DEPARTMENT OF THE INTERIOR
FRANKLIN K. LANE, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

BULLETIN 662—E

MINERAL RESOURCES OF THE KANTISHNA REGION, ALASKA

BY

STEPHEN R. CAPPS

Mineral resources of Alaska, 1916—E

WASHINGTON
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ILLUSTRATIONS.

MINERAL RESOURCES OF THE KANTISHNA REGION.

By Stephen R. Capps.

INTRODUCTION.

The region discussed in this report lies on the north side of the Alaska Range and includes portions of the basins of Nenana and Kantishna rivers. (See Pl. XV.) It includes the southern portion of the Tanana lowlands and some of the outlying mountain ridges, though nowhere reaching the crest of the range, and lies between meridians 149° and 151° 10′ west longitude, and parallels 63° 25′ and 64° 15′ north latitude. Figure 7 shows the relation of this area to surrounding portions of Alaska.

The discovery of gold in the Canadian Klondike and the consequent influx of prospectors and miners resulted in the beginning of systematic exploration in this region. The first accurate surveys in this vicinity were made in 1898, when two United States Geological Survey parties reached the Alaska Range. One of these parties, conducted by George H. Eldridge and Robert Muldrow, ascended Susitna River and crossed the divide to the head of Nenana River. The other party, in charge of J. E. Spurr and W. S. Post, ascended to the head of Skwentna River, crossed the Alaska Range, and descended the Kuskokwim. Thus some of the major features of the range were outlined, although neither of these parties reached the region here discussed. The first survey to be extended to the Kantishna region was made in 1902, when a Geological Survey expedition under the leadership of A. H. Brooks and D. L. Reaburn proceeded from Cook Inlet to the head of the Skwentna, crossed the Alaska Range, and traversed the northwest flank of the range as far eastward as Nenana River, thus crossing the region from west to east. In 1903 and 1904 the great gold rush to the Fairbanks district took place and prospecting was stimulated throughout the Tanana Valley. In 1905 gold placer gravels were discovered in the Kantishna Hills, north of Mount McKinley, and several thousand gold seekers came to the scene of the new diggings. Most of these were disappointed, but a few located paying ground, and the district has been producing since that time. Furthermore, within the last few years a number of promising gold lodes have been found in the

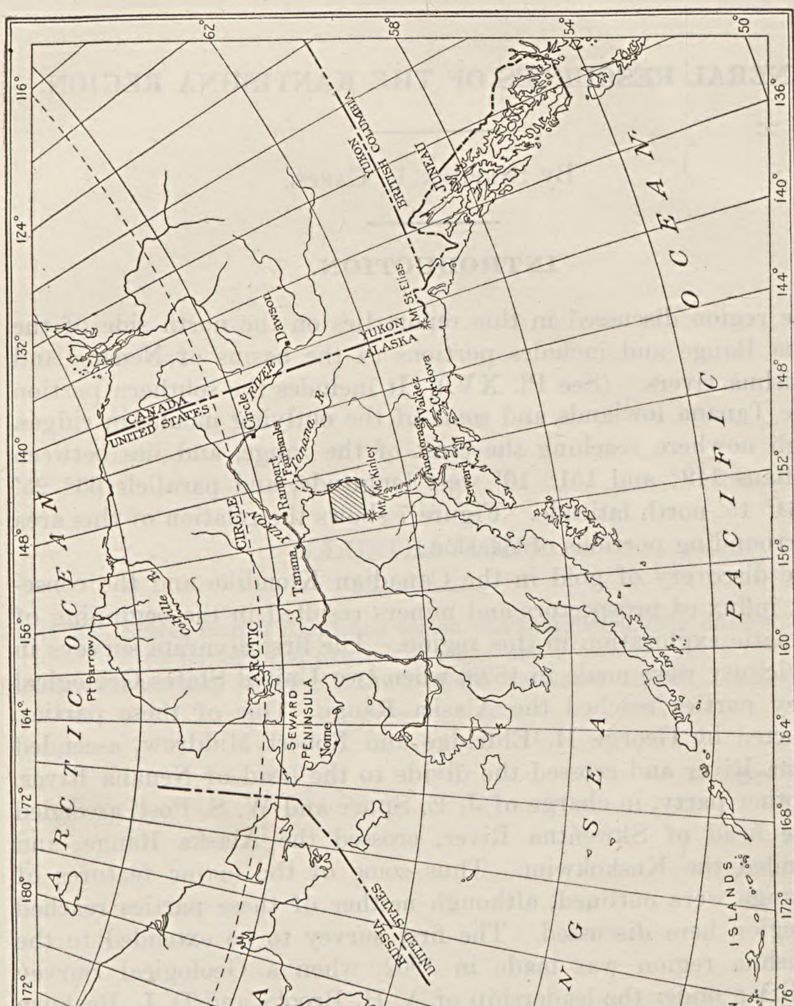


FIGURE 7.—Index map showing location of the Kantishna region.

district. The beginning of vigorous construction work on a Government railroad from Seward to Fairbanks, by way of the Susitna and Nenana valleys, has made it likely that many mining claims in the Kantishna district which were not worked under the old conditions of difficult access and costly transportation will become valuable, and a demand has arisen for more detailed and more recent information about the region than was available. Accordingly two parties were sent to this field in 1916 to extend the topographic and geologic mapping. The topographic party, in charge of C. E. Giffin, commenced work on Nenana River at the mouth of Dry Creek and carried the mapping westward to include the Kantishna mining district. The geologic party, in charge of the writer, covered much the same ground, and at the end of the season several weeks were spent in a study of the placer and lode deposits of the Kantishna district.

Before this work was commenced a general knowledge of the geology of the region had been gained by earlier expeditions. In 1902 Brooks[1] and Prindle had crossed the region and had mapped the surface distribution of the various formations along this route. In 1906 Prindle[2] again made a hasty trip to the then newly discovered Kantishna diggings. In 1910 the writer[3] mapped an area between Nenana and Delta rivers, adjoining this region on the east. Detailed reference to the work of these geologists will be made in a more complete report on this region, now in preparation, but full use has been made by the present writer of their published and unpublished notes. Especial acknowledgment is due to the pioneer work of Brooks and Prindle, for they recognized and outlined all the major rock formations and in the almost complete lack of fossils from this area it is largely on the basis of their observations that the age of several of the formations is determined.

The conclusions reached in this paper and the distribution of formations shown on the accompanying geologic sketch map (Pl. XV) are the result of a merely preliminary study of the material at hand and are subject to modifications in the fuller report.

GENERAL FEATURES OF THE DISTRICT.

GEOGRAPHY.

Few areas in the world exceed in scenic grandeur the Alaska Range in the vicinity of Mount McKinley. That mountain itself, having an elevation of 20,300 feet, is the loftiest peak in North America, and

[1] Brooks, A. H., The Mount McKinley region, Alaska: U. S. Geol. Survey Prof. Paper 70, 1911.
[2] Prindle, L. M., The Bonnifield and Kantishna regions: U. S. Geol. Survey Bull. 314, pp. 205-226, 1907.
[3] Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, 1912.

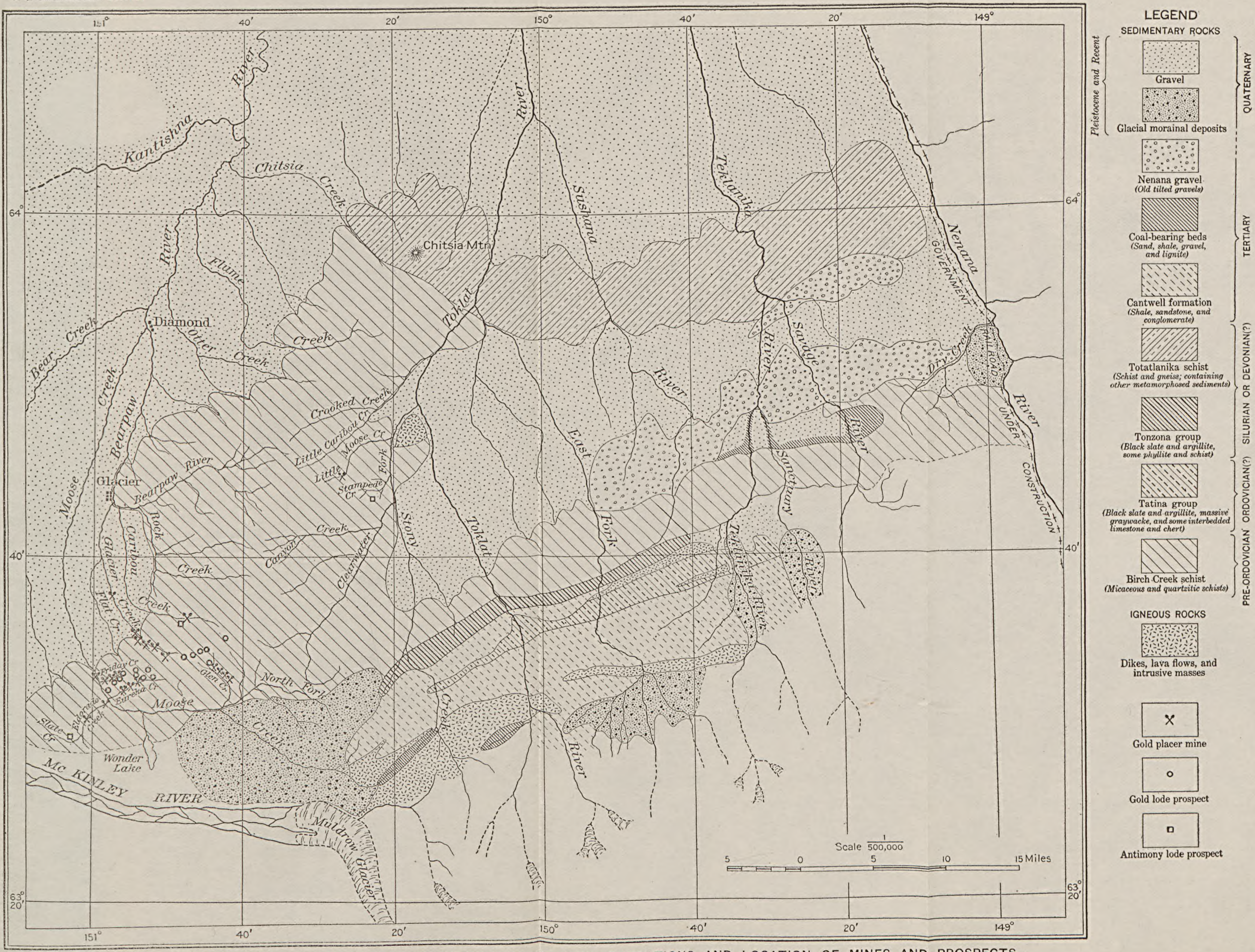
with its companion peak, Mount Foraker, can be seen from Yukon River, on the northwest, to Cook Inlet, on the south. Although both of these impressive ice domes surpass by several thousand feet the highest of their neighbors, they stand amidst a multitude of rugged and magnificent mountains. The line of perpetual snow lies at an elevation between 6,000 and 7,000 feet, and above it all surfaces not too steep to hold snow are buried beneath an icy covering. From this mountain mass great glaciers descend all the larger valleys to the mountain front, and the crest of the range is therefore inaccessible except to the man who is willing to endure the hardships of alpine work. In the winter of 1916 Congress passed an act to establish the Mount McKinley National Park, containing an area of about 2,200 square miles, and thus preserved for the people the mountain scenery and the prolific herds of wild game that have made the north slope of this part of the Alaska Range notable. With the completion of the new Government railroad this national park will become accessible and will afford a splendid area for study and recreation in the midst of America's most inspiring natural surroundings.

Only a small part of the main Alaska Range is included in the area here described, but plans are under way to extend the geologic and topographic mapping to include the main range from Broad Pass to Mount McKinley and the northwest face of the range for some distance southwest of the mountain. The area here described comprises some of the long mountain ridges that extend northward from the crest of the range; several subsidiary mountain ridges that lie north of and parallel to the main range; the so-called Kantishna Hills; and the low, basin-like areas that lie between and north of the foothill ranges.

Two large streams, Nenana and Kantishna rivers, both tributaries of the Tanana, receive the drainage from this region. Nenana River borders the area on the east, and to it Teklanika River, which drains the eastern portion of the area, is tributary. Kantishna River drains a wide area west of the Nenana Basin and within the region here described is fed by Toklat River and its glacial waters and by the clear waters of Bearpaw River, draining the north and west slopes of the Kantishna Hills.

GLACIATION.

The higher portions of the Alaska Range constitute the feeding ground for many glaciers, and an ice stream is to be found in the head of almost every valley that drains from the divide. These glaciers are smallest where the mountains are low, but from the loftier portions of the range great valley glaciers flow down radially



SKETCH MAP OF KANTISHNA REGION, SHOWING DISTRIBUTION OF ROCK FORMATIONS AND LOCATION OF MINES AND PROSPECTS.

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in all directions. Glacial ice is most abundantly developed on the southeast slope of the range, as the precipitation is heavier on that side than in the Tanana Basin, and the glaciers that drain to the Pacific are thus much larger than those whose waters flow to Yukon and Kuskokwim rivers. In the area here described there are no large glaciers, but the streams that cross it are fed from the melting ice fields and carry abundant débris supplied by the ice tongues. The present glaciers are, however, of small size compared to the ice streams that in times past flowed northward from the range far out into the foothills. That greater glaciers were formerly present is now to be recognized by the shape into which they eroded their beds and by the deposits of glacial débris they laid down in moraines and as glacial outwash gravel. The influence of the ice advance was thus felt far beyond the borders of the glaciers themselves, for the turbid streams built up valley deposits of glacial gravels that extend many miles north of the area that was actually covered by ice.

ROUTES OF TRAVEL.

The remoteness of the Kantishna region from established lines of transportation has made travel to it difficult and the transportation of supplies expensive. Even the mail arrives at very irregular intervals, for no mail route to the mining district has been established and mail is brought in only by courtesy of the chance traveler. Often the camp is isolated from communication with the outside world for weeks or months at a stretch. During the season of surface mining in summer the miners are busily engaged in working their ground and rarely make trips to Tanana River, the nearest line of communication.

Fairbanks has, until 1916, been the center of supplies for the Kantishna district, and most of the supplies taken to the mines have been hauled in from Fairbanks in the winter by dog sleds. The customary route followed Tanana River down to the mouth of the Nenana, ascended that stream to the base of the foothills, a distance of 30 miles, and thence proceeded westward along the base of the foothills to Knight's roadhouse on Toklat River, north of Chitsia Mountain. The trail then followed up the Toklat and its tributary Clearwater Fork to Myrtle Creek, up Myrtle Creek and across a low divide to Spruce Creek, and down that stream and Moose Creek to the mines on Moose Creek and its tributaries. The total distance by this route from Fairbanks to Moose Creek at the mouth of Eureka Creek is about 165 miles. Now that the town of Nenana has been established at the mouth of Nenana River it is likely that many of the supplies for the mines will be purchased at Nenana and the sled haul shortened by 55 miles.

Summer travel to the Kantishna region goes almost exclusively by boat. The regular river steamboats run to the mouth of Kantishna River, and shallow-draft launches may be used to ascend that stream and its tributary, Bearpaw River, to the head of navigation at Diamond. From Diamond it is necessary in summer to go afoot to the mining claims, and in winter dog sleds are used. It is also possible to take launches up Kantishna River to McKinley River, and up that stream to the abandoned town of Roosevelt, which is about as distant as Diamond from the mines on Eureka Creek. The route overland from Roosevelt lies through a country that is swampy in the summer, and this route has been little used in recent years.

It has been the prevailing custom for each miner to bring in his own supplies early in the spring by dog sled, so that no commercial rate for winter freighting is definitely established. Some provisions, especially those of the kind that are damaged by freezing, have been brought from Fairbanks to Diamond by launch in summer at a freight charge of 4 to 6 cents a pound.

Summer travel to the parts of this area other than the immediate vicinity of the mines is negligible. During the season's field work between Nenana River and the Kantishna mining district the Survey parties encountered no one and found no evidence that anyone had been there recently. No summer trails were seen, although a number of trappers' cabins and tents indicate that a few men spend their winters in trapping and hunting within the area. The country is, however, easily passable in summer for pack horses. The gravel bars of the larger streams afford firm footing for horses, and there are many low divides through the north-south ridges, so that it is easy to pass from one stream basin to the next. To one who is familiar with the difficulties of summer travel in many other parts of Alaska this region offers a pleasant relief from boggy ground and brush.

VEGETATION.

Much of this region lies above timber line. The Tanana lowland is dotted with marshes, interspersed with patches of small timber, including spruce, birch, tamarack, and cottonwood; the spruce greatly predominates over the other varieties. The heaviest stands of timber appear in the better-drained areas, particularly along the banks of the streams and on the lower slopes of the hills. Along the larger valleys the timber reaches farther south into the mountains. Thus in the Nenana Valley timber extends southward beyond the area included in this report. Savage River has spruce as far south as the head of its upper canyon. The valleys of Sanctuary River and the Teklanika have some timber within 10 or 15 miles of their heads, and Toklat River and its East Fork have trees along the lower flanks of the mountains equally far south. Stony Creek is timbered to the mouth of Boundary Creek, and Moose Creek to the mouth of Willow Creek. In general, timber extends up the valleys to elevations between 2,500 and 3,000 feet, though exceptionally stunted spruce trees may be found at an elevation of 3,500 feet or more. In practically all the valleys willow bushes of sufficient size to furnish tent poles and firewood may be found above the last timber.

Grass for forage is generally obtainable in all parts of the area where timber or brush for camping purposes are to be found. A certain variety of vetch that grows on the stream gravel bars is also eagerly eaten by horses after the seed pods have formed. During the summer, therefore, horses will do well if allowed sufficient time for grazing and unless the work required of them is too severe. With the advent of heavy frosts in the fall, however, the vegetation loses its nutritive qualities, and horses must be supplied with hay and grain if they have to do heavy work. In other parts of interior Alaska where climatic conditions appear to be equally severe horses have passed the winter successfully without being fed or cared for in any way. Although the experiment has not been tried in this area, it seems likely that in the more favorable places horses would winter if they were turned out in good condition.

GAME.

The north side of the Alaska Range west of Nenana River is remarkable for the abundance and variety of its big game. Probably no other area in Alaska is so well stocked with sheep, caribou, and moose. The white mountain sheep are confined to the main range and the more rugged foothills, but within their chosen area they may be seen daily in large bands. Caribou are present both in the mountains and in the foothills. East of the Toklat basin a few were seen, but in the valley of the main Toklat and westward to Muldrow Glacier they were especially abundant, in herds some of which contained hundreds of individuals. Moose are present in all the timbered areas, and their range thus lies north of the principal feeding grounds of the sheep and caribou. Black bears are also distributed throughout the timbered districts, and grizzly bears range the area above timber line. Rabbits and ptarmigan are abundant in some years, but few were seen during the summer of 1916. A considerable number of fur-bearing animals, notably fox, lynx, mink, and marten, are captured each winter. Beaver are especially numerous in the lowlands.

NATIVES.

There are no settlements of natives in the region here considered. The Indians of interior Alaska depend upon fish for the main item of diet, both for themselves and for their dogs, and consequently have their permanent villages at places where they can most easily obtain fish. The principal native settlements nearest this area are a large village on Tanana River about a mile above the mouth of Nenana River; another at Tanana, on Yukon River; a small settlement on Lake Minchumina; and another at Telida, on the upper Kuskokwim. Natives from these villages occasionally journey to the mountains on trapping or hunting trips, but as they are able to kill moose in the lowlands, nearer their settlements, they spend little time in the mountainous country.

GENERAL GEOLOGY.

CHARACTER OF THE ROCKS.

The rocks of the Kantishna region range from highly metamorphic mica schists and gneisses, through less altered but deformed sediments of Paleozoic age, to the slightly indurated Tertiary coal-bearing beds and to the unconsolidated terrace gravels and the deposits of present streams. Interspersed with these materials are igneous rocks of various ages and of all degrees of alteration and metamorphism. Except in the outermost belt of foothills the rocks on the north flank of the Alaska Range are dominantly of sedimentary origin, although, as may be seen from the sketch map (Pl. XV), considerable areas are occupied by intrusive materials and lavas. Hasty reconnaissance trips to the heads of several valleys have shown that sediments predominate to the crest of the range.

The distribution of the rock formations as shown on the map has been determined only by hurried reconnaissance surveys, in which a wide scope of country was visited in a short summer field season. It has therefore been possible to subdivide and outline the several units in only an approximate manner. Time was not available to follow out all the formational boundaries, and when the geologic field work was done no topographic map was available, so that it was necessary later to adjust the geologic boundaries to the finished map in the office. Furthermore, most of the rock formations here described have so far failed to yield fossils in this district, and their age determination is therefore dependent upon their correlation with similar beds in other localities, or upon their relations to other formations whose age has been established. The age to which some of these formations are assigned may therefore be changed in the future, when fossils are discovered or when the stratigraphic succession is more fully worked out. Under these circumstances it is inevitable that the outlines of the formations as shown will be found to be somewhat in error upon critical examination in the field. Nevertheless, the map is believed to represent with a fair degree of accuracy the general outlines of the formations represented, and to furnish at least a guide for the later worker who has time and facilities for more refined mapping.

STRUCTURE.

The prevailing structural trend of the region is east-northeast, parallel to the axis of the Alaska Range, and has been determined by movements similar to those which brought the present range into existence. The uplift of the present mountain mass, however, did not produce all the metamorphism which some of the rocks have undergone, for that uplift took place in post-Mesozoic time, and before it began some of the rocks here represented, notably the Birch Creek schist and the associated gneisses, had been severely metamorphosed by forces applied in the same direction as those that forced up the present mountains. The Alaska Range was therefore formed along a zone of weakness that had previously yielded to stress. In its uplift the beds were both folded and faulted, and both of these processes were operative in developing the main range and the parallel ranges of foothills, with the broad basins between them.

SEDIMENTARY AND METAMORPHIC ROCKS.

Birch Creek schist.—The oldest rock formation that occurs in this area is the Birch Creek schist, which forms an outlying ridge of mountains extending from Nenana River westward to Stony Creek and west of that stream expands to include most of the Kantishna Hills. West of the Kantishna district the outline of the schist area is not well known, but to the east it extends beyond Delta River and forms a prominent element of the Alaska Range there. The material of the Birch Creek schist consists for the most part of highly contorted and fissile mica and quartzite schists and phyllites and includes garnetiferous and carbonaceous schists. These rocks are believed to represent metamorphosed sediments. In general they may be readily recognized by their thin, flaky cleavage and the abundance of mica, which gives them a greenish to silvery appearance. These rocks are of especial economic importance, for they are in places cut by gold, silver, lead, and antimony bearing quartz veins, and all the workable gold placer gravels so far found have been derived from this schist series.

The age of these rocks is uncertain. From their general appearance and character they have been correlated with the Birch Creek schist of the Yukon-Tanana area, which is believed to be pre-Ordovician.

Tatina group.—The Birch Creek rocks are bordered on the south by a narrow belt of the Tonzona group, south of which, in another narrow belt parallel to the schist, is a series of beds composed predominantly of black slates and argillites, massive graywackes, and some interbedded limestone and chert, all more or less intricately folded and metamorphosed. Brooks classified these rocks with his Tatina group, which he regards as partly Ordovician and possibly in part Silurian. No fossils were found in these rocks between Nenana River and Muldrow Glacier, and no positive additional evidence of their age was procured. From purely stratigraphic grounds, however, there seems to be a possibility that the beds in this area are younger than the Tonzona group. Their position with relation to the Tonzona is what would be expected if they overlay it, and they are directly overlain by the Cantwell formation, of Mesozoic (Tertiary) age. Faulting has been so severe in this region, however, that the normal relations are difficult to ascertain, and these beds are therefore left in the position in the stratigraphic column where they were placed by Brooks.

Totatlanika schist.—A series of quartz-feldspar schists and gneisses younger than the Tatina group form the northernmost range of foothills and extend from a point east of Nenana River westward across the Toklat basin and include the northeast end of the Kantishna Hills, in the vicinity of Chitsia Mountain. These rocks, which have been called the Totatlanika schist, are characterized by the presence of porphyritic schist or augen gneiss, containing phenocrysts of feldspar and quartz and believed to have been formed by the metamorphism of rhyolite or rhyolite porphyry. Associated with the porphyritic schist are finer-grained schists and some carbonaceous slaty schists and in the vicinity of Chitsia Mountain some sandy limestones that are of sedimentary origin. Time was not available for separating the igneous from the sedimentary material in the outer range of foothills, and they have been outlined together on the map with a single pattern. The whole series has been severely metamorphosed and plicated. As no fossils were found in this area there is no definite evidence of the age of these rocks. East of Nenana River they overlie the Birch Creek schist, of pre-Ordovician age. Brooks[1] has correlated the sedimentary phases with his Tonzona group, which he regards as of Devonian or Silurian age.

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[1] Brooks, A. H., The Mount McKinley region, Alaska: U. S. Geol. Survey Prof. Paper 70, p. 75, 1911.

Tonzona group.—Along the south border of the Birch Creek schist, between Teklanika River and Stony Fork of Toklat River, there is a narrow belt of black slates and argillites, with some phyllites and schists, that lie upon the Birch Creek schist. In many ways these rocks resemble some of the sedimentary materials included with the Totatlanika schist, but they are comparatively free from material of igneous origin. Brooks[1] has included these rocks with his Tonzona group, which on the basis of its stratigraphic relations he considers to be of Devonian or Silurian age. As no further definite evidence on their age was obtained they are therefore here classified as Devonian or Silurian.

Cantwell formation.—Associated with the beds of the Tatina group and overlying them unconformably is a thick series of sediments, the Cantwell formation, composed of conglomerate, coarse sandstone, and shale. These beds have a thickness of several thousand feet and form a prominent element of the north flank of the Alaska Range. From plant remains found in them and by correlation with other plant-bearing beds east of Nenana River these sediments are classified as of Kenai or early Tertiary (Eocene) age. The beds are generally uptilted, folded, and faulted and locally are cut by intrusive rocks and interbedded with lava flows.

Coal-bearing Tertiary beds.—The Cantwell beds are succeeded by the coal-bearing Tertiary deposits that are so abundantly represented just east of this area, in the Nenana coal field. These beds are generally little consolidated and consist of sands and clays, with lignite interbedded locally. They occupy small areas in the valleys of the higher mountains and larger areas in the open basins between the foothill ranges. In the basin of Teklanika River considerable areas are occupied by the coal-bearing sediments, although the surface exposures are small because of a widespread covering of younger gravels. There can be no doubt that in that basin, at least, there is a large amount of workable lignite, and scattered outcrops of the same formation occur as far westward as the Kantishna mining district, indicating that there may be large bodies of coal that are for the most part concealed by the gravel covering.

The age of the coal-bearing beds is not positively known, for the fossil evidence seems to disagree to some extent with the stratigraphic evidence. Heretofore the coal-bearing materials of the Nenana coal field have been considered to be, at least in part, of Eocene age. Fossil plants collected from the Cantwell formation east of Nenana River by Moffit[2] have been definitely determined as

[1] Brooks, A. H., op. cit., p. 76.

[2] Moffit, F. H., The Broad Pass region, Alaska: U. S. Geol. Survey Bull. 608, pp. 48–49, 1915.

Eocene. Collections made from this same formation by Brooks[1] in the Toklat basin and by the writer in the Teklanika basin have also been determined to be Eocene. The stratigraphic evidence, however, seems to show rather conclusively that the Cantwell beds are considerably older than some of the coal-bearing beds. In the absence of definite paleontologic evidence the coal-bearing materials are here assigned to the Tertiary but are believed to be younger than the Cantwell.

Nenana gravel.—In the basins of Nenana and Teklanika rivers and of East Fork of Toklat River there are certain thick gravel deposits, known as the Nenana gravel, that overlie the Tertiary coal-bearing sediments and have been faulted and tilted with them. These gravels reach a maximum thickness of at least a thousand feet, are deeply oxidized, and in general are conformable with the underlying coal-bearing sediments. They are believed to be of Tertiary age.

Unconsolidated deposits.—Among the unconsolidated and undeformed deposits of the region are the glacial moraine deposits, the bench and terrace gravels, which are in part composed of glacial outwash material, and the deposits of the present stream flats. The only morainal materials in this area were left by the ice during the last stage of glaciation and are confined to the mountainous portions of the area. At a few places distinguishable terminal moraines are present, but in general the glacial materials form only a thin covering over the mountain flanks. The bench and terrace gravels are of wide extent in the lowlands between the foothill ranges and in the Tanana lowland. They consist of materials derived from a number of sources—outwash materials from the ancient glaciers, reworked gravels from the Tertiary formations, and deposits laid down by the present streams before the flood plains now occupied were established. The gravels included in this classification are all related to the present topography of the region and retain the attitude in which they were laid down. They are of Pleistocene and Recent age.

The gravels along the flood plains of the present streams, although composed in part of outwash from the existing glaciers, represent the last stage of geologic activity and, with the accumulations of rock débris on the mountain slopes and of soils and vegetable humus on the gentler slopes, are the product of present-day geologic process.

IGNEOUS ROCKS.

Igneous rocks of various types and of different ages are present throughout the Kantishna region. They include certain greenstones that are included in and are deformed with the Birch Creek schist; the Totatlanika gneisses are in large part of igneous origin; beds of

[1] Brooks, A. H., op. cit., p. 82.

greenstone underlie the Cantwell in places; and both the Cantwell and the Tertiary coal-bearing beds are cut by intrusives and contain interbedded lava flows. Dike rocks of granitic material cut the schists in the Kantishna Hills, and large masses of granitic rock are known to be present in the Alaska Range north of the area here described.

ECONOMIC GEOLOGY.

HISTORY OF MINING.

The basin of Tanana River assumed importance as a placer-mining region on the discovery of rich placer gravels in the Fairbanks district. As a consequence of that discovery a great stampede to the Tanana Valley took place in 1903 and 1904. Most of the gold seekers went to the new town of Fairbanks or to the creeks in that vicinity, but a few penetrated to the north slope of the Alaska Range and carried on the search for gold there. The discovery of gold in the Kantishna district was an indirect result of the Fairbanks rush. In 1904 Joe Dalton and his partner Reagan prospected in the basin of Toklat River and after having found encouraging amounts of gold returned to Fairbanks that fall. The next spring Dalton and another partner named Stiles returned to the Toklat and prospected on Crooked Creek, a tributary heading in the Kantishna Hills 16 miles northwest of Mount Chitsia. In the summer of 1905 two other prospectors, Joe Quigley and his partner Jack Horn, had been told by some trappers that there was gold in Glacier Creek, and they came in to investigate. They found gold in paying quantities, staked the creek, and in June of that year carried the news of their discovery to Fairbanks, and so started the Kantishna stampede. The stampeders began to arrive at Glacier Creek about July 15, 1905. Meanwhile Dalton and Stiles, who had heard nothing of the Quigley-Horn discovery, had followed the southeast side of the Kantishna Hills and arrived at Friday Creek. They found gold there and on July 12 staked that stream. On July 20 they staked Discovery claim on Eureka Creek, but thinking themselves entirely alone in the country they staked only the one claim, having determined to prospect the upper portion of the stream. They went up Eureka Creek and on their way back met a man named Cook, who had come in with the stampede and had made his way up Moose Creek to the mouth of Eureka Creek. Cook said he had staked claims Nos. 1 to 4 on Eureka, so Dalton and Stiles returned and staked the rest of the creek above claim No. 4.

During the later part of the summer and the fall of 1905 the Kantishna district was the scene of great excitement. Several thousand persons arrived, most of them by boat up Kantishna River and its tributaries, Bearpaw and McKinley rivers, during the season of open water, and by dog sled later in the fall after snow had fallen. Practically every creek that heads in the Kantishna Hills was staked from end to end, and the benches and intervening ridges were not ignored. Within a few weeks a number of towns were established, the largest of which were Glacier, on Bearpaw River at the mouth of Glacier Creek; Diamond, at the mouth of Moose Creek; and Roosevelt and Square Deal, on McKinley River. At each of these places dozens of log cabins, stores, hotels, and saloons were erected, and between them and the creeks a constant stream of gold seekers traveled back and forth. By midwinter, however, it became generally known that rich shallow diggings, the eternal hope of the prospector, were restricted to a few short creeks, and the exodus began. In the summer of 1906 vigorous mining was done on the richest ground, but by fall the population had dwindled to about 50, those who remained being the few who had obtained paying claims or who were convinced that thorough prospecting held out sufficient promise of new discoveries.

The winter of 1906 saw the nearly complete desertion of the towns of Roosevelt, Square Deal, and Diamond. Glacier, being nearest to the creeks, was and still is used as winter quarters by a number of miners who prefer to spend the cold months in the shelter of the timber and near their fuel supply rather than haul wood to their summer camps.

Since 1906 the population of the Kantishna district has remained nearly stationary at 30 to 50 persons. In 1916 there were 35 persons in the district, and of this number over half were men who had staked claims during the first stampede and had worked them more or less continuously since that time. It was placer gold that first attracted attention to this camp, and the only gold so far produced has come from the placer gravels. In recent years, however, considerable attention has been given to prospecting for lode deposits. Veins carrying gold and silver and the sulphides of lead, zinc, and antimony occur in the district, and a large number of lode claims are now held. No lode mine has yet been developed to a producing basis, but there is good reason to believe that eventually the lodes may outstrip the placers in the value of their metal yield.

GOLD PLACERS.

GENERAL FEATURES.

The productive gold placer deposits of the Kantishna district all occur in the basins of the streams that head in the Kantishna Hills and radiate in all directions from the higher peaks. The so-called Kantishna Hills are actually rugged mountains of considerable size and are known as hills only because of their nearness to the towering peaks of the Alaska Range. As each stream basin is separated by high dividing ridges from its neighbors and direct travel from one basin to another is difficult, the routes generally used follow the bases of the higher mountains, and the placer workings are therefore much farther apart, by trail, than their close spacing on the map would indicate. These conditions have resulted in the development of a number of small and rather isolated mining camps between which there is little travel during the busy summer season. Paying deposits of gold placer gravel were found in 1905 and 1906 on all the streams that are now productive except Little Moose Creek, and although considerable prospecting has been done in the last 10 years only a small amount of workable ground has been discovered since the early years of this camp. This may be due in part to the fact that only the richest claims can now be worked at a profit, but most of the men in the district own ground from which they are confident they can make a living, and the summer is employed in mining the proved ground rather than in prospecting in areas of less certain value.

The streams that have added to the gold production of the district are Moose Creek and its tributaries, Glen, Eureka, Friday, and Eldorado creeks; Glacier and Caribou creeks, tributaries of Bearpaw River; and Little Moose Creek, which flows into Clearwater Fork of Toklat River.

MINING CONDITIONS.

All the placer mining that has so far been done in the Kantishna district has been open-cut mining, the method commonly employed being to groundsluice off the upper part of the gravel within a foot or so of bedrock and shovel the remaining gravel and the necessary amount of bedrock into the sluice boxes by hand. Most of the miners plan to complete the season's groundsluicing early in the spring, during the period of greatest stream flow, but a few have built automatic dams and are thus enabled, by alternately storing the water and then releasing a large volume for a short period, to groundsluice even in times of low water. The whole operation of open-cut placer mining is, however, definitely limited to the period of stream flow. In this district nearly all the placer mines lie above timber line, at altitudes of 1,600 to 3,000 feet. At such altitudes the streams do not commonly run free from ice until sometime in May and freeze again late in September, and the mining season is therefore limited to about four months. Late in the summer, too, some of the smaller streams diminish so much in volume that sufficient water for sluicing is lacking, and the mining season is thus restricted still further. The experienced miners in this camp count upon a working season of 100 to 120 days.

Most of the gravel deposits along the streams are in thawed ground, and the miners in general encounter little difficulty with ground frost. Certain of the elevated benches, however, in which gold in commercial quantities is known to occur, are permanently frozen, and before the gravels can be sluiced they must be thawed, either by the use of steam or by stripping away the insulating cover of surface vegetation and muck to make the gravels accessible to the warm air and the direct rays of the sun.

The remoteness of this mining camp from established lines of transportation has resulted in greatly increasing mining costs. Little labor is employed at stipulated wages, for most of the claims are worked by the owners or on a royalty basis, but for such labor as is employed the prevailing wages are $6 a day and board for a 10-hour day, or $1 an hour without board. Even at such wages, however, it is difficult to obtain labor, for there is no means of ready communication with any settlement, and the men in the camp at any one time include only those who remained from the preceding year and those who come in over the ice in the winter or by boat in the spring.

The necessary supplies and mining equipment for the season's operations are brought to the district by the operators, either by launch to Diamond and thence by sled to the mines or by sled all the way from Fairbanks during the winter. The quantity and assortment of his supplies must therefore be determined by each miner several months in advance of the working season, and he has to invest a considerable amount of capital for an unusually long period. No store is maintained in the district, and whatever supplies a man unexpectedly finds he needs during the summer he must procure from his neighbors or do without. As a result of the difficulty and expense of landing freight at the mines and the long time involved in procuring equipment, only the most primitive methods of mining have been employed. All the gold so far recovered has been taken out by pick and shovel.

With the exception of the mining claims on Moose Creek, all the placer ground mined in 1916 lies above timber line, and wood for fuel as well as lumber for mining purposes must be brought from a distance.

This distance varies on the different creeks. On Glen Creek timber grows within 1 to 3 miles of the mines. Eureka and Friday creeks are devoid of timber, which must be obtained from the basin of Moose Creek, 1 to 5 miles from the workings. On Glacier Creek no timber is obtainable for a distance of 8 miles from the head of the creek, and the length of haul for the uppermost placer claims now worked is about 6 miles. The mine on Caribou Creek is 5 miles from timber line, and that on Little Moose Creek is perhaps 2 miles from the nearest trees that are large enough to supply sluice-box lumber. In the early days of the camp sawmills were operated to furnish lumber, but these were soon dismantled, and now all needed lumber must be cut by whipsaw.

ORIGIN OF GOLD PLACERS.

As is shown in Plate XV, the entire Kantishna mining district lies in an area in which the underlying rock is the Birch Creek schist, cut by relatively small bodies of intrusive rocks. The intrusive rocks are of a wide range in age. Some appear to have suffered as severe metamorphism as the schists that inclose them. Other bodies of intrusive material are somewhat metamorphosed, but less so than the schists and were intruded after metamorphism was started, but before it was completed. Still other intrusive bodies are not at all folded and were injected after the schists had reached their present condition. Among these youngest intrusives are some dikes and stocks of granite porphyry and quartz porphyry that may be genetically related to the mineralized quartz veins. The schists are in places highly siliceous and include beds of quartzite schist. Throughout the area in which it occurs the Birch Creek schist contains numerous quartz veins and veinlets, distributed through the entire rock mass. Gash veinlets and lenticular bodies of quartz, lying parallel to the schistosity, are particularly abundant, but as a rule quartz veins of this character are not regular or continuous for long distances but pinch and swell abruptly. Tiny reticulating veinlets of quartz cutting the schist in all directions are also common. Many quartz veins of this type have been twisted and metamorphosed with the inclosing schist. In the area of the Kantishna Hills, especially along the main divide and from the heads of Caribou and Myrtle creeks westward to the basin of Moose Creek, there are many large quartz veins that cut across the cleavage planes of the schist, stand at steep angles, and maintain their strike, dip, and thickness for considerable distances along the outcrops. These veins are, in general, younger than the gash veins that follow the schistosity and are true veins, of more recent age than the last period of vigorous metamorphism. Several quartz veins of this type have been found to contain visible free gold in encouraging quantities, and mortar tests show that native gold is rather widely distributed in these veins. Furthermore, the largest and most continuous gold-bearing quartz veins that have been found are in the basins of those streams whose placers have yielded the most gold. This seems to be conclusive proof that the gold of the placer gravels was derived, at least in large part, by the erosion of the larger quartz veins that cut the schists. The gash veins and veinlets of quartz in the schists may also have added their contribution of gold to the stream placers, and the presence of placer gold in greater or less amount in almost all the streams that flow through the schists indicates that some of these veins are gold bearing, but the richest placer gravels have been found in basins in which the larger veins occur.

The local origin of the placer gold is also confirmed by the appearance of the gold itself. In Friday and Eureka creeks, immediately below the outcrops of some large quartz veins, the placer gold is surprisingly rough and angular. Many nuggets show the unworn crystalline form that the gold had as it lay within the vein quartz, and few nuggets in any clean-up show any appreciable effects of attrition. To anyone familiar with the usual appearance of placer gold it is immediately evident that this gold is recovered at no great distance from the outcrop of the vein in which it originated. Downstream, away from the outcrops of gold-bearing quartz, the placer gold becomes finer and more smoothly worn, as would be expected if the gold has been derived from the quartz veins and has been transported to increasingly greater distances from its bedrock source.

The influence of glaciation upon the distribution of gold placer deposits in the Kantishna region has differed in the different stream basins, and although the glaciers have doubtless played their part in the erosional history of the district, the ice was much less abundant here than in the higher mountains of the Alaska Range. It has now been established that there have been at least two epochs of glaciation on the north side of the Alaska Range, one much earlier than the other, the evidence of which is better preserved. It is difficult in certain places to determine the limits reached by the separate ice sheets, for evidences of the earlier glaciation can easily be mistaken for those of the later, and a proper discrimination of the data can be made only after more detailed field work has been done. Nevertheless, it is certain that at one time Muldrow Glacier was much larger than it is now and that it overflowed the northern border of its present basin and spread northward across the upper basin of Moose Creek, to lie against the south flank of the Kantishna Hills. One tongue from this ice lobe flowed northward into Clearwater Fork of Toklat River, another down Moose Creek past Eureka and Eldorado creeks, and still another westward along the present course of McKinley River. The highest ridges of the Kantishna Hills were never overridden by ice, but the higher and more favorably situated valleys in them supported small ice tongues, which extended radially from the crest in all directions but which never attained sufficient length to reach beyond the confines of the narrow valleys. Of the gold-producing streams Glen, Glacier, and Caribou creeks were glaciated in their upper ends, but the Eureka, Friday, and Eldorado Creek basins were not high enough ever to have originated glaciers. Abundant erratic boulders occur throughout the basin of Moose Creek above Eureka and in the valleys of Eldorado and Eureka creeks nearly to their heads. These were not found in direct association with morainal deposits, but they indicate that at some time the basin of Moose Creek was filled with ice, which lay high against the south flank of the Kantishna Hills and which left the boulders that now appear. The peculiar courses followed by lower Spruce and Glen creeks also indicate changes of drainage due to glacial occupancy.

To just what extent the gold-producing streams were once occupied by glaciers and their preglacial placer deposits removed by ice erosion has not been definitely determined, for the glacial evidences are inconspicuous and poorly preserved. It can be stated, however, that in those portions that were glaciated the erosion of the ice was sufficiently severe to disturb or remove the greater part of the preexisting gold placer deposits, so that any concentrated deposits of gold that are now present are due to the erosion of streams since the ice retreated. Below the edges of the glaciers stream erosion was retarded during the ice advance, for the waters were burdened with an unusually large supply of rock waste, and this they deposited as outwash gravels beyond the ice edge. The streams assorted the materials of the outwash gravels to some extent, but much less than is common in normal, lightly loaded streams.

With the final shrinkage and disappearance of the glaciers from this district the streams commenced their task of readjusting their valleys to conditions of normal erosion. Less heavily loaded than when they were receiving glacial waters, they began to intrench themselves in the deposits of outwash gravels, which now appear as high benches or terraces along the lower streams, especially those on the north side of the Kantishna Hills. In cutting down through these gravels the streams in places occupied somewhat different courses from those along which they had formerly flowed, and canyons show the position of obstructions encountered in the downward cutting.

Bench or terrace gravels along Moose, Glacier, and Caribou creeks have been shown to contain encouraging amounts of placer gold, and in one or two places the gold content has been sufficient to warrant mining. During intrenchment of the streams through these gravels the gold they contained, as well as that supplied by the erosion of gold-bearing quartz veins, was deposited in the stream beds, resulting in the present workable placers.

WHITE GRAVELS.

Among the miners in this district a misconception prevails regarding certain white quartz gravels that occur along the north flank of the Kantishna Hills. These gravels have been noted especially in the valley of Glacier Creek, near the point where the schist bedrock plunges downward to the northwest and disappears beneath the deposits of unconsolidated materials. They are nowhere conspicuous on the surface but have been found in place only in prospect holes, although gravels of this type have been noted in the stream deposits of Glacier Creek below the point where the schist bedrock disappears. The most complete information concerning the white gravels was procured from a prospect shaft sunk on the bench west of Glacier Creek, opposite the upper end of claim No. 13. This shaft, after penetrating a few feet of the ordinary bench gravels, encountered a body of white rounded quartz gravel that continued without interruption to a depth of 114 feet, at which the sinking was discontinued without reaching bedrock. Most of the material on the dump is vein quartz, distinctly rounded and waterworn, ranging in size from fine sand to pebbles 6 inches in diameter. The resemblance of this material to the "white channel" gravels of the Klondike was at once apparent to the prospectors, who entertained high hopes of finding rich gold placer deposits in it, but although some fine gold was panned from the material excavated, no paying concentration of gold was found. A study of the geologic relations on Glacier Creek indicates that the white gravels there constitute the base of the Tertiary coal-bearing formation that is so fully developed to the east near Nenana River. In that area the base of the Tertiary beds, which lie upon the Birch Creek schist, is commonly made up of a nearly pure deposit of white quartz pebbles and sand. This relation continues westward across the basin of Teklanika River, and, no doubt, the Glacier Creek white gravels are of similar origin. The gravels are believed to represent the detritus from an old land mass which had been deeply weathered and from which the more easily decomposed materials had been removed, leaving abundant residual quartz scattered over its surface. A period of more active stream erosion followed, and this quartz was removed, rounded by the streams, and deposited as a widespread blanket over the lowlands. It was brought to the lowlands by many small streams rather than by a single large one, and in the lowlands that were aggraded by the gravel deposit there was little tendency to concentrate any gold that may have been present in the quartz. Throughout the area in which they have been studied these white quartz gravels contain a little gold, but nowhere have concentrations sufficiently rich for placer mining been found. At the Glacier Creek locality the exposures are not good, but so far as known the white gravels are not overlain directly by the coal-bearing Tertiary beds, but by a thick deposit of tilted oxidized gravels, which in the Nenana district succeed the coal-bearing beds. This means either that the coal-bearing beds were removed by erosion from over the white quartz gravels before the later yellowish gravels were laid down, or that in this place coal-bearing beds were never developed and the oxidized gravels were laid down directly upon the white gravels. The white-gravel deposit on Glacier Creek therefore differs in mode of origin from the Klondike "white channel," and being probably of early Tertiary age it is apparently much older than the gravels of the Klondike.

SOIL FLOWS.

A factor that has exercised a notable influence upon the gold placer deposits in many valleys is the large volume in which detrital material from the valley walls moves down the slopes and out upon the stream gravel deposits and the rapidity with which this movement takes place. In this latitude both the annual and the daily range of temperature are great, and consequently rocks disintegrate rapidly, especially rocks so fissile as the schists that form the bedrock within the Kantishna district. The disintegration is probably not so rapid during the months of constant low temperatures as in the spring and fall when the temperature crosses the freezing point twice daily. The mantle of rock disintegration products soon becomes frozen, for in the higher parts of this area the ground is permanently frozen beneath a thin covering of vegetation and soil. The disintegrated rock is soon covered by mosses, heather, and other plants that form a tough mat. Erosion of this detrital material by streams is slow, for in spite of steep slopes the vegetal covering is tenacious, and the ground frost greatly retards stream cutting. As a result of these factors the surface mantle of detritus, composed of the so-called muck of decomposing plant remains, soil, and rock fragments, both fine and coarse, accumulates to a thickness of several feet, even on steep slopes, and is almost immune to erosion by surface streams. The material has, however, a decided tendency to creep bodily down the slopes. During the warm summer season the surface portion becomes thawed, and as it contains large amounts of water it tends to move downward by gravity. In most places this movement is slow, for the feltlike mat of vegetation retards it, and the surface features developed have the appearance of broad, flat lobes, such as would be formed by the flow of a very viscous mass on a steep slope. In places, however, the cover of vegetation becomes torn, and the semifluid mass of muck, soil, and rock fragments flows rapidly down the slope to the valley. In some recent flows of this kind that were examined the thickness of the surface material that flowed out was determined by the depth to which thawing had taken place before the thawed mass broke its surface covering of vegetation. Although several such fresh soil flows were seen and the old, healed scars of great numbers of similar flows were recognized, the prevailing movement of detritus is by slow, scarcely perceptible creep.

The economic bearing of these soil movements upon the placer deposits of the district is to be observed in many of the narrow valleys where mining is in progress. In the headward portions of the streams the valleys are narrowly V shaped, and each creek has a flood plain a little wider than the stream itself. Mining operations have disclosed the fact that in many places flows of detritus containing muck, soil, and coarse talus have moved down the valley sides and out upon the stream gravels and have buried the pay streak many feet deep. In such places the richness of the gold concentration must determine whether or not the excavation of the "slide" from the valley side is justified. Such "slides" occur on Eureka, Friday, Glacier, and Little Moose creeks. On Little Moose Creek a large mass of material, rendered unstable by the excavation of creek gravels at its base, flowed suddenly into the placer workings, covered the sluice boxes, and filled the cut with mud. In other places the unusual depth to bedrock encountered by prospectors is no doubt due to the influx of surface material from the valley sides, and it is likely that many claims containing concentrated deposits of placer gold now unavailable for mining would yield a profit if the overburden due to soil flowage were absent.

MINES AND PROSPECTS.

During August, 1916, all the mines and prospects on which work was being done were visited, and the following pages contain brief descriptions of the general conditions prevailing at that time. The position of the mines and prospects is shown in Plate XV, and in the discussion they are grouped under the stream valleys in which they occur and are described in order from the uppermost claim downstream.

GLEN CREEK.

Claims Nos. 1 and 2 on right fork.

Some mining was done by one man on claim No. 1, the lowest claim on the right fork of Glen Creek. A large part of the season was spent in building an automatic dam, but during the period of low water the dam leaked so badly that it would not fill up and flush, and only 36 linear feet of bedrock below the dam had been cleaned. In previous years considerable work was done on claim No. 2, by the ordinary method of groundsluicing and shoveling in. Boxes 12 inches wide, set on a grade of 10 to 12 inches to the box length, are used. The bedrock is composed of quartzite and micaceous schist, and boulders are large and abundant. On claim No. 2 the depth to bedrock averages about 6 feet, but a short distance below the dam, on claim No. 1, the bedrock surface plunges suddenly downward, and a shaft 34 feet deep, sunk near the forks, failed to reach it.

The gold is bright, coarse, and rough, and many nuggets weighing from 1 to 7 ounces each have been recovered. The sluice-box concentrates contained abundant black sand, garnets, galena, and iron pyrite, indicating that the gold has been derived from sulphide-bearing quartz veins. Such veins crop out at the head of this basin and doubtless have furnished gold to the placer gravels.

Claim No. 9.

In July, 1916, three men were mining on claim No. 9. An automatic dam was in operation, and a cut nearly 500 feet long had been groundsluiced. Bedrock had been cleaned for a distance of about 150 feet in this cut. The gravels range from 5 to 8 feet in depth and contain numerous boulders and slabs of schist, some of which are too large for one man to handle. The stream flow was sufficient for the mining operations, and 12-inch sluice boxes, set on a grade of 7½ inches to the box length, were used. The gold is coarse and rather rough and assays from $15 to $15.80 an ounce. Many of the nuggets are discolored, but the fine gold is bright and yellow. Many nuggets ranging from 1 to 3½ ounces have been found. The sluice-box concentrates contain numerous pieces of galena and black-coated pebbles and small boulders of the manganese metasilicate rhodonite. It is reported that about half of claim No. 9 has been mined.

Claim No. 7.

No one was present on claim No. 7 at the time it was visited, but it is reported that one man was mining there in 1916. In July some groundsluicing had been done, but little gravel had been shoveled into the sluice boxes. The mining conditions on this ground, a large part of which is said to be worked out, are much the same as on claim No. 9.

Other claims on Glen Creek.

Some mining has been done on Glen Creek each year since 1906, and a number of claims have contributed to the gold production. Claim No. 6, below which little more than prospecting has been done, has been partly mined, and No. 7 is largely worked out. Parts of claims No. 8 and No. 8 fraction have been worked, and claim No. 9 is about half exhausted. No extensive mining has been done above claim No. 9 on the main creek, but on the right fork parts of claims Nos. 1 and 2 have been mined.

EUREKA CREEK.

Claim No. 13.

The uppermost claim on which mining has been done on Eureka Creek is claim No. 13, on which one man has been working since 1906. Sluicing operations were begun on the lower end of the claim and have now been carried upstream for a total distance of about 1,000 feet. The bedrock of this creek, composed of Birch Creek schist, varies in hardness from place to place, hard quartzitic phases alternating with softer mica schist. The foliation of the schist here strikes roughly parallel with the direction of the valley of Eureka Creek and dips at high angles. At the time of visit ground to the depth of 11 feet was being mined, for the pay streak was buried by the movement of materials from the north valley wall. An automatic dam was used for ground sluicing, but during the season of 1916 the water supply was insufficient for satisfactory mining. Sluice boxes 12 inches wide, with pole riffles, were set on a 9-inch grade, and below these were set boxes with false bottoms on a grade of 5 inches to the box length. Boulders and slabs of rock, some of them 4 feet in diameter, are numerous and add to the difficulties of mining. Practically all the gold occurs on bedrock, and much of it is disclosed by stains from the decayed rock. The gold is said to assay $16 an ounce, and, although coarse, is finer and smoother than that taken from the claims below. The largest nugget taken from this ground weighed 2¼ ounces.

Eureka group.

The lowest ground on which active mining was done on Eureka Creek in 1916 is the Eureka group, consisting of claims Nos. 5 to 12 above Discovery, which is at the mouth of the creek. On this group a strip about one cut wide (about 20 feet), and including the bed of the stream, has been mined from the lower end of claim No. 5 up to and including a part of claim No. 9, and mining has been carried on here each year since 1905. Until recently all mining had been done by pick and shovel, and only the richest gravels—those in the creek bed—could be handled at a profit. In 1916 an automatic dam was built on the upper end of the group, and through its use mining costs have been so reduced that a much wider strip of gravels can be profitably exploited. It is reported that the cost of mining has been reduced from $45 a box length (168 square feet) under the old method of groundsluicing and shoveling in to $20 a box length by the automatic-dam method. The gravels are sluiced off until the high points of bedrock are exposed, and only about 6 inches of gravel is shoveled by hand. The owner reports that tests show that little gold is lost by this method. The gravels have averaged about 7 feet in thickness in the stream bed and 8 to 9 feet on the low benches. Coarse boulders are not unusually abundant, and, although a few have to be broken by explosives, most of them can be thrown aside by hand. On the lower end of claim No. 9 the creek flat widens to about 40 feet, and the whole flat was being worked at the time of visit (August, 1916). The owner plans to continue mining by the present automatic-dam method to the head of the group of claims and then work the ground on the lower claims on either side of the creek channel—ground that by the old method would not pay. The bedrock is the Birch Creek schist, the character of which changes from place to place. In cleaning bedrock it is necessary to remove only a part of the schist where the rock is comparatively soft, but in the harder phases the gold has penetrated more deeply into the cracks, and 2 feet of bedrock must be removed to recover all the gold. The gold is bright yellow, except those pieces which have lain on decayed and rusty bedrock and are discolored. It assays from $15 to $15.20 an ounce. A large part of the gold recovered is in rough, angular pieces that show little or no evidence of stream abrasion. Many pieces show unworn crystal surfaces and are certainly derived from gold-bearing lodes near by. In many nuggets quartz is intermingled with the gold, and the sluice-box concentrates contain abundant galena, giving additional evidence that the gold was concentrated from the quartz veins that crop out on the ridges that border this stream basin. Stibnite and black sand are also caught on the riffles. The placer gold from Eureka Creek is also unusually coarse. Half of that recovered is said to occur in pieces having a value of 5 cents or over, and much is still coarser. One nugget from claim No. 9 had a value of $100, and another taken from Discovery claim in 1906 was worth $900.

The water supply on Eureka Creek is ordinarily abundant for sluicing operations throughout the open season. Four boxes 11 by 13 inches in cross section set on a grade of 9 inches to the box length, two equipped with pole riffles and two with Hungarian riffles, are used, and the lower boxes, with false bottoms, are set on a grade of 5 inches to the box length. Two or three men were employed throughout the season.

On claim No. 12 of the Eureka group one man operating on a lease was mining for part of the season. The conditions encountered were much the same as on claim No. 9, the gravels being from 7 to 9 feet in thickness.

Other mining.

In the earlier years of mining activity in this district placer mining was done on all the claims from the mouth of Eureka Creek up to claim No. 5, and the main stream bed has now been mined up to and including part of claim No. 9. Throughout the length of these nine claims, however, there are locally patches of gravel on each side of the creek which are known to contain considerable placer gold but which were left by the miners in their haste to work the richest and most easily accessible ground. As the richer gravels of the main creek bed become exhausted, the less easily handled "side pay" on these claims will be mined, and by the use of more economical methods, such as automatic-dam sluicing, these neglected areas are likely to yield a satisfactory profit to the miners.

FRIDAY CREEK.

Friday Creek, a small tributary of Moose Creek from the east, joins that stream 1½ miles below the mouth of Eureka Creek. The valley of Friday Creek is only 2 miles long, and the gradient of the stream is steep and its valley narrow. The stream flat is in general not more than 15 or 20 feet wide, and for a considerable part of its length the creek flows in a narrow, canyon-like cut between rock walls, with only narrow and shallow gravels in the stream bed.

Claim No. 2.

One man was mining on the upper end of claim No. 2, the creek bed in the lower part of the claim having already been mined out, although some workable ground is said to remain along the sides of the strip that has been mined. Mining conditions here are much the same as on the other claims on this creek. The stream gravels range in width from 15 to 150 feet, and in places the pay streak runs under slide material from the valley sides. Locally this slide material is frozen. Boulders and slabs of the schist bedrock, too large to pass through the sluice boxes, are abundant, but none are too large for one man to handle. The gold is rough and coarse, nuggets of a maximum value of $50 having been found. The gold taken from the surface of the bedrock is usually discolored and rusty, but the gold from the gravels is bright.

Claim No. 1.

Claim No. 1 has been mined since 1914 by the owner, who also holds a 300-foot fractional claim adjoining the upper end of claim No. 1. The ordinary method of groundsluicing and shoveling in is employed, and a hose, with water under pressure, is used to clean the bedrock. Sluice boxes set on grades ranging from 8 to 16 inches to the box length are lined with pole and Hungarian riffles. The schist bedrock ranges in character from hard, dense rock to soft, soapy, decayed material, and experience has shown that the hard bedrock has retained most of the gold and the softer phases are, in general, only slightly productive. The creek-bed gravels range in depth from 3 to 4 feet, but in places the pay streak is covered with slide material from the valley sides, and an overburden 10 to 15 feet thick must be removed to reach the bedrock. The gold is coarse and very rough, having come from the eroded portions of quartz veins that crop out on the mountains near by. The largest nugget taken from this claim weighed 6½ ounces, and many pieces weighing over an ounce have been found. Black sand and galena are the most abundant heavy concentrates in the sluice boxes. Most of this claim has now been mined, but the fractional claim immediately above it is still unworked.

Discovery claim.

The lowest claim on which active mining has been done on Friday Creek is Discovery claim, the second claim above the mouth of the stream. Two men have been mining here each summer since 1908, and the stream channel has been about mined out, the only unworked ground being a side cut near the upper end of the claim. On the upper portion of this ground the bedrock consists of schist, the foliation of which strikes roughly parallel with the trend of the valley and dips at high angles. About 300 feet above the lower end of the claim the bedrock floor steepens and disappears beneath a gravel filling so thick that so far prospect holes have failed to penetrate it. Mining has been done only by pick and shovel, the pay gravels averaging between 3 and 4 feet in thickness. Two sluice boxes lined with pole riffles and one with Hungarian riffles, set on a grade of 9 inches to the box length, are used, and below them boxes with false bottoms are set on a 5-inch grade. The gold is bright, coarse, and extremely rough. Many nuggets show the crystalline character of the gold as it came from the vein quartz, and quartz is common in the nuggets. Few pieces show conspicuously the effects of stream abrasion, and it is certain that much of the placer gold had its bedrock origin in the gold-bearing quartz veins that crop out in this basin, particularly on the ridge between Friday and Eureka creeks. The gold is said to assay $14.82 an ounce and is associated in the sluice boxes with abundant galena and black sand.

ELDORADO CREEK.

At several places on Eldorado Creek, especially at a point about 2 miles above the mouth of the stream, there is evidence that some placer mining has been done, though no one was working there at the time of visit. The bedrock at the place mentioned is a black slaty phase of the schist that strikes in general northeast and dips steeply to the southeast. The gravels apparently range from 2 to 4 feet in thickness. It is reported that the gold is too unevenly distributed for successful mining. The gold is said to be bright, well worn, and finer than that on Friday and Eureka creeks, and to assay about $16.25 an ounce.

MOOSE CREEK.

The valley of Moose Creek, beginning at the mouth of Eldorado Creek and extending 3½ miles downstream, is held as a block of claims by the owners, who have mined on this ground each year since 1906. Discovery claim lies at the upper end of this property, and it is evident that most of the placer gold in this part of the valley of Moose Creek has been supplied by the tributaries Eureka, Eldorado, and Friday creeks, for no workable ground has been found in the valley above the point which the gravels from Eureka and Eldorado creeks have reached. Only mining on a small scale, by pick and shovel, has been done in Moose Creek valley. Moose Creek is a large clear stream that flows over a gravel flat and is generally bordered by gravel benches, though in places it swings to one side or the other of its valley and cuts against the rock valley walls. About 3 miles below the mouth of Eureka Creek it enters a rock canyon, through which it flows for some distance. Its gradient is so gentle that difficulties are encountered in obtaining water under sufficient head for sluicing and in obtaining a dump for tailings from the sluice boxes.

At the time of visit two men were mining opposite the mouth of Eureka Creek, on a gravel bench whose lower edge stands 10 or 12 feet above the level of Moose Creek. Water was obtained through a ditch that is supplied by Eldorado Creek. Pick and shovel methods were used. Twelve lengths of sluice boxes, 12 by 14 inches in cross section and set on a grade of 5 inches to the box length, were so arranged as to dump directly into Moose Creek. The gravels mined averaged 8 feet in thickness and lay upon a false bedrock composed of blue clay, sand, or semiconsolidated gravel. The gold is distributed throughout the thickness of the gravels, but there is a notable concentration on the false bedrock. Practically no gold has been found within or beneath the material composing the false bedrock, and no one has so far succeeded in sinking a hole through this material to the underlying schist. The gold taken from the gravels is coarse and yellow, but that taken from the surface of the false bedrock is discolored, some of it being nearly black. Although it has probably been derived in large part from the Eureka Creek basin, the gold from Discovery claim averages finer than that found in Eureka Creek, and most of it is in flat, well-worn particles. It is reported that considerable mining has been done at three other localities on this block of claims and that assessment work, including the clearing away of brush and timber, and prospecting have been done each year.

GLACIER CREEK.

Glacier Creek heads against the north side of the Kantishna Hills, flows northwestward through a deep valley eroded in schist for a distance of about 5 miles, and emerges from the mountains, to flow in a northerly direction to its junction with Bearpaw River through a valley intrenched in a broad gravel-covered upland. For the upper 5 miles the stream occupies a valley floored with stream gravels of moderate depth, lying upon schist bedrock. North of the mountains the depth to bedrock increases so as to be below the limit of ordinary open-cut placer-mining operations, except in a few short stretches through which the stream has cut shallow canyons in the schist. Except in these short canyons, the stream in the lower 10 miles of its course flows over a gravel flat that is bordered by high, smooth-topped ridges, in which no hard rocks crop out but which are composed for the most part of rather ancient, tilted gravels—the Nenana gravel.

Placer gold has been found both in the stream gravels and on the benches of Glacier Creek throughout its length, but mining operations have been successfully conducted only in the upper 8 miles of the valley.

Claim No. 20.

The uppermost claim on which mining was done in 1916 is claim No. 20, situated 1½ miles above the point at which Glacier Creek emerges from the mountains. On this claim two men were sluicing gravels that averaged about 5 feet in thickness and lay on schist bedrock. Sluice boxes 12 inches square in cross section, lined with pole and Hungarian riffles and set on a grade of 6 to 8 inches to the box length, were in use. The gold is said to occur both in the stream gravels and on the surface of bedrock. That from the gravels is bright and yellow, but that taken from bedrock is generally stained and discolored. The gold is coarse but is said to be unevenly distributed, rich spots being surrounded by lean areas, in which there is insufficient gold to pay the cost of mining.

Claim No. 18.

One man was mining on claim No. 18 and has worked there each summer since 1908. A splash dam and a bedrock drain had been erected, but a freshet in the spring washed out the dam and filled the drain and made mining difficult. Large boulders are especially abundant on this claim, and the difficulties of mining are increased by the tendency of the pay streak to run beneath the coarse angular talus of the valley sides. The gravels in the stream bed range from 3½ to 9 feet in depth. Black sand and garnets are said to be abundant in the sluice-box concentrates.

Claim No. 14.

Claim No. 14, on Glacier Creek, is the site of the first discovery of placer gold in paying quantities within the Kantishna district, and it has been mined intermittently since 1905. About 900 feet of the creek bed and a portion of the west bench have been worked. One man was mining on the lower end of this ground in 1916. A bedrock drain has been installed, and mining was carried on by the usual method of groundsluicing and shoveling in the gravels and the surface of the bedrock. The schist bedrock ranges from soft, decayed material, that has retained the gold poorly, to hard, firm rock, on which the gold is most abundant. Some gold occurs in the stream gravels, but the richest concentration is on the surface of the bedrock. The gold content varies markedly within short distances, almost barren stretches of gravel being succeeded by other stretches of rich ground. Few large nuggets are found on this claim, the gold occurring for the most part in flat well-worn pieces the size of rice grains.

An irregularly shaped area, measuring in its maximum dimensions 160 by 200 feet, has been mined on the west side of Glacier Creek, on a bench that has a steep face 40 feet high at the creek edge and slopes upward toward the west. As shown by the section along the creek, this bench is composed for the most part of schist, over the surface of which is a gravel deposit of varying thickness, laid down by Glacier Creek at a time when the bench surface was the valley bottom, before the present stream canyon was eroded. To mine this bench a ditch was built to tap Glacier Creek at the lower end of claim No. 16. The width of the bench below the ditch line at the lower end of claim No. 14 is about 200 feet. Mining was done by running successive cuts from the ditch to the edge of the bench, and the tailings were discharged over the bench into Glacier Creek. The gravels on the bench surface ranged from 3 to 20 feet in thickness and were frozen in places, so that it was necessary to strip the cut and allow the material to thaw for a while before the loosened material could be removed. In working down the valley an old channel on the bedrock surface of the bench was found, diverging to the northwest, away from Glacier Creek. Along this channel the gravels became constantly thicker, and mining was discontinued at the point where the channel passed so far below the surface of the bench gravels that the bedrock would no longer drain to Glacier Creek. It is reported that the bench gravels worked yielded a good profit to the miners, but the increasing depth of the ground and the difficulties in keeping the ditch in repair so increased mining costs that no mining on this bench has been done for several years.

Claim No. 12.

Two men were mining on the upper end of claim No. 12 with pick and shovel. A cut about 240 feet long had been groundsluiced and most of the material shoveled into the boxes. The gravels, which lie on schist bedrock, average 6 feet in thickness and contain comparatively few boulders. Although one nugget valued at $80 is said to have come from this claim, most of the gold is comparatively fine, and nuggets are not common. It is reported that only a small part of this claim has been mined.

Other mining on Glacier Creek.

Since 1905 considerable mining has been done on Glacier Creek on claims that were not being worked in 1916. Some mining was done on claim No. 13; claims Nos. 15, 16, and 17 were largely exhausted; and claims Nos. 18, 19, and 20 all produced some gold. Certain claims on Yellow Creek are said to have been fairly rich, but they, too, were mined out. A good deal of prospecting and a little mining have been done on the claims below No. 12, but except on the stream flat through a canyon extending for about a mile below Discovery claim and that in another canyon just above the mouth of the stream, the stream gravels are so deep that ordinary mining methods fail to reach bedrock. The deep ground is said to begin on claim No. 11. It is reported that an 80-foot prospect hole sunk on claim No. 10, a 90-foot hole on claim No. 9, and an 80-foot hole on claim No. 7 all failed to reach bedrock.

CARIBOU CREEK.

Caribou Creek in its upper portion flows almost due west and is fed from the south by a number of tributaries that drain the highest peaks of the Kantishna Hills. At 10 miles below its head Caribou Creek swings to the north, and thence it flows between broad gravel-topped ridges to its confluence with Bearpaw River.

The only ground in the Caribou Creek basin on which mining was done in 1916 comprises a group of eight claims extending along the valley of Caribou Creek from Last Chance Creek to Crevice Creek. The area that has been mined is a strip extending 1,200 feet upstream from the mouth of Last Chance Creek and ranging in width from 10 feet through the canyon to 70 feet at the upper end of the cut, where the creek flat widens above the head of the canyon. The gravels were from 2 to 3½ feet thick in the stream bed and reached a thickness of 7 feet on some of the bars. Large boulders, some of them so large that it was necessary to mine around them, were numerous in the canyon, but above it none too large for one man to handle were encountered. Sluice boxes 10 inches square in cross section and lined with pole riffles were set on a grade of 9 inches to the box length. Water is always sufficiently abundant in Caribou Creek at this place for pick and shovel mining. In fact, inconvenience is more likely to result from too much rather than from too little water. The slopes in the basin of Caribou Creek are so steep that the stream responds quickly to any rainfall, and a heavy rain is likely to so flood the stream that mining must be suspended until the stream falls. The gold occurs throughout the thickness of the stream gravels but is especially concentrated on bedrock. That in the gravels is bright and yellow, but most of that on the bedrock is darkly stained and discolored. The gold taken from the canyon is coarse, the largest nugget found having a value of $110. That found above the canyon is fine and occurs in flat, flaky pieces. It is said to assay $13.50 an ounce. Associated with the gold in the sluice boxes are pebbles of magnetite, ilmenite, and the calcium tungstate scheelite and numerous large garnets. Four men were employed throughout most of the summer.

Very little mining has been done on Caribou Creek and its tributaries, except that on the group of claims just described. A small amount of gravel has in former years been sluiced on claims Nos. 3 and 4, and a good deal of prospecting has been done both in the stream gravels and on the high benches. The benches are said to carry promising quantities of gold, but the bench gravels are frozen, and the cost of thawing has so far prohibited mining on them.

LITTLE MOOSE CREEK.

Little Moose Creek is a small western tributary that joins the Clearwater Fork of Toklat River 3 miles above its mouth. For its entire length it flows through a deep, narrow valley bordered by rugged mountains of schist. The only mining in progress on this stream in 1916 was at a point 5 miles above its mouth, on claim No. 20, where two men were working. An automatic dam had been constructed, but it was not completed until late in the spring, and by that time the water supply had become too small for the most satisfactory operation of the dam. In the mining done in 1916 no bedrock had been uncovered by the middle of August, though some gold had been recovered from the gravels. Large boulders are confined almost wholly to the surface gravels, the deeper gravels being almost free from them.

It is reported that, except on claim No. 7, the gravel is so deep on all the ground below claim No. 18 that bedrock can not be reached by ordinary methods of open-cut mining.

Some mining has been done in past years on claims Nos. 18 and 19. It is reported that the stream gravels range from 8 to 10 feet in thickness, although in many places slide material from the valley sides has covered the pay streak to so great a depth that mining costs are prohibitive. The gold is coarse and shotty and not greatly worn. Although one-third of the gold recovered is said to be in pieces worth 50 cents or more, very large nuggets are not common, the largest taken from this creek having a value of $20. The gold is of low grade and is said to assay about $12 an ounce. Small nuggets of native silver are said to be present in almost every clean-up.

The creep of soil and talus is especially rapid in this creek valley and in those of adjacent streams. The small excavations made in the course of placer mining have at times been sufficient to disturb the equilibrium of the adjoining valley slopes, and large quantities of muck, soil, and coarse rock have suddenly slid into the mining cuts, burying sluice boxes and causing much annoyance. The unusual depth of the stream gravels in this valley is due, at least in part, to the rapid downward creep of detritus from the valley sides, which fills the valley floor more rapidly than the small stream can remove it.

PROSPECTS.

In the foregoing description of mines in this district all claims are included on which active mining was in progress in August, 1916, and some mention has been made of the results of mining in earlier years on ground that was not being worked at the time of visit. It is inevitable, however, that in a camp where so many men have come and gone and where the only record of past developments is in the memory of those men who have remained the record of mining should be incomplete. During the two years following the first gold discovery in this camp and the attendant stampede a large amount of prospecting was done on all the streams that drain the Kantishna Hills as well as in adjacent regions. The evidence of the work of those prospectors is everywhere to be found, in old cabins, prospect holes, and pits. As a result of their work the distribution of paying gravels, under the conditions then prevailing, was proved to be limited to the streams described above. Placer gold was, however, found widely distributed, and in many places it occurred in quantities almost sufficient to warrant mining at that time. Unfortunately, most of the information these men obtained at so great a cost of money and effort is now lost. With the better transportation that will be made available by the completion of the Government railroad along Nenana River mining costs may be so reduced that placer gravels heretofore unavailable may be mined at a profit.

Among the streams in the district that may become productive in the future are Rainy and Spruce creeks, tributaries of upper Moose Creek from the south; Myrtle, Moonlight, Stampede, and Crooked creeks, all eastward-flowing streams tributary to Clearwater Fork or to Toklat River; Flume Creek, which flows northwestward from the south end of the Kantishna Hills to Bearpaw River; and a number of headward tributaries of Bearpaw River. On all these streams coarse gold has been found in encouraging quantities. By simple panning, with little preliminary excavation, members of the Geological Survey parties found coarse gold in nuggets ranging in value from 10 to 30 cents on at least three streams on which no mining had been done. Numerous coarse colors were found on the benches of Clearwater Fork of Toklat River, and prospectors report that gold may be found at many places between Toklat and Nenana rivers.

TOTAL PRODUCTION OF PLACER GOLD.

The task of estimating the amount of placer gold that this district has produced presents many difficulties, and any estimate made can be considered accurate only in so far as it represents in a general way the volume of gold produced from this camp. Mining operations have been carried on by many men for a period of 12 years, and no accurate record has been made of the gold production. It has therefore been possible only to obtain estimates of the production from the men most intimately acquainted with the developments on the several creeks and by comparing and combining these estimates to arrive at an approximate figure. The total production of placer gold in the Kantishna district to the end of 1916 is here estimated as $380,000. This figure will appear too small to many persons, for there is a constant tendency among most miners to overestimate the production on the creeks with which they are least familiar. About half of the total output, however, was mined by men from whom exact figures were obtained, and it is believed that the total is not more than 10 per cent in error. The annual production for the last few years has been between $30,000 and $40,000.

FUTURE OF PLACER MINING.

No attempt at placer mining by other than the simplest methods has ever been made in this district. The difficulty of access to the region is perhaps the main cause of the failure to apply hydraulic or mechanical methods to the working of the gravels, but the small size of most of the rich creeks and the small amount of ground to be worked on any one claim have also favored the elastic methods of pick-and-shovel mining. At present, however, the richest of the shallow gravel deposits have already been worked out. For the leaner but more extensive deposits of gravel remaining more elaborate methods must be employed, but for the man with sufficient capital and an understanding of the problems involved the installation of a hydraulic plant, mechanical elevators, or a dredge may result in vastly greater profits than those gained by the man with little equipment aside from his own muscle and resourcefulness. It has been shown that the creek flat and benches of Moose Creek below Eureka Creek contain locally enough gold to pay for mining by hand methods. Systematic prospecting may show that these gravels are extensive and valuable enough to justify the installation of a hydraulic plant or a dredge. Similarly both the bench gravels and the stream flats of lower Glacier and Caribou creeks are known to be gold bearing and may some time yield a profit if mined on a large scale. Extensive gravel deposits on Clearwater Fork may also prove to be sufficiently rich to justify extensive mining. The success of any such large operations will depend, however, upon thorough and systematic prospecting to determine the value, extent, and physical character of the gravel deposits; upon the careful and wise choice of the proper equipment for mining; upon a close determination of the probable costs of operation; and, last but by no means least, upon wise and honest supervision and control.

LODE DEPOSITS.

GENERAL FEATURES.

Although no ores from lode deposits within the Kantishna district have yet been reduced, and no metal has been commercially recovered from them, there has been much active prospecting for lode deposits within the last few years; a number of veins containing gold, at least one carrying much silver, and three held for their antimony content have been discovered, and varying amounts of development work have been done on them. The prospective value of the lodes in this district can not be judged by the fact that they have so far yielded no production. Their remote situation and difficulty of access have delayed their development. Most of those who have prospected for lode deposits have been men of small means, without financial backing to undertake extensive underground mining or the erection of milling plants. The time and effort required to reach the lode prospects in summer have prevented the visit of many capitalists who might have undertaken the financing of mine development. The completion of the new railroad to the Tanana Valley, however, is likely to bring a new phase of mining activity to this district. Although no single vein has so far been developed to the point where the success of a mine is assured, there are nevertheless a number of prospects that are of sufficient promise to warrant thorough exploration and are likely some day to bring this camp into the list of gold lode producers.

All the lodes that have been considered worthy of any development occur within a rather small area. They lie along the highest part of the Kantishna Hills and are included in a belt 27 miles long and 6 miles wide, extending from Clearwater Fork of Toklat River in a S. 60° W. direction to and across Moose Creek. It is not certain, however, that other valuable lodes do not occur outside of the belt just described. There is abundant quartz float outside of this belt, but in the higher and more rugged mountains the steep slopes and the absence of a continuous surface covering of vegetation have rendered prospecting easiest, and most of the prospects lie high on the ridges. There is reason to expect that more intensive prospecting in the future will disclose the presence of many other veins at lower altitudes.

All the lodes so far found occur in similar geologic surroundings. The prevailing rock throughout the district has been called the Birch Creek schist, as it is believed to be a part of the same schist series that crops out in the area between Yukon and Tanana rivers. This schist is a highly metamorphosed rock, much folded and contorted and showing a variety of phases from place to place. A common phase is a dense quartzitic rock, locally rather massive but commonly showing much mica and exhibiting a more or less well-developed schistose cleavage. Fine silvery mica schists with highly developed cleavage are common and in places are studded with garnets. Dark carbonaceous schists and greenstone showing various degrees of metamorphism are also present. The general strike of the foliation of the schist is northeast, and dips at all angles may be found, as the beds are in general closely folded.

The larger quartz veins, including those whose principal valuable metals are gold, silver, and antimony, all cut the Birch Creek schist. There is a marked uniformity in the direction of strike, the main veins so far exposed all trending between N. 45° E. and N. 70° E. Although this trend is parallel to the general structure of the schist, most of the veins cut across the foliation of the schist that incloses them. The ore-bearing veins dip steeply, from 50° to 90°, and so far as can be made out hold their direction of strike and angle of dip rather constantly. They thus fall into a different category from the numerous lenticular and distorted veinlets and stringers of quartz that are so common in the schist which lie parallel to its foliation. The ore-bearing veins here described therefore occupy fissures that were opened and filled after a large part of the regional metamorphism to which the schists have been subjected was completed. There has been some movement along the vein openings since the ore was deposited, but this may be ascribed to local uplift or warping, for the veins themselves have not been notably deformed. The study of the ore deposits was hampered by the meagerness of the underground workings. The 11 longest tunnels aggregate 891 feet, and the two shafts only 70 feet. The longest tunnel is 188 feet from portal to breast, and 5 tunnels are over 100 feet long. Several of the tunnels are now caved in so that an examination was impossible. In addition to the underground workings the veins have been exposed by a large number of open cuts, but most of these were slumped and a thorough examination of the veins in them was impossible without clearing them, time for which was not available.

The different veins examined vary widely in the abundance of their metallic minerals and also in the proportions of those minerals in respect to one another. The assemblage of minerals, however, is much the same in all the mines. The more important minerals recognized were gold, silver, arsenopyrite, pyrite, galena, sphalerite, stibnite, and chalcopyrite. All these minerals are considered to be primary minerals—that is, they were brought into the veins directly by the ore-bearing solutions or were the result of chemical action between those solutions and the inclosing country rock. At the outcrops of the veins there is in places a shallow zone in which leaching and oxidation have been in operation and secondary minerals, such as iron oxide and lead carbonate, are found; but this surficial zone of weathering is shallow and tunnels driven into the quartz veins show unaltered vein material only a few feet beneath the surface. Along some open cracks and in places where the ore is shattered and broken the effects of oxidation and weathering have penetrated more deeply.

There are no facilities in the Kantishna district for having assays made, and such ore samples as are taken out for assay by the prospectors are in general sent to Fairbanks. The lack of easy transportation has made communication with Fairbanks infrequent, and there is a long delay between the time of collecting the ore sample and the receipt of the assay returns. This has resulted in rather haphazard prospecting, for the prospector, having found a promising-looking quartz ledge, may spend several months in development work before the receipt of his assay returns confirms his judgment or brings him disappointment. As a consequence of the difficulties in procuring assays, the prospector has been forced to rely upon such simple methods of determining the value of the ore as he has at hand. The most commonly used of these methods is to grind the ore in small hand mortars and pan the pulp thus obtained. This procedure serves, in a way, to determine the presence or absence of free gold, but the quantitative results are uncertain and may be misleading. Only a small piece of vein material can be crushed at a time, and because of the labor involved the prospector is likely to crush only what he deems to be the most promising pieces of ore and thus to raise false hopes as to the average value of his ore body. It is only by taking large samples across the entire vein at frequent intervals that a determination of the average content of the vein may be obtained. Furthermore, tests made by mortar and pan give no information concerning the gold in the ore that is not in the form of free gold. Most gold-bearing sulphide ores contain a certain percentage of gold so entangled with the sulphides that it can not be released by simple crushing and amalgamation, but for its recovery requires chemical treatment or smelting. The amount of gold so carried may be sufficient in quantity to justify mining. Reliable assays should be made to obtain definite figures on the value of the ore, in order to ascertain whether or not the opening of a mine and the construction of a mill are justified.

As already stated, comparatively few assays of ores from this district have been made, and most of those are not available for publication. One or two mining engineers have made rather thorough examinations of certain properties and have collected average samples from the ore bodies, but naturally their assay returns are not to be had for general use.

Difficulty is encountered by the prospectors in this district in keeping their tunnels in repair from year to year. A short distance below the surface permanent ground frost is encountered, and most of the tunnels when driven, in winter, are dry. After a tunnel has been opened, however, melting begins on the advent of warm weather, and ground that at first was solid and required no timbering begins to slump. As a result many tunnels are now caved in and inaccessible. It has been found, however, that tight bulkheads and close-fitting doors to cut off the circulation of air keep the tunnels frozen in summer. If underground work is done in summer and artificial ventilation is necessary, this tendency of the ground to thaw and slump is likely to necessitate the placing of heavier and more numerous timbers to keep the workings open and safe.

In the following pages the veins are described in the order in which they occur from east to west.

GOLD-LODE PROSPECTS.

MAMMOTH CLAIM.

At the head of Crevice Creek, a tributary of Caribou Creek, an open cut has been excavated on the Mammoth claim, situated high on the side of Spruce Peak, about 500 feet below the summit. This cut was reported to have slumped in and so was not visited, but it is said that there is at that place a large mineralized quartz vein. No figures concerning its gold content were obtained.

LLOYD PROSPECT.

On the east fork of Glen Creek a short distance above its mouth a tunnel has been driven 24 feet into the face of a cliff on the north side of the stream. At the tunnel mouth the cliff face shows a large amount of siliceous material that seems to be a rather pure quartzite, interbedded with the schist. Both the inclosing schist and the quartzite have been twisted into a close sigmoid fold that at one place gives a vertical exposure of quartzite 18 to 20 feet high. The quartzite has been mineralized, and some vein quartz has been introduced into it. Pyrite, chalcopyrite, and sphalerite were recognized, and gold is said to be present. It is reported that no work has been done on this claim for several years.

HUMBOLDT PROSPECT.

The Humboldt claim lies at the head of the east fork of Glen Creek, on the high ridge that forms the crest of the Kantishna Hills at this place. The schist here strikes N. 37° W. and dips 27° SW. A tunnel said to be 48 feet long, driven in a westerly direction, was so caved in at the time of visit that it could not be examined. It was apparently started on the cropping of a vertical quartz vein that strikes N. 55° E., but it is said that the tunnel diverged from the vein and that no quartz showed at the breast. The main vein is 3 to 4 feet wide and consists of milky white to somewhat stained and rusty quartz. The vein is massive and shows no noticeable banding but contains some small inclusions of schist. No metalliferous minerals, except iron oxide, were noted, although galena and sphalerite are reported. Associated with the main vein are two or three other smaller parallel veins, all lying within a zone that measures about 30 feet across. Numerous large pieces of the vein quartz, broken from the croppings, lie about on the surface near the tunnel mouth, and it is said that several hundred pounds of this surface ore was shipped to Fairbanks for treatment and yielded promising returns, mostly in free gold. A tent and blacksmith shop have been erected at the tunnel mouth, and another tent stands in the valley below. No one was working on this property at the time it was visited (August, 1916).

SKOOKONA PROSPECT.

A number of open cuts have been excavated on the top of the high ridge about 1 mile east of Glacier Peak, where the schist strikes N. 20° E. and dips 15°–30° E. Several open cuts and a 12-foot shaft have been made on a large quartz vein that seems to lie parallel to the schistosity and apparently has a maximum thickness of 20 feet. It forms a capping for the ridge on which the cuts lie, and all the principal exposures may be upon the same vein. The quartz is characteristically milk-white, though in places it is stained by iron oxide. Little evidence of mineralization is to be seen. Not enough development work has been done to show positively the structure or relations of this quartz body.

GLEN PROSPECTS.

Two tunnels have been driven near the top of Glacier Peak, a high mountain on the ridge between the heads of Glen and Glacier creeks. At this place the schist strikes due north and dips 40° W. The upper tunnel, now caved in, is said to be 40 feet long, with a winze in the end. The lower tunnel was evidently driven to cut the quartz vein that crops out on the slope above. As judged by its shattered croppings the vein appears to be about 10 feet wide and to consist of white to gray banded quartz. Pyrite, sphalerite, and possibly galena were noted in the quartz on the dump. No evidence of recent work was seen, and no one was present on the property at the time of visit. It is said that the quartz carries promising amounts of gold, but no figures were obtained as to the average gold content.

McGONAGALL PROSPECT.

The McGonagall prospect, on a gold quartz vein, lies near the head of Glacier Creek, at an elevation of approximately 3,400 feet. A substantial cabin has been erected near the vein cropping. The vein as exposed by the outcrops and in an open cut seems to strike N. 70° E. and dip 50° SE., and it is said to show a maximum thickness of over 8 feet. A 12-foot tunnel, driven into the mountain at the vein cropping, is lagged except at the breast, which showed only schist. On the surface many large pieces of white quartz, some 2 feet in diameter, show iron oxide along the broken faces and inclose lenses and bunches of mica schist. Some finely disseminated pyrite was observed along small fractures in the quartz.

It is reported that the best ore so far found on this property was taken from a small quartz vein in the creek bed below the cabin. A ton of this ore has been shipped to Fairbanks for a mill test. No one was present on this ground in August, 1916.

GREISS PROSPECT.

The Greiss prospect comprises the adjoining Malachite and Azurite claims, both on the north side of upper Eureka Creek. On the Malachite claim a 13-foot tunnel has been driven on the north valley slope, opposite the upper end of placer claim No. 13. This tunnel, evidently driven to cut a zone of quartz-bearing schist, is timbered but shows in the breast black schist with small quartz veinlets.

West of the tunnel an open cut exposes black slate schist, finely banded and carrying numerous quartz veinlets lying parallel to the foliation of the schist, which strikes N. 45° E. and dips 30° NW. Pyrite, in cubes as large as a quarter of an inch in diameter, is locally abundant in both quartz and country rock. Tiny calcite veinlets cut across the schistosity. The quartzose zone in the slate schist is at least 4 feet thick and contains streaks of white clayey material full of quartz fragments. In the absence of the owner no other workings were found, and no information was gained as to the gold content of the ore.

EUREKA PROSPECTS.

A group of claims, said to be named the Eureka group but locally known as the Taylor property, lies on the north valley slope of Eureka Creek, about 3 miles above its mouth. These claims have been developed by the Lower Eureka and Upper Eureka tunnels and an open cut, and a cabin has been constructed near the mouth of a southward-flowing tributary of Glacier Creek. The Lower Eureka tunnel is situated on the north side of Eureka Creek, near the top of a steep bluff. It is timbered for 20 feet, but beyond the timbered part it is caved in. The total length of the tunnel is said to be 40 to 50 feet. This tunnel was driven on a mineralized zone that is about 8 feet wide and apparently strikes N. 25° E. and dips 80° NW. This zone has a distinct hanging wall, though the footwall is not well exposed. It contains abundant quartz which incloses numerous horses and lenses of schist, and the whole is much crushed and rusty, the broken quartz and schist being in part recemented by iron oxide. The inclosing schist strikes N. 15° E., and the tunnel is driven in a direction a few degrees east of north. The surface vein material is so oxidized and coated with iron rust that little evidence of other mineralization can be seen. Some pieces of quartz on the dump, however, show white quartz with finely disseminated pyrite, some galena, and a little stain of copper carbonate.

The Upper Eureka tunnel is over 600 feet above the lower tunnel and about 4,000 feet northeast of it. It was driven N. 67° E. for 100 feet and has three branches, the total length of underground workings being about 144 feet. The tunnel is driven along the strike of a vertical quartz vein. On its northwest side it follows the wall of the vein, and on its southeast side it has a straight, smooth parting in the vein for a wall. In the outer 100 feet of tunnel the vein quartz is shown to be at least 7 feet wide, and one wall of the vein is not exposed. There has been some movement along the contact between quartz and schist, as both schist and vein material are somewhat shattered and broken. The vein as a whole is fractured, and the broken surfaces of quartz are covered with iron oxide.

At 100 feet from the tunnel entrance another quartz vein at least 3 feet thick, striking N. 30° W. and dipping 20° SW., seems to cut off the main vertical vein on which the tunnel was started. Not enough work has been done to determine the relations of these veins.

The country rock at this place is a dense, quartzitic schist, containing mica and coarse granules of quartz. It strikes N. 30° E. and dips 24° NW. The vein material ranges from white glassy to gray mottled quartz, with some dark rock containing quartz and sulphides, much stained and discolored. Iron pyrite is widely disseminated through the vein filling, and locally abundant pyrite, sphalerite, and a little galena were seen. No report was obtained as to the gold content of this lode.

PENNSYLVANIA AND KEYSTONE PROSPECTS.

The Pennsylvania and Keystone claims are described together, as they adjoin each other, are held by the same owner, and are staked along the strike of veins that are continuous from one claim to the other. These claims, which lie on the north side of Eureka Creek, are crossed by Iron Creek, a small southeastward-flowing tributary of Eureka Creek. They have been developed by a large number of open cuts, although no underground work had been done at the time of visit.

The main vein on this property is a quartz vein averaging 3 feet in thickness, striking N. 50° E. and dipping 56° S. It crops out at the point of discovery on the Keystone claim and has been traced thence along the strike northeastward across Iron Creek and up the opposite side of that valley. About twenty open cuts made by stripping off the vegetation and loose surface material show that the vein is continuous and preserves its direction of strike, angle of dip, and thickness for at least several hundred feet along the outcrop. In the weathered surficial portions of the vein so far uncovered the quartz is broken and oxidized and generally rusty in appearance. Arsenopyrite and pyrite are abundant, and locally the quartz is heavily mineralized with arsenopyrite, sphalerite, and galena. Small pieces of vein quartz mortared and panned as a rule show free gold, and on many pieces of ore coarse particles of free gold can be distinguished with the unaided eye. Development work had not progressed far enough to disclose the vein below its weathered surface portion, and no assays of average samples of ore had been made.

In the valley of Iron Creek, 100 feet above the crossing of the vein just described, there is another quartz vein striking N. 54° E. and standing about vertical. This vein shows a maximum of 6 feet of quartz, 2 feet of which, on the southeast wall of the vein, is banded and broken. The quartz contains iron sulphides, and gold can be panned from its surface croppings. If this vein maintains a trend uniform with that at the place where it has been uncovered, it should intersect the main vein a short distance east of Iron Creek.

An open cut just east of Iron Creek, made to intersect the main vein, encountered a small quartz stringer three-fourths of an inch to 6 inches wide, in the oxidized portion of which were pockets of very rich gold ore. Several ounces of fine crystalline gold was panned from the decayed surface of this veinlet, and specimens were preserved that showed a spongy network of delicate gold crystals, any sulphides that may originally have been present having been leached out and oxidized. Only a small amount of this exceptionally rich ore was found in the small excavation at that place, and its relation to the main vein had not been determined, but its presence indicates the possibility of the existence of rich ore shoots in these veins.

GOLD KING CLAIM.

The Gold King prospect lies near the head of Iron Creek, high on the ridge between Eureka Creek and the head of Friday Creek. Development work on this claim consists of two tunnels, the lower of which, at an elevation of about 3,150 feet, is said to be 30 feet long but is caved 20 feet from the portal. It is reported that in this tunnel the quartz vein averaged 4 feet in width. About 50 feet above the lower tunnel, on the same vein, a second tunnel has been driven for 7 feet. Here the quartz vein, which strikes N. 70° E. and stands vertical, is shown to be over 6 feet wide, only one wall of the vein being exposed. The inclosing schist is fractured and disturbed but strikes about N. 80° E. and dips 20° S. The freshly fractured vein quartz is white and massive, although the croppings and the old fracture faces are stained with iron rust. Arsenopyrite, sphalerite, and galena were noted, and the oxidized croppings of quartz are said to assay several dollars in gold to the ton and to carry a trace of silver. The residual material on the surface is reported to show colors of gold on panning.

GOLDEN EAGLE CLAIM.

The Golden Eagle Claim is at the head of Friday Creek, on the ridge that separates the Friday Creek basin from that of Iron Creek, a tributary of Eureka Creek. The property is developed by several open cuts and by a tunnel. The open cut in which the first discovery was made showed a vein cropping 3 feet wide, of which 2 feet consisted of vein material heavily mineralized with galena, pyrite, sphalerite, and copper carbonates and containing considerable free gold. The tunnel was driven on a crushed and slickensided zone, to intersect the vein shown in the open cut. The inclosing schist there strikes N. 55° E. and dips 51° SE., and the crushed zone strikes parallel with the schist but dips at a steeper angle. The tunnel has a total length of 145 feet and shows bunches of quartz along the crushed zone, within which both quartz and schist are mineralized. The heavily mineralized vein material, which on the surface showed a width of 2 feet, in the tunnel averages only a few inches wide, with a maximum of 18 inches, but its gold tenor is said to be most encouraging. Tests made by crushing in a hand mortar and panning the pulp show abundant particles of free gold, and assays have shown gold to the amount of several hundred dollars a ton.

LITTLE ANNIE CLAIM.

The Little Annie claim lies on the northwest side of the Friday-Eureka Creek divide, a short distance below the summit. In addition to a number of open cuts this claim is developed by a tunnel with a total of 147 feet of underground workings. The schist country rock here strikes N. 18° W. and dips 15° W. The main tunnel trends south and was driven to intersect a vein which appears in an open cut on the hillside above. The main vein was encountered 90 feet from the portal, and a drift 42 feet long was driven S. 59° W. along the vein. A crosscut 60 feet from the portal runs S. 55° W. for a distance of 10 feet. The main vein consists of quartz, is from 3 to 4 feet thick, and dips 65° SE. The footwall is sharply defined and is much slickensided, with horizontal striations, showing that horizontal movement has taken place between the vein and the footwall since the quartz was deposited. The quartz contains disseminated pyrite and pans a little gold. No galena or sphalerite was seen in the underground workings, but these minerals are probably present, for pieces of solid galena several inches in diameter have been found on the surface near the outcrop of the vein. A piece of this float galena on assay yielded 124 ounces of silver to the ton.

Between the footwall of the main vein and the 10-foot crosscut there is a zone 27 feet wide, lying parallel to the main vein, in which the schist is so intricately cut by small quartz veinlets a few inches in thickness that more than half of the whole zone appears to be composed of quartz. Assays of the vein material have shown that the quartz carries a few dollars a ton in gold.

SILVER PICK CLAIM.

The Silver Pick claim lies southwest of the Little Annie and Golden Eagle claims, on the same ridge and at about the same elevation. It is developed by several open cuts and by a straight tunnel 188 feet long, driven S. 30° E. The schist country rock strikes S. 5° W. and dips 50° W. At the tunnel portal one edge of a quartz vein that panned gold was cut, but the thickness of this vein was not determined. At 54 feet from the portal a vein striking N. 35° E. and dipping 68° NW. was penetrated. This vein is 5 feet thick and is composed of rusty quartz containing numerous bunches of galena. A picked sample of this galena is said to have assayed several hundred ounces of silver to the ton, and the ore is said to carry a fraction of an ounce of gold to the ton.

The main vein near the breast of the tunnel consists of a 13-foot zone striking N. 35° E. and dipping 67° SE. and is therefore approximately parallel in strike with the vein already described but lies 130 feet to the northeast. It consists of a 1-foot layer of calcite on the footwall, above which is a 12-foot zone, more or less sheeted, of quartz and schist, the quartz predominating in bulk over the country rock. In this zone there is little galena to be seen in the tunnel, but galena is abundant along the outcrop of the vein. The whole zone is brecciated and leached, and large open cracks extend from the tunnel to the surface. Pyrite, arsenopyrite, and small amounts of galena and sphalerite were observed.

GALENA CLAIM.

The Galena claim lies on the northeast side of Moose Creek, on the end of the ridge that divides the Friday Creek basin from that of Eureka Creek. The development work consists of a number of open cuts, now caved in, and a tunnel, evidently driven to intersect a vein that was exposed in the open cuts. The tunnel, which runs S. 50° E., is 27 feet long and has a 6-foot crosscut at the breast, where a distinct plane of movement, with some gouge, strikes N. 45° E. and dips 63° SE. Adjoining the gouge-filled fracture and on the footwall side of it is a body of quartz, white to mottled with blue-gray patches, that is heavily mineralized with pyrite, arsenopyrite, galena, and sphalerite. Any one of these sulphides may occur in nearly pure bunches, or they may all be intimately intermingled. Galena was seen in nearly pure stringers 2 inches or more thick, and an assay of it yielded 131 ounces of silver to the ton.

There is no sharp break between ore body and country rock on the footwall side of the vein, the mineralization merely becoming less as the distance from the hanging wall increases. Veinlets of ore extend into the country rock but pinch out within short distances. So far as could be determined by an examination of the short stretch of the lode exposed in the crosscut, the heaviest mineralization occurred within 4 feet of the gouge-filled fracture. Exploration has not been carried beyond that fracture, and the presence or absence of ore beyond it has not been determined. The owner was not in the district at the time this property was visited, and the proportion of gold to silver in the ore is not known, although it is reported that gold is present, and the deposit is classed as a gold lode.

OTHER GOLD-LODE PROSPECTS.

Many lode claims in addition to those already described have been staked in this mining district, and on some of them the annual assessment work is done. Other prospects have been staked and later abandoned. It has been the intention of the writer to describe here only those properties that seemed of sufficient importance to the owners to warrant underground development or the excavation of sufficient open cuts to expose the vein. It may well prove, however, that some veins which have received little attention may upon exploration show great promise, and undoubtedly the district contains many veins that have not yet been discovered.

ANTIMONY LODES.

GENERAL FEATURES.

Within the Kantishna district there are several claims held for their content of the antimony trisulphide, stibnite. Genetically the antimony lodes are directly related to the gold lodes above described. The veins have the same association of minerals, but they contain antimony in large masses; whereas in the gold lodes antimony, although occasionally recognized, is a minor constituent. The presence of veins containing considerable masses of stibnite has been known since the first years of mining activity in this region, but the remoteness of the district and the prevailing low price of antimony prevented the exploitation of the antimony deposits, although a minor amount of development work was done on two of them. After the outbreak of the European war the price of antimony rose from 5 to 7 cents a pound to the unprecedented price of 37½ to 40 cents at the end of 1915. As a result of this great demand interest in the Alaska stibnite ores increased, and production began at several mines.[1] In the Kantishna district the response to the increased price of antimony was somewhat sluggish, for communication with that district is slow, and much uncertainty existed as to the value of antimony on any particular date.

Furthermore, it was not feasible to take ore to the navigable waters of Kantishna River except by sled in winter, and thence by boat the following summer to Tanana. Even from the Tanana several weeks would elapse before the ore could be delivered to a purchaser in the States. It is apparent, therefore, that at least three or

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

four months and possibly a longer time must elapse between the date of mining antimony ore in the Kantishna district and its delivery at the market. When to the cost of mining is added the transportation charge of sled and small-boat haulage to the Tanana and of freight thence to Seattle or San Francisco, no great margin of profit is left for the producer even at the highest war prices. In addition to this high cost there was also to be considered the instability of the market and the possibility of a sudden drop in the price of antimony. At 40 cents a pound for antimony there might be a fair profit in shipping stibnite ore from this district. At 25 or 30 cents a pound the producer might face a serious loss. As a result little mining was done on stibnite ore in 1915, and none was shipped. In 1916 some ore was mined and stacked, but at the time of this writing no antimony from the Kantishna has reached the market.

TAYLOR MINE.

The Taylor mine, or, as it is commonly called, the Antimony mine, lies near the head of Slate Creek, a headward tributary of Eldorado Creek. The property was first staked in 1907, but the title lapsed, and the ground was restaked by the present owner. It is said to include a group of claims, but development work has been confined to the driving of a tunnel 97 feet long, with 22 feet of crosscuts, and to the excavation of an open cut immediately above the tunnel. As shown in the open cut and tunnel, a strong fissure along which movement has taken place strikes N. 50° E. and dips 82° SE., and this fissure limits in most places the southeastern extent of the main ore body, although a little ore appears on the southeast side of this fissure. The ore body has a maximum width of 15 feet and constitutes a reticulated stockwork of quartz and stibnite, with irregular bunches and horses of decomposed clayey schist, all much broken and confused. The inclosing quartzite schist strikes north and dips 28° E.

The stibnite occurs in veins and veinlets of almost pure stibnite as much as 2 feet wide, and also in irregular lenses and bunches. Some of it is solid and unaltered, but in other places the ore is crushed and broken and consists of small fragments of quartz and stibnite recemented by yellow and reddish secondary oxidation products that upon analysis are found to consist of the antimony ochers stibiconite and kermesite. The principal ore bodies, which occur within 6 or 8 feet of the main fissure, seem to lie in the stockwork obliquely to the main fissure, the ore lenses and veinlets in general dipping 60° NW. The stibnite occurs predominantly as aggregates of acicular crystals, but masses of fairly granular material are also present. The ore so far mined was estimated to consist of about 125 tons of hand-sorted stibnite. Most of this ore was taken from the open cut. That excavated from the tunnel was of lower grade, as it contained smaller bunches of pure stibnite and more quartz and schist. In the absence of facilities for machine concentration much stibnite that could not be separated from the gangue by hand sorting was thrown on the dump. Three men were employed on this property in 1916. A project was under way to bring in motor trucks to be used in hauling the antimony ore from the mine to navigable water on McKinley Fork of Kantishna River, at a point about 4 miles above the abandoned town of Roosevelt, from which the ore was to be taken by small boat to Tanana River.

CARIBOU LODE.

In the basin of Caribou Creek near the mouth of Last Chance Creek, a tributary from the southeast, there is a stibnite-bearing lode on which some development work has been done. This lode was visited by Prindle[1] in 1906, and the following description of the property is made from information procured by him and by the writer. Little work has been done on it since 1906, and at the time the property was visited in 1916 the shafts were full of water and inaccessible. The property consists of two lode claims, the Pioneer and the Caribou, which lie across the lower valley of Last Chance Creek. Two shafts have been sunk, one 40 feet deep on the west bank of Last Chance Creek and another 30 feet deep on the east bank. The vein strikes N. 40° E. and dips about about 67° SE. It is approximately 4 feet wide and consists of a mixture of quartz and stibnite. In the western shaft a vein of pure stibnite 1 foot wide is said to lie along the northwest wall and to become narrower toward the bottom of the shaft. The quartz is massive to crystalline and is intimately intergrown with the stibnite, which occurs as a mixed aggregate of fine-grained, massive sulphide intermingled with acicular crystals 2 inches or more in maximum length. Within the coarsely crystalline stibnite there are many long individual quartz prisms lying parallel with and surrounded by the stibnite. The country rock inclosing the vein is hornblende schist, which is much contorted, but which in the main strikes N. 65° E. and dips 35° NW. On Caribou Creek, several hundred feet northeast of the shafts, is the outcrop of a fissure striking N. 45° E. and dipping 75° SE., which is believed to be the continuation of the antimony lode but which at that place shows only a little quartz.

Three samples of antimony ore collected from this property in 1906 were assayed. One yielded 4 ounces of silver to the ton, one

[1] Prindle, L. M., The Bonnifield and Kantishna regions: U. S. Geol. Survey Bull. 314, p. 219, 1906.

2.76 ounces of silver and 0.12 ounce of gold, and the third 0.12 ounce of gold but no silver. Another sample, assayed for gold only, yielded 0.02 ounce to the ton. No ore from this lode has been marketed.

STAMPEDE LODE.

About 2 miles above the mouth of Stampede Creek, a tributary of Clearwater Fork of Toklat River from the southwest, on the southeast valley wall, a claim has been staked on a lode deposit of stibnite, here called the Stampede lode. The only development work that has been done is the excavation of a large open cut in 1916. The country rock, a reddish quartzite schist, at the nearest outcrop to the lode that seemed undisturbed strikes northwest and dips 30° NE. At the lode outcrop, near the top of a rounded ridge, the surface is covered by a mantle of disintegrated rock, and the schist itself is much disturbed by frost and by creep, so that it is difficult to ascertain the relation between the ore and the country rock. In the floor of the open cut and exposed at its face is a large body of nearly pure stibnite, apparently at least 12 feet thick across the vein. The ore in the face of the cut was faulted and slickensided, and no good exposures of the contact of ore with schist were seen. A little quartz is present in the ore, but one man had in three weeks removed and stacked 40 or 50 tons of selected stibnite almost entirely free from visible gangue or impurities, much of it in lumps 6 inches to 1 foot in diameter. The vein in which the stibnite occurs, probably as a large lens, strikes northwest and apparently dips 65° SW. A branch vein of stibnite is seen by the distribution of broken surface ore to strike northeast. The stibnite is mostly in the form of a close-grained, massive aggregate in which small scattered crystals may be distinguished. Some more coarsely crystalline stibnite is also present, but in subordinate amounts. It is reported that a sample of ore from this vein showed on assay 69.8 per cent of antimony, 1 per cent of arsenic, and no silver or lead.

Another vein carrying stibnite with much intermingled quartz is said to crop out on the opposite side of Stampede Creek along the general direction of strike of the Stampede lode, but no development work has been done on it.

LIGNITE.

OCCURRENCE.

Tertiary deposits containing lignitic coal occur at intervals throughout the area considered in this report. They are widespread just east of Nenana River, in the Nenana coal field, where deeply cut valleys expose numerous beds of lignite. The coal-bearing beds are overlain, in the Nenana field, by a heavy body of oxidized gravels that in many places seems to rest conformably upon them. West of Nenana River, in the Kantishna area, outcrops of both the coal-bearing beds and the succeeding gravels are found here and there near the north flank of the Alaska Range, at least as far westward as the headwaters of Bearpaw River, and at some of these localities beds of lignite occur. No single exposure discloses lignite in the abundance in which it is found in the Nenana field, and it is doubtful if such beds are to be found elsewhere. The area of coal beds and the quantity of lignite coal west of Nenana River, however, may be out of proportion to the amount to be seen in the outcrops. In this area the beds are not generally dissected by deep valleys with bare walls, as on Lignite and Healy creeks, but are bared by the cutting of small gullies. Furthermore, a widespread blanket of later gravel deposits covers the coal-bearing areas, so that outcrops are scarce and poor. The widespread geographic distribution of the localities in which beds of the coal-bearing series occur, however, and the presence in these beds of lignitic coal at widely-separated localities, indicate that there may be present beneath a covering of younger materials a much larger quantity of lignite than is now known.

In the following paragraphs is given a brief description of the localities west of Nenana River at which beds of lignite were seen.

TEKLANIKA BASIN.

SAVAGE FORK.

A number of exposures of lignite were seen in the basin of Savage Fork, the eastern branch of Teklanika River. The southernmost of these occurs near Ewe Creek, a small westward-flowing tributary that drains the north slope of the schist mountains north of the divide between Dry Creek and Savage Fork. About a mile above the mouth of Ewe Creek, on its north side, is a prominent light-colored bluff composed of decayed schist and blue-white clays. Just east of the bluff, at the mouth of a small southward-flowing stream, a 2-foot bed of weathered lignite is exposed, but its relations are obscured by vegetation and waste material. A few hundred yards up the same small gulch a 10-foot bed of lignite striking about east and dipping 30° S. forms a waterfall in the gulch. As the schist crops out only a short distance north and south of this exposure, it is probable that the area underlain by coal at that place is small.

On the north side of Ewe Creek, extending from its mouth eastward for nearly a mile, a bed of lignite showing a maximum observed thickness of 9 feet crops out at intervals at the edge of the stream flat. The relations of the lignite to the overlying and underlying beds are not exposed. The bed strikes N. 75° E., and as it dips about 20° N. beneath the broad branches north of the outcrop, it may have an area of several square miles. The lignite was free from partings and appeared to be of about the same grade as the average lignite of the Nenana field.

On the west side of Savage Fork, about a quarter of a mile below the mouth of Ewe Creek, an imperfect exposure in the stream bluff shows a short section of a 14-foot lignite bed, which strikes N. 85° E., dips 15° N., and is overlain by 40 feet of cross-bedded sandstone. The coal-bearing beds are covered unconformably at the top of the bluff by 8 feet of coarse yellow gravel, above which lies 20 feet of fine gravels. About 1½ miles below this outcrop an excellent exposure along the same bluff shows a total of 25 feet and 8 inches of lignite in five beds, as indicated below:

Section of lignite-bearing beds on Savage Fork 1¾ miles below the mouth of Ewe Creek.

	Ft.	in.
Terrace gravels	15	0
Unconformity.		
Clay	24	0
Lignite	6	0
Clay	1	6
Lignite	9	0
Clay	2	0
Lignite	1	2
Clays, sands, and silts	32	0
Shale	3	0
Gray sandstone	3	0
Lignite	3	6
Dark-gray shale	2	0
Light-gray shale	3	0
Dark-gray shale	2	0
Gray sands	4	6
Dark-gray shale	3	0
Gray sands	3	0
Lignite	6+	

These beds at the south end of the exposure strike about N. 20° W. and dip 10° W., but toward the north end the dip steepens in a sharp flexure. There a lignite bed, poorly exposed but apparently 5 or 6 feet thick, crops out and is seemingly at a higher stratigraphic position than the top of the section given above. The whole coal-bearing series is covered unconformably at the top of the bluff by terrace gravels. On the east side of Savage Fork, a short distance above the exposure just described, a bed of lignite, much disturbed by surface creep but apparently 8 feet thick, crops out in a small tributary valley. Its relations are not clear, but it is probably to be correlated with one of the beds in the section given above.

The numerous lignite outcrops observed in this portion of the Savage Fork basin, between the schist hills on the south and the high gravel ridges on the north, indicate that there is at this place an area of probably several square miles that is underlain by lignite in beds of workable thickness. Time was not available for the careful structural work necessary for outlining the probable extent of the several lignite beds.

A little impure lignite was observed in the east bank of Savage Fork about 1½ miles above its mouth, but no considerable lignite beds were seen there.

SANCTUARY RIVER.

On the east side of Sanctuary River 3 miles above its mouth a 15-foot bluff along the stream shows a 3-foot lignite bed, interbedded with gray clays and gravels. The beds have here been compressed into an anticlinal fold, on the north flank of which the lignite dips downward below the stream level. The general strike of the anticline is east.

TOKLAT BASIN.

EAST FORK OF TOKLAT RIVER.

The East Fork of Toklat River is formed by the junction of a number of northward-flowing streams that drain from the crest of the Alaska Range. Below their confluence there is a considerable amount of lignite upon the stream bars in pebbles and in small piles of fragments formed by the weathering of larger pieces. The source of this material was not ascertained, but it is almost certainly in the basin-like depression that forms a low divide extending from a point near the head of East Fork of Toklat River to the Toklat at its forks.

TOKLAT RIVER.

On Toklat River near its upper forks a low pass connects that basin with the valley of upper Stony Creek. Three miles above the mouth of the stream flowing eastward from the pass three beds of lignite, from 1 to 4 feet in thickness, cropping on the south side of the stream were seen by members of the Survey party but were not visited by the writer. In the same valley, about 1 mile above the mouth of the stream, a bluff composed of the shales, gravels, and sands of the coal-bearing series shows a 2-inch bed of impure lignite.

KANTISHNA BASIN.

Moose Creek, a headward tributary of Bearpaw River, in the Kantishna basin, heads in the high mountains 9 miles northeast of the terminus of Muldrow Glacier. Near the extreme head of this stream there is a basin-like area floored with beds of the Tertiary coal-bearing series, and a number of exposures show thin beds of carbonaceous material and impure lignite. At one locality near the Moose Creek-Stony Creek divide, on the north side of the valley and 350 feet above its floor, is the weathered outcrop of a 12-foot lignite bed, which strikes N. 80° E. and dips 55° S. This bed seems to lie near the base of the coal-bearing series at that place and overlies a purple, discolored shale, beneath which is volcanic material. The lignite croppings were observed for a short distance along the flank of the mountain, but the areal distribution of this bed is not known, though its structural relations indicate that it dips beneath the beds to the south, and in this basin it may possibly have an area of a few square miles.

Lignite fragments were seen also 6 miles below the lignite exposure just described, in the stream gravels of the northeast fork of Moose Creek. A hasty examination failed to disclose the bed from which the scattered fragments were derived, but it is reported that a bed of lignite 10 feet thick is exposed along the south bank of that stream about 2 miles above its mouth. Coal from this place has been taken to the placer mines on Moose Creek and is said to be of fair quality. Lignite is also reported to occur in the canyon along the north edge of Muldrow Glacier, a few miles above its terminus.

Some fragments of lignite were noted on the bars of Glacier Creek about 1½ miles above its mouth. The deposit from which they were derived was not seen, but it is evident that the coal-bearing formation is present in this locality, although for the most part covered by younger gravels.

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