NOTES ON THE GEOLOGY OF UPPER NIZINA RIVER

By Fred H. Moffit

INTRODUCTION

The part of the Nizina River drainage basin that lies adjacent to Nizina Glacier, including Skolai Creek, the West Fork of the Nizina River, the Chitistone River, and McCarthy Creek, has long been regarded by geologists who have worked in the Wrangell Mountain and White River districts as probably containing the key to a number of geologic problems that bear on the origin and occurrence of the copper deposits of Chitina Valley. These problems relate especially to the stratigraphy and structure of the copper-bearing formations and to the causes that resulted in the deposition of copper ores where they are now found. The district is small, is extremely rugged, and is occupied in considerable part by glaciers whose streams are difficult to cross in warm weather and are at times impassable. Obstacles to geologic mapping are therefore greater than a casual glance at a map might seem to indicate, although the difficulty of reaching the district has been greatly reduced by the successful construction of a bridge over the Nizina River.

The trails leading from McCarthy to Skolai Pass and the head of the White River traverse the valleys of the Nizina River and Skolai Creek. Consequently the district outlined has been visited a number of times by geologists, who gave it some attention in the course of travel between the Nizina and White River districts but were unable to study it carefully through lack of time or unfavorable seasonal conditions.

An opportunity to give the geology of the upper Nizina Valley some additional study arose in the summer of 1927. A party consisting of Andrew M. Taylor and the writer was organized at McCarthy about the middle of June and spent the following two and one-half months in mapping the geology of the district outlined above in as much detail as the time and weather permitted. The party was equipped with five horses and the necessary camp gear. Supplies for the summer were obtained at McCarthy, where the horses also were hired, and the first camp of the season was made on upper McCarthy Creek on, June 20. The writer feels that much of the success of the work was due to Mr. Taylor's intimate knowledge of the country and to his skill in everything connected with traveling through it and living in it. In addition to other activities Mr. Taylor assisted in making most of the fossil collections.

Geologic mapping was not done in detail, yet more time was given to the work than is possible in the usual reconnaissances that the Geological Survey makes in Alaska. Unfortunately a part of the area studied has not been mapped topographically, and a still larger part is represented only by a map which was made in the early days of exploration and which, although it has served its purpose well, is not sufficiently accurate to represent many geologic features. It was therefore necessary to use a small plane table and open-sight alidade for sketching the drainage system and locating rock outcrops and formation boundaries on upper McCarthy Creek, the Chitistone River, and the West Fork of the Nizina River.

It is not intended to give here a full account of the geology of the district but rather to present certain new features that were observed during the season, with enough of the general geology, which is already well known and fully described in other publications, to make them understandable. A comprehensive account of the geology of the Chitina Valley and other parts of the Copper River Basin is in preparation and will be published later.

PREVIOUS WORK

Previous work in this district began with the exploratory expeditions of Schwatka and Hayes[1] in 1891 and of Rohn[2] in 1899. Schwatka and Hayes crossed Skolai Pass, which they were the first white men to see, from the White River and reached the Nizina by way of the Skolai Creek Valley but had no time for making geologic observations away from their line of travel. Rohn crossed the Nizina, Rohn, and Chisana Glaciers from the Nizina River to the Chisana River, laying the foundation for much of the geologic work since done in the Chitina Valley. Schrader and Spencer[3] made a geologic reconnaissance in 1900 that covers part of the area here described. A more detailed geologic survey of part of the Nizina district was made by Moffit and Capps[4] in 1909 and furnishes some of

[1] Hayes, C. W., An expedition through the Yukon district: Nat. Geog. Mag., vol. 4, pp. 117–162, 1892.

[2] Rohn, Oscar, A reconnaissance of the Chitina River and Skolai Mountains, Alaska: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 2, pp. 393–445, 1900.

[3] Schrader, F. C., and Spencer, A. C., The geology and mineral resources of a portion of the Copper River district, Alaska: U. S. Geol. Survey Special Pub., 1901.

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

the data contained on Plate 3. In 1914 Capps[5] spent several days in the Skolai Creek Valley and included his observations on a geologic map of the Chisana-White River district. The writer visited the upper part of McCarthy Creek and the Chitistone River in 1922 and made some studies whose results were not published but are included in this report. All these expeditions added something to the knowledge of parts of the district but left much to be learned, a statement which is also true of the work done in 1927, for the problems to be solved are too complicated to be worked out without detailed maps and considerable time.

PHYSICAL FEATURES

The area under consideration is on the southeast border of the Wrangell Mountains and includes over 350 square miles of extremely rugged country with a relief of more than 6,600 feet between the mouth of the West Fork and the high mountains south of Skolai Creek and of more than 8,800 feet between the West Fork and Frederika Mountain (10,820 feet), north of Skolai Creek. Regal Mountain (13,400 feet), at the head of McCarthy Creek and the West Fork, is not included in the area mapped. The five streams mentioned—the Nizina River, the West Fork, Skolai Creek, the Chitistone River, and McCarthy Creek—receive the greater part of their waters from melting glacier ice and are subject to great variations in volume depending on the temperature. In early spring and late fall they offer little trouble to travelers, but in midsummer they are sometimes crossed with great difficulty, if at all. As a rule, however, the men who know the streams ford them with their horses at the established crossings with little interruption, sometimes waiting from evening till morning to take advantage of the lower water.

The Nizina River and Nizina Glacier extend southward through the middle of the area. McCarthy Creek, which flows into the Kennicott River and thus into the Nizina, and the West Fork lie on the west side of the Nizina. The Chitistone River, which joins the Nizina 5 miles below the West Fork, flows southwestward from the vicinity of Russell Glacier and Skolai Pass. Skolai Creek flows westward from Russell Glacier, reaching Nizina Glacier opposite its tributary Regal Glacier, or about 5 miles from the south end of Nizina Glacier and 15 miles north of the mouth of the Chitistone River. Skolai Creek receives only a small part of the drainage of Russell Glacier, whose waters for the most part flow northeastward to form the White River. The principal tributary of Skolai Creek

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

is Frederika Creek, a short tributary from the north that arises in Frederika Glacier. Nizina Glacier forms a dam across Skolai Creek and causes its waters to collect in a narrow lake, about 2 miles long at its maximum extent, which breaks out periodically, flooding the Nizina and sometimes causing damage to the bridge near McCarthy.

The Chitistone River Valley offers a more direct route for travel from McCarthy to the White River and the Shushana gold placers than Skolai Creek, but it involves a high climb over the so-called "goat trail" to avoid the canyon above Chitistone Glacier and is less used than the Skolai Valley during those periods when the Nizina River and the ice of Nizina Glacier are favorable for travel, a condition that is sometimes not present for several years at a stretch. The old trail by way of Skolai Creek kept to the west side of Nizina Glacier for several miles from the lower end and then took a course diagonally across the ice to the north side of Lower Skolai Lake, but a new trail along the east side of the glacier has been cut by the Alaska Road Commission and was traveled by several parties in 1927. If this trail is extended, and especially if some work can be done to make it easier to pass Lower Skolai Lake and the canyon between the lake and Frederika Creek, both of which necessitate a high climb over rough country, it will doubtless become the established route to the White River.

GEOLOGY

OUTLINE

The rocks that are most widely distributed in this district are sedimentary rocks and bedded tuffs and lava flows. Massive intrusive rocks are not well represented in the area studied and are confined to a small area near Frederika Mountain, another on Skolai Creek, and possibly one other locality. Similar rocks are found in the mountains of lower McCarthy Creek and are shown on the map (pl. 3) but lie outside the area to which most attention was given. The oldest rocks that have been recognized are of Permian age and include a great thickness of lava flows, bedded tuffs, massive limestone, shale, limy sandstone, and grit. The next younger formation is the Nikolai greenstone, of Permian or Triassic age, which is overlain by rocks of Upper Triassic age, which include the Chitistone limestone, Nizina limestone, and McCarthy shale and reach a thickness of at least 5,500 feet. Possibly the Permian rocks underwent some folding before the Upper Triassic sediments were deposited, but the evidence for this is not yet complete. However that may be, both the Permian and the Upper Triassic rocks were folded and subjected to weathering and erosion before the next younger beds, the Cretaceous sandstone and shale, were formed. The Cretaceous beds are largely of marine origin and are widely distributed in the Chitina Valley. Their thickness in the Nizina district is probably not less than 2,000 feet. They also are folded but much less so than the older formations. The folds as a rule are open and broad, and in places the beds show only a moderate tilting.

After the Cretaceous beds were deposited a period of volcanism began in Eocene time, which yielded possibly 3,000 feet of lava flows and tuffs. These surface effusive rocks and fragmental deposits are extensively developed in the Wrangell Mountains, where they make up much of the highland area. Originally they formed a continuous sheet of great extent that hid all the older rocks beneath, yet erosion has not only cut through them but has carved deep valleys in the underlying formations. In a few localities fresh-water leaf-bearing beds of sandstone and shale containing thin coal seams have been found at the base of these Tertiary volcanic rocks and furnish evidence for assigning them to the Eocene. These beds appear to be small in extent and local in their distribution. The Tertiary volcanic rocks, like the Cretaceous sediments, do not lie in their original horizontal position but are slightly tilted in most places.

Stream gravel and glacial morainic material, together with loose waste on the mountain slopes and a little volcanic "ash," complete the list of geologic formations known in the district.

STRATIGRAPHY

PERMIAN ROCKS

The Permian rocks of the Nizina district, although highly interesting geologically, have never been thoroughly studied and can not be described in much detail. They consist largely of volcanic material—lava flows and tuffs—but are interstratified with sedimentary deposits of limestone, shale, sandstone, grit, and chert of varying appearance and composition, which, however, do not appear to be distributed uniformly throughout the thickness of Permian beds but seem to form an intermediate group, dominantly of sedimentary rocks, with volcanic rocks above and below. The sandstone and grit members are limy in some localities but highly siliceous in others. The most conspicuous of the sedimentary beds is a massive limestone not less than 800 feet thick, which is locally highly crystalline and nearly everywhere is abundantly fossiliferous. It is best exposed on the north side of Skolai Creek.

The Permian rocks within the area here described occupy the valley of Skolai Creek from Frederika Glacier to Nizina Glacier, extend across to the west side of Nizina Glacier, occupying the lower slopes of Chimney (Goat) Mountain, and are exposed near Chitistone Glacier in the Chitistone Valley. In all these places the peaks of the mountains whose bases they form are capped with the younger volcanic rocks.

The base of the Permian rocks has not been recognized, but the lowest beds that have been included with them are dark lava flows and tuffs of unknown thickness that occupy most of the lower slopes of Skolai Valley from the Frederika Creek Valley to Nizina Glacier. Similar rocks crop out below the Permian limestone at the north end of Russell Glacier. These volcanic beds are everywhere folded and faulted and locally have taken on a subschistose structure.

The beds that overlie the lower volcanic rocks are dominantly sedimentary but contain tuffs and lava flows in considerable amount. The section of these beds is not uniform throughout the district. The most conspicuous difference is the absence of the massive limestone in places, but probably the variation in other members is as great, though less noticeable. Sufficient evidence to show whether this variability is an original feature of sedimentation or the result of an unconformity was not obtained. A brief description of several localities of Permian rocks will indicate the differences mentioned.

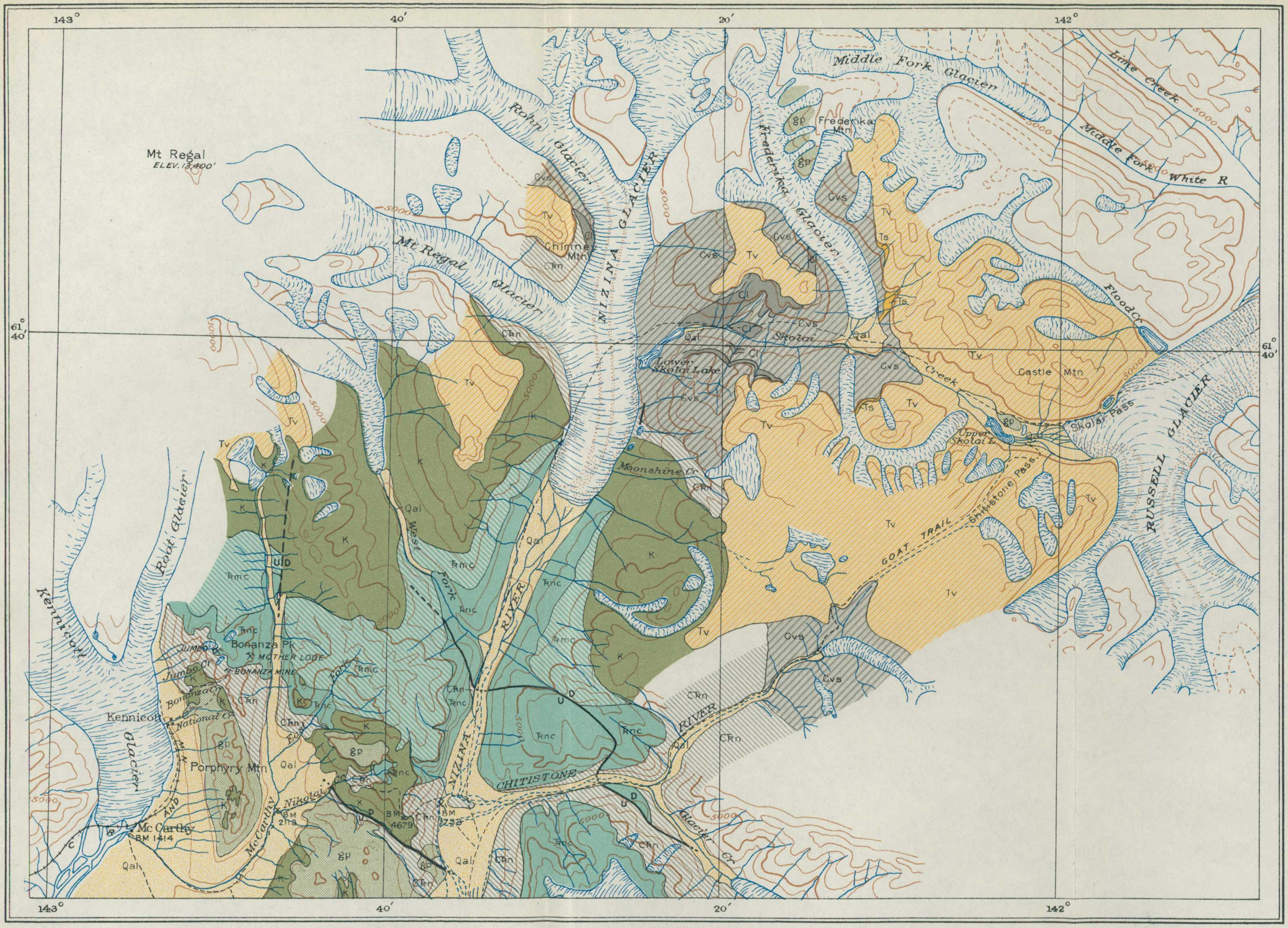
The horseshoe-shaped glacier south of Skolai Creek occupies a high valley locally known as the Hole in the Wall. Permian sedimentary rocks form the lower part of the west wall of this valley south of Frederika Creek. The vertical wall is too steep to be climbed, but the following approximate section gives some idea of the beds:

Section in west wall of Hole in the Wall

	Feet
Sandstone and quartzite	300+
Tuff and fragmental material	40
Thin-bedded shale and sandy beds	100
Basalt flow	30
Banded siliceous rock, white or yellowish white, speckled in places	50
Thick basalt flows.	

These beds are believed to be below the massive limestone that appears farther west in the Skolai Valley. The sedimentary members are all fossiliferous.

Beds of hard gray fossiliferous limestone and white crystalline limestone appear on the west side of Frederika Glacier about 2 miles northwest of the south end and extend northward a considerable but unknown distance.



EXPLANATION

QUATERNARY

Qal — Alluvium (*Stream gravel; includes beach gravel on McCarthy Cr.*)

TERTIARY — *Eocene*

Tv — Lava flows and tuff

Ts — Shale and sandstone with thin beds of coal

CRETACEOUS OR TERTIARY

gp — Granitic and light-colored porphyritic intrusive rocks

CRETACEOUS

K — Sandstone and shale

TRIASSIC — *Upper Triassic*

Ŧmc — McCarthy shale

Ŧnc — Nizina and Chitistone limestones

CARBONIFEROUS OR TRIASSIC — *Permian or Triassic*

CŦn — Nikolai greenstone

CARBONIFEROUS — *Permian*

Cvs — Volcanic and sedimentary rocks

Cl — Limestone

Fault — D, downthrow; U, upthrow

GEOLOGIC SKETCH MAP OF UPPER NIZINA RIVER, ALASKA

Topography by D. C. Witherspoon, 1908; C. E. Giffin, 1914; and Fred. H. Moffit, 1922-1927

Geology by Fred. H. Moffit and S. R. Capps, 1909; Fred. H. Moffit, 1922-1927

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

2 1 0 2 4 6 8 10 Miles

Contour interval 1,000 feet

Datum is mean sea level

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

The massive Permian limestone is conspicuous in the upper mountain slopes on both sides of the Skolai Valley midway between Frederika and Nizina Glaciers. It forms the prominent limestone peak called the Golden Horn and is crossed by the trail on Tinplate Hill. The limestone of the Golden Horn is probably not less than 800 feet thick. This locality is one of the more favorable places for observing the limestone but possibly does not exhibit its full original thickness, for erosion may have removed part of the limestone as well as other overlying Permian beds. The limestone of the Golden Horn weathers to a reddish or yellowish brown, from which the name of the mountain is taken, and in places is recrystallized to a fairly coarse marble, probably as the result of intrusion. The rocks underneath the thick limestone include brownish shale and sandstone, coarse limy sandstone in lenticular beds, grit, chert, and another thin limestone bed interstratified with tuffs and lava flows, some of which have pillow structure. These beds are probably better exposed on the south side of Skolai Creek, south of the Golden Horn, but lack of time prevented a careful study of them. The lower thin limestone is exposed there in several gulches.

Permian limestone is well exposed in the lower slopes of Chimney (Goat) Mountain west of Nizina Glacier and extends for more than a mile along the glacier in a series of high bluffs. The limestone is notable for the great numbers of crinoid fragments that it contains. The top is impure and knotty and overlies white crystalline limestone containing siliceous lenses as much as several inches in thickness. A hard reddish-brown member with abundant small crinoids is also present. The limestone extends diagonally up the slope northward to a point 1,000 feet above the ice and dips southwest. At the south end of the area, near the border of the ice, the limestone is overlain by 75 to 100 feet of brown-weathering sandy or tuffaceous beds with here and there a rolled pebble or cobble. On top of this is 30 to 40 feet of soft gray tuffaceous rock, including angular blocks of white and reddish-brown limestone containing crinoids and corals together with fragments of other rocks. Then above the tuffaceous rock come lava flows which extend southward toward Regal Glacier and were not examined close at hand.

One of the most instructive sections of Permian rocks examined during the summer is on the east side of Nizina Glacier beginning about a mile from Lower Skolai Lake and extending south half a mile. A shallow box canyon through which flows a little stream lies parallel to the ice margin and is separated from it by a long, low hill several hundred yards across. The rocks exposed in this canyon range in strike from N. 50° W. to west and dip about 75° S. The stream runs S. 15° W., and consequently the canyon cuts the beds approximately at right angles. The following section is well exposed in the canyon. The youngest beds or top of the section given below are at the south end of the canyon.

Section in canyon on east side of Nizina Glacier near Lower Skolai Lake

	Feet
Amygdaloidal basalt, presumably of Nikolai age.	
Coarse tuff	75
Fine-grained brownish tuff	10
Black shale with thin beds of limy sand or grit; strike N. 50° W., dip 75° W	125
Thin lenses of brownish shale in limy grit	20
Light-gray fine-grained yellow-weathering intrusive or flow	75
Hard fine-grained white pyritiferous limestone in beds 2 feet or less thick, interstratified with black shale	30
Basalt	20
Black shale with white limy beds and knotty limestone interstratified with grit or fine conglomerate, grading downward into thin-bedded shale and sandstone in beds 2 feet thick or less	200
Thin-bedded shale and coarse limy sandstone or grit, limy conglomerate with shaly phases, and impure limestone	300
Basalt	50
Black shale	150
Basalt and tuff	50
Thin-bedded hard white crystalline limestone in beds 3 feet or less thick	25
Basalt	15
White crystalline limestone	10
White and speckled grit or fine conglomerate with a few quartz pebbles as much as half an inch in diameter; strike due east, dip 75° S	90
Basalt	20
Gray limy beds and black shale, resting on fine gray tuffaceous limy conglomerate and shale; strike N. 65° W., dip 75° S	275
Basalt and tuff with a little shale and fossiliferous limy beds	(?)
	1,505+

The thicknesses given are paced distances, measured across the edges of the beds, and are not reduced to true thicknesses, as the errors in pacing are probably as great as the errors in thickness resulting from the dip of the beds. Nearly all the sedimentary members of this section are highly fossiliferous. The beds of the lower part of the section at the north end of the canyon abut against basalt flows on the west that form the small hill and are separated from the sedimentary rocks by a fault that strikes N. 5° E. and dips 75° W. A great thickness of tuff and basalt underlies the section given and another great thickness of flows lies above it to the south of the canyon. The writer is of the opinion that the basaltic flows overlying the sediments are the lower part of the Nikolai greenstone. Unfortunately it is not possible to trace the lava flows southward to the Chitistone limestone at the lower end of Nizina Glacier, for the intervening area is occupied by Cretaceous sandstone and shale.

Another area of Permian rocks is found in the vicinity of Chitistone Glacier. This area is less satisfactory for study than that of the Skolai Valley but furnishes further evidence of the age and stratigraphic relations of the Nikolai greenstone and the Permian sediments. The extent of this area is not known. Undoubtedly the Permian beds continue northward to Skolai Creek but are covered by the younger lava flows of the intervening mountains. They were not identified in Chitistone Glacier, but they may extend a considerable distance southeastward from the head of the glacier and eastward toward Russell Glacier.

The following approximate section will give an idea of the rocks along the south side of the Chitistone River for 2½ miles southwest from the glacier. All the beds dip southwestward. The Nikolai greenstone, which forms the top of the section, occupies all the intervening area between the sedimentary Permian beds and the Chitistone limestone on the west side of Glacier Creek. The section is given to show what the beds are rather than to indicate their thickness, as careful measurements were not made.

Section on south side of Chitistone River southwest of Chitistone Glacier

Nikolai greenstone.	
Greenstone tuff, grading into lava flows above.	Feet
Thin-bedded chert containing beds or lenses of brown-weathering tuff; strike N. 45° W., dip 40° SW	75–100
Light-gray, bluish-gray, and black cherts in beds as much as 6 inches in thickness, several hundred feet.	
Basalt flows, several hundred feet.	
Black or dark-gray slate, containing local beds of sandstone as much as 6 inches in thickness and one bed of angular conglomerate 3 inches thick, overlain by 18 inches of coarse gray sandstone	300
Yellowish-weathering conglomerate, mostly fine but with a few pebbles 2 inches or less thick	20
Interbedded brownish-weathering sandstone and shale, several hundred feet.	
Basalt flows, several hundred feet.	
Yellowish-weathering chert and basalt of unknown thickness.	

The thickness of the volcanic and sedimentary beds in the section is probably several thousand feet, but because of faulting it may appear greater than it actually is. Evidence was found to indicate that the beds on the northeast side of Chitistone Glacier dip northeastward, which would put the glacier on the axis of a northwestward-trending anticline. Fossils are not numerous in the sedimentary beds of the section, but enough were found to leave no questions as to the age of the sandstone and limestone containing them. Most of the fossils were in loose fragments of rocks that were observed in place near by, but their original locality was not felt to be in doubt.

The several areas of Permian rocks bear evidence that they were formed in a time of pronounced volcanic activity. Tuffs and lava flows probably make up much the larger part of the Permian rocks of the district. They are present in all the localities where Permian sediments are known, and in many places they interrupted the deposition of sediments. The conditions under which they were formed are in contrast to those of Mesozoic time, as the beds of that age, which overlie the Permian, contain little if any volcanic material. The next period of active volcanism attended by the extrusion of lavas and tuffs did not begin till Eocene time.

The Permian sedimentary beds and the volcanic rocks associated with them were folded and faulted, and at least a part of them were raised above the sea and subjected to atmospheric erosion for a long time before the Upper Triassic sediments were laid down. The structure of the beds is imperfectly known, but in places the trend lines of folds approximate the strike of the younger sediments, extending in a more or less northwesterly direction. The different degrees of metamorphism observed are probably in part the result of intrusion by hot igneous rocks and in part the result of folding. Some of the limestone is locally so thoroughly recrystallized that it is now a coarse marble and bears a strong resemblance to the Carboniferous marble on the north side of the Wrangell Mountains.

Fossils were found in most of the sedimentary deposits referred to the Permian. In places they are exceedingly numerous so that the collector has little to do but select the specimens that come nearest to being perfect, yet the number of species is less than might be expected from the number of individuals. The fossils give definite evidence of the Permian age of the rocks.

Permian sediments are found in other parts of Alaska, especially on the upper Yukon and in southeastern Alaska. The nearest localities, however, are in the upper White River Valley near Russell Glacier and in the upper Copper River region.

PERMIAN OR TRIASSIC ROCKS

NIKOLAI GREENSTONE

The age of the Nikolai greenstone is not yet definitely known. The formation has been described many times, and a further detailed description will not be given here. It has been found in many localities on the north side of the Chitina Valley, and in the Nizina district it consists of not less than 5,000 feet of basaltic lava flows that have suffered some chemical alteration and commonly have a dark-green color. Amygdaloidal and porphyritic phases are common. Although moderately folded, the flows were strong and resisted deformation more successfully than the Triassic limestones and than most of the overlying sedimentary deposits. Fracturing and faulting took place extensively, and slickensided blocks are abundant. The presence of copper minerals and stain is so common in the Nikolai greenstone wherever it crops out that some genetic connection between the greenstone and the copper deposits of the Chitina Valley seems to be a necessary assumption.

The greenstone is present on the west side of the Nizina River opposite the mouth of the Chitistone River, in the Chitistone Valley, and on both sides of Nizina Glacier within the area under discussion. No opportunity was found to visit the area south of Regal Glacier, but the areas on the east side of Nizina Glacier and on the Chitistone River were studied. (See sections, pp. 150, 151.) In both places the sedimentary beds of the Permian dip conformably under tuff deposits, which grade upward within a short distance into basalt flows without intercalated sediments. Both of these areas appear to offer good evidence for regarding the Nikolai greenstone as the culminating deposit of a period of volcanism that continued throughout Permian time, as it is known in this district. Whether the extrusion of lava continued into Triassic time is a question on which no evidence is known to the writer. One of the most puzzling problems connected with the greenstone is its relation to the overlying Chitistone limestone. In most places where the contact of the two formations has been exposed a few inches or feet of red or gray shale is present. Faulting between the greenstone and limestone along the contact plane is common, and the shale appears to have acted as a lubricant to facilitate the motion. Aside from this bed faulting, no discordance of structure between the lava flows and the limestone beds in the Chitina Valley is known to the writer. Nevertheless the absence of Lower and Middle Triassic and the lower part of Upper Triassic sediments in the Chitina Valley—a general condition in Alaska—suggests a period of erosion between the greenstone and limestone, if the greenstone is of Permian age, or between the Permian sediments and the greenstone, if the greenstone is of Upper Triassic age.

The section of Permian sediments given on page 149 shows a bed of tuffaceous material containing angular fragments of fossiliferous Permian limestone overlying Permian limestone beds of the same kind. These angular fragments were interpreted in the field as material dragged along by the tuffs and lavas from the Permian beds through which they were ejected rather than as material from a land mass of Permian rocks undergoing erosion at the time the volcanic outbursts occurred. Limestone fragments were not seen in the tuff at the base of the greenstone on the east side of Nizina Glacier nor on the Chitistone River, and the structural conformability of sediments and lava flows was not questioned.

In view of the facts just related the writer is inclined to the belief that the lavas of the Nikolai formation were extruded in Permian rather than Triassic time, but he does not regard the question as fully settled yet.

UPPER TRIASSIC ROCKS

The Upper Triassic rocks of the Nizina district comprise the Chitistone limestone, the Nizina limestone, and the McCarthy shale. A detailed description of these formations has been given in other publications of the Geological Survey [6] and will not be repeated here.

The Chitistone and Nizina limestones were originally described as one formation, the Chitistone limestone, which has its finest exposures on McCarthy Creek and on the west side of the Nizina River at the mouth of the Chitistone River. In these localities 3,000 feet of limestone is exposed in sections of diagrammatic clearness, comprising all the beds from the Nikolai greenstone below to the McCarthy shale above. The section on McCarthy Creek shows approximately 1,900 feet of distinctly bedded limestone weathering to a light bluish-gray color, resting on greenstone and dipping about 30° NE. Above the gray limestone comes possibly 1,100 feet of limestone in somewhat thinner beds which, in larger exposures, shows a brownish color due to weathering. Examination of fresh specimens of these limestone beds shows that in general the lower section, or Chitistone limestone, is made up of light-gray, bluish-gray, or in places, generally near the top, dark-gray beds. Thin shale partings are present in places between limestone beds but are commonly absent between the thicker beds. Irregularly shaped bodies and knots of black chert are numerous in the upper part of the lower formation (Chitistone limestone) but are scarce if present at all near the base. A brownish color is seen in places on the weathered surfaces in the Chitistone but is more conspicuous on freshly exposed bedding planes. Dolomitization has taken place in some beds in the lower part of the Chitistone limestone and plays a useful part in the exploration for copper at Kennecott.

The upper brownish-weathering beds, to which Martin gave the name Nizina limestone, are commonly dark gray and as a rule are

[6] Moffit, F. H., and Capps, S. R., Geology and mineral resources of the Nizina district, Alaska: U. S. Geol. Survey Bull. 448, pp. 21–30, 1911. Martin, G. C., The Mesozoic stratigraphy of Alaska: U. S. Geol. Survey Bull. 776, pp. 6–32, 1926.

separated by thin partings of shale that become more prominent in the upper part of the section. No chert knots were noticed in the Nizina limestone in this district. The fine exposure of Upper Triassic limestone on the east side of McCarthy Creek shows a rhythmical alternation of zones of thin beds and thick beds, but the thick beds become less conspicuous at the top.

The Nizina limestone is overlain by the McCarthy shale, a fairly homogeneous formation with a thickness of at least 2,500 feet. The base of the shale is distinctly bedded, like the underlying limestone, but is darker and consists of alternating beds of hard black or gray argillite and soft black shale in which argillite predominates. The argillite beds commonly range in thickness from 1 foot to 18 inches and rarely exceed 3 feet. The shale beds as a rule are only a few inches thick. In places the argillite resembles a black chert with conchoidal fracture, but practically all the beds of this nature were found to effervesce when tested with acid. Chert beds in the lower part of the McCarthy shale are exposed at some places in the Chitina Valley but are believed to be a local phase of the formation, due to the effects of intrusion by igneous rocks, and not a continuous widespread member.

The thin-bedded basal part of the formation consists of only a few hundred feet of strata and grades above into black shale with indistinct bedding except in a few places where a thin seam of argillite or limestone is included. Erosion proceeds rapidly in the soft black shale and gives rise to numerous deep cuts into hills that probably once had a more smooth and flowing contour than now. These gulches have steep slopes of great extent on which vegetation is unable to secure a foothold.

Within the district under consideration the Upper Triassic limestone and shale are well developed on McCarthy Creek, on both sides of the Nizina River below Nizina Glacier, and on the Chitistone River. One other small area of Triassic rocks was found on the north side of the Skolai Valley, 2,000 feet above the creek and halfway between Frederika and Nizina Glaciers. At this locality a small remnant of shale with Triassic fossils that has escaped removal by erosion rests on the Permian limestone. The exposures consist of loose material scattered over an area of several acres. No undisturbed ledges were seen in place, but the loose shale fragments apparently cover too large an area to be erratic material transported from some other locality. The significance of this occurrence lies in the absence of all the Triassic limestone and the Nikolai greenstone which should be beneath the shale. This same condition holds at the north end of Russell Glacier, where, however, a much greater thickness of shale is probably present. Possible explanations for this condition are either that the greenstone and limestone never were there or that, although originally present, they were removed by erosion before the shale was deposited. No evidence to establish either one of these suppositions was obtained during the summer's work, and the question is still open in the mind of the writer.

Some structural features of the Triassic rocks are considered under the heading " Structure."

CRETACEOUS ROCKS

Geologic studies in the Chitina Valley during recent years have shown that rocks of Cretaceous age are more widely distributed than was formerly supposed. The Cretaceous rocks of the Nizina district comprise chiefly marine shale and sandstone that have a thickness of several thousand feet. They occupy the upper parts of McCarthy Creek and West Fork Valleys, several square miles on both sides of Nizina Glacier, and other small areas. Before they were deposited the Triassic sediments had been deformed, raised above sea level, and then submerged again but not till after a large part of them had been removed by erosion, as is shown by a marked structural unconformity at the base of the Cretaceous beds.

Detailed sections of the Cretaceous sediments have not been made. In a broad way the section on McCarthy Creek includes a small thickness of basal sandstone and sandy shale overlain by a great thickness of black shale. The shale in turn is overlain by brown-weathering sandstone that forms the highest beds exposed. A massive bed of conglomerate several hundred feet thick on the east side of McCarthy Creek near its head is included with the Cretaceous rocks, although its age is not yet proved. The Cretaceous sandstones of the upper part of the section include a few thin beds or lenses of coal. All the beds show deformation in some degree, but the soft black shales show much more folding than the stronger sandstones that are associated with them.

The section of Cretaceous beds on the West Fork and on the west side of Nizina Glacier resembles that of McCarthy Creek but was not studied carefully, as time was lacking. Apparently the Cretaceous sandstone rests on Nikolai greenstone south of Regal Glacier, and the beds exposed there reach a thickness of about 3,000 feet. Cretaceous rocks are well exposed east of Nizina Glacier. About 3 miles south of Skolai Lake the Cretaceous rocks overlie the Nikolai greenstone. They extend southward along the glacier for a mile or more but find their greatest development in the mountains to the east, where at least 3,000 feet is exposed. The basal beds include a conglomerate of no great thickness with scattered pebbles 3 inches or less in diameter, 75 feet of gray sandstone overlain by 20 feet of coarse black grit and then brown-weathering sandstone that dips gently south. A mile south of this locality, on the north side of Moonshine Creek, the brown Cretaceous sandstone and sandy shale contain numerous round concretions as much as 3 feet in diameter. These beds, which are overlain by about 600 feet of horizontally bedded soft gray shale that contains thin sandstone beds and concretions, form the lower slopes of the flat-topped mountain south of Moonshine Creek. The soft shale weathers easily to form soft mud. The top of the mountain has an altitude of a little more than 6,000 feet, and its precipitous north side gives a fine exposure of nearly horizontal beds that are the basis of the following highly generalized section. The thicknesses given are based on estimates of the proportionate parts of the section made up by the different members as viewed from a distance.

Generalized section in north side of mountain south of Moonshine Creek

	Feet
Brown-weathering sandstone	400
Brown-weathering shale and sandy shale with sandstone beds	800
Brown-weathering sandstone	800
Soft gray shale with local sandstone beds and concretions	600
Brown-weathering sandstone and sandy shale with large sandy concretions	100?
Conglomerate	?
	2,700+

A vast amount of Cretaceous shale and sandstone has been removed by erosion, and areas that once were certainly occupied by such rocks show no evidence of them now. On the other hand little patches of sandstone appear unexpectedly in many places as a thin veneer on ridges and capping on mountain tops.

The Cretaceous sediments show less folding than the Upper Triassic limestone and shale but more than the overlying Tertiary volcanic rocks, although in places the parallelism between the bedding planes of the sandstone and of the Tertiary tuff beds and lava flows is practically perfect.

TERTIARY ROCKS

The Tertiary volcanic rocks have received less attention than almost any other rocks of the Wrangell Mountains and are probably less known. This fact does not appear strange when it is realized that they occupy the highest and most inaccessible parts of the mountain group and in most places can not be reached without much difficulty. Furthermore, they are not known to contain valuable mineral deposits and thus have not been commercially important.

The Tertiary rocks within the area under discussion are dominantly andesitic and basaltic lava flows intercalated with tuff beds. Black glassy obsidian is abundant in the morainal débris on the west side of Frederika Glacier but was not seen elsewhere. It probably belongs among the latest outpourings of volcanic material and may possibly be younger than the Tertiary, as is the thick deposit of white volcanic "ash" that caps some of the mountains north of lower Skolai Creek. Included among the Tertiary rocks also is a comparatively small thickness of fresh-water leaf-bearing clay, sandstone, and conglomerate containing thin beds of coal, which lies at the base of the volcanic rocks on Frederika Creek.

The lavas and tuffs form the tops of all the high mountains north of a line drawn from McCarthy Creek Glacier to Chitistone Glacier. They are conspicuous in the landscape even at a distance because of the fine development and regularity of their bedding and because of the variation in color, which emphasizes the bedding. The beds have a low northerly dip that is so small as to be almost unnoticeable, and they therefore appear to be practically horizontal. Another striking feature of the volcanic rocks is the marked development of columnar structure in some of the lava flows. This structure is well exhibited in the upper part of Chimney Mountain, on the west side of Nizina Glacier, where the columns form a vertical wall around three sides of the mountain. Precipitous steplike slopes and impassable walls are characteristic of the volcanic deposits wherever they are seen.

Most of the lava flows are highly vesicular and in places are porphyritic, the most conspicuous phenocrysts being large tabular crystals of amber-colored feldspar. Vesicular lavas are, however, much more abundant than the porphyritic varieties and in many places are even more striking in appearance because of the irregular nodules of blue and white chalcedony and the crystalline quartz which were deposited in the vesicles.

One of the most interesting features connected with the volcanic deposits is the presence of leaf-bearing fresh-water beds and coal beds at their base in at least one locality. These beds are found along the lowest slopes of the east side of the Frederika Valley, extending from the glacier to Skolai Creek, and in a small area in their line of strike south of Skolai Creek. They bear further evidence to support the opinion of earlier workers that the lava flows and tuffs were poured out on a land surface and not into the sea.

The best exposures for studying the fresh-water beds are in the gulches near the lower end of Frederika Glacier, where the following section was measured:

Section in gulches near lower end of Frederika Glacier

	Feet
Basalt, great thickness.	
Light-yellowish tuffaceous bed	12–15
Gray sandy shale splitting into thin sheets	5
Black shale	15
Black sandy shale splitting into thin sheets	5
Coarse gritty tuff or sandstone, thin sandstone beds, variegated fine clay, black shale, and thin coal beds; abundant fossil leaves	150
Gray, yellowish-weathering conglomerate, finer above, containing local beds of shale	100
Brown-weathering conglomerate with well-rounded pebbles 2 inches or less in diameter	20
Basalt (Permian?).	
	310

In a near-by gulch on the south the upper part of the section is as follows:

	Feet
Basalt, great thickness.	
Tuff	20
Gray sandstone	20
Basalt flow	60
Tuff	18
Sandstone	4
White and gray fine-grained clay	10
Black and gray shale	4

All the sedimentary members of the first section, above the conglomerate, and of the second section also contain fossil leaves, which are especially abundant and well preserved in the beds just above the coal beds.

The fresh-water beds strike from north to N. 25° E. and dip gently to the east under the lavas and tuffs that make up the mountains on the east side of the Frederika Valley.

The section of fresh-water deposits is difficult to study, except in gulches where water exposes a fresh surface of the beds, for the soft clays wash over and hide everything on the hill slopes. These clays make up most of the middle part of the general section. They are gray or light gray or white, have a uniform fine grain, and when wet become a sticky mass like hard grease. The coal is in thin beds that range from an inch or less to a foot in thickness and has no commercial value.

Outcrops of the fresh-water beds continue north for about 2 miles and possibly farther, but the exposures are too poor to give much additional information. Apparently the thickness of beds grows less in that direction. Between Frederika Glacier and Skolai Creek the exposures are poor. No exposures were seen in the canyon of Skolai Creek, but outcrops of gray and black shale and white to light-gray clay beds, including thin lenses of coal, are found south of Skolai Creek at the base of the Tertiary volcanic rocks east of the glacier opposite Frederika Creek. The beds contain well-preserved leaves and so far as could be determined do not exceed 75 feet in thickness.

The collections of fossil leaves from the fresh-water sedimentary beds were submitted to E. W. Berry for identification and determination of their age. Mr. Berry says that "All lots appear to be of approximately the same age and are doubtless to be correlated with the Kenai." They are therefore assigned to the Eocene and thus fix a more definite time for the beginning of the latest period of volcanism in this district. In a geologic sense this period has apparently continued without interruption to the present time, although no outpouring of lavas has taken place in the Wrangell Mountain district within the observation of white men.

LIGHT-COLORED GRANITE AND PORPHYRITIC INTRUSIVE ROCKS

The preceding descriptions have made evident the fact that a large proportion of the rocks of this district are igneous. Most of them, however, are lava flows and tuffs that were poured out or ejected on the surface, and because of their bedded structure they possess some of the characteristics of sedimentary deposits. They predominate so greatly over the intrusive rocks that those rocks are relatively insignificant in amount. The intrusive rocks were not studied in detail and do not require an extended description. Moreover, the order of their presentation here is not an indication of their relative age. They occur mostly in the form of dikes and sills and may be divided into light-colored quartz diorite porphyry, which is abundant in some localities, as in the black shales of lower McCarthy Creek, and dark, more basic rocks, which cut both the sedimentary and the volcanic rocks and supposedly were to a large extent the feeders that supplied molten rock for the surface flows, and if so must be of Tertiary age. The light-colored dikes are not numerous within the area studied, except on lower McCarthy Creek, where they cut shale of Cretaceous age. However, they are believed to have a genetic connection with the gold deposits of the Nizina district and possibly also with the copper deposits and are consequently of economic importance. A small area of related rocks much like those of McCarthy Creek was noted on the west and southwest sides of Frederika Mountain at the north edge of the area under consideration. These rocks consist of light-gray hornblende granite of medium grain but with finer-grained light-colored porphyritic phases that show feldspar phenocrysts and with dark fine-grained phases that show hornblende phenocrysts. In places on the east side of Frederika Glacier the moraines are made up almost wholly of these rocks. Another small area is the low knob north of Upper Skolai Lake, which apparently is a thick sill of light-gray granitic rock.

The form and color of a prominent two-peaked mountain between Nizina Glacier and the Chitistone River suggests that this mountain also may be made up of the granitic rock, a conclusion that is somewhat strengthened by the presence of light-colored dikes in the near-by Cretaceous sandstone and shale.

The dark basaltic dikes and sills are numerous in the black Cretaceous shale that underlies the Tertiary volcanic rocks of McCarthy Creek and are present in Tertiary fresh-water sedimentary beds east of Frederika Glacier but are most abundant in the Tertiary volcanic rocks themselves, where it is evident that the overlying flows had to break through the tuff deposits and the chilled lavas to reach the surface.

STRUCTURE

One of the outstanding problems connected with mining and the search for copper deposits in the Nizina district is the structure of the beds in which the ore bodies occur. This problem has a bearing on the development of any new deposits that may be discovered, as well as on the exploitation of known deposits like those of Kennecott. So far as the copper deposits are concerned, only the structure of the Nikolai greenstone and the Chitistone limestone is of immediate concern, although the structure of the other formations may have a bearing not yet recognized. As it is impracticable, if not impossible, to map most of the smaller structural details that are met in mine development, the account of the structure given here will deal only with the major features.

In a large way the rocks under consideration form a broad, shallow syncline that trends a little south of northwest. The Permian rocks of Skolai Creek and Rohn Glacier are the oldest known rocks on one flank of the syncline—the northeast side—and the Nikolai greenstone is the oldest on the other, although if the section were carried somewhat farther south, rocks of lower Carboniferous (Mississippian) age would be met. The Nikolai greenstone, moreover, appears on both sides of the syncline but is not continuously exposed. If the Nikolai greenstone is assumed to be of Permian age, then it appears probable that the greenstone formed a land mass exposed to erosion in early Triassic time, for no rocks of Lower and Middle Triassic age are known in this region. On the other hand, the seeming structural conformity of the greenstone with both the underlying Permian sedimentary beds and the overlying Chitistone limestone (Upper Triassic) and the failure so far to find any surface that can be definitely recognized as a weathered or eroded land surface make the problem a difficult one to solve. The Permian sedimentary rocks were folded and eroded before part of the Upper Triassic beds were deposited, as is shown by remnants of McCarthy shale that rest on Permian limestone on Skolai Creek, both the Nikolai greenstone and the Triassic limestones being absent. In connection with this fact, it should be kept in mind that the Upper Triassic sediments represent a gradual transgression of the sea on the land and that the Permian limestone, on which are found Upper Triassic shale north of Skolai Creek, may still have been above water while the Triassic limestones were being formed in a basin to the south. The general trend of folds in the Permian and Upper Triassic rocks is practically the same, so far as is known, but the older rocks appear to be more faulted. Some of the Permian rocks have locally become schistose.

After the deposition of the Upper Triassic McCarthy shale there came a period of folding and elevation, when the Triassic beds and the greenstone were raised above the sea and a great part of them were removed by erosion, so that later, when another transgression of the sea took place, the Cretaceous sediments were laid down upon the truncated beds of the older rocks. The Cretaceous sediments, in turn, were folded and elevated above the sea and, as would be expected, show less folding than the Triassic beds but more than the overlying Tertiary volcanic rocks.

All these facts find expression in the structure of the district. In general, the Chitistone limestone along its southern boundary between the Nizina River and Kennicott Glacier strikes northwest and dips 30°–35° NE., but toward the northeast as is apparent on the Nizina River, McCarthy Creek, and Kennicott Glacier, it flattens out and becomes practically horizontal. The north limb of the synclinal fold is not known and probably is buried beneath the younger sediments and volcanic deposits. South of the Chitistone River the limestone appears to be less disturbed and has a lower dip than west of the Nizina River.

The structure of the Chitistone limestone is made more complicated by the presence of numerous faults, the most striking of which is the great thrust fault that appears in the limestone wall of the Nizina River a short distance below the West Fork. This fault has nearly the same strike as the bedding of the limestone and follows the same course as Glacier Creek and the lower valley of the West Fork. The fault dips southwest, and the limestone and greenstone on that side have been thrust over the limestone on the northeast for many hundreds if not thousands of feet. This fault is plainly visible on both sides of the Nizina River but was not recognized on McCarthy Creek. Another fault of large displacement is indicated by the relations of the Permian rocks of the Skolai Creek Valley, where the scarp of the southwestward-dipping limestone bed, high above the creek on the south side of the valley, is discordant with the limestone of the north side and suggests that the Permian rocks south of the creek have been raised with reference to those on the north along an east-west fault that follows much the same course as the creek itself. Failure to find evidence of this fault in the Tertiary volcanic rocks of upper Skolai Creek suggests further that this fault, if present, is of pre-Tertiary age. Most of the faults, however, are of smaller displacement and are less readily observed. One large system includes faults with steep dips and with strikes that range from about north to northeast. Faults belonging to this system carry some of the most valuable ore bodies in the mines at Kennecott and may have had a controlling influence in determining the location of the upper Nizina River, McCarthy Creek, and the east fork of Kennicott Glacier. A fault of this kind on the east side of Nizina Glacier below Skolai Lake brings the fossiliferous Permian beds into contact with the volcanic rocks along their strike. Several such faults may be seen on McCarthy Creek. One on the west side of that stream faults Chitistone limestone against Nikolai greenstone about 2 miles above the East Fork. Another on the east side brings Chitistone limestone against black Cretaceous shale and can be traced for 4 or 5 miles in the upper valley.

Another variety of fault, which is much more difficult to recognize but is widely prevalent in the limestone, consists of those known as bed faults. These faults indicate movement of one bed on another along the bedding planes and seem to indicate an adjustment of beds like that which occurs when the leaves of a book are bent. Some of these folds break across diagonally from one bedding plane to another, cutting the bed at an angle so small that the fault plane is almost parallel to the bed plane. A movement of the Chitistone limestone on its contact plane with the Nikolai greenstone is an example of the bedding-plane faults that has been recognized in many places. The one important influence which the bedding-plane faults have long been known to have had on the deposition of the ores at Kennecott is that of directing the course of the copper-bearing solutions and thus, in some places, preventing the extension of an ore body from one limestone bed to the adjacent one. Some of the copper-bearing veins of the Bonanza mine terminated below at a bedding-plant fault a short distance above the limestone-greenstone contact, and at this place a notable expansion of the ore body took place. A vertical cross section thus showed a more or less wedge-shaped mass of ore with its base at the bedding-plane fault and its thin edge pointed upward. S. G. Lasky,[7] of Kennecott, has pointed out in a paper recently prepared for publication that the bedding-plane faults probably also had a strong influence in the production and location of cross faults, which he finds hold a definite relation to the changes in strike and dip of the bedding-plane faults.

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[7] Lasky, S. G., Transverse faults at Kennecott and their relation to the main fault system: Am. Inst. Min. and Met. Eng. Yearbook, 1929, pp. 303–317.