LODE DEPOSITS NEAR THE NENANA COAL FIELD.

By R. M. Overbeck.

INTRODUCTION.

The lode prospects described in this report were visited during the summer of 1916 by G. C. Martin and party in the course of a rather detailed examination of the coal-bearing areas of the Nenana coal field. The part of the field that was investigated extends from Nenana River eastward about 18 miles and from Healy Creek northward about 22 miles and lies approximately within the limits of 148° 25′–149° 01′ west longitude and 63° 54′–64° 10′ north latitude. (See accompanying map, Pl. XVII.) The mouth of Hoseanna Creek is about 50 miles south of the new town of Nenana, at the junction of Nenana and Tanana rivers, and about 70 miles on a direct line southwest of Fairbanks. The Government railroad, now under construction, is projected to cross to the west side of Nenana River about 4 miles above the mouth of Moose Creek and 8½ miles below the mouth of Hoseanna Creek.

No lode mining has been done in the area outlined, and prospecting has not been extensive. Gold is the principal mineral sought. A gold quartz claim was staked several years ago on McCuen Gulch, in the SE. ¼ sec. 1, T. 10 S., R. 5 W. A mineralized zone that apparently is gold bearing is reported from Fourth of July Creek about half a mile above its mouth. A stibnite lode was located a few years ago on Cody Creek in the SE. ¼ sec. 8, T. 11 S., R. 7 W., and in 1916 was relocated. In 1915 and 1916 prospecting became more active, owing to the finding in Eva Creek of float rock that was heavily mineralized with arsenopyrite, bismuth, and bismuthinite and that was reported to carry gold. Search for the source of this rock led to the discovery of several mineralized zones, and about 20 locations (claims and tunnel sites) were made on Eva Creek and on Moose Creek.

The purpose of this report is to give a few facts that may be helpful to the prospector concerning metallization in the region, for the coming of the railroad and the opening of the coal fields will doubtless stimulate the search for lode deposits. Unfortunately, however, prospecting has not been extensive enough to furnish much information about the occurrence of ore bodies.

The area described in this paper lies in the northern foothill belt of the Alaska Range. This belt, which is about 25 miles wide where Nenana River cuts through it, is bounded on the north by the Tanana Flats. More or less discontinuous ridges, separated from one another by rather broad, flat structural valleys that run parallel to the main range, make up the foothill belt. Schists and igneous rocks form the more rugged ridges, and partly consolidated clays, sands, and gravels form the valleys and some of the high rounded hills. Jumbo Dome, the highest hill in the region, has an elevation of 4,500 feet, and the Nenana near the mouth of Moose Creek an elevation of 1,000 feet—a total difference in relief of 3,500 feet. The streams that drain the region flow northward into the Tanana and westward into the Nenana. The chief northward-flowing stream is the Totatlanika, which with its branches drains about two-thirds of the area investigated. Healy, Hoseanna, Walker, and Moose creeks are westward-flowing streams. Totatlanika Creek and its tributary, California Creek, run in canyons where they cut through the schist ridges, and Hoseanna Creek has a narrow, steep-sided valley deeply incised in the partly consolidated clays, sands, and gravels of the coal-bearing formation. The streams near the lode prospects are small and furnish barely enough water for small placer workings. The annual precipitation in the region is small, being at Fairbanks about 11.5 inches. Timber line lies about 2,100 feet above sea level. The trees (spruce and cottonwood) grow chiefly along the stream courses and are mostly small and of little use for construction. The Tanana Flats, however, are fairly well covered with spruce and should supply some mine timber. Lignite is abundant in the coal fields. In 1916 a wagon road ran from Nenana through the flats almost to the foothills, and thence a good horse trail follows the gravel ridges to Hoseanna Creek. Horse feed grows profusely.

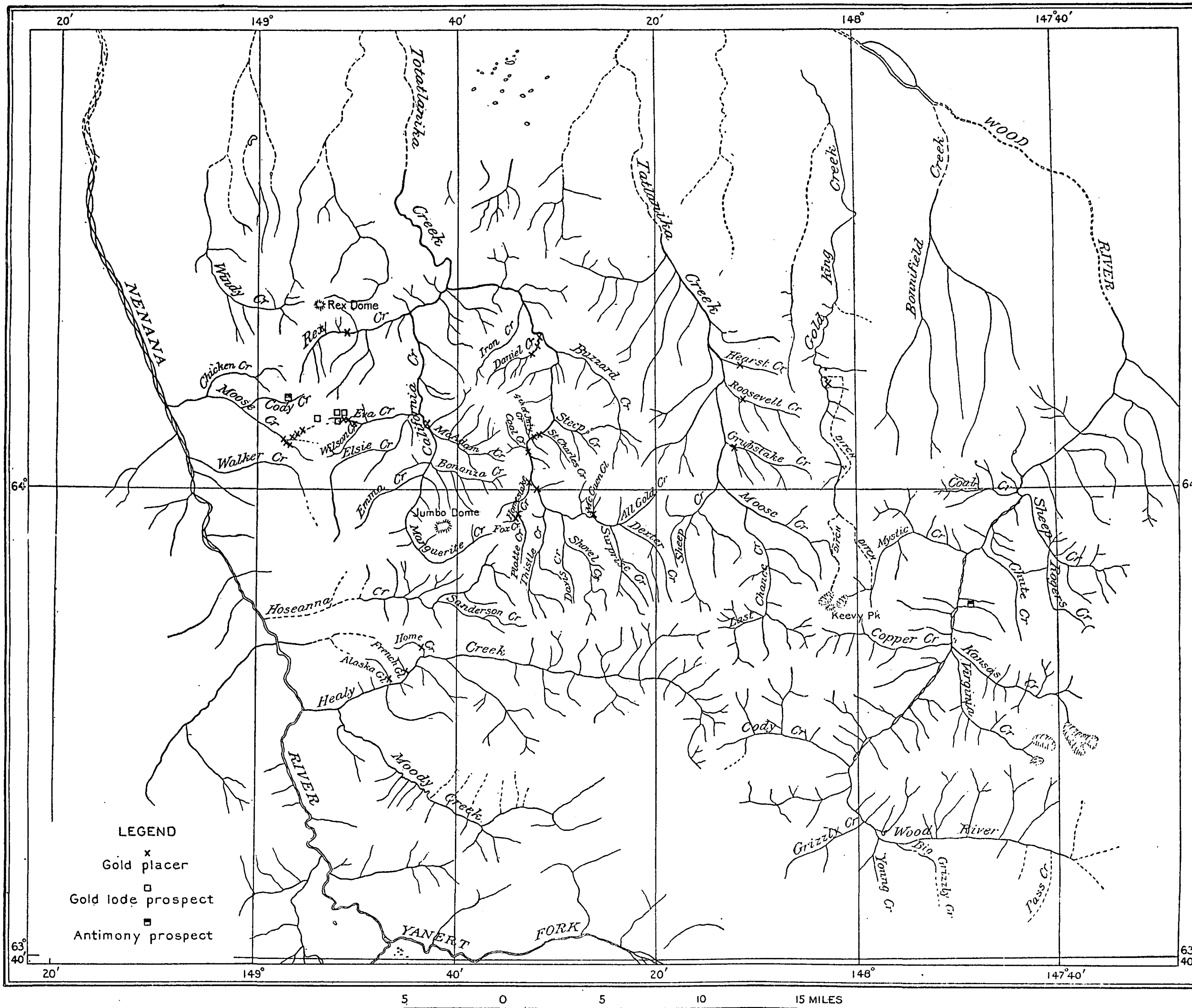
GEOLOGY.

The main geologic features of the region are known through the investigations of Brooks and Prindle (1902),[1] Prindle (1906),[1] and Capps (1910).[2] As the work of 1916 was limited practically to the areas in which the coal-bearing rocks crop out, a description of the rocks of the district as a whole is abstracted from Capps's report.

The oldest rocks of the region, the Birch Creek schist, form the greater part of the high mountains on the north slope of the Alaska Range. They comprise a great series of metamorphosed sediments, which now appear as quartz and mica schists and phyllites, with schistose and micaceous quartzite. * * * No evidence has been found in the Bonnifield region which would determine the age of this schist series, but from its relations with younger fossil-bearing

[1] Brooks, A. H., and Prindle, L. M., The Mount McKinley region, Alaska: U. S. Geol. Survey Prof. Paper 70, 1911.

[2] Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, 1912.



MAP SHOWING LOCATION OF LODE DEPOSITS AND GOLD PLACERS NEAR THE NENANA COAL FIELD.

formations in other places it has been provisionally determined to be of pre-Ordovician age.

Next younger than the Birch Creek schist and forming the foothill ranges to the north of the main mountain range is a thick series of quartz-feldspar rocks, to which the name Totatlanika schist is here applied, from typical exposures along the creek of that name. These are for the most part metamorphosed igneous rocks but include some infolded beds of sedimentary origin. * * * The whole series was * * * folded, faulted, and greatly metamorphosed. Near Nenana River the schists appear at the surface across a belt 18 miles wide, although in places they are covered by younger deposits. * * * The quartz-feldspar schists and the associated beds of sedimentary origin are provisionally assigned to the Devonian or Silurian.

The period of metamorphism was succeeded by a long period of time during which the area here considered stood above the sea and was denuded to a surface of slight relief. Of this erosion period no record is left in the deposits of the Bonnifield region. The next younger beds are of lower Tertiary age (Eocene) and consist of loosely cemented conglomerates, sands, clays or shales, and lignitic coal occupying basins formed between ridges of the older schists. * * * The lower Tertiary beds, although locally folded and faulted, present a young appearance as compared with the schists on which they lie.

After the coal-bearing series was deposited, the uplift of the Alaska Range began, and the folding of the rocks formed a number of depressed basins in which the lower Tertiary beds were preserved. Between these basins and in the Alaska Range proper the uplift exposed the loosely cemented materials to erosion, and they were removed from much of the area which they had formerly covered.

A rather thick series of gently folded clays, sands, and gravels, which are younger than the coal-bearing rocks and which may be of Pleistocene age, rest on the schists and on the coal-bearing formation at many places. These deposits are the Nenana gravel described by Capps.[1] Bench gravels and alluvial gravels along the courses of the present streams are the youngest rocks of the region.

Igneous rocks later than those which make up the Totatlanika schist are abundant. They occur as intrusive bodies that cut the schist and as flows. Quartz porphyry, dacite, hornblende andesite, and andesite are the types represented.

The unaltered sedimentary rocks of the region, although they contain coal beds that would be highly important as a source of fuel in the event of the development of lodes, have had no direct part in the formation of the lode deposits and so will not be further discussed.

The schists, which are sedimentary and igneous rocks that have changed their character under the action of great differential pressures, have been separated by Capps into two types—the Birch Creek schist, which consists chiefly of altered sedimentary rocks, and the Totatlanika schist, which consists of altered igneous rocks. The Birch Creek schist, which occupies but a small part of the

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[1] Capps, S. R., op. cit., p. 30.

region, is not associated there with lode occurrences, but much of the gold in the placers of Tanana Valley and in part of Yukon Valley is believed to be derived from it.

The country rock of the prospects is the fine-grained dark carbonaceous phase of the Totatlanika schist. It is described by Capps[1] as follows:

> Associated with the altered igneous rocks, especially in the lower part of the series, are commonly to be found beds of carbonaceous shales and schists and some quartz conglomerate, which are certainly of sedimentary origin. * * * It is probable that the laying down of the sediments was interrupted at times by the extrusion of igneous rocks, so that they belong properly to the same time period. The beds of clastic origin are prominent only near the base of the Totatlanika schist.

Specimens of this schist from the lode prospects differ somewhat in appearance. The typical dark schist is nearly black, is fine grained, consists chiefly of quartz (?) and carbonaceous material, and is cut by numerous small stringers of quartz. Through the action of the weather the rock becomes soft and breaks into thin black leaves and plates. Other rocks contain much sericite and weather light yellow. These two types are probably altered sediments. Some of the light varieties, however, resemble altered rhyolites in texture, and hence may be of igneous origin. The dark schist, the weathered outcrops of which look much like coal, is found near all the prospects, and on a branch of California Creek a body of iron-mineralized rock was observed just beneath a belt of the black schist. Whether this phase of the schist is connected genetically with the lode deposits is not known, but the field association of black schist and prospects is at least suggestive, and the prospector in this region should search carefully for lode mineralization wherever he sees outcrops of black schist.

The igneous bodies near the prospects are dikes and rather small, irregularly shaped, intrusive masses, which cut the Totatlanika schist and project above it as spines, as walls, or as mounds of platy rock. All the intrusive rocks are of the same general type, but the great difference in amount of alteration in rock bodies closely associated in the field points to a difference in age. Unsheared and sheared dikes, for example, are found close together. An abundance of quartz and orthoclase occurs in the rocks of both the sheared and the unsheared masses. The sheared rock is dark and shows some banding. The bands are lines of small overlapping lenticular areas of quartz and feldspar, which alternate with lines of dark fine-grained sericitic material. The unsheared rock is light brown or light gray, does not show banding, and is characterized by the prominence of clear quartz grains, or phenocrysts, which are about one-thirtieth of an inch in

[1] Capps, S. R., op. cit., p. 25.

diameter. Feldspar crystals of the same size as the quartz grains are also abundant but are not so noticeable as the quartz. The microscopic study of these rocks confirms the field determination of quartz porphyry. Phenocrysts of quartz and orthoclase are set in a fine-grained groundmass, which consists in the unsheared rocks of intimately intergrown quartz and orthoclase, and in the sheared rocks of crushed quartz and feldspar, sericite, and possibly chlorite and other alteration minerals.

A genetic relation between the quartz porphyry—acidic intrusive rocks—and the lodes is suggested by their association in the field. This association is shown by the following examples. At the head of Moose Creek a number of the smaller acidic intrusive bodies are exposed, placer gold is found in the stream that cuts the bodies, and near them a stibnite lode and a gold claim have been located. Dikes occur on Eva Creek near the present lode prospects and above the placer workings. On Wilson Creek mineralized schist that carries a little gold was discovered near a large siliceous dike. A siliceous dike occurs near the gold lode prospect at the head of McCuen Gulch. Placers are being worked on Homestake Creek, which cuts a less siliceous rock, quartz diorite, but no lodes have been found near this stream. Little or no placer mining has been done on the streams that drain the slopes of Jumbo Dome, an intrusive body of hornblende andesite. The prospector should learn to recognize the siliceous intrusive bodies in the field and to realize that they probably played some part in the formation of the lodes.

As a result of the action of great forces the rocks of the region are faulted and folded and the older rocks have been converted to schists. The effect of rather recent movement is shown by the gentle folding and faulting of the Nenana gravel, which may be of Pleistocene age. Faults and fault zones may be important factors in the localization of ore deposits. They may, for example, afford passageways for mineralizing solutions. One of the prospects in the region was in a small shear zone in the schist, and all the present prospects are near a large fault that can be traced along Eva Creek, across the head of Moose Creek, and into Cody Creek. There seems, then, to be a relation in this region between the distribution of mineralization and faulting.

To summarize, the prospector should note the following facts about the occurrence of lode prospects in the district: (1) They are in the schist; (2) they are associated with the fine-grained dark schist; (3) they are near small acidic intrusive bodies; (4) they are related to faulting.

MINERALOGY.

None of the prospects have been opened up sufficiently to furnish specimens of the mineralized rock. The best material so far found occurs as float in Eva Creek, and consists chiefly of a mixture of arsenopyrite and quartz, in which are small amounts of native bismuth and bismuthinite and in some specimens a very little chalcopyrite and pyrite. The mineralized rock weathers rusty brown on the surface and its crevices and cracks are lined with green, yellow, and gray coatings that are probably alteration products of the arsenical minerals. Crushed specimens of these rocks are reported to yield gold when panned, and assays of hand specimens show the presence of some gold. Crystals of gold were obtained from the weathered rock of one of the prospects.

Arsenopyrite (an iron-arsenic-sulphur compound), the most abundant metallic mineral present, is not valuable as an ore mineral, but it may be useful to the prospector as an indication that metallization has taken place, as in this and neighboring regions gold is found in places associated with arsenopyrite. The mineral is recognized easily by its tin-white color, metallic luster, and hardness. (It will scratch the blade of a pocket knife.) Arsenopyrite is a very common mineral and has little economic importance. "Arsenic" (arsenic trioxide), which is extensively used in the manufacture of glass and of insecticides, is obtained in this country as a by-product of the smelting of ores rich in arsenical minerals.

Native bismuth and bismuthinite are abundant in some specimens from Eva Creek, and they are reported from the other prospects in the vicinity. Native bismuth that has been exposed to the weather is recognized by its rather deep yellow tarnish. A fresh piece of bismuth has a high metallic luster and is gray but has a distinct pinkish tinge. The mineral is very soft and can easily be cut with a knife.

Bismuthinite (bismuth sulphide) is a soft lead-gray metallic mineral with a high luster. It differs from native bismuth in color; the native bismuth has a decided pinkish tinge, which the bismuthinite lacks. It is not so hard as arsenopyrite, which it resembles somewhat in color. Fine-grained bismuthinite may be difficult to distinguish from fine-grained stibnite.

The uses of bismuth are few. It finds its most extensive application as salts for medicinal purposes. Its low melting point makes it useful in the manufacture of fuses for electric wiring systems and of plugs in devices for protection against fire. Its use as a metal is restricted, owing to its extreme brittleness, although it has been used somewhat for type metal. Practically all the bismuth obtained in this country comes as a by-product from the smelting of ores rich in bismuth minerals. In 1915 about 44,000 pounds of metallic bismuth, valued at $108,000, was imported. It sold at $2.50 to $3.50 a pound. Ores containing less than 10 per cent of bismuth can not be sold in this country at the present time, and the demand for bismuth ores is so small that the rates per ton of ore would be very low. It is to be hoped, however, that a demand will spring up and that much bismuth ore now on the dump heap may some day be valuable.

The antimony ore from the Rambler lode, on Cody Creek, is rather pure stibnite (antimony trisulphide) in a confused crystalline aggregate. A blackish tarnish covers exposed surfaces of the stibnite where weathering has not advanced far enough to form the usual yellow or gray crusts of decomposition minerals (stibiconite?). Stibnite is lead-gray, and has a metallic luster. It is very soft and can easily be scratched with a knife or even with a brass pin. Fine-grained stibnite can be distinguished only with difficulty from other fine-grained gray metallic minerals. Coarse-grained stibnite occurs in long, needle-like crystals, which are commonly bent and broken. The stibnite is distinguished from native bismuth by the pinkish hue of the freshly broken bismuth.

Antimony is used as an alloy in making type metal and babbitt metal, and in making shrapnel, and at present the demand for it is rather large. The price before the war was about 7 cents a pound; since then it has fluctuated widely and has reached 50 cents a pound. The present price (1917) ranges from 14 to 25 cents. About 833 short tons of antimony ore, carrying about 58 per cent of antimony, was shipped from Alaska in 1915 and sold in San Francisco at an average price of about $86 a ton.[1] About 1,460 tons of ore was mined and shipped during 1916. Most of this ore was from the Fairbanks district.

The accessory minerals, pyrite and chalcopyrite, occur in very minor amount. They are distinguished from practically all other metallic minerals by their yellow color. Pyrite, an iron sulphide, is typically very light brass-yellow; chalcopyrite, an iron-copper sulphide, is a rather deep greenish yellow. Pyrite and chalcopyrite are distinguished from one another by their difference in hardness; chalcopyrite can be scratched with a needle or with the point of a knife blade, whereas pyrite is harder than the knife blade and will scratch it. The yellow tarnish on native bismuth may cause it to be mistaken for chalcopyrite, but the true color of the bismuth is revealed when the tarnish is scratched away.

TYPE OF ORE BODY.

As prospecting and exploratory work have not been sufficiently extensive to disclose the actual condition and extent of the supposed ore bodies, their mode of occurrence can only be surmised. Most of the mineralization probably took place by deposition from solutions in shear zones or in fissures in the schist.

[1] Brooks, A. H., Antimony deposits of Alaska: U. S. Geol. Survey Bull. 649, pp. 7–8, 1916.

GENESIS.

Concerning the genesis of the deposits only tentative generalizations can be made, for the facts necessary for definite conclusions are lacking. In the absence of conclusive field evidence, an attempt was made to get some light on the origin of the ores by an examination of thin sections and polished surfaces. Good specimens were lacking, but presumptive conclusions may be drawn from certain relations of the minerals. The ores were probably deposited from solutions rich in silica, partly as fissure fillings and partly, perhaps, by replacement of the schist, under conditions of rather high pressure and moderate temperature. No minerals that are formed characteristically under very high pressures and at high temperatures were found, nor is the quartz, which, with the possible exception of the quartz with the stibnite, is clear and in rather large crystals, of the fine-grained variety that at many places accompanies ores which are formed near the surface by heated solutions.

The sequence of crystallization of the ore minerals can be inferred in a general way from the polished sections. The first minerals deposited were quartz and arsenopyrite. Quartz began to crystallize apparently before the arsenopyrite and continued after all the arsenopyrite had come from solution. Examples of quartz cut by stringers of arsenopyrite, of quartz and arsenopyrite that show what Graton and McLaughlin[1] call "mutual boundaries," and of quartz stringers that surround and run between grains of arsenopyrite are abundant. A little orthoclase accompanies the quartz. Laths of sericite and of chlorite are associated with the arsenopyrite and with the bismuth minerals. Sericite occurs as an alteration product of the orthoclase.

The next metallic mineral to crystallize was apparently the accessory mineral chalcopyrite, which shows rather good crystal form, is definitely later than the quartz, is seemingly later than the arsenopyrite, and is definitely earlier than the bismuth minerals.

The native bismuth is apparently full of inclusions in the surface examined. The inclusions are so fine grained that they can not be surely identified, although the numerous laths present are probably chlorite or sericite. Bismuthinite is seemingly later than the native bismuth complex, which it crosses in stringers, and it is later than the laths (sericite or chlorite (?)), which it cuts and to some degree replaces. The laths, if correctly identified, are probably of hydrothermal origin.

Stibnite is not associated with the other metallic minerals in the sections examined, and consequently its relation to them is not known. Neither gold nor pyrite occurs in the polished surfaces.

[1] Graton, L. C., and McLaughlin, D. H., Ore deposition and enrichment at Engels, Cal.: Econ. Geology, vol. 12, p. 17, 1917.

The order of crystallization of ore and gangue minerals seems to be as follows: Quartz and arsenopyrite, chalcopyrite, native bismuth, bismuthinite.

The source of the mineralizing solutions is the next point to be considered. Capps[1] makes the following statement about the origin of the lodes of the Bonnifield region (specifically of the Wood River basin):

> Associated with the schists of the main range, which have been correlated with the Birch Creek schist of the Fairbanks region, also cutting the quartz-feldspar schists to the north, are many intrusive granitic rocks, and there is some reason to believe that the mineralization of the schists may be due to these intrusions.

Brooks[2] says of the lodes of the Yukon-Tanana region as a whole that "there appears to be close genetic relation between the gold deposits and the granite intrusive rocks." In the Nenana region no large bodies of granite were found, although small granitic intrusive bodies are fairly abundant. These small granitic bodies, apparently to the exclusion of other igneous types, occur near all the present lode prospects and are probably related to them genetically. Field evidence does not show whether the deposits are related to the sheared or the unsheared granite intrusives or to both.

The geologic period of mineralization is not definitely known. The deposits are younger than the schists (referred provisionally to the Silurian or the Lower Devonian) in which they occur, and they are not found in the Tertiary rocks of the region. The granitic rocks with which metallization is probably associated are thought to belong to the "general period of intrusion, beginning possibly in late Paleozoic time and in some parts of the province extending through to the Upper Cretaceous, but having its maximum development late in the Jurassic."[3] If mineralization took place at a time when igneous activity was waning, the age of the deposits would be late Mesozoic. Prindle[4] says of the Fairbanks lodes that "the metallization probably occurred near the end of the Mesozoic era."

The seeming localization of some of the prospects along a fault that cuts Pleistocene (?) gravels does not necessarily indicate a Pleistocene age for the deposits. The region has been only slightly disturbed since the deposition of the early Tertiary coal-bearing rocks, and the fault may simply represent a zone of weakness which has persisted from Mesozoic time. This zone was probably not developed before very late Mesozoic time, for otherwise it would have

[1] Capps, S. R., op. cit., pp. 52–53.

[2] Brooks, A. H., Geologic features of Alaskan metalliferous lodes: U. S. Geol. Survey Bull. 480, p. 63, 1911.

[3] Brooks, A. H., The Mount McKinley region, Alaska: U. S. Geol. Survey Prof. Paper 70, p. 52, 1911.

[4] Prindle, L. M., A geologic reconnaissance of the Fairbanks quadrangle, Alaska: U. S. Geol. Survey Bull. 525, p. 72, 1913.

lost its identity in the orogenic movements of the earlier Mesozoic. This fact, then, suggests that mineralization took place after early Mesozoic time. As metallization was found nowhere in the district in Tertiary rocks, and as the granitic rocks with which metallization is apparently genetically connected were nowhere seen to cut Tertiary rocks, the assumption, based on negative evidence, is made that metallization in the district took place in late Mesozoic time.

Nothing definite could be learned about the age of the stibnite deposit. The fact that the stibnite occurs alone and was not found in association with the arsenopyrite and bismuth minerals suggests that it may belong to a different period of mineralization. Brooks[1] says that "the formation of stibnite lodes of Alaska seems to have taken place principally in Tertiary time."

A summary of the probable events connected with metallization in the region is as follows: The sulphides accompanied by gold were deposited from solutions in shear zones and possibly in fissures under conditions of rather high pressure and moderate temperatures; the solutions were derived from acidic magmas that formed the granitic dikes; arsenopyrite and quartz were deposited first and were followed by the bismuth minerals; metallization took place probably in late Mesozoic time, or, possibly, even in early Tertiary time.

PROSPECTS.

Almost no underground development work has been done on the claims in the district. A tunnel 35 feet long and a shaft 15 feet deep at the end of the tunnel were opened in the loose rock on the south side of Eva Creek, for the purpose of locating the source of the mineralized float rock in Eva Creek. Gold was panned from decomposed rock at the mouth of the tunnel, but the shaft was flooded before anything definite could be ascertained as to the existence of an ore body. On Eva Creek, about a quarter of a mile below the mouth of this tunnel, some of the decomposed material from a shear zone in the schist yielded some gold when panned. The decomposed material consisted of pyrite, arsenopyrite, chlorite, and scorodite (?). This shear zone strikes N. 15° E. and dips 75° S. On the north side of Eva Creek several shallow pits have been sunk into mineralized schist, but no information could be obtained concerning the extent or character of this mineralization. A hand specimen of oxidized schist carrying arsenopyrite and pyrite from a claim at the head of Moose Creek, in sec. 10, T. 10 S., R. 7 W., was found on assay to carry gold.

The stibnite claim, the Rambler lode, is on the north side of Cody Creek, a tributary of Moose Creek, in sec. 8, T. 10 S., R. 7 W. A shallow crosscut and two shafts, which were not accessible when the

[1] Brooks, A. H., Antimony deposits of Alaska: U. S. Geol. Survey Bull. 649, p. 9, 1916.

prospect was visited, are on the property. The crosscut in the hillside exposes two lenticular bodies of stibnite in a greatly oxidized fine-grained sericite schist. The two lenses are about 4 feet apart. The larger one strikes about N. 70° E., dips 75° SE., and cuts across the schistosity of the country rock at a small angle. The greatest thickness shown was about 5 inches, and the greatest length was about 3 feet. A quartz stringer about an inch thick, which consists of a weathered sugary form of quartz, occurs with the stibnite and lies at some places in the footwall and at others in the hanging wall. Some of the ore at the shaft, which lies several hundred feet west of the crosscuts, appeared to come from a body of ore that is larger than those exposed in the crosscuts. The lenses consisted almost entirely of stibnite of both coarsely granular and finely granular character. The stibnite that has been exposed for a long time to the weather is coated with light-yellow earthy decomposition products (stibiconite?).

DEPOSITS IN NEIGHBORING DISTRICTS.

A few facts which might be of assistance to the prospector in the Nenana region about lode occurrences in adjacent regions geologically similar are here summarized from Survey reports.[1]

FAIRBANKS DISTRICT.

The rocks in the Fairbanks district are cut by many igneous intrusives. Quartz veins which range from less than an inch to 12 or 15 feet in width are common. These veins have a strike parallel generally to the strike of the country rock, and their dip is in most places steep. A little orthoclase may be associated with the quartz. The quartz of the productive veins is commonly milky white.

The metallic minerals that occur in these quartz veins are pyrite, stibnite, arsenopyrite, galena, sphalerite, bismuth, and gold. Pyrite is the most abundant and under the action of the weather alters to the familiar rusty-brown limonite. Stibnite is found with gold in some of the richest quartz veins. Arsenopyrite is rather abundant and occurs in some places with gold and stibnite. Bismuth intergrown with gold has been picked up in placers, and is reported[2] with

[1] Prindle, L. M., Auriferous quartz veins of the Fairbanks district: U. S. Geol. Survey Bull. 442, pp. 210–229, 1910.
Brooks, A. H., Geological features of Alaskan metalliferous lodes: U. S. Geol. Survey Bull. 480, pp. 43–94, 1911.
Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, 1912.
Prindle, L. M., Katz, F. J., and Smith, P. S., The Fairbanks quadrangle: U S. Geol. Survey Bull. 525, 1913.
Chapin, Theodore, Lode mining near Fairbanks: U. S. Geol. Survey Bull. 592, pp. 321–356, 1914.

[2] Chapin, Theodore, op. cit., p. 325

bismuthinite (bismuth sulphide) "in a very rich gold-bearing vein quartz." Galena (lead sulphide) that carries silver and sphalerite (zinc sulphide) occur in the Fairbanks district. Cassiterite (tin oxide) and wolframite (tungsten ore) are found in placer concentrates.

BONNIFIELD DISTRICT.

Some lode mining has been done on Wood River, the first large river east of the Nenana. This district was visited by a Survey party in 1910. The country rock is quartz-feldspar schist that is cut by intrusive granitic rocks, and the mineralization seems to be related genetically to these intrusives. The deposits appear to be of two kinds—mineralized bodies of schist, or igneous rock, and quartz veins. The gold is associated with pyrite. At one locality a zone of rhyolite porphyry and at another a body of black quartzitic schist, both heavily mineralized with pyrite, are reported to carry gold. On another of the creeks a large quartz vein that consists of massive milky quartz and in places is stained with limonite carries gold, but the assay values were too low to admit of mining under conditions existing at that time.

GOLD PLACERS NEAR THE NENANA COAL FIELD.

By A. G. Maddren.

INTRODUCTION.

The Nenana district lies in the northern foothill belt of the Alaska Range, along the southern border of the Tanana Valley, between 147° 40′ and 149° 20′ west longitude and 63° 50′ and 64° 15′ north latitude. This area has been described under the name "Bonnifield region" by Prindle[1] and Capps.[2] Prindle included all areas of placer mining between Wood River and Nenana River in the "Bonnifield placer region," which is equivalent to the area here called Nenana district. Capps applied the name "Bonnifield region" more broadly to include a large area of the foothill province east of Wood River, in addition to that between Wood and Nenana rivers. The considerable areas of lignite deposits that occupy portions of the Bonnifield placer region, as defined by Prindle, constitute what is now commonly called the Nenana coal field, and as the placer gold deposits discussed in this report are distributed throughout the general area occupied by the lignite-bearing sediments and in some localities are closely associated with them, a common geographic designation for both seems desirable.

The field observations upon which this report is based were made incidentally to detailed stratigraphic work on the lignite deposits of the Nenana coal field during the summer of 1916, under the direction of G. C. Martin. As field work on the lignite deposits was restricted to the western half of the district the observations of the writer on the placers cover only that part of the area. The notes here presented on the placers of the eastern half of the district are based on information gathered from miners and prospectors. The information given in this paper is more or less supplemental to that obtained by Prindle in 1906 and by Capps in 1910, although some of the workings they noted are now abandoned and several others have been developed since their visits. Their reports have been freely drawn upon.

[1] Prindle, L. M., The Bonnifield and Kantishna regions: U. S. Geol. Survey Bull. 314, pp. 207–213, 1907.

[2] Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, 1912.

GEOGRAPHY.

The part of the northern foothill province of the Alaska Range included in the Nenana district is well marked off on the west by Nenana River and on the east by Wood River. These rivers rise in the main range, to the south, and flow northward, by direct courses in deep valleys, across the moderately mountainous foothill belt. On the south the foothill belt is limited by the higher mountains of the northern front of the Alaska Range, whose rugged ridges attain altitudes of 5,000 to 6,500 feet. On the north the foothill belt terminates with a somewhat abrupt east-west front that stands from 2,000 to 3,000 feet above the Tanana Valley lowlands. These lowlands or broadly terraced plains slope gently northward and extend along the base of the foothills for about 25 miles, to Tanana River. As thus bounded by high mountains on the south, valley lowlands on the north, and large river valleys on the east and west, the Nenana district comprises a rectilinear block of the foothill province, about 50 miles from east to west and 25 miles from north to south, covering thus an area of about 1,250 square miles.

Although considerable areas in the eastern and western parts of the district are drained by tributaries to Wood and Nenana rivers, respectively, its greater part is drained by Totatlanika and Tatlanika creeks, large streams that rise wholly within the central foothill area of the district. These streams, like Nenana and Wood rivers, flow northward across the dominant easterly trend of the foothill ridges. All four of these trunk streams continue northward from the foothills across the Tanana Valley lowlands and discharge into Tanana River. (See Pl. XVII.)

The Nenana district, especially in its western half, exhibits three chief forms of topography. These are, in order of prominence, a series of nearly parallel east-west ridges whose general altitude ranges from 3,000 to 4,000 feet; a series of depressions between the foothill ridges, from 1,000 to 2,000 feet below the crests; and a number of narrow canyons eroded to depths of 500 to 1,500 feet across the mountain ridges from south to north by the trunk streams of the district. Thus the foothill belt as a whole is one of marked diversity, but nevertheless its chief features have a rather regular arrangement, those due primarily to structure trending generally east and those due primarily to drainage development transecting the structural trend south to north.

GOLD PLACERS.

GENERAL CONDITIONS.

The first discoveries of placer gold in the Nenana district were made in 1903 and 1904 by prospectors who came chiefly from Fairbanks, the supply center of the region, on Tanana River about 60 miles to the north. Additional discoveries have been made from year to year on creeks that were not closely examined during the initial period of prospecting, and it is probable that still other localities of gold-bearing gravels may be found here in the future. It is estimated that from 50 to 100 men were engaged in prospecting and mining in the district during the earlier years of development, but during the last 10 years the number has ranged from 30 to 50.

The localities where placer gold is known to occur are distributed throughout the district, in the drainage areas of all the trunk streams. In the Nenana Valley gold is found in the basins of three eastern tributaries to the main river—Moose, Hoseanna, and Healy creeks. In the Totatlanika basin gold occurs on California Creek and its tributaries, Rex and Eva creeks, at a number of points along the main course of the Totatlanika above the mouth of California Creek, and in Daniel, July, and Homestake creeks and McCuen Gulch, tributaries to its upper course. In the Tatlanika basin productive mining has been done on Grubstake and Roosevelt creeks, and gold is reported to be present in Hearst Creek and along the bed of the main stream for several miles. Mining has been done at several localities along Gold King Creek.

In general placer-mining claims have been staked and restaked from year to year on practically every stream of any size in the district, and prospecting has been done at hundreds of points along these streams by digging open cuts and shallow holes.

NENANA VALLEY.

Moose, Hoseanna, and Healy creeks are the three largest tributaries to Nenana River from the east in the foothill belt. They drain considerable areas in the western and southwestern parts of the district.

MOOSE CREEK.

GENERAL FEATURES.

Moose Creek empties into Nenana River about 45 miles above its mouth by the course of the river, or 38 miles by the line of the Government railroad that is now being constructed along the east side of the Nenana to a point about 4 miles above the mouth of Moose Creek, where it is to cross the river and continue southward along its west bank. Moose Creek is about 10 miles south of the northern border of the foothill belt. Its basin comprises about 20 square miles on the eastern slopes of the Nenana Valley. It is formed by two headwater streams, Big Moose and Little Moose creeks, which join about 6 miles from the Nenana. Little Moose Creek flows northwestward, and the main creek continues in the same direction. Big Moose

Creek enters from the northeast, and about 2 miles below its mouth another tributary, Cody Creek, enters from the east. Two miles farther downstream Chicken Creek, the largest tributary to Moose Creek, flows into it from the northeast.

GEOLOGY.

The basin of Moose Creek is eroded in schist that is overlain by a thick mantle of gravels. The schist is best exposed along the deeper parts of the main drainage courses, where the gravels have been eroded away by the streams. The schists are also denuded of the overlying gravels on the divides between the sources of Cody Creek and Rex Creek and between Cody and Chicken creeks. Near the junction of Chicken Creek with Moose Creek the bedrock slopes of the Nenana Valley disappear beneath terraces of gravel several miles wide that extend along Nenana River throughout the foothill belt.

The thick deposits of high gravels that overlie the schists within the Moose Creek basin occur chiefly on the ridges and spurs between Cody, Big Moose, and Little Moose creeks and along the divide at the heads of these streams. On these ridges the gravels range in thickness from 300 to 500 feet, but apparently they are erosional remnants of a considerably greater thickness of gravels which formerly covered the whole Moose Creek basin. These gravels appear to be much thicker north and south of Moose Creek along the eastern slopes of the Nenana Valley and in other parts of the district.

DRAINAGE.

The drainage system of the Moose Creek basin is clearly due to rapid downward erosion by the present streams through the thick gravels and into the underlying schist bedrock. The amount of vertical down-cutting into the schist ranges from 200 to 500 feet along the stream courses.

Nenana River, the controlling factor in the development of this drainage system, has recently intrenched its course to a depth of several hundred feet below an older valley floor several miles wide. The surface of this older valley floor now has the form of broad gravel terraces that extend along the river throughout its foothill section. These broad terraces, together with many narrow ones high on the valley slopes, indicate successively lowered flood plains in the course of the valley's erosion to its present form.

Moose Creek has adjusted itself to the recent abrupt down-cutting of the Nenana by intrenching the lower 2 miles of its course across the broad gravel terraces of the main valley. The down-cutting has been continued up the creek and its larger tributaries nearly to their sources, and in some parts of the basin small gorges have been cut into the schist bedrock. Thus narrow rock benches that represent remnants of an older valley floor have been formed here and there. These rock benches within the Moose Creek basin appear to be directly related to one or more of the broad gravel terraces of the Nenana Valley. Together these features indicate that the more or less rapid down-cutting of Nenana River and its tributaries has been arrested at intervals for periods long enough to enable the streams to work laterally and widen their flood plains. That these periods of arrested down-cutting were not long, however, appears to be shown by the fact that no very wide or continuous benches have been formed within the bedrock portion of the Moose Creek basin.

PLACERS.

The principal placer claims in the Moose Creek basin are on Big Moose and Little Moose creeks and along the main stream for about a mile below their junction. Big Moose and Little Moose creeks are each about 2½ miles in length, but most of the mining on them has been done along the lower mile of their courses. They rise on a gravel ridge, 3,000 feet in altitude, that divides them from Eva and Wilson creeks, which flow eastward into California Creek. The junction of Big Moose and Little Moose creeks has an altitude of about 1,900 feet. Big Moose Creek falls about 300 feet in the lower mile of its course. Little Moose Creek falls about 250 feet in the same distance, and this grade continues down Moose Creek for a mile below the junction.

The first gold production of consequence in the Moose Creek basin is reported to have been made in the later part of the summer of 1909, when about 100 ounces was mined from a gravel-covered bench with schist bedrock near the mouth of Big Moose Creek. Seven men are reported to have mined in this part of the basin in 1910, and since then about the same number of men have been mining each summer. In 1916 eight men were mining on four claims in this basin. Three men were working on a claim on the main creek just below the junction of Big Moose and Little Moose creeks, two men were mining a claim on Big Moose Creek about a mile above its mouth, and two claims were being mined by three men on Little Moose Creek about half a mile above its mouth. Mining on another claim on Big Moose Creek just above the one that was worked was discontinued for the season because the open cut was filled with waste gravel by a flood in June. In fact, the unusually high water at that time set back mining on all the claims in some measure, as it washed out some of the automatic dams used in ground sluicing and carried more or less waste gravel into open cuts that had been prepared for shoveling in.

The yield of placer gold from the Moose Creek basin during the period 1909 to 1916 is stated to have averaged the equivalent of good wages, or about $7 a day to the shovel. It is estimated that the value of the total output of gold to date is about $30,000.

The placer gold occurs chiefly along the present stream beds, associated with gravels from 2 to 4 feet thick. Some gold also occurs with older stream gravels on rock benches that now stand about 15 feet above the streams. It is reported that prospects of gold may be obtained at some points in the high gravels that rest on the upper slopes of the valley, but no mining of these gravels has been attempted. The gold has not been found in pay streaks, but so far as mining has disclosed appears to be distributed in more or less disconnected patches of gravel or pockets in the bedrock.

Cody Creek is reported to contain prospects of placer gold, but no mining was being done on it in 1916. A lode of stibnite (antimony sulphide) occurs in the basin of this stream and may be associated with gold that is the source of the placer prospects.

Chicken Creek is about 5 miles long and has its source against that of Rex Creek to the east. No placer gold is known to have been mined from this stream, although evidences were observed of claims having been staked along its course. Lignite-bearing sediments occur in a small area along the north bank of Chicken Creek, about half a mile above its junction with Moose Creek, and small quantities of this lignite have been utilized as forge fuel by the miners for sharpening picks, but it is stated to be of inferior quality.

MINERALIZATION AND SOURCE OF THE GOLD.

Antimony sulphide occurs in the valley of Cody Creek. Another locality of sulphide mineralization was discovered in 1916 on Little Moose Creek near its source, in a saddle that divides it from Eva Creek. The chief metalliferous mineral at this prospect is gold-bearing arsenopyrite, one assay of which shows a value of $24 to the ton.

This mineralization is believed to be directly connected in origin with dikes and stocks of igneous rock intruded into the schists of the Moose Creek basin at several localities and with other intrusives that are probably present but not now known.

From the evidence at hand the writer is strongly inclined to credit the chief source of the placer gold of Moose Creek basin to mineralized zones in the schist bedrock and to consider that the gold, at least in greater part, has been derived directly from the schists by the erosion of the present streams since the schists were denuded of the thick overlying gravels. In other words, the overlying gravels are not considered to have contributed very much gold to the present placers of Moose Creek.

HOSEANNA CREEK.

GENERAL FEATURES.

Hoseanna Creek, sometimes called Lignite Creek, is a large stream about 15 miles in length that discharges into Nenana River from the east about 12 miles south of Moose Creek. The valley of this stream is 3 or 4 miles wide from north to south and as a whole forms a marked depression in the east-west foothill belt. This depression is almost entirely occupied by a thick formation of lignite-bearing sediments, of early Tertiary (Eocene) age, that are but slightly consolidated. Because of the relative softness of the lignite-bearing formation, Hoseanna Creek and its tributaries have been able to erode the valley deeply, bringing the drainage into adjustment with the most recent down-cutting of Nenana River. As a result of this rapid intrenchment practically all the streams of the Hoseanna Valley flow in gorges bounded by bluff slopes from 100 to 300 feet high, and the flood plains of the streams are narrow. Even the valley floor of the main stream is in few places more than a quarter of a mile in width.

The Hoseanna Valley is bounded on the south by a ridge of schists that forms the divide between it and the valley of Healy Creek. On the north it is separated from the drainage basin of California Creek and the headwaters of the Totatlanika by broad ridges that are composed chiefly of the lignite-bearing formation of the district, overlain by high gravels such as occur about the sources of Moose Creek. In fact, these high gravels extend continuously along the eastern slopes of the Nenana Valley from the head of Moose Creek to the lower part of the Hoseanna Valley.

Prospects of placer gold are reported to occur in the bed of Hoseanna Creek about 3 miles above its mouth and on Popovich and Sanderson creeks, two of its tributaries.

POPOVICH CREEK.

Popovich Creek empties into the Hoseanna from the north about 6 miles above its mouth. It is about 4 miles long and drains a deep gulch like most of the other tributaries to the main stream, especially on the north. The lower 1¼ miles of Popovich Creek is deeply intrenched across the lignite-bearing formation of the valley, whose beds here trend east and dip north. The upper course of the stream and its several headwater branches are deeply eroded into the high gravels that overlie the lignite formation. These gravels are very thick on this part of the northern divide of the Hoseanna Valley and in their basal portions, along the stream cuts, show stratification with structural dips of 10°–15° N. that are similar to those of the lignite-bearing sediments beneath them. This indicates that at least a part of the gravels have been deformed to about the same degree and in the same manner as the lignite-bearing sediments. Higher on the slopes, however, structural deformation of the gravels is not so evident and much of the material seems to be reworked gravel that lies horizontally upon the beveled strata of the older gravels.

Stream gravels resting on a lignite-bearing bedrock along the lower course of Popovich Creek are reported to contain some placer gold. A small amount of prospecting of these gravels was done during 1916 by one man. As these present stream gravels are without doubt derived chiefly from the tilted gravels that structurally overlie the lignite formation in the upper part of the valley it seems most reasonable to assume that the source of any placer gold in this valley must be in the old tilted gravels. These gravels, however, have not been prospected thoroughly enough to justify definite conclusions regarding the placer gold they may contain. The conditions, both stratigraphic and erosional, presented on Popovich Creek appear to be the same as those in the lower part of the Healy Creek valley, a few miles to the south, where the lignite formation is overlain by a great thickness of tilted gravels that seem definitely to contain placer gold. (See p. 372.)

SANDERSON CREEK.

Sanderson Creek is a large headwater branch of Hoseanna Creek about 5 miles long that discharges into the main stream about 10 miles above its mouth. The lower mile of this creek is intrenched in the lignite formation; its middle course lies along the contact between the lignite formation and the underlying schists; and the upper half of its valley is entirely in the schists. These schists form the mountainous ridge that divides the Hoseanna Valley on the north from the Healy Valley on the south. The upper part of Sanderson Creek has eroded its valley into these schists to a depth of 1,000 feet or more.

A number of placer claims have been located and relocated along Sanderson Creek during the last 10 years, but no mining of consequence appears to have been done on any of the claims. At several points along the middle course of the creek there are abandoned sluice boxes which apparently have not been used recently. Several men are reported to have worked on this creek in 1906, and many of the claims have been relocated since that time.

Prospecting on this creek seems to have been confined to its middle course, where the stream flows along the contact between schists on the south and the lignite formation on the north. To judge from the general geologic conditions of the valley this part of Sanderson Creek does not appear to be as favorable for placer gold as its upper part, where the headwater branches are eroded entirely in highly metamorphosed schists exhibiting evidences of strongly sheared zones with quartz vein mineralization.

HEALY CREEK.

GENERAL FEATURES.

Healy Creek is the largest tributary to Nenana River from the east in the foothill belt. It is 25 miles long and discharges into the Nenana about 5 miles south of Hoseanna Creek, or 54 miles above the mouth of Nenana River by the line of the Government railroad now being built up this valley. The valley of Healy Creek trends almost directly west and is comparatively broad but deep, its slopes rising 1,500 to 3,000 feet, from an old valley floor about a mile wide, to divides that stand 5 or 6 miles apart. The older floor of the valley is now represented by benches from 100 to 300 feet above the present flood plain, which is relatively narrow. These benches have been produced by the recent intrenchment of Healy Creek and its tributaries. The tributaries have not only cut sharp, narrow gorges across the benches but have eroded deep gulches up the valley slopes well toward their heads. The valley previous to its recent intrenchment appears to have had a U-shaped cross section, with rather smooth slopes and a broad, flat floor that strongly suggests former occupation and molding by a glacier. The intrenchment of this valley, like that of Moose and Hoseanna valleys, has been controlled by and is in adjustment with the recent downward erosion of Nenana River across the foothill belt. The mountain summits along the southern divide of the Healy Creek valley have altitudes of 5,000 to 6,000 feet and may be considered to mark the northern front of this portion of the Alaska Range.

GEOLOGY.

The greater part of the Healy Creek valley is eroded in micaceous and quartzitic schists. Practically all the slopes and divides of the valley on both sides are composed of schistose rocks except along the western 6 miles on the north, where there is a thick series of semiconsolidated gravels underlain by lignite-bearing sediments.

Although the schistose bedrock of the valley might appear favorable for gold mineralization from which placers might be concentrated, no placer gold deposits whose origin is directly related to the present erosion in the schists have been found within the valley.

The only valuable deposit of placer gold known in the Healy Creek valley is closely associated with the thick gravels that overlie the lignite formation in the lower part of the valley on its north side. As this occurrence seems to afford evidence of the presence of placer gold in some parts of the old gravels of the region the essential geologic relations of these gravels to the older rocks in this locality are here considered in some detail in order that comparisons may be made with other localities.

The geologic section of the lower 10 miles of the Healy Creek valley comprises schists, lignite-bearing sediments, and a great thickness of gravels. The schists form the south slopes of the valley and may be dismissed from further consideration with the statement that the lignite-bearing formation rests upon them unconformably.

The lignite-bearing formation extends along the bottom of the valley throughout its lower 10 miles as a belt about 1 mile wide, whose general structural trend is west, corresponding with the direction of the valley. Nearly all the western half of this belt lies on the north side of Healy Creek, and the greater part of its eastern half lies on the south side—that is, Healy Creek cuts the belt transversely about the middle of its length.

The lignite beds in this belt strike S. 65°–80° W. and dip 25°–35° N. The stratigraphic thickness of the formation is fully 1,500 feet and possibly 2,000 feet, to judge from measurements made by Prindle[1] about 2 miles above the mouth of Healy Creek and by Capps[2] about 6½ miles above the mouth.

In the downstream half of the belt, where the top of the lignite-bearing beds extends along the benches and lower north slopes of the valley, the strictly lignite-bearing sediments are overlain, with what may or may not be depositional conformity, by about 500 feet of soft sandy shales that appear to be practically barren of lignite beds, although they contain some thin disconnected layers of lignitized vegetable remains. The relation of these sandy shales to the lignite-bearing beds beneath them appears to be close; but their somewhat different lithologic character and the apparent absence of well-developed beds of lignite in them seem to point to the conclusion that they are not of the same age as the typical lignite-bearing sediments of the region. In this connection it is suggestive that in another part of the district, on Roosevelt Creek near its mouth, plant-bearing beds possibly younger than the typical lignite formation of the region are indicated by fossil leaves that occur in a considerable thickness of fine sediments beneath thick gravels. (See p. 399.) On Roosevelt Creek, as on lower Healy Creek, placer gold in the present stream gravels appears to be derived from older placers in the thick deposits of gravels that seem to overlie a considerable thickness of fine sediments which are younger than the typical lignite-bearing

[1] Prindle, L. M., The Bonnifield and Kantishna regions: U. S. Geol. Survey Bull. 314, p. 223, 1907.

[2] Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, pp. 57, 58, 1912.

formation of the region. Brooks[1] has discussed the stratigraphic features here mentioned, but at the time of his writing there were no data available about the occurrence of placer gold in the old gravels of the Healy Creek valley.

The sandy shales just considered are overlain by about 200 feet of strongly cross-bedded sands containing lenticular beds of gravel and a number of pieces of lignitized wood that have the appearance of having been deposited with the sands and gravels as stream-washed driftwood. The upper part of this 200 feet of cross-bedded sands and gravels grades upward into coarse heavy-bedded gravels whose stratigraphic thickness is at least 2,000 feet. This thick deposit of gravels has been named the Nenana gravel by Capps.[2]

The strong cross-bedding of the sands immediately beneath the typical Nenana gravel in the Healy Creek section and the heavy bedding of the gravels themselves furnish ample evidence that these sediments have been laid down by streams that were much more vigorous than those of the drainage system which existed during the deposition of the lignite formation and the overlying 500 feet of sandy shales in the Healy Creek valley. Observations made by the writer 4 to 6 miles above the mouth of Healy Creek seem to indicate that the cross-bedded sands immediately beneath the heavy-bedded gravels are a basal phase of the Nenana gravel composed chiefly of reworked sediments derived from the older lignite-bearing sediments and associated sandy shales, these older sediments apparently having been locally subjected to strong stream erosion and redeposition during the initial stage of drainage development that produced and built up the thick Nenana gravel.

The character of the Nenana gravel in the Healy Creek valley may be observed to advantage along the courses of several small tributaries that have eroded deep gulches across the stratification of the gravel from north to south. To judge from the cleanest exposures along these gulches, the gravels are moderately coarse throughout their thickness of 2,000 feet or more. They contain a considerable proportion of cobbles as much as 6 inches in diameter. Most of the pebbles are between 1 and 2 inches in diameter, and the percentage of pebbles less than 1 inch in diameter is relatively small. However, there is enough sand and grit mixed with the pebbles to compact them firmly as a whole, and at some horizons these finer sediments form beds several feet in thickness that are continuous as distinctive strata for considerable distances.

[1] Brooks, A. H., The Mount McKinley region, Alaska: U. S. Geol. Survey Prof. Paper 70, pp. 102, 103, 1911.

[2] Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, pp. 30–34, 1912.

The Nenana gravel comprises pebbles of schist, quartzite, slate, black, green, and red chert, white vein quartz, granite, and a variety of other igneous rocks. All these rocks are known to occur in the Alaska Range, from which the chief part of the gravel is believed to have been derived. The most abundant pebbles appear to be those of vein quartz and quartzite. Some of the schist fragments at or near the base of the deposits in some localities are flat, slabby, and angular and do not seem to have been transported far from their bedrock source, but the thoroughly rounded and polished condition of most of the pebbles and cobbles indicates they have been subjected to considerable wear by running water and that probably they have been transported some distance.

Although there are a number of large boulders, some of which are 10 to 15 feet in greatest dimensions, in the beds of the gulches that dissect the Nenana gravel in the Healy Creek valley, it is not clear that these are derived from the older gravels, for few of the boulders observed actually embedded in the stratified gravels where they are freshly exposed along the gulches are more than 1 foot in diameter. The writer is inclined to consider that practically all the very large boulders that occur in the present stream beds or upon the slopes and benches of their valleys have been derived from glacial deposits that were laid down on an older surface of the gravels before they were eroded to their present form.

The prevailing color of the gravels is rusty brown, owing to the deep and general oxidation they have undergone. The fine sediments that occupy the spaces between the pebbles are in places slightly cemented by iron oxide, and some strata of considerable thickness are consolidated to conglomerate. This cementation, however, is rarely firm enough to resist atmospheric disintegration and as a result the gravels yield rapidly to erosion. Even comparatively small streams cut deep gulches into the gravels, as may be observed in the Healy Creek valley, and larger streams erode valleys of considerable width. The ready erosion of these gravels is probably due largely to the fact that well-rounded pebbles are easily moved by comparatively small volumes of running water.

The Nenana gravel is well developed along the upper north slopes and divide of the Healy Creek valley for a distance of about 4 miles, from 2 to 6 miles above the mouth of the main stream. The tilted gravels that now occupy this area are apparently only a remnant of a belt that formerly extended considerable distances to the east and to the west. The eastern portion appears to have been removed through erosion by Healy Creek and the western portion through erosion by Nenana River.

In the section on Healy Creek the gravels present a measurable stratigraphic thickness of at least 2,000 feet, and it is probable that they may have a maximum thickness of 3,000 feet in this locality.

The dominant bedding planes of the thick Nenana gravel and of the immediately underlying cross-bedded sands that are considered to be a local basal phase of the gravel on Healy Creek appear to have practically the same trend. The strikes are from west to N. 85° W.; the dips are rather uniformly 19° N. throughout the lower 1,000 feet of the gravel and 15°–35° N. in the upper 1,000 feet.

The northward dip of these sediments appears to be primarily due to a fault movement that has tilted not only the gravels but likewise the lignite formation beneath them, the two having been brought to their present attitude as a structural unit or block. The trend of this fault is east (in general parallelism with the strike of the gravels, and the movement along it has resulted in the downthrow of the Nenana gravel to the south so that it now abuts abruptly against schists that mark the north (upthrown) side of the fault. These schistose rocks form the divide between Healy and Hoseanna valleys.

The section of the Healy Creek valley thus shows a thickness of at least 4,000 feet of stream-laid sediments, the lower and upper halves of which differ in general lithologic character and appear to have a distinguishable discordance in strike, although the differences in dip are not so pronounced. The average difference of strike between the lignite formation and the Nenana gravel appears to be about 20°; and the average dip of the gravel, at least in its basal members, appears to be somewhat less than that of the lignite formation.

This apparent discordance in structure appears to indicate a depositional unconformity between the lower and upper halves of the section that is also marked by the differences in character of the sediments. These differences, however, are not equally evident in all exposures and may be practically unrecognizable at some points. Nevertheless there seems to be little question that there is in this locality an unconformity due to a change in the drainage conditions between the period during which the lignite-bearing sediments were deposited and the period during which the thick gravels were accumulating. The drainage conditions of the earlier period appear to have been those of comparatively moderate stream erosion with deposition, favorable for the formation of lignite beds; and the drainage conditions of the later period were evidently those of very vigorous stream erosion which in the beginning was strongly degrading and favorable for the production and transportation of great quantities of well-rounded gravels. This later period of vigorous erosion was also favorable for the production of placer gold in areas where the country rocks contained lode gold.

PLACER GOLD.

Placer gold occurs in the present stream gravels of three tributaries to lower Healy Creek—Alaska, French, and Home creeks, named in upstream order. These streams are from 2 to 3 miles in length and discharge into Healy Creek from the north about 3, 4, and 5 miles, respectively, above its mouth. Although the volume of these streams is comparatively small they have eroded gulch valleys to depths of 300 to 600 feet across the Nenana gravel, which forms the upper north slopes of this part of the valley. This deep erosion by streams so small is accounted for partly by the stream grade, which is between 250 and 300 feet to the mile, and partly by the fact that the gravels are only slightly cemented and are well rounded.

These gulch valleys are eroded in practically no other deposits than the Nenana gravel, except that glacial deposits may have formerly overlain the gravels and have since been removed from the areas now drained by the streams. The only evidence of the former presence of glacial deposits found in these drainage areas consists in large boulders that occur with the recently washed stream gravels, chiefly along the beds of the gulches. These boulders do not appear to be derived from the tilted gravels, and their large size and variety of composition suggest that glaciers were the only agency competent to transport them to their present positions.

It seems probable that any placer gold in the present stream gravels of French and Alaska gulches is derived from the Nenana gravel, and this conclusion is also supported by the evidence as to the derivation of the placer gold in the present stream gravels of Home Creek, for the schists on the upper course of this stream do not appear to have produced placer gold during the erosion of the gulch.

There are no definite data at hand as to whether the placer gold in the Nenana gravel is confined to a few particular stratigraphic horizons in these gravels or is somewhat widely scattered throughout their thickness. So far as known no attempt has been made, even of a superficial character, to prospect for gold in the Nenana gravel itself. It is significant, however, that placer gold is known to occur at about the same horizon in each of the three large gulches that transect the Nenana gravel in Healy Creek valley. From the evidence furnished by the distribution of the reconcentrated placer gold in these gulches it seems likely that this gold has its chief source in the lower 500 feet of the Nenana gravel.

It is not known when placer gold was discovered in these gulches, but the first mining seems to have been done in 1913 on Home Creek, which is the largest of the three.

HOME CREEK.

Home Creek is about 3 miles long. Its lower half flows in a direct course somewhat east of south across the belt of Nenana gravel, and its upper half flows east along or near the fault line that marks the northward limit of these tilted gravels in this valley. The upper section of Home Creek thus seems to have had its position and direction determined by the fault. The upper section of this valley has been eroded almost entirely in the gravels, for the schists that form the north slopes of the valley appear to have been little more than cleared of the gravels that formerly abutted against them, and only a few steep gulches have been cut into the schistose rocks by short tributaries.

It is reported that no placer gold has been found in the material eroded from these gulches in the schists and practically none in the stream gravels along the upper half of Home Creek, although it is evident that a great quantity of the Nenana gravel has been removed from this part of the valley. This apparently indicates that the schists of the north slopes of the upper valley have not been eroded sufficiently to produce placers, even if they contain gold, and that the part of the Nenana gravel that has been removed by erosion along the fault line does not contain sufficient placer gold to form valuable deposits even after the concentration of a large quantity of gravel. The structural attitude of the Nenana gravel in the Healy Creek valley indicates that the part of it that has been eroded away along the upper valley of Home Creek is from 1,000 to 2,000 feet above the base of the section.

The lower 1½ miles of Home Creek has eroded a gulch across the Nenana gravel belt of the Healy Creek valley to a depth of about 500 feet. The present flood plain of the stream occupies practically the whole width of the bottom of this gulch, which is narrow throughout its length, being in few places more than 150 feet wide. The grade of the bed of Home Creek is between 5 and 6 per cent, consequently the transportation of the well-rounded gravels along it is very active, especially during times of flood, when the volume of water is probably sufficient to occupy the whole bed of the gulch. All the gravels along the bed of the gulch are cleanly washed, very little fine sediment being deposited with them. The flood plain gravels rarely accumulate to a greater thickness than 4 or 5 feet, and their average thickness is about 2 feet. However, the stream is often temporarily clogged and diverted from one side of its flood plain to the other by large slides of gravel from the steep gulch slopes.

The cross-bedded sands and gravels that are considered to form the basal part of the Nenana gravel in the Healy Creek valley are exposed in low bluffs at the mouth of Home Creek, where that stream enters the flood plain of Healy Creek. Thus the lower 1½ miles of Home Creek is eroded across the whole stratigraphic thickness of the Nenana gravel as developed in this locality, and the bedrock upon which the recent gold-bearing stream gravels of Home Creek rest is composed entirely of the tilted Nenana gravel. This gravel is semiconsolidated along Home Creek gulch, but in general its cementation is so slight that it will barely stand upon exposure to ordinary disintegration, although a few members have more resistance than others and present more or less distinct outcrops along the valley slopes, chiefly in fresh exposures caused by slides. The gravel bedrock along the immediate course of Home Creek, however, appears to be quite uniformly compact and must be loosened with picks in mining.

Most of the mining on Home Creek has been done in the bed of the stream from one-fourth to three-fourths of a mile above its mouth. In 1913 four men brought two boatloads of supplies to the mouth of Home Creek from the Tanana by way of Nenana River and Healy Creek and began operations, which have been conducted along this section of the creek each summer since by two or three men. The method consists of groundsluicing the present stream gravels down to the bedrock of semiconsolidated gravel and shoveling the material thus concentrated into sluice boxes together with a few inches of the bedrock after it has been loosened with picks.

The gold recovered is fairly coarse and worn. It consists of about equal proportions of shotlike nuggets, whose value varies from 25 cents to $1, and of heavy flakes, from one-eighth to one-half of an inch in dimensions, that have been flattened or bent as if hammered and rolled by moving pebbles.

Owing to the rough and uneven character of the coarse semiconglomeratic bedrock, care has to be exercised in cleaning the surfaces of cuts after the stream gravels have been concentrated down to them. All seepage water must be excluded to prevent the loss of gold from the shovels, and it is probable that a certain amount of fine gold is lost in spite of careful shoveling.

The value of the gold produced on Home Creek for the four years of mining that has been done probably does not exceed $4,000.

FRENCH AND ALASKA GULCHES.

French and Alaska gulches are eroded in the Nenana gravel belt from north to south, in the same manner as the lower half of Home Creek, with the difference that their streams have not worked headward across the entire width of gravels to the schists on the north. The volume of these streams is considerably less than that of Home Creek; but nevertheless the gulches are eroded into the gravel to depths of 300 to 500 feet, and thus expose a considerable stratigraphic thickness of the gravel from the base upward.

Prospecting on both these gulches has demonstrated that their present stream gravels contain placer gold, but mining has not been undertaken because of insufficient water supply. In Alaska Gulch nuggets whose value is from $2 to $3 have been found.

TOTATLANIKA BASIN.

PRINCIPAL FEATURES.

Totatlanika Creek is a large stream, about 60 miles long, the upper half of which lies wholly within the foothill belt and the lower half within the Tanana Valley lowlands. The lowland section flows northward from the foothills by a direct course that is parallel with the corresponding section of Nenana River, about 15 miles to the west.

The basin of the upper half of the Totatlanika covers an area of about 275 square miles. The eastern part of this basin is drained by the upper section of the main stream and its western part by a large branch named California Creek. California Creek and the upper Totatlanika lie 5 to 7 miles apart and flow northward roughly parallel to one another across the greater part of the foothill belt to the southern flanks of the northernmost foothill ridge, beyond which they converge and join to form the main Totatlanika. From this junction the main stream flows northward to the Tanana Valley lowlands through a narrow, recently eroded valley 1,000 to 1,500 feet deep and 5 miles long.

Broadly considered the foothill part of the Totatlanika basin is characterized by a succession of three highland and three lowland belts that alternate with one another and trend east in general parallel arrangement. Each of these contrasting belts presents more or less continuity of form within itself, although they vary somewhat in this regard and also in width, which is in general from 3 to 5 miles. The mountain summits along the high belts have altitudes of 3,000 to 4,000 feet, and the bottoms of the valleys in the low belts stand from 1,000 to 2,000 feet lower.

The lowland belts are occupied chiefly, especially along their bottoms and lower slopes, by the lignite-bearing sediments of the region, which rest upon schists and are overlain in some places by thick gravel deposits. The semiconsolidated state of these sediments accounts for the deeply eroded forms they now present. The highland belts are composed almost entirely of hard schistose rocks, although in some areas the lignite formation and high gravels extend up on the higher slopes to considerable elevations above the valley bottoms, and a few isolated patches of these sediments lie near and even upon the crests of the schist ridges.

It seems clear from the distribution and attitude of the schists and overlying lignite sediments that the primary factors in the development of the highland and lowland belts are the regional folding and faulting that deformed the foothill region after the lignite deposits and at least some of the overlying gravels were laid down and before the present drainage system had dissected the region so deeply. Nevertheless it is evident that the removal of large quantities of material by differential erosion in the alternating belts of hard and soft rocks after they were deformed has been the most important factor in forming the lowland belts and accentuating the intervening highland belts.

California Creek and the upper Totatlanika flow northward across the eastward-trending highland and lowland belts through a corresponding succession of narrow canyons and wide basins, and in consequence their valleys present considerable diversity in topographic development and a variety of conditions that control the distribution of stream gravels.

It is probable that the present drainage system originated on an approximately even land surface that sloped northward from the high flanks of the Alaska Range to the Tanana Valley lowlands, and that its arrangement has not been disturbed to any extent since its establishment. Apparently few prominences of the hard schistose rocks that underlie the sedimentary deposits of the region in which the greatest amount of erosion has taken place projected above the sloping surface of the foothill belt when the present drainage system established its direct northward courses, for otherwise the stream courses would probably have assumed a more complicated form than they now exhibit.

CALIFORNIA CREEK VALLEY.

GENERAL FEATURES.

California Creek is about 20 miles long, and its valley comprises two well-developed basin areas, situated along its lower and middle courses, and a less well defined headwater basin that lies along the south flanks of a prominent isolated mountain mass named Jumbo Dome. These three basins are separated by two belts of schist through which California Creek has cut deep canyons. The canyon section between the lower and middle basins is about 3 miles long and 1,000 feet deep, and the one between the middle and headwater basins, around the west flank of Jumbo Dome, is about 1 mile long and several hundred feet deep.

Prospecting for placer gold has been carried on throughout the valley of California Creek. Evidences of this work in the form of holes and open cuts may be observed at a number of points along the main stream and many of its tributaries. Mining operations, however, have been undertaken only at three widely separated localities, two of which have been abandoned for several years. One of these localities is on Rex Creek, a large tributary to the main stream from the west in its lower basin; another is on California Creek where it enters the canyon between the middle and lower basins; and the third is on the upper part of Eva Creek, a tributary from the west that drains the southwestern portion of the middle basin. The last-named locality was the only one in the valley where placer mining was being done in 1916.

REX CREEK.

Rex Creek is about 8 miles long and flows eastward to enter California Creek about 2½ miles above the confluence of that stream with the upper Totatlanika. The headwaters of Cody and Chicken creeks, tributaries of Moose Creek, lie immediately west of the sources of Rex Creek.

The upper 5 miles and the upper slopes of the lower 3 miles of the Rex Creek valley are practically all eroded in schist. The bottom and lower slopes of the lower 3 miles of the valley are occupied by the lignite formation, and a narrow strip of these sediments extends along the north bank of the stream in its middle 2 miles. There is also a small remnant of these sediments in the saddle at the head of the valley between Rex and Chicken creeks. It is probable that the lignite formation formerly extended along the whole length of the valley, at least in its bottom part, before it was eroded to its present depth. Thus the schist along the upper 5 miles of Rex Creek has probably not been denuded of the lignitic sediments for a long period of time and therefore a comparatively small amount of recent stream erosion has taken place in the schist. A measure of this erosion seems to be afforded by narrow gorges in the schist about 50 feet in depth along some sections of the headwaters of the creek and particularly by a number of sharp gulches that have been eroded in the schist along the southern slope of the upper half of the valley.

Placer claims have been located and relocated along Rex Creek throughout its length since 1905, and a considerable amount of prospecting has been done at a number of points in the present stream bed and on benches in areas of schist and of lignitic sediments, but so far the only section of the valley where mining has been undertaken is between 3 and 4 miles above the mouth of the stream, and operations here have been abandoned for several years.

Along the upper half of Rex Creek no profitable placer-gold deposits appear to have been found, or rather it has been stated that the value of the deposits is not sufficient to encourage mining with the amount of water available in this part of the valley.

The middle section of the valley, between 3 and 4 miles above its mouth, where the best prospects of gold appear to occur and where mining has been done at several places, occupies a basin-like expansion above a gorge or wide canyon that is cut by the main creek to a depth of 200 feet across the nose of a spur of schist that projects from the north slope of the valley. This expansion extends southward up the valley of a large tributary that drains the high schist ridge which forms the valley slopes. The headwater branches of this tributary have eroded deep gulches in the schist ridge, and across the upper parts of these gulches the schist is intruded by several dikes. No mineral deposits were observed in the schist in actual connection with these dikes, but quartz veinlets occur here and there throughout the schist. A smaller gulch tributary flows from this schist ridge into Rex Creek about half a mile upstream from the large tributary, and the most extensive placer deposits that have been mined are on a low sloping bench that extends along the south side of Rex Creek between these gulches. The schist of the spur that separates these tributaries extends down into the bottom of the main valley and forms the bedrock upon which the gold-bearing gravels rest.

The sloping bench in which most of the mining has been done is about 500 feet wide, and its upper margin stands about 50 feet above Rex Creek. To judge from the tailing dumps of the old workings practically all the bench gravels consist of the schistose rocks of the valley. These gravels range in thickness from 4 to 8 feet, and the schist bedrock upon which they rest shows considerable decay, as if it had been protected from stream erosion for a long time since the gravels were deposited upon it. The gravels also appear to show the effect of decay since they were laid down. They are fairly coarse but contain no boulders that can not be easily handled.

Capps,[1] who visited this locality in 1910, states that the gold occurs in the basal part of the gravels close to bedrock and that some of it has penetrated into the decayed schist to a depth of about a foot. The gold is stated to be bright and fairly coarse. At the time of Capps's visit three men were engaged in mining this bench ground, but the operations were discontinued in the middle of that summer because the returns were insufficient to make pick and shovel work profitable. Apparently mining has not been resumed at this locality since 1910.

Water for washing the gravels was brought from Rex Creek and the small gulch tributary at the upper end of the bench by a ditch, about half a mile in length, dug along the upper edge of the bench. The workings consist of several open cuts that extend from the ditch across the bench diagonally down the valley, and their area and the quantity of tailings indicate that a considerable yardage of gravels was mined.

[1] Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, p. 47, 1912.

In the bed of Rex Creek just above and below the mouth of the large tributary that enters from the south open cuts have been dug across several of the sharp meanders of the main stream, probably with the combined purpose of testing the recent gravels in these bends and later serving in combination with dams to divert the main creek from its channel in order that its present bed might be prospected. In the gorge by which Rex Creek discharges from the basin-like area along its middle course may be observed the remains of several wing dams that were evidently built for the purpose of diverting the main creek in order that the present stream gravels and schist bedrock might be prospected, but no information is at hand as to the results of this work. However, it has been reported that all of these attempts at mining in the bed of the main creek were handicapped by the difficulty of obtaining adequate drainage for thorough prospecting.

It is reported that the value of the total quantity of gold produced from Rex Creek is about $5,000.

CALIFORNIA CREEK.

The only known attempt to mine the gravels in the main valley of California Creek was made at the head of the canyon that separates the middle from the lower basin of this valley, about 5 miles above the mouth of Rex Creek. Two men worked at this locality during a part of the summer of 1910, digging a bedrock drain along the eastern margin of the present flood plain, where it is bounded by a low gravel bench that represents a previous flood-plain level. It is stated that the stream gravels were found to be about 6 feet deep and to rest on schist bedrock, but that their gold content is not sufficient to warrant pick and shovel mining.

The source of the placer gold that is reported to occur in the present stream gravels at the head of this canyon of California Creek was probably in the schist bedrock, in which the upper end of the canyon is eroded. Quartz veins are numerous in a high detached hill of schist immediately west of the head of the canyon. Some of these veins are 8 to 10 inches thick in their wider parts, and much of the quartz is stained with iron oxides, indicative of metallic mineralization. It is not improbable that some of these veins contain gold, although none was observed, and it appears unnecessary to assume that the placer gold at the head of the canyon was derived from the sediments, or more particularly the high gravels that overlie the lignite formation and that have been removed from the middle basin of California Creek.

EVA CREEK.

Eva Creek, together with a tributary of about equal size named Elsie Creek, drains a large area in the northwestern part of the middle basin of California Creek. It is about 5 miles long and rises on a high gravel-capped ridge opposite Big Moose Creek to the west. The stream flows about due east along the northern border of the middle basin and empties into California Creek about half a mile below the head of the canyon between the middle and lower basins. Eva Creek in eroding its present outlet into the California Creek canyon has cut a subsidiary canyon through schist along the lower half mile of its course and thus has isolated the prominent schist hill that contains quartz veins described in connection with the placer deposits in the upper part of the main canyon. This hill has the appearance of formerly being a part of a spur from the main schist ridge to the north, and it is very probable that the lower course of Eva Creek discharged into California Creek around the south flanks of the hill before the canyon of California Creek was eroded to its present depth; or it may be possible that California Creek discharged at one time through the canyon section of lower Eva Creek.

A large part of the Eva Creek valley is eroded in the high gravel deposits that overlie the lignite-bearing sediments of the middle basin of California Creek, but apparently the lignite formation has not been exposed by the erosion of this stream. These gravels, together with some associated sands and silts, occupy the greater part of the valley, especially in its middle 3 miles, where they cover all of the low divide on the south between Eva and Elsie creeks and extend along the northern slopes of the valley up to their middle heights in the form of benches that rest against the upper slopes of schist.

Along the upper 1½ miles of Eva Creek the bottom of the valley is occupied by a considerable area of schist from which the covering of high gravels has been removed by comparatively recent stream erosion. The high gravels that now surround this schist area and form the upper slopes of the headwater basin have the appearance of being the erosional remnants of a much thicker deposit of gravels which formerly not only occupied the whole headwater basin but extended downstream throughout its length. These gravels are the eastward extension of those that occur on the interstream ridges of the Moose Creek basin and form the divide between Moose and Eva creeks. There is also another considerable area of schist, denuded of the high gravels by recent stream erosion, on the western slopes of the basin of Wilson Creek, a headwater tributary to Eva Creek from the southwest. The present configuration of the Eva Creek valley indicates that at least 300 feet of the high gravel has been eroded from this valley along the course of the present stream below the mouth of Wilson Creek, which joins Eva Creek about 3 miles above its mouth.

The depth of erosion that has occurred in the area of denuded schist in the upper basin of Eva Creek may also be estimated. The upper slopes of this headwater basin are composed chiefly of the high gravels, and to judge from the height of the base of these gravels above the present bed of the stream the schist along the bottom of this basin has been eroded to a depth of about 300 feet since it was denuded of the gravel cover. Thus a considerable amount of schist has been removed from this part of the valley over an area of about half a square mile. This erosion of the schist in the upper basin of Eva Creek and its tributary basin of Wilson Creek is comparable to that which has occurred along the courses of Big Moose and Little Moose creeks, across the divide 1 to 3 miles to the west (described on p. 366), but on Eva Creek the quantity of schist eroded away has been much less.

As on other streams in the district, placer claims have been located along Eva Creek for the last twelve years. The first attempt at mining, however, seems to have been made in 1915, when two men opened a small cut in the stream bed in the schist area of the upper valley. This work demonstrated that there is a small quantity of placer gold in the present stream gravels at this point and also disclosed indications of lode mineralization in the schist bedrock. These indications consist of heavy pieces of schist float that contain arsenopyrite and native bismuth in considerable amount, together with small amounts of other sulphides. Panning tests of this float lode material show that it contains some flour gold in a free state together with a few larger pieces of gold that have sharp angular edges and crystalline faces. Assays of the sulphides show that they are gold bearing, so that a source of gold from which placers might be derived is indicated in the schists of upper Eva Creek. The lode mineralization of Eva Creek and Moose Creek is described elsewhere by R. M. Overbeck. (See pp. 360–361.)

In 1916 a more comprehensive placer-mining operation was undertaken on Eva Creek about a quarter of a mile downstream from the locality where work was done in 1915, at a point about a quarter of a mile above the mouth of Wilson Creek. Here three men built an automatic dam and groundsluiced a cut in stream gravels 3 to 4 feet thick.

The bedrock upon which the stream gravels of this claim rest is composed of the stratified gravels and sands of the basal part of the high gravel deposit that overlies the schist in this valley. These old gravels are here cemented by iron oxide to a somewhat firm conglomerate. As exposed in a bluff on the south side of the creek, opposite the workings, near their contact with the schist, they strike northeast and dip 23° SE. Thus it is evident that the stratified gravels and sands are upturned along the flanks of the schist upon which they rest and that the present stream has beveled them in forming its flood plain. No evidence was observed that the placer gold in the stream gravels of this claim has its source in the bedrock of tilted and cemented gravels, although such a source is possible. On the other hand, it is more probable that the placer gold is derived from the schist area immediately upstream from this claim.

The fact that no notable concentrations of placer gold have been found along the remainder of the valley, although it is clear that a large quantity of the high gravel has been eroded and concentrated by Eva Creek, seems to point to the conclusion that the old gravels carry very little if any gold in this drainage basin.

WINTER AND MARGUERITE CREEKS.

Prospecting for placer gold has been done at a number of points on the headwater streams of California Creek that drain the flanks of Jumbo Dome, the prominent mountain 4,500 feet high that occupies an isolated position near the head of the valley. The streams that have been examined most thoroughly are Winter Creek, which drains the northeastern flanks of Jumbo Dome, and Marguerite Creek, which flows along the southern and western flanks of this mountain. Many old prospect holes may be observed along the courses of these streams, but although the stream gravels appear to have been thoroughly prospected there are no data at hand upon which to base a statement as to the presence or distribution of placer gold in their basins.

UPPER TOTATLANIKA CREEK.

GENERAL FEATURES.

The upper Totatlanika lies from 5 to 7 miles east of California Creek and flows northward across the foothill belt in general parallelism with that stream. The major features of the valley comprise three basin areas separated by two belts of mountainous country across which the valley is eroded in the form of canyons. These features of relief are similar to those that characterize the valley of California Creek and in fact are their eastward continuations, although there are differences of detail in the two valleys. Some of these differences may be noted as follows:

A minor canyon, the Daniel Creek canyon, is eroded across an area of schist for about a mile in the lower or northernmost basin of the valley, about 2 miles below Murphy Canyon, which separates the lower basin from the middle basin.

The middle basin of the upper Totatlanika differs from the corresponding basin of California Creek in that it is eroded chiefly in schistose rocks, the lignite-bearing sediments that seem to have formerly overlain the schist of this basin having been eroded away in greater part.

The middle basin is separated from the upper or headwater basin of the Totatlanika by a rugged mountainous belt whose summits reach altitudes of 3,500 to 4,000 feet. These mountains are composed largely of igneous rocks intruded in schist. In some respects this highland belt is similar to the Jumbo Dome area, to the west, with which it is topographically connected; but it is different in that all the larger streams have eroded deep gorges across the mountains. Homestake Creek, the westernmost headwater tributary of the Totatlanika, has cut a deep and narrow canyon through this barrier between the upper and middle basins. The main Totatlanika also has eroded a deep gorge across these mountains from southeast to northwest for a distance of several miles above the mouth of Homestake Creek, and two large southern tributaries in this section, named Thistle and Davis creeks, have likewise eroded deep gorge valleys across the mountains along the lower mile of their courses and thus maintained their adjustment with the down cutting of the valley.

The headwater basin of the Totatlanika is in reality a part of the same belt of lowland in which the valley of Hoseanna Creek, to the west, is deeply intrenched. Although these contiguous basins are separated topographically by a broad transverse divide they are nevertheless so closely related that they may be considered to form one continuous lowland; and geologically they are actually a continuous belt, for the lignite-bearing sediments that occupy the greater parts of both areas extend for 20 miles from east to west through the two basins. The Totatlanika headwater basin is 5 to 6 miles wide from north to south and about 8 miles from east to west. In general aspect its surface is broadly undulating, but in detail it is somewhat dissected transversely by the headwater streams that flow across it from south to north. These streams have intrenched their courses to a depth of several hundred feet below the interstream areas. The chief headwaters of the Totatlanika have their sources on the steep flanks of mountains of schistose rocks that bound the basin on the south. The summits of these mountains stand at altitudes of 5,000 to 6,000 feet, or about 3,000 feet above the surface of the basin area. These mountains may be considered to be an outlier of the Alaska Range in this locality, although to the west, where they form the divide between Hoseanna and Healy creeks, their altitude decreases to 3,000 feet.

The discovery of placer gold in the Totatlanika valley is stated to have been made at the mouth of McCuen Gulch in February,

1905. Since that time most of the placer gold produced in the Nenana district has been mined from the foothill section of this valley at several localities along the main stream and on several of its tributaries. Most of the gold has been obtained from Homestake and July creeks, but a considerable amount has also been mined from the gravels of the main stream in the middle basin of the valley, especially in the lower part of this basin, near the head of Murphy Canyon.

It is reported that gold "colors" may be obtained at almost any point in the stream gravels along the present bed of upper Totatlanika Creek from its junction with California Creek to a point above McCuen Gulch, or for a distance of about 20 miles. Placer claims have been staked throughout this distance during the last 10 years, but mining has been done upon only a few of these claims in the middle basin, between the head of Murphy Canyon and a point about half a mile above the mouth of Homestake Creek. In this section the conditions for the concentration of placer gold in commercial amounts seem to be more favorable than elsewhere in the valley.

In the lower basin, through which the Totatlanika flows for about 10 miles of its course, large tracts of flood-plain gravels have been held under location for a number of years, in the form of association-group claims, in the belief that the deposits might be valuable for dredge mining. There are considerable areas of stream gravels in this lower basin that may be easily mined by this method, but no data are at hand regarding the amount of placer gold that may be contained in the deposits, and up to the present time no attempt has been made to prospect the ground with dredge mining in view. The only mining that has been done in the lower basin is on a tributary named Daniel Creek.

DANIEL CREEK.

Daniel Creek flows into the Totatlanika from the southwest at a point about 2½ miles downstream from the lower end of Murphy Canyon. It is a stream of comparatively small volume, about 4 miles long, whose valley may be divided into three sections—an upper one comprising two large headwater gulches; a rather open basin area along the middle of the stream, about 1 mile in length; and a narrow lower section intrenched to a depth of several hundred feet, also about 1 mile in length.

The two headwater branches of Daniel Creek have their sources high on the northern flanks of the mountain belt of schistose rocks that separates the lower and middle basins of the main valley. Both of these branches have eroded deep gulches into the schist along the upper mile of their courses, but so far as known this erosion has not resulted in the concentration of placer gold in the gravels of these gulches.

The lower courses of the two headwater branches of Daniel Creek flow into the middle basin of the valley and join in its central part. This basin is eroded chiefly in slightly consolidated lignitic sediments that are overlain by the Nenana gravel about the borders of the basin. Remnants of this gravel also rest on the lower flanks of the schist spurs that bound the upper part of the basin and occupy considerable areas on the higher slopes of the valley below the middle basin. It seems evident that a considerable amount of the Nenana gravel, together with some lignitic sediments that underlie it in the middle basin, has been eroded away during the development of the Daniel Creek valley. From the junction of the headwater branches of Daniel Creek to its mouth, a distance of about 2 miles, the stream has cut below the base of these sedimentary deposits and intrenched its course to a depth of 100 feet or more into harder and much older schist that forms the basement upon which the slightly consolidated sediments rest.

For half a mile below the junction of the headwater branches of Daniel Creek its flood plain has a width of 300 to 600 feet and consists of gravels about 10 feet thick that rest on schist bedrock. At the lower end of the middle basin the stream flows for about an eighth of a mile through a narrow gorge which is formed by spurs of schist bedrock along the lower valley slopes. Below this contracted section the valley floor again broadens to a width of 200 to 400 feet, which it maintains to a point within about a quarter of a mile of the mouth of the stream. The lower quarter mile of Daniel Creek is confined in a narrow rocky gorge several hundred feet in depth, eroded in schistose rocks. The Totatlanika also in this part of its course flows in a canyon, eroded in schist to a depth of several hundred feet, that extends for some distance above and below the mouth of Daniel Creek.

The basin and gorge sections of the Daniel Creek valley are directly due to the unequal resistance to erosion offered by the slightly consolidated sediments and the hard schistose rocks that the stream has encountered along its course.

Placer claims have been located along Daniel Creek since 1905, as on most of the other streams in the Totatlanika Valley, but mining operations have been undertaken upon it only during the last three years.

The most valuable claims extend along the lower mile of the creek and are four in number, each of the regulation length of a quarter of a mile. The claim at the mouth of the creek is designated Discovery claim and the other as Nos. 1, 2, and 3 above Discovery. These four claims cover the more or less constricted section of the valley that extends from the basin area along its middle course to its mouth.

The middle basin is also under placer location, but no mining has been done in that area up to the present time.

Along the lower mile of its course Daniel Creek has eroded to a depth of about 150 feet into the schistose rocks that underlie a mantle of Nenana gravel several hundred feet thick. Thus the steep slopes of this narrow section of the valley are of schist in their lower parts and of gravel in their upper parts. Considerable quantities of gravel loosened from the upper slopes have slumped down and partly obscured the schist bedrock of the lower slopes along some parts of the valley, but along other parts the schist bedrock is well exposed, and several spurs of schist project into the valley alternately from opposite sides along claims 1, 2, and 3 above Discovery.

Between these bedrock spurs there are along both sides of the creek narrow sloping benches that range in width from 50 to 150 feet and stand from 5 to 20 feet above the stream. These benches are composed of a mixture of blocks and smaller slabs of schist, cobbles, and gravels derived from the higher slopes, and considerable earthy detritus. This material is very poorly washed except that along the immediate bed of the stream. As a whole this detritus appears to be more a mixture of material that has accumulated from the valley slopes by sliding and creeping than a normal stream deposit.

The greater part of the alluvium along the valley floor does not contain permanent frost. However, there are small areas in which the results of seasonal freezing survive well into the following summer, and it may be that some of the deeper alluvium is more or less permanently frozen.

The first mining on Daniel Creek is reported to have been done in 1914 by two men on the lower end of claim No. 1 above Discovery, at the head of the gorge through which the stream discharges into the Totatlanika from the wider part of its valley covered by claims Nos. 1, 2, and 3 above Discovery. The work on this claim consisted of a small automatic dam by means of which a cut about 40 feet wide and 200 feet long was groundsluiced down to bedrock through about 4 feet of gravels. It is reported that about $1,500 worth of gold was mined from this cut. Some parts of the cut yielded $70 worth of gold to the box length—that is an area 12 feet long by 14 feet wide, comprising about 168 square feet.

During 1916 three men mined on the lower part of claim No. 3 above Discovery, about half a mile above the former workings. The first dam they built was destroyed by a flood in the middle of June, and the second one had been in operation only a few days at the time of the writer's visit, early in July. At that time a cut from 20 to 40 feet in width and about 300 feet in length had been partly groundsluiced, but the gravels were not yet sufficiently concentrated on bedrock for shoveling into the sluice boxes. During the first week in July the volume of Daniel Creek was sufficient to fill the pond above the dam only three times an hour, and the miners were hoping for enough rainfall to increase the stream flow to a volume that would fill the pond at 5-minute intervals in order that they might expedite their work. The production of gold from this operation was not learned.

So far as was learned the placer gold of Daniel Creek consists chiefly of rather fine particles that are somewhat rounded or worn. The evidence at hand seems to indicate that placer gold in commercial amounts is restricted to the lower mile of the valley. As the Nenana gravel in the upper part of the valley does not appear to have yielded placer gold in notable amounts, and as there is no reason for believing that the same gravel along the lower mile of the valley is more auriferous than elsewhere in this locality, it may be inferred that the schist bedrock along the lower mile of the valley is a probable source for the placer gold that now occurs along that section of Daniel Creek. No convincing evidence, however, was obtained as to the gold-bearing character of the particular belt of schistose rocks that has been eroded by the stream, although these rocks were observed to be mineralized to some extent with vein quartz.

PLACERS OF THE MIDDLE BASIN.

HISTORY OF MINING.

Placer gold has been mined from the stream gravels of the upper Totatlanika in its middle basin at several localities between the head of Murphy Canyon and a point about half a mile above the mouth of Homestake Creek, a distance of about 3 miles. The gravels along this section of the stream are reported to be gold bearing throughout, but the better concentrations appear to be somewhat localized. Most of the mining has been done in the lower part of the basin on three claims that cover the approach and entrance of the stream into Murphy Canyon. These claims are designated Discovery claim and Nos. 1 and 2 below Discovery.

Gold was first found on Discovery claim in March, 1905, and some mining was done on this ground during the summer of that year. In 1906 the chief mining was done on claim No. 1 below Discovery. No mining of any consequence has been done on claim No. 2 below Discovery, but it is stated that the gravels on this claim contain good prospects. Although these claims have not been actively mined each year since their location, they are still in the possession of the discoverers, and considerable work has been done upon them from time to time in order to retain them until conditions for fuller development become more favorable, especially in the matter of transportation of supplies to the district. The combined gold production from these three claims up to the present time is estimated to be worth about $15,000.

The comparatively large volume of Totatlanika Creek during most seasons of the year makes the problem of mining the gravels in the bed of the stream more one of controlling the water than of obtaining an adequate supply for washing the gravels. The grade of the stream is about 100 feet to the mile in this part of its valley, and the quantity of water varies greatly. Dams with flood gates have been built across the stream to regulate the flow and facilitate groundsluicing; and these have been supplemented by wing dams to divert the stream to one side of its flood plain while the other side was being mined.

From time to time open-cut mining has been done on the bars and low flood-plain gravel benches of the Totatlanika at a number of points between July Creek and Homestake Creek, but none of these operations have led to extensive developments, because the control of the main stream is difficult. For example, two men worked at a point about a mile above July Creek during the early part of the summer of 1916 until their workings were washed out by a flood. In the later part of the summer one man was mining bar gravels in the main stream bed about half a mile above the mouth of Homestake Creek. The gravels at this locality were about 3 feet in depth, and the bedrock consists of much jointed and contorted slate. The gold obtained is rather fine and much flattened. The yield was stated to be the equivalent of current wages, or about $6 a day to the man.

BEDROCK AND MINERALIZATION.

The middle basin of the upper Totatlanika is eroded chiefly in schistose rocks. Although there is evidence that a large part of this basin was formerly occupied by lignitic sediments overlain by the Nenana gravel, such as are now present in most of the other valley basins of the district, only small remnants of these sediments still remain in this part of the Totatlanika Valley.

The schists comprise rocks of both igneous and sedimentary origin. The igneous schists are feldspathic and most of them are porphyritic. The sedimentary schists might in large part be called slates and are more or less carbonaceous. These black slaty rocks occupy the greater part of the southern half of the basin, where they crop out across the valley in several successive belts that strike northwest and dip 40°–50° NE. The feldspathic schists occupy the northern half of the basin and appear to overlie the sedimentary schists. Both types of schist have reached about the same degree of metamorphism, and both are intruded by dikes of siliceous composition and granular character. These dikes likewise show the effects of considerable alteration, being strongly sheared and recrystallized to a degree that indicates they were intruded into the country rocks before the end of the regional metamorphism.

Quartz veins are abundant in both kinds of schist but particularly in the slates, and the sheared dikes also contain vein quartz in many places. The siliceous dikes intruded into the schists are probably the primary agency of gold mineralization in this basin, and probably also the greater part of the placer gold in the present stream gravels has been derived from the schists through erosion since the lignitic sediments and high gravels were removed from the basin.

CHARACTER OF THE DEPOSITS.

The width of the stream gravels on the three claims in the lower part of the middle basin ranges from about 400 feet on Discovery claim to about 100 feet at the lower end of claim No. 2 below Discovery, where the stream is crowded between the converging walls of Murphy Canyon. The gravels range in thickness from 3 to 6 feet and consist of typical stream-bar material throughout the width and length of the flood plain. They are rather coarse, containing many cobbles as much as 6 inches in diameter and a number of boulders from 1 to 2 feet in greater dimensions. The percentage of small pebbles and sand is not large. Altogether the deposits are cleanly washed and show the effects of reworking or shifting from one part of the flood plain to another due to the fluctuations in the stream flow.

The bedrock is of schist, the surface of which is rather irregular and blocky in character. Many of the joint crevices in this schist are rather open, and the particles of gold penetrate some of them to a depth of 2 or 3 feet.

Practically no permanent frost is present in the stream-washed deposits, probably because there is an abundant and free percolation of water through them during the greater part of the year.

JULY CREEK.

An instance of the close relation between gold mineralization and the dikes that intrude the schists is disclosed by mining operations on July Creek, one of the streams of the middle basin. July Creek is a small stream, about 2 miles long, that discharges into the Totatlanika from the western slopes of the valley about half a mile above the head of Murphy Canyon, or approximately at the boundary line between Discovery claim and claim No. 1 below Discovery on the main stream. The valley of this tributary is eroded in schists and along the lower half mile of its course is narrow and bounded by steep walls 100 to 150 feet in height.

At a point about a quarter of a mile above the mouth of July Creek the schists are intruded by a dike that trends across the gulch in a northeasterly direction. The stream gravels along the creek from this dike down to the mouth have been found to contain placer gold in sufficient quantity to make mining profitable, but it is significant that practically no placer gold whatever has been found in the gravels of the gulch above this dike. Although lode gold has not been observed in this dike or the schists that it intrudes, the evidence points to the conclusion that the dike is the mineralizing agency on which the placer gold along the lower part of July Creek is dependent, or, at least, that the gold has a bedrock source in the schists near the dike rather than in the Nenana gravel that formerly overlay the schists. For if even part of the placer gold of July Creek was derived by reconcentration from deposits of the Nenana gravel that formerly overlay the schists some gold should still remain in the stream gravels above the dike, as there is evidence that the Nenana gravel was formerly present in the area now drained by upper July Creek. The sharp upstream limit in the distribution of placer gold along July Creek at the position of the dike therefore seems to indicate that this dike is closely connected with the mineralization in the schists from which the placer gold is derived.

It is reported that much of the gold mined from July Creek was rough, and that some of it was attached to vein quartz. The largest nugget mined was worth about $25.

As the gold-bearing gravels on July Creek are limited in extent almost to one narrow gulch claim, they were mined out in about two years by pick and shovel. Most of this mining was done during the summers of 1910 and 1911. Along some parts of the claim the gravels yielded $200 worth of gold to the box length (168 square feet). A total production of fully $10,000 worth of gold is reported to have been obtained from this claim.

It is highly probable that placer gold has been carried from July Creek, along with its gravels, and deposited in the flood plain of the Totatlanika, especially on claim No. 1 below Discovery, which extends downstream from the mouth of July Creek. In fact, it seems likely that July Creek may be the source of much of the placer gold that occurs in the gravels of the main stream for some distance below it, although some of the gold may have been brought down the Totatlanika from the region above July Creek, and some may be derived from local bedrock sources below July Creek, for the Totatlanika has eroded this part of its valley to a considerable depth into schistose rocks. The mineralized belt of lower July Creek may extend across the valley of the Totatlanika, for the dike on July Creek trends in a northeasterly direction, although its outcrop has not been traced to the main stream. The schists along this part of the Totatlanika contain many quartz veins.

HOMESTAKE CREEK.

Homestake Creek, which has been the most productive placer-gold stream in the Nenana district up to the present time, is the westernmost headwater tributary of the Totatlanika from its upper basin and discharges into the middle basin of the main valley, about 2 miles above July Creek, through a deep canyon eroded across the mountainous belt that separates these two basins. The total length of Homestake Creek is about 5 miles, but the upper 3 miles of its course is locally known as Platte Creek and the name Homestake Creek is generally applied to the lower 2 miles of the stream, or to that part which flows through the canyon. The upper 3 miles of the valley shows a marked contrast in topographic character to the lower 2 miles in that it is a part of the broad undulating headwater basin of the Totatlanika eroded in the soft lignite-bearing sediments and overlying gravels.

The volume of Homestake Creek is comparatively small and seems particularly so in comparison with the canyon along its lower course, which is about 1 mile long and is eroded to a depth of about 1,000 feet. There may be some doubt that the stream in its present form is to be credited with the amount of erosion represented by this canyon, for the catchment area of Homestake Creek in the upper basin of the Totatlanika is limited to about 5 square miles. It is probable that formerly the drainage area was much more extensive.

The highland belt that separates the middle and upper basins of the Totatlanika is made up chiefly of massive igneous rocks that are intruded into schists. These intrusive rocks occupy an area about 1½ miles wide from north to south and 5 miles long from east to west and extend from a point 2 miles west of Homestake Creek to a point about 3 miles east of that stream. Two other tributaries of the Totatlanika, Thistle and Davis creeks, situated about 1 and 2 miles east of Homestake Creek respectively, have also eroded deep gorges in these rocks from south to north. The valleys of these three streams dissect the igneous mass into a group of prominent mountains, whose summits stand at altitudes ranging from 3,000 to nearly 4,000 feet.

The igneous rocks that form most of these mountains are andesitic but contain a considerable amount of quartz and might properly be termed dacites. These rocks show considerable decomposition and on the surface have a general dark reddish-brown color due to the development of iron oxides through weathering.

No particular evidence of quartz vein mineralization was observed in these massive igneous rocks, but the carbonaceous slates along the northern border of the intrusive mass in the middle basin of the Totatlanika contain a considerable number of small quartz veins, and some evidence of vein-quartz mineralization was also observed in a narrow belt of deeply disintegrated schist that crops out along the southern border of the intrusive rocks at the head of Homestake Creek canyon, especially along the course of Fox Gulch, a short tributary from the west. The stream gravels along the lower part of Fox Gulch and along Homestake Creek for half a mile below the mouth of this tributary, in the entrance to the canyon, are the richest gold placers of the valley, and their intimate association with the contact zone of schist that forms the bedrock of this part of the valley suggests that the placer gold may be derived from the schist.

Placer gold was discovered on Homestake Creek in the summer of 1905, and during that year eight or nine claims were located along the lower 2 miles of the stream from its mouth to a point a short distance above Fox Gulch. One or more claims were also located on the lower course of Fox Gulch. Discovery claim is about a mile above the mouth of the creek, in the middle of the canyon, and the other claims are numbered consecutively up and down the stream. These claims cover all that part of Homestake Creek valley that is eroded in hard igneous or schistose bedrock, and good prospects of placer gold may be obtained from the stream gravels of practically every claim.

In general the stream deposits along the lower $1\frac{1}{2}$ miles of the valley consist of rather coarse, poorly assorted gravels mixed with many large boulders and considerable quantities of cobbles, although in several small areas where the valley bottom widens to 300 or 400 feet the gravels are finer and better assorted than elsewhere. The stream bed along the narrowest part of the canyon, from one-half to $1\frac{1}{2}$ miles above its mouth, contains numerous large boulders and angular blocks of igneous rock derived directly from the steep valley slopes, which are mantled with thick accumulations of talus. The upper part of this canyon is more open in form, and the stream deposits in it are much finer than those below, consisting chiefly of finely broken up schistose rocks that contain relatively few large boulders, although the deposits include some well-rounded pebbles of the Nenana gravel derived from the headwater area above. The bedrock of this part of the valley consists chiefly of schist, and it is evident that a large part of the gravels are of local derivation.

Placer mining has been done on Homestake Creek since 1906. Most of the mining has been done on the four claims above Discovery claim and the claim on lower Fox Gulch, and nearly all of this ground is considered to be now worked out, although it is probable that considerable gold still remains in the gravels.

An inadequate supply of water has limited all operations to ordinary open-cut pick and shovel work with small sluice boxes and has prevented the development of the ground in a systematic manner. The flow of water from the small headwater area of Homestake Creek is ordinarily so scanty that it is necessary to pond the stream by means of dams back of which the water is accumulated at night in order to obtain sufficient water to wash the gravels the next day. The disintegrated character of the schistose gravels and the fact that they contain considerable finer detritus and are not much compacted facilitates mining with the small quantity of water available, which rarely exceeds a full sluice head except during periods of more than average rainfall.

The gravels are from 3 to 6 feet in thickness, and most of the gold occurs in their lower part and in the upper foot of decomposed schist bedrock. It is reported that yields of $200 to $250 to the box length have not been uncommon on some of the ground. This is the equivalent of $5 to $7 a cubic yard.

The period of greatest activity in mining on Homestake Creek was from 1906 to 1909, during which more or less work was done on all the claims from Discovery claim, in the canyon, upstream to and a short distance above Fox Gulch and on the lowermost claim on that tributary. Since 1910 the chief work has been done on the claim that extends above and below the mouth of Fox Gulch, and in 1916 two men were engaged in mining on the lower part of this claim in some low bench gravels along the west side of the valley bottom.

It is estimated that about $80,000 worth of gold has been produced from the placer claims on Homestake Creek that extend upstream from Discovery claim to and including Fox Gulch. A few thousand dollars' worth of gold has also been mined from the claims on the lower part of Homestake Creek below the canyon. In 1907 one man worked on claim "No. 4 below," just above the mouth of the creek, and in 1916 one man was engaged in mining on this claim during the later part of the summer.

McCUEN GULCH.

McCuen Gulch is on the north side of the upper Totatlanika about 5 miles above the mouth of Homestake Creek. It is about 1½ miles long and carries a very small quantity of water except during periods of heavy rainfall, and even at such times it drains quickly because of its steep grade, which is more than 1,500 feet between its mouth and source. As a whole the gulch is not very deeply dissected into the mountain slope along its upper course, but its lower quarter of a mile is somewhat sharply intrenched to a depth of about 100 feet across a sloping bedrock bench that marks a former flood plain of the valley of the upper Totatlanika. It is along this lower section of the gulch that placer gold has been mined.

The mountain slopes in which McCuen Gulch is eroded are made up of schistose rocks that are intruded by one or more dikes near the head of the gulch. One of these dikes consists of siliceous granitic rock and is sheared, like other dikes that are intruded into the schists at many localities throughout the district. Some small veins of iron-stained quartz occur in the schist in the vicinity of the sheared dike, and the dike rock itself contains some veinlets of quartz.

Placer gold was first found in the basin of the Totatlanika at the mouth of McCuen Gulch in February, 1905, and this discovery caused the excitement that resulted in the location of placer claims on practically all the streams in the district during the following summer and autumn. No information is at hand regarding the amount of gold that has been mined from this gulch, but it probably does not exceed $2,000. It is reported that one man mined several hundred dollars' worth of gold from this gulch in 1915. In August, 1916, one man was engaged in groundsluicing a small open cut with the intention of mining before the season closed.

All the mining on McCuen Gulch has been done within 1,500 feet of its mouth. In fact, it is only along this section of the stream that there is much alluvium in the gulch. The alluvial deposit is from 5 to 10 feet in thickness and 50 to 100 feet in width and consists of a relatively small proportion of well-rounded gravel mixed with numerous blocks and slabs of schist and considerable finely divided schist detritus. As a whole the material is poorly assorted and shows the lack of sufficient water in the stream to wash and concentrate the gravels thoroughly.

Although this gulch has yielded little placer gold, it is of interest in that the gold appears to be derived from a local bedrock source in mineralized schistose rocks rather than by reconcentration from the Nenana gravel.

TATLANIKA AND GOLD KING CREEKS.

LOCATION AND GENERAL FEATURES.

Tatlanika Creek lies about 10 miles and Gold King Creek about 16 miles east of the upper course of Totatlanika Creek. These two streams are of similar character and together drain the greater part of the foothill belt between the basin of the Totatlanika and the valley of Wood River. Their valleys extend from south to north across the foothill belt, a distance of about 20 miles, and are eroded to depths of 1,000 to more than 1,500 feet below the adjacent broad ridges. These valleys do not present the diversity of relief that characterizes the foothill basin of Totatlanika Creek, because they are eroded in thick and widespread deposits of the Nenana gravel, except in their headwater sections and in a short canyon on the lower Tatlanika.

The general geology and gold placers of Tatlanika and Gold King creeks were examined by Prindle[1] in 1906 and by Capps[2] in 1910. Since then these valleys have not been visited by members of the Geological Survey, but placer mining has been continued on them up to the present time at several localities. The writer obtained a few notes regarding these later developments from miners on the Totatlanika who are familiar with the district.

TATLANIKA CREEK.

Practically all the placer mining in the valley of Tatlanika Creek has been done on three tributaries, named, in upstream order, Hearst, Roosevelt, and Grubstake creeks, which discharge into the main stream from the east along the middle part of its course. More or less mining has been done on these streams since 1905, but the most continuous work has been done on Grubstake Creek, where from two to six men have been employed each year. Roosevelt Creek appears to rank next to Grubstake Creek in importance, and Hearst Creek has been the least productive of the three streams. It is reported that four men were engaged in mining on Grubstake Creek and one man on Roosevelt Creek in 1916.

Hearst, Roosevelt, and Grubstake creeks are from 2 to 4 miles long and of comparatively small volume. They are streams of like character, especially with regard to the geology of the areas they drain and the conditions under which the placer gold occurs along their courses. Their sources are fully 1,000 feet above their mouths, on the higher slopes of a broad ridge of the Nenana gravel that separates the valley of the Tatlanika from that of Gold King Creek, to the east. The upper halves of the valleys of all three of these tributaries are eroded in the thick Nenana gravel, but the lower courses, from 1 to 2 miles above their mouths, are eroded below the base of the Nenana gravel to a depth of 100 feet or more in semiconsolidated sediments composed of interbedded clays, sands, and gravels, with some thin beds of lignite. These underlying deposits are very similar in general composition to the thick lignite-bearing sediments that occupy large areas in the basins of Totatlanika, Hoseanna, and Healy creeks and elsewhere in the region, and on this basis they would be considered to be of Eocene age. However, fossil plant remains that have been obtained from these sediments near the mouth of Roosevelt Creek seem to indicate that they may be younger than the typical lignite-bearing formation of the region.

The chief points of interest with regard to the plant-bearing clays, sands, and gravels in the Tatlanika Valley are that these

[1] Prindle, L. M., The Bonnifield and Kantishna regions: U. S. Geol. Survey Bull. 314, pp. 210–212, 1907.

[2] Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, pp. 47–51, 1912.

sediments form the bedrock upon which the placer gold of Hearst, Roosevelt, and Grubstake creeks is now concentrated; that the thick Nenana gravel overlies these sediments; and that the stratigraphic relations of the Nenana gravel with the semiconsolidated sediments upon which it rests appear to be similar to those exhibited in the valley of lower Healy Creek (see pp. 372–373), where about 500 feet of sandy shales with cross-bedded sands and gravels containing some lignitic layers underlie the Nenana gravel and overlie the typical lignite-bearing formation of the region. In both localities there is strong evidence that the placer gold in the present stream gravels is derived by reconcentration from older placers in the Nenana gravel and that these older placers are most probably in the basal part of the formation.

The placer gold on Hearst, Roosevelt, and Grubstake creeks occurs chiefly in about 2 feet of the present stream gravels that rest on a bedrock composed of interbedded clays, sands, and gravels, with some semiconsolidated lignitic layers. This bedrock is overlain by the thick mass of the Nenana gravel in which the valleys are chiefly eroded.

A large area along the flood plain of Tatlanika Creek has been held under placer locations in the form of association-group claims of 160 acres each for the last 10 years. This tract of claims is reported to extend along the bottom of the valley for a distance of 10 miles or more, from a point above the mouth of Grubstake Creek downstream to the short canyon eroded in hard schist about 7 miles below the mouth of Hearst Creek. Along this section of its course Tatlanika Creek has cut a valley floor from one-fourth to three-fourths of a mile wide and distributed over it a large quantity of reworked gravels derived from the thick Nenana gravel. It is reported that the bar gravels along this section of the stream, together with low bench gravels, contain prospects of placer gold, and that the prospecting of these deposits with drills was to be undertaken during 1917. If these gravels prove to contain profitable amounts of placer gold they could probably be easily mined by means of dredges, for they apparently occur under geologic conditions similar to those that characterize the placers of Hearst, Roosevelt, and Grubstake creeks as described. It is also probable that some of the placer gold contained in the gravels of the main stream may be derived from these three tributaries.

GOLD KING CREEK.

Placer gold has been mined from a few claims on Gold King Creek since 1903. Prindle reports that about 12 men were working on this stream in 1906, and Capps states that claims 19 and 21 below

Discovery were under operation in 1910. It is reported that two persons were mining on this stream in 1916. All this mining has been done in the bed of the main creek at localities where the present reworked stream gravels are from 4 to 8 feet thick and rest on a bedrock of clay. Some of the gold is recovered from the gravels, and some from the soft clay bedrock upon which it is concentrated. All the mining has been done by open-cut pick and shovel methods.

The conditions under which placer gold occurs in Gold King and Tatlanika creeks appear to be similar. The valley of Gold King Creek differs from that of Tatlanika Creek in that its bottom has not been widened so much by lateral erosion. This valley is V-shaped in cross section. Its tributaries have not eroded flood plains back from the main stream like those of Hearst, Roosevelt, and Grubstake creeks in the Tatlanika basin.

It appears as if the clay bedrock along the narrow bed of Gold King Creek, upon which the placer gold is concentrated at the localities where mining is being done, may be the equivalent of the formation upon which placer gold is concentrated in the valley of Tatlanika Creek, the difference between the two valleys being that Gold King Creek has barely eroded its bed down to or a few feet below the base of the thick Nenana gravel, whereas Tatlanika Creek has eroded its valley floor to a depth of 100 feet or more below the Nenana gravel and laid bare a considerable area of the underlying formation by lateral erosion.

A large hydraulic mining enterprise on Gold King Creek that had been under construction for several years and was nearly ready for operation in 1910, at the time of Capps's visit, is reported to have been abandoned in the later part of that summer after a trial run of only a few days. This project comprised a system of ditches about 11 miles in extent that was designed to convey 3,000 miner's inches of water from the upper part of Gold King Creek to a point on the eastern slopes of the valley, where it was to be delivered to a pipe line under a head of 700 feet. The intention was to mine the thick Nenana gravel on the lower slopes of the valley, but apparently no systematic prospecting of the gravels to be mined was done before the project was undertaken.

SUGGESTIONS TO PROSPECTORS.

As has been pointed out with reference to the gold placers of Home, Alaska, and French creeks, tributaries of Healy Creek (see pp. 376–379), there are no positive data at hand as to whether the placer gold supposed to be contained in the Nenana gravel is confined to one or a few particular beds or horizons in that formation, or is somewhat widely distributed throughout its thickness. The evidence furnished by the distribution of placer gold in the present stream gravels of

French, Alaska, and Home creeks, however, affords a basis for the surmise that this gold has its chief source in the lower 500 feet of the Nenana gravel, whose thickness in Healy Creek valley is fully 2,000 feet and in the valleys of Tatlanika and Gold King creeks at least 1,500 feet.

So far as known, no comprehensive attempt has been made to prospect for gold in the Nenana gravel itself. As pointed out by Capps,[1] if such work is undertaken, it is essential that tunnels should be driven far enough into the deposits to reach undisturbed beds that have certainly not been enriched by gold from some outside source. With little doubt it is most advisable to undertake such prospecting at or near the base of the Nenana gravel rather than higher in the section.

Another suggestion to be borne in mind is that made by Prindle[2] with reference to the placers of Tatlanika Valley, which also applies to the deposits in the valley of Gold King Creek:

> A point to be emphasized is that the soft clays and sands which form the bedrock are just as truly bedrock to the stream gravels that overlie them and carry the gold as if they were hard rock. A thickness of several hundred feet of these unconsolidated deposits may overlie the hard bedrock, and any attempt to sink through them to the solid formation would be not only a most difficult task, but, inasmuch as the only run of gold known overlies them, would be in all probability useless.

This suggestion is particularly applicable to the drilling operations which, according to report, are to be undertaken in the main valley of the Tatlanika.

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[1] Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, p. 50, 1912.

[2] Prindle, L. M., The Bonnifield and Kantishna regions: U. S. Geol. Survey Bull. 314, p. 211, 1907.