of large, closely compressed folds with parallel limbs, bringing about a reduplication of beds that would not be suspected unless the folds were seen. (See fig. 4.) At other localities the folding has been intense, and has resulted in intricate contortion, sharp overturned and broken folds, and faulting. (See fig. 5.)

The folding, faulting, and deformation that are now observed in the Cantwell were brought about by the mountain-building processes that created the present Alaska Range. Certainly no mountains ex-

FIGURE 4.—Sketch showing overturned fold in Cantwell formation on East Fork of Toklat River. River bluff is 400 feet high.

isted in early Tertiary time in the area now occupied by the Cantwell formation, for its materials were of necessity deposited in low-lying areas. A part of the deformation is believed to have preceded the deposition of the succeeding coal-bearing Tertiary beds, for it is thought that locally they lie unconformably upon the eroded edges of the Cantwell. The great uplift and folding, however, occurred in later Tertiary time, and involved not only the Cantwell but also younger Tertiary formations.

Sufficiently detailed field work to determine accurately the thickness of the Cantwell formation has not yet been done. The base of

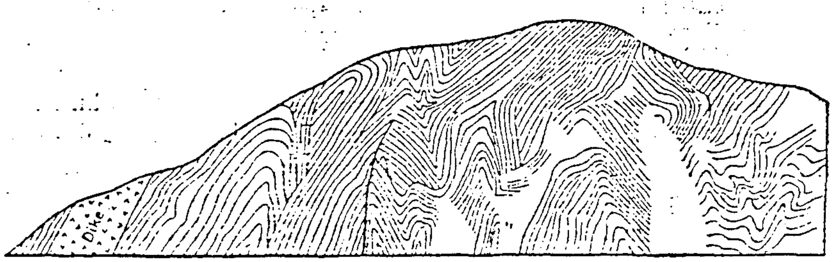


FIGURE 5.—Sketch showing structure of shales and grits of Cantwell formation in the basin of East Fork of Toklat River.

the formation has been observed at several places; but as the beds form a great folded syncline and are generally uncovered by younger deposits, the rugged mountains formed of this material represent only the portion of the beds that have remained, an unknown amount of the formation having been removed by erosion. Its top has not been recognized. Many peaks composed entirely of Cantwell sediments stand from 2,000 to 2,500 feet above adjacent stream beds, and Sabie Mountain, between Teklanika and East Fork of Toklat rivers, rises

3,000 feet above the valley to the west, although the beds there are not flat lying. The area occupied by the Cantwell in this region has a maximum known width of at least 12 miles, but in that area the beds have been folded, faulted, and tilted, and the same bed may be crossed many times by one journeying from the north to the south edge of the area. It is difficult to conceive that so wide a belt of rugged mountains could be composed of a single formation unless its normal thickness is to be measured in thousands of feet. Moffit[1] calculated a thickness of approximately 2,700 feet in a single mountain in the Broad Pass region near the mouth of Jack Creek and believed that that measurement represented only a part of the section. Brooks[2] estimated a thickness of at least 2,000 feet in Toklat basin. From the incomplete evidence now at hand it appears to the writer that both these estimates are too low, and that the thickness of the Cantwell beds in the Toklat basin is at least 3,000 feet, and may be much more.

AGE AND CORRELATION.

In Eldridge's original description of the Cantwell formation he expressed no opinion as to its age. The first attempt to assign these beds to a definite stratigraphic position was made by Brooks[3] as a result of his field work in 1902, during which he traced the formation from a point near Muldrow Glacier eastward to Nenana River and for 25 miles up Yanert Fork. He found the Cantwell formation lying unconformably upon beds of probable Middle Devonian age and expressed the opinion that it was pre-Eocene, although recognizing its structural and lithologic resemblance to Eocene beds in other parts of Alaska. Brooks even found Eocene plant remains in shales resembling the Cantwell shales, but they were associated with faults, and from other considerations he concluded that the Cantwell formation was pre-Mesozoic; and that if so, it would most likely be Carboniferous. Moffit,[4] however, as a result of his work in the Broad Pass region in 1913, unqualifiedly assigned the Cantwell to the early Tertiary (Eocene). He collected fossil plants from several localities on the West Fork of Wells Creek, and the following forms in his collection were identified by F. H. Knowlton and Arthur Hollick:

Locality 6565. Ten miles east of mouth of Jack River.
- Taxodium tinajorum Heer.
- Taxodium dubium (Sternberg) Heer?
- Sequoia langsdorfii (Brongniart) Heer?
- Populus arctica Heer?
- Daphnogene kanii Heer.

[1] Moffit, F. H., op. cit., p. 47.
[2] Brooks, A. H., op. cit., p. 81.
[3] Op. cit., p. 82.
[4] Moffit, F. H., op. cit., pp. 48–49.

Locality 6567. Ten miles east of mouth of Jack River (near 6565).

Aspidium heerii Ettingshausen?
Taxodium dubium (Sternberg) Heer?
Ginkgo adiantoides (Unger) Heer?

The leaves collected by Brooks from Toklat basin included forms like three of the species in lot 6565.

Another fragmentary collection obtained by the writer on Big Creek, a tributary of Teklanika River, at a point about 4 miles above the mouth of Big Creek, was examined by F. H. Knowlton, who reports as follows:

Locality 7278.

There are two types of conifers present—isolated leaves of *Pinus?* sp. and what appear to be branchlets of *Sequoia langsdorfii*—but the shape and attachment of the leaves are not clear. The dicotyledons represent at least three species, but no specimen is well enough preserved to permit certain identification. One strongly suggests *Corylus macquarrii*, but it is without margin; another might be a *Platanus*, but this is uncertain.

From the data available I am not in position to make a very positive age determination, but in my opinion it is probably Tertiary and Kenai in age. It may be as old as uppermost Cretaceous, but I do not think so.

From the facts already stated the Cantwell formation as shown on the geologic map (Pl. II, in pocket) is assigned definitely to the early Tertiary (Eocene), for although the fossil plants collected from this area are alone too few and too imperfect to establish the age of the formation, the stratigraphic continuity of the formation eastward to the fossil localities found by Moffit is believed to be proved, and the lithology of the formation is characteristic and uniform in both areas.

TERTIARY COAL-BEARING FORMATION.

CHARACTER AND DISTRIBUTION.

Coal-bearing Tertiary sediments, supposed to be of Eocene age, have for many years been known in the basin of Nenana River, in the Nenana coal field. Their distribution was first shown by Brooks[1] and Prindle, as the result of field studies made in 1902 and 1906. In 1910 Capps[2] again examined the area between Nenana and Delta rivers and mapped the coal-bearing rocks there. In 1916 G. C. Martin and his assistants made a detailed study of a part of the Nenana coal field. Martin's report on the areas is now in press. These and other investigations have shown that coal-bearing Tertiary deposits occur on the north slope of the Alaska Range and on its eastward continuation, the Nutzotin Mountains, from the head of Kuskokwim River northeastward and eastward to the international boundary between Alaska and the Canadian Yukon. Throughout most of this distance the beds as known occupy only small areas, and occur either as small warped basins surrounded by older rocks or as beds that dip beneath a cover of later materials. Only in the area between Little Delta River on the east and Teklanika River on the west have any considerable areas of the coal-bearing sediments been noted. By far the largest area of the coal-bearing formation, and that containing the most abundant coal, lies just east of Nenana River, in the basins of Hoseanna, Healy, and Totatlanika creeks, adjoining the region here described. Within the Kantishna region some beds of the coal-bearing formation occur in the basin of Dry Creek, and it is reported that coal beds crop out on the west bank of Nenana River, opposite the mouth of Healy Creek. The formation may be of considerable extent at that place, but, if so, it is covered for the most part by younger materials. Remnants of the basal portion of the coal-bearing formation occur on the divide between Dry Creek and Savage River, and in the Teklanika basin the beds outcrop in such a way as to show the presence there of a considerable area of coal-bearing materials in warped and faulted basins. This area may be considered a western extension of the Nenana coal field, though in places the coal-bearing formation has been removed by erosion. The broad basin extending from Nenana River opposite Hoseanna Creek westward to the Kantishna Hills may contain a large area of the coal-bearing Tertiary beds. On Savage and Teklanika rivers, near their junction, and on Crooked Creek, at the base of the Kantishna Hills, outcrops of this formation occur, and the lack of other areas between Teklanika and Toklat rivers, as shown on the geologic map (Pl. II, in pocket), is more likely to be due to the fact that the basin has been little studied than to the actual absence of the formation between the outcrops shown. Two small basins of the coal-bearing formation were seen in the higher mountains, one at Highway Pass between Toklat River and Stony Creek, and the other between Stony Creek and the extreme southeast head of Moose Creek. Other small areas were mapped on Glacier Creek, a tributary of Bearpaw River from the west slope of the Kantishna Hills.

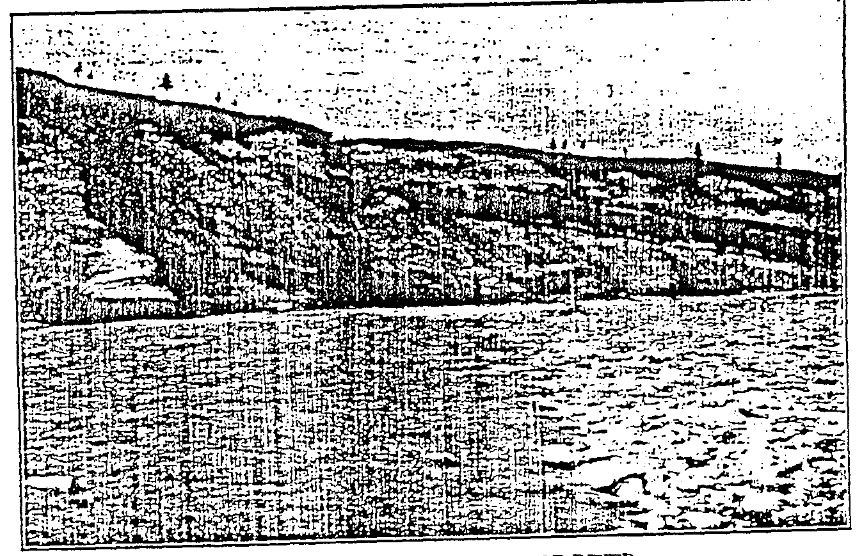
[1] Brooks, A. H., op. cit., pl. 9.
[2] Capps, S. R., op. cit., pp. 26–30 and pl. 2.

Any complete description of the coal-bearing Tertiary beds on the north side of the Alaska Range must refer to the basins of Hoseanna (Lignite) and Healy creeks, just east of Nenana River, for it is there that the formation is best exposed and contains the greatest thickness of coal. Furthermore, as that coal field lies on the route of the Government railroad, now under construction, the commercial development of coal mines is certain to be first undertaken there. On Healy

Creek ion measured by Prindle showed a total thickness of 1,900 feet of coal-bearing beds, consisting of gravel, shale, sands, and lignite, of which 220 feet was lignite in 23 separate beds. The stratigraphic relations at that locality are typical of the formation at many other places. The basal beds consist of about 100 feet of smoothly rounded chert and white quartz pebbles in a matrix of white sand and kaolinic material, lying unconformably upon the Birch Creek schist. This basal member, with its conspicuous white color, is characteristic over wide areas, and is of great value in recognizing the base of the formation. Above the white basal gravels are alternating beds of shale, clay, sand, and lignite, with some fine gravels. The lignite beds are thickest and most numerous in the lower half of the formation, where there are seven beds aggregating 174 feet of coal. In the upper half of the section the coal occurs in thinner beds, and fine gravels are more abundant. The formation is succeeded above, in apparent conformity, by a thick deposit of gravel.

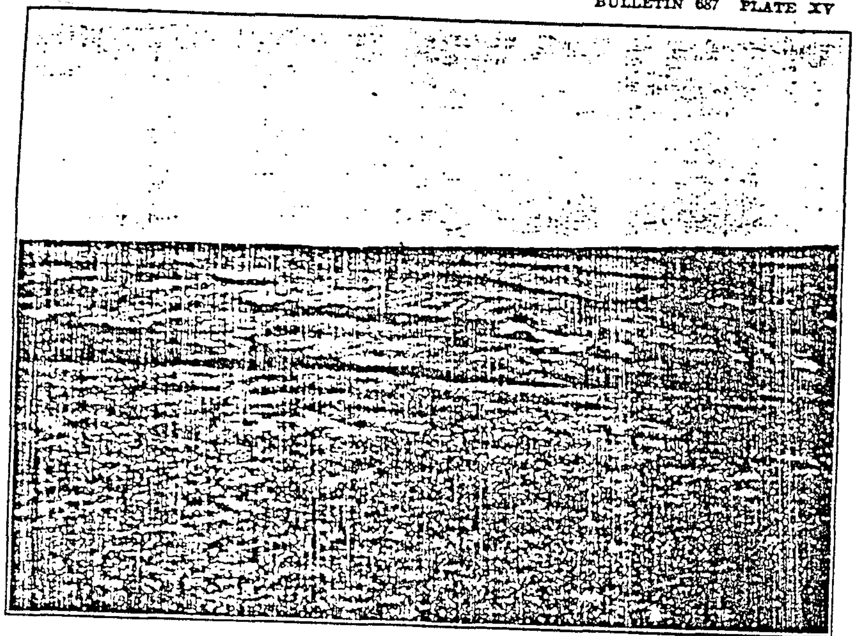
In the basin of Dry Creek only the basal white gravels were observed, dipping beneath a covering of younger materials. The white gravels also occur as a thin layer upon the schist in the Dry Creek-Savage River divide and are there scattered remnants of the formation, most of which has been removed by erosion.

In the basins of Savage and Teklanika rivers west of the head of Dry Creek there is a coal field including several square miles, in which the presence of worakble coal beds of good quality is indicated by the outcrops of lignite along the streams, though later gravels cover most of the probable coal-bearing area. The base of the formation, consisting of white quartz gravels and sands, lies unconformably upon the Birch Creek schist to the south, and the beds dip northward beneath the terrace gravels. (See Pl. XIV, *B*.) The structure of the beds apparently carries them beneath the hills of Nenana gravel, but faulting may cut them off. Coal beds were examined at a number of localities. On the south side of Ewe Creek, 1½ miles above its mouth, one lignite bed, 10 feet thick, apparently of small area, crops out in a small tributary gulch, and another bed 2 feet thick shows near the main stream. On the north bank of Ewe Creek a lignite bed 9 feet thick crops out at intervals for a mile above the mouth of the stream and dips northward. On Savage River north of Ewe Creek a bluff on the west side of the valley shows a short exposure of a lignite bed 14 feet thick dipping northward and overlain conformably by cross-bedded sands. The coal formation is there capped by horizontal terrace gravels. Farther downstream the same bluff shows five coal beds, aggregating 25 feet 8 inches in thickness, interbedded with clays, shales, and sands, dipping northwestward. (See Pl. XIV, *A*.)

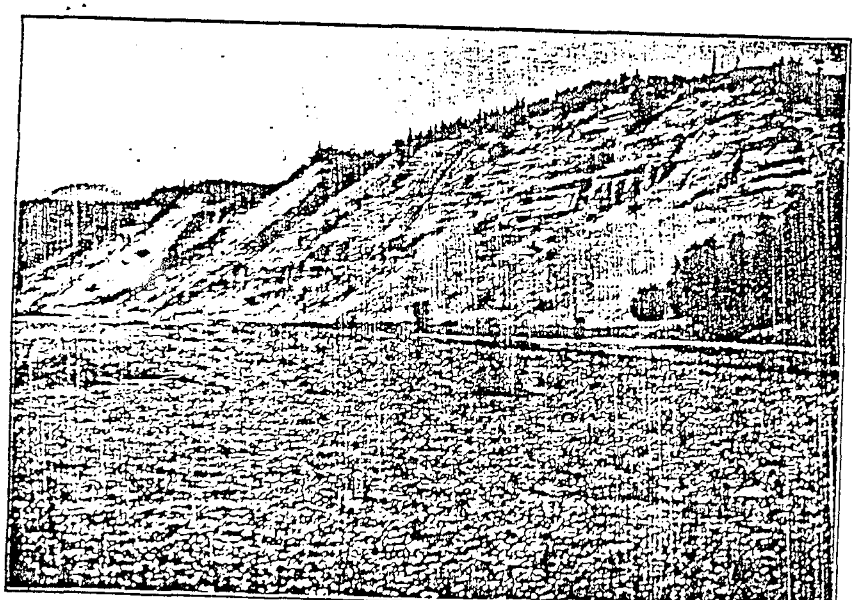


A. BEDS OF LIGNITE ON SAVAGE RIVER.

B. BASAL BEDS OF THE TERTIARY COAL-BEARING FORMATION ON SANCTUARY RIVER.



A. SOIL FLOWS IN BASIN OF MOOSE CREEK.



B. SANDS, CLAYS, AND GRAVELS OF THE TERTIARY COAL-BEARING FORMATION ON CLEARWATER FORK OF TOKLAT RIVER.

The section as roughly measured was as follows:

Section of coal-bearing formation on west side of Savage Fork, 2 miles below the mouth of Ewe Creek.

[See Pl. XIV, *A*.]

	Ft.	in.
Gravels of horizontal terrace	15	
Unconformity.		
Clay	24	
Lignite	6	
Clay	18	
Lignite	3	6
Clay	2	
Lignite	1	2
Clays and sands (poorly exposed)	32	
Shale, dark gray	3	
Sandstone, fine gray	3	
Lignite	3	6
Shale, dark gray	2	
Shale, light gray	3	
Shale, dark gray	2	
Sands, gray	4	
Shale, dark gray	3	
Gray sands		
Lignite	6	
Bottom not exposed.		

On the east side of Savage Fork, a quarter of a mile above the section just described, a lignite bed about 8 feet thick is exposed. Too little work has been done to determine whether or not all the lignite beds on Ewe Creek and Savage River are separate beds, or whether the same bed shows at more than one locality.

A small, imperfect exposure of the coal-bearing formation, with a little impure lignite, was seen 1½ miles above the mouth of Savage River.

Sediments of the coal-bearing formation occur along both Sanctuary and Teklanika rivers for 3 miles above their junction. In most of the exposures no lignite beds were seen, but on the Teklanika, half a mile north of the mountains of Birch Creek schist, a lignite bed 3 feet thick shows in the east stream bluff.

In the eastern half of Highway Pass, between Toklat River and Stony Creek, on the north valley wall, there is a small area of the coal-bearing formation, consisting of shales, sandstone, and fine gravels, and a little impure lignite. In the same area, on the south side of the valley, three lignite beds from 1 to 3 feet thick, are reported to crop out.

A pass between Stony Creek and the extreme southeast branch of Moose Creek contains a narrow basin of the coal-bearing formation. Exposures in the valley bottom show an alternating series of clays, san... ...vels, and some streaks of impure carbonaceous material a few inches thick. Scattered through the formation there are lignitized streaks and logs that still show knots and branches and annual rings of growth. On the north edge of this basin the beds of the coal formation dip steeply to the south. Near their margin a bed of weathered lignite, 12 feet thick, associated with purple shale, lies close to a mass of intrusive andesite porphyry, and the discoloration of the shale is believed to be the result of contact metamorphism. Near Stony Creek the beds of this formation contain abundant blocks of extrusive rock and are interbedded with columnar lava.

In the basin of Glacier Creek, in the Kantishna mining district, the white basal gravels of the coal-bearing formation have been disclosed by prospect holes dug near the line of contact between the Birch Creek schist and the southeast edge of the terrace gravels. Farther down the same stream the white gravels crop out in the stream bluffs, again in a position that indicates that they lie upon the schist. Obscure exposures and scattered fragments of lignite on the stream bars of lower Glacier Creek suggest that the formation is present over a considerable area but beneath a cover of younger gravels.

High bluffs of unconsolidated sands, clays, and gravels that are believed to belong to the coal formation occur at several localities in the valley of Clearwater Fork of Toklat River. (Pl. XV, *B*.)

STRUCTURE AND THICKNESS.

The principal features of the structure of the coal-bearing formation in the areas in which it was studied and mapped have already been described, but the facts may again be briefly summarized. The sediments that make up this formation were deposited by streams in low, basin-like areas at a time when the site of the present Alaska Range was yet a region of low relief, a fact indicated by the character of the sediments themselves, for they are dominantly fine shales, clays, and sands. The deposition of the lignite beds must have taken a long period of time, during which little detrital rock material was laid down, for the coal beds were formed by the slow growth and accumulation of vegetation, and while they were being built little stream-borne débris was brought in. The detrital materials are much finer than the sediments now being handled by the streams, and point to low gradients and comparatively sluggish streams. The drainage lines then followed a general easterly direction, in contrast to the present drainage lines, which run north and south.

Much of the deformation and uplift of the Alaska Range has been accomplished since the coal-bearing formation was laid down, and the mountain-building processes of folding and faulting have affected these deposits as well as the older rocks of the region. The compression with the consequent warping of the crust during the growth of the range was comparatively slight in the foothills area, in which the coal-bearing sediments are most abundant, but in the higher mountains was severe, and the small areas of this formation that occur there are more highly deformed than those farther north. Thus each of the areas in the Upper Toklat basin is a syncline, with both limbs lying upon older rocks and dipping steeply toward the axis of the basin. The Teklanika coal-bearing area, lying as it does in a broad basin in the foothills belt, is only moderately compressed, and the observed dips show a monoclinal structure with the beds dipping northward. Similarly, the imperfect exposures on Glacier Creek, west of the Kantishna Hills, indicate moderate northward monoclinal dips. East of Nenana River the same generalizations with regard to the structure hold true. In upper Healy Creek, in a mountainous area, the coal-bearing formation is compressed into a syncline with steep dips on the limbs. In the basins of Hoseanna and Totatlanika creeks, within the foothills belt, the dips are more gentle and the deformation is less severe.

Little information concerning the thickness of this formation was obtained from the Kantishna region, for the exposures there are small and discontinuous. The nearest locality at which anything like a complete section is exposed is on lower Healy Creek, where the formation is about 1,900 feet thick. Farther west, in the region here considered, the formation probably does not reach so great a thickness. The beds were laid down in shallow basins in which deposition took place first in the lowest parts; later, as the beds increased in thickness, their area also increased. Thus the formation continued to expand in area, the higher beds overlapping the older rocks of the river basin. Only over the deepest part of the basins was the full thickness of beds developed, and measurements taken elsewhere will show an incomplete section, even though the formation is exposed from the underlying older rocks to the cover of Nenana gravel.

AGE AND CORRELATION.

The age of this formation has been determined largely from the fossil plants that have been found in it, and from its lithologic resemblance to similar beds in other parts of Alaska that have also yielded fossil plants. Although plant remains in the form of lignite and of carbonaceous imprints of leaves and twigs are common, they have in general been so completely lignitized that the plant forms can no longer be determined. Furthermore, the inclosing sediments are little consolidated, and the plant imprints will not stand the handling necessary to bring them out for identification. In the Nenana coal field the best fossil leaves have been collected from beds that h[illegible]een hardened by the burning out of adjacent coal beds, and fr[illegible]ch materials a number of forms have been identified. No collections have been made in this region.

The fossil leaves found in the coal-bearing formation just east of Nenana River indicate that it is early Tertiary, and the Eocene coal-bearing formation of Alaska has often been referred to under the name of Kenai formation. This is the age assigned to the plants taken from the Cantwell formation, already described. The studies of the Cantwell and the coal-bearing sediments in this area, however, show that there is a decided difference in both lithology and structure between these two sedimentary series, a greater difference than can be accounted for by the more severe alteration of the Cantwell due to its position along the line of greatest metamorphism of the Alaska Range. The chief differences between the two formations may be briefly summarized as follows: The Cantwell beds are everywhere well indurated, and comprise hard rocks, including shales, sandstones, and hard conglomerates, whereas the beds of the coal-bearing formation are almost everywhere little consolidated, and include sands, clays, and fine gravels. The Cantwell is prevailingly of dark, somber colors, being composed for the most part of dark-gray to black beds, whereas the coal-bearing formation is conspicuously light colored, its prevailing shades being white, cream, and buff. The Cantwell formation, although presenting large, clean exposures, has nowhere been found to contain thick coal beds, whereas the coal-bearing beds, even those in the midst of areas of highly deformed Cantwell sediments, are less steeply folded, and preserve their light colors and incoherent character.

As the coal-bearing beds and the Cantwell beds were not found anywhere in direct contact their relative ages have not been proved, but the coal-bearing formation seems clearly the younger. Its general lack of induration and its lesser deformation indicate this, as does also the stratigraphic position of the beds at the localities in Toklat River and Stony Creek. The coal-bearing beds in Highway Pass form a simple syncline, whereas the Cantwell beds in Divide Mountain, just to the east, are highly deformed. The coal-bearing beds were there deposited in a valley that had previously been eroded into a group of hard rocks of which the Cantwell is one formation. Farther west, in the pass between Stony Creek and the southeast head of Moose Creek, the same situation exists. The Cantwell in the area just north of the pass, where it is separated from the coal-bearing beds only by a narrow belt of igneous material, is standing on edge and is composed of thoroughly indurated black materials. The coal-bearing beds, apparently here also deposited in a valley eroded into the lavas and Cantwell sediments, are unconsolidated, of light colors, and much less deformed than the Cantwell. They contain [illegible]es of a conglomerate that is identical in general appearance with much of the Cantwell conglomerate. If the conglomerate pebbles were derived from the Cantwell the younger age of the coal-bearing beds at this place is proved, for the Cantwell conglomerate, to have yielded the pebbles, must first have been indurated to a hard rock and then subjected to erosion.

The facts above cited have convinced the writer that the coal-bearing formation is younger than the Cantwell, although the case can not be considered as conclusively proved until the two formations are found in direct contact or until a distinction is recognized between the floras which they contain. If his conclusions, based on structural, stratigraphic, and lithologic grounds, prove to be correct, then the assemblage of fossil plants that have hitherto been referred to the Kenai must have a wider stratigraphic range than has been supposed, and the rocks containing them must vary widely in lithology, deformation, and age.

NENANA GRAVEL.

CHARACTER AND DISTRIBUTION.

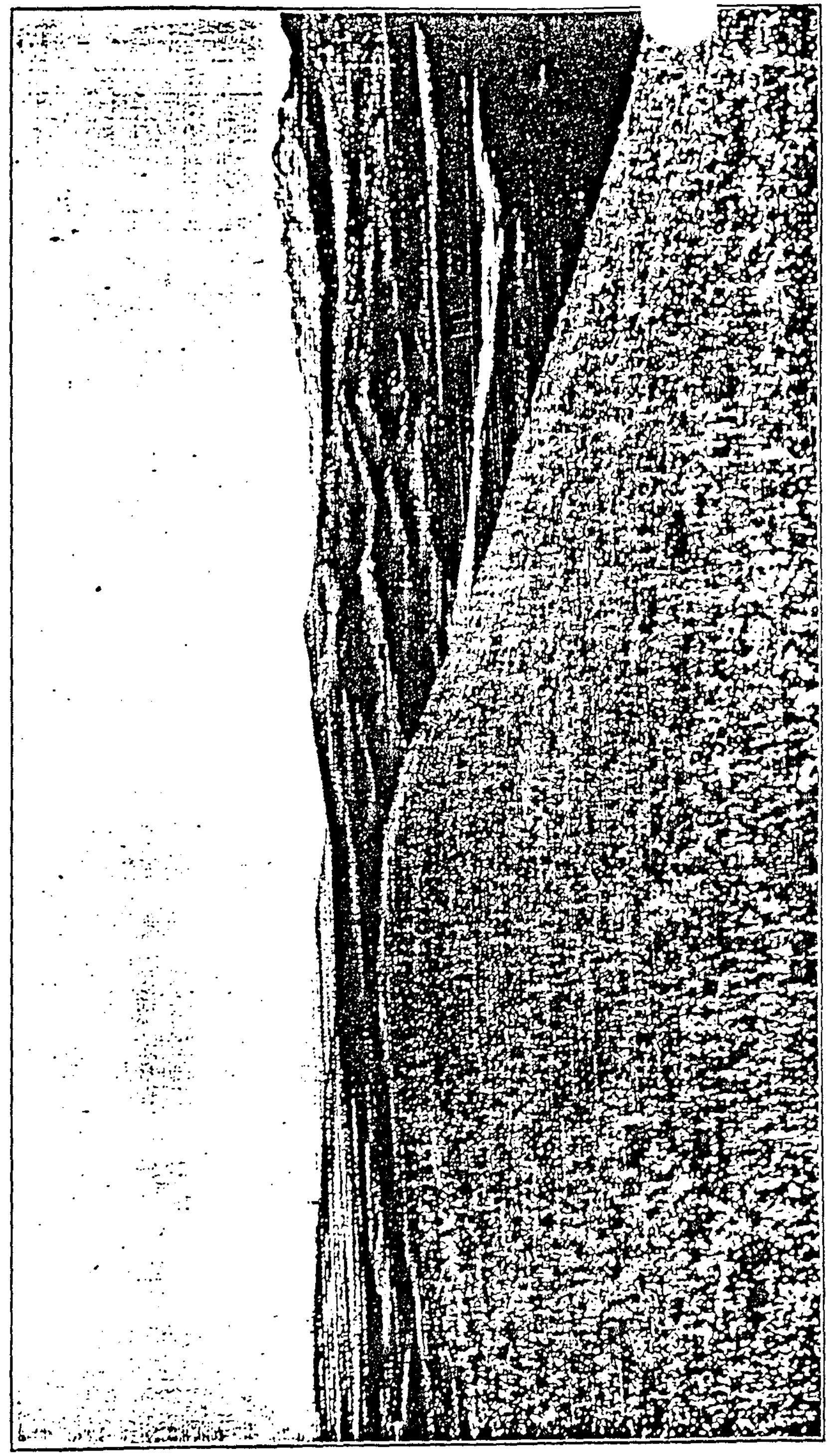
The term Nenana gravel was first used by Capps[1] to designate a series of elevated gravels that reaches a widespread development on the north flank of the Alaska Range and is well exposed on both sides of Nenana River near the mouths of Hoseanna (Lignite), Healy, and Dry creeks. These gravels were first studied by Brooks and Prindle in 1902, were regarded as of glacial origin, and were grouped with the other Pleistocene deposits on the geologic map.[2] Prindle again visited the Bonnifield and Kantishna regions in 1906, and although he published no geologic map he added much to our knowledge of the distribution and stratigraphy of the various geologic formations. His study of the elevated gravels there, which led him to a different conclusion as to their age, is discussed on page 54. In 1910 Capps studied the gravels in the Bonnifield region, outlined the areas in which they occur, and arrived at the conclusion that they are of Tertiary age. In the progress of the present investigation the Nenana gravel was encountered and more information was gained in regard to its extent and stratigraphic relations. The study of the Nenana coal field by G. C. Martin[3] and his associates, also made in 1916, should give much detailed information concerning the relations of the Nenana gravel to the coal-bearing Tertiary in that locality.

[1] Capps, S. R., op. cit., pp. 20–34.
[2] Brooks, A. H., op. cit., pl. 9.
[3] U. S. Geol. Survey Bull. 664 (in press).

The [illegible] work done by the geologists cited above has furnished outlines of the areas occupied by these high-level gravels between the Kantishna Hills on the west and Delta River on the east. East of Nenana River they occur as irregular patches bordered by older rocks, as scattered gravel capping ridges from which most of the deposit has been removed by erosion, and as extensive areas forming prominent ridges and ranges of hills. West of the Nenana they reach their greatest extent between that stream and the East Fork of Toklat River, where they form a conspicuous range of foothills. (See Pl. XVI.) Less extensive areas were mapped on Sanctuary River above its lower canyon, near the mouth of Savage Fork, and on Glacier Creek in the Kantishna mining district. On the geologic map (Pl. II, in pocket) they have been shown only where their character is evident and where they are not covered by later materials. In the area of their greatest extent, west of Dry Creek, they dip northward beneath the younger gravels and may be continuous beneath the surface with the gravels shown near the mouth of Savage Fork, and possibly occur in large areas along the whole depression extending from Nenana River to the Kantishna Hills. They probably also occur in the area north of the northernmost range of foothills and may even occupy the surface in parts of that area. No opportunity was available for a careful study of that part of the field. Furthermore, these gravels may be present in the lowland of upper Kantishna River, although they have not been differentiated there.

The Nenana gravel comprises a thick series of unconsolidated or only loosely cemented material consisting in large part of beds of rather coarse, well-rounded gravel, with only a minor amount of sand. Most of the pebbles are small, ranging from 1 inch to 3 inches in diameter, but cobbles a foot in diameter were seen. In one well-exposed section on Dry Creek about 5 per cent of the bluff was composed of thin beds of sand. The pebbles include many kinds of rock, among which the commonest are quartz, quartzite, schist, and conglomerate, as well as many kinds of igneous material. All these rocks occur in the Alaska Range, to the south, and the gravels were no doubt derived from the main range. At some places the gravels are sufficiently indurated to stand in steep cliffs, but on weathering the sand matrix crumbles and frees the pebbles. A characteristic feature of the Nenana gravel is its yellow or buff color, which distinguishes it sharply from most of the more recent gravels. This color is due to the oxidation of iron-bearing minerals in the sandy matrix and in the pebbles and indicates that the deposit is older than the blue and gray unoxidized gravels of the present stream valleys.

The topographic features formed by erosion on the gravel deposits are generally smoothly rounded, and throughout most of the area



VIEW EASTWARD ALONG NENANA GRAVEL RIDGE OF TEKLANIKA BASIN.

in which they occur the gravels are so deeply cov... by loose surface material and by vegetation that their structure can not be made out. Only where vigorous streams have cut into the gravel hills and formed bare bluffs can sections showing the character and structure of the beds be found. The present topography is due in part to the structure of the material, but the readiness with which the gravels break down and the absence of any hard, resistant beds have given the hills their smooth outlines.

STRUCTURE.

The character and composition of the gravel beds indicate that they were laid down by streams. They show the same arrangement of material, lack of complete assortment, and lenses and thin beds of sand that are seen in the stream gravels now being deposited along the larger streams, and they include no well-stratified and assorted silts and sands such as are commonly formed in bodies of standing water. This gravel series was probably laid down by streams flowing northward from the mountains, after they had been rejuvenated and steepened by the uplift of the mountain mass. The steepened streams, able to carry more and coarser material than formerly, removed large quantities of rock from the mountains, rounded and shaped that material as it was carried northward, and deposited it at the edge of the lowland as a great, compound alluvial fan, the deposits of each stream spreading laterally along the slopes to join those of its neighbors to the east and west.

Since the gravels were laid down the mountain-building processes have continued, and the gravels themselves are locally tilted, uplifted, and faulted. The hills extending from lower Dry Creek to Sushana River exhibit monoclinal dips to the north as great as 12°. On their south edge the gravels are cut off, apparently, by a fault; to the north they dip beneath the younger deposits. In the valley of Glacier Creek the beds at the single exposure where they were studied also dip northward, and this is the prevailing dip in the Nenana coal field where the gravels, which apparently lie conformably upon the Tertiary coal-bearing formation, dip 10° to 15° N. Similar structural relations have been found east of Nenana River, where the Nenana gravel in general shows deformation in about equal degree with the associated coal-bearing sediments.

THICKNESS.

The most complete section of the gravel that has been measured is that on lower Healy Creek, where Prindle[1] found it about 2,000 feet thick, lying in apparent conformity upon the coal-bearing for-

[1] U. S. Geol. Survey Bull. 501, fig. 3, p. 58, 1912.

mation. The writer[1] estimated that its thickness was even greater on Gold King Creek, though the exposures there were too poor to permit exact measurements. On lower Dry Creek a steep, bare bluff shows above 700 feet of uniform oxidized gravels. An estimate of the thickness of the formation at the high ridge north of the Dry Creek-Ewe Creek divide, in which the vertical thickness and the dip of the beds were taken into account, indicates a thickness perpendicular to the bedding of about 1,600 feet. The gravel reaches its greatest thickness on this ridge. At other places it is thinner, either because of erosion of part of it or because it did not accumulate there so abundantly as at the other places mentioned. If it was deposited in the way already described, it must originally have varied greatly in thickness from place to place, owing to the unevenness of the surface upon which it was laid down and to the natural thinning of the alluvial fans toward their borders. At present the gravel ranges from a deposit having the maximum thickness noted, 2,000 feet, to a thin layer or even to scattered pebbles on the ridges from which all but a remnant of the formation has been removed.

AGE AND CORRELATION.

The age of the Nenana gravel is still somewhat uncertain. No fossils, either plants or other organisms, have been found in it, and any conclusions as to its age must be based upon its stratigraphic relations to other formations and upon its physiographic position, general structure, and resemblance to other formations of less doubtful age. As first mapped by Brooks[2] it was grouped with the Quaternary deposits, and was considered Pleistocene. Prindle[3] and Capps,[4] both of whom studied the gravel in the Bonnifield region, observed that in many places it apparently lies conformably upon the coal-bearing formation, and that in those places the gravel has been deformed in equal degree with the coal-bearing formation. The imperfect exposures of the two formations west of Nenana River also indicate a general parallelism of bedding between the gravel and the coal-bearing sediments. On the other hand, near Wood River, in the Bonnifield region, the gravel is little deformed, and lies unconformably upon the steeply dipping coal measures, so that at least a part of the gravel is much younger than the coal-bearing formation. The apparent anomalies in different parts of the field are best explained by considering the physical conditions in the region when the gravel deposition began. The laying down of the coal-bearing series was terminated by an uplift of the Alaska Range, which caused the steepened streams to discharge coarse material over areas that had before received only silts, sands, and fine gravels. The uplift was probably not everywhere equal, so that in one place coarse gravels may have been laid down conformably upon the coal-bearing formation, while elsewhere that formation remained uncovered. As the coal-bearing formation also became involved in the uplift its beds may here and there have been tilted and eroded and later unconformably covered with gravel. Therefore conformity between the two formations might exist at one place, whereas they might be in unconformable contact at another place not far distant.

[1] Capps, S. R., op. cit., p. 32.

[2] Brooks, A. H., op. cit., pp. 108–109.

[3] Prindle, L. M., The Bonnifield and Kantishna regions: U. S. Geol. Survey Bull. 314, p. 222, 1907.

[4] Capps, S. R., op cit., pp. 32–34.

In studying the relations of the two formations it is necessary to bear in mind the fact that gravel beds composed of material derived from the Nenana gravel may so closely resemble it in color and composition that the two can be distinguished only with great difficulty. This difficulty was experienced at many places along the east side of Nenana River, below Hoseanna Creek, where the Nenana gravel forms an important element of the east valley wall. There reworked gravels, obviously derived from the Nenana gravel of the slope above, form terraces along the valley side and should be correlated with much younger terraces than those formed of the Nenana gravel which they so closely resemble. At some places the reworked materials lie upon the Nenana gravel, and their later age can be determined only in those rare exposures which exhibit the structure of both classes of material. Such reworked materials also lie unconformably upon the coal-bearing sediments, and unless their true character is recognized they give the impression that the section shows an unconformity between the Nenana gravel and the coal-bearing formation. The actual relations between the Nenana gravel and the coal-bearing formation can be determined only by careful study, in which a keen discrimination is made between undisturbed Nenana gravel and the closely similar but reworked and much younger terrace materials derived from them.

The determination of the time at which the deposition of the gravels ceased is also difficult. Brooks considered them Pleistocene, supposing that they were laid down by flood waters during the retreat of the Pleistocene glaciers. It now seems certain, however, that during the last great ice advance the glaciers moved down valleys that had already been deeply eroded in the Nenana gravel. The terminus of the Nenana Glacier at its maximum stand during the last glacial stage stood at the mouth of Dry Creek, where a distinct terminal moraine was deposited. No evidence of glaciation of that stage was observed below Dry Creek. As the Nenana gravel had been uplifted and deeply eroded before that ice advance it is certainly older than that stage. Our knowledge of the glacial history of Alaska before the last great ice advance is scanty, but locally there have been at least two glacial stages,[1] one much earlier than the other, and there may have been several. Thick deposits of glacial till and tillite are found in the valley of White River, near the international boundary, and the conditions that caused successive glacial stages there no doubt affected other parts of Alaska also. In 1910 the writer[2] noted large boulders on the top of the Nenana gravel, near Hoseanna Creek, and in the valley of Gold King Creek, and though he could not explain their presence he expressed doubt as to their glacial origin, for they lay high above the limits reached by ice during the last glacial advance. At that time an earlier stage of glaciation in Alaska had not been recognized. Similar boulders were observed in 1916 on the top of the Nenana gravel hills near Savage River. In that year G. C. Martin and his associates found many such boulders on the high ridge between Totatlanika basin and Nenana River, and they consider them as of glacial origin. If so they represent a glacial advance that antedated by a long period the last ice advance, and were placed in their present position by a glacier much larger than the last one, if the ridge on which they lie has not been uplifted since they were dropped there. Although the establishment of a glacial origin for these boulders will modify the previous conclusions as to the maximum extent of the glacial ice, it does not prove the glaciofluvial origin of the Nenana gravel. All the boulders observed lie on the top of the Nenana gravel, which must have been present before the ice advanced to it, in order to receive glacial boulders on its surface. The physiographic development of the gravel, which, after its uplift and tilting, was eroded into mature topographic forms, with deep intersecting valleys, indicates a considerable age for the gravel, as does also its thorough oxidation. The apparent stratigraphic conformity of the gravel with the coal-bearing formation, where both have been steeply tilted and deformed, also points to a similar age for both formations.

To summarize briefly, the Nenana gravel, as studied over a long belt along the north flank of the Alaska Range, appears to be generally conformable with the coal-bearing formation, though locally unconformities appear. Its deformation, advanced oxidation, and mature topographic forms indicate that it is of considerable age. It is certainly much older than the deposits of the last stage of glaciation which lie in valleys deeply eroded into the gravel. Boulders, apparently glacial, lie on its surface high above the limits

[1] Capps, S. R., The Chisana-White River district, Alaska: U. S. Geol. Survey Bull. 630, pp. 63–67, 1916.

[2] Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, pp. 33–34, 1912.

reached by the last great glaciers, but those boulders have been seen only on the surface of the gravel and not interbedded in it.

Any determination of the age of the Nenana gravel can be only tentative. It is younger than the Tertiary coal-bearing formation and much older than the last glacial deposits. The writer is inclined to classify it as Tertiary.

IGNEOUS ROCKS.

Igneous rocks are found in all the formations discussed in this report, from the Paleozoic Birch Creek schist to the Tertiary coal-bearing formation, and a microscopic study of them in thin section was made by R. M. Overbeck. They have almost as wide a range in age as the sedimentary rocks. Thus the Birch Creek schist contains basic greenstones that were apparently lava flows extruded upon and interbedded with the water-laid sediments of which the formation is largely composed. If the greenstones are actually interbedded with the sediments, they are of course of the same age. The Tatina group, although cut by intrusive rocks, is comparatively free from igneous material. The Tonzona group, though dominantly sedimentary, contains some metamorphic rocks of igneous origin, and the Totatlanika rocks are composed predominantly of metamorphosed igneous materials.

A series of greenstone flows, apparently at least 2,000 feet thick, appears beneath the Cantwell sediment in the upper Toklat basin. The beds are prevailingly dark-green, brown, or deep purple, are commonly amygdular, and in some flows show ellipsoidal structure. These characteristics indicate that the greenstones were poured out as lava flows on the surface, or perhaps in part beneath water. The section studied contained little interbedded sedimentary material and no fossils. The only stratigraphic relation that could be made out was that the greenstones appear to lie unconformably beneath the Cantwell and are therefore pre-Tertiary. Although conclusive evidence of their age has not been found in this region, the suggestion is made that they may be late Paleozoic or early Mesozoic. In the Broad Pass region Moffit[1] found similar greenstones that he tentatively classified as Triassic. At the headwaters of White River a similar group of lavas seems to be transitional between the Paleozoic and Mesozoic.[2] Lavas that seem to be a continuation of those in the Chisana-White River district have been mapped in the Nizina district[3] as the Nikolai greenstone, where they lie conform-

[1] Moffit, F. H., The Broad Pass region, Alaska: U. S. Geol. Survey Bull. 608, pp. 26–28, 1915.

[2] Capps, S. R., The Chisana-White River district, Alaska: U. S. Geol. Survey Bull. 630, p. 47, 1916.

[3] Moffit, F. H., and Capps, S. R., Geology and mineral resources of the Nizina district, Alaska: U. S. Geol. Survey Bull. 448, p. 63, 1911.

ably be[illegible] the Triassic Chitistone limestone and were considered Triassic or pre-Triassic. Similar amygdaloidal greenstones, either of upper Paleozoic or lower Mesozoic age, are found in other parts of Alaska, so that during one of those periods lavas of that type were poured out over wide areas in Alaska. In the absence of definite evidence from the Kantishna region the age of the greenstones of the upper Toklat basin must remain undetermined for the present and their correlation with the late Paleozoic or early Mesozoic greenstones of other parts of the territory must be considered as a suggestion only.

The occurrence of rhyolite, andesite, and diabase lavas in both the Cantwell and the coal-bearing Tertiary beds has already been mentioned, and those flows in the coal-bearing beds apparently represent the latest volcanic outbursts in this region.

Dikes and sills of granular intrusive rocks, including diabase and andesite and rhyolite porphyries, cut all the formations up to and including the coal-bearing Tertiary beds. In the vicinity of the Kantishna mines larger masses of granitic materials, including quartz porphyry containing abundant orthoclase, cut the Birch Creek schist, and in the vicinity of Muldrow Glacier, south of the area shown on the accompanying map (Pl. I), there are considerable areas of andesite, of dacite and rhyolite porphyry, and of granodiorite. These granitic materials are presumably related to the intrusion of large masses of granitic rocks within the Alaska Range—intrusions that have been generally considered to be of Jurassic age.

QUATERNARY DEPOSITS AND HISTORY.

PREGLACIAL CONDITIONS.

The uplift of the Alaska Range, which began in early Tertiary time, proceeded intermittently. After the first elevation the coarse, stream-laid materials that comprise the Cantwell formation were laid down. This elevation was followed by a period of quiescence, during which the finer coal-bearing sediments and the vegetation that later became lignite coal accumulated. Another uplift caused the steepened streams to bring down the Nenana gravel. The continued growth of the mountains then began to spread northward and involved the area now included in the foothills. Faulting and folding elevated the foothills belt, and the vigorous northward-flowing streams began to intrench themselves in the easily eroded Nenana gravel, in the coal formation, and in the ridges of hard rock that crossed their courses. As these soft materials yielded to stream cutting much more rapidly than the hard rocks the basin between the rock ridges were widened and deepened while the streams were engaged in their long task of cutting canyons through the rock ridges. The valleys lying within the Tertiary unconsolidated sediments thus reached a mature topography while [illegible]anyons in the schists and gneisses were still young.

GLACIAL CONDITIONS.

OLDER GLACIATION.

At the beginning of Pleistocene time a change of climate occurred, involving an increase in precipitation and perhaps also a colder mean annual temperature, so that areas in the high mountains received more snow each winter than melted during the succeeding summer. This continued year after year; the snow banks enlarged and joined, and valley glaciers were formed. At first glaciers could exist only at the heads of valleys in the high mountains, but as the process continued many ice tongues, converging from the headwaters of the streams, joined to form great valley glaciers that extended downward toward the flanks of the mountains.

Our knowledge of the events of early glacial time in Alaska is meager. In the northern part of the United States and in Canada there were a number of glacial advances, separated by long periods of time, during which the ice edge withdrew to the north; but the evidence for Alaska is not so complete. The last great stage of glaciation in Alaska was without much doubt contemporaneous with the last or late Wisconsin continental glaciation,[1] but the earlier stages of Alaska glaciation have not yet been correlated with those that occurred in the central part of the continent. Indeed, it is only within the last few years that positive evidence of more than one stage of glaciation in Alaska has been found. In 1891 Russell[2] observed on the southern slopes of Mount St. Elias some elevated marine deposits containing boulders that he believed to be of glacial origin. Maddren[3] in 1913 studied the same deposits, and agreed with Russell in assigning to the boulders a glacial origin. In 1914 the writer[4] found a thick series of deformed beds of glacial till and tillite and associated outwash gravels in the upper basin of White River, the whole series being undoubtedly much older than the deposits laid down by the glaciers during their last great advance. The last glacial stage was correlated rather definitely with the late Wisconsin stage of continental glaciation. In 1910[5] the writer also observed many large boulders on the surface of the Nenana gravel

[1] Capps, S. R., The Chisana-White River district, Alaska: U. S. Geol. Survey Bull. 630, pp. 69–75, 1916.

[2] Russell, I. C., An expedition to Mount St. Elias: Nat. Geog. Mag., vol. 3, pp. 170–173, 1890; Second expedition to Mount St. Elias, in 1891: U. S. Geol. Survey Thirteenth Ann. Rept., pt. 2, pp. 24–26, 1893.

[3] Maddren, A. G., Mineral deposits of the Yakataga district: U. S. Geol. Survey Bull. 592, pp. 131–132, 1914.

[4] Capps, S. R., The Chisana-White River district, Alaska: U. S. Geol. Survey Bull. 630, pp. 63–75, 1916.

[5] Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, pp. 33–34, 1912.

near Nenana River, and, although he considered the possibility of their glacial origin, he was at that time inclined to doubt that they had been brought to their present position by glacial ice, as they lay high above the elevation reached by the glaciers during their last great advance. In 1916 similar boulders were found on top of the Nenana gravel near Savage River, and G. C. Martin and his associates, while studying the Nenana coal field, reached the conclusion that the boulders there are certainly of glacial origin. Thus evidence is accumulating that there have been recurrent glacial stages in Alaska, separated by long intervals during which the ice retreated.

In the basin of Nenana River the evidence furnished by the large erratic boulders indicates that at one time an ice tongue pushed down that stream to the north edge of the foothills, and that at the mouth of Hoseanna Creek its surface stood at an elevation of at least 3,800 feet, or 2,600 feet above the present level of Nenana River, near by. An even greater elevation of the ice surface is indicated by boulders on the Nenana gravel ridge east of Savage River and north of the Ewe Creek-Dry Creek divide, where they were found at a height of 3,980 feet. These figures are based on the conclusion reached by Martin that the boulders are glacial, and on the assumption that no uplift of the gravel hills has occurred since the boulders were dropped, an assumption concerning which we have at present no evidence, either for or against. Farther west, in the upper basin of Moose Creek, erratic boulders occur in positions along Moose Creek itself and in the valleys of its tributaries, Eureka and Eldorado creeks, that show the former presence of ice to a considerable elevation. Those boulders, however, may have been laid down by the greatly expanded Muldrow Glacier at the time of the last ice extension. Elsewhere in the region no evidence of a glacial stage earlier than the last notable one has been obtained.

ADVANCE OF THE LAST GREAT GLACIERS.

No matter how many major glacial advances there have been in this region, it is known that before the last glacial stage began a long time elapsed during which there were no large glaciers in the main mountain valleys, and that the normal processes of weathering and stream erosion were in operation throughout this area. With a renewal of climatic conditions favorable for ice accumulation, however, the ice tongues began once more to grow and to push northward down the stream valleys. In advancing over a country long bared to the action of atmospheric agencies they encountered great quantities of soil, talus, and stream gravels which they picked up and carried northward. As the glaciers removed the surface materials, the rock-filled ice moved over fresh rock, which it ground down and from

which it plucked out great blocks of rock. By these processes, which were in operation for a long time, the irregularities of the valley walls and bed were removed, and broad glacial troughs, now so characteristic of the mountain valleys, were formed.

EXTENT OF GLACIATION.

As already stated, glacial boulders and beds indicate that during an earlier glacial stage ice advanced down the valley of Nenana River as far as the north front of the foothills. Similarly, in the valley of upper Moose Creek and near the mouth of Clearwater Fork of Toklat River there are erratic boulders that suggest the former presence of ice, but in those places the outer limits reached by the last great glaciers have not been accurately determined, and the boulders may have been deposited during the final advance of the ice.

During their last advance the glaciers of the Alaska Range left moraines that show definitely the farthest northern position they reached. Thus in the valley of Nenana River a distinct terminal moraine extends to the mouth of Dry Creek, and below that point there is no definite evidence of glaciation of that stage. Similarly, in the valleys of Sanctuary and Teklanika rivers the outermost recognizable terminal moraines lie north of the prominent eastward-trending range of mountains composed of Birch Creek schist. (See Pl. II, in pocket.) In Toklat basin, likewise, the evidence indicates that the mountain glaciers terminated within the mountain valleys and failed to cross the high ridge of Birch Creek schist. In the vicinity of Muldrow Glacier, however, there is every indication that that ice tongue was formerly much expanded. It overrode the divide into upper Moose Creek, filled the upper basin of that stream to a considerable depth, and was flanked on the north by the Kantishna Hills. Some of the ice from this glacier moved northward into the basins of Stony River and Clearwater Fork of Toklat River, but the main outlet was westward along McKinley River. Some ice pushed a short distance northward through the upper canyon of McKinley River, but the main ice tongue is believed to have moved westward into the valley of Birch Creek, west of the area here described. Extensive morainal deposits were laid down in the upper basin of Moose Creek and over the McKinley River-Moose Creek divide. (See Pl. II, in pocket.) The exceptionally large size reached by Muldrow Glacier at that time, in comparison with the much smaller glaciers in the valleys to the east, is due to the altitude of the mountain slopes that drain to it and to the size of the upper Muldrow basin. That glacier once received the ice from the north slope of the range, in its highest part, for a distance extending eastward for more than 30 miles.

The limit reached by the glacial ice in the Kantishna region during the last great stage of glaciation corresponds well with the outermost moraines recognized in the Bonnifield region to the east.[1] Thus in the valleys of Wood River, Little Delta River, Delta Creek, and Delta River the ice tongues, as shown by their morainal deposits, reached almost to the northern front of the mountains, if not a short distance beyond. The glaciers that moved down Nabesna and Chisana River valleys, still farther east, terminated a short distance beyond the border of the mountains. On the south slope of the Alaska Range the situation was very different. The precipitation on that slope was apparently much heavier than on the north or inland slope, for the glaciers there were much larger than those in the Yukon basin. At the time of maximum glaciation the entire basins of both Copper and Susitna rivers were occupied by glaciers. The Susitna Glacier not only extended southward into the Cook Inlet depression but was of sufficient depth to send a northward-flowing tongue through Broad Pass into the valley of Nenana River. Similarly, the Copper River glacier overflowed northward through the range into the valley of Delta River and through other passes still further east. This dissimilarity in the abundance of glacial ice on opposite sides of the same range must have been due in large measure to the difference in precipitation on the two sides.

RETREAT OF THE ICE.

After the glaciers had reached their greatest extension another change in climate, perhaps a decrease in precipitation, came about, which was less favorable to the growth and support of the ice fields, so that they began to shrink both in thickness and in area. The withdrawal of the ice tongues, like their advance, was not constant but was marked by a number of oscillations; but as the supply of snow in the mountains, on the whole, diminished, the sum of the many minor advances, halts, and retreats was a corresponding diminution of the ice-covered area. This diminution continued until many valleys that had once contained large glaciers were free of ice and such other glaciers as still persisted were greatly shrunken. The present glaciers of the Alaska Range are remnants of Pleistocene glaciers, and the ice withdrawal that marked the end of Pleistocene time is believed to have brought about the retreat of the glaciers to approximately the positions they now occupy.

PRESENT GLACIERS.

No important glaciers appear on the accompanying map (Pl. I, in pocket), for the area here discussed comprises only the northern spurs

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

and valleys of the Alaska Range; it does not include the crest of the main Susitna-Tanana divide. Few mountains in this area are high enough to maintain perpetual snows. Farther south, along the crest of the mountain range, glaciers are still found in the heads of nearly all the valleys. Between Nenana River and Muldrow Glacier the mountains are of only moderate height, and the northward-flowing glaciers are small, the largest being only a few miles long. Farther west, toward the higher peaks of the range, the glaciers are larger. Muldrow Glacier, which stands near the head of Moose Creek, at the southern border of the area mapped, is the largest glacier that drains the inland front of the Alaska Range. Heading near the very summit of Mount McKinley, it flows northeast, then north, and then west, and emerges from the mountains at the head of McKinley River, having a total length of 39 miles.

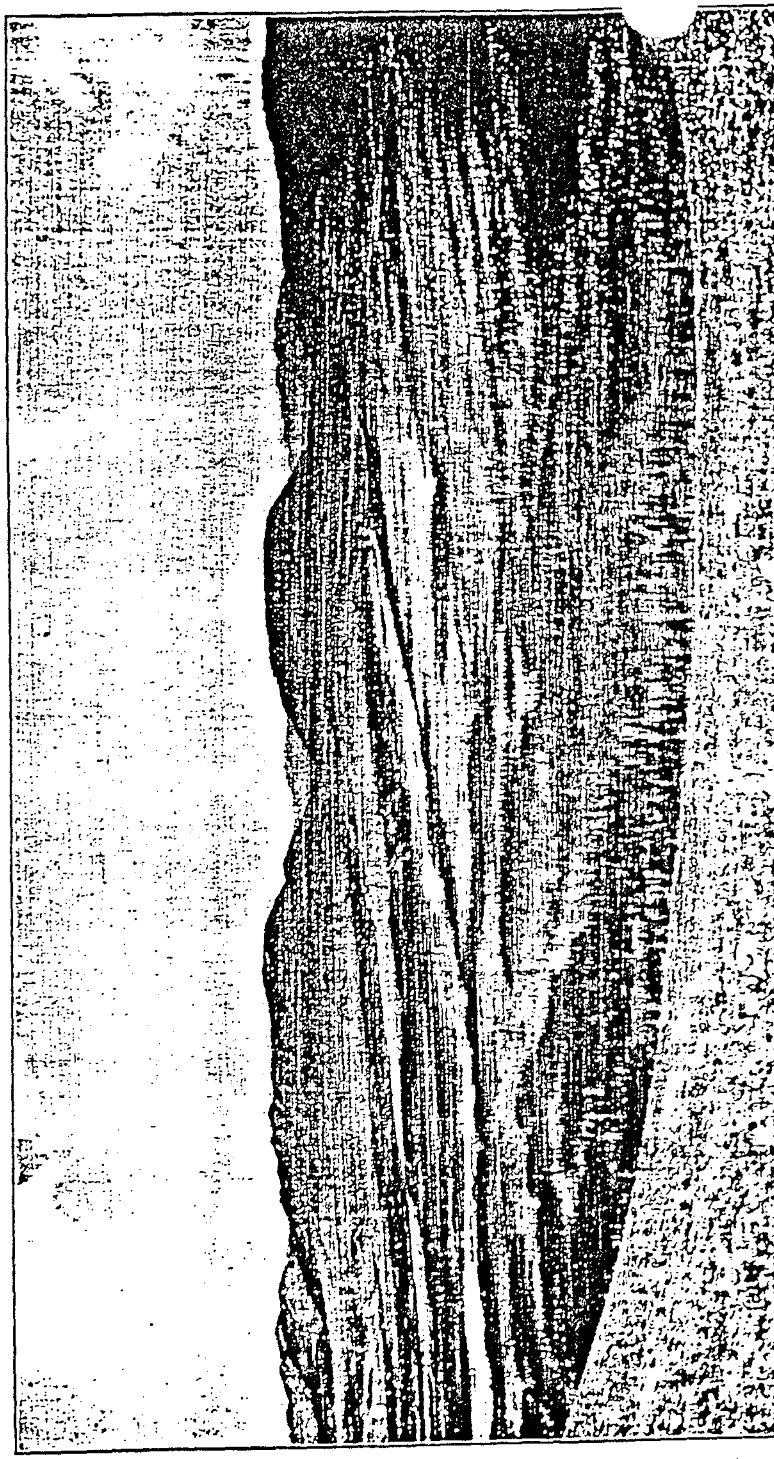
GLACIAL DEPOSITS.

Although deposits of morainal material are widely distributed throughout the area covered by the glaciers during their last great advance they are in most places hidden by vegetation and are inconspicuous. At a few places there are readily recognizable terminal moraines, which mark the outermost stand of the ice during its last period of expansion. One such moraine lies on the west side of Nenana River just above the mouth of Dry Creek. (See Pl. II, in pocket.) Its surface, like that of most other moraines, is hummocky and irregular, and the larger depressions in it are occupied by ponds and lakelets. It is so overgrown with moss and brush that it affords little opportunity for a study of the materials of which it is composed. Another terminal moraine, in the upper valley of Sanctuary River, is formed of two crescentic ridges that converge downstream and are separated from one another by the flat over which the present stream flows. A similar terminal moraine may be recognized on Teklanika River, where the ice advanced about as far as it did on Sanctuary River. A broad basin in the upper valley of East Fork of Toklat River is floored with morainal materials that show no distinctive glacial topography, but the northernmost stand of the ice in that basin and in the valley of Toklat River is not accurately known, for no terminal moraines were observed. Glacial materials and evidences of glacial erosion were seen in both valleys as far downstream as the canyons through the ridge of Birch Creek schist, but the canyons were apparently not glaciated, and the northward-moving ice in the valleys probably extended no farther than the canyons. A large area north and northwest of the terminus of Muldrow Glacier, occupying the upper basin of Moose Creek and extending into the basin of Stony Creek, is covered with glacial moraine and outwash gravels. The area is one of smooth slopes and flat-topped ridges, which are so well covered with vegetation that good exposures are rare. Outcrops of hard rock are lacking, but gravels and a few erratic boulders scattered over the surface indicate that at least the surficial deposits are glacial.

TERRACE GRAVELS.

Large areas in the Tanana lowland and in the basins between the foothill ranges are covered with stream-laid gravels that are related to the present topography but that lie above the level reached by the present streams, even when they are at flood stage. These gravels form terraces along the stream valleys and occupy the interstream areas in those basins that lie between the foothill ranges and in the great lowland north and northwest of the foothills. (See Pl. XVII.) The term "terrace gravels" has been applied to all material of this class, to distinguish it from the much older and generally deformed Nenana gravel and from the deposits of the present streams.

The terrace gravels are stream laid, and resemble the deposits of the present streams in composition, structure, and degree of assortment. They consist primarily of well-rounded gravels, varying considerably in coarseness from place to place, intermingled with which are considerable sand and silt, both as an interstitial filling between the pebbles and in irregular beds and lenses. In general the terrace gravels are undeformed, and their surface slopes are the slopes of deposition, somewhat modified by subsequent erosion. Their topographic position indicates that they were laid down by streams that followed in a general way the courses of the present drainage lines, but they have been left in their present elevated positions by the lowering of the adjacent stream valleys through normal stream erosion. The terrace gravels are commonly little oxidized; they maintain their original grayish color and thus contrast sharply with the thoroughly oxidized and yellow Tertiary gravels. In most exposures examined they are not very thick, though they range from 2 or 3 feet to 20 feet or more, but they cover wide areas to a depth sufficient to hide the underlying deposits. Their surface is commonly covered with vegetation. Locally the character of the terrace gravels is strongly influenced by the character of near-by materials from which they were originally derived. Thus, along the east bank of Nenana River many deposits were seen that, as shown by their physiographic position and form, obviously belong with the terrace gravels, but that were composed of oxidized and yellow materials closely resembling in appearance the Nenana gravel. In those places the distinction must be based on the physiographic evidence, for the



CANYON IN BIRCH CREEK SCHIST ON TEKLANIKA AND SANCTUARY RIVERS.

terrace gravels there have been derived wholly or in la[illegible]rt from near-by ridges of Nenana gravel and retain the oxidized character of the ancestral deposit but have taken on the physiographic form of the much younger terrace materials.

The general physical condition and form of the terrace gravels, their resemblance to similar materials in the Bonnifield region, and their relations to the glacial moraines indicate that in part at least they are composed of outwash materials laid down beyond the ice border at the time of the last great ice advance. At some places they consist of material brought from a distance by streams. At others they are composed largely of material of local derivation that has been rehandled and reshaped into new physiographic forms but moved no great distance from its source.

The fact that in a single stream valley there may be a series of terraces, one above the other, shows conclusively that the materials composing those terraces vary considerably in age, the lowest being the youngest and the highest the oldest. Such stream terraces have probably been continuously in process of formation from glacial time until the present, and the terrace gravels therefore range in age from Pleistocene to Recent. Placer gold has been found in encouraging amounts at several places in the terrace gravels, and at one place a considerable amount has been recovered by mining. The so-called "benches" on Moose, Glacier, and Caribou creeks are auriferous, and it is possible that the terrace gravels may at some time be extensively mined.

PRESENT STREAM GRAVELS.

The gravel deposits of the present streams have been laid down under conditions essentially like those that now exist in the region. In this class are included only gravels that occupy the flood plains of the present streams and that may be overflowed in periods of high water. As a result of their method of formation the stream gravels appear on the map (Pl. II, in pocket) as long, narrow bands following the windings of the stream valleys. These deposits are really continuous, but at places where there are narrow rock canyons the streams may entirely cover the valley floor, or the stream deposits may appear only as patches too small to be shown on a map of this scale.

The width of the belt of gravels along any stream depends in large measure upon the size of the stream, the shape of the valley floor, and the amount of material that the stream carries in suspension. Most of the streams that are fed mainly by water from melting glaciers are heavily loaded with detritus and flow in many branching channels over wide gravel flats. Nenana and Toklat rivers are of this type.

The streams of this area that are not glacier-fed and that flow clear water have in general only narrow flood plains. Bearpaw River and its tributaries are of this type, although, as shown on Plate II, the stream gravels have been mapped to include the meanders of the stream and are therefore wider than the actual flood plain.

Along any single stream the gravels are coarsest in the high mountains, where the stream is confined in a narrow valley and has a high gradient, and become progressively finer with increasing distance from the mountains. Thus Toklat River above Chitsia Mountain and for some distance north of it has in general a wide-floored valley of gravels, over which the heavily loaded stream flows in many branching and constantly shifting channels. Farther north, as the gradient becomes more gentle, the stream drops the coarser materials, carries mainly sand and silt, and flows in a single channel between steep silt banks. Bearpaw River, by contrast, flows clear water, is little inclined to anastomose, has only a narrow flood plain, and meanders deviously between steep banks of sand and silt.

SOIL FLOWS.

Stream erosion in the higher mountains in this region, as in all well-watered regions of high relief, is vigorous, and the streams are actively engaged in shaping the surface by the rapid erosion of the steep, mountain-side gulches, where vegetation is sparse, and by their attacks upon the valley walls as they cut laterally. In the foothills and the intervening basins, however, where the slopes are more gentle, and where the lower elevation is more favorable to the growth of vegetation, a group of subarctic plants, including sphagnum and other mosses, many varieties of grasses, and low shrubs have formed a tough mat of vegetation over the surface that effectually retards the removal of rock waste by streams. Furthermore, in this region the ground remains permanently frozen a short distance below the surface, especially in places where the surface cover of plants affords effective insulation from summer melting, so that stream cutting is thus further retarded by frozen ground. As the matlike cover of turf and moss prevents the streams from attacking the frozen ground, the products of disintegration and weathering are removed by soil creep, or soil flow. Many types of soil flow or of rock-waste movement have been recognized, varying in activity from landslides and sudden flows of soil and mud to soil creep and flowage, in which the movement is much too slow to be visible but which gives surprising results in the amount of transportation accomplished. In the Kantishna region both types of soil movement are in operation. At many places great scars appear on the hillsides—scars formed by the sudden breaking of the turf and the rapid downward flow of large volumes

of mud, rock fragments, and turf, which, being suddenly released, moved to a position of equilibrium in the nearest valley bottom. About a dozen such mud flows, which had evidently moved only a few weeks before the region was visited, were observed, and a few of these were so recent that the surface mud had not begun to dry. The flows ranged in length from 100 to 500 feet and generally showed an expanded, spatulate form at the upper end of the break and a confused piling up of materials in the valley bottom, with a lobelike extension downstream. At many places the flows had dammed small valleys to a depth of 8 or 10 feet above the previous level of the streams. An examination of one very recent flow showed that the soil and vegetable matter, locally called "muck," were saturated with water, and that all the material above the level of ground frost, a distance of 3 or 4 feet below the surface, had moved. The material from the upper end of the scar had slipped along the surface of the ground-frost level. In the neighborhood of the recent flows, and in fact throughout the entire region, countless similar scars on the hillside, now overgrown by a new cover of vegetation, show the process has long been in operation and that the aggregate amount of material moved in this way is very great.

The physics of these sudden soil flows are not well known; they offer an interesting and almost new problem for the investigator. The controlling factors, however, are believed to be slope, vegetative cover, water content, and temperature. Vegetation quickly establishes itself on any favorable slope and, by forming a tenacious fibrous mat, almost completely inhibits the removal of loose material by surface waters. The insulation afforded by the vegetation also favors the permanent freezing of the ground to a level within a short distance from the surface. During the summer, when melting lowers the ground-frost level, frost action and physical disintegration, accompanied by chemical decay, bring about the accumulation of soils and fragmental rock materials. At the same time the accumulation of vegetation and the trapping of wind-blown material by the vegetation build up a layer of wind-blown materials. This mass is saturated with water, and the intermittent growth and melting of ice crystals within the mass makes it very porous. During the long, warm days of spring and early summer the surface portion of this mass thaws, and the melting snows supply abundant water to saturate the whole layer of thawed material. As the mass thaws it becomes semifluid but is held in place by the feltlike cover of roots and moss. As thawing proceeds still further, the mass of water-soaked soil may become too heavy for the vegetation to hold, and if so the turf parts, releasing a great quantity of mud and rock fragments, with slabs of the overlying turf. This material moves down the slope to the valley bottom, where it flattens out, and the scar above is later recovered by a new growth of plants.

The slow type of soil flowage is in operation over large areas, and though less spectacular than the sudden movements, it is actually in the magnitude of its results a much more effective agent of transportation.

The origin and action of the slow soil flows are much the same as those of the sudden and violent flows. The mantle of residual soil, fragmental rock, muck, and vegetation accumulate in the same way. The flows are large and numerous only in areas of permanently frozen ground and the soil in motion consists only of the surficial layer that thaws during the summer. The flows occur only in soil having a large content of water. The types of slow soil flow, however, are numerous. On some high slopes, where the elevation is unfavorable to the rapid growth of vegetation, soil flow may take place uniformly over considerable areas, and the whole surface layer may move downward under the impulse of repeated freezings, the frost heave accomplishing a slight forward movement each time the freezing temperature is exceeded. In such areas the surface slopes are smooth and rounded, and the active movement of the soil may be recognized by the arrangement of rock particles and of vegetation along the lines of downward movement. In general such flows bear only a scanty and incomplete cover of vegetation. A second type of slow soil flow, and one that produces in the aggregate a vast amount of transportation, is in fact almost identical in operation with the sudden flows described above, but in this type the turf is not completely ruptured. In these flows the fairly steep surface slopes, the mantle of soil and muck, the permanently frozen subsoil, the matted plant cover, and the complete saturation with water are all present. After the superficial layer of muck and soil has thawed the semifluid mass tends to sag down the hillside, stretching the turf into a flat, bulbous form. As the turf is tenacious and feltlike, however, it stretches but does not break, and by the continued growth of the surface plants its strength is maintained as the stretching proceeds. In this way a hillside may be entirely covered by mammillary lobes, closely grouped and constantly creeping downhill. The lobes vary greatly in size, ranging from small flows a few feet in height and width at the front edge to large flows, 8 to 10 feet high, having a continuous scalloped front edge several hundred feet long. A single hillside may show many small, separate lobes and a few larger ones, formed by the coalescing of many smaller ones. One variety appears as long, wavelike terraces, successive waves appearing one above the other, the front of each wave lying along the hillside at a nearly uniform elevation.

Though several distinct types of soil flows have been mentioned, there are gradational phases between the types. Thus at one place on the upper slope of a hill there were lobate or mammillary flows; farther down the slope the turf was torn into irregular patches that had been separated from one another by the soil creep; and still farther down much of the surface was free from vegetation, the movement was of nearly uniform speed over the bare slope, and the rock particles and vegetation appeared in linear, ribbon-like bands. In the mammillary or lobate flows the turf may be completely ruptured and produce a small sudden mud flow similar in every respect except size to the large sudden flows already described. (See Pl. XV, A, p. 47.)

Soil flowage of all the slow types is effective on low slopes. The sudden flows of mud were observed only on fairly steep hillsides, but the lobate and terrace-like flows and the areas of uniform movement on nearly bare surfaces occur on mild slopes, some of them as gentle as 10°.

The downward flow of soils, whether rapid or scarcely perceptible, has a direct economic bearing upon the gold placer deposits at different places in the Kantishna Hills, and the effects of the flow may be seen in many valleys where mining is in progress. In the headward portions of the streams the valleys are steep and narrow, and the creeks flow over flood plains that are little wider than the streams themselves. 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 to a depth of many feet. Such "slides," as they are locally called, have been encountered by miners on Eureka, Friday, Glacier, and Little Moose creeks, and on Little Moose Creek a large mass of material, rendered unstable by the excavation of the creek gravels at its base, flowed suddenly into the placer workings, covering the sluice boxes, and filling the cut with a great mass of talus-bearing mud. At some places the unusual depth of bedrock is no doubt due to the influx of surface material from the valley sides, and many claims containing placer gold that are now unavailable for mining would probably yield a profit if the overburden due to soil flowage were absent.

An interesting example of the manner in which a small stream may be rendered ineffective as an agent of erosion was observed in the valley of upper Stampede Creek, where at some places soil flows have encroached so rapidly upon the stream bed that the creek has been unable to remove the material as fast as it reached the valley bottom. Even in stretches where the creek gradient is steep the vegetation-covered banks bulge out from each side and have almost met in place above the stream, which flows in a bed only a few feet wide between high, overhanging banks. At many points a slight advance of the two opposing banks would completely block the stream and force it to flow at a level several feet above its present bed; and no doubt such an event has not been uncommon in the history of that valley.

SUMMARY OF GEOLOGIC HISTORY.

The various rock formations represented in the Kantishna region have now been described, and their age and stratigraphic relations to one another have been discussed, as far as the information available warrants. From the character of the rocks, their degree of metamorphism, their structure, and their interrelations, some of the main events in the geologic history of the area may be almost certainly inferred. Definite correlations of the older formations are, however, unfortunately, not yet made, for they contain few fossils, which are so essential in determining the age of sedimentary formations. Furthermore, many pages of the record are missing, for long periods of the earth's history are unrepresented in this region by rock formations. Several such breaks that are not yet recognized may have occurred. The absence of sediments representing these periods must be accounted for either by assuming that the region was during these times a land mass and so received no water-laid material during these periods, or that beds were laid down but have since been removed by erosion. Fortunately, some formations that are missing here are represented in other parts of Alaska by sediments, the study of which yields information concerning the conditions that prevailed when they were deposited.

The earliest event recorded in the rocks was the deposition, in pre-Ordovician time, of a thick series of sediments, including quartz sands, shales, and a little limestone, with which were interbedded some basic lava flows. After its deposition this whole assemblage was closely folded and metamorphosed and was elevated above the surface of the waters, to be subjected for a long period—how long we do not know—to subaerial weathering and erosion. These materials now constitute the Birch Creek schist. The next event of which we have a record consisted of the submergence of the Birch Creek sediments and the laying down upon them, possibly in Ordovician time, of a series of black shales and limestone—the Tatina group. These sediments were also folded and metamorphosed, uplifted, and eroded, and were later submerged and covered, after a period of uncertain length, by a series of mudstones—the Tonzona group. The deposition of the Tonzona sediment was repeatedly interrupted by great flows of rhyolitic lavas, which finally completely buried the sediments and accumulated in great thickness. Another period of severe metamorphism followed which still further folded and altered the older sediments, and changed the Tonzona sediments to slates, and the rhyolite flows to gneisses, schists, and phyllites, forming the Totatlanika schist. A long gap in the record intervenes between the deposition of the Totatlanika lavas and the next well-defined sedimentary formation. This gap includes the later part of the Paleozoic era and perhaps all of Mesozoic time. The Kantishna region was probably not a land mass during all of that very long time. In other parts of Alaska sediments and volcanic materials, aggregating many thousands of feet in thickness, were laid down during that time, and the Kantishna region also was at intervals probably depressed beneath sea level and received sediments, and at other times lavas were outpoured upon its surface and igneous rocks were intruded at depths within the crust. The only sediments that have been recognized as apparently belonging to this period are certain small areas of limestone that may be of Mesozoic age and the thick beds of basic lavas and greenstones that may be either late Paleozoic or early Mesozoic. The granitic intrusive rocks that are so abundant in the main range south of this area and throughout many parts of Alaska were also intruded during middle Mesozoic time, when also the metamorphism of the Birch Creek schist, the Tatina sediments, and the materials of the Tonzona group and Totatlanika schist was continued until they had been converted almost to their present condition.

Thick deposits of detrital material accumulated in this region during the Tertiary period and it has apparently remained a land mass since the beginning of that period, as there is no evidence of its later submergence. Furthermore, it is believed that for a considerable period during late Mesozoic time the area now occupied by the Alaska Range and the foothills to the north was above water and that during that time it was eroded by streams and reduced to a region of low relief. An important geologic event that occurred during the closing stages of the Mesozoic era or at the beginning of the Tertiary period was the uplift of a part of the Alaska Range, probably along its present axis. This movement was the first of a series of uplifts that by their combined movements have given rise to the range that now contains the loftiest peak on the continent, Mount McKinley. To what height the range rose during the first upward movement we do not know, but certainly to an elevation high enough to rejuvenate the streams so that they flowed over steep gradients and handled coarse materials. The detritus thus removed by the streams at first consisted of coarse gravels, which were carried to the flanks of the mountains and there deposited as widespread gravel fans of low slope. As erosion in the mountains and deposition in the lowlands continued, the stream-laid deposits were increased until accumulations several thousand feet thick were formed. Gravel beds are present from the top to the bottom of this material, the Cantwell formation, but its upper part contains a much larger proportion of fine sandstones and shales and a smaller proportion of gravels than the basal part, indicating that erosion had already reduced the ruggedness of the mountains from which the material came. The accumulation of detritus in the lowlands also decreased the gradient of the streams and rendered them less able to handle coarse gravels.

After the Cantwell formation had been laid down another uplift of the range occurred, which involved not only the area previously uplifted but also the basins in which the Cantwell sediments were deposited. The Cantwell beds, now consolidated into firm conglomerates, sandstones, and shales, were uplifted, folded, and faulted and rapidly eroded by the once more steepened streams. Great valleys were cut into them and into the associated older formations. The rugged topography of the mountain belt was again reduced to modern slopes and the streams discharged little coarse material.

A second group of Tertiary sediments now began to accumulate in the broad valleys and basins of the area north of the mountain crest. These materials included some fine gravels but were predominantly sands and muds. The deposition of clastic materials was, however, only intermittent, and during long periods vegetation grew and accumulated in the lowlands and formed thick beds of peat. From time to time the growth of the peat deposits was interrupted by renewed stream deposition and the organic accumulations were covered by sands and muds. In this way an alternating series of sedimentary beds and beds of organic material, the Tertiary coal-bearing formation, was built up and in places reached a thickness of nearly 2,000 feet. As the load of sediments above any peat bed increased, the organic materials were compressed, other chemical and physical changes took place, and the peat was gradually altered to lignitic coal.

The building of the coal-bearing formation was interrupted by another period of uplift in this region. This uplift was most pronounced in the region south of the largest coal-bearing areas, but the movement extended far enough northward to involve parts of the coal formation also. The steepened streams again brought down abundant coarse material—the Nenana gravel—which accumulated along the flanks of the growing mountains. At many places the Nenana gravel appears to lie conformably upon the coal-bearing formation, but at other places the coal-bearing beds were apparently uplifted and eroded before they were covered by the gravel or other material, indicating that the uplift of the foothills region proceeded unequally in different places, some areas remaining quiescent while others were being elevated and tilted. At some places the gravels reached a thickness of 2,000 feet; at others they were much thinner.

After the Nenana gravel was deposited the main range and the foothills were still further elevated. The mountains grew both by bodily uplift and by folding and faulting, and all the Tertiary beds were more or less deformed. The folding, however, was less severe than that to which the Cantwell formation had been earlier subjected, and consisted of compression that tended to narrow the basins of coal-bearing materials into shallow synclines. Faults trending east and west, some of which have displaced the coal-bearing beds and the Nenana gravel for several hundred feet, have been observed, and the development of the foothill ranges is due to both folding and faulting. At the close of Tertiary time the Alaska Range and its subsidiary foothill ridges had probably been elevated to approximately their present position, and the agencies of erosion had actively attacked the young mountains and had cut great valleys in them. The gravels of the foothills and the associated coal-bearing beds had also been greatly eroded, and had been reduced to rounded and well-drained topographic forms. Across the hard-rock ridges that lay athwart their valleys the streams had cut deep, narrow canyons, but in intervening areas that were floored with unconsolidated Tertiary materials great basins had been excavated.

In early Pleistocene time in Alaska, as at many other places on the continent, extensive glacial deposits were formed. Just when the first glacial expansion took place in the Kantishna region we do not know, but there is strong evidence of at least two glacial stages here and there may have been others of which we have no proof. The ice advanced from the mountains and spread northward along the main valleys to the foothills. Boulders on the high ridges near Nenana Valley indicate that an earlier glacier there reached a great thickness and extended to the north front of the foothills within 30 miles of Tanana River. By its erosion and transportation of materials it must have greatly modified the topography of the mountains and of the lowlands, into which its outwash gravels were carried by the streams. This earlier glacial stage was followed by a period of ice withdrawal in which the normal agencies of stream erosion and atmospheric weathering were active. During the last stage of glaciation ice tongues again advanced northward through the valleys, repeating the earlier advance, though perhaps on a reduced scale, and further impressing ice-carved features on the valleys. Having reached their maximum expansion the glaciers, influenced by a change of climate, again shrank back into the mountains to about the positions they now occupy. After their retreat stream erosion and deposition again became active, talus and soil were formed anew by the erosion and weathering of the surfaces laid bare by the ice, and vegetation once more established itself on the rock slopes, morainal deposits, and outwash gravels. The streams are still engaged in the task of adjusting their gradients, disturbed by ice erosion, to conditions of normal stream transportation and erosion.

The present surface forms in this region are the composite result of the many vicissitudes that the region has undergone since the beginning of the Tertiary period. Elevation, folding and faulting, the accumulation of Tertiary detritus, and repeated periods of stream erosion, each followed by deposition and renewed uplift, have each had an effect in shaping the surface. Unequal uplift in the foothills, giving rise to alternating belts of hard rock and of unconsolidated materials, formed stream valleys in which broad, mature basins are interrupted by deep, narrow canyons. Several periods of erosion, during which the surface was reduced to a somewhat uniform plain, may still be recognized at favorable places. Thus along the depression which extends east and west between the head of Dry Creek and Teklanika River, as well as in places on the Kantishna Hills, an inclined-plane surface, cut from the rocks of the Birch Creek schist, appears on the mountain flanks. The plane of this erosion surface coincides with the base of the Tertiary coal-bearing formation, and seems to represent a part of the surface upon which the coal-bearing sediments were deposited. This erosion surface was thus protected from dissection for a long period by the Tertiary deposits, which upon elevation have locally been removed to bare once more the old rock plain on which they were laid down. Elsewhere in the mountains parts of old erosion surfaces whose age has not been definitely fixed may still be recognized. The problem of deciphering the physiographic history of the region is complicated by the number of erosion surfaces, by their unequal warping and tilting, and by the fact that the erosion by ice and by streams occurred at intervals in the Quaternary period. Enough of the old erosion surfaces probably remains, however, to afford abundant results to the student of physiography who has the opportunity to study this area carefully.

ECONOMIC GEOLOGY.

HISTORY OF MINING.

The basin of Tanana River first became of interest as a placer-mining region on the discovery of rich placer gravels in the Fairbanks district. Gold seekers, attracted by that discovery, rushed to the Tanana Valley in 1903 and 1904. Most of them 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 gold in encouraging amounts returned to Fairbanks that fall. The next spring Dalton and another partner, Stiles, returned to the Toklat and prospected on Crooked Creek, a tributary heading in the Kantishna Hills 16 miles south 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 stampede to Kantishna. The stampeders began to arrive at the scene of the discovery about July 15, 1905. Meanwhile Dalton and Stiles, having heard nothing of the Quigley-Horn discovery, had traveled along the southeast side of the Kantishna Hills and arrived at Friday Creek. Prospecting there they found gold, and on July 12 they staked that stream. On July 20 they staked Discovery claim on Eureka Creek, but thinking themselves entirely alone in the country they staked only that claim, having determined to prospect first the upper part of the stream. They went up Eureka Creek, and on their way back to the mouth of that stream they met a man named Cook, who had come in with the rush and had made his way up Moose Creek to the mouth of Eureka Creek. Cook said he had staked claims No. 1 to No. 4 on the Eureka, so Dalton and Stiles returned and staked the rest of the creek above claim No. 4.

Late in the summer and in the fall of 1905 the Kantishna district was the scene of great excitement. Several thousand people then arrived, most of them coming by boat up Kantishna River and its tributaries, Bearpaw and McKinley rivers during the season of open water, and by dog and sled later in the fall after snow had fallen. Practically every creek that heads in the Kantishna Hills was staked from source to mouth, and the benches and intervening ridges were not ignored. Within a few weeks a number of towns were built, 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 Kantishna River. At each of these places 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 an exodus began. The richest ground was mined vigorously during the summer of 1906, but by fall the population had dwindled to about 50, those who remained being the few who had staked paying claims or who were convinced that thorough prospecting held out sufficient promise of new discoveries.

In the winter of 1906 Roosevelt, Square Deal, and Diamond were almost completely deserted. Glacier, being nearest to the creeks, is still used as winter quarters by a number of miners who prefer to spend the cold months in the shelter of the timber, near their fuel supply, rather than to haul wood to their summer camps.

Since 1906 the population of the Kantishna district has remained nearly stationary, ranging from 30 to 50. In 1916 there were 35 persons in the district, and more than half of this number were men who had staked claims during the first stampede and who had worked them more or less continuously since that time. It was placer gold that first attracted attention to this camp, and the only production so far has been made 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 brought to the stage of production, but eventually the lodes will probably outstrip the placers in the value of their metal output.

GOLD PLACERS.

GENERAL FEATURES.

The productive gold placer deposits of the Kantishna district are all in the basins of the streams that head in the Kantishna Hills and radiate outward 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 as direct travel from one basin to another is difficult, the routes generally used extend around the base of the higher mountains, and the placer workings are therefore much farther apart by trail than their close spacing on the map would indicate. This condition has produced a number of small and rather isolated mining camps between which

there is little travel during the busy summer. In 1905 and 1906 paying deposits of gold placer gravel were found on all the streams that are now productive except Little Moose Creek, and although considerable prospecting has been done during the last 10 years only a small amount of workable ground has been found 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, but most of the men in the district own ground from which they are confident they can make a living, and they employ the summer in mining the proved ground rather than in prospecting areas in which there is less certainty of finding valuable placers.

The creeks that have added to the gold production of the district are Moose Creek and its tributaries Glen, Eureka, Friday, and Eldorado; 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 work, in which the upper gravels are groundsluiced off to within a foot or so of bedrock and the remaining gravels and the necessary amount of bedrock are shoveled into the sluice boxes by hand. Most of the miners plan to complete the season's ground sluicing 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 releasing a large volume for a short time, to groundsluice even at times of low water. The whole operation of open-cut placer mining is, however, definitely limited to the period of stream flow. Nearly all the placer mines in this district lie above timber line, from 1,600 to 3,000 feet above sea level. At such altitudes the streams commonly run free from ice sometime in May and remain open until late in September, and the mining season is therefore limited to a period of about four months. Late in summer, too, some of the smaller streams diminish so much in volume that they do not supply sufficient water for sluicing, this lack of water restricting the mining season 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 few miners encounter difficulty with ground frost. Some of the elevated benches, however, in which gold occurs in commercial quantities are permanently frozen, and before the gravels can be sluiced they must be thawed by steam or must be stripped of their insulating cover of surface vegetation and muck to allow the warm air and the direct rays of the sun to thaw out the frost.

This camp is so far from established lines of transportation that the cost of mining is much greater than it would be in a more accessible district. Few men are employed at a stipulated wage, for most of the claims are worked by the owners or on a royalty, but those who are employed usually receive $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, as there is no ready communication with any settlement, and the men in the camp at any one time include only those who remained from the previous year and those who came in over the ice in the winter or by boat in the spring.

The supplies and mining equipment needed for the season's work 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. By this method the quantity and assortment of each miner's supplies must be determined by him several months in advance of the working season, and demands a considerable investment of capital for an unusually long period. No store is maintained in the district, and whatever supplies a man unexpectedly needs during the summer must be procured from his neighbors or can not be had at all. As a result of the difficulty and expense of carrying freight to the mines and of the long time required to procure a desired article, only the most primitive methods of mining have yet been employed. All the gold recovered so far 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 must be brought from a distance, which varies on the different creeks. On Glen Creek timber grows within 1 mile to 3 miles of the mines. Eureka and Friday creeks are devoid of timber, which must be obtained from the basin of Moose Creek at points 1 mile to 5 miles from the workings. On Glacier Creek no timber is obtainable for 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. Sawmills were operated to furnish lumber in the early days of the camp, but these were soon dismantled, and now all needed lumber must be cut by whipsaw.

ORIGIN OF GOLD PLACERS.

As is shown in Plate II, the underlying rock in the Kantishna mining district is the Birch Creek schist, which is cut by relatively small bodies of intrusive rocks that differ widely in age. Some appear to

have been as greatly metamorphosed as the schists that inclose them; others are somewhat metamorphosed but less so than the schists and were intruded after the metamorphism was started but before it was completed. Still other intrusions are not at all folded and were injected after the schists had reached their present condition. Among the class last mentioned were some dikes and stocks of granite porphyry and quartz porphyry, which may be genetically related to the mineralized quartz veins. The schists are locally highly siliceous and include beds of quartzite schist. Numerous quartz veins and veinlets are everywhere distributed through the Birch Creek schist. Gash veinlets and lenticular bodies of quartz lying parallel to the schistosity are particularly abundant, but most 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 Kantishna Hills, especially along the main divide 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 a uniform strike, dip, and thickness for considerable distances along the outcrop. Most of these veins are younger than the gash veins that follow the schistosity and are true fissure veins of more recent age than the last period of vigorous metamorphism. Several quartz veins of this type 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 the streams which had the richest gold placer ground. This fact seems to prove conclusively that at least a large part of the gold of the stream placer gravels was derived by erosion from the fissure quartz veins that cut the schists. The gash veins and veinlets of quartz in the schist 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 also are gold bearing, but the richest placer gravels have been found in basins in which the larger fissure 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 forms that the gold had as it lay within the vein quartz, and few nuggets in any clean-up show 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. It becomes finer and more smoothly worn as it passes downstream and away from the outcrops of gold-bearing quartz, as would be expected if it had been derived from the quartz veins and had been transported to increasingly greater distances from its bedrock source.

The influence of glaciation on the distribution of gold placer deposits in the Kantishna region has varied in the different stream basins, and although the glaciers have doubtless played their part in the erosional history of the district, the ice was here much less abundant than in the higher mountains of the Alaska Range. The fact is now established that there have been at least two stages of glaciation on the north side of the Alaska Range, one long before the last one, the evidence of which is best preserved. This fact being recognized, it is difficult in certain places to determine the limits reached by the separate ice sheets, for glacial deposits or action of the earlier stage can easily be mistaken for those of the later, and a proper discrimination 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, 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 of this ice lobe flowed north onto Clearwater Fork of Toklat River, another flowed down through the canyon of Moose Creek past Eureka and Eldorado creeks, and still another flowed westward along the present course of McKinley River. The highest ridges of the Kantishna Hills were never overridden by ice, but some of the higher valleys in them supported small ice tongues, which extended radially from the crest in all directions but 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 basins of Eureka, Friday, and Eldorado creeks were not sufficiently elevated to originate 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 boulders are not directly associated with morainal deposits, but their presence indicates that at one time the basin of Moose Creek was filled with ice, which lay high against the south flank of the Kantishna Hills. The peculiar courses followed by lower Spruce and Glen creeks also indicated 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 evidence of glacial action is inconspicuous and poorly preserved. The fact can be stated, however, that in those parts that were glaciated the ice disturbed or removed the greater part of the preexisting gold placer deposits, so that any concentration of gold that is now present is due to erosion by 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, which they deposited as outwash gravels beyond the edge of the ice. The streams sorted in some degree the outwash gravels but much less than they would have been sorted by normal lightly loaded streams.

After the glaciers had disappeared from the Kantishna district the streams commenced the task of readjusting their valleys to conditions of normal erosion. Less heavily loaded than when they received glacial waters, they began to intrench themselves into the deposits of glacial 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 flowed in somewhat different courses from those along which they had formerly flowed, and canyons show the position of obstructions they encountered in their downward cutting.

The bench or terrace gravels along Moose, Glacier, and Caribou creeks contain some placer gold, and in one or two places sufficient to warrant mining. While the streams were intrenching themselves in these gold-bearing gravels the gold in the gravels, as well as that supplied by the erosion of gold-bearing quartz veins, was deposited in their beds, forming the present workable placer gravels.

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. The gravels form no conspicuous surface features but 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 obtained from a prospect hole sunk on the bench west of Glacier Creek, opposite the upper end of claim 13. This shaft, after penetrating a few feet of the ordinary bench gravels, encountered a body of white, rounded quartz gravel, which continued without interruption to a depth of 114 feet, at which place the sinking was discontinued without reaching bedrock. Most of the material on the dump is vein quartz, distinctly rounded and water-worn, ranging in size from fine sand up 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 deposits of placer gold in it, but no paying concentration of gold was found, although some fine gold was panned from the material excavated. A study of the geologic relations on Glacier Creek indicates that the white gravels there constitute the base of the Tertiary coal-bearing formation which is so fully developed farther east, near Nenana River. There the base of the Tertiary beds, where they lie upon the Birch Creek schist, is commonly made up of a nearly pure deposit of white quartz pebbles and sand. This relation is found to continue westward across the basin of Teklanika River, and no doubt the white gravels of Glacier Creek are of similar origin. The gravels are believed to represent the detritus from an old land mass that had been deeply weathered and from which the more easily decomposed materials had been removed, leaving abundant residual quartz scattered over its surface. Later 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 any gold that may have been present in the quartz showed little tendency to concentrate. 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 heavy 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 the coal-bearing beds were never developed, and that the oxidized gravels were laid down directly upon the white quartz gravel beds. The white gravel deposit on Glacier Creek therefore differs in mode of origin from the "white channel" of the Klondike, and being probably of early Tertiary age is apparently much older than the gravels of the Klondike.

SOIL FLOWS.

A factor that has exercised an important 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 onto

the stream-gravel deposits and the rapidity with which this movement takes place. A brief description of the various types of soil flows and a discussion of the factors that cause them have already been given on pages 66–70.

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

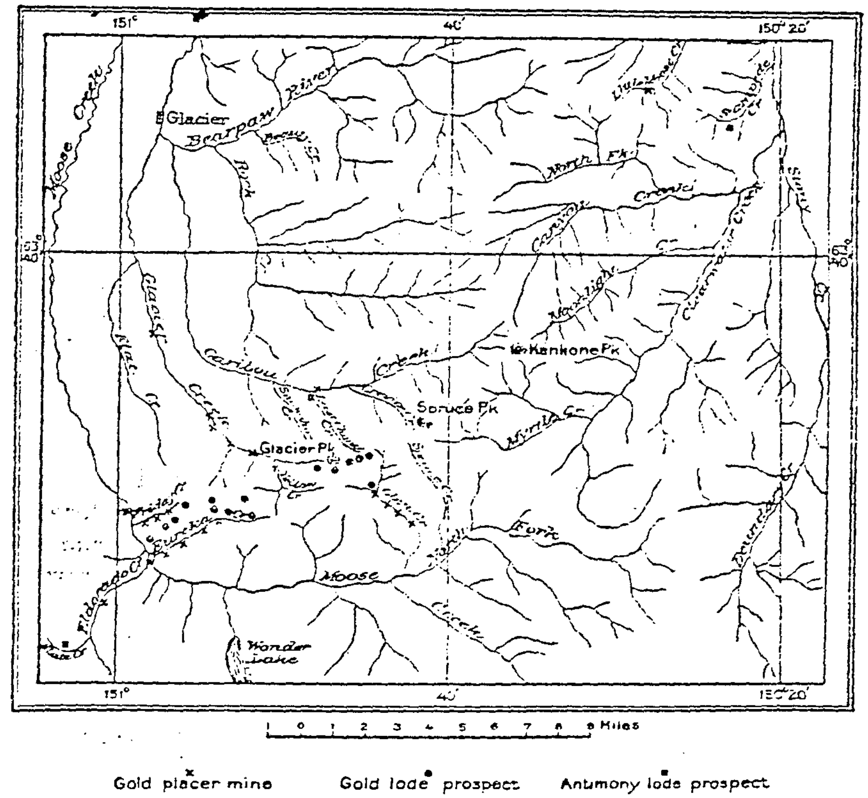


FIGURE 6.—Sketch map of a part of the Kantishna region, showing approximate positions of mines and prospects.

descriptions of the general conditions prevailing on these claims at that time. The positions of the mines and prospects are shown in figure 6, and in their discussion they are grouped under the name of the stream valley in which they occur and are described in order from the uppermost claim downstream.

GLEN CREEK.

Claims 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 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 at the time of visit. In previous years considerable work was done on claim 2 by the ordinary method of ground sluicing and shoveling in. Boxes 12 inches wide, set on a grade of 10 to 12 inches to the box length, are used. Bedrock is composed of quartzite and micaceous schist, and boulders are large and abundant.

On claim No. 2 the depth to bedrock averaged about 6 feet, but a short distance below the dam, on claim No. 1, the bedrock surface plunged suddenly downward, and a shaft 34 feet deep, sunk near the forks, failed to reach bedrock.

The gold is bright, coarse, and rough, and many nuggets weighing from 1 ounce to 7 ounces each have been recovered. The sluice-box concentrates contain abundant black sand, garnets, galena, and iron pyrite, indicating that the gold has been derived from sulphide-bearing quartz veins. Such veins outcrop at the head of this basin, and they 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 ground-sluiced. Bedrock had been cleaned for 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. The nuggets are often discolored, but the fine gold is bright and yellow. Many nuggets ranging from 1 ounce to 3½ ounces have been found. The sluice-box concentrates contain numerous pieces of galena and many 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 one man is reported to have been mining there in 1916. In July, 1916, some ground sluicing 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 produced gold. 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 claim No. 8 and 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 parts of claims No. 1 and No. 2 on the right fork have been mined.

EUREKA CREEK.

Claim No. 13.—The uppermost claim on Eureka Creek on which mining has been done is claim No. 13, where one man has been working every season since 1906. Sluicing was begun on the lower end of the claim and has now been carried upstream for about 1,000 feet. The bedrock of this creek, which is composed of Birch Creek schist, varies in hardness from place to place, hard quartzitic phases alternating with softer mica schists. 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 was being mined to a depth of 11 feet, for the pay streak was buried by materials carried down from the north wall of the valley. An automatic dam was used for ground sluicing, but during the season of 1916 the water supply was insufficient for satisfactory mining. Twelve-inch sluice boxes with pole riffles were set on a 9-inch grade, and below these, boxes with false bottoms were set on a grade of 5 inches to the box length. Boulders and slabs of rock, some 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 discolored by stains from the decayed bedrock. The gold is said to assay $16 an ounce, and although coarse is less coarse and rough 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, a block of eight claims, Nos. 5 to 12 above Discovery, which is at the mouth of the creek. On this group a strip about 1 cut wide, 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 work had been done with pick and shovel, and only the richest gravels—those in the creek bed—would warrant mining. In 1916 an automatic dam was built on the upper end of the group, and through its use the cost of mining has been reduced from $45 to $20 a box length (168 square feet). By the new method a much wider strip of gravels can be profitably exploited. 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 the tests show little loss of gold 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 are 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 using the present automatic-dam method on the Eureka group of claims and also intends to use it on the lower claims on either side of the creek channel—ground that would not pay if worked by the old method. The bedrock is composed of the various phases of Birch Creek schist, the character of which changes from place to place. In cleaning bedrock it is necessary to remove only the surface of the schist where that material 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 that have lain on decayed and rusty bedrock and are discolored. It assays from $15 to $15.20 an ounce and is remarkably coarse, a large part of it being in rough, angular pieces that show little or no evidence of stream abrasion. A number of pieces show unworn crystal surfaces and are certainly derived from near-by gold-bearing lodes. In many nuggets quartz is intermingled with the gold, and the sluice-box concentrates contain abundant galena. These facts furnish additional evidence that the gold is a concentration from the quartz veins that outcrop on the ridges around this stream basin. Stibnite and black sand are also caught on the riffles. The placer gold from Eureka Creek is unusually coarse. Half of that recovered is said to occur in pieces having a value of 5 cents or more, and much is in coarser nuggets. 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 throughout the open season. Four boxes 11 by 13 inches in cross section and set on a grade of 9 inches to the box length are used, two of which are equipped with pole riffles and two with Hungarian riffles, 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 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 in this district placer mining was done on all the claims from the mouth of Eureka Creek up to claim No. 5, and, as already stated, 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, patches of gravel that lie here and there on each side of the creek contain considerable placer gold that was 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, however, the less easily handled "side pay" on these claims will be mined, and in these neglected areas the use of more economical methods, such as automatic-dam sluicing, will probably yield satisfactory profit to the miners.

FRIDAY CREEK.

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

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 of worked ground. The 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 slides 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 big for one man to handle. The gold is rough and coarse, nuggets worth $50 having been found. The gold taken from the surface of bedrock is usually discolored and rusty, but that obtained 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 ground sluicing and shoveling in is employed, and a hose, with water under pressure, is used to clean bedrock. Sluice boxes set on grades varying from 8 to 16 inches to the box length are lined with pole and Hungarian riffles. The schist bedrock ranges from hard dense rock to soft, soapy, decayed material, and experience has shown that though the hard bedrock has retained most of the gold, the softer phases of bedrock are in general only meagerly 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 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 outcrop on the mountains near by. The largest nugget taken from this claim weighed 6½ ounces, and many pieces weighing more than an ounce have been found. Black sand and galena are abundant 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 this creek is Discovery claim, the second claim above the mouth of the stream. Two men have been mining there each summer since 1908, and the stream channel has been about worked out, the only unworked ground being a side cut near the upper end of the claim. In the upper part of this ground the bedrock consists of schist, the foliation striking roughly parallel with the trend of the valley and dipping at high angles. About 300 feet above the lower end of the claim the bedrock floor steepens and disappears beneath a gravel filling of such thickness that prospect holes have failed so far to penetrate it. The mining here has been done only by pick and shovel, the pay gravels ranging 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 form 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 much of the placer gold certainly had its bedrock origin in the gold-bearing quartz veins that outcrop 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 that stream, some placer mining has evidently been done, though no one was working there at the time of visit. The bedrock at that place is a black slaty phase of the schist, striking in general northeast and dipping steeply southeast. The gravels apparently range from 2 to 4 feet in thickness. The gold, which is reported to be too unevenly distributed for successful mining, is said to be bright, well worn, and finer than that on Friday or Eureka creeks and to assay about $16.25 an ounce.

MOOSE CREEK.

The valley of Moose Creek from the mouth of Eldorado Creek for 3½ miles downstream is held as a block of claims by men who have mined on this ground each year since 1906. Discovery claim lies at the upper end of the property, and it is apparent that most of the placer gold in this part of the valley of Moose Creek has been supplied by Eureka, Eldorado, and Friday creeks, for no workable ground has been found in the valley above the gravels contributed by Eureka and Eldorado creeks. In this valley gold has been mined on a small scale only, by pick and shovel. Moose Creek is a large, clear stream, flowing over a gravel flat, generally bordered by gravel benches, though in places it swings to one side of its valley or the other and cuts against rocky 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 slight that difficulties are encountered in obtaining water under sufficient head for sluicing and in obtaining a dump for tailing from the sluice boxes.

At the time of visit two men were mining opposite the mouth of Eureka Creek on a gravel bench the lower edge of which 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 gravels. The gold is distributed throughout the whole thickness of gravels but is notably concentrated on the false bedrock. Practically no gold has been found within the materials composing the false bedrock, or beneath them, 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 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.

General features.—Glacier Creek heads against the north side of the Kantishna Hills, flows about 5 miles northwestward through a deep valley eroded in schist, from which it emerges from the mountains and flows northward to its junction with Bearpaw River through a valley intrenched into a broad, gravel-covered upland. For the upper 5 miles of its course the stream occupies a valley floored with s[illegible] gravels of moderate depth lying on schist bedrock. North of the mountains the depth to bedrock increases so much as to be below the limit of ordinary open-cut placer-mining, except in a few short stretches where the stream passes through shallow canyons in the schist. With the exception of 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 outcrop 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 has been successful 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. There 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 gravel and on the surface of bedrock. That from the gravels is bright and yellow, but that 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 had worked there each summer since 1908. A splash dam and a bedrock drain had been constructed, but a freshet in the spring washed out the dam and filled the drain, making 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 in depth from 3½ to 9 feet. 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, during which period 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 had been installed, and mining was carried on by the usual method of ground sluicing and shoveling in the gravels and the surface of the bedrock. The schist bedrock varies in character from soft, decayed material that contains little gold to hard, firm rock in which it is abundant. Some gold occurs in the stream gravels, but the richest concentration is on the surface of the bedrock. The gold deposits vary markedly within short distances, almost barren stretches of gravel succeeding stretches of rich ground. Few large nuggets are found on this claim, as the gold occurs mostly in flat, well-worn pieces the size of rice grains.

Mining has been done in an irregularly shaped area, measuring in its maximum dimensions 160 by 200 feet, 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 in the section along the creek, this bench is composed for the most part of schist, on the surface of which lies a gravel deposit of varying thickness, laid down by Glacier Creek when the bench surface was the valley bottom and before the present stream canyon was eroded. This bench was mined by building a ditch to tap Glacier Creek at the lower end of claim No. 16, and at the lower end of claim No. 14 the width of the bench below the ditch line 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. The bench gravels that were worked are said to have yielded a good profit to the miners, but the increasing depth of the ground and the difficulties encountered in keeping the ditch in repair so increased the 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 by pick and shovel. A cut about 240 feet long had been ground-sluiced and most of the cut has been shoveled into the boxes. The gravels, which lay on schist bedrock, averaged 6 feet in thickness and contained 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. Only a small part of this claim is reported to have been mined.

Other mining on Glacier Creek.—During the years since 1905 considerable mining has been done on Glacier Creek on claims that were not being worked in 1916. Thus some mining was done on claim No. 13. Claims No. 15, No. 16, and No. 17 were largely exhausted, but No. 18, No. 19, and No. 20 produced some gold. Certain claims on Yellow Creek are said to have been very 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 the stream gravels are so deep that ordinary mining methods fail to reach bedrock, except in 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 deep ground is said to begin on claim No. 11, and 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.

In its upper part Caribou Creek flows almost due west and is fed from the south by a number of tributaries that drain the highest peaks of the Kantishna Hills. Ten miles below its head Caribou Creek swings to the north and 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 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 varying 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 that were encountered were too big for one man to handle. Sluice boxes 10 inches square in cross section, 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 after a heavy rain the stream is likely to be so flooded that mining must be suspended until it falls. The gold occurs throughout the whole thickness of the stream gravels but is especially concentrated on bedrock. That in the gravels is bright and yellow, but that on the bedrock is usually darkly stained and discolored. The gold taken from the canyon is coarse, the largest nugget found having a value of $110; but that from above the canyon is fine, occurs in flat, flaky pieces, and is said to assay $13.50 an ounce. Pebbles of magnetite, ilmenite, and the calcium tungstate, scheelite, and numerous large garnets are associated with the gold in the sluice boxes. Four men were employed during most of the summer.

A small amount of gravel has in former years been sluiced on claims No. 3 and No. 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 gold deposits, 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 of Clearwater Fork of Toklat River, and joins it 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 being done at a point 5 miles above its mouth, on claim No. 20, where two men were working. An automatic dam had been constructed but was not completed until late in the spring, by which 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 up to the middle of August, though some gold had been recovered from the gravels. Large boulders are confined almost wholly to the surface gravels.

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

Some mining has been done in past years on claims No. 18 and No. 19. The stream gravels are reported to range from 8 to 10 feet in thickness, although in many places slide material from the valley sides has covered the pay streak to a depth so great that mining costs were prohibitive. The gold is coarse and shotlike 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 reported to be present in almost every clean-up.

The creep of soil and talus is especially rapid in the valley of this and 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, in part at least, to the rapid downward creep of valley-side detritus, which fills the valley floor more rapidly than the small stream can remove it.

GOLD PLACER PROSPECTS IN THE KANTISHNA REGION.

The foregoing description includes all claims in this district on which mining was in active progress in August, 1916, and makes some mention of the results of mining in earlier years on ground that was not being worked at the time of visit, but a historical sketch of the mining done in a camp where so many men have come and gone, and where the only record of past work is in the memory of those who have remained, must necessarily be incomplete. During the two years following the discovery of gold 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. Evidence of the work of the early prospectors is seen everywhere—in old cabins, prospect holes, and pits—and by their work they found that the gravels which would yield pay under the conditions then prevailing were limited to the streams already described. They also found, however, that placer gold is widely distributed, and that it occurs in many places in quantities almost sufficient to warrant mining at that time. Unfortunately, most of the information obtained by these men at so great a cost of money and effort is now lost. With the better means of transportation that will be afforded by the Government railroad to be built along Nenana River the cost of mining may be so greatly reduced that placer gravels heretofore unavailable may be worked 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 north; 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 northern 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 only a little preliminary excavation members of the Geological Survey 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.

Mining has been done in the Kantishna district for 12 years by many men, who have made no accurate record of the gold they produced. A comparison and combination of the estimates made by men who are most intimately acquainted with the work done on the numerous creeks shows that the total production of placer gold in the district to the close of 1916 was about $380,000. Many will consider this estimate too small, for there is a constant tendency among most miners to overestimate the production on creeks with which they are least familiar. The figures for about half the total production, however, were furnished by men who actually mined the gold, and the total is believed to be 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.

As has already been stated, no placer mining by other than the simplest methods has ever been done in this district. The inaccessibility of the region, the small size of most of the rich creeks, and the small amount of ground to be worked on any one claim, have perhaps prevented the use of hydraulic or mechanical methods in working the gravels and have also favored the use of the more elastic method of mining by pick and shovel. The richest shallow gravel deposits have now been worked out, however, and the leaner but more extensive deposits that still remain must be worked by more elaborate methods. The man with sufficient capital and with an understanding of the problems involved would gain much greater profit by installing a hydraulic plant, a mechanical elevator, or a dredge, than can be gained by the man who has little equipment and who must rely upon only his own muscle and resourcefulness. The gravels of the creek flat and benches of Moose Creek below Eureka locally contain gold enough to justify mining by hand, and systematic prospecting may show that these gravels are of great enough extent and value to justify the installation of a hydraulic plant or a dredge. Both the bench gravels and the stream flats of lower Glacier and Caribou creeks are also gold bearing and may sometime yield a profit if mined on a large scale. The large gravel deposits on Clearwater Fork may also be sufficiently rich to justify extensive mining. The success of any such operations will depend, however, upon thorough and systematic prospecting to determine the value, extent, and character of the gravel deposits; upon the careful and wise choice of the proper equipment for mining; upon a close determination of the probable cost of operation; and last, but by no means least, upon wise and honest supervision and control.

LODE DEPOSITS.

GENERAL FEATURES.

There has been much active prospecting for lode deposits in the Kantishna district during the last few years, and a number of veins containing gold, at least one rich in silver, and three containing antimony, have been discovered, and more or less of development work has been done on them. No ores obtained from lode deposits in the district have yet been reduced, however, so that no metal has been recovere[illegible] them, yet the prospective value of the lodes can not be judged by the fact that they have so far yielded no metal. Their inaccessible situation has delayed their development, and most of the prospectors for lode deposits have been men of small means, without the financial resources required for extensive underground mining, or for building milling plants. The time and effort required to reach the lode prospects in summer have prevented capitalists from visiting them, but the completion of the railroad to the Tanana Valley may, perhaps, establish lode mining in this district. Although no single vein has been so far developed as to assure a successful mine, there are nevertheless a number of prospects that are of sufficient promise to warrant thorough exploration and that are likely some day to bring this camp into the list of gold lode producers.

All the lodes that have been considered worthy of development lie along the highest part of the Kantishna Hills, in a belt 27 miles long and 6 miles wide, extending from Clearwater Fork of Toklat River S. 60° W. to and across Moose Creek, but it is by no means certain that other valuable lodes do not occur outside of this area. Quartz float is abundant outside of this high area, but the steep slopes and the absence of a continuous surface cover of vegetation in this high and more rugged ground have made prospecting there easiest, so that most of the prospects lie high on the ridges. More thorough prospecting will probably disclose many veins at lower altitudes.

All the lodes so far found occur in similar rocks. The prevailing rock throughout the district has been called the Birch Creek schist, as it is believed to be a part of the schist series of that name which crops out in the area between Yukon and Tanana rivers. This schist is highly metamorphosed, much folded and contorted, and shows a variety of phases from place to place. It is commonly a dense, quartzitic rock, locally rather massive but generally containing much mica and exhibiting schistose cleavage. It includes fine, silvery mica schists, which show highly developed cleavage and in places are studded with garnets. It contains also dark, carbonaceous schist and greenstone in various degrees of metamorphism. The foliation of the schist usually strikes northeastward and dips at all angles, as the beds are in general closely folded.

The larger quartz veins, including those that carry gold, silver, and antimony, all cut the Birch Creek schist. The strike of the main veins so far exposed is decidedly uniform—between N. 45° E. and N. 70° E. Although their strike is parallel to that of the schist, most of the veins cut across the foliation of the schist which incloses them. The ore-bearing veins dip at angles ranging from 50° to 90°, and as far as can yet be made out hold their direction of strike and angle of dip rather constantly. They thus fall into a different category from numerous lenticular and distorted veinlets and stringers of qu in the schist that lie parallel to its foliation. The ore-bearing veins here described are therefore fissure veins, which were opened and filled after a large part of the regional metamorphism to which the schists have been subjected was completed. Some movement has occurred along the vein openings since the ore was deposited, but this may be ascribed to local uplift or warping without much deformation, for the veins themselves have not been notably deformed since they were deposited. The study of the ore deposits was hampered by the meagerness of the underground workings. The 11 longest tunnels together measure only 891 feet, and the two deepest shafts together measure only 70 feet. The longest tunnel that could be entered is but 188 feet from portal to breast, and each of five other tunnels measures little more than 100 feet. Several of the tunnels are now caved in and could not be examined. The veins have been exposed not only by the underground workings but by a large number of open cuts, yet as most of these were slumped it would have been necessary to clear them in order to examine them, and no time was available for that work.

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

There are no facilities in the Kantishna district for making assays, and most of the samples of ore that are taken out by prospectors for assay have been sent to Fairbanks. Communication with Fairbanks is difficult and infrequent, so that a long delay elapses between the collection of a sample of ore and the receipt of the assay return. This delay causes rather haphazard prospecting, for the prospector who has found a promising-looking quartz ledge may spend several months in development work before his assay return 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 ore as he has at hand, the most common method being to crush the ore in a small hand mortar, and to pan the pulp thus obtained. This method determines, in a way, the presence or absence of free gold, but its quantitative results are uncertain and may be misleading. Only a small piece of vein material can be crushed at one time, and as the labor involved is considerable, the prospector is likely to crush only what he considers the most promising pieces of ore, so that the result is apt to raise false hopes as to the average value of his ore body. The average tenor of a vein can be determined only by taking accurately representative large samples at frequent intervals across the entire vein.

Furthermore, tests made by mortar and pan give no information concerning the gold in the ore that may not be in the form of free gold. Most gold-bearing sulphide ores contain a certain percentage of gold that is so combined with the sulphides that it is not released by simple crushing and amalgamation and can be recovered only by chemical treatment or smelting. The quantity of gold so carried may be sufficient to justify mining, and reliable assays should always be made to determine the value of any 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 which have been assayed, but naturally the assays were not made for general use.

Prospectors in this district have difficulty in keeping their tunnels in repair from year to year. A short distance below the surface the ground is permanently frozen. The tunnels when driven are usually dry, and in them the temperature tends to remain constantly below the freezing point, but if a tunnel is opened in warm weather the ground in it, which was solid and required no timbering, begins to thaw and slump. Many tunnels are therefore now caved in and inaccessible. Tight bulkheads and close-fitting doors that cut off the circulation of air, however, will keep the tunnels frozen in summer. As most of the tunneling has been done in winter, when the outside air is cold, work at that time is unimpeded by thawing. 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 will be described in order from east to west.

GOLD LODE PROSPECTS.

MAMMOTH CLAIM.

At the head of Crevice Creek, a tributary of the Caribou, an ope cut has been excavated on the Mammoth claim, which is high on tl side of Spruce Peak, about 500 feet below the summit. This cut wa reported to have slumped, so it was not visited, but it is said t display a large mineralized quartz vein. No information concernin its gold content was obtained.

LLOYD PROSPECT.

The Lloyd prospect is on the east fork of Glen Creek not fa above its mouth, where a tunnel has been driven 24 feet into the fac of a cliff on the north side of the stream. At the mouth of the tunnc in the face of the cliff there is a large bed of siliceous material tha seems to be rather pure quartzite interbedded with the schist. Bot the inclosing schist and the quartzite have been twisted into a clos sigmoid fold that at one place gives a vertical exposure of quartzit 18 to 20 feet high. The quartzite is mineralized and contains som vein quartz, which carries pyrite, chalcopyrite, sphalerite, and, it i said, some gold. It is reported that no work has been done on thi claim for several years.

HUMBOLT PROSPECT.

The Humbolt prospect lies at the head of the east fork of Glen Creek, on the high ridge that forms the crest of the Kantishna Hills The schist here strikes N. 37° W. and dips 27° SW. A tunnel said to be 48 feet long, driven westward, was so caved in at the time o visit that it could not be examined. This tunnel was apparentl started on the cropping of a vertical quartz vein that strikes N 55° E., but it is said to have diverged from the vein and that n quartz showed at the breast. The main vein is 3 to 4 feet wide an consists of milky white to somewhat stained and rusty quartz. I is massive and shows no noticeable banding but includes some smal inclusions of schist. Little mineralization except iron oxide wa noted, though galena and sphalerite are reported. Associated witl the main vein are two or three smaller parallel veins, all lying within a zone that measures about 30 feet across. Numerous larg pieces of the vein quartz, broken from the croppings, lie about or the surface near the mouth of the tunnel, and it is said that severa hundred pounds of this surface ore was shipped to Fairbanks fo treatment and yielded good returns, mostly free gold. A tent anc blacksmith shop have been erected at the mouth of the tunnel, anc another tent stands in the valley below. No one was working or this property at the time it was visited, in August, 1916.

SKOOKONA PROSPECT.

The Skookona prospect consists of a number of open cuts on the top of a high ridge about a mile east of Glacier Peak, a high mountain on the ridge between the heads of Glen and Glacier creeks. The schist there strikes N. 20° E. and dips 15°–30° E. Several open cuts have been made and a 12-foot shaft has been sunk 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 are made, and the principal exposures may be on the same vein. The quartz is characteristically milk-white, though in places it is stained by iron oxide. Little mineralization is apparent. Too little development work has been done to show positively the structure or relations of this body of quartz.

GLEN PROSPECTS.

Two tunnels, known as the Glen prospects, have been driven near the top of Glacier Peak. The schist there 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 obstructed at the time of visit but was reported to be nearly 300 feet long and was evidently driven to cut the quartz vein that crops out on the slope above. Its shattered surface croppings indicate that the vein, which consists of white to gray banded quartz, is about 10 feet wide. 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. The quartz is said to carry promising amounts of gold, but no figures were obtained as to the average gold content.

McGONAGALL PROSPECT.

A gold quartz prospect known as the McGonagall prospect lies near the head of Glacier Creek, at an elevation of about 3,400 feet, and a substantial cabin has been erected near the outcrop of the vein. The vein, as exposed by the surface outcrops and in an open cut, seems to strike N. 70°–110° E. and dip 50° to the south and is said to show a maximum thickness of more than 8 feet. A 12-foot tunnel, driven into the mountain at the outcrop of the vein, 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. 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 mill test. No one was present on this ground in August, 1916.

GREISS PROSPECT.

The Greiss prospect comprises two adjoining claims, the Malachite and Azurite, 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 veinlets of quartz. An open cut west of the tunnel exposes black slate schist, fine 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 veinlets of calcite 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 fragments of quartz. As the owner was absent at the time of visit no other workings were found, and no information was gained as to the value of the gold in the ore.

EUREKA PROSPECT.

A group of claims, said to be called the Eureka group but locally known as the Taylor property, lies on the north slope of the valley of Eureka Creek about 3 miles above its mouth. These claims have been worked by two tunnels, the Lower Eureka and the Upper Eureka, and by an open cut. A cabin has been built near the mouth of a southward-flowing tributary of Glacier Creek. The Lower Eureka tunnel is on the north side of Eureka Creek near the top of a steep bluff. It is timbered for 20 feet, beyond which 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, about 8 feet wide, that 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, inclosing 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 a few degrees east of north. The surface vein material is so greatly oxidized and so much coated with iron rust that little other mineralization can be seen. Some pieces 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 more than 600 feet higher than the lower Eureka and is about 4,000 feet northeast of it. It was driven N. 67° E. for 100 feet and from it have been run three branches. The total length of these underground workings is about 144 feet. The tunnel is driven along a vertical quartz vein. Its northwest side follows the wall of the vein, and its southeast side follows a straight, smooth parting in the vein. In the outer 100 feet of tunnel the vein quartz is at least 7 feet wide, and one wall of it is not exposed. Some movement has occurred along the contact between the quartz and the schist, as both are somewhat shattered and broken. The vein as a whole is fractured, and the broken surfaces of quartz are covered with iron oxide. One hundred feet from the entrance of the tunnel there is another quartz vein, at least 3 feet thick, striking N. 30° W. and dipping 20° SW., which seems to cut off the main vertical vein on which the tunnel 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 varies from white, glassy quartz to gray, mottled quartz, and includes some dark rock containing quartz and sulphides, much stained and discolored. Iron pyrite is widely disseminated through the vein, and pyrite, sphalerite, and a little galena were locally abundant. No report was obtained as to the gold content of this lode.

PENNSYLVANIA AND KEYSTONE PROSPECTS.

The Pennsylvania and Keystone prospects are here described together, as they adjoin one another, 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, and have been worked by a large number of open cuts. No underground work had been done on them 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 discovery on the Keystone, and has been traced thence along the strike northeastward across Iron Creek and up the opposite side of that valley. Between 15 and 20 open cuts, made by stripping off the vegetation and loose surface material, show that the vein is continuous and that it preserves its direction of strike, its angle of dip, and its 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 is generally rusty. Arsenopyrite and pyrite are abundant, and locally the quartz is heavily mineralized with arsenopyrite, sphalerite, and galena. Small pieces of vein quartz that were mortared and panned showed free gold, and on many pieces of ore coarse particles of free gold could 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 which strikes N. 54° E. and dips about vertical. This vein shows a maximum width 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 specimens taken from the outcrop. 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-quarters 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. This exceptionally rich ore was found in only slight amount in the small excavation made 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 PROSPECT.

The Gold King prospect lies near the head of Iron Creek, high on the ridge between Eureka Creek and the head of Friday Creek. The work done 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. The quartz vein in this tunnel is reported to average 4 feet in width. Fifty feet above the lower tunnel, on the same vein, a second tunnel has been driven for 7 feet. Though only one wall of the vein is exposed the vein there, which strikes N. 70° E. and dips vertical, is shown to be over 6 feet wide. 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, though the outcrop and the old fracture faces are stained with iron rust. Arsenopyrite, sphalerite, and galena were noted; and the oxidized surface quartz is 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 PROSPECT.

The Golden Eagle prospect is at the head of Friday Creek on the ridge that separates the basin of Friday Creek from that of Iron

Creek, a tributary of Eureka Creek. The property is developed by several open cuts and a tunnel. The open cut by which the vein was discovered showed that it is 3 feet wide, of which 2 feet consisted of vein material heavily mineralized with galena, pyrite, sphalerite, and copper carbonates and contained 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 is 145 feet long and shows bunches of quartz along the crushed zone, within which both quartz and schist are mineralized. The heavily mineralized vein material that showed a width of 2 feet on the surface averages a width of only a few inches in the tunnel and has a maximum thickness of 18 inches, but it is said to carry considerable gold. Tests made by crushing specimens in a hand mortar and panning the pulp show abundant particles of free gold, and assays are said to have indicated a content of several hundred dollars a ton in gold.

LITTLE ANNIE PROSPECT.

The Little Annie prospect is on the northwest side of the Friday-Eureka creek divide a short distance below the summit. This claim is developed by a number of open cuts and a tunnel having a total length of 147 feet. The schist country rock here strikes N. 18° W. and dips 15° W. The main tunnel was driven southward to intersect a vein whose outcrop appears in an open cut on the hillside above. It encountered the main vein 90 feet from the portal, where a drift 42 feet long was driven S. 59° W. along the vein. A second drift, started 60 feet from the portal, runs S. 55° W. for 10 feet. The main vein consists of quartz 3 to 4 feet thick and dips 65° SE. The footwall is sharply defined and is much slickensided with striations, which show 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 they are probably present, for large pieces of solid galena several inches in diameter have been found on the surface near the crop 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 and parallel to the main vein in which the schist is so much cut by small quartz veinlets a few inches thick that more than half the zone appears to be composed of quartz. Assays of the vein material have shown that the quartz carries a few dollars in gold to the ton.

SILVER PICK PROSPECT.

The Silver Pick prospect lies southwest of the Little Annie and Golden Eagle claims, already described, on the same ridge and at about the same elevation. It is worked 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 portal of the tunnel one edge of a quartz vein that panned gold was cut, but the thickness of this vein was not determined. A vein striking N. 35° E. and dipping 68° NW. was penetrated 54 feet from the portal. This vein was 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 100 ounces of silver to the ton, and the ore is said to carry a fraction of an ounce of gold to the ton.

Near the breast of the tunnel the main vein 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 northeast of it. This zone consists of 1 foot of calcite on the footwall and 12 feet of quartz and schist, more or less sheeted, the quartz predominating in bulk over the country rock. Little galena is seen in the tunnel, but it is abundant along the surface crop 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, and along some of the cracks deposits of a soluble salt, which on analysis proved to be the iron sulphate melanterite, were found.

GALENA PROSPECT.

The Galena prospect lies on the northeast side of Moose Creek, on the end of the ridge between the basins of Friday and Eureka creeks. The work done consists of a number of open cuts, now caved in, and a tunnel, evidently driven to intersect a vein that cropped out 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. Next to the gouge-filled fracture, on the footwall side, there 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 be intimately intermingled. Galena was seen in nearly pure stringers 2 inches or more thick, and an assay made of this galena yielded 131 ounces of silver to the ton.

There is no sharp break between the ore body and the country rock on the footwall side of the vein; the mineralization merely becomes less as the distance from the hanging wall increases. Veinlets of ore extend into the country rock but pinch out in short distances. An examination of the short stretch of the lode that is exposed in the crosscut shows that the heaviest mineralization occurs within 4 feet of the gouge-filled fracture. Exploration to determine the presence or absence of ore has not been carried beyond that fracture. As the owner was not in the district at the time this property was visited, the proportion of gold to silver in the ore is not known, though it is reported that it contains gold, and the deposit is therefore classed as a gold lode.

OTHER GOLD LODE PROSPECTS.

Many other lode claims have been staked in this district, and on some of them the annual assessment work is done, but others have been staked and later abandoned. The writer has described here only those properties that seemed of sufficient promise to the owners to warrant underground development or the excavation of sufficient open cuts to expose the vein. Some veins that have received little attention, however, may on exploration show great promise, and undoubtedly many veins exist that have not yet been discovered.

ANTIMONY LODES.

PRESENT CONDITIONS.

Within the Kantishna district there are several claims that are held for their content of the antimony trisulphide, stibnite. Genetically the antimony lodes are directly related to the gold lodes already described, and the veins have the same association of minerals, but in the antimony lodes antimony occurs 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 in this region, but the remoteness of the district and the prevailing low price of antimony prevented the exploitation of the deposits, although some development work was done on two of them. After the outbreak of the European war the price of antimony advanced from 5 cents a pound to the unprecedented price of 40 cents a pound, which it reached 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 increases in mining in response to the increased price of antimony were 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 water of Kantishna River, except by sled in winter and thence by boat to Tanana

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

the following summer. Even after the ore reaches Tanana several weeks must elapse before it can be delivered to a purchaser in the States. At least three months and possibly a longer time must therefore elapse between the date the ore is mined and the date it reached the market. When to the cost of mining is added the cost of transportation by sled and small boat to the Tanana and the 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 these high costs the instability of the market and the possibility of a sudden drop in the price of antimony must be considered. At 40 cents a pound the producer might make a fair profit in shipping stibnite ore, but at 25 or 30 cents a pound he might sustain a serious loss. As a result little stibnite ore was mined in 1915, and none was shipped. Some ore was mined and stacked in 1916, but at this time (1917) no antimony from the Kantishna region 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 the work done 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. The open cut and the tunnel show a strong fissure along which movement has taken place. This fissure strikes N. 50° E. and dips 82° SE., and forms the southeast wall of the main ore body, though a little ore is seen on its southeast side. 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 29° E.

Almost pure stibnite occurs here in veinlets and in veins, the largest 2 feet thick, and in irregular lenses and bunches. In some places it is solid and unaltered, but in others it is crushed and broken and consists of small fragments of quartz and stibnite recemented by yellow and reddish secondary oxidation products, which on 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 with their longest diameter oblique to the main fissure, the ore lenses and veinlets in general dipping 60° NW. The stibnite occurs predominantly as aggregates of acicular crystals but includes also masses of fine-grained material. About 125 tons of hand-sorted stibnite has been mined, most of which was taken from the open cut. That taken from the tunnel was of lower grade, as the pure stibnite occurred there in smaller bunches, and the ore contained 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, and 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.

Caribou lode, in the basin of Caribou Creek, near the mouth of Last Chance Creek, a tributary from the southeast, is a stibnite-bearing lode on which some development work has been done. This property was visited by Prindle [1] in 1906, and the following description is written from information gathered by Prindle and by the writer. Little work has been done on the property since 1906, and at the time it 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 67° SE., is about 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, the largest 2 inches or more in length. Within the coarsely crystalline stibnite there are mingled many long prisms of quartz, which lie parallel with and are surrounded by the stibnite. The country rock inclosing the vein is much-contorted hornblende schist, the general strike of which is N. 65° E. and the general dip 35° NW. On Caribou Creek, several hundred feet northeast of the shafts, is an outcrop of a fissure that strikes N. 45° E. and dips 75° SE. It is believed to be the continuation of the antimony lode but 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 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.

[1] Prindle, L. M., The Bonnifield and Kantishna regions: U. S. Geol. Survey Bull. 314, p. 210, 1906.

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 wall of the valley, a claim has been staked on a lode deposit of stibnite, called the Stampede lode. The only work done here is a large open cut excavated in 1916. The country rock, a reddish quartzite schist, as seen at the nearest outcrop to the lode that seemed undisturbed, strikes northwest and dips 30° NE. At the outcrop of the lode, near the top of a rounded ridge, the surface is covered with a mantle of disintegrated rock, and the schist itself is much disturbed by frost and by creep, so that the relation between the ore and the country rock is difficult to ascertain. In the floor of the open cut and at its face is a large body of nearly pure stibnite, apparently at least 12 feet thick. 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. The ore contains only a little quartz, and one man had in three weeks removed and stacked 40 or 50 tons of selected stibnite, almost entirely free from visible gangue or impurities and 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 northwestward and apparently dips 65° SW. From this vein a branch vein of stibnite strikes northeastward. The stibnite is mostly a close-grained, massive aggregate containing small scattered crystals but includes some that is more coarsely crystalline. A sample of ore from this vein is reported to have showed on assay a content of 69.8 per cent antimony, 1 per cent arsenic, and no silver or lead.

Another stibnite-bearing vein, which follows the general course of the Stampede lode but contains much quartz, is said to crop out on the opposite side of Stampede Creek. No work has been done on it.

LIGNITE.

PRESENT DEVELOPMENT.

Tertiary deposits containing lignitic coal occur at intervals throughout the area considered in this report. They are of large extent just east of Nenana River, in the Nenana coal field, where deeply cut valleys expose the formation which there contains numerous beds of lignite. The coal-bearing beds in the Nenana field are overlain by a heavy body of oxidized gravels, which in many places seem to lie conformably upon them. West of Nenana River, in the area under discussion, 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 west as the headwaters of Bearpaw River. At some of these localities there are beds of lignite. No single exposure discloses lignite in the abundance in which it is found in the Nenana field, and it is doubtful whether it occurs so abundantly elsewhere. The area of coal beds and the quantity of lignitic coal west of Nenana River, however, may be out of proportion to the amount seen in the outcrops. In this area the beds are not generally dissected by deep valleys that have bare walls, as they are 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 rocks, so that outcrops are infrequent and poor. The widespread geographic distribution of the beds of the coal-bearing series, however, and the presence of lignitic coal in these beds at widely separated localities indicate that a much larger quantity of lignite than is now known may lie beneath a covering of younger materials.

The localities west of Nenana River at which beds of lignite were seen are briefly described below.

TEKLANIKA BASIN.

Savage River.—Lignite is exposed at several places in the basin of Savage River, the eastern branch of Teklanika River. The southernmost of these exposures is near Ewe Creek, a small westward-flowing tributary that drains the north slope of the schist mountains north of the Dry Creek-Savage River divide. About a mile above the mouth of Ewe Creek, on its north side, there is a prominent light-colored bluff composed of decayed schist and blue-white clays. Just east of this bluff, at the mouth of a small southward-flowing stream, a 2-foot bed of weathered lignite is exposed. 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 both to the north and south of this exposure, the area underlain by coal at that place is probably small.

On the north side of Ewe Creek a bed of lignite that shows a maximum thickness of 9 feet crops out at intervals at the edge of the stream flat from the mouth of the creek eastward for nearly a mile. The relations of the lignite to the overlying and underlying beds were not exposed. As this bed strikes N. 75° E. and dips about 20° N. and thus lies beneath the broad benches 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 River, about a quarter of a mile below the mouth of Ewe Creek, a short section of a 14-foot lignite bed is poorly exposed in the bluff above the stream. It strikes N. 85° E., dips 15° N., and is overlain stratigraphically by 40 feet of cross-bedded sandstone. The coal-bearing beds at the top of the bluff are covered unconformably by a horizontal bed of coarse yellow gravel 8 feet thick above which lies a horizontal bed of fine gravel 20 feet thick. A mile and a half below this outcrop, along the same bluff, the following section, which shows a total of 25 feet 8 inches of lignite, in five beds, is excellently exposed:

Sections of lignite-bearing beds on Savage River, 1½ miles below the mouth of Ewe Creek.

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

The strike of the beds at the south end of the exposure is about N. 20° W. and the dip is 10° W., but toward the north end the dip steepens in a sharp flexure. At that end 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 a horizontal bed of terrace gravel. On the east side of Savage River, 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 to the beds in the section listed above are not clear, but it should probably be correlated with one of them.

The numerous outcrops of lignite observed in the part of Savage River basin that lies between the schist hills on the south and the high gravel ridges on the north indicate that there is at this place a coal field, probably several square miles in area, in which lignite occurs in beds of workable thickness. Time was not available for the careful structural work necessary to determine the probable extent of the several beds of lignite.

A little impure lignite was observed in the east bank of Savage River about 1½ miles above its mouth, but no large beds of lignite 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 here have been compressed into an anticlinal fold, on the north flank of which the lignite dips 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 the crest of the Alaska Range. The stream bars below the junction contain a considerable amount of lignite 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 Toklat River at its forks.

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

KANTISHNA BASIN.

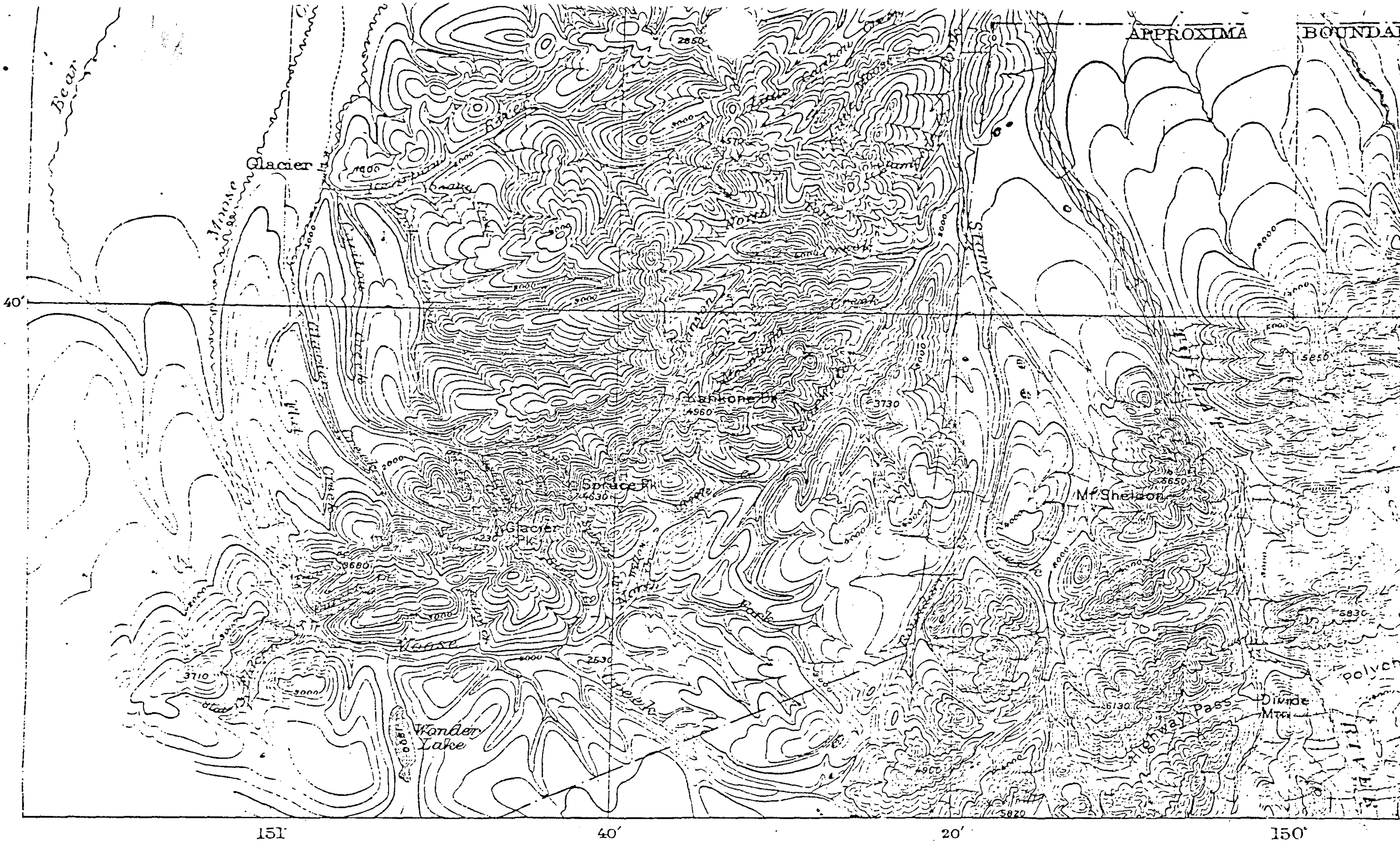
Moose Creek.—Near the extreme head of Moose Creek, a tributary of Bearpaw River, in the Kantishna basin, which rises in the high mountains 9 miles northeast of the terminus of Muldrow Glacier, there is a basin-like area floored with beds of the Tertiary coal-bearing formation. A number of exposures there show thin beds of carbonaceous materials 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 a weathered outcrop of a 12-foot bed of lignite, which strikes N. 80° E. and dips 55° S. This bed seems to

lie near the base of the coal-bearing formation at that place, and overlies a purple discolored shale, which is underlain by volcanic material. The outcrops of this bed of lignite were observed for a short distance along the flank of the mountain, but the areal distribution of the 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.

Six miles below the lignite exposure just described Moose Creek forks, and fragments of lignite were seen in the stream gravels of the northeast fork also. A hasty examination failed to disclose the bed from which these fragments were derived, but it is reported that a bed of lignite 10 feet thick is exposed along the south bank of that fork 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 there are areas of the coal-bearing formation in this locality, though they are for the most part covered by younger gravels.

INDEX.



Alfred H. Brooks, Geologist in charge of division.
Topography and control by C. E. Giffin, J. W. Bagley,
R. B. Oliver, and D. C. Witherspoon.
Land surveys and included topography by General Land Office.
Geodetic position by General Land Office and
U. S. Coast and Geodetic Survey.
Railroad location and survey of Nenana River by
Alaskan Engineering Commission (railroad under construction).
Datum of C. E. Giffin area is mean lower low water, Portage Bay,
derived from elevations by Alaskan Engineering Commission.
Elevations of other portions as previously published.
Surveyed in 1906, 1910, 1913, and 1916.

RECONNAISSANCE MAP OF NENANA-K

Scale $\frac{1}{250,000}$

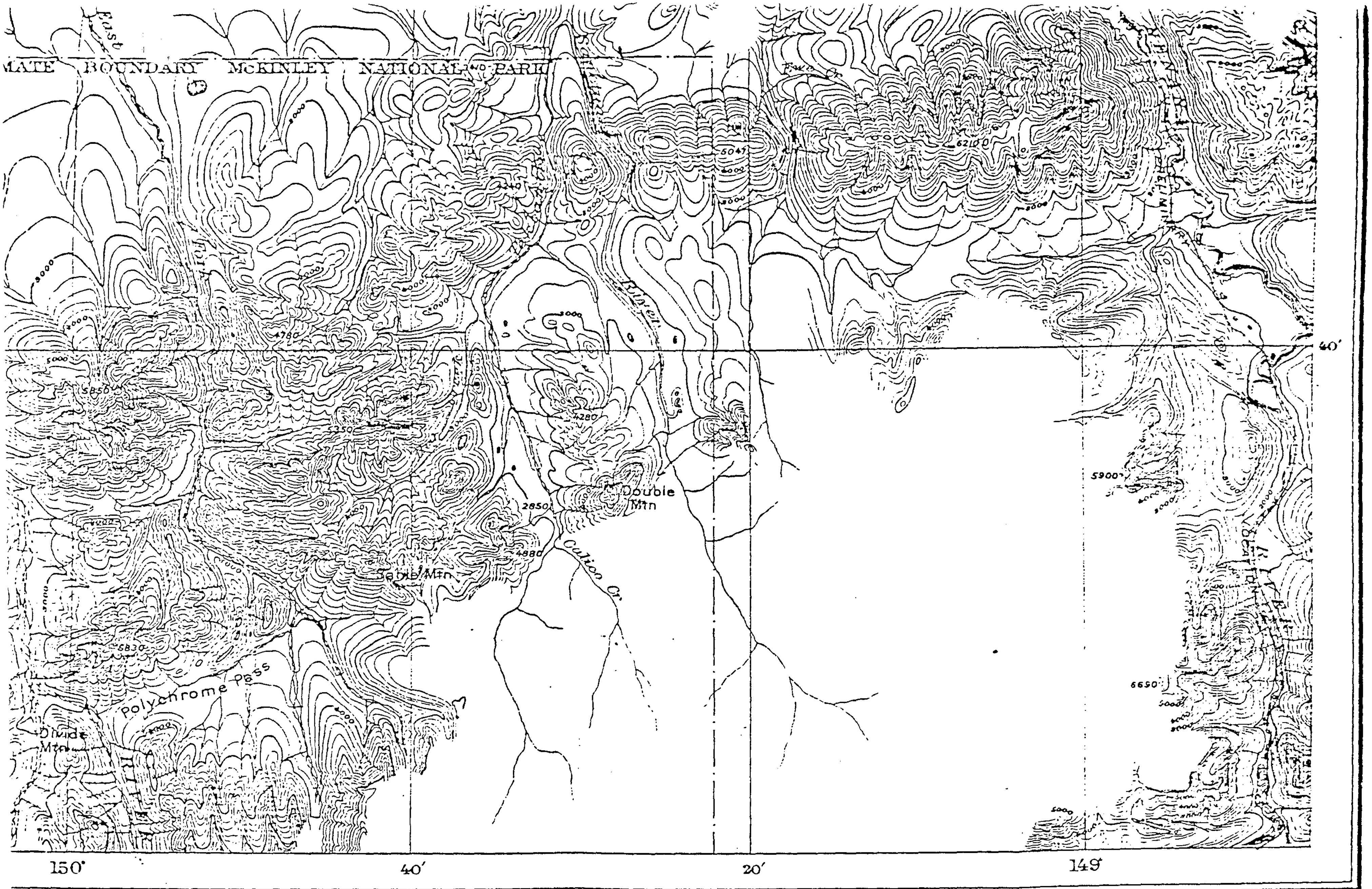
5 0 5

5 0 5 10

Contour interval 200 feet

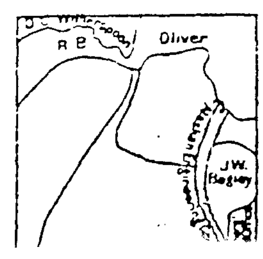
Dotted lines represent approximate topograph

1919



NANA–KANTISHNA REGION, ALASKA

A.HOEN & CO. BALTIMORE



le 1/250,000

5 10 15 Miles

10 15 20 Kilometers

ur interval 200 feet

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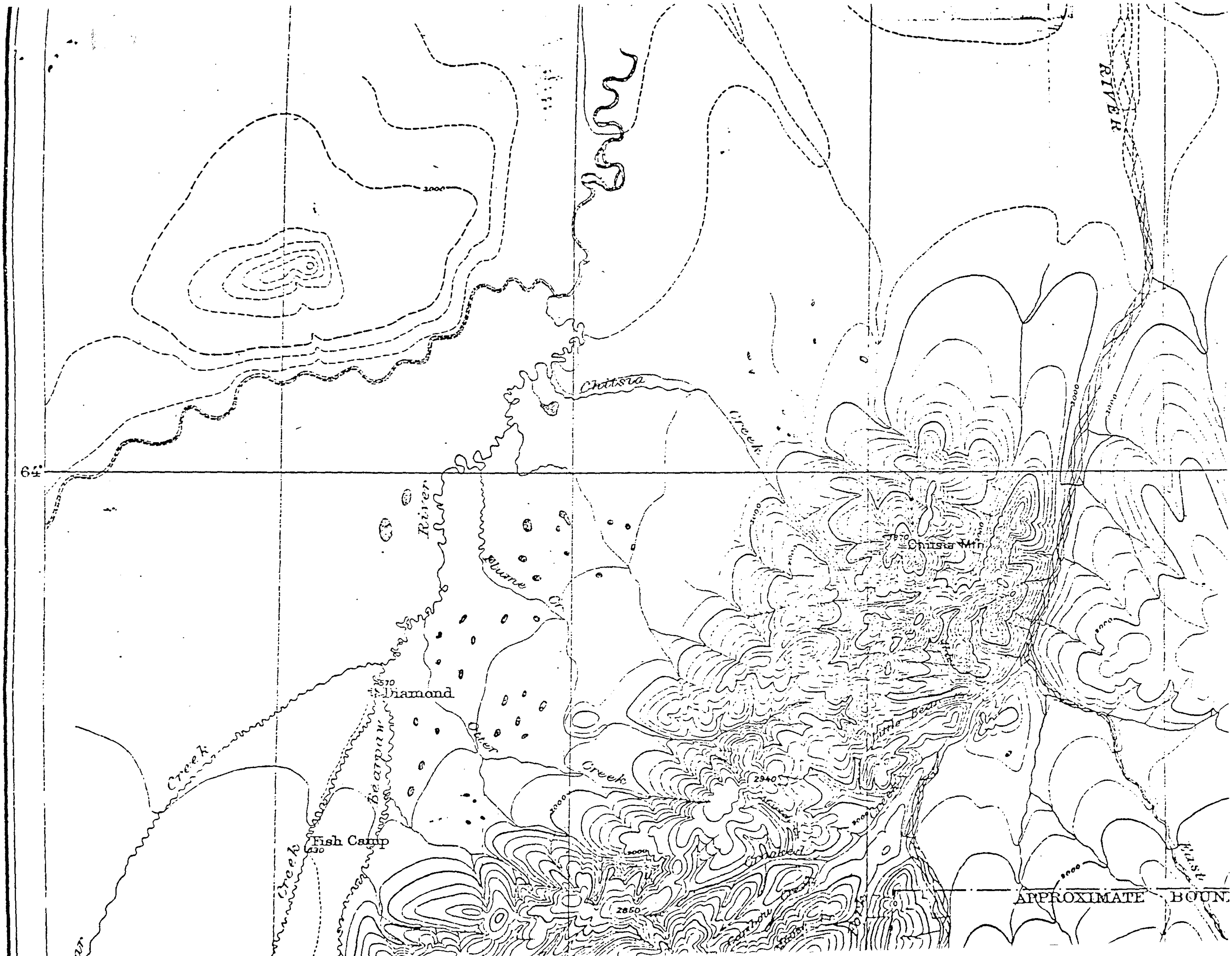
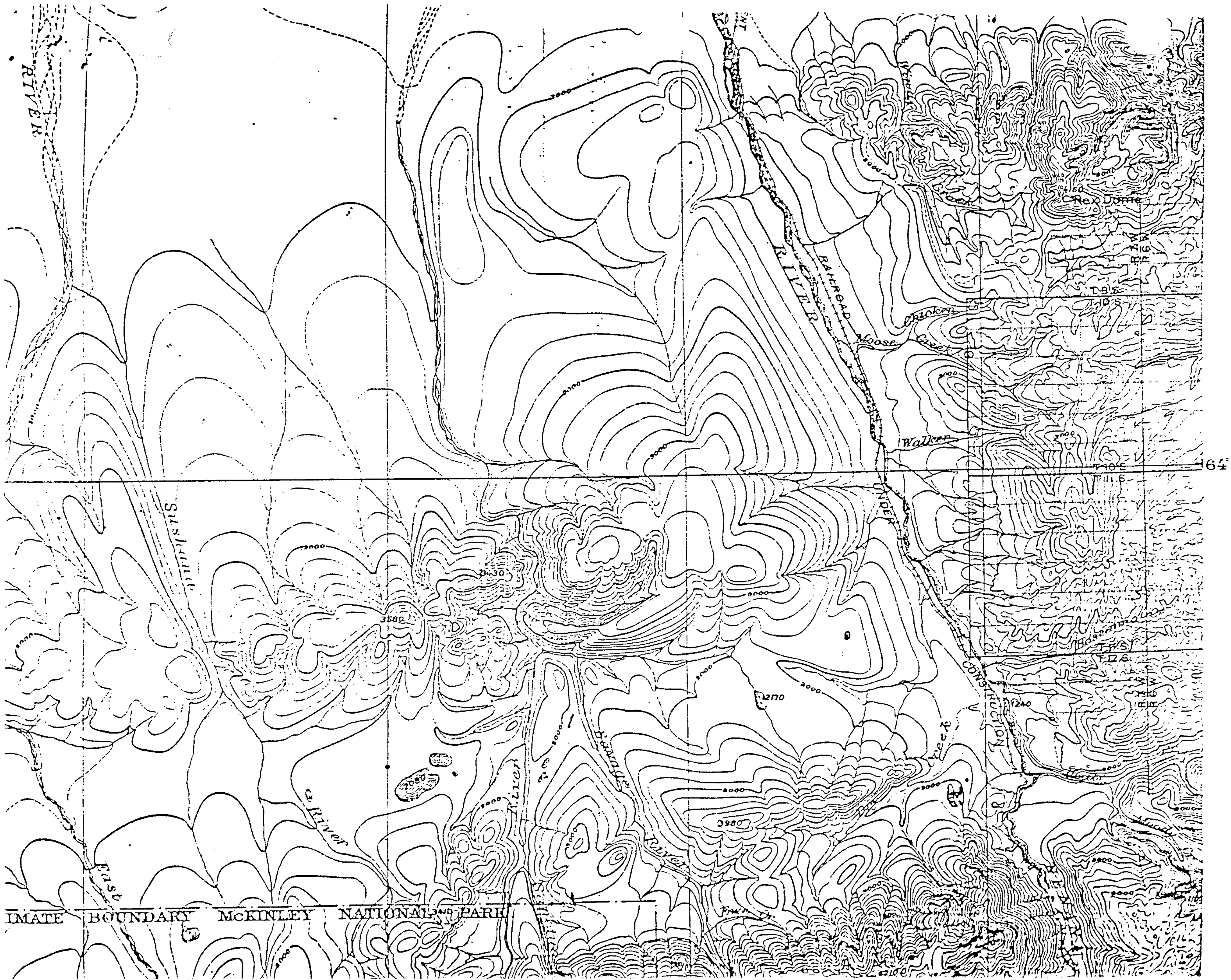
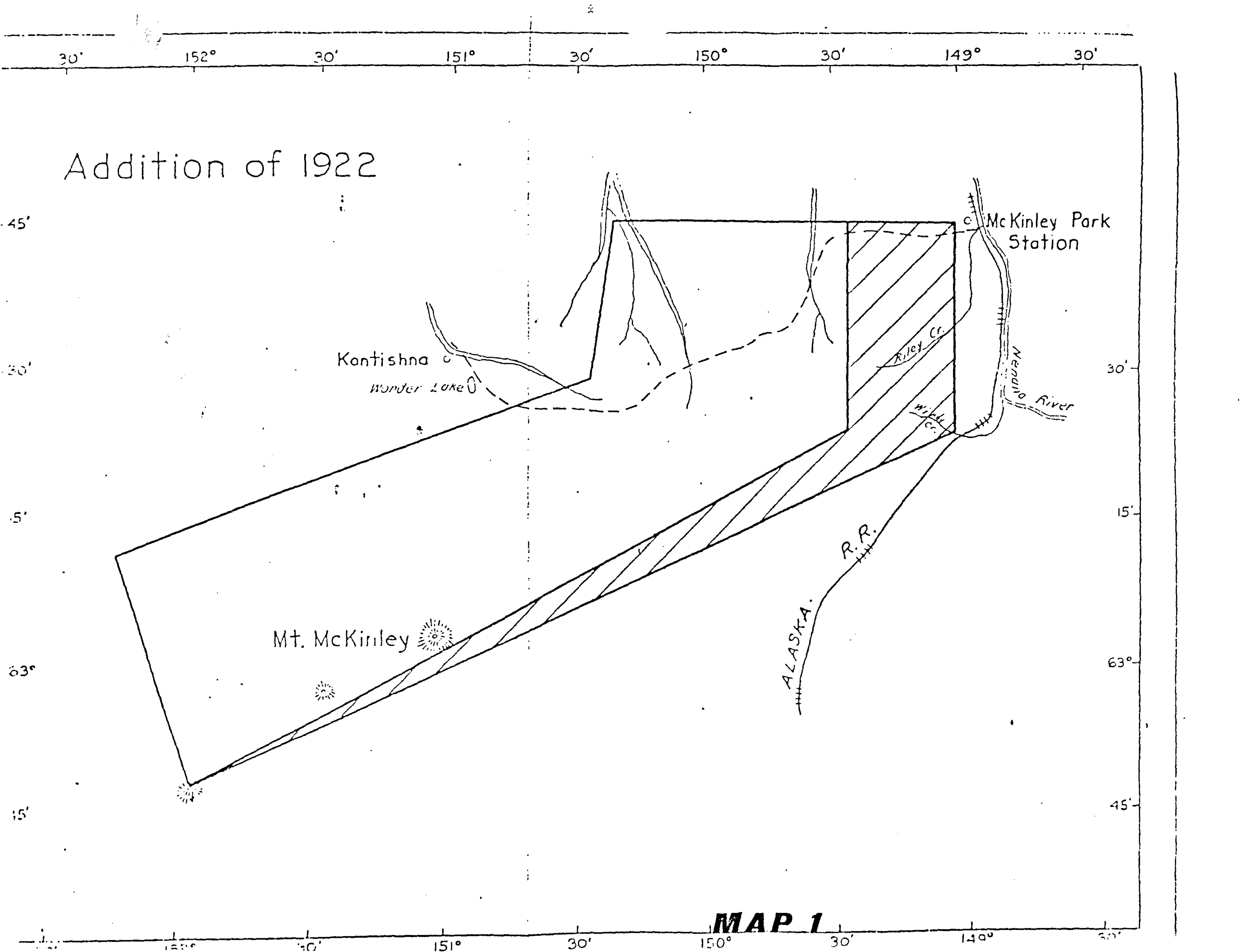


64°
RIVER
Chitsia
Creek
River
Flume
Cr
Chitsia Mtn
Diamond
Creek
Outer
Creek
Bearpaw
Creek
Fish Camp
2940
2850
Crooked
East
APPROXIMATE BOUN


RIVER
Rex Dome
RIVER
RAILROAD
Chicken
Moose
Walker
64°
T.9S.
T.10S.
T.10S.
T.11S.
T.11S.
T.12S.
Sushana
3580
3980
2170
1240
CONSTRUCTION
River
River
River
Creek
East
IMATE BOUNDARY McKINLEY NATIONAL PARK

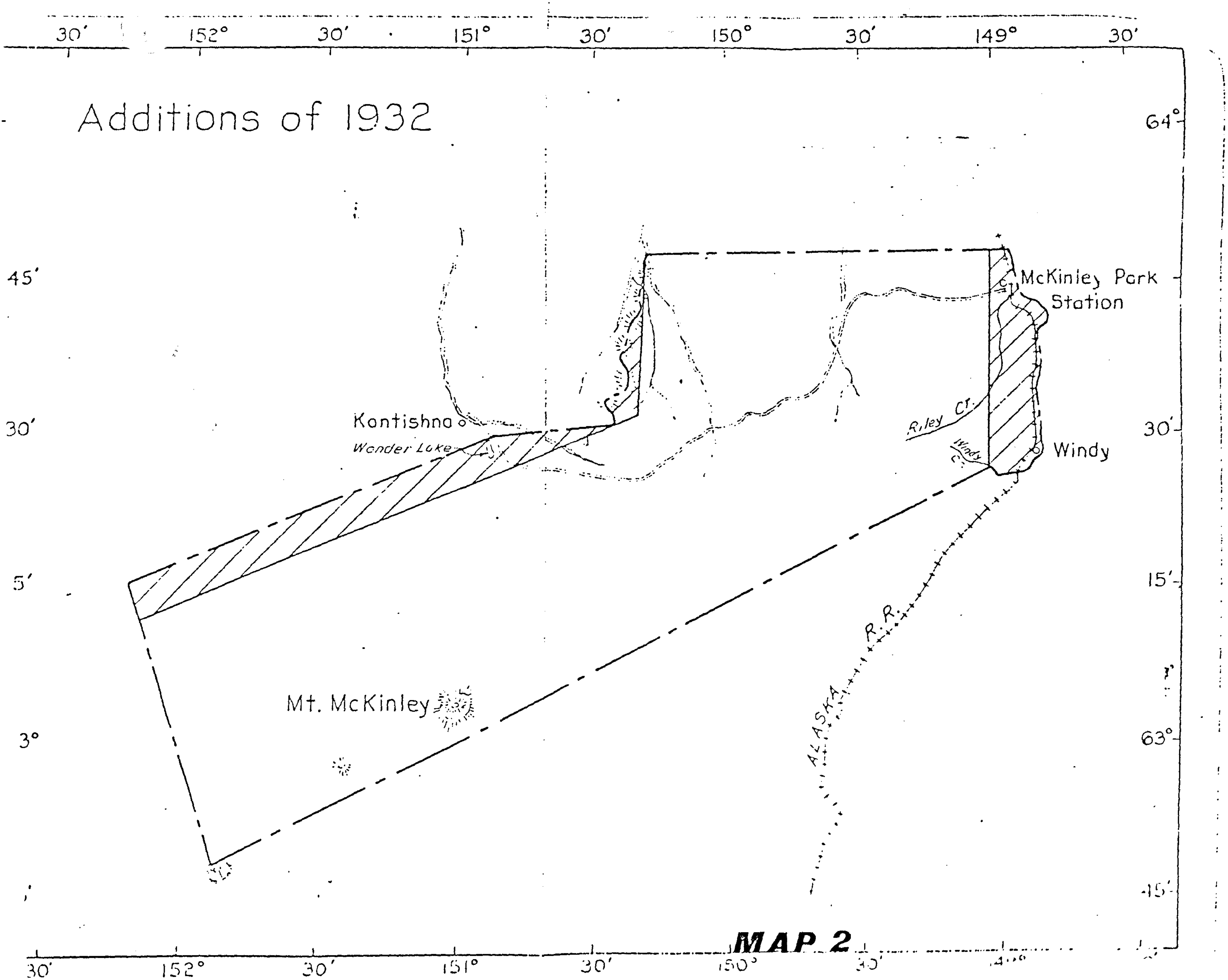
Map 1, Addition of 1922.



Addition of 1922
McKinley Park Station
Kantishna
Wonder Lake
Riley Cr.
Nenana River
Mt. McKinley
ALASKA R.R.
30' 152° 30' 151° 30' 150° 30' 149° 30'
45' 30' 15' 63° 45'

MAP 1

Map 2, Addition of 1932.



Additions of 1932
McKinley Park Station
Kantishna
Wonder Lake
Riley Cr.
Windy
Mt. McKinley
ALASKA R.R.
30'
152°
30'
151°
30'
150°
30'
149°
30'
64°
45'
30'
15'
63°
45'

MAP 2

ANNUAL REPORT OF THE ALASKA ROAD COMMISSION
FISCAL YEAR 1924

REPORT UPON THE CONSTRUCTION AND MAINTENANCE OF MILITARY AND POST ROADS, BRIDGES AND TRAILS; AND OF OTHER ROADS, TRAMWAYS, FERRIES, BRIDGES, TRAILS, AND RELATED WORKS IN THE TERRITORY OF ALASKA

TWENTIETH ANNUAL REPORT

1924
PART II

BOARD OF ROAD COMMISSIONERS
FOR ALASKA

JUNEAU, ALASKA
1924

ROUTE 46D—McKINLEY PARKTRAIL....(2 MILES WAGON ROAD 85 MILES TRAIL)

This trail leaves McKinley Park Station, Mile 348 Alaska Railroad, passing through the heart of McKinley National Park which is teeming with wild life, and on into the Kantishna mining district. The trail is used by trappers, prospectors, miners and tourists.

The past season actual construction work was inaugurated on this route. A very good showing was made with the small allotment available. Two miles of road were built, including the following items of work:

Grading, 12 to 16 feet wide	1.9 miles
Clearing	9.6 acres
Bridges, native timber	1—126-foot trestle
Corduroy	175 feet
Culverts	52 lineal feet

The location was extended 3 miles beyond this season's construction. One-half mile of this season's work was on a steep side hill, a part of which was in solid rock. This section included some of the heaviest work in the first 15 miles of the route.

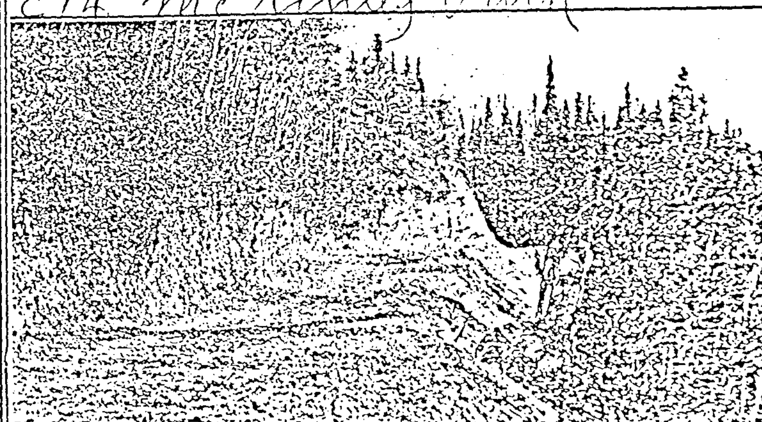
It is the present plan to prosecute this work on a much larger scale next season.

A portion of the money expended this season was contributed by a private party through the Park Superintendent.

Expenditure:

Alaska Road Commission	$4,261.49
Contributed	700.25
Total	$4,961.7[illegible]

C14 McKinley Park



MILE 1½, MT. McKINLEY NATIONAL PARK.

ANNUAL REPORT ALASKA ROAD COMMISSION. 165

III. EXPENDITURE OF OTHER FUNDS SUPERVISED BY THE BOARD.

COMPOSITE OF RECEIPTS AND EXPENDITURES FOR FISCAL YEAR 1924 FROM THE TWENTIETH ANNUAL REPORT OF THE ALASKA ROAD COMMISSION

(Original pages indicated)

EXPENDITURES IN DETAIL.

FEDERAL APPROPRIATIONS AND "ALASKA FUND" AND FUNDS CONTRIBUTED BY THE TERRITORY OF ALASKA AND OTHERS.

ANNUAL REPORT ALASKA ROAD COMMISSION. 157

EXPENDITURES IN DETAIL—(Continued.)

46D	McKinley Park Trail	3,301.49	960.00	4,261.49
46E	Diamond-Telida		398.52	398.52
46G	Kobi-Bonnifield	538.73		538.73
47	Coldfoot-Wiseman	1,942.61	600.00	2,542.61
49	Davidson's Landing-Taylor		4,221.25	4,221.25
51	Talkeetna-Cache Creek, 1st.Sec.	11,413.12	5,000.00	16,413.12

164 ANNUAL REPORT ALASKA ROAD COMMISSION.

II. CONTRIBUTED FUNDS.

ACT OF CONGRESS APPROVED JUNE 30, 1921, ALASKA SPECIAL FUND.

e Territory:

Act Legislature approved April 21, 1919, Public Roads, Bridges, Trails and Ferries.

Fiscal Year:		
1920	$115,517.94	
1921	85,746.61	$201,264.55
Approved May 7, 1921, Public Roads, Bridges Trails and Ferries.		
Fiscal Year:		
1921	$ 28,000.00	
1922	43,237.28	
1923 (Includes $20.45 refund)	88,533.33	159,770.61
Approved May 5, 1921, Nizina River Bridge.		
Fiscal Year:		
1922	$ 5,000.00	
1923	20,000.00	25,000.00
Approved May 7, 1921, Shelter Cabins.		
Fiscal Year:		
1922	$ 6,500.00	
1923	3,500.00	10,000.00
Approved May 4, 1923.		
Fiscal Year 1924:		
Shelter Cabins	$ 15,000.00	
Public Roads, etc. (refunds $635.78)	91,961.13	106,961.13
Total Territory		$502,996.29
By Others:		
Fiscal Year 1922:		
City of Valdez	$ 220.02	
City of Wrangell	500.00	
City of Sitka	500.00	
Alpine Club of Skagway	463.75	1,683.77
Year 1923:		
ty of Valdez	$ 601.83	
ity of Juneau	777.71	1,379.54
Fiscal Year 1924:		
Stewart & Denhart	$ 540.00	
National Park Service	500.00	
City of Nome	3,500.00	4,540.00
Total Contributed Funds		$510,599.60

Fiscal Year 1920 and prior years		
Fiscal Year 1921:		
1. For the Territory of Alaska:		
Kuskulana Bridge		750.00
2. For the Chief of Engineers, U. S. Army:		
Rivers and Harbors, Fish Traps, etc.		1,602.50
Total	$	2,352.50
Fiscal Year 1922:		
1. For the Territory of Alaska:		
Chairman, 3rd Division	$	7,812.19
Chairman, 4th Division		21,365.00
2. For the Quartermaster General, U. S. Army:		
Ft. Wm. H. Seward water supply		2,502.02
3. For the Chief of Engineers, U. S. Army:		
Rivers and Harbors, Fish Traps, etc.		47,503.46
Total	$	79,182.67
Fiscal Year 1923:		
1. For the Territory of Alaska:		
Chairman, 3rd Division	$	10,855.72
Chairman, 4th Division		15,717.11
Seward Peninsula Railroad		24,010.65
2. For the Chief of Engineers, U. S. Army:		
Rivers and Harbors, Fish Traps, etc.		21,145.12
3. For The Alaska Railroad		$1,590,570.09
Total		$1,662,298.69
Fiscal Year 1924:		
1. For the Territory of Alaska:		
Chairman, 3rd Division	$	14,993.86

Account No.	Name	Miles	Expenditure
	Overhead		$ 30.00
10B	Seward-Nash	2½	4,814.20
35B	Palmer-Mile 26½	8½	867.08
35Q	Edlund Road	½	994.29
55	Kenai-Russian River	60	359.25
61	Strelna-Kuskulana	16	1,499.98
75	Anchorage-Eagle River	13½	564.57
75A	Anchorage-Lake Spenard	4	2,552.53
75B	Whitney Road	6	1,213.15
75C	Chester Creek Boat Landing	1	500.00
93A	Bull River Bridge and Trail	4½	1,598.81
	Totals	116½	$ 14,993.86

Chairman, 4th Division .... $ 20,000.50

Account No.	Name	Miles	Expenditure
	Overhead		$ 70.00
7A	Summit-Chatanika	11	500.00
7B	Fox-Olnes (Includes Dome Cr.)	13	2,112.00
7C	Summit-Fairbanks Creek	13	1,500.00
7D	Ester Creek	13	4,955.00
7DA	College Spur	½	500.00
7GA	Lazelle Road	2½	186.00
7H	Little Eldorado	6	1,500.00
7J	Fairbanks-Chena Hot Springs	64	314.00
7K	Olnes-Livengood	54	288.00
7N	Farmers' Birch Hill	9	3,145.00
7NA	Isabelle Creek	2	150.00
7T	Farmer's Chena Slough	4½	1,000.00
15A	Central House-Circle Hot Spgs.	9	1,200.50
23A	Olnes-Beaver	115	2,580.00
	Total	316½	$ 20,000.50

Tolovana Tram Road		$ 6,400.00
2. For the Chief of Engineers, U. S. Army:		
Rivers and Harbors, Fish Traps, etc.		$ 37,802.90
Improvement of Nome Harbor	$ 17,890.03	
Improvement of Wrangell Harbor	6,325.46	
Survey of Tolovana River	300.00	
Preliminary Examination of Yukon-Kuskokwim Portage	2,972.15	
Preliminary Examination of Gastineau Channel and adjacent waters	53.00	
Investigation of Port Facilities	25.00	
Public Hearings, Fish Traps, etc.	10,237.26	
Total	$ 37,802.90	
3. For The Alaska Railroad		$ 1,511,878.05
Construction and Operation of Railroads in Alaska	$ 161,745.97	
Construction and Equipment of Railroads in Alaska, 1922-23	401,613.81	
Maintenance and Operation of Railroads in Alaska, 1923	210,482.17	
Construction and Equipment of Railroads in Alaska, 1923-24	323,188.02	
Maintenance and Operation of Railroads in Alaska, 1924	394,212.71	
Operation of River Steamboats, 1924	20,635.37	
Total	$1,511,878.05	
4. For National Park Service:		
Mt. McKinley National Park Road		$ 700.25
Total of Supervised Funds, Fiscal year 1924		$ 1,591,776.56
Grand Total, Supervised Funds		$ 3,872,943.87
Grand Total, All Funds		

ANNUAL REPORT OF THE ALASKA ROAD COMMISSION
FISCAL YEAR 1925
REPORT UPON THE CONSTRUCTION AND MAINTENANCE OF MILITARY AND POST ROADS, BRIDGES AND TRAILS; AND OF OTHER ROADS, TRAMWAYS, FERRIES BRIDGES, TRAILS, AND RELATED WORKS IN THE TERRITORY OF ALASKA

TWENTY-FIRST ANNUAL REPORT 1925

PART II OPERATIONS

46D—The McKinley Park Scenic Road was extended 8 miles. This project was initiated as a cooperative project between the Alaska Road Commission and the National Park Service in 1922. The Alaska Road Commission has been utilizing its funds in reconnaissance, surveys, location, purchase and freighting of supplies, accumulation of equipment, etc., so that upon National Park funds becoming available, work could be aggressively pushed ahead.

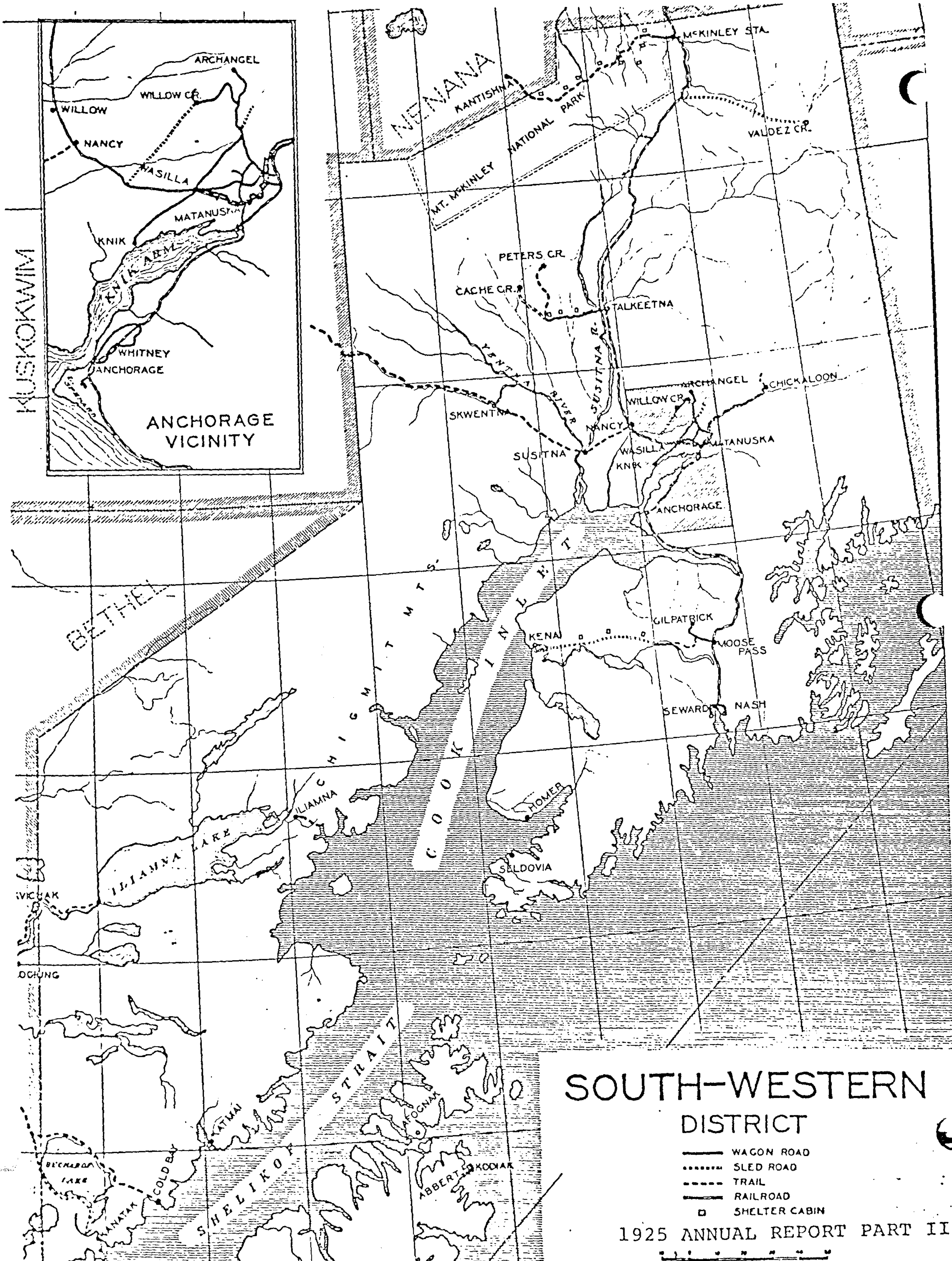
The National Park section of the project was adopted by Congress in the Act of April 9, 1924, providing for a 3-year road program for the National Parks. It provides for the construction of 33 miles of road and 70 miles of trail within the Park at a first cost of $272,700. The first National Park funds to become available were appropriated by the Act of March 3, 1925, for the supsupport of the activities of the Interior Department. $80,000 were allotted to this project for the fiscal year.

At the close of the fiscal year an office building 24x26 feet, a one story frame structure painted and containing 4 rooms, was erected at McKinley Park Station; also a one story frame warehouse 30x45 feet with a railway unloading platform and with a warm storage addition 15x24 feet. A powder house 10x12 feet was erected at Mile 4, and two 14x16 ft. log cabins facing each other with an 8 ft. roofed over space between at the Savage River Crossing, Mile 13, were completed.

Eight Army tents 10x10 feet with 3 rounds of logs below, had been erected on the 86 mile trail across the Park to Kantishna post office. This trail had been brushed out, tripodded, and signs erected during the fiscal year 1923.

Final location has been run for the entire 36½ miles of road. 14 miles have been cleared and grubbed, 10 miles graded, and a total of 8 miles from McKinley Park Station partially surfaced. All supplies for the current season's operations have been purchased, landed at McKinley Park Station and about 500 tons of bridge lumber, forage, provisions, corrugated iron culverts, and other supplies freighted over the snow to Savage River Camp, and some bridge lumber and forage have been freighted on to the Sanctuary River crossing at Mile 21. At the end of the fiscal year there were expendable supplies on hand valued at $9,017.80.

Expenditures for the fiscal year, including supplies on hand and cost of freighting over the snow: National Park Service $80,020; Alaska Road Commission $6,565.67, and the Territory of Alaska (shelter cabin fund) $202.50; total $86,788.17.



1925 ANNUAL REPORT PART II

United States Department of the Interior

OFFICE OF THE SOLICITOR
ALASKA REGION

222 West 8th Avenue, #34
Anchorage, Alaska 99513-7584
(907)271-4131

IN REPLY REFER TO:
NPS.AK.306

COPY FOR YOUR INFORMATION

NOV 1 '89

October 30, 1989

MEMORANDUM

TO: Regional Director
Alaska Region
National Park Service

FROM: Attorney
Office of the Regional Solicitor
Alaska Region

SUBJECT: Review of Memorandum on Legal
Status of Denali Park Road
Your Ref. L3027 (ARO-OL)

Pursuant to your request to this office, we have reviewed your memorandum of July 8, 1988 from the Chief of the Land Resources Division concerning the Denali Park Road. We have no legal problems with the five fact issues discussed or the interpretation of these facts. We would like to suggest certain information which might bolster your opinion.

Attached is a legal opinion on Kantishna Road of Linda Walton, Assistant Attorney General for the State of Alaska, dated September 23, 1982, in which she finds that the National Park Service does have authority to restrict travel and regulate the "Kantishna Road" within the boundaries of the 1932 park. Although her memo contemplates the existence of a possible easement by implication or necessity over this portion of the road (a position with which we disagree), she does recognize that there would be no legal means to impose such an easement. On the whole, it appears that this opinion from the Attorney General's Office supports National Park Service jurisdiction and ownership of the Denali Road.

It should be noted that in the opinion of the Assistant Attorney General of Alaska there is reference to the Highway Act of 1956 (PL 84-627). The funds for expenditures in areas administered by the National Park Service were appropriated for the Secretary of Interior to be administered pursuant to 16 U.S.C. § 8, et seq. Therefore, this Act does not in any way bolster jurisdiction of the Department of Commerce over the park road.

To the extent that the Denali Road is within the park as it existed prior to January 30, 1922, 16 U.S.C. 347, the authority and ownership of the road is very clear. Before there was any construction on the road, in the mid-to-late 1920's, the Secretary of the Interior was given exclusive control over the construction and improvement of roads in national parks on April 9, 1924. 16 U.S.C. § 8. This jurisdiction has never been repealed or transferred, so that any construction on the road within the pre-1932 park was under the direction and jurisdiction of the Department of Interior. Therefore, for the portion of the road in the pre-1932 park, it is clear that no one but the Secretary of Interior has ever had jurisdiction.

If you have any questions, please call Regina Sleater of this office at 271-4131.

F. Christopher Bockmon

Attachment

MEMORANDUM State of Alaska

TO: Robert Venusti, Director
Planning and Programming
Department of Transportation
600 University Avenue, Suite D
Fairbanks, Alaska 99701

DATE: September 23,1982

FILE NO:

TELEPHONE NO:

FROM: Linda Walton LW
Assistant Attorney General
604 Barnette, Room 228
Fairbanks, Alaska 99701

SUBJECT: Legal Opinion on Kantishna Road

At your request, I have researched the authority of the National Park Service to restrict access to the Kantishna Road, via the McKinley Park Road. The combined Park and Kantishna Road crosses the northern part of the area formerly known as Mt. McKinley Park and passes from the northern park border on to the Kantishna through the area known as the Denali National Monument (Preserve). The Park Service purports to have regulatory authority pursuant to 36 CFR 1 - 7, as authorized by 16 USC 3, which provides:

> The Secretary of the Interior shall make and publish such rules and regulations as he may deem necessary or proper for the use and management of the parks, monuments, and reservations under the jurisdiction of the National Park Service, and any violation of any of the rules and regulations authorized by this section and sections 1, 2 and 4 of this title shall be punished by a fine of not more than $500 or imprisonment for not exceeding six months or both, and be adjudged to pay all costs of the proceedings. . . .He may also grant privileges, leases, and permits for the use of land for the accommodation of visitors in the various parks, monuments, or other reservations provided for under section 2 of this title, but for periods not exceeding thirty years; and no natural curiosities, wonders, or objects of interest shall be leased, rented, or granted to anyone on such terms as to interfere with free access to them by the public. . . .And provided further, That no contract, lease, permit, or privilege granted shall be assigned or transferred by such grantees, permittees, or licensees without the approval of the Secretary of the Interior first obtained in writing:...

The State, on the other hand, received, pursuant to the Alaska Omnibus Act, a quitclaim deed to the road from the Department of Commerce. The quitclaim deed covers the road only from the northern park boundary to Kantishna airfield and is 200 feet wide by authority of PLO 2665 where it is mentioned as a "feeder road. There may be some limitation on the right to federal government's legal control over access via the McKinley Park Road, based on a written or implied easement, but the legal remedy is unclear. However, to determine the true status of the McKinley Park road, additional research into U.S. or territorial government archives will be necessary. I will outline below the relevant history and law which leads to my tentative conclusion.

HISTORY

Mount McKinley Park was first created in 1917, and its boundaries were extended in 1922 and 1932, by 39 Stat. 938, 42 Stat. 359, and 47 Stat. 68, codified at 16 USC 347 and 355. Until 1932, the Park did not extend as far as Wonder Lake.

I have researched the records of the Alaska Road Commission (A.R.C.), and discovered the following:

The commission was created by act of 1/27/1905 under the authority of the War Department. There were several entities with authority over roads, in the years following. In 1916, the Department of Agriculture was given control of the Bureau of Public Roads, by the Highway Act of July 11, 1916. However, this act was, according to the Alaska Road Commission, largely inapplicable in Alaska and roads remained under the War Department. The Federal Highway Act of 1921 transferred responsibility from the Council of National Defense to agriculture, but excepted the powers and duties of agencies dealing with national parks and of military agencies dealing with highways used primarily for military purposes. This law apparently did not affect any roads in Alaska, as the A.R.C. continued under the jurisdiction of the War Department. Agriculture had jurisdiction in Alaska only over national forests in Southeast Alaska and Chugach. In 1919, the Territorial Road Commission (TRC) was created by H.B. 25, 1919 Session Laws Ch. 11. The act provided in part:

> Section 2. The Territorial Board of Road Commissioners shall have authority to enter into co-operative agreements, with the Board of Road Commissioners for Alaska, and the Secretary of Agriculture of the United States, or other federal authority, for the construction, repair and maintenance of any public road, bridge or ferry, within the Territory of Alaska. In the case of co-operative work, the Territorial Treasurer is authorized to deposit in the United States Treasury, the funds agreed upon to cover the share of the Territorial Road

> Commission in such co-operative projects as are entered into, in accordance with the provisions of this Act. Such funds shall be expended by the Disbursing Officer of the federal authority designated in the co-operative agreement, and a detailed statement of expenditures from such funds so deposited shall, upon the completion of the project for which they were deposited, be furnished to the Territorial Treasurer. Any unexpended balance of such Territorial funds shall be returned.

It is probable that a legal document of some type exists which outlines the expectations of the A.R.C., the T.R.C. and the National Park Service, because of the below described sequence of events, regarding this road.

The first mention of a road to Kantishna is found in the 1921 reports of the Alaska Road Commission, which designate it as Route 46, and note expenditures by the Alaska Road Commission of $4,571.63. However, the 1922 Road Commission' reports make it clear that the 1921 Kantishna road extended from Lignite to Kantishna, not through the Park. The 1922 report labels the Lignite-Kantishna road as 46B. The 1922 report also notes plans to build route 46D, in cooperation with the National Park Service, from Mile 344 on the railroad through the Park to the Kantishna Post Office and then in a loop back to Mile 63 on the railroad "through the finest hunting round in Alaska". This route is the route followed by the present Kantishna road, through the Park, as far as Kantishna. By act of Congress on April 9, 1924, the National Park Service was authorized to construct roads within Park boundaries, and the first funds were appropriated to the Park Service for the McKinley Park road on March 3, 1925.

The Alaska Road Commission reports concerning this road in subsequent years are attached. It appears from these that the road was constructed through the section of land within then existing Park boundaries, primarily with Park Service funds, although the Alaska Road Commission, Territorial Road Commission, and private individuals also contributed. Clearly, the section of the road outside the Park boundaries (as they existed before 1932) was not paid for by the Park Service, but by the Alaska Road Commission and Territorial Road Commission. It also appears that work was first performed on the road within the then existing Park boundaries by Alaska Road Commission funding and private contributions in 1923, before the Park Service had funds to contribute. The road was used for access to mining claims and hunting areas, and by trappers, prospectors, and tourists; the Commission notes that one of the primary purposes of the road was to develop traffic for the government railroad (Alaska Railroad). Since the purpose of construction was obviously for public use, it may well be that before the ARC or private contributors began construction through the Park, they had some type of access agreement with the NPS.

The portion of the road beyond the Park Boundaries, as they existed before 1932, became a public right of way pursuant to RS 2477, through public use and the acts of the ARC and TRC. 43 USC 932 (RS 2477) was repealed October 21, 1976, but without affecting rights previously acquired thereunder. It provided:

> The right-of-way for the construction of highways over public lands not reserved for public uses, is hereby granted.

Thus, if a road or trail existed prior to 1976 and prior to withdrawal of the relevant portions of the land for Park purposes, that right-of-way would still exist. This law is clearly helpful as to the Denali Preserve portion of the road and to the portion outside the pre-1932 Park boundaries, but probably does not apply to the rest of the Park portion, unless my information is incorrect, and a trail was, in fact, there before the 1917 act creating the Park, withdrawing the land from entry, and reserving it for public uses. In Colorado v. Toll, 268 U.S. 228, 69 L.Ed. 927 (1925) the Supreme Court allowed the State of Colorado to maintain a suit intended to prove that an RS 2477 right of way existed prior to creation of Rocky Mountain National Park and that therefore, the Park Service could not regulate the public road. I do not know the ultimate decision regarding this road, as it is not again reported after remand. Subsequent cases, infra, have questioned the holding in Colorado v. Toll.

In 1932, by 48 USC 321, control over and responsibility for construction of roads in Alaska was transferred from the Alaska Road Commission, under the War Department, to the Department of the Interior. The Department of the Interior also at that time had control over the national parks, and in that same year the Park Boundaries were extended beyond Wonder Lake. The records of the ARC probably were also transferred to Interior, including any possible agreement regarding the road.

The Highway Act of 1956 (P.L. 627) transferred road authority from the Department of the Interior to the Department of Commerce. The 1956 act gave authority over forest service highway appropriations to the Department of Commerce for apportionment in the states and in Alaska (Sec. 103). The Act also appropriated funds for expenditures in areas administered by the National Park Service (Sec. 104a), without stating who would apportion and administer the appropriation. Money was also appropriated for expenditure within Indian reservations on roads "provided that the location, type, and description and. . . . construction shall be under the general supervision of the Secretary of Commerce" (Sec. 104(c)). Presumably, construction of Park roads was also intended to be under Commerce authority.

Thus, if this road was improved after 1956, (my understanding is that road improvements or expansion did occur in the 1950's but, but I have been unable to verify this) it was probably improved with funds under Commerce control. This would not necessarily mean that the Park Service is deprived of regulatory authority, but again there may be some memorandum of agreement regarding public access.

Section 107(a) authorized the Territory of Alaska to share in funds "herein or hereafter authorized for projects on the Federal-aid primary and secondary highway systems. . . with the money to be expended by the Secretary of Commerce directly or in cooperation with the Territorial Board of Road Commissioners, and Section 107(b) provides:

> . . . functions, duties and authority pertaining to the construction, repair and maintenance of roads, tramways, ferries, bridges, trails and other works in Alaska, conferred on the Department of the Interior under the act of June 30, 1983 (47 Stat. 446; 48 USC 321a), are hereby transferred to the Department of Commerce and thereafter shall be administered by the Secretary of Commerce or under his direction by such officers as may be designated by him.

The legislative history found at 1956 U.S. Code Cong. & Ad. News 2893, provides in part "with the transfer of functions there is to be transferred the personnel, funds and property used or held in connection with those functions."

However, the responsibility for the Park Service roads was not conferred on the Department of Interior by 48 USC 321(a), but, rather, by national park legislation previously cited, and by the act of 1/31/31, 46 Stat. 1053, 16 USC 8a-c. Thus, this law did not transfer Park Service roads from Interior to Commerce. It would, however, have transferred any interest in the Kantishna Road (including rights of access to it via the Park Road) held by the Alaska Road Commission pursuant to an agreement between the TRC, ARC and NPS, and the commerce quitclaim deed would have transferred the same interest to the State of Alaska.

> On December 1, 1980, Congress again extended the boundaries of McKinley Park by adding Denali Preserve, and renamed the whole, Denali National Park and Preserve, by Section 202(3)(a) 16 USC, 410 hh-1 of the Alaska National Interest Lands Conservation Act. Section 203 provides in part "subject to valid existing rights, the Secretary shall administer the lands, waters and interests therein, added to existing areas or established by the foregoing sections. . . as new areas of the National Park System pursuant to. . .16 USC 1 *et seq*."

Thus, whatever rights the State had in the road prior to December 1, 1980, it clearly retained thereafter. As to that portion of the newly withdrawn ("Denali Preserve" or "Monument"), the State surely had unfettered rights to regulate and develop and maintain the road from the time of the Commerce deed forward. The State would also have, in the absence of an agreement to the contrary, an RS 2477 right of way in that portion of the Park Road beyond the pre-1932 boundaries. And if there was an agreement of some type regarding a right of public access across the McKinley Park portion of the road it might remain in effect or might have expired by its own terms. I have not yet searched for TRC archives, as you may not wish to have that extra time spent in view of the conclusion below.

COMMON LAW DOCTRINES POSSIBLY APPLICABLE

In the absence of a written agreement, common-law doctrines such as easement by implication or necessity may protect the State and the public's right to gain access via the Park road to that part of the Kantishna Road beyond the Park Boundary, which clearly is a State highway.

An easement by implication can be deemed to exist by operation of law if, upon conveyance to a third party there exists and obvious servitude over one part of land owned by the grantor, to the portion conveyed. However, an easement will not be implied where there is evidence that no easement is intended.

In this case all the property was once in common ownership of the United States, and in fact upon passage of 48 USC 231(a) the road through the Park, and the continuation of the road beyond to the Kantishna, were both under the common ownership of the Department of Interior. Thus it could be argued that upon conveyance of a portion of the road to Commerce, and then to the State, an easement by implication arose over the unconveyed portion within Park Boundaries. Whether an easement will be implied depends upon the apparentness, permanency, continuousness and necessity of the use implied. Since this road probably was the primary access road to the Kantishna at the time of Statehood and had probably been used continuously by those residing in the Kantishna, and since the road is reasonably necessary for access, there is a good argument that an easement by implication exists. However, I have not found a case one way or the other which indicates whether the doctrine of implied easements may be applied against governmental entities. Certainly a prescriptive right cannot be acquired against a sovereign since no one can adverse possess against the sovereign. But an easement by implication does not arise from adverse possession, thus an implied easement might be found to exist over government land.

Although the State has a possible legal claim that the entire Kantishna Road is a public road, based either on an agreement or an easement by implication or necessity, any lawsuit over the same would be in federal court, and I suspect public (and perhaps the judge's) sympathy would favor the federal government's right to control the road. Moreover, it is doubtful that the State or private residents would have a right to an injunction against the Park Service to protect their legal property rights, in light of recent case law. Several cases, Switzerland Co. v. Udall, 337 F.2d 56 cert den 380 U.S. 914, and Arthur v. Fry, 300 F. Supp 622 (1969) have undermined the holding in Colorado v. Toll, supra and held that neither a State nor private parties may sue the federal government or federal Park Service employees to enjoin obstruction of roads because the doctrine of sovereign immunity precludes suits for injunctive relief. The opinions have suggested that the Park Service may take public or private rights of way, away from their owners, and that the only remedy is in damages (i.e. tort or inverse condemnation.

ANSWERS TO SPECIFIC QUESTIONS

In the absence of an agreement to the contrary,

(a) The Park Service probably does have authority to restrict travel, to the extent deemed by the Park Service reasonably necessary for accomplishment of Park Service goals. Attempts to "unconditionally restrict travel" could be resisted by the State, but because of the above cases an injunction might not be obtainable, and damages may be the only remedy.

(b) The Park Service can restrict public use of the road at night, after shuttle bus service ceases, so long as some recognized purpose of the Park Service is furthered by such restriction. I assume reasons such as protection of wildlife could be argued, as well as conflicts with daytime bus traffic.

(c) The question of whether the Park Service can allow some classes of citizens access, but not others, is a very close one. Absent public or private easement of some type, the Park Service is fully empowered to decide which classes of vehicles, i.e., commercial, or tourist will have access, and discrimination between types of users has been repeatedly sustained pursuant to 16 USC 3. However, if there is an easement by implication over the Park road, to the portion of the road which is State-owned, the easement is a public easement, not a private one. The logical conclusion would be that the Park Service, therefore, cannot discriminate against members of the public, depending on their business in the Kantishna. However, some cases involving implied private easements have held that the use of the easement cannot become excessive, that the easement is only implied for the types of travelers and uses expected at the time it was created. I suspect that a court would apply this reasoning and conclude that the Park Service can differentiate between classes of citizens including beneficiaries of public or private easements, in allowing access even if an easement or public right of way does exist. Moreover, if any member of the public, or the State sued over Park Service restrictions, as stated above the probable remedy would be in damages, rather than injunctive relief.

(d) Continued expenditure of public funds, including State funds, is legal even though the Park Service can landlock the public highway, so long as the Park Service has not yet taken action totally to cut off access. There is nothing in State statutes which specifically precludes expenditure of State funds in a situation of this type. However, public funds may be expended only for public purposes. The "purpose" section at AS 19.05.125 is probably most relevant to this question. It provides:

> The purposes of ch. 5 - 25 of this title is to establish a highway department capable of carrying out a highway planning, construction, and maintenance program which will provide a common defense to the United States and Alaska, a network of highways linking together cities and communities throughout the state (thereby contributing to the development of commerce and industry in the state, and aiding the extraction and utilization of its resources), and otherwise improve the economic and general welfare of the people of the state.

I believe that expenditure of State funds is justifiable here on the theory that even though access to the State road is subject to federal restriction, the State road aids in the extraction and utilization of State resources, and links together communities. However, the advisability of expenditures is subject to question. In view of the fact that the Park Service probably could entirely shut down the road with the State's only remedy being damages for its loss, it may well be more beneficial to expend State funds on development of a new unrestricted road to the Kantishna, rather than on a road which may not be usable in the future. Moreover, if expansion of use by private property owners, mandated a widening of the road within the Park or Preserve boundaries, it is highly unlikely that the State could secure additional lands or federal financial assistance for such a project.

The relevant statute involving expenditure of federal funds is 23 USC 138, which provides:

> It is hereby declared to be the national policy that special effort should be made to preserve the natural beauty of the countryside and public park and recreation lands, wildlife and waterfowl refuges, and historic sites. The Secretary of Transportation shall cooperate and consult with the Secretaries of the Interior, Housing and Urban Development, and Agriculture, and with the States in developing transportation plans and programs that include measures to maintain or enhance the natural beauty of the lands traversed. After the effective date of the Federal-Aid Highway Act of 1968, the Secretary shall not approve any program or project which requires the use of any publicly owned land from a public park, recreation area, or wildlife and waterfowl refuse of national, State, or local significance as determined by the Federal, State, or local officials having jurisdiction thereof, or any land from an historic site of national, State, or local significance as so determined by such officials unless (1) there is no feasible and prudent alternative to the use of such land, and (2) such program includes all possible planning to minimize harm to such park, recreational area, wildlife and waterfowl refuge, or historic site resulting from such use. In carrying out the

> national policy declared in this section the Secretary in cooperation with the Secretary of the Interior and appropriate State and local officials, is authorized to conduct studies as to the most feasible Federal-aid routes for the movement of motor vehicular traffic through or around national parks so as to best serve the needs of the traveling public while preserving the natural beauty of these areas.

Any additional rights or way granted would be revocable without compensation pursuant to 36 C.F.R. 14.9m, which provides:

> That [a] right-of-way herein granted shall be subject to the express covenant that it will be modified,adapted, or discontinued if found by the Secretary to be necessary, without liability or expense to the United States, so as not to conflict with the use and occupancy of the land for any authorized works which may be hereafter constructed thereon under the authority of the United States.

CONCLUSION

In summary I would say that if the State wishes to pursue a claim that it has an easement to the Kantishna Road via the McKinley Park Road, such an argument would be supportable, especially if a search into Territorial Road Commission or federal government archives revealed a written agreement. However, the federal government could elect to pay compensation rather than allowing access, and there is little the State could do to prevent extinguishment of its rights by compensation. The impediments to further development of this road outlined above should cause the State to give serious consideration to development of an alternative route, if indeed the same is justified by present and projected future activity in the Kantishna area.

LLW:bsw

STATE OF ALASKA

DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

OFFICE OF THE COMMISSIONER

STEVE COWPER, GOVERNOR

P.O. BOX Z
JUNEAU, ALASKA 99811-2500
PHONE: (907) 465-3900

April 29, 1988

Mr. Stan Leaphart
Executive Director
Citizen's Advisory Commission
on Federal Areas
515 Seventh Avenue, Suite 310
Fairbanks, AK 99701

Dear ~~Mr. Leaphart~~ Stan:

This letter is in response to correspondence you have sent to the Attorney General and I regarding state ownership of the Nabesna Road in the Wrangell-St. Elias National Park and Preserve, and the McKinley Park Road in the McKinley National Park and Preserve. With regard to your first letter addressed to the Attorney General and dated September 1, 1987, by memorandum dated October 30, 1987 the Assistant Attorney General assigned to answer your request concluded that your questions could not be answered on legal principles alone and suggested that the appropriate procedure would be to have the line agencies involved answer your questions as a policy matter. In this regard, this letter represents answers that the Department of Transportation and Public Facilities (DOT&PF) can provide to your questions and may be viewed as a policy statement of this department for the roads you have referenced.

I have been requested to state as a matter of policy what ownership interest the department wishes to assert in the two roads you have asked about. Having said that, I hope it is understood that this letter is not intended to provide a legal analysis of the ownership issues that may be involved and if one is needed you should pursue that as an independent request from your agency.

In your letters you have linked together the Nabesna Road and the McKinley Park Road as if the state has an equal interest in both roads. In our analysis of the issues involved, DOT&PF views the interests we have in these two roads as being of different origin with distinct historical uniqueness. We have a history of controlling and maintaining the Nabesna Road, which is on the State Highway System, while we have had no known control or responsibility for the McKinley Park Road. For this purpose, I have separated my discussion of the two roads into separate segments of this letter to avoid any confusion regarding our view of this matter. We feel that the question of what rights we have in the respective roads should not be intermingled.

MCKINLEY PARK ROAD

You have raised the possibility that the state may be able to assert an RS 2477 right-of-way for the McKinley Park Road. In all references that we have seen regarding the development of the current McKinley Park Road, there is no evidence that a trail existed prior to the formation of the McKinley

National Park. In fact, contemporaneous records of the Alaska Road Commission concerning the development of the McKinley Park Road would appear to be conclusive that a trail did not exist prior to the formation of the Park. As you are most likely aware, RS 2477 granted rights-of-way over federal land not otherwise reserved. Since our information would indicate that the Park was reserved prior to the road being developed, it would tend to discount the advisability of attempting to assert that an RS 2477 right-of-way may exist on the McKinley Park Road. As with all of our historical research, we remain open to new facts being raised which would shed additional light on the issue. However, the state has never asserted an RS 2477 right-of-way over the McKinley Park Road and I have seen no new evidence to cause us to reconsider our position.

You have correctly noted that the Quitclaim Deed of 1959 from the Secretary of Commerce to the State of Alaska includes a reference to the McKinley Park Road. We cannot explain how the Quitclaim Deed ended up referencing the McKinley Park Road since historical documents would not lend credibility to its inclusion. As a general rule, we would agree that the inclusion of a road in the Quitclaim Deed raises a presumption that responsibility for the road was transferred to the state. However, historical information we have reviewed would cast doubt on this presumption and would instead raise a likelihood that the McKinley Park Road portion of FP 52 was inadvertently included in the Quitclaim Deed. In 1964 DOT&PF recognized this probability by dropping all references to the McKinley Park Road from the State Highway System. As stated previously, we have never had any known control or responsibility for the road. Again, we remain open to new evidence being presented to us that would shed additional light on the issue.

NABESNA ROAD

Our understanding of the situation with the Nabesna Road is completely different. We believe that the Department of Commerce's Quitclaim Deed of 1959 transferred to the State of Alaska "all rights, title, and interest of the Department of Commerce" in the Nabesna Road. Although this language at first glance would seem to convey a fee interest to the state, our interpretation of the interest that the Alaska Road Commission held, which was later transferred to the Department of Commerce, was a duty to locate, design, construct and maintain roads in the Territory of Alaska. The department's position is that it was this same interest that was transferred to the State of Alaska by the Omnibus Act of 1959 and the subsequent Quitclaim Deed.

With regard to the interest we have in roads conveyed by the Quitclaim Deed, it has always been the policy of this department to vigorously defend our right to complete control over all highways and roads duly transferred to the state. Toward this end, the department has actively asserted any and all powers necessary to insure that all rights-of-way are protected for the use and enjoyment of the public and that the department's ability to perform the duties it is charged with under the statutes of the State of Alaska is not restricted. It is not, however, the policy of this department to assert powers beyond what we reasonably believe to be those conveyed to us or are necessary for the performance of our statutory duties.

In short, with regard to the Nabesna Road, it is our view that the state possesses exclusive control of the road right-of-way as a result of the Quitclaim Deed. In addition, we also believe the state could assert an RS 2477 claim to the road if necessary. While there may be some who would want to debate the technical legal classification for the interest we have in the Nabesna Road and other roads transferred under the Quitclaim Deed, we maintain that our right to control the use of this road is not limited by federal authority. Any claim of right beyond that necessary to carry out our statutory duties is unnecessary.

GENERAL RS 2477 ISSUES

Your letter to me of February 12, 1988 also raises some points concerning the development of a state policy on RS 2477 rights-of-way which need clarification. For your information, this department shares responsibility with the Department of Natural Resources for the development of a state RS 2477 policy. This department's commitment is to the protection of potential RS 2477 rights-of-way which may serve as future transportation corridors or highways and, as such, we will continue to play a central role in the resolution of the RS 2477 issue.

At the present time both departments have been concentrating their efforts to work with the Governor's Office in Washington D.C. so that discussions can be concluded with the principles of the various federal agencies working on a new federal RS 2477 policy statement. We are pleased with the results of these discussions to date and will continue to support this effort as best we can. Additional work here in Alaska is needed following completion of this effort, and we hope to re-initiate our policy efforts this summer.

Sincerely,

Mark S. Hickey
Commissioner

cc: Judith Brady, Commissioner, Department of Natural Resources
John Katz, Special Counsel State/Federal Relations, Office of the Governor
Lynn Harnisch, Regional Director, Northern Region, DOT&PF
Tom Hawkins, Deputy Commissioner, Department of Natural Resources
Ray Price, Special Staff Assistant, Office of the Governor
Rod Swope, Special Staff Assistant, Office of the Governor
Ron Clarke, Special Staff Assistant, Office of the Governor
Sally Gibert, Division of Governmental Coordination, Office of the Governor
Jack McGee, Assistant Attorney General, Department of Law
M. Clyde Stoltzfus, Special Assistant to the Commissioner, DOT&PF

- Alaska RR - Kantishna District (Riley Creek & Lignite Routes) - 1920
- Valdez Creek Recon (Cantwell - Denali) - 1920
- Lignite - Stampede Creek (1946 remarks)

February 11, 1946

MEMORANDUM for Mr. Smith:

Re: Lignite-Stampede Creek.

My first employment with the Alaska Road Commission in 1920 covered a reconnaissance trip from Lignite to the Kantishna and from Kantishna to McKinley Park for the purpose of selecting the most favorable ~~wagon~~ Railroad road route to the Kantishna from the railroad. Report of this trip is on file here. The Lignite route was rejected on account of swamps. Great difficulty was experienced in getting two miles through this country in September.

In spite of report, 40 miles of staked, definite location was made from Lignite in 1922—and abandoned. In 1924 the Park road was started.

Even a narrow road from Lignite to Stampede Creek under present conditions would cost at least $750,000. The permanent bridges Mr. Pilgrim requests would cost from $50 to $150 a foot and they would not be permanent if cut down to span only the channels. According to my 1920 report, 4005 feet of bridges would be required to reach Stampede Creek, exclusive of small creeks. Twelve-foot wooden trestles, if suitable, could be built for $50 a foot—12' steel for $150 a foot.

Anyone with sufficient experience knows that tractor freighting costs more than truck freighting on a good road. Our reaction if a road is contemplated to Stampede Creek: that it be a branch of the Park road. No country would be developed between Lignite and Stampede by a road. The Park Service might be interested in a branch down the Toklat to the boundary.

Nothing but temporary work can be done on the crossings for a small amount of money, as has already been demonstrated.

HAWLEY STERLING,
Acting Chief Engineer.

HS:JJ

~~13/51-2~~ 13/78-1

Memorandum of November 16, 1920 from Hawley W. Sterling, to Board of Road Commissioners.

BOARD OF ROAD COMMISSIONERS FOR ALASKA
VALDEZ, ALASKA

November 16, 1920.

From: Hawley W. Sterling, Fairbanks,

To: Board of Road Commissioners, Juneau.

Subject: Kantishna and Valdez Creek Reconnaissance Surveys.

Gentlemen:

Having completed maps of the Kantishna and Valdez Creek regions, together with a table of comparison and a table of approximate costs of two Kantishna routes and also data on the preferred route to Valdez Creek, I have the following written report to make of the trip and the various routes traveled.

In brief, my movements after leaving Fairbanks on July 27, at which time I was called here to confer with you regarding the proposed trip, are as follows,-- left Nenana on July 31 and returned to my personal camp, remaining there until August 23 when I came to town to see Mr. Frederick D. Browne Engineer in Charge of the Alaskan Engineering Commission at Nenana, in regard to securing pack horses, camp equipment and supplies from the Railroad people.

Will say here that Mr. Browne extended all privelegees possible in the way of telephone service, loan of pack outfit and consent to purchase at any of the stores along the line. Because the Engineering Commission was very short of pack animals at the time,- in fact they were renting all available stock,- I was obliged to purchase.. Nor were there any for sale at Nenana, but having caught Carl White at Nenana who was then on his way to Brooks, I made arrangements to purchase three pack horses from him which he had at the Log Jam. A man was sent with White on his launch up the Tolovana river to bring the stock overland to the railroad at Dunbars. After waiting until Sept. 1st for stock to arrive I received a telegram from White, then at Brooks, saying the horses had strayed off and were lost in the hills. Alec Funk had come from Fairbanks with two mules in the meantime and sold them to me at $200 a head.

With a packer and two mules I left Nenana on Sept. 3rd for the end of steel where secured store supplies and after packing up proceeded to Singletons roadhouse opposite Lignite, Mile 366 on Government Railroad, where we

From: H.W.S.

To: A.R.C.

Subject: Sheet 2

Stayed overnight. Left for Kantishna on Sept. 4th over the Lignite route arriving at Kantishna on Sept. 13th, remaining there two days and leaving on Sept. 16th for the railroad at Morino's roadhouse mile 347 via the Riley Creek route, arriving on Sept. 21st.

Left for Nenana Sept 22nd to secure supplies and map for Valdez Creek trip, returning to Morino's on Sept. 26th and leaving the 27th. Spent the 28th at Bain's roadhouse and the 29th at Carlson's roadhouse, leaving for Valdez Creek via the Jack River route Sept. 30th. Because of the inability to secure a geological map of the Nenana River-Valdez Creek country , an Indian guide who had been in the district twelve years was employed for the trip.

We arrived at Valdez Creek Oct. 3rd, where every courtesy was extended by Mr. C. N. Norton, watchman for the McKinley Placers Co.,- remaining there overnight and returning to Bain's roadhouse on the railroad at mouth of Jack River on Oct 7th. On Oct. 8th left for Morino's roadhouse where we stopped overnight and went on to the end of steel at Healy, Mile 360, on Oct. 9th and from there to Nenana by rail the same day.

The mules were left in care of the Alaskan Engineering Commission at Healy where they are working for their feed, the pack outfit and tent was returned to the Engineering Commission, stove, dishes etc. were left in care of Arnt Greve at Jack River, and the odds and ends of grub left over after returning from Valdez Creek were turned over to the Jack River roadhouse.

From Oct. 10th to 14th was spent at Nenana settling accounts with the Engineering Commission, and paying other bills, two days of that time being spent on personal affairs. On Oct. 15th I returned to Fairbanks and have employed the time since in making up maps and reports of the routes traveled.

L

From: H.W.S.

To: A.R.C.

Subject: Sheet 3

The engineering equipment used consisted only of compass, clinometer, tape and note book. The compass was used to get the general direction only from Lignite to mouth of Canyon Creek, the course being checked up on the 1919 U. S. Geological Survey map, Bulletin 687 by Stephen R. Capps, which was invaluable to the writer and found to be correct in every particular. The clinometer was used in getting slopes and grades, distances guessed either by pacing or timing. Stream crossings of importance were measured with tape and sufficient notes taken to insure the accompanying estimates being accurate as considered on a reconnaissance survey.

Since no accurate map of the Nenana River-Valdez Creek region was available until my return to Fairbanks, the location of the different routes as shown on the map cannot be taken as exact though the variance from their true location is of no material consequence, the general direction and water courses followed being correct.

Two routes were covered to Kantishna from the railroad at different points and two to Valdez Creek from the railroad at different points. The various features of the proposed Kantishna routes will be taken up first. There was some talk in the Kantishna country of a route from there to Broad Pass and it is true that that trip has been made by prospectors. It was my intention after returning from Valdez Creek to attempt finding a route from Sullivans roadhouse on the Susitna side of Broad Pass to Kantishna but from all the information I could gather the route is entirely impracticable for a wagon road, the route necessarily passing over from 20 to 25 miles of glacier. This information was vouched for by one Le Gault who has been in that district the past five years and claims to have been to the heads of the streams leading from vicinity of Muldrow Glacier to the Susitna River.

Upon leaving Lignite it was the intention also upon returning to look over the country up Dry Creek to

BOARD OF ROAD COMMISSIONERS FOR ALASKA
VALDEZ, ALASKA

From: H.W.S.

To: A.R.C.

Subject: Sheet 4

Savage River, but having seen so many advantages of the Riley route this trip was abandoned. The Dry Creek route to Savage River is adjacent to that of the Lignite route and to all appearances , from a distance, is the same character and formation as the latter.

1 - THE KANTISHNA ROAD.

By way of comparison the following is to be said of the two Kantishna routes, one known as the Lignite or lower route, 74 miles in length as traveled, the other known as the Riley Creek or upper route, 87 miles in length as proposed. The comparison of the lower route as traveled with the upper route as proposed is used because the data on the upper route as proposed is accurate while the data on the lower route as proposed would be more or less guess work, the two lower routes varying to such a large degree and the country up Boundary Creek and down Moose Creek having been seen only from a distance. Enough is known however to conscientiously say that the cost of the lower route as proposed would exceed considerably that of the route as traveled on account of extra rock work, side hill work and extra crossings up Boundary and down Moose Creeks.

In making the trip from Lignite to Kantishna I followed as nearly as possible a straight line as suggested by Colonel Gotwals from Lignite to the mouth of Canyon Creek a tributary, as shown on map, of Clearwater Fork. The route from there follows up Canyon Creek and down Caribou Creek, across Glacier Creek, the headwaters of Flat Creek and thence up Moose Creek to Kantishna.

With so many available routes to choose from, the one as traveled from Lignite to mouth of Canyon Creek is undesirable to say the least, approximately 50% of the distance being niggerheads, glacier muck and a combination of glacier muck and gravel. Side trips to points from 200 to 700 feet higher up the foothills were made and the same material was found. This is proven also by Joe Clark and Billy Stewart, two prospectors met at Kantishna, who made the trip in from

From: H.W.S.

To: A.R.C.

Subject: Sheet 5

Lignite to Canyon Creek with horses, keeping up high enough to cross the important streams just below the canyons, from 3 to 6 miles south of our route of travel. The higher ground is not quite as soft for road building but the streams are cut deeper into the hills and the course necessarily followed would be circuitous or continually up and down with consequent heavy grades.

It is noted by the table of comparison that the average elevation of the Lignite route is 2211 while that of the Riley route is 2826. I am safe in saying that in order to get better ground the Lignite road would have to be kept up to an average elevation equally as high as the Riley road and even then it could not compare favorably with the latter route. The character of the formation on the two roads is illustrated somewhat by noting that our pack animals were down numerous times enroute from Lignite and only once on the Riley route. Also by the fact that the former route of 74 miles required practically 48 hours actual travel while the latter route of 84 miles, as traveled, required only 40 hours.

A bad feature of this Lignite route is that it holds the north slope practically the entire distance and if it is deemed desirable to build a road from Lignite to the lower Kantishna country, or in other words from Lignite to Glacier City and thence to Eureka, I suggest that a route which would keep the south or sunny slope most of the distance be investigated. This route would be a sidehill road keeping to the north row of hills to the Toklat River, making one crossing of Savage and Middle Rivers and one crossing of the East Fork and main Toklat Rivers,- thence up the Toklat to Crooked Creek, up Crooked Creek to its source and over divide to the Bearpaw River and down the Bearpaw to Glacier City ad from there up Glacier , Flat and Moose Creeks to Kantishna. The so-called "Proposed Lignite route" is located on the map in preference to the above route because it would be the shortest route to the terminus at the mouth of Eureka Creek and tap more directly the mineral district. On the other hand the Crooked Creek route would provide easy access to a considerable placer area.

BOARD OF ROAD COMMISSIONERS FOR ALASKA
VALDEZ, ALASKA

From: H.W.S.

To: A.R.C.

Subject: Sheet 6.

Practically all that can be said in favor of the Lignite route as against the Riley route is that it is eleven miles shorter but it is a certainty that better time could be made over the latter route on account of it being dryer, firmer ground all the way. To build a road on the lower route equivalent in cost of maintenance and permanency as could be constructed on the upper route at the cost as estimated, would mean hauling and spreading gravel over at least 50% of the distance at a prohibitory figure. The estimated cost of grubbing and freighting material on the upper route is greater than on the lower,- the grubbing on account of the route following the course of Middle River thru heavy timber for approximately ten miles and the freighting due to the longer haul for bridge timber. The most suitable bridge material is found on the Riley route, located on Middle River and Morris Creek, many trees seen on Middle River being 20 inches in diameter.

Except for short open stretches the lower route is covered with buck and willow brush averaging 24 inches in height where there is no timber. Timber is found only on streams from edge of bench to edge of bank and consists of scrub spruce from 2 to 8 inches with occasional trees on the Middle and Toklat Rivers as large as 14 inches. On the Riley route timber is found for a distance of five miles up Morris Creek, Morris Creek divide is covered with heavy buck brush from 24 to 48 inches high while from there to Middle River it is open except for patches of buck brush from 10 to 24 inches. The route then follows up Middle River for ten miles thru spruce timber large enough for bridge material. After leaving Middle River there is practically no undergrowth until reaching a point 10 miles west of Thorofare Pass on McKinley Fork which marks the beginning of a growth of willows and scrub cottonwood,- this continues for 7 miles when a mile and a half of Spruce and cottonwood timber from 2 to 14 inches is passed thru, ending three quarters of a mile from Wonder Lake. From this point to Kantishna there are patches of spruce, cottonwood and willows from 2 to 8 inches.

BOARD OF ROAD COMMISSIONERS FOR ALASKA
VALDEZ, ALASKA

From: H.W.S.

To: A.R.C.

Subject: Sheet 7

No quick sand was encountered during the entire trip on either route.

After finishing an unprejudiced table of comparison and estimate of costs, the Riley route has been selected and recommended as the most suitable for constructing a wagon road to Kantishna from the Government Railroad, for the following reasons

1 - Cost of construction is less.

2 - Cost of maintenance would be less.
Too much cannot be said of the difference in cost of maintenance of the two routes,- a large percentage of the lower route is on sidehill of cutting, running, sloughing glacier muck, while there are many stretches of from one to eight miles on upper route of flat dry gravel, requiring little or no upkeep after the initial cost.

3 - Passes thru a greater mineralized belt.
The country thru which route passes has hardly been prospected but is spoken of favorably by geologists and prospectors who have seen it. Shortly before my arrival at Kantishna Mr. Joe Quigley returned from the vicinity of Thorofare Pass with samples of copper ore carrying 75 % copper.

4 - Offers a natural gateway to McKinley National Park and passes thru the park approximately sixty miles. By way of suggestion, it is probable that the Park Board would be willing to appropriate a share of the funds to build this road since it would open the park to a large extent.

5 - Affords a direct route to the mineralized district at the headwaters of the Kuskokwim River.

BOARD OF ROAD COMMISSIONERS FOR ALASKA
VALDEZ, ALASKA

From: H.W.S.

To: A.R.C.

Subject: Sheet 8

6 - Would make an automobile boulevard or truck road at considerably less expense than any other route would make a mediocre wagon road. The country as it stands is such that two men and a team and wagon with a light load could drive from the railroad to Kantishna, while the hard dry gravels of Middle River and McKinley Fork offer a natural automobile highway. A wagon has already been driven from the railroad to Middle River, a distance of 25 miles.

7 - Stream crossings are fewer, banks are not so high and distance in elevation from banks of cross streams to benches is less. There is little or no driftwood, streams from summer observation do not glacier to any extent and there is no run of ice in the spring, the largest body of water crossed being the main water course in Middle River, 18 inches deep and 50 feet wide, thus indicating that pile driven bridges will serve the purpose providing sufficient penetration can be obtained as it seems possible without testing for distances to bed rock, large boulders or other impenetrable matter.

8 - More work can be done in a working season with less men on the upper route than on the lower on account of the former being 75 % team and grader work. With the railroad in process of construction this is an important item, since labor will not be plentiful.

9 - A gravel surfaced road or a mixture of soil and gravel can be had 85 % of the distance without hauling,- gravel in most instances being found less than 12 inches under surface.

10 - No frozen material found in middle of September.

BOARD OF ROAD COMMISSIONERS FOR ALASKA
VALDEZ, ALASKA

From: H.W.S.

To: A.R.C.

Subject: Sheet 9

11 - Has a lighter average grade than the lower route.

Following is a comparison of the length of the crossings on both routes,-

	LIGNITE	RILEY
Savage River	125 ft.	250 ft.
Sanctuary "	Not crossed	160 "
Middle "	800 ft.	700 "
Sushana "	160 "	Not crossed
East Fork Toklat River	820 "	600 ft.
Toklat River	2100 "	1200 "
Stony Creek	320 "	200 "
Clearwater Fork	1200 "	Not crossed
Canyon Creek	100 "	" "
Glacier "	100 "	" "
Friday "	100 "	" "
Eureka "	100 "	" "
Moose "	Not crossed 5925	300 ft. 3410

The names of the following persons are offered as references, all of them having seen the Riley route and most of them both routes, - prospectors, Joe Quigley of Kantishna, Perry Bigelow of Fairbanks, Joe clark, Harry Lucky and Mr.Brooker of Nenana, and Stephen R. Capps of the U. S. Geological Survey. Mr. Capps, I believe, is quite familiar with the country and no doubt could offer some additional information.

At the time of my visit to the Kantishna there were approximately 100 people in the district, some engaging in placer mining on a small scale and others in lode mining and prospecting. These people were scattered over an area of 30 square miles though most of them in the vicinity of Kantishna and the Aiken mine. The settlement formerly known as Shamrock City or Eureka but now known as Kantishna lies on the right limit of Moose Creek, a few hundred feet upstream from the mouth of Eureka Creek. Here is located the Postoffice and the Commissioners office and should the outlook continue to be as bright

From: H.W.S.

To: A.R.C.

Subject: Sheet 10

as it has the past year, this place would probably be the nucleus of the future town.

It is known that the following creeks have gold bearing placers which might be worked if cheaper transportation is provided,- Glen, Rainy, Eureka, Friday, Eldorado, Moose, Glacier and Caribou. These creeks have all produced gold and it is fair to say that there are others which will. Two large outfits are going ahead next working season, having shipped in their supplies via the water route to Roosevelt on the Kantishna River, - these are the McKinley Gold Placer Mining Co. on lower Caribou Creek and a company of local capitalists on Moose Creek in vicinity of Friday, Eureka and Eldorado Creeks. Both companies are installing hydraulic plants and intend working on a large scale. New and encouraging pay was found this summer on Little Moose Creek, a tributary of Clearwater Fork.

The greatest interest shown at present in the district is toward lode prospecting, the Aiken property being the only one developed to any extent up to date. This property is situated on Friday Creek. However, prospects have been found this summer on Eureka, Eldorado and Rainy Creeks which have warranted their finders going ahead with development work this winter.

Should other discoveries be made in the lower Kantishna country, a ridge road from Kantishna to Glacier City could be constructed at an approximate cost of $ 2500 a mile, acting as a feeder for both Glacier and Caribou Creeks. A branch of six miles up Moose Creek would supply Rainy and Glen Creeks, the left limit of Moose being the natural route to follow.

Past experience has shown that a winter road and a summer road are two entirely different propositions. Neither the Lignite route or the Riley route could be considered as winter roads except in a winter of very slight snowfall such as the winter of 1918-1919 and even then the road would probably be impassable on account of drifts,- it being a windy country. Any winter road from the railroad would naturally pass thru the flat lower country below the hills to the Bearpaw River

BOARD OF ROAD COMMISSIONERS FOR ALASKA
VALDEZ, ALASKA

From: H.W.S.

To: A.R.C.

Subject: Sheet 11

and thence up that stream. This route would leave the railroad at Mile 390 and pass thru timber practically the entire distance.

Any attempt to build a scratch road or trail into the Kantishna country would result in a waste of time and money, as one mile of road built well is of more value in this locality than ten miles built shabbily for the same money. What the Kantishna country needs to help develop it is a truck road which will permit the carrying of ore and supplies in two days to and from the railroad. Such a road can be built over the Riley route that will be of lasting benefit to the country, to say nothing of offering an unsurpassed scenic trip thru McKinley park to the base of Mt. McKinley.

Three flurries of snow were encountered on the trip and one and one half days of rain. Two inches of fresh snow lay in Highway Pass for a distance of one and one half miles on Sept. 18th. Aside from this the weather was admirable.

Should the Kantishna road be built, I suggest that from May 15 to June 15 be the time to commence the survey, as any attempt to survey a summer road in the winter might result in a location unfair to the Alaska Road Commission and to the people who may have occasion to pass over the road.

2 - THE VALDEZ CREEK ROAD.

Unfortunately the trip to Valdez Creek from the located route of the Government railroad was started so late in the Fall that there was only a limited amount of time to be given to it. We left Carlson's roadhouse, Mile 319½, over the Jack River route on Sept. 30th in a snow storm and returned to Bain's roadhouse, Mile 326, over the Nenana River route on Oct. 7th, in a snow storm. However, there was no snow at any time between these dates. Three inches of snow lay at Bain's on evening of Oct. 7th and but for this an investigation of the route up Middle Fork would have been made.

The route as traveled up Jack River and thence up the east fork and across Brushkana Creek would be so prohibitive in cost

From: H.W.S.

To: A.R.C.

Subject: Sheet 12

of construction that it is not to be considered as a possible route and no attempt has been made to compare it with the Nenana River route. Jack River for fifteen miles runs thru a narrow valley, the mountains rising on both sides so abruptly from the bank of the stream that it was necessary to cross it no less than forty times to get to the head. This piece of the route alone would necessitate three miles of solid rock work and seven miles of steep sidehill work consisting of loose rock and slide. To keep anything like a direct course, the Brushkana River flats must be crossed not to mention numerous other flat, sluggish, thickly covered willow drains between the head of Jack River and Bruskana. The small flat drains are from two hundred feet to a half mile wide with intervehing ridges of glacier gravel and granite boulders covered with very thick buck brush 36 inches in height. A belt of scrub timber runs thru the valley at the headwaters of the Nenana on the Jack River route but offers a decidedly impracticable route for road building on account of numerous marshy drains, lakes, swamps, niggerheads and mossy humps and hollows underlaid with glacier muck. The Jack River route to make any kind of a road would be in the open all but two miles of the distance, would be at an average elevation of approximately 4000 feet and to get on firm ground would be circuitous to say nothing of the bad features of Jack River heretofore mentioned.

From what information I could gather of the routes up the main Jack River or up the Middle Fork Of the Chulitna as compared with the Nenana River route, I am safe in recommending the latter without having seen the other two. The Nenana route is shorter, holds an average elevation lower than the other routes mentioned and passes thru more timber. The route is gravel 65 % of the distance, is dry practically all of the way and would make an ideal automobile or truck road. The entire route is thru an old glacier country, being particularly noticeable for 25 miles of the upper Nenana River where there are long glacier moraines of gravel and boulders, glacier knolls, hollows and numerous lakes. This route would have a tendency to produce some activity on Dukes, Wells and Levine Creeks where little prospecting has been done but where gold has been found.

BOARD OF ROAD COMMISSIONERS FOR ALASKA
VALDEZ, ALASKA

From: H.W.S.

To: A.R.C.

Subject: Sheet 13

The Nenana River route is a summer route and would also be more suitable for winter travel than any of the other three routes. It would seem that a good winter route would follow up the Nenana River and thence across the string of lakes to the Susitna but the Nenana has been found dangerous to travel on account of the warm streams coming in and the ice being cut away from underneath, causing many portages and never knowing when or where the river may be cut open. The hills rise so precipitously in places that it is impossible to follow the stream continuously unless it is safely frozen over. At present there is very little travel to and from the railroad.

Only one company operates in the Valdez Creek region, known as the McKinley Placers Co., an hydraulic outfit which has been operating for a number of years and which employs from 35 to 55 men during thw working season; approximately $ 50000 was taken out last summer and considerable dead work performed. The company had ceased operations for the season only a few days before my arrival and though some of the party had gone out the usual route to Gulkana, a party of nine men and fifteen head of horses had left for the railroad via the main fork of Jack River, it being their intention henceforth to freight all supplies from south end of steel via Carlson's roadhouse, a distance of 110 miles rather than 250 miles from Chitina as in former years. They were nine days on the way when I left and had not arrived.

There are a number of creeks in the adjacent country and tributary to Valdez Creek which carry placer gold but the prohibitive cost of supplies and the inaccessibility of the country has prevented any great amount of prospecting. Good pay was found last summer on a tributary of Valdez Creek by Mr. Pete Monahan.

This reconnaissance work was done between August 23 and November 1, 1920. Routes amounting to 275 miles were covered. The total cost was $ 1805.28 or $ 6.56 per mile. Accompanying this report are quantity and cost estimates, map tracings and blueprints of country showing various routes.

Yours very truly,

Hawley W. Sterling.

ESTIMATES COMPARI LIGNITE AND RILEY CREEK W ON ROAD ROUTES TO KANTISHNA.

	Flat Work Longest Pc., Miles	Shortest Pc., Miles	Total Miles	Approx. Yardage	Side Hill Work Longest Pc., Miles	Shortest Pc., Miles	Total Miles	Approx. Yardage
LIGNITE	2.3	0.02	47.9	118358	1.8	0.02	24.3	81847
RILEY	8.0	0.20	72.7	172678	2.0	0.02	12.8	40064

	LOOSE ROCK WORK Longest Pc Miles	Shortest Pc Miles	Total Miles	Approx Yardage	Solid Rock Work Longest Pc Miles	Shortest Pc Miles	Total Miles	Approx. Yardage
LIGNITE	0.70	0.01	11.7	36621	0.04	0.002	0.40	7040
RILEY	1.8	0.01	5.5	17215	0.20	0.20	0.20	3520

	TEAM AND GRADER WORK LOngest Pc Miles	Shortest Pc Miles	Total Miles	Approx. Yardage	HAND WORK Longest Pc Miles	Shortest Pc Miles	Total Miles	Approx. Yardage
LIGNITE	1.5	0.02	26.2	61482	1.8	0.002	46.0	138723
RILEY	8.0	0.02	65.1	152758	1.8	0.002	20.4	59984

	WET-GLACIER MUCK Miles	DRY Miles	NIGGERHEADS Miles	GRAVEL WITHIN 1 FOOT Miles	DISTANCE Miles
LIGNITE	29.8	42.4	24.4	26.0	74
RILEY	2.7	84.3	1.0	74.0	87

	HEAVY STRIPPING Miles	Acres	FROZEN Miles	THAWED Miles	CLEARING OPEN Mi	Ac	TIMBER Mi	Ac	LIGHT Acres	MED Ac	HEAVY Acres
LIGNITE	30.8	47.9	6.5	65.7	52.5	222.7	19.7	143.4	200.1	136	30
RILEY	9.0	34.9	---	855	64.2	47.5	22.8	165.8	35.0	122.3	56

	GRADES Plus Miles	Minus Miles	Miles Level Total	Long Pc	Miles 10% Tot	Lg Pc	Average	GRUBBING Miles	Ac	CORDUROY Lin. Ft.
LIGNITE	35.5	22.2	16.3	4.0	7.7	1.0	3.26%	19.7	76.4	6520
RILEY	58.2	38.6	10.2	4.0	2.0	0.5	2.69%	22.8	88.4	2000

BRIDGE WORK

Cribbed and Pole Decked

	Number 12'	24'	36'	50'	60'	10" Cribbing Lin. Ft.	10" Caps and Stringers Lin. Ft.	Total Lin. Ft.
Lignite	125	43	2	10	8	34084	19240	3584
RILEY	18	27	21	4	3	19186	11599	2000

Sheet 2 -

Cribbed and Pole Decked Bridges - Cont.

	6" Decking Lin. Ft.	8" Guard Rail Lin. Ft.	Iron Lbs.	Highest Elev. Feet	Av. Elev. Feet
LIGNITE	107720	7920	14080	3500	2211
RILEY	60272	4292	7947	3900	2826

PILE DRIVEN AND POLE DECKED BRIDGES,

	Longest Structure Lin. Ft.	Total Lin. Ft.	No. Bents	Piles Lin. Ft.	Hewn 10" Caps and Stringers Lin. Ft.
LIGNITE	2100	5944	353	25416	43996
RILEY	1200	5855	345	25875	41784

	6" Pole Decking	8" Guard Rail	Iron
LIGNITE	163040 L.F.	11912 L.F.	22030 Lbs.
RILEY	160592 L.F.	11798 L.F.	21700 Lbs.

	11-2 by 4 LOG BOX CULVERTS: Number	Logs Lin. Ft.	Iron Lbs.	HAUL OF TIMBER FOR BRIDGES: 8" Logs hauled 1 mile - Lin. Ft.	Hauled 1 mile Tons
LIGNITE	327	114450	11445	731186	4387
RILEY	192	67200	6720	1340240	8041

	LONGEST HAUL TIMBER Miles	TRAVEL BY PACK TRAIN Total hrs.	Av. Miles per hr.	DIST. THRU PARK Miles
LIGNITE	7	47 2/3	1.55	20
RILEY	12	40 1/12	2.09	60

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5 degree slope or less considered flat work, estimate based on road as being 32 feet from edge of ditch to edge of ditch for team and grader work. In wet ground estimate based on twelve foot road bed averaging one foot in depth, ten foot berm.

Side hill work figured as being on an average 20 degree slope.

Small bridges cribbed 2 to 3 logs high on each end and 4 or 5 stringers used, depending upon the length of the bridge. Pile driven structures have 4 piles to bent, 18 foot spans, 6 18 foot stringers to span, caps 20 feet, pole decking 16 feet long.

Log box culverts, 6" logs, three high, - 8' sills spaced two feet, bottom log 24 feet.

KANTISHNA WAGON ROAD ROUTES
Comparison of Approximate Cost of Construction.

	LIGNITE ROUTE	RILEY ROUTE	REMARKS
Clearing	8281.50	6434.00	Light @ 15 dollars Acre, Med. @ $30, Heavy @ $40.
Grubbing	5730.00	6630.00	@ 75 dollars Acre
Stripping	7664.00	5584.00	@ $160 Acre
Grading	115628.00	82339.50	See note below
Corduroy	1736.00	533.80	
Ditching	10000.00	7500.00	Estimated
Bridges	38494.80	32494.78	
Bridge Crew	19000.00	16000.00	Approx. 50% cost material
Culverts	15336.30	9004.80	
Freighting Timber	3948.30	7236.90	
Engineering	3500.00	3500.00	
Overhead	22931.89	17725.78	10% of total.
Camp equipment, Machinery, Tools, Scrapers etc.	25225.08	19498.36	10% total including overhea
Total	277475.87	214481.92	
Average per Mile	3749.67	2465.31	

Note - Cost prices with exception of solid rock and team and grader work based on contract prices of Alaskan Engineering Commission, Nenana.

Prices for grading as follows -

Team and grader work	at	25	cents Cu. Yd.
Loose Rock	"	90	" " "
Solid "	"	200	" " "
Side Hill other than rock	"	50	" " "
Flat work by hand	"	60	" " "

Prices for bridge timber and poles as follows -

Peeled cribbing, stringers, guard rail	@ 8	cents	Lin. Ft.
" 6 inch decking	@ 5	"	" "
" 10 to 14 inch piling	@ 12	"	" "
Hewed 10 inch caps and stringers	@ 25	"	" "
Iron	@ 14	"	Lb.
Peeled 6" culvert logs in place	@ 12	"	Lin. Ft.
Hauling bridge timber	@ 90	"	Ton Mile

PROPOSED VALDEZ CREEK WAGON ROAD

Data on the Upper Nenana River Route from Mile 326, Government Railroa

			COST	REMARKS
Distance	55	Miles		
Flat Work	48	"		
	115383	Cu. Yds.		
Side hill Work	7.0	Miles		
	21910	Cu. Yds.		
Loose Rock	4.5	Miles		
	14085	CU. Yds.		
Solid Rock	None			
Team & Grader Work	38	Miles		
	89173	Cu. Yds.	$ 22293.25	
Hand Work	17	Miles		
	48120	Cu. Yds.	26681.00	
Total Yardage	137293	" "		
Wet- glacier muck	1.5	Miles		
Dry	53.5	"		
Niggerheads	1.5	"		Short stretches
Gravel within 1 Ft.	36	"		
Heavy Stripping	11	"		
	42.6	Acres	6816.00	
Frozen ground	None			Frost 12" or less.
Thawed "	55	Miles		" over 12"
Open	35.5	"		
	150.6	Acres		
Timber	19.5	Miles		
	141.9	Acres		
Clearing - light	127.3	"		35' wide
" medium	122.1	"		35 and 60 ft. wide
" heavy	21.9	"	6448.50	60 ft. wide
Grubbing	19.5	Miles		
	75.6	Acres	5670.00	32 ft. wide
Corduroy	3000	Lin. Ft.	800.00	16 " long
Grades, plus	18	Miles		
" minus	17	"		
level	20	"		
Average grade	1.15	%		
Bridges, cribbed and pole decked, no.				
12 feet	20			
24 "	10			
36 "	6			
50 "	5			
60 "	7			
Total lin. ft.	1366			
10" cribbing	14196	Lin. Ft.		
10" stringers	8500	" "		
6" decking .	39600	" "		
8" guard rail	2924	" "		
Iron	5435	Lbs.		
Bridges, pile driven and pole decked, no.				
Longest structure	2400	Lin. Ft.		
Total no. bents	199			
Total length	3490	" "		
Piles	15920	" "		
10" hewed caps and stringers	21440	" "		
6" decking	95728	" "		
8" guard rail	6990	" "		
Iron	11679	Lbs.	20089.27	

Sheet 2 - VALDEZ CREEK WAGON ROAD

			COST	REMARKS
Culverts, number	110			
6" logs	38500	Lin. Ft.		
Iron	3850	Lbs.	$ 5159.00	
Haul of timber for bridges "				
1000 L. F. 82				
logs	818.4			
Tons	3673		3305.70	
Longest haul	5	Miles		
Actual travel by pack train	26.5	Hours		
Avg. per hr.	2.08	Miles		
Highest elevation	3500	Feet		
Average "	2844	"		
Ditching			5000.00	
Bridge Crew			10000.00	
Engineering			2000.00	
Overhead			11426.27	
Camp equipment, tools, scrapers, machinery etc.			12568.89	
Total Cost			$ 138257.89	
Average Cost Per Mile			$ 2513.78	

COMPARISON OF THREE ROUTES TO THE KANTISHNA.

		RILEY	LIGNITE	CLEARWATER
1-	Length	87 Miles	76 Miles	83 Miles
2-	Cost per Mile	$2500	$3750	$3300
3-	Winter or Summer Route	Summer 4 months	Both, problematical	Both, problematical
4-	Amt. developed country	One coal property	8 Miles.	36 Miles
5-	Future development	Promising future, 70 Miles	Promising future, 35 Miles	12 Miles
6-	Comparison of cost of maintenance, calling Riley Creek Route 100.	100	225	150
7	Passes thru McKinley Park	60 Miles	20 Miles	Parallells Boundary, 40 Mile
8	Distance of Railroad Terminus from Seward	347 Miles	363 Miles	366 Miles.
9-	Best Axerage Grade, calling Clearwater 1	2	3	1
10	Glacial Streams to be crossed	Bad	Some	None
11	Passes thru timber	23 Miles	20 Miles	45 Miles
12-	Crossings, general conditions	Medium	Bad	Good

1923 map of Mt. McKinley District, Alaska Road Commission

WAR DEPARTMENT

ALASKA ROAD COMMISSION

JUNEAU, ALASKA

San Francisco,
April [illegible], 1922.

Hon. Stephen T. Mather,
Director, National Park Service,
Washington, D. C.

My dear Mr. Mather:

As requested in your wire through Mr. W. B. Lewis, Superintendent, Yosemite National Park, handed to me on April 16th, I am submitting below estimates for proposed work for Mt. McKinley National Park. The System proposed is as indicated in the brief report, accompanied by blue print, which I discussed with you and Mr. Cammerer recently. Upon my return to Juneau where I shall have access to the necessary maps and reports, I can submit more detailed figures if desired.

We contemplate starting serious work this summer upon our three-quarter of a million dollar road project for the relief of the Kantishna mining district. This commercial road will lie entirely outside of the park limits, and will join the Government railway near Lignite, about Mile 362. The figures submitted below are based upon the assumption that we will do the Park work with the same organization and plant that we will have accumulated for our own work in that region. To build up a separate organization for your work would of course increase the cost materially.

<u>ESTIMATE 1.</u>

Pack trail from McKinley Park Station to Kantishna Post Office, about 110 miles, 6 ft. to 10 ft. wide, with necessary native timber bridges, shelter cabins, etc., passable for pack trains in summer and dog teams or single horse drawn double-ender sleds in winter - $ 30,000.00

<u>DISTRIBUTION</u>

National Park Service, - $ 25,000.00

Alaska Road Commission - $ 5,000.00

The above estimate is on the assumption that all construction within the park limits will be charged to you, and we will pay for the necessary construction outside the park limits to tie in to our commercial road system.

Copy for Mr. [illegible]

SCHEDULE II.

For the improvement of the above pack trail to automobile standard as follows:

McKinley Park Station to Middle River, 25 miles;

Muldrow Glacier to Park Limits, 8 miles;

Extension beyond Park limits via Wonder Lake to Kantishna Post Office, 6 miles;

A standard graded and drained road, maximum grade 10%, surfaced with about 7" of glacial gravel 14 ft. wide, with necessary bridges and other structures at $10,000. per mile - - - - - - - - - - - - $390,000.00

DISTRIBUTION

National Park Service - - - - - - - - - - - $330,000.00

Alaska Road Commission - - - - - - - - - - $ 60,000.00

The above estimate is based upon the average cost of construction, including maintenance during the construction period of our standard light auto road in Alaska. In the vicinity of the more important towns we build a heavier type of construction. We can of course comply with any specifications that you may prescribe, but it is believed that the above construction will adequately serve the needs of the park for an indefinite period, and can be readily accomplished in one or two seasons. Depending upon how future developments may change the situation, it will at any time be possible to extend the system or to raise the standard of construction in any section.

The Alaska Road Commission will agree to perform the above work upon a contract basis at a pre-determined price, or will agree to do the work and submit the vouchers for actual cost to your Service for payment, the total cost not to exceed a pre-determined figure.

Anticipating our work upon our Kantishna project this season, we located the first 35 miles last fall, established caches at convenient points and put in a few temporary bridges. We also established a depot on the Government railroad, so that we are in shape to attack the job aggressively immediately after the break-up.

I gather from your telegram that you intend to submit an estimate for the road construction (Est. II) above contemplated. If accepted by Congress, these funds would then be available for the 1923 working season. In order to be in shape to handle actual construction next summer, considerable preliminary work should be done this year. I realize of course that your service has no funds available. Another reason why some show of activity should be made this summer is the fact that many tourists will come to Alaska on account of the completion of the Government Railroad and the opening of the National Park, and some of them will be disappointed at not being able to take an automobile right up to the top of Mt. McKinley. Your Service, the Railroad Commission and ourselves will all come in for adverse criticism, regardless of the facts in the case, or of the actual responsibility.

On the assumption that we are to do the work next summer (1923), provided your funds become available, I am prepared to go ahead in connection with our activities in the Kantishna District and mark the proposed pack trail, erect a few temporary bridges, place army tents in all the passes and at other suitable points to provide temporary shelter until log cabins can be built, and do such other work as can be accomplished at a reasonable expenditure so as to make the proposed trail safe for the more hardy tourists. This work will be accomplished at our expense, plus such assistance as I may be able to secure from the railroad organization. The above will meet the immediate situation and will line the whole job up for aggressive action in 1923. We shall of course work in cooperation with your Superintendent, Mr. Harry Karstens, and will submit full reports and comply fully with any of your requirements.

If the procedure outlined in the preceding paragraph meets with your approval, please wire me at once at my Juneau Office, in order that proper instructions may be issued to our Engineering organization. There will be plenty of time for arranging the details later by correspondence.

Trusting that the above estimates meet your requirements, I am

Very truly yours,

(Sgd.) Jas. G. Steese

Telegraph of April 26, 1922 from Arno B. Cammerer, Assistant Director, National Park Service to James Steese, President, Alaska Railroad Commission [sic].

NARA, [illegible], WASH, RG 79, Mt McKinley Central Files, 1907-33, entry 6 (630) Pending

BUREAU OR OFFICE OF National Park Service

Washington (Place.), April 26, 1922 (Date.) A. M. P. M.

To James G. Steese, President Alaska Railroad Commission, Juneau, Alaska.

Reference your cordial SanFrancisco letter April twentieth we gladly accept your kindly offer cooperation in marking proposed pack trail Mount McKinley Park, erecting temporary bridges, placing Army tents for temporary shelter in passes until appropriations are granted us to go ahead with construction of trails and roads same to be at your expense. Please keep in touch with Karstens whom we are also wiring direct.

CAMMERER.

From .... (Name of sender)

Title of sender

Charge: .... (Insert name of office to which bill should be presented for payment.)

Appropriation: MT. McKINLEY.

PAID .... (Insert "In cash," if so paid.) By SENDER

COPY TO MR. ALBRIGHT.

Dept. Iden. Card No. ....

Rec'd payment: $ .... Operator: ....

Letter of May 11, 1922 from Col. James Steese, President, Board of Road Commissioners to Arno B. Cammerer, Assistant Director, National Park Service.

JUNEAU, ALASKA

May 11th, 1922.

Mr. Arno B. Cammerer
Assistant Director,
National Park Service,
Washington, D. C.

My dear Mr. Cammerer:

Upon my arrival here about ten days ago I found your telegram of April twenty-sixth accepting our offer to do some preliminary work on the Mount McKinley Park Station - Wonder Lake Trail, as outlined in my letter of April twentieth from San Francisco.

Our Chief Engineer, Major Gotwals, left for the Westward a few days ago and will give the necessary instructions on the ground for this work. I have instructed him to get in touch with Superintendent Karstens and also Woodbury Abbey of the General Land Office who is about to begin operations on the survey of the east and southeast boundaries of the Park and who has given us valuable information concerning the best crossings and other data on the proposed trail. I shall advise you later as to the work accomplished.

With kindest regards,

Cordially yours,

Jas. G. Steese
President.

JGS:D