were first discovered during the winter of 1908–9, near the winter trail crossing about 1 mile from Tofty post-office. Two or three self-dumping steam hoists were soon installed and active mining was at once commenced. The results are reported as satisfactory.

Quartz Creek, one of the headwater streams of Sullivan Creek, carries coarse gold, and open-cut mining has been carried on there for the last two summers. The ground is shallow and is cheaply worked when the water supply will permit.

PRODUCTION.

The estimated value of the gold production in this district previous to 1904 and the annual value since and including 1904 are given in the following table:

Value of production of gold from Hot Springs district.

Previous to 1904	$262,900	1908	$150,000
1904	146,500	1909	325,000
1905	120,000		
1906	180,000		1,359,400
1907	175,000		

FORTYMILE AND EAGLE DISTRICTS.

The Fortymile and Eagle districts were not visited by members of the Survey last year, but the reports from those sections indicate that the season of 1909 was exceptionally prosperous.

Fortymile district.—The results of the work of two dredges on Walker Fork and one on the South Fork of Fortymile River that were successfully operated throughout the season have demonstrated that this form of mining is practicable, notwithstanding the remoteness of the placers, which renders the introduction of heavy machinery very expensive.

The following table, based on information furnished by E. R. Brady, United States commissioner at Jackwade, shows the progress and distribution of work on the principal creeks of the district during 1909:

Mining operations in Fortymile district.

Stream.	Winter, 1908-9.			Summer, 1909.		
	Number of claims.	Number of men.	Production.	Number of claims.	Number of men.	Production.
Walker Fork	10	10	None.	3	30	$130,000
Jackwade Creek	12	40	$25,000	10	35	20,000
Chicken Creek	12	30	10,000	12	30	6,000
Franklin Creek			5,000			5,000
Canyon Creek			None.			5,000

Incomplete reports from Ingle Creek show that substantial results were obtained by winter work. Lilling Gulch, a small tributary of Ingle Creek, was also mined by drifting and open-cut work. On Napoleon Creek the mines were worked by both open cuts and drifting and a relatively large output as compared with previous years was reported.

The value of the production for 1909, estimated at $225,000, indicates a gain of about $75,000 over that of 1908, and the increase is probably due chiefly to the improvement in mining methods.

The estimated value of the gold production in this district previous to 1904 and the annual value since and including 1904 are given in the following table:

Value of production of gold from Fortymile district.

Previous to 1904	$4,000,000	1908	$150,000
1904	307,000	1909	225,000
1905	256,000		
1906	204,000		5,282,000
1907	140,000		

Eagle district.—In the Eagle district American Creek was probably the principal producer, but some mining was also done on Crooked and Barney creeks and Seventymile River. A total gold output of about $25,000 was reported.

SALCHAKET-TENDERFOOT DISTRICT.

MINING CONDITIONS.

Tenderfoot and Banner creeks.—Tenderfoot Creek, which probably leads the Salchaket-Tenderfoot district in point of output and has been the best producer in the past, is now conceded to be about worked out. Mining on this creek was actively carried on during the winter of 1908–9, but in the early summer operations commenced to decline and by the middle of July only a few mines were in operation.

The above statement applies equally well to Banner Creek and its tributaries. After the winter dumps were washed work was discontinued on all but one or two claims. Democrat Creek, a small tributary of Banner Creek, was an important producer.

Salchaket basin.—In the Salchaket basin prospecting has been carried on for several years with indifferent results. Caribou and Butte creeks have received the major portion of the work and have rather uniformly shown values sufficient to warrant further prospecting.

During 1909 Caribou Creek has come to the front as a producer and considerable local enthusiasm has been aroused by the results. Values are reported on two or three claims, and although a well-defined pay streak has not been traced it is believed that further work will prove that one exists. Some machinery has been installed and it is understood that some minor ditch work has been accomplished. Drifting is accompanied by difficulties because of the thawed ground. Although the depth to bed rock averages about 30 feet, open-cut methods have been adopted in part.

Several men were prospecting on Redmond Creek during the winter of 1908–9, and during the last summer two of the men continued prospecting near the mouth of Mosquito Fork. There the depth to bed rock is said to be from 40 to 50 feet and sufficient prospects to indicate the proximity of a pay streak were reported.

PRODUCTION.

Very little information is available showing the progress of work in this section for 1909. From the few reports that have been received, the output is estimated at $150,000, which is a decided decrease from that of 1908.

The estimated annual and total values of gold production in this district since its discovery in 1905 are given in the following table:

Value of production of gold from Salchaket-Tenderfoot district.

1905	Prospects.
1906	$100,000
1907	375,000
1908	375,000
1909	150,000
	1,000,000

OCCURRENCE OF WOLFRAMITE AND CASSITERITE IN THE GOLD PLACERS OF DEADWOOD CREEK, BIRCH CREEK DISTRICT.

By BERTRAND L. JOHNSON.

INTRODUCTION.

The known occurrences of tungsten and tin minerals in the Yukon-Tanana region are restricted to the Fairbanks, Hot Springs, and Birch Creek districts. Wolframite[a] (a manganese-iron tungstate, $(FeMn)WO_4$) was first recognized in this region in 1908 in concentrates from the gold placers of Deadwood Creek, in the Birch Creek district, and later in the auriferous concentrates from the placers on Fairbanks and Little Eldorado creeks, in the Fairbanks district. Cassiterite (tin dioxide, SnO_2) was found in concentrates from Cleary Creek, in the Fairbanks district, in 1904. It has since been found on Twin and Eldorado creeks, in the Fairbanks district, and also in the Hot Springs district. Recently it was identified in concentrates from Mastodon Creek, in the Birch Creek district, and also in association with the wolframite at the Deadwood Creek locality. In June, 1909, a Survey party visited Deadwood Creek, and the following description is based on the data obtained by the writer at that time.

GEOGRAPHY.

Deadwood Creek rises in the long line of hills culminating in Mastodon and Porcupine domes and flows northeastward to its junction with Crooked Creek, 30 miles southwest of Circle. It is 15 miles in length. The upper 10 miles of its course lies within the hills, where the narrow valley is bordered by long level-topped ridges 2,000 feet above the stream. The lower portion of the valley merges gradually with the low, level alluvial flats of Crooked Creek. Switch Creek is the most important tributary. Through most of its course Deadwood Creek flows close to the steep east side of the valley. There is

[a] The tungsten minerals used as ores are hübnerite, a tungstate of manganese; wolframite, a tungstate of iron and manganese; ferberite, a tungstate of iron; and scheelite, calcium tungstate. The first three minerals grade into one another, and a chemical analysis is necessary for an exact determination of the mineral species. The MnO content of this group ranges from zero in pure ferberite to 23.4 per cent in pure hübnerite. The intermediate members of this series, with a MnO content of 3 to 15 per cent approximately, are usually considered as wolframite. A recent determination made in the chemical laboratory of the United States Geological Survey shows the tungsten mineral occurring in the Deadwood Creek placers to contain 7.3 per cent of MnO, and it is therefore referred to in this report as wolframite.

a well-defined, gravel-covered, rock-cut bench on the west side of the valley, approximately one-half mile in width, rising gradually toward the west from 75 to 200 feet above the stream. Poorly defined gravel benches occur at lower levels.

The supplies for this creek are brought from Circle. During the summer of 1909 the government wagon road from Circle was extended to the Central House, on Crooked Creek. From Central House the Deadwood Creek trail is passable for wagons as far as the mouth of Switch Creek. The rates for freighting are 10 to 15 cents a pound in the summer and 2 to 3 cents a pound in the winter.

GEOLOGY.

The bed rock consists of closely folded metamorphic rocks, principally of sedimentary origin and regarded as pre-Ordovician in age, and an intrusive granite. Quartzite schists and quartz-mica schists predominate, but carbonaceous, greenstone, and chloritic schists are present. Sulphides and magnetite occur, disseminated throughout the metamorphic rocks, and may have resulted from the metamorphism of the original sediments, or may have been subsequently introduced at the time of the granitic intrusion. The schists are garnetiferous in places. Exposures of the granite were observed at four localities in the vicinity of the tungsten placers. (See fig. 5.) The rock is a light-colored porphyritic biotite granite, with abundant feldspar phenocrysts. The age of the intrusion of the granite mass is not known. The nearest similar intrusive rocks whose age is rather definitely determined are those of the Rampart region, where Upper Cretaceous rocks have been intruded.

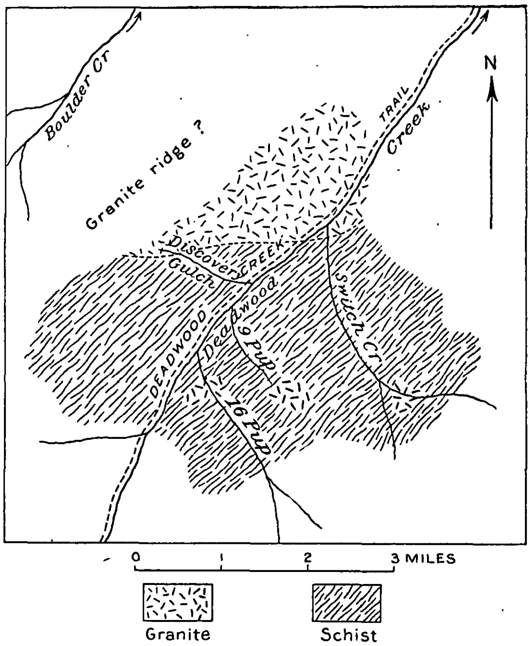

FIGURE 5.—Geologic sketch map of Deadwood Creek.

Numerous quartz veins are found in the metamorphic rocks. These veins vary considerably in size, ranging from a fraction of an inch to several feet in width, though most of them are but a few inches wide. A few small quartz veins were seen, which were closely folded with the inclosing schists. Most of the veins, however, cut across the foliation of the schists, are not folded, and are therefore younger than the regional metamorphism which produced the schists. They were probably formed during the final stages of the consolidation of the intrusive granite mass. The rusty appearance of a few of these later quartz veins indicates the former presence of sulphides, but the greater number of the veins show no surface signs of mineralization. Numerous bowlders showing feldspar-bearing quartz veins cutting schist can be seen in the creek gravels. Arsenopyrite occurs in association with these quartz-feldspar veins, especially on Switch Creek. On Deadwood Creek wolframite pebbles with mica and quartz attached have been found in the placers. Fragments of schist containing gold-bearing quartz veins have been found in the Birch Creek region, and gold nuggets with attached vein quartz have been found on many of the claims on Deadwood and Switch creeks. Mineralized fracture zones permeated by quartz stringers carrying pyrite and galena have been found in the schists on the upper part of Deadwood Creek.

The unconsolidated deposits of the area are divisible into creek and bench gravels. The creek gravels are distributed over a stream flat several hundred feet wide. The depth to bed rock varies in the creek bed from 3 to 12 feet, and on the high bench to the west from 6 to 20 feet. The gravels in both localities are composed of the varieties of rocks outcropping within the drainage area of the creek. They consist of subangular fragments, mostly under a foot in diameter, irregularly arranged, and containing much fine material.

OCCURRENCE OF THE WOLFRAMITE AND CASSITERITE.

No exposures of the wolframite or cassiterite in place were seen. A small wolframite-bearing vein was reported to have been found in a prospect hole sunk while prospecting the high-bench gravels for gold, on the high bench west of Deadwood Creek, near the junction of Deadwood Creek and Discovery Gulch.[a] At the time of the writer's visit this prospect hole had caved in and was filled with water. No wolframite could be found on the dump.

Wolframite and cassiterite occur most abundantly in the placer gravels of Deadwood Creek a short distance below the mouth of Discovery Gulch. Concentrates collected from the sluice boxes here are composed principally of these two minerals. Placer wolframite is also reported from Discovery Gulch. It is not known to occur in the stream gravels of Deadwood Creek above the mouth of this gulch, nor has any been detected in the examinations of the concentrates

[a] The name Discovery Gulch is used to designate the small gulch which enters Deadwood Creek from the west near "Discovery Deadwood," about 1 mile above the mouth of Switch Creek.

collected above this point. It is not known whether these minerals are present in the high bench gravels. The placer wolframite is found on all the creek claims on Deadwood Creek for at least 4 miles below Discovery Gulch, but it is not as plentiful on the lower claims as above the mouth of Switch Creek. The coarsest and most abundant wolframite and cassiterite are found on the west side of Deadwood Creek, a short distance below Discovery claim. The wolframite occurs in waterworn cleavage fragments, with slightly rounded edges. The color and streak are both dark brown. The largest piece seen measured 1.7 by 0.8 by 0.8 inches, but pieces three times as large as this are reported to have been found. The largest piece of cassiterite observed in the concentrates measured 1 by $\frac{3}{4}$ by $\frac{1}{2}$ inch. Most of the concentrates collected, however, passed through an 8-mesh sieve.

Concentrates from several claims on Deadwood and Switch creeks were examined. Associated with the gold in the concentrates were found wolframite, cassiterite, magnetite, ilmenite, arsenopyrite, pyrite, galena, limonite, garnet, tourmaline, and quartz. Wolframite was not detected in the Switch Creek concentrates. Cassiterite was found in all the concentrates examined, but most abundantly in those from Deadwood Creek between Discovery Gulch and Switch Creek. Magnetite was very abundant in the Deadwood Creek concentrates, but nearly absent from those collected on Switch Creek. The sulphides—arsenopyrite, pyrite, and galena—were found principally on Switch Creek.

VALUE OF PLACER TIN AND TUNGSTEN OF DEADWOOD CREEK.

The best data available at present indicate that where the wolframite and cassiterite are found most abundantly in the stream gravels they will yield an average of 1 to 2 pounds of concentrates (principally wolframite and cassiterite with some magnetite and garnet) per cubic yard of gravel. Labor at present on this creek costs $8 a day, provided the miner boards himself. The average amount of dirt moved per day per man during the open season is approximately 4 cubic yards. To meet expenses alone this would require that the gravel have a value of $2 a cubic yard. Were the concentrates entirely of wolframite and cassiterite, without gold or impurities, their value under present conditions would probably not exceed 50 cents per cubic yard of gravel, so that the value of the concentrates obtained per day would be only about $2. This would not cover the expense of working these gravels for wolframite and cassiterite alone by the methods now in use on the creek, but as the gold caught in the sluice boxes more than pays expenses, the wolframite and cassiterite in the concentrates, if saved and sold, would represent an additional profit. Tin, however, is treated as a very serious impurity in tungsten ores, and it is hard to say how such ores would be received, although the two minerals can readily be separated by electro-magnetic methods.

Tungsten ores are now selling at about $6.25 a unit (the unit being 1 per cent, 20 pounds per ton of ore, of tungsten trioxide) for ore running 60 per cent or more of tungsten trioxide. A 60 per cent ore at this rate is worth about $375 a ton, or, as a more convenient basis for figuring, about 18¾ cents a pound.

Pure cassiterite (SnO_2) containing 78.6 per cent of tin would, at the present market price of tin, 32⅞ cents a pound, be worth approximately 26 cents a pound.

CONCLUSIONS.

Tungsten and tin minerals are generally confined to quartz veins and pegmatites associated with granitic rocks. As a rule, the veins cut the igneous rocks, but they are also found penetrating adjacent sedimentary or metamorphic rocks. Their common occurrence in regions where auriferous quartz veins are abundant is worthy of notice. These tungsten and tin bearing quartz veins are supposed to have been formed during the final stages of the cooling and consolidation of intrusive granitic magmas, the mineralized solutions and vapors given off at that time filling the cracks and fissures due to the contraction of the cooling mass.

The wolframite and cassiterite found in the placer gravels of Deadwood Creek are probably derived from the quartz veins which cut the granites and schists of the region. Veins carrying these minerals may occur anywhere within the area of influence of the granitic intrusives or within the granitic rocks themselves.

Regarding the prospective economic importance of the occurrences of these minerals in bed rock nothing definite can be said. The occurrence of cassiterite in the concentrates is more widespread than that of wolframite, and the cassiterite-bearing veins are probably the more numerous. A study of the concentrates collected on Deadwood and Switch creeks indicates a decided localization of cassiterite and wolframite in the Deadwood Creek placers in the vicinity of Discovery Gulch, and in this region the wolframite-bearing veins probably occur. It appears probable, also, that both cassiterite and wolframite will be found in the same veins.

WATER SUPPLY OF THE YUKON-TANANA REGION, 1909.

By C. E. Ellsworth.

INTRODUCTION.

A systematic investigation of the water supply in the Fairbanks district was begun in 1907 by C. C. Covert,[a] of the United States Geological Survey. Although daily records were kept on several streams in the Fairbanks district, the work was mainly of a reconnaissance nature, preliminary to a more detailed study of the available water supply from the drainage areas contiguous to the various mining sections in the Yukon-Tanana region.

In 1908[b] the work was continued by C. C. Covert and the writer and extended to the Circle and Rampart districts. Daily records were kept on all streams where observers could be obtained, and estimates of daily flow have been made.

In 1909 similar work was done in this region by the writer, and the object of this report is to present the results of the season's work in as comprehensive a form as the space will permit. Those interested in the water supply of these districts should also consult the reports already referred to, which have been freely quoted in the preparation of this report.

The writer arrived at Fairbanks April 1, and until the early part of May spent the time chiefly in making preparations for the work of the summer. The object in view was to continue as many of the 1908 stations as possible. It was found necessary to discontinue several of the old stations, but a few new ones were established. Two trips were made up Tanana River as far as McCartys, in addition to the work in the Fairbanks, Rampart, and Circle districts. The records cover the period from April 20 to October 6. Estimates of daily discharge from an area of about 5,000 square miles have been made, and about 400 square miles of this area was studied in detail.

Acknowledgments are due to many residents of the region for courtesies extended and aid given to the work. Special acknowledgments for those supplying gage readings are due to the Bachelor

[a] Henshaw, F. F., and Covert, C. C., Water-supply investigations in Alaska, 1906–7: Water-Supply Paper U. S. Geol. Survey No. 218, 1908.

[b] Covert, C. C., and Ellsworth, C. E., Water-supply investigations in the Yukon-Tanana region, Alaska, 1907–8: Water-Supply Paper U. S. Geol. Survey No. 228, 1909.

Creek Mining Company, the Mammoth Creek Mining Company, the Tofty Gulch Mining Company, and Messrs. W. H. Bayless, C. F. W. Cassidy, James Climie, Dave Currier, F. E. Diver, James Fitzsimmons, Alfred Johnson, J. F. Kelley, M. E. Koonce, J. A. Laird, J. W. McCluskey, Wm. Mosiman, W. F. Munson, Charles Nelson, C. R. Rieger, Peter Ryden, Joseph Sanders, A. F. Stowe, and S. M. Wheeler.

CONDITIONS AFFECTING WATER SUPPLY.

Precipitation in the form of rain or snow is primarily the source of all water supply. In the Yukon-Tanana region the chief factor influencing the distribution of this supply is the imperviousness of the frozen ground, which prevents any considerable underground storage, and consequently makes impossible a uniform distribution of the total run-off. In warmer climates the main source of supply for most of the streams during the low-water periods is derived from that portion of the rainfall and melting snow which seeps into the ground and slowly percolates through until it finally joins the surface watercourses again at a lower elevation. That process, however, is relatively insignificant in this latitude for the reasons above set forth.

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

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

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

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

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

PRECIPITATION.

The precipitation records during the mining season of 1909 show that at Circle and Kechumstuk the rainfall was considerably above the average. At Fairbanks there was a slight increase over the mean, and at Rampart and Fort Egbert there was a small decrease. At all the stations, however, with the exception of Fort Egbert, there was a marked increase over the rainfall of 1908.

Although there is a wide difference from month to month and from year to year in the rainfall at the various stations in the Yukon-Tanana region, the mean yearly precipitation at each station for the period covered by the records is uniformly close to the average of the means of all the stations. In other words, the records show no uniform difference in precipitation throughout this area.

The following table gives the monthly precipitation at all points in the Yukon-Tanana region where records have been kept subsequent to 1903. Such scattered records as were kept previous to 1903 have been compiled by Abbe.[a]

Monthly precipitation, in inches, at stations in Yukon-Tanana region, 1903–1909.

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

Station.	Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Central	1906	0.50	0.06	0.05	0.47	0.86	4.91	4.82	1.85	0.52	0.70	0.80	0.35	15.95
		6.1	1.0	1.4	1.7	2.0	......	......	......	......	7.0	8.0	4.0	34.2
Do	1907	1.04	.42	2.57	.93	.57	2.21	1.40	......	......	......	......	......	......
		10.0	4.0	24.0	3.0	1.5	......	......	......	......	......	......	......	......
Circle	1906	......	......	......	......	......	......	......	......	......	......	......	.75	......
		......	......	......	......	......	......	......	......	......	......	......	9.5	......
Do	1907	1.02	.57	.28	.15	.29	......	1.36	2.79	1.73	......	......	.63	......
		8.5	7.8	3.25	......	......	......	......	......	......	......	......	8.2	......
Do	1908	1.23	.25	.76	1.45	.29	.20	.87	1.08	2.21	.40	.75	1.11	10.60
		9.2	2.5	6.8	8.0	......	......	......	......	......	3.0	8.5	11.2	51.2
Do	1909	.44	.47	.17	.75	.60	2.24	3.25	1.02	......	......	......	......	......
		4.5	5.2	1.0	3.0	......	......	......	......	......	......	......	......	......
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	......	......	......	......	......

[a] Abbe, Cleveland, jr., Prof. Paper U. S. Geol. Survey No. 45, 1906, pp. 189-200.

Monthly precipitation, in inches, at stations in Yukon-Tanana region, 1903–1909—Cont'd.

Station.	Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Fairbanks	1904	......	......	......	......	......	......	......	......	......	......	1.10	2.00	......
Do	1905	.92	.50	.05	.20	......	......	......	2.63	.86	......	1.20	.60	......
		9.1	5.0	.5	2.0	......	......	......	......	......	......	12.0	5.1	......
Do	1906	1.75	.37	.33	.10	.36	1.05	2.82	1.50	.25	.30	.65	1.15	10.63
		17.5	3.7	3.3	1.0	......	......	......	......	......	.6	6.5	11.5	44.1
Do	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	1.10	.11	.52	.96	.73	.71	.15	.47	.51	.65	6.54
		4.2	2.1	11.0	.8	......	......	......	......	......	......	......	8.1	26.2
Do	1909	.90	.08	.05	.66	.38	1.64	1.90	......	.39	.80	.52	......	......
Faith Creek	1907	......	......	......	......	......	......	1.87	3.00	2.97	......	......	......	......
Fort Egbert	1903	.58	.81	.54	.12	1.38	.57	2.40	.97	2.97	......	......	......	......
Do	1905	......	......	......	......	.33	1.95	1.52	2.72	3.38	2.96	.93	.68	......
Do	1906	......	.14	2.19	.00	.54	.51	2.54	1.28	.01	1.71	.51	.07	......
		......	1.0	11.0	......	......	......	......	......	......	.46	8.5	1.0	......
Do	1907	1.45	.21	......	.25	.40	1.89	1.48	1.98	1.45	1.12	.40	......	......
		2.0	2.0	......	.15	.55	......	......	......	......	13.0	4.0	......	......
Do	1908	.12	.25	.75	.10	......	2.16	2.47	1.02	1.48	.18	.82	1.09	......
		3.0	2.5	7.5	1.0	......	......	......	......	......	6.0	7.0	11.0	......
Do	1909	.16	.07	.11	.34	.28	2.35	1.77	.95	......	......	......	......	......
		2.0	1.0	1.0	2.0	......	......	......	......	......	......	......	......	......
Fort Gibbon	1903	.37	.73	1.14	.23	.16	.38	1.76	......	.48	.22	.33	Tr.	......
Do	1904	.08	.55	.35	.09	.22	.33	1.95	3.80	.35	.39	.07	.70	8.88
Do	1905	.37	.47	Tr.	......	.84	1.50	4.90	3.02	......	......	1.10	.18	......
Do	1906	.65	.20	.30	Tr.	1.00	......	......	......	......	[a].50	.99	.27	......
		6.0	2.0	3.0	......	......	......	......	......	......	[a]5.0	9.9	2.7	......
Do	1907	1.26	......	.53	......	.30	......	2.58	2.31	2.32	1.22	.03	......	......
		12.6	......	5.0	......	......	......	......	......	4.0	12.0	1.5	......	......
Do	1908	.23	.26	.90	0	1.16	......	.96	1.13	1.60	.45	......	.60	......
		4.0	6.0	17.0	0	......	......	......	......	2.25	6.0	......	6.5	......
Do	1909	.05	.10	.37	......	......	......	......	......	......	......	......	......	......
		.5	.5	......	......	......	......	......	......	......	......	......	......	......
Kechumstuk	1904	......	......	......	......	1.80	.83	2.23	.94	.64	.30	.03	.23	......
Do	1905	.90	.10	.05	.40	.20	1.58	.40	1.48	2.16	1.18	.36	.20	9.01
Do	1906	.36	.05	.06	.27	1.69	1.61	3.25	2.51	.51	.31	.29	.20	11.11
		4.0	.5	1.0	5.0	......	......	......	......	......	4.3	.5	3.0	18.3
Do	1907	.12	.20	.27	Tr.	1.30	2.03	1.60	2.14	.49	.72	.40	......	......
		2.0	3.0	4.0	......	12.0	......	......	......	2.0	9.0	4.0	......	......
Do	1908	0	0	.41	.40	1.78	1.77	2.30	2.22	1.35	......	.90	.20	......
		0	0	5.0	4.0	......	......	......	......	......	......	9.0	2.0	......
Do	1909	0	.30	.10	.20	0	3.66	3.39	......	......	......	......	......	......
		0	.5	1.0	......	0	......	......	......	......	......	......	......	......
Miller House	1909	......	......	......	......	......	......	2.98	1.26	.60	.93	.30	......	......
		......	......	......	......	......	......	......	......	4.0	8.0	3.0	......	......
North Fork	1905	......	......	......	......	......	......	......	1.91	1.86	......	.50	.20	......
Do	1906	.70	.50	.10	.80	1.98	2.74	2.69	1.01	.72	.42	.55	.38	12.59
		7.0	5.0	1.0	8.0	......	......	......	......	......	3.2	4.5	4.5	33.2
Do	1907	.69	.28	.27	Tr.	1.34	1.92	1.57	3.19	2.0	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	1.09	......
		......	......	......	......	......	......	......	......	......	24.0	3.3	6.8	......
Do	1908	......	1.32	......	.42	.58	1.80	2.02	.99	2.45	.75	.35	.61	......
		......	10.5	......	5.0	......	......	......	......	4.5	6.9	4.4	12.6	......
Do	1909	.68	.09	.03	......	......	......	......	......	......	......	......	......	......
		8.8	2.0	.5	......	......	......	......	......	......	......	......	......	......
Rampart	1905	......	......	......	......	......	1.33	1.99	2.19	1.70	1.20	1.43	.33	......
Do	1906	.63	.08	.17	.04	.40	.15	1.86	2.40	.59	.61	.95	.33	8.21
		7.2	2.0	1.8	.5	......	......	......	......	......	......	10.2	3.5	25.2
Do	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	.73	1.14	......
		11.5	6.9	8.1	......	......	......	......	......	......	5.1	3.6	16.8	......
Do	1909	.09	.10	.37	.51	1.04	.85	2.01	1.41	.36	......	.35	......	......
		1.4	1.2	6.2	5.6	......	......	......	......	1.5	......	3.6	......	......
Summit road house	1907	......	......	......	......	......	......	2.71	3.27	[b]3.33	......	......	......	......
Tanana Crossing	1904	......	......	......	......	.76	......	.78	.89	1.06	.15	.10	.90	......
Do	1905	.24	.08	.18	.00	.14	......	.37	2.95	......	1.40	.60	......	......
Do	1906	.30	.00	Tr.	......	......	......	......	......	......	......	......	......	......

[a] October 7 to 31.

[b] September 1 to 22.

Precipitation records for May to August, inclusive, at various points in the Yukon-Tanana region may be summarized as follows:

Summary of precipitation in Yukon-Tanana region.

Station.	Maximum.		Minimum.		Mean, inches.	Duration of records.
	Inches.	Year.	Inches.	Year.		
Circle	7.11	1909	2.44	1908	5.07	1907–1909
Fairbanks	5.73	1906	2.92	1908	4.76	1906–1909
Rampart	7.75	1907	3.79	1908	5.57	1905–1909
Fort Egbert	6.52	1905	4.87	1906	5.68	1903, 1905–1909
Fort Gibbon	10.26	1905	3.30	1904	5.76	1903–1908
Kechumstuk	9.06	1906	3.66	1905	7.10	1904–1909

The table above shows that a total precipitation as high as 10.26 inches and as low as 2.44 inches has occurred during the mining season.

HYDRAULIC DEVELOPMENT.

During the season of 1909 several small ditches were completed and others were commenced, but no large development was undertaken. For the last three years the country has experienced such a drought that the outlook for a successful venture in water-power development or gravity system of supply by any new ditch construction was discouraging. Nearly all the areas that are now being worked by hydraulic methods or that will be worked by plants under construction are creek deposits with a shallow depth of gold-bearing gravel. Very few bench deposits are known and the gradients of the bed rock underlying the creek deposits are invariably too low to permit hydraulicking without elevating the gravel. It requires about twice as much water to operate the elevator as it does to deliver the material to it. As a result the demand frequently exceeds the supply during the low-water periods and operations have to cease until there is a rain. Natural reservoir sites at a suitable elevation with a sufficient drainage area are lacking and the expense of constructing large dams is prohibitive.

The method now being tried on Eagle and Mammoth creeks, in the Circle district (see p. 237), may prove to be better suited to the conditions prevailing in the interior of Alaska than elevators. In the vicinity of nearly all the camps an ample supply of water is available at a lower elevation than the mines and can be brought to them only by pumping. Experience has shown that in nearly every instance where pumping water for placer mining has been tried, unless unusually economical means of developing power were possible, the costs were prohibitive. The total value of the gold to be removed through the agency of a certain system of water supply or power must be balanced against the cost of installation as well as operating expenses, for as soon as the gold is worked out the plant is practically valueless.

The development of electricity and its transmission to the mines in the Fairbanks district for pumping, operating dredges, and the various other uses to which it might be put has been under consideration for the last three years. Records were kept on Chatanika and Little Chena rivers during 1907 and 1908, and on Washington Creek during 1908, to determine the horsepower that might be developed from these streams.[a] Stream flow is known to vary greatly from year to year and these records do not cover a period long enough to permit the extremes to be predicted, but they are of sufficient duration to enable the engineer to determine if more extensive investigations are warranted.

The Circle district has shown the greatest activity in hydraulic development (see pp. 234–239) of all the mining sections visited by the writer. It is too early to predict the success or failure of the ventures, but it is hoped that some method may be devised whereby the working of low-grade ground may be put on a paying basis. The days of the bonanzas are numbered unless new ones are discovered and the future of the camp must soon come to depend on working ground of low tenor on a large scale.

Very little was accomplished in hydraulic development in the Rampart district during the last season. Few if any of the mines have an adequate supply of water after the middle of June except for a short time after a rain, and the problem of increasing that supply has been much discussed among the mine owners and operators. The records of stream flow for the last two seasons show that the country has a low summer run-off, and this evidence, combined with the comparatively high elevation at which the mines are located, should be sufficient to check any hasty expenditure in new ditch construction.

On the north side of the Yukon-Tanana divide Little Minook and Little Minook Junior creeks have drainage areas so small that it is with the utmost difficulty that anything is accomplished during the summer. Even the washing of winter dumps during the spring run-off has to be carried on as rapidly as possible in order to clean them up before the low-water season commences. Minook Creek has been and is still to some extent considered as a possible source of relief. However, an examination of the discharge measurements that have been made during the last two years and a careful consideration of the elevation at which the water would have to be diverted in order to be carried to the mines by gravity indicate that this stream should no longer be considered in a favorable light. There is no doubt that an adequate supply of water is available for pumping, but it is very

[a] Water-supply investigations in the Yukon-Tanana region, Alaska, 1907 and 1908: Water-Supply Paper U. S. Geol. Survey No. 228, 1909, p. 100.

doubtful if such a method would prove profitable in view of the small quantity of gravel to be moved and the high cost of power.

On the south side of the divide, in the Hot Springs section of the Rampart district, the mines are more poorly supplied with water and the possibilities of increasing it are small. The developments in this section are described on pages 241–243.

Any remarks that seem unfavorable to hydraulic mining are not made with the intention of discouraging such methods but rather of encouraging a more careful investigation of the water supply and other factors necessary for the success of such a project.

MISCELLANEOUS MEASUREMENTS.

A great many miscellaneous measurements were made during the season of 1909 at points where it was impracticable to attempt to procure daily records.

A comparison of the run-off per square mile at the various points where daily records were obtained shows a general trend of similarity, but the daily variations and in some cases the monthly departures from the average are so great that extreme care should be used in making any estimates from these measurements.

The season was characterized by extreme fluctuations in the stage of the streams, a fact which renders these miscellaneous data far more uncertain than those obtained during 1907–8, when a more uniform flow was maintained during the summer.

EXPLANATION OF DATA AND METHODS.

The methods of carrying on the work and collecting the data were essentially the same as those previously used for similar work,[a] but were adapted to the special conditions found in Alaska.

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

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

[a] See Water-Supply Papers U. S. Geol. Survey Nos. 94, 95, and 201.

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

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

"Acre-foot" is equivalent to 43,560 cubic feet and is the quantity required to cover an acre to the depth of 1 foot. It is commonly used in connection with storage problems.

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

The determination of the quantity of water flowing past a certain section of a stream at a given time is termed a "discharge measurement." The quantity is the product of two factors—the mean velocity and the area of the cross section. The mean velocity is a function of surface slope, wetted perimeter, roughness of bed, and the channel conditions at, above, and below the gaging station. The area depends on the contour of the bed and the fluctuations of the surface. The two principal ways of measuring the velocity of a stream are by floats and current meters.

All measurements by the engineers of the Survey were made with the current meter, but as float measurements can readily be made by the prospector, the method is described below.

The floats in common use are the surface, subsurface, and tube or rod floats. A corked bottle with a flag in the top and weighted at the bottom makes one of the most satisfactory surface floats, as it is affected but little by wind. In flood measurements good results can be obtained by observing the velocity of floating cakes of ice or débris. In all surface-float measurements the observed velocity must be multiplied by 0.85 to 0.90 to reduce it to the mean velocity. The subsurface and tube or rod floats are intended to give directly the mean velocity in the vertical. Tubes give excellent results when the channel conditions are good, as in canals.

In measuring velocity by a float, observation is made of the time taken by the float to pass over the "run"—a selected stretch of river from 50 to 200 feet long. In each discharge measurement a large number of velocity determinations are made at different points across the stream, and from these observations the mean velocity for the whole section is determined.

The area used in float measurements is the mean of the areas at the two ends of the run and at several intermediate sections.

FAIRBANKS DISTRICT.

DESCRIPTION.

The area known as the Fairbanks district extends about 60 miles to the north of Fairbanks and is from 40 to 50 miles wide. The greater part of the region lies in the lower Tanana basin, but a portion to the northwest drains directly to the Yukon. Generally speaking, the district embraces three divisions—a low, broad alluvial plain, a moderately high plateau, and a mountain mass.

The low, broad plain forms the bottom lands of the lower Tanana Valley, which in this section is divided into several parts by the Tanana and its sloughlike channels. The main slough starts near the mouth of Salcha River, about 30 miles above Fairbanks, where it diverts a portion of the Tanana waters. Its course is along the foothills of the plateau to the north, and it receives Chena River about 7 miles above Fairbanks. The plain is swampy and is well covered with timber along the banks of the streams. In the vicinity of Fairbanks it has a general elevation of about 500 feet above sea level.

The plateau is drained by streams tributary to Tanana River, which flow through rather broad, unsymmetrical valleys and most of which extend in a northeast-southwest direction. Their bottom lands range in elevation from 500 to over 2,000 feet above sea level, and the dividing ridges are in general 2,000 to 3,000 feet above the stream beds. That portion of the plateau which comes under discussion in this report is drained principally by Little Chena and Chatanika rivers. The upper region of these drainage basins is crosscut by a zigzag range, which separates the Yukon from the Tanana drainage.

The mountain mass north of this plateau forms what might be termed the apex of the divide between the Tanana and the Yukon drainage basins, its highest points reach altitudes 4,000 to 5,000 feet above sea level, and its corrugated slopes are drained principally by tributaries to Yukon River.

All drainage areas tributary to the Tanana are similar in character. The streams have little slope except near their source and flow over wide gravelly beds in shifting and tortuous courses, keeping to one side of the valley. Most of the channels have rather steep banks that form approaches to broad, level bottom lands which extend 1,000 to 4,000 feet or more before they meet the abrupt slopes of the dividing ridges. The drainage basins are 4 to 15 miles wide and are cut up by small tributary streams that flow through deep and narrow ravines.

A large portion of the area is covered with a thick turf, known as tundra, which is wet, spongy, and mossy and ranges in thickness from 6 inches to 2 feet. In some localities this is meadow-like, producing a rank growth of grass and a variety of beautiful wild flowers. Ground ice is found beneath this tundra in many places, particularly on the northern slopes, where the scanty soil supports little timber or other vegetation. The soil of the southern slopes is, for the most part, gravelly clay, underlain by a mica schist which affords suitable ground for ditch construction. When stripped of its mossy covering and exposed to the sun it thaws rapidly, so that the plow and scraper can be used to advantage.

Above altitudes of 2,000 to 2,200 feet practically the only vegetation is a scrubby, bushy growth which attains a height of 2 to 4 feet. In general the country below this altitude is timbered by spruce and birch, with scattered patches of tamarack and willow along the banks of the smaller streams. The timber increases in density and size toward the river bottoms, where the prevailing growth is spruce, much of which attains a diameter of 18 to 24 inches.

The Fairbanks mining district lies between Little Chena and Chatanika rivers. It embraces an area of about 500 square miles and extends 30 miles north of Fairbanks, which is situated on Chena Slough nearly 12 miles above its confluence with the Tanana. Most of the producing creeks rise in a high rocky ridge, of which Pedro Dome, with an elevation of about 2,500 feet, is the center. At least half of the mines are located at an elevation of over 800 feet, and 25 per cent are over 1,000 feet above sea level.

GAGING STATIONS.

The following list gives the points in the Fairbanks district at which gages were established or discharge measurements made in 1909:

Gaging stations in Fairbanks district, 1909.

Chatanika River drainage basin:
- Chatanika River near Faith Creek.
- Chatanika River below Poker Creek.
- Homestake Creek at mouth.
- Charity Creek below Homestake Creek.
- Charity Creek at mouth
- Hope Creek at mouth.
- Faith Creek at mouth.
- Smith Creek at mouth.

Chatanika River drainage basin—Continued.
- Pool Creek at mouth.
- McManus Creek above Smith Creek.
- Sourdough Creek at mouth.
- Cassiar Creek at mouth.
- Flat Creek below 3d Pup.
- Flat Creek below 1st Pup.
- Kokomo Creek above Rusty Gold Creek.
- Cleary Creek above Wolf Creek.
- Chatham Creek at mouth.
- Wolf Creek at mouth.

Goldstream Creek drainage basin:
- Fox Creek 1 mile above mouth.

Little Chena River drainage basin:
- Fish Creek above Fairbanks Creek.

CHATANIKA RIVER DRAINAGE BASIN.

Chatanika River is formed by the junction of Faith and McManus creeks, which drain the high ridge constituting the divide between the lower Tanana and Yukon basins. The river flows southwestward, in a winding course, through a long and rather narrow valley, and unites with the Tolovana from the east about 30 miles above the confluence of that stream with the Tanana. Its course lies mostly to the west side of the valley, which is from half a mile to 7 miles wide and about 80 miles long. The drainage area of the river above its mouth is approximately 1,300 square miles.

From the junction of Faith and McManus creeks the stream has a shifting, gravelly bottom. In low and medium stages it flows in a series of pools and rapids in a channel 75 to 200 feet wide; during the high-water period it may spread through several channels covering a width of 100 to 400 feet. This high-water channel is usually well defined by steep, alluvial banks ranging from 8 to 10 feet in height.

Below Poker Creek, a tributary from the right about 40 miles downstream from the junction, the valley widens and the bottom lands become marshy and swampy. From the left the Chatanika receives Cleary, Eldorado, Dome, and Vault creeks and other less important streams from the mining district proper. Below these tributaries the valley narrows to a gorgelike channel, which it follows for about 10 miles; below this the dividing ridges disappear and the stream meanders through the low swampy grounds to the north of Tanana River. About 10 miles from its mouth Goldstream Creek, its largest tributary, joins it from the left.

The average elevation of the divides in the upper drainage area of the Chatanika is between 3,000 and 4,000 feet above sea level, and the altitude of the ridges bounding the valley on the east and west is about 2,000 feet. Below an altitude of 1,800 to 2,000 feet the slopes are heavily timbered.

The tributary streams from the right are short and precipitous, flowing through V-shaped valleys; those from the left have less precipitous courses and broader valleys and gradually lose themselves in the rather broad expanse of swamplike bottom lands.

The altitude and drainage area of the upper Chatanika has attracted the attention of "outside" capital for some time. The general topography has seemed suitable for a possible water supply by ditch line to the mining district proper, and the favorable slope of portions of Faith and McManus creeks has made them attractive to the promoter for hydraulicking.

Daily discharge, in second-feet, of Chatanika River below Poker Creek, 1909.

[Drainage area, 456 square miles.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	......	621	319	911	168	110
2	......	588	300	872	157	110
3	......	621	359	794	146	110
4	......	474	449	588	135	92
5	......	502	359	474	130	92
6	......	359	283	449	130	......
7	......	283	359	424	130	......
8	......	338	380	654	130	......
9	3,620	1,180	402	1,630	176	......
10	3,380	1,220	654	1,740	219	
11	3,080	474	833	1,420	204	
12	3,080	338	530	872	176	......
13	2,970	300	449	559	152	......
14	1,320	319	720	424	152	......
15	1,680	266	833	424	130	......
16	3,260	266	588	359	130	......
17	3,200	234	474	338	164	......
18	3,380	204	474	300	219	......
19	2,160	190	424	311	152	......
20	1,080	176	319	300	152	......
21	502	176	250	289	152	......
22	474	164	219	278	164	......
23	833	152	234	267	130	......
24	1,740	266	402	256	130	......
25	1,520	449	424	245	130	......
26	1,420	300	359	234	130	......
27	1,220	559	300	223	130	......
28	757	687	283	212	130	......
29	757	424	266	201	152	......
30	720	359	266	190	141	......
31	757	......	338	179	......	......
Mean	1,870	416	414	530	151	103
Mean per square mile	4.10	0.91	.91	1.16	.33	.23
Run-off, depth in inches	3.51	1.02	1.05	1.34	.37	.04

The following table gives the horsepower (80 per cent efficiency) per foot of fall that may be developed at different rates of discharge and shows the number of days on which the discharge and the corresponding horsepower were respectively less than the amounts given in the columns for "discharge" and "horsepower."

Estimated discharge and horsepower for Chatanika River below Poker Creek, 1907–1909.

Discharge (second-feet).	Horsepower (80 per cent efficiency) per foot of fall.	Days of deficient discharge.		
		1907.	1908.	1909.
88	8	....	....	0
110	10	....	....	2
121	11	....	....	5
132	12	....	....	17
154	14	0	....	26
176	16	5	0	27
198	18	17	5	39
220	20	27	27	46

The above table shows entirely the reverse of what would be expected after an examination of the precipitation records at Fairbanks and Circle during the last three years, and furthermore it confirms the belief that a wide variation in precipitation, even in adjoining drainage basins, is to be expected in the Yukon-Tanana region.

Miscellaneous measurements in Chatanika River drainage basin, 1909.

Date.	Stream and locality.	Drainage area.	Dis-charge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
June 6	Chatanika River near Faith Creek	132	229	1.73
June 26	.....do	132	239	1.81
August 17	.....do	132	134	1.02
June 26	Homestake Creek at mouth	5.6	16.4	2.93
August 16	.....do	5.6	7.7	1.38
June 26	Charity Creek below Homestake Creek	6.5	30	4.62
August 16	.....do	6.5	13.7	2.11
June 26	Charity Creek at mouth	8.0	37	4.62
August 16	.....do	8.0	16.5	2.06
June 26	Hope Creek at mouth	20.3	77	3.79
August 16	.....do	20.3	33	1.63
June 6	Faith Creek at mouth	51	151	2.96
June 26	.....do	51	148	2.90
August 17	.....do	51	88	1.73
June 6	Smith Creek at mouth	34	26	.76
June 27	.....do	34	54	1.59
August 16	.....do	34	25	.73
June 27	Pool Creek at mouth	14	32	2.29
August 16	.....do	14	10.6	.76
June 6	McManus Creek above Smith Creek	42.8	67	1.57
June 27	.....do	42.8	52	1.21
August 16	.....do	42.8	29	.68
August 17	Sourdough Creek at mouth	16.5	25	1.52
Do	Cassiar Creek at mouth	7.3	2.6	.36
June 5	Flat Creek below 3d Pup	7.0	5.1	.74
August 17	Flat Creek below 1st Pup	16.9	10.0	.59
Aug. 18	Kokomo Creek above Rusty Gold Creek	26.1	12.7	.49
July 17	Cleary Creek above Wolf Creek	3.4	1.9	.56
August 19	.....do	3.4	3.7	1.09
July 17	Chatham Creek at mouth	3.0	.55	.18
August 19	.....do	3.0	1.4	.47
July 17	Wolf Creek at mouth	3.8	.71	.19
August 19	.....do	3.8	1.5	.39

The following measurements were made on streams outside of the Chatanika basin:

OTHER STREAMS.

Other miscellaneous measurements in Fairbanks district, 1909.

Date.	Stream and locality.	Drainage area.	Dis-charge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
June 16	Fox Creek 1 mile above mouth	4.1	1.2	0.29
June 4	Fish Creek above Fairbanks Creek	39	22	.56
June 28	.....do	39	48	1.23

CIRCLE DISTRICT.

DESCRIPTION.

The area to the north of the Yukon-Tanana divide, between latitude 143° 40′ and 146° 50′, is known as the Birch Creek region of the Circle district. Generally speaking, it occupies two geographic divisions—a low, broad alluvial plain and a high plateau.

The northwestern portion of the low, broad plain forms the bottom lands of the Yukon Flats north of Crazy Mountains; the southeastern portion occupies an irregular area surrounded by a low ridge along the Yukon, the Crazy Mountains, and the range of hills 20 to 40 miles farther south. This portion is cut by Birch and Crooked creeks; it is well timbered along these streams and contains large areas of meadow-like swamp land that furnish forage for both summer and winter use.

The plateau division, whose longer diameter trends east and west, occupies a position between two distinct ridges—the eastern extensions of the White Mountains. The ridge to the south is high and barren and forms the main Yukon-Tanana divide; that to the north is lower, irregular, and barren, separates the upper tributaries of the Birch Creek drainage from the lower, and is itself divided by the deep canyon-like gorge through which Birch Creek flows on its way to the Yukon.

At elevations of 2,000 feet or more above sea level the country is as a rule barren and rocky; below this altitude, especially in the flats where Birch and Crooked creeks join, considerable timber is found.

GAGING STATIONS.

The following is a list of points in the Circle district at which gages were established or measurements made in 1909:

Gaging stations in Circle district, 1909.

- Birch Creek proper:
  - Birch Creek at Fourteenmile House.
- Preacher Creek drainage basin:
  - Preacher Creek below Bachelor Creek.
  - Bachelor Creek below Costa Fork.
  - Bachelor Creek at mouth.
- North Fork of Birch Creek drainage basin:
  - Mastodon Fork of Eagle Creek above ditch intake.
  - Miller Fork of Eagle Creek above ditch intake.
- Eagle Creek at mouth.
  - Ptarmigan Creek at mouth.
  - Golddust Creek at mouth.
  - Fish Creek at mouth.
  - Butte Creek at mouth.
  - Bear Creek at mouth.
  - Twelvemile Creek 5 miles above mouth.
  - Twelvemile Creek above East Fork.
  - East Fork of Twelvemile Creek at mouth.
  - Harrison Creek above North Fork.
  - Harrison Creek below North Fork.
  - North Fork of Harrison Creek at claim "No. 10 above."
  - North Fork of Harrison Creek at claim "No. 5 above."
  - North Fork of Harrison Creek at mouth.

Crooked Creek drainage basin:
- Crooked Creek at Central House.
- Mammoth Creek at Miller House.
- Independence Creek at mouth.
- Mastodon Creek at mouth.
- Porcupine Creek above ditch intake.
- Porcupine Creek above Bonanza Creek.
- Bonanza Creek above ditch intake.
- Mammoth Creek ditch at intake.
- Mammoth Creek ditch at outlet.
- Boulder Creek at mouth.
- Deadwood Creek above Switch Creek.
- Switch Creek at mouth.
- Quartz Creek at trail crossing.

BIRCH CREEK DRAINAGE BASIN.

Birch Creek is tributary to the Yukon almost exactly on the Arctic Circle, about 25 miles directly west of Fort Yukon. Its mouth is about 5 miles west of the confluence of Chandalar River with the Yukon. The north and south forks join to form the main stream about 40 miles south of the town of Circle. Below this junction the general direction of flow is northwestward with a gradual increase in deviation from the north, and the stream roughly parallels the Yukon for 100 miles at a distance of about 10 miles. Its drainage is almost entirely from the west and for most of the distance it flows through a low, broad valley, which gradually merges with the flats of the Yukon. The principal tributaries are Preacher and Crooked creeks. The headwaters of the South Fork interlock with those of Salchaket and Charley rivers.

Daily discharge, in second-feet, of Birch Creek at Fourteenmile House, 1909.

[Drainage area, 2,150 square miles.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	......	3,290	1,800	3,020	960	792
2	......	3,430	1,500	2,690	925	792
3	......	3,290	1,340	2,460	890	......
4	......	3,160	1,160	2,820	858	......
5	......	3,020	1,160	2,210	838	......
6	......	2,950	1,180	1,940	825	......
7	......	2,760	1,160	1,860	792	......
8	......	2,560	1,340	1,830	792	......
9	......	3,810	1,480	1,920	792	......
10	......	8,640	1,640	2,460	760	......
11	......	5,260	1,800	2,920	760	......
12	......	4,440	2,340	2,430	760	......
13	......	4,790	3,810	2,180	730	......
14	......	4,580	5,700	1,980	748	......
15	4,130	5,170	8,280	1,800	760	......
16	5,260	4,230	5,950	1,600	760	......
17	7,060	3,120	3,670	1,500	792	......
18	8,600	4,050	2,560	1,380	825	......
19	9,970	3,490	1,580	1,270	812	......
20	9,870	2,790	1,400	1,240	792	......
21	9,550	2,380	1,360	1,800	792	......
22	8,380	2,090	1,310	2,010	760	......
23	7,080	1,860	1,240	1,690	773	......
24	4,750	1,920	1,160	1,500	792	......
25	4,270	2,400	1,050	1,360	792	......
26	3,950	2,760	1,020	1,240	792	......
27	3,850	2,920	960	1,240	773	......
28	3,740	2,720	1,180	1,160	760	......
29	3,630	2,380	2,500	1,100	760	......
30	3,430	1,980	2,660	1,030	792	......
31	3,320	......	2,980	974	......	......
Mean	5,930	3,410	2,200	1,830	799	792
Mean per square mile	2.76	1.59	1.02	.85	.37	.37
Run-off, depth in inches	1.74	1.77	1.18	.98	.41	.03

PREACHER CREEK DRAINAGE BASIN.

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

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

Daily discharge, in second-feet, of Bachelor Creek below Costa Fork, 1909.

[Drainage area, 11.4 square miles.]

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1		19.2	10.2	7.6	21		12.2	8.4	
2		17.8	9.6	7.6	22		11.2	8.4	
3		18.2	9.2	7.6	23		29	7.9	
4		18.2	9.2	7.6	24		12.5	7.9	
5		19.2	9.2	7.6	25	31	12.5	7.9	
6		17.8	8.9	7.6	26	28	11 2	7.9	
7		16.6	8.9	7.6	27	23	10.4	7.9	
8		14.5	9.4	7.6	28	21	10.2	7.9	
9		14.5	10.4	7.6	29	20	10.0	7.6	
10		16.6	11.2	7.3	30	19.6	10.2	7.6	
					31		10.2	7.6	
11		15.6	10.8	7.3					
12		12.8	10.2	7.3	Mean	24	15.9	8.9	7.5
13		18.2	9.2	7.3	Mean per square mile	2.11	1.39	.78	.66
14		17.8	9.2	7.3					
15		18.2	9.2	7.3	Run-off, depth in inches	.47	1.60	.90	.37
16		16.6	9.2						
17		14.2	8.9						
18		30	8.4						
19		22	8.4						
20		14.5	8.4						

Miscellaneous measurements in Preacher Creek drainage basin, 1909.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. mi.	*Sec.-ft.*	*Sec.-ft.*
August 15	Preacher Creek below Bachelor Creek	121	115	0.95
Do	Bachelor Creek at mouth	26.4	16.4	.62

NORTH FORK OF BIRCH CREEK DRAINAGE BASIN.

Eagle Creek, which is formed by the junction of Mastodon and Miller forks, unites with Ptarmigan Creek to form the North Fork of Birch Creek. The headwaters are opposite to those of Crooked Creek.

The North Fork takes a southwesterly course for about 7 miles, to the point where it receives Twelvemile Creek and turns abruptly to the south, following that direction for about 8 miles. It is then joined by a fair-sized unnamed tributary from the west and makes a right-angle turn to the east, roughly following that course to its confluence with the South Fork, a distance of approximately 45 miles. Harrison Creek is the principal tributary from the north and Clums Fork from the south.

Daily discharge, in second-feet, of Mastodon Fork of Eagle Creek above ditch intake, 1909.

[Drainage area, 4.1 square miles.]

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1		6.0	6.0	0.67	21	8.0	2.7	4.9	
2		4.1	12.9	.25	22	10.2	2.1	4.1	
3		4.1	8.8	.25	23	10.2	2.1	3.4	
4		4.1	7.0	.13	24	10.2	2.1	2.7	
5		3.4	6.0	.00	25	8.0	2.1	2.7	
6		4.1	6.0	.00	26	8.0	2.1	2.1	
7		7.0	8.0		27	10.2	1.6	2.1	
8		7.0	10.2		28	8.0	2.7	1.6	
9		17.1	15.5		29	8.0	10.2	1.6	
10	10.2	8.0	12.9		30	8.0	8.0	1.1	
11	18.7	6.0	8.0		31		7.0	.67	
12	26	6.0	8.0		Mean	13.1	6.2	5.5	0.22
13	22	15.5	6.0						
14	18.7	18.7	4.9		Mean per square mile	3.20	1.51	1.34	.05
15	15.5	12.9	4.1						
16	12.9	8.0	3.4		Run-off, depth in inches	2.50	1.74	1.54	.01
17	29	6.0	3.4						
18	15.5	4.1	3.4						
19	10.2	3.4	4.1						
20	8.0	3.4	6.0						

Miscellaneous measurements in North Fork of Birch Creek drainage basin, 1909.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. mi.	*Sec.-ft.*	*Sec.-ft.*
June 10	Miller Fork of Eagle Creek above ditch intake	2.6	9.9	3.81
June 24	Eagle Creek at mouth	15.5	19.4	1.25
August 14	....do	15.5	22	1.42
June 24	Ptarmigan Creek at mouth	19.0	34	1.79
August 14	....do	19.0	27	1.42
June 24	Golddust Creek at mouth	13.6	15.9	1.17
August 14	....do	13.6	15.7	1.15
June 24	Fish Creek at mouth	6.0	6.6	1.10
August 14	....do	6.0	7.1	1.18
Do	Butte Creek at mouth	9.2	5.6	.61
June 24	Bear Creek at mouth	12.4	21	1.69
August 14	....do	12.4	12.9	1.04
Do	Twelvemile Creek 5 miles above mouth	10.4	4.6	.44
June 24	Twelvemile Creek above East Fork	18.9	17.6	.93
August 14	....do	18.9	19.5	1.03
June 24	East Fork of Twelvemile Creek at mouth	22.9	51	2.23
August 14	....do	22.9	18.5	.81
July 22	Harrison Creek above North Fork	21.6	19.1	.88
Do	Harrison Creek below North Fork	47.3	52	1.10
August 13	North Fork of Harrison Creek at claim "No. 10 above"	6.3	15.7	2.49
June 13	North Fork of Harrison Creek at claim "No. 5 above"	11.4	108	9.47
Do	....do	11.4	96	8.42
June 14	....do	11.4	49	4.30
June 22	....do	11.4	28	2.46
June 23	....do	11.4	17.9	1.57
July 22	North Fork of Harrison Creek at mouth	25.1	36	1.43

CROOKED CREEK DRAINAGE BASIN.

Crooked Creek, which is formed by the junction of Mammoth and Porcupine creeks, meanders through a rather broad valley for about 30 miles and discharges its waters into Birch Creek about 10 miles above the Fourteenmile House. Not far below the Central House the valley loses its identity in the flats of Birch Creek.

Mastodon and Independence creeks unite to form Mammoth Creek, which receives Miller Creek about 2 miles below this junction from the west. The total length of that portion of the stream called Mammoth Creek is less than 4 miles.

Deadwood and Boulder creeks are tributaries from the south below and above the Central House, respectively. They follow parallel courses about 3 miles apart, with a length of about 18 miles.

Albert Creek, the principal tributary from the north, drains the southern slope of the Crazy Mountains.

Daily discharge, in second-feet, of Crooked, Mammoth, and Porcupine creeks, 1909.

Day.	Crooked Creek at Central House (drainage area, 161 square miles).				Mammoth Creek at Miller House[a] (drainage area, 37.1 square miles).				Porcupine Creek below Bonanza Creek[b] (drainage area, 39.9 square miles).			
	May.	June.	July.	Aug.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	......	358	60	50	......	138	138	63	......	20	23	7.2
2	......	377	50	50	......	122	126	60	......	18.9	23	16.8
3	......	451	32	42	......	113	128	58	......	28	26	16.2
4	......	604	32	50	......	128	149	55	......	20	23	16.2
5	......	584	32	50	......	128	128	50	......	18.9	22	15.6
6	......	451	32	46	......	128	115	45	......	16.8	21	15.3
7	......	377	60	50	......	134	107	......	......	31	21	15.0
8	......	396	60	60	......	162	113	......	......	43	25	15.0
9	28	414	60	66	......	228	140	......	......	77	38	15.0
10	37	176	50	73	......	186	162	......	......	45	45	15.0
11	28	294	50	73	......	158	154	......	246	33	33	14.4
12	37	252	55	46	......	144	137	......	490	29	31	15.0
13	32	273	293	32	......	1,170	130	......	246	288	28	15.0
14	28	212	196	29	......	635	126	......	231	150	28	15.0
15	62	142	148	29	305	744	115	......	329	160	21	15.0
16	122	102	82	29	380	294	107	......	170	56	18.7	......
17	190	318	55	29	180	169	103	......	170	33	18.2	......
18	237	194	50	23	420	140	99	......	120	30	18.2	......
19	122	90	42	21	342	128	93	......	85	24	18.2	......
20	62	82	42	21	228	113	103	......	75	19.3	18.2	......
21	55	73	36	30	180	109	111	......	68	17.5	18.2	......
22	48	73	32	21	169	97	113	......	66	18.2	18.2	......
23	88	66	32	21	154	93	99	......	64	16.2	17.5	......
24	190	73	32	21	216	93	91	......	58	15.6	16.8	......
25	221	66	32	21	194	84	84	......	54	15.3	16.2	......
26	221	90	32	21	228	82	84	......	50	15.0	15.6	......
27	161	82	32	21	202	75	87	......	46	16.2	15.6	......
28	161	82	39	21	202	82	79	......	42	17.9	15.0	......
29	205	60	73	21	169	138	73	......	38	25	15.0	......
30	305	60	60	21	144	126	69	......	34	25	15.0	......
31	305	......	50	21	......	138	66	......	......	27	14.4	......
Mean	128	229	62	36	232	202	111	55	134	43.5	22	15.4
Mean per square mile	3.45	6.17	1.67	.97	1.44	1.25	0.69	0.34	......	......	......	......
Run-off, depth in inches	2.95	6.88	1.92	1.12	.86	1.44	.80	.08	......	......	......	......

[a] These values are only approximate owing to an uncertainty in the amount of water diverted above.
[b] These values show the run-off from the area above the gage less the amount diverted by the Bonanza Creek ditch.

Daily discharge, in second-feet, of Bonanza and Deadwood creeks, 1909.

Day.	Bonanza Creek above ditch intake (drainage area, 7.9 square miles).				Deadwood Creek above Switch Creek (drainage area, 21.3 square miles).			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	....	16.0	16.8	12.2	....	12.5	17.5	8.0
2	....	15.7	17.9	11.1	....	8.0	17.5	8.0
3	....	25	17.9	10.8	....	8.0	17.5	8.0
4	....	17.9	15.2	10.8	....	8.0	12.5	8.0
5	....	15.7	17.9	10.6	....	5.0	12.5	8.0
6	....	14.5	17.9	10.4	....	5.0	12.5	5.0
7	....	15.2	15.7	10.1	....	25	12.5	5.0
8	....	15.2	17.1	10.1	....	25	17.5	5.0
9	....	18.5	17.9	10.0	....	17.5	17.5	5.0
10	....	19.2	17.9	10.0	....	17.5	17.5	5.0
11	....	19.2	15.5	9.8	....	17.5	17.5	5.0
12	82	19.2	17.7	9.8	....	12.5	17.5	5.0
13	40	49	16.8	9.8	....	77	12.5	5.0
14	38	18.2	16.3	9.8	....	25	12.5	5.0
15	32	34	15.7	....	....	17.5	12.5	5.0
16	32	19.2	15.2	....	25	17.5	12.5	5.0
17	32	16.8	14.5	....	105	12.5	12.5	5.0
18	30	16.8	14.0	....	53	12.5	12.5	5.0
19	28	16.3	14.0	....	25	12.5	12.5	5.0
20	27	16.3	13.5	....	25	8.0	12.5	5.0
21	26	16.0	13.3	....	17.5	8.0	12.5	5.0
22	26	16.0	13.3	....	17.5	8.0	8.0	....
23	26	16.0	12.9	....	17.5	8.0	8.0	....
24	24	15.7	12.4	....	17.5	5.0	8.0	....
25	22	15.2	15.0	....	25	5.0	12.5	....
26	20	14.7	14.8	....	25	5.0	8.0	....
27	20	15.0	14.0	....	17.5	12.5	8.0	....
28	20	15.5	13.8	....	17.5	17.5	8.0	....
29	20	16.3	13.5	....	12.5	36	8.0	....
30	19.2	16.3	13.3	....	12.5	36	8.0	....
31	....	16.3	12.9	....	....	36	8.0	....
Mean	30	18.4	15.3	10.4	28	16.8	12.5	5.7
Mean per square mile	3.80	2.33	1.94	1.32	1.31	.79	.59	.27
Run-off, depth in inches	2.68	2.69	2.24	.68	.73	.91	.68	.21

Miscellaneous measurements in Crooked Creek drainage basin, 1909.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. mi.	*Sec.-ft.*	*Sec.-ft.*
June 14	Independence Creek at mouth	13.2	41	3.11
June 21	.....do	13.2	21	1.59
August 13	.....do	13.2	14.2	1.08
June 14	Mastodon Creek at mouth	10.2	32	3.14
June 21	.....do	10.2	23	2.25
August 13	.....do	10.2	11.1	1.09
June 21	Miller Creek at mouth	10.5	19.0	1.81
August 13	.....do	10.5	10.1	1.01
August 12	Porcupine Creek above ditch intake	17.8	25	1.40
August 11	Mammoth Creek ditch at intake	....	16	....
August 12	.....do	....	15.6	....
June 12	Mammoth Creek ditch at outlet	....	1.8	....
June 14	.....do	....	3.1	....
August 12	.....do	....	12.9	....
June 15	Boulder Creek at mouth	38.8	44	1.13
June 20	.....do	38.8	33	.85
August 10	.....do	38.8	22	.57
June 16	Switch Creek at mouth	5.8	2.3	.40
August 10	.....do	5.8	1.7	.29
June 18	Quartz Creek at trail crossing	8.4	28	3.33

RAMPART DISTRICT.

DESCRIPTION.

The area originally known as the Rampart district embraces three main drainage areas, as follows: Minook and Troublesome creeks, tributary to Yukon River, and Baker Creek, tributary to the Tanana.

The town of Rampart, situated on the left bank of the Yukon just below the mouth of Minook Creek, was long the main supply point for the entire region, and from it all the mining outfits and provisions were hauled on sleds in winter and packed on horses in summer. Now, however, the Baker Creek area is by far the largest producer, and since several stores have been opened at Hot Springs, about 6 miles from Tanana River on Baker Slough, Rampart has ceased to be the main trading point and the term "Rampart district" is now understood by some to include only Minook and Troublesome creeks. In this report, however, the original meaning is retained.

The divide between the Minook Creek and Baker Creek drainage basins has a general but very irregular east-west direction, with a notable break to the north at the head of Hutlinana Creek. It varies in elevation from 1,000 to 4,000 feet, Wolverine Mountain being the highest point. The northern area is rugged and mountainous, with narrow valleys and precipitous slopes, even down to the mouths of the streams; the southern area, although rough at the headwaters, broadens out below into alluvial flats in which the streams are sluggish.

Timber sufficient for fuel is found in most of the valleys and lower slopes of the Rampart region. Spruce, birch, and poplar are abundant on the hillsides near Hot Springs and along the Tanana.

GAGING STATIONS.

The following list gives the points in the Rampart district at which gages were established or measurements made in 1909:

Gaging stations in Rampart district, 1909.

- Yukon River drainage basin:
    - Yukon River at Rampart.
    - Squaw Creek at mouth.
    - Minook Creek drainage basin—
        - Minook Creek below Granite Creek.
        - Minook Creek above Little Minook Creek.
        - Granite Creek at mouth.
        - Ruby Creek at mouth.
        - Hoosier Creek at claim "No. 11 above."
        - Little Minook Creek at claim "No. 9 above."
        - Hunter Creek at claim "No. 19 above."

Yukon River drainage basin—Continued.
- Troublesome Creek drainage basin—
  - Troublesome Creek above Quail Creek.
  - Troublesome Creek below Quail Creek.
  - Quail Creek at claim "No. 7 above."
  - Quail Creek at claim "No. 9 below."
  - Nugget Gulch at mouth.

Tanana River drainage basin:
- Baker Creek drainage basin—
  - Baker Creek at road crossing.
  - Hutlinana Creek above Denver Creek.
  - Hutlinana Creek above Cairo Creek.
  - Eureka Creek above Boston Creek.
  - Pioneer Creek above What Cheer Bar ditch intake.
  - What Cheer Bar ditch at intake.
  - New York Creek at Thanksgiving ditch intake.
  - California Creek at Thanksgiving ditch intake.
  - Thanksgiving ditch one-quarter mile above outlet.
- Patterson Creek drainage basin—
  - Sullivan Creek above Tofty ditch intake.
  - Quartz Creek at mouth.
  - Midnight Sun ditch near outlet.
  - Cache Creek at Baker Slough trail crossing.

YUKON RIVER AT RAMPART.

A cross section and a discharge measurement of the Yukon River were obtained on May 1, 1909, just above the mouth of Rampart Creek, which is a small tributary from the south at the lower end of the town of Rampart. The bed is thought to be of a semipermanent character and the channel is straight for at least 1,000 feet above and below the point of measurement. The banks on each side are high with long, gentle slopes. The left slope is of cemented gravel and bowlders; the right is of small gravel and is liable to slight changes. At the time the cross section was made, the ice varied in thickness from 4 to 4½ feet, which was probably the maximum for the winter. The width of the top of the ice was 1,560 feet, while the width of the water's surface was 1,300 feet, which shows that for 260 feet the ice was in contact with the bed of the river. This does not mean, however, that the water froze from the surface to the bed of the stream for that distance. The stage of the river at the time of the first ice cover in the fall was considerably higher than at the time of the measurement, and as the water surface lowered the width decreased and the ice sheet fell, coming into contact with that portion of the bank which was previously submerged and assuming a surface sloping on each side toward the center of the stream. The greatest depth of water below the bottom of the ice was found to be 15.9 feet, at a distance of 420 feet from the left edge of the ice.

In the early part of May, when the discharge of the tributaries into the main stream commences to increase rapidly, the greater volume raises the ice sheet until it breaks away from the shore ice. This parting of shore and main ice indicates that the beginning of navigation is about to commence and is a momentous occasion for the people of the interior.

The river usually closes about the middle of October and opens about the middle of May. In the spring of 1909 the first movement of ice was noted on the night of May 17 and in a few hours the whole mass was broken up.

On May 19 and 21, after the flow of ice had been reduced from one solid mass to free-flowing cakes, two float measurements were made by timing the passage of ice cakes over a 500-foot range. No means were at hand to determine accurately the distance of the cakes from the shore, but the velocity and section were sufficiently uniform, so that no large errors were liable to be introduced through the uncertainty in the location of the floats. The measurements are, however, only approximate. The stage of the stream was considerably above the mean for the summer.

The average fall of the river from Fort Yukon to the mouth has been approximately estimated at 6 inches to the mile.

Discharge measurements of Yukon River at Rampart, 1909.

Date.	Width.	Area.	Mean velocity.	Discharge.	Gage height.	Drainage area.	Discharge per square mile.
	Feet.	*Sq. ft.*	*Ft. per sec.*	*Sec.-ft.*	*Feet.*	*Sq. mi.*	*Sec.-ft.*
May 1	1,360	11,700	0.93	10,900	[a]51.6	206,000	0.05
May 19	1,750	58,100	6.32	367,000	80.9	206,000	1.78
May 21	1,750	58,500	6.31	369,000	81.1	206,000	1.79

[a] Bottom of ice.

NOTE.—The gage height is the distance of the water surface above an assumed datum.

SQUAW CREEK.

Squaw Creek enters the Yukon just above Rampart, directly opposite Minook Creek. A measurement made May 15, 1909, at the mouth gave a discharge of 484 second-feet.

MINOOK CREEK DRAINAGE BASIN.

Minook Creek heads on the northern slope of Eureka Dome, flows northeastward for about 4 miles, and then takes a northerly course through a remarkably straight valley to Yukon River, which it joins just above Rampart. It is about 25 miles long and drains an area of 198 square miles, the major portion being on the east of the stream. The basin is covered with a light growth of timber which furnishes an ample supply for fuel but very little suitable for milling.

The chief tributaries are Chapman, Hoosier, Little Minook, and Hunter creeks from the east and Granite, Ruby, and Slate creeks from the west. Above Granite Creek the valley is narrow and V-shaped; below that point it broadens out and has perhaps a maximum width of one-half mile. The western slope is precipitous through the entire length; the eastern slope below Chapman Creek is more gradual, with prominent benches. In the upper course the stream is crooked, meandering from one side of the valley to the other; the lower part is comparatively straight.

Just below the mouth of Slate Creek the Minook spreads into a number of branches in a wide gravel flat. This flat, which is typical of many Alaskan streams, is probably due to a change in the grade of the creek. The stream here is unable to carry the gravels of the swifter water above and so spreads them upon the flat. Here are found the so-called winter glaciers, some of which last through the short summers. In 1904 a quarter or half acre of "winter glacier" still remained when the September frosts occurred. This ice owes its origin to the fact that, as the water freezes in the fall, the channel is greatly narrowed. The resulting hydrostatic pressure cracks the ice and the water overflows and freezes. This process is repeated until a considerable thickness of ice is accumulated.[a]

Discharge measurements of Minook Creek above Little Minook Creek, 1909.

	Sec.-ft.
May 14	179
Do	387
May 18	2,040
July 29	112
August 1	88
September 7	47

[a] Hess, F. L., The Rampart placers: Bull. U. S. Geol. Survey No. 337, 1908, pp. 67-68.

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

Day.	Minook Creek above Little Minook Creek[a] (drainage area, 130 square miles).		Hoosier Creek at claim "No. 11 above"[b] (drainage area, 25.7 square miles).					Little Minook Creek at claim "No. 9 above" (drainage area, 5.9 square miles).				
	May.	June.	May.	June.	July.	Aug.	Sept.	May.	June.	July.	Aug.	Sept.
1	......	1,070	......	136	18.7	18.7	6.8	......	32	2.2	2.4	0.8
2	......	1,120	......	126	9.0	23	6.8	......	30	2.1	2.4	.8
3	......	1,180	......	115	9.0	14.8	6.8	......	27	2.0	2.4	.8
4	......	1,070	......	115	9.0	35	6.8	......	24	1.9	2.4	.8
5	......	942	......	90	6.8	157	6.8	......	22	1.8	28	1.0
6	......	814	......	66	5.3	35	6.8	......	20	1.8	33	1.2
7	......	685	......	60	5.3	266	6.8	......	18	1.8	38	1.2
8	......	475	......	53	53	497	6.8	......	15.6	28	43	1.3
9	......	496	......	78	23	729	......	......	18	15	47	1.3
10	......	518	......	66	6.8	586	......	......	20	5.0	71	1.4
11	......	540	......	53	11.7	443	......	......	22	.8	52	1.4
12	......	630	......	96	9.0	300	......	......	25	.8	47	1.5
13	220	1,070	65	80	6.8	157	......	......	28	.8	42	1.6
14	268	630	130	44	5.3	88	......	......	15	.8	37	1.7
15	865	630	540	35	5.3	18.7	......	......	2.4	.8	32	1.8
16	1,460	......	490	35	5.3	18.7	......	71	2.4	.7	20	1.5
17	2,060	......	729	23	5.0	18.7	......	167	2.4	.7	12	1.2
18	2,240	......	499	23	4.7	16.8	......	140	2.5	.7	6.0	.8
19	1,280	......	205	18.7	4.4	14.8	......	110	2.6	.7	1.8	......
20	810	......	78	18.7	4.1	14.8	......	80	2.7	.6	1.5	......
21	540	......	53	18.7	3.2	13.8	......	52	2.8	.6	1.2	......
22	494	......	14.8	18.7	2.2	12.8	......	23	2.8	.6	1.2	......
23	448	......	33	14.8	205	11.7	......	36	2.8	2.4	1.1	......
24	2,320	......	346	346	136	10.0	......	49	2.8	32	1.1	......
25	4,200	......	656	315	115	8.4	......	62	28	20	1.0	......
26	2,600	......	115	115	23	6.8	......	76	2.8	10	1.0	......
27	740	......	115	53	23	6.8	......	63	28	2.4	.9	......
28	740	......	115	35	23	6.8	......	50	2.6	8.3	.8	......
29	1,070	......	136	29	23	6.8	......	37	2.5	5.3	.8	......
30	975	......	258	23	23	6.8	......	37	2.4	2.4	.8	......
31	1,180	......	157	......	14.8	6.8	......	37	......	2.4	.8	......
Mean	1,290	790	249	77	26	114	6.8	68	12.0	5.0	17.1	1.2
Mean per square mile	9.92	6.08	9.69	3.00	1.01	4.44	.26	11.53	2.03	.85	2.90	.20
Run-off, depth in inches	7.01	3.39	6.35	3.35	1.16	5.12	.09	6.86	2.26	.98	3.34	.13

[a] Gage heights were kept until September 8, but it was not thought advisable to make daily estimates after June 15 because of extreme shifting channel conditions.
[b] These values are only approximate because of insufficent measurements and shifting channel.

Miscellaneous measurements in Minook Creek drainage basin, 1909.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. mi.	*Sec.-ft.*	*Sec.-ft.*
September 9	Minook Creek below Granite Creek	47.3	15.2	0.32
Do	Granite Creek at mouth	26.9	5.9	.22
Do	Ruby Creek at mouth	10.6	2.6	.25
May 16	Hunter Creek at claim "No. 19 above"	34.4	1,000	29.07
May 19	do	34.4	326	9.48
July 30	do	34.4	28	.81
August 2	do	34.4	21	.61
September 10	do	34.4	5.8	.17

TROUBLESOME CREEK DRAINAGE BASIN.

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

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

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

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

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

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

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

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

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

Miscellaneous measurements in Troublesome Creek drainage basin, 1909.

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

BAKER CREEK DRAINAGE BASIN.

Baker Creek and its tributaries drain a roughly fan-shaped area 542 square miles in extent. The greatest width of this basin from east to west is 37 miles, and its greatest width from north to south 21 miles.

The name Baker Creek is applied to the extreme western fork. It heads near Sullivan Creek on the south slope of Roughtop Mountain and flows eastward for about 17 miles; it then makes a right-angle turn to the south around the north end of Bean Ridge, which it follows closely for about 4 miles below the turn and then crosses the flat and receives its two largest tributaries, Hutlinana and Hutlitakwa creeks, which drain over half the entire area. It is about 28 miles long and enters the Tanana 70 miles from the Yukon.

The system of main and tributary streams is very unsymmetrical, about 88 per cent of the area lying on the left side. South of the creek the country rises abruptly to the summit of Bean Ridge and furnishes no tributaries of importance. On the north the valley spreads out into a broad alluvial flat with a very gradual slope to the area near the heads of the tributaries, where it rises abruptly to the summit of the divide.

The basin as a whole is favored with an abundant and diversified growth of timber. In the upper portion this growth is small but has furnished sufficient supply for fuel and cabins; on the flats, particularly in the lower valley of the Hutlinana, there is considerable spruce suitable for milling. On the slope near Hot Springs there is a heavy growth of birch and poplar.

Baker Creek has so low a gradient that its water can never be conveyed to any of the present mines by a gravity system, but as a supply for pumping it is ample, and it is so situated that it is worth consideration for that purpose.

Discharge measurements of Hutlinana Creek above Cairo Creek, 1909.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Sec.-ft.*
April 20	C. E. Ellsworth	0.32	[a] 0.4
May 23	do	2.48	173
July 6	C. M. Hamshaw	.99	23
Do	do	.99	24
July 11	do	1.01	25
July 25	Harry Turnbull	1.17	44
Do	do	1.25	37
Do	C. E. Ellsworth	1.23	41
July 26	do	1.17	34
July 31	Harry Turnbull	1.40	53

[a] This measurement shows the discharge of the hot springs. The creek was frozen solid above.

Daily discharge, in second-feet, of Hutlinana Creek above Cairo Creek, 1908-9.

[Drainage area, 42.7 square miles.]

Day.	1908.		1909.				
	Sept.	Oct.	Apr.	May.	June.	July.	Aug.
1	15	15	....	15	81	24	49
2	15	15	....	19	81	24	45
3	16	15	....	4.5	91	24	53
4	18	15	....	11	91	24	91
5	19	15	....	7.5	81	24	176
6	19	15	....	15	77	24	113
7	19	14	....	24	72	24	81
8	19	13	....	43	67	30	81
9	19	12	....	62	62	30	315
10	19	11	....	71	53	23	176
11	19	11	....	71	45	24	113
12	19	11	....	102	45	25	91
13	19	11	....	62	53	24	71
14	19	11	....	81	62	24	53
15	19	11	....	138	53	24	53
16	19	11	....	102	45	24	45
17	19	11	....	112	45	19	45
18	22	11	....	122	45	19	....
19	24	11	....	132	37	19	....
20	24	11	0.4	142	37	19	....
21	24	11	1.0	152	34	24	....
22	22	11	2.0	162	30	37	....
23	21	10	1.5	173	30	37	....
24	20	9	1.0	190	62	53	....
25	19	8	2.0	204	45	41	....
26	19	7.5	1.0	163	37	37	....
27	18	11	2.0	113	30	37	....
28	17	11	1.0	91	24	37	....
29	16	....	1.5	81	24	37	....
30	15	....	2.0	81	24	66	....
31	....	....	....	81	....	53	....
Mean	19.1	11.7	1.4	91	52	30	97
Mean per square mile	.45	.27	.03	2.13	1.22	.70	2.27
Run-off, depth in inches	.50	.28	.01	2.46	1.36	.81	1.44

Daily discharge, in second-feet, of New York and California creeks and Thanksgiving ditch, 1909.

Day.	New York Creek at Thanksgiving ditch intake (drainage area, 4.7 square miles).					California Creek at Thanksgiving ditch intake (drainage area, 6.7 square miles).				Thanksgiving ditch one-fourth mile above outlet.				
	May.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	May.	June.	July.	Aug.	Sept.
1	......	6.0	1.0	1.0	1.4	......	3.7	3.2	2.6	......	4.7	2.8	2.6	3.4
2	......	6.0	1.0	1.0	1.4	......	3.6	3.2	2.6	......	4.7	2.6	3.0	3.2
3	......	6.0	1.0	2.1	1.4	......	3.6	3.5	2.6	......	4.7	2.6	4.7	3.2
4	......	6.0	1.0	4.2	1.4	......	3.6	3.7	2.6	......	5.6	2.8	6.4	3.4
5	......	6.0	1.0	12.9	1.4	......	3.5	5.1	2.6	......	4.7	2.6	9.8	3.4
6	......	3.7	1.0	9.0	1.2	......	3.5	4.6	2.6	......	4.0	2.6	6.8	3.0
7	......	3.7	1.0	6.0	1.2	......	3.4	3.8	2.6	......	3.4	2.4	9.1	3.0
8	......	3.7	1.2	6.0	......	......	4.3	4.0	......	......	7.5	4.0	9.1	......
9	......	3.7	1.8	100	......	......	4.0	8.3	......	......	5.6	4.7	10.9	......
10	......	2.1	3.4	81	......	......	4.3	6.6	......	......	6.4	7.5	6.4	......
11	......	2.1	2.4	23	......	......	4.2	3.4	......	......	5.6	6.4	6.4	......
12	......	2.4	2.1	11	......	......	3.7	3.5	......	......	6.1	4.7	8.6	......
13	......	2.9	1.4	7.9	......	......	3.5	3.6	......	......	6.4	3.7	9.1	......
14	......	2.4	1.8	5.5	......	......	3.5	3.5	......	......	5.6	3.7	10.4	......
15	......	2.1	1.4	3.7	......	4.6	3.5	3.7	......	......	5.6	3.2	8.6	......
16	......	2.1	1.0	3.7	......	4.8	3.5	3.4	......	......	5.6	2.8	8.2	......
17	......	2.1	1.0	2.9	......	4.2	3.5	3.4	......	......	4.4	2.6	6.4	......
18	......	1.8	.90	2.9	......	4.3	3.5	3.4	......	......	4.0	2.5	6.4	......
19	......	1.2	.75	2.9	......	4.0	3.5	3.2	......	......	3.7	2.2	6.4	......
20	......	1.2	.75	2.4	......	4.0	3.5	3.2	......	......	3.4	2.1	5.0	......
21	......	1.0	.75	2.1	......	4.0	3.4	3.0	......	......	3.4	2.1	4.7	......
22	......	1.0	.70	2.1	......	4.0	3.2	2.9	......	......	3.2	2.0	4.7	......
23	......	1.0	1.4	2.9	......	4.0	3.6	3.2	......	......	3.2	3.2	5.6	......
24	......	2.1	3.4	2.4	......	4.8	4.2	2.9	......	......	6.1	6.1	4.7	......
25	49.0	3.4	2.1	2.1	......	4.9	3.5	2.9	......	7.1	7.5	4.0	4.7	......
26	31.0	2.1	1.4	2.1	......	4.3	3.5	2.8	......	4.0	4.7	3.4	4.0	......
27	20.1	2.1	1.4	2.1	......	4.0	3.5	2.8	......	6.1	4.0	3.4	3.7	......
28	12.9	1.4	2.1	2.1	......	3.8	3.5	2.8	......	6.4	3.4	4.0	3.4	......
29	11.0	1.0	1.8	1.8	......	3.8	3.5	2.6	......	6.8	3.2	3.4	3.4	......
30	9.8	1.0	1.4	1.4	......	3.8	3.4	2.6	......	6.4	3.2	3.4	3.4	......
31	9.8	......	1.2	1.4	......	......	3.3	2.6	......	6.1	......	3.0	3.4	......
Mean	20	2.8	1.4	10	1.3	4.2	3.6	3.6	2.6	6.1	4.8	3.4	6.1	3.2
Mean per square mile	4.26	.60	.30	2.13	.28	.63	.54	.54	.39	......	......	......	......	......
Run-off, depth in inches	1.11	.67	.35	2.46	.07	.38	.62	.62	.10	......	......	......	......	......

Daily discharge, in second-feet, of Pioneer Creek and What Cheer Bar ditch, 1909.

Day.	Pioneer Creek above What Cheer Bar ditch (drainage area, 8.1 square miles).				What Cheer Bar ditch at intake.		
	May.	June.	July.	Aug.	June.	July.	Aug.
1		12.3	3.0	3.8	4.2	3.0	3.6
2		9.4	3.0	3.0	4.2	3.0	3.0
3		15.2	3.0	9.4	13.3	3.0	6.8
4		12.3	3.0	15.2	10.4	2.9	7.8
5		12.3	3.0	39	10.4	2.8	25
6		9.4	3.0	22	7.8	2.7	16.7
7		9.4	3.0	15.2	7.8	2.6	13.3
8		7.0	4.7	18.4	5.8	4.2	16.7
9		7.0	7.0	22	5.8	5.8	21
10		7.0	4.7	22	5.8	4.2	21
11		4.7	4.7	34	4.2	4.2	21
12		4.7	4.7	83	4.2	4.2	21
13		9.4	3.0	34	7.8	3.0	21
14		7.0	3.0	26	5.8	3.0	16.7
15		4.7	3.0	15.2	4.2	3.0	13.3
16		4.7	3.0	15.2	4.2	2.6	13.3
17		4.7	3.0	12.3	4.2	2.6	10.4
18		4.7	3.0	10.8	3.0	2.6	9.1
19		4.7	3.0	10.8	3.0	2.6	9.1
20		4.7	2.8	9.4	3.0	2.5	7.8
21		4.7	2.6	8.2	3.0	2.3	6.8
22		4.7	2.4	7.0	3.0	2.1	5.8
23		3.0	4.7	15.2	3.0	4.7	13.3
24		9.4	7.0		5.8	7.8	
25		7.0	4.7		4.2	4.2	
26	80	4.7	4.7		4.2	4.2	
27	49	4.7	4.7		4.2	4.2	
28	30	3.0	3.8		3.0	3.6	
29	22	3.0	3.8		3.0	3.6	
30	22	3.0	3.8		3.0	3.6	
31	15.2		3.8			3.6	
Mean	36	6.8	3.8	19.6	5.2	3.5	13.2
Mean per square mile	4.44	.84	.47	2.42			
Run-off, depth in inches	.99	.94	.54	2.07			

Miscellaneous measurements in Baker Creek drainage basin, 1909.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. mi.	*Sec.-ft.*	*Sec.-ft.*
May 26	Baker Creek at road crossing	232	1,910	8.23
July 21	.....do	232	27	.12
July 24	.....do	232	159	.69
September 3	.....do	232	54	.23
July 7	Hutlinana Creek above Denver Creek	23.7	11.9	.50
July 26	.....do	23.7	24	1.01
September 5	.....do	23.7	9.1	.38
July 22	Eureka Creek above Boston Creek	5.2	1.2	.23
July 23	.....do	5.2	6.9	1.33
September 4	.....do	5.2	2.4	.46

PATTERSON CREEK DRAINAGE BASIN.

Patterson Creek is formed by the junction of Sullivan and Cache creeks and is tributary to Tanana River about 40 miles below the mouth of Baker Creek. It drains an area of low relief, the most prominent feature being Bean Ridge, on the south, which furnishes several small tributaries. Woodchopper Creek is tributary to Patterson Creek about 6 miles from the Tanana.

Sullivan Creek, the right fork of Patterson Creek, rises on the south slope of Roughtop Mountain and for about 10 miles flows a little west of south through a wide valley with gentle slopes and high, broad benches. Birch and spruce timber suitable for cabins and fuel is abundant in the lower valley.

Daily discharge, in second-feet, of Sullivan Creek above Tofty ditch intake, 1909.

[Drainage area, 20.7 square miles.]

Day.	May.	June.	July.	Aug.	Sept.	Day.	May.	June.	July.	Aug.	Sept.
1	......	13.8	2.3	2.1	2.8	21	......	2.9	16.2	3.0	......
2	......	13.8	2.1	1.9	2.8	22	......	2.8	16.2	2.8	......
3	......	12.1	2.3	18.5	2.8	23	......	2.8	7.7	2.6	......
4	......	24	2.3	10.4	2.8	24	......	2.8	13.8	2.4	......
5	......	31	2.1	106	2.8	25	......	6.6	7.7	2.2	......
6	......	31	2.0	82	2.8	26	......	4.0	9.0	2.0	......
7	......	18.5	2.0	24	2.8	27	......	3.4	12.1	2.0	......
8	......	12.1	4.0	106	2.8	28	24	2.8	6.6	2.0	......
9	......	7.7	3.4	158	2.8	29	13.8	2.7	4.3	2.0	......
10	......	7.7	2.8	110	2.8	30	5.5	2.6	5.5	2.0	......
11	......	6.6	3.4	70	2.8	31	9.6	......	3.4	2.0	......
12	......	6.6	2.8	40	2.8	Mean	13.2	8.6	5.7	26	2.8
13	......	6.6	2.8	15	2.8	Mean per square mile	.64	.42	.28	1.26	.14
14	......	5.5	4.0	7.7	2.8	Run-off, depth in inches	.10	.47	.32	1.46	.07
15	......	5.5	7.7	7.7	2.8						
16	......	5.5	4.0	5.5	2.8						
17	......	4.8	2.9	3.4	2.8						
18	......	4.0	2.8	3.4	......						
19	......	3.8	2.8	3.4	......						
20	......	3.8	16.2	3.2	......						

NOTE.—Some water was diverted by the Midnight Sun ditch during periods of ample supply.

Miscellaneous measurements in Patterson Creek drainage basin, 1909.

Date.	Stream and locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. mi.	*Sec.-ft.*	*Sec.-ft.*
July 20	Quartz Creek at mouth	11.3	1.3	0.12
July 18	Cache Creek at Baker Slough trail crossing	22.7	2.5	.11
May 28	Midnight Sun ditch near outlet	....	6.5	....

SALCHAKET DISTRICT.

DESCRIPTION OF AREA.

The Tanana precinct, which includes the Salchaket district, embraces the area drained by the Tanana and its tributaries from and including Salchaket River to a point on Tanana River south of Lake Mansfield. The larger streams included in this area are Salchaket, Goodpaster, Volkmar, and Healy rivers from the north and Delta River from the south. Tenderfoot and Banner creeks, which have been the largest gold producers in this district, are tributary to the Tanana about 75 miles southeast of Fairbanks and about midway between Goodpaster and Salchaket rivers from the same side.

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

Salchaket River rises opposite the head of the South Fork of Birch Creek, about 25 miles from the Yukon. The average fall of the river from the Splits to the mouth is 10 feet to the mile, and from a point about 2 miles from the summit of the divide at the headwaters it averages 19 feet to the mile. At the mouth, which is 40 miles from Fairbanks, a ferry, post-office, store, and roadhouse are located and excellent accommodations are at hand for the traveler.

Redmond Creek joins the Salchaket from the south about 15 miles above the mouth.

Little Salchaket River is tributary to the Tanana from the east about midway between the town of Salchaket and the Salcha telegraph station.

GAGING STATIONS.

The following list gives the points in the Salchaket district at which gages were established or discharge measurements made in 1909:

Gaging stations in Salchaket district, 1909.

Tanana River at McCartys.
Banner Creek above Buckeye Creek.
Banner Creek near mouth.
Buckeye Creek near mouth.
Salchaket River at Salchaket.
Redmond Creek above Mosquito Creek.
Little Salchaket River at road crossing.

MEASUREMENTS.

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

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

Day.	Banner Creek near mouth (drainage area, 21.5 square miles).			Salchaket River at Salchaket (drainage area, 2,170 square miles).			Redmond Creek above Mosquito Creek (drainage area, 24.7 square miles).		
	July.	Aug.	Sept.	July.	Aug.	Sept.	July.	Aug.	Sept.
1	....	....	7.8	....	7,460	1,730	....	28	5.8
2	....	....	6.6	....	5,700	1,630	....	69	5.3
3	....	....	6.6	....	6,300	1,530	....	145	5.3
4	....	....	6.6	1,730	5,590	1,630	....	65	5.3
5	....	....	6.6	1,710	5,260	1,630	....	38	6.2
6	10.6	....	6.6	1,630	4,060	1,630	....	17.3	7.5
7	6.6	....	6.6	1,630	4,250	1,630	5.0	12.2	8.8
8	10.6	....	5.4	1,800	4,540	1,630	6.7	13.4	10.2
9	5.4	....	5.4	2,840	5,480	1,530	5.5	22	7.2
10	6.6	....	7.8	2,840	5,940	1,530	8.3	36	6.7
11	5.4	....	6.6	2,840	4,940	1,530	10.2	24	7.2
12	5.4	....	6.6	3,380	4,440	1,480	8.6	28	6.7
13	10.6	....	5.4	3,220	4,160	1,480	27	14.5	6.2
14	10.6	....	6.6	4,640	3,540	1,480	22	10.2	8.6
15	9.2	....	6.6	7,300	3,060	1,480	36	9.4	12.2
16	7.8	....	6.6	9,130	2,760	1,480	12.2	9.4	12.2
17	7.8	....	12.2	6,860	2,410	1,350	6.7	8.6	11.2
18	7.8	....	9.2	3,960	2,340	1,350	5.3	7.2	7.9
19	5.4	....	7.8	4,740	2,340	1,350	5.2	6.2	8.7
20	4.3	....	6.6	4,440	2,480	1,350	4.6	73	9.5
21	3.3	....	6.6	4,160	2,910	1,350	4.3	45	10.2
22	3.3	....	6.6	2,840	3,060	1,350	4.0	32	10.2
23	5.4	....	6.6	2,690	3,060	1,350	4.3	17.3	10.2
24	5.4	....	7.8	2,690	2,910	1,350	7.2	12.2	....
25	5.0	....	4.3	3,220	2,690	1,350	6.7	7.9	....
26	4.3	....	4.3	2,910	2,480	1,350	4.6	7.2	....
27	5.4	9.2	....	2,480	2,340	1,350	4.5	6.7	....
28	10.6	9.2	....	2,410	2,200	1,350	6.7	6.2	....
29	17.2	9.2	....	4,740	2,010	1,350	40	6.2	....
30	29	7.8	....	6,580	1,780	1,350	53	5.8	....
31	....	7.8	....	7,800	1,750	....	47	5.8	....
Mean	8.1	8.6	6.8	3,830	3,690	1,460	13.8	25	8.2
Mean per square mile	.38	.40	.32	1.76	1.70	.67	.56	1.03	.33
Run-off, depth in inches	.35	.07	.31	1.83	1.96	.75	.52	1.19	.28

Miscellaneous measurements in Salchaket district, 1909.

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