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THE SUSLOTA PASS DISTRICT

UPPER COPPER RIVER REGION ALASKA

BY

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THE SUSLOTA PASS DISTRICT, UPPER COPPER RIVER REGION

By Fred H. Moffit

ABSTRACT

The Suslota Pass district includes the part of the Alaska Range that lies between Mentasta Pass and the Nabesna River. This part of the range is about 35 miles wide, from the lowlands of the Copper River on the southwest to those of the Tanana River on the northeast, and its average height is less than that of any other part of the range east of Mount McKinley. It has been difficult of access until recently and is without established trails, although some prospecting and trapping has been carried on within it. The usual approach is by way of the Copper River Valley. The range is here made up of rugged mountains rising to a maximum height of 9,200 feet and possesses an intricate system of narrow strongly glaciated valleys that afford comparatively easy access to most of it.

The bedrock geology is apparently simple insofar as the number and distribution of formations is concerned. Metamorphosed tuffs and lava flows with a minor proportion of sediments, chiefly limestone, form a belt about 10 miles wide along the southwest side of the area. This belt of rocks, of Permian age, trends northwestward and forms the foothills of the range. It is bordered on the northeast by a wider belt of Mesozoic sedimentary beds, including ribbon-banded argillite, slate, sandstone, quartzite, conglomerate, and limestone. These beds are folded, and the folds trend northwestward with the axis of the Alaska Range in this vicinity. In places the sediments have been altered by the intrusion of igneous rocks or from other causes, but they show much less metamorphism than the Permian rocks, which they overlie unconformably. The Mesozoic sediments, like the Permian volcanic rocks, are intruded by granular igneous rocks that belong in large part to the diorite family and in places are extensively displayed. Fossils collected from the Mesozoic limestone show that Upper Triassic and Lower Cretaceous beds are present, and although no Jurassic beds were identified it appears probable from evidence afforded in nearby areas that they may be present also.

Unconsolidated glacial and stream-laid deposits are widely distributed within the area.

Prospecting at different places has shown the presence of metallic minerals and has resulted in the staking of both lode and placer claims. One gold-lode mine at White Mountain, on the Nabesna River, was brought into production in 1931 and gives promise of a successful future.

INTRODUCTION

This paper gives a preliminary account of a geologic reconnaissance made in 1931 in the eastern part of the Alaska Range between Mentasta Pass and the Nabesna River. The district lies between the the head of the Copper River on the southwest and the Tanana River on the northeast and includes tributaries of both streams, although much the larger part of the drainage goes to the Tanana River. A square with sides 40 miles long running northeast and northwest and so placed as to reach from the Copper River to the Tanana Flats and from Mentasta Pass to the Nabesna River would outline the area that is described. This area includes about 1,600 square miles, only one fifth of which drains to the Copper River. Suslota Pass is the lowest point of the divide between the two rivers within the district. It has long been used by the natives in traveling between the Copper River and the Tetling Lakes and was the route followed by Allen [1] in 1885 in his remarkable exploratory trip across Alaska. This part of the Alaska Range is remote from the more frequented routes of travel and has not been much visited but is becoming more accessible with the extension of the highway up the Copper River.

The geologic field work described is a continuation of surveys begun by the writer on the Slana and Tok Rivers in 1929. These surveys are contributions to an investigation of the mineral resources of the eastern part of the Alaska Range, and it is hoped that they may be extended so as eventually to include both sides of the range as far west as the Delta River.

PREVIOUS EXPLORATIONS

The earliest published reference to Suslota Pass and its vicinity was made by Allen [2] in his account of an exploration which he carried out under the direction of the War Department in 1885. His map indicates somewhat imperfectly the route which he followed in crossing the Alaska Range from Batzulnetas to the Tetling Lakes, and the text of his report suggests that the pass beginning at Suslota Lake, which he called Miles Pass but which is better known as Suslota Pass, will probably prove to be the best route between the Copper River country and the Yukon Basin, a prediction which because of later discoveries was not fulfilled. After Allen's visit the upper Copper River and Tanana region received little attention for many years.

A topographic and geologic reconnaissance of a large area, of which the district under consideration is only a small part, was

[1] Allen, H. T., Report of an expedition to the Copper, Tanana, and Koyukuk Rivers, in the Territory of Alaska, in the year 1885, War Department, 1887.

[2] Idem, p. 71.

made by D. C. Witherspoon and Frank C. Schrader in 1902. The topographic map made at that time by Witherspoon[3] was issued shortly afterward, but the geologic results were not published in full, although a part of Schrader's observations in the area north of the Nabesna River were included on the geologic map that accompanied the report on a geologic reconnaissance made by Knopf, Capps, and the writer[4] in the Nabesna-White River district in 1908.

The district adjacent to the Suslota Pass district on the northwest was studied by the writer[5] in 1929.

RELIEF AND DRAINAGE

The Alaska Range between Mentasta Pass and the Nabesna River has a width of about 35 miles and is lower than any other part of the range east of Mount McKinley, yet it presents a rugged topography and a forbidding aspect. The range is here limited on the southwest and northeast by the flat, poorly drained lowlands of the Copper and Tanana Rivers, dotted with lakes and "niggerhead" swamps and crossed irregularly with bands of scrubby spruce upon the drier gravel ridges, from which the mountains rise abruptly. These lowlands on both sides are a little more than 2,000 feet above the sea. The highest peak within the area reaches 9,200 feet. It is therefore evident that the maximum relief is about 7,000 feet. In general, however, the relief, as judged from a large number of heights, is between 3,000 and 4,000 feet.

Narrow ridges and sharp peaks are characteristic of most of the area, although some of the lower hills on the flanks of the range are broad and smooth topped. Most of the valleys are narrow, and the drainage is intricate, giving evidence of a comparatively young topography.

The larger streams of the district, practically the boundary lines of the area under consideration, are the Copper, Slana, Nabesna, and Tanana Rivers. They are all swift, muddy glacial streams, lacking most of the features that make a river beautiful. The Little Tok River and Bear Creek with their tributaries drain the northern part of the area and flow north and northeast to the Tanana. Bear Creek is also a glacial stream and is milky in summer, but the Little Tok is usually clear, although several of its branches head in small glaciers and are sometimes loaded with glacial silt. Suslota Creek, a clear-water stream that flows into the Slana River, is the principal contributor to the Copper River drainage. Jack and

[3] Witherspoon, D. C., U.S. Geol. Survey Prof. Paper 41, pl. 20, 1905.

[4] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska: U.S. Geol. Survey Bull. 417, 1910.

[5] Moffit, F. H., The Slana district, upper Copper River region: U.S. Geol. Survey Bull. 824, pp. 111–124, 1932.

Platinum Creeks on the south are tributaries of the Nabesna River, heading against Bear Creek in the highest mountains of the district, and receive part of their water from small glaciers. They flow southeastward, and their valleys furnish convenient routes for travel between the Copper and Nabesna Rivers.

Practically all the streams occupy valleys that were once filled with ice, as is plainly shown by morainal deposits and the sculpturing of the mountain sides. A few small glaciers are still found in the higher mountains, as has been mentioned, but are insignificant in comparison with the great ice fields and streams of the neighboring Wrangell Mountains to the southwest. The largest of them, a small glacier about 2½ miles long, which flows from the north side of the highest peak in the district, is regarded as the head of Bear Creek. Other smaller glaciers are found along the ridge to the northwest and southeast for a total distance of approximately 15 miles. Nearly all of them lie within the Tanana River drainage basin.

The largest lake within the area described is Suslota Lake. It is a narrow body of water, over 2 miles long, crowded between two hills, where the natural outlet is obstructed by gravel deposits. Jack Creek Lake lies on the divide between the Nabesna River and the Copper River drainage basins and is smaller than Suslota Lake. Many other small lakes and ponds are scattered throughout the district. Scores of them are present in the wide glacial valley leading from the Little Tok River to Bear Creek, and they are particularly numerous near the head of Tuck Creek.

The drainage of parts of the district shows features of unusual interest. Morainal deposits and outwash gravel are well developed in many places and have affected the run-off in different ways. Extensive underground drainage is shown by the disappearance of streams which sink into gravel and by their reappearance as large springs. On the other hand, the combination of uneven surface and impervious gravel deposits, or the blocking of bedrock channels has produced the numerous ponds and small lakes. A small lake about one third of a mile long on the divide between Platinum Creek and Totschunda Creek was formed by a great landslide from the limestone cliffs on the southwest, which blocked a small tributary of Platinum Creek. Less than a quarter of a mile below this dam on Platinum Creek there are two cold mineral springs, which have built up large deposits of calcareous tufa and are much frequented by the mountain sheep and other animals that like the water and the salty taste of the decomposing lavas nearby.

TRAILS

The district is practically without established routes of travel. It was formerly approached by the military trail from Valdez to Eagle and a branch trail that crossed the Slana River near its mouth and led to the Nabesna River by way of either Platinum or Jack Creek. The old military trail has given place to a new highway along the north side of the Copper River from the Richardson Highway near Gulkana. This highway was not completed in 1931 but is in use as far as the Cobb Lakes, 3 miles from Slana. Bridges over Ahtell Creek and the Slana River have been built, and the right of way south of the Slana has been cleared of trees as far as Batzulnetas. An old Indian trail leads from Batzulnetas to Suslota Lake. It is well marked and fairly dry in the timbered areas near the Copper River but traverses so much wet bunch grass or "niggerhead" swamp and is so indistinct between Natat and Suslota Creeks that it offers little aid to a pack train. The best route to the upper tributaries of the Little Tok River is over the hill west of Suslota Lake and through Suslota Pass, but no trails except game trails are found beyond Suslota Lake. Travel with horses, however, is usually less difficult than on the Copper River lowland if some judgment in choosing a route is used, for the gravel ridges furnish good going in most places, and the undergrowth is not heavy. Suslota Lake and Suslota Pass are on the route followed by the natives in travel between Batzulnetas and the Tetling Lake district. The "Indian trail", which exists chiefly in the minds of the natives, turns from the Little Tok into the valley of Tuck Creek, and 5 miles beyond the low, swampy divide between the two streams it reaches the valley of Moose Creek and a pass to the Tetling Lake drainage basin. This appears to be the route followed by Allen, yet there were doubtless variations from this route as it has been described. Another pass to the Tetling Lakes is at the head of Trail Creek east of Mentasta Pass. The natives in their hunting and trapping expeditions use numerous routes and short cuts which they have learned, but these are usually of less help to white travelers than the many game trails, which are often well worn and may be depended on to give the easiest routes across ridges and through valleys.

CLIMATE AND VEGETATION

Records of instrumentally measured temperature and precipitation for the district are not available, but a general statement concerning the climate based on experience may be of interest to prospective visitors. The annual precipitation is moderate, as is that of a large part of central Alaska. The snowfall is light, but the snow lies long on the ground, and the winter is cold. Probably because of the greater elevation and the influence of the high mountains spring comes later and fall earlier than in the southern part of the Copper Basin. The growing season is therefore short. The summer of 1931 was warm and showed a large proportion of fair days, although thunder showers were of almost daily occurrence in parts of the area during July and August.

This part of the Alaska Range furnishes ample supplies of forage for horses in the summer months. The luxuriant growth of "red-top" grass, so common in parts of Alaska, is not found here, but other grasses, especially the variety known as "bunch grass", are present to take its place. The best feed for horses is commonly found in the upper valleys above timber line or on the gravel bars of the larger streams. Horses accustomed to the country supplement the grass by browsing on willow and other plants. Sufficient forage for working horses should not be expected till the middle of June and will usually fail by the 10th of September; the working season for stock not provided with feed in addition to that which they can get for themselves is thus not over 90 days. Horses have wintered regularly for several years on the bars of the Nabesna River, but no work was required of them.

The floors of the larger valleys are commonly covered with timber, which consists mainly of spruce but includes balsam poplar along the streams and aspen and birch on the dry gravel ridges and hill slopes. The spruce commonly does not form extensive compact stands but is distributed unevenly over the valley floors in an arrangement that depends largely on the drainage. Well-drained areas produce a good growth. Low, wet areas support only a scrubby growth or are bare. The stretches bare of timber are commonly covered with bunch grass in the form of "niggerheads" and are difficult or impossible for loaded horses to traverse in wet weather. Narrow fringes of trees along the stream courses or clumps of trees on drained ground are usual and give the lowland areas an appearance of open parks between boundaries of trees. This arrangement is characteristic of the lowlands east of the Copper River and the wide valley occupied in part by Tuck Creek. Much of the spruce timber will be valuable for little except firewood, but under favorable conditions it reaches a size suitable for lumber. The trees for piling and timbers, as well as the decking, for the bridges over Ahtell Creek and the Slana River were cut on the Slana in 1931 and floated down that stream nearly 20 miles to a small mill on Ahtell Creek, where they were sawed for use.

POPULATION

The district might almost be described as having no population, for the few people included in the list live on the borders of the area and not within it. There is a white trader, Lawrence DeWitt, and a small native village on the Slana River at the mouth of Ahtell Creek. James Brown has a homestead on the Nabesna River at the mouth of Jack Creek. The Nabesna Mining Co., of which Carl Whitham is manager, employs a force of about 20 men at its mine on White Mountain between Jacksina and Jack Creeks. These men constituted the whole permanent white population in 1931.

The principal native village is Batzulnetas, on Copper River 10 miles above the Slana. It is made up of two groups of cabins nearly half a mile apart and includes only a few families, although there is evidence to show that it was formerly larger. Allen states that he found 31 men, 10 women, and 15 children when he visited it in 1885. Although Batzulnetas is a permanent village and not simply a fish camp, its location was doubtless determined by the advantages which the site offers for catching salmon. A native winter village a few miles west of Suslota Lake is occupied part of the year. There was formerly a village at the south end of Suslota Lake, but this was abandoned many years ago, and only a modern cache and the partly caved pits of several old houses remain to indicate its existence.

The natives spend much of the summer in obtaining a winter supply of salmon for themselves and their dogs and the winter in hunting and trapping, yet a shortage of food is no uncommon occurrence. In recent years most of the younger men have been employed by the Alaska Road Commission during the open season and were thus given an opportunity to enlarge somewhat an uncertain and meager income.

The name " Batzulneta " is given by Allen[6] as that of the chieftain of the village at the time of his visit, but according to a statement made to the writer by one of the inhabitants it is not the name by which they know the village. Batzulnetas was the scene of an incident of some interest in Alaskan history. Allen[7] presents in his narrative all the facts he could assemble relating to an exploration of the Copper River Valley in 1848 by the Russian Serebrenikof, all the members of whose party were killed by the natives. Only a part of Serebrenikof's notes were recovered, and no facts to indicate the limits of his exploration were known by white men in Allen's time. It now appears to be well established that Serebrenikof's party, some of whom were Aleuts, was destroyed at Batzulnetas by a combined attack of the inhabitants of that village and its vicinity in retaliation for ill treatment by the Russians.

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[6] Allen, H. T., op. cit., p. 67.
[7] Idem, pp. 19–22.

GEOLOGY

SUMMARY

The lack of detailed information gives to the geology of the district an appearance of simplicity that is apparent rather than real, for it is probable that more thorough examination would result in a subdivision of the units used in mapping the area. The field work on which plate 2 is based was a reconnaissance and is believed to have determined the geologic features of most significance to the prospector, although it did not yield a great variety of the details which extended study would bring out and which are essential for a complete understanding of the stratigraphy and structure. The boundary lines between formations are generalized in some degree, as in some places the actual boundaries are obscure or are hidden by unconsolidated deposits, and in others they cannot be made to agree with the generalizations of a reconnaissance topographic map.

The oldest rocks that are recognized consist of a belt of lava flows and tuffs nearly 10 miles wide that extends from the Slana River to the Nabesna River along the southwest side of the range in this area. It includes a minor proportion of sedimentary beds, chiefly limestone, and many intrusive masses. The limestone is locally fossiliferous and furnishes the basis for assigning a Permian age to the associated bedded volcanic rocks. This belt of dominantly igneous rocks is bordered on the northeast by a much wider belt of sedimentary rocks, including finely banded argillite, slate, sandy slate, quartzite, sandstone, conglomerate, and a few isolated limestone beds, which lie unconformably on the volcanic rocks. These rocks reach a great thickness and possibly include beds representative of each of the three great periods of Mesozoic time—Triassic, Jurassic, and Cretaceous—although only Upper Triassic and Lower Cretaceous are now identified with certainty. They have been intruded by a variety of coarse-grained granitic rocks, which locally are extensively developed and form high rugged mountains.

Tertiary lavas occur in a small area, but sedimentary rocks of Tertiary age have not been recognized within the district, and the next younger formations are unconsolidated deposits of sand, gravel, and unsorted waste laid down by water or ice. Glacial deposits are typically developed over much of the area.

PERMIAN ROCKS

Character and distribution.—The oldest rocks recognized in the Suslota Pass district are dominantly of igneous origin and consist of lava flows and tuffs with which a minor proportion of sedimentary beds, chiefly limestone, is interstratified. The bedded rocks are cut by numerous granular intrusive bodies, some of which are probably older than the overlying Mesozoic sediments, although it is difficult to distinguish between these intrusive rocks and those that invaded the sediments in Mesozoic or later time. The volcanic rocks are grouped together on the basis of their field association and the occurrence of fossiliferous limestone beds with them. There appears to be little sedimentary material other than limestone, which in this district occurs in only a few small, disconnected areas, interbedded with the lava flows and tuffs, although in some places in neighboring districts argillaceous deposits are present in considerable amount. The sediments therefore furnish little aid in a study of the structure and thickness of the bedded volcanic rocks with which they occur, and such information must be sought chiefly from the volcanic rocks themselves.

In general the volcanic rocks are all more or less altered from their original form and show the development of secondary minerals and new structure. In places they are schistose or subschistose. Most of the rocks are distinctly granular and are green or gray. In places beds or zones several hundred feet in thickness have a rusty color on the weathered surface and are schistose in texture, showing fine flakes of mica on the cleavage surface. Their appearance suggests that they may be altered tuffs or argillaceous sediments.

The limestone also is altered and in some places is thoroughly recrystallized. Where it was intruded by masses of diorite, garnets and other minerals have developed in such a way as almost to destroy the identity of the original beds. Such alteration has been selective, being greater in some beds than in others, possibly depending on the original composition of the limestone. In contrast with this kind of alteration the original gray limestone in places has become finely granular, bleached, and almost snow-white. Limestone areas are erratic in distribution and nowhere can be traced uninterruptedly for long distances, a feature that probably results from several causes, among which the most effective are folding, faulting, and the removal by erosion of much of the original deposit before the Mesozoic beds were laid down. Furthermore, the Permian limestone is doubtless covered in places by the later sediments.

The largest exposure of limestone within the area is that on White Mountain south of Jack Creek. This exposure makes up nearly the whole east face of the mountain except the top, where volcanic rocks overlie the limestone. No fossils were found in this locality, and the rock is classed with the Permian limestone because of its location and relation to other rocks, although in its massive basal member and overlying thin beds it bears a resemblance to the Upper Triassic Chitistone and Nizina limestones of the Chitina Valley.

The next largest areas are on Platinum Creek and in the mountain west of Suslota Pass, from both of which fossils were collected. In the Platinum Creek area limestone beds of Mesozoic age are also present and may be confused with the Permian limestone where the distinguishing fossils are not obtained.

The Permian rocks occur in a continuous belt, hidden in places by gravel deposits, which extends from the Slana River southeast to the Nabesna River and is part of a much longer belt beginning near the head of the Slana River and extending southeastward along the northeast side of the Wrangell Mountains to the international boundary and beyond.

Thickness and structure.—The Permian rocks between the Slana and Nabesna Rivers afford less favorable conditions for the study of thickness and structure than the corresponding areas to the northwest, for they are less extensively developed and their structure is more obscure. Although not much new information concerning the thickness or structure of the bedded volcanic rocks was obtained, it is known from work in other places [8] that in a general way the Permian section consists of a basal and an upper part that are dominantly volcanic and that the total thickness possibly exceeds 7,000 feet in these localities. The limestone of White Mountain between Jacksina and Jack Creeks is not definitely known to be of Permian age but is so represented on the geologic map. It consists of a basal member made up of massive limestone about 1,000 feet thick, overlain by thin-bedded limestone at least 500 feet thick. This is the thickest section of Permian sedimentary rocks known in the district. The limestone beds at the head of Platinum Creek and near Suslota Pass are only a few hundred feet thick at the most.

The Permian rocks are more altered chemically and mineralogically than the Mesozoic rocks and appear to have undergone more folding and faulting. They also appear to be intruded by igneous rocks more extensively.

Age and correlation.—The age of the rocks referred to the Permian epoch is determined in part from fossils contained in the sedimentary members interbedded with the volcanic material. In the Suslota Pass district fossils were found chiefly in limestone, but in other districts they are present in tuffaceous and argillaceous sediments also. Although not all the Permian sediments contain fossils, the deposits in many places are highly fossiliferous, probably more so than any other deposits in the Copper River Basin known to the writer. All the rocks older than the Mesozoic shown on the geologic map are represented as Permian because of their association with the fossiliferous sediments, although proof for the age of some of the lava flows and tuff beds is lacking. Sediments of early Carbon-

[8] Mendenhall, W. C., Geology of the central Copper River region, Alaska: U.S. Geol. Survey Prof. Paper 41, pp. 33–36, 1905. Moffit, F. H., Notes on the geology of upper Nizina River: U.S. Geol. Survey Bull. 813, pp. 147–154, 1930.

iferous age are present in the Chitina Valley and the lower part of the Copper River Basin, but no evidence for extending them into the Suslota Pass district has yet been found. Moreover, the Permian is known to have been a time of great volcanic activity, and it therefore appears more probable that the volcanic rocks regarded as the lower part of the Permian in the upper basin of Copper River are correctly assigned than that they belong among the older Pennsylvanian sediments.

Fossils were obtained by Schrader in 1902 from the limestone area on the north side of Suslositna Creek west of Suslota Pass and from beds near the head of Platinum Creek. These localities were revisited by the writer in 1931, and additional collections were made from Suslositna Creek. Four localities are represented. The fossils collected by Schrader were identified by Charles Schuchert. Those obtained by the writer were submitted to George H. Girty with the request to compare them with the collections of Schrader, which was done with substantial agreement as to the original identifications. According to Mr. Girty, who has had most to do with the Permian collections from Alaska, the fossils from Platinum Creek are typical Alaskan Permian insofar as is indicated by the small number of genera. The fossils from Suslositna Creek are also regarded as Permian, although the fauna is considerably unlike that of the Platinum Creek locality. The following forms were identified:

1581 (Schrader). Near head of Platinum Creek. Identified by G. H. Girty.

Rhombopora sp.
Chonetes aff. C. granulifer.
Productus aff. P. aagardi.
Pustula sp.
Marginifera? cf. M. typica var. septentrionalis.
Rhynchopora aff. R. nikitini.
Spirifer aff. S. fasciger.
Spiriferina sp.

1520 (Schrader). North side of Suslositna Creek, from tributary about 3 miles west of the Suslota Pass. Identified by Charles Schuchert.

Schwagerina sp. undetermined.
Clisiophyllum sp. undetermined.
Lithostrotion n. sp. aff. L. irregulare Phillips.
Cyathophyllum sp.
Rhombopora, several sp.
Chonetes sp. undeterminable.
Productus sp. undeterminable.
Pugnax or Rhynchonella sp. undeterminable.
Spirifer of the S. striatus group.

7046 (Moffit). Same creek as 1520, about a mile from its mouth. Identified by G. H. Girty.

Cyathophyllum sp.
Lonsdalia sp.
Rhombopora sp.
Orthotichia aff. O. morganiana.

7046a (Moffit). Near 7046. Identified by G. H. Girty.

Aulophyllum sp.
Rhombopora sp.
Chonetes aff. C. flemingi.
Pustula aff. P. fasciata.
Pustula aff. P. wallaciana.
Pustula aff. P. porrecta.
Marginifera aff. M. timanica.
Aviculipecten sp.

Permian rocks consisting chiefly of volcanic tuffs and lava flows and interstratified calcareous sediments are much more typically developed in the Skolai Pass district, on the White River, and at the head of the Chistochina River than in the Suslota Pass district, although it is now believed that all these places represent only different parts of the same succession of formations.

MESOZOIC SEDIMENTS

Character and distribution.—The Mesozoic sediments, which adjoin the Permian rocks on the northeast and make up most of the Alaska Range between the heads of the Copper and Tanana Rivers, are shown on plate 2 as a unit, but in fact they include a variety of rocks deposited in widely separated periods of time, which would be differentiated if they were well enough known to make it possible. It seems unlikely to the writer that any Permian or older rocks have been included in the area mapped as Mesozoic, but in the absence of definite evidence for the age of all the formations this possibility must be kept in mind.

The dominant aspect of the Mesozoic rocks as seen in the landscape is dark. In general they are clay rocks rather than sand rocks, but both varieties are widespread. They include argillite, slate, sandstone, quartzite, conglomerate, and limestone and intermediate varieties between these forms. A notable feature of the sediments in many parts of the area is a banding that results from a regular alternation of sediments. This feature is particularly characteristic of much of the argillaceous deposits, which throughout great thicknesses show a regular ribbonlike alternation of dark and light beds ranging from a fraction of an inch to several inches, although not commonly more than 2 inches in most localities. In places the banding is plainly due to the alternation of dark clay beds with beds containing a larger proportion of very fine sandy siliceous material, and in such places clean-cut boundary lines may often be seen between succeeding pairs of light and dark beds that grade into each other without sharp boundaries. In other places the reason for the banding is less evident, as the texture of the beds seems the same to the eye, although the color is different. The regularity and persistence of the banding are remarkable and show that the conditions under which the rhythmical alternation of sediments took place must have continued throughout a long interval of geologic time. The argillite shows joints and fracture planes but commonly lacks slaty cleavage and breaks into angular blocks rather than into plates. In places, notably in the mountains west of Suslota Pass, the banded argillite was indurated by the intrusion of igneous rocks. In a few places adjacent to the intrusive rocks the argillite beds are not only indurated but are whitened so as to become conspicuous objects in the landscape.

Siliceous beds, including sandstone and quartzite, increase in proportion to argillaceous beds as the northeast side of the range is approached and predominate over argillaceous beds in the high part of the divide between the Little Tok River and the Tetling Lakes. In this vicinity, moreover, the siliceous rocks are quartzite rather than sandstone.

Conglomerate is less common than the argillite and sandrock. A coarse conglomerate bed which contains a variety of material including well-rounded fragments of granitic rock, argillite, and other rocks but which is characterized by a large proportion of limestone fragments was seen in many places between Suslota Pass and the head of Totschunda Creek. The limestone fragments occur as well-rounded pebbles and cobbles and as angular blocks, one of which measured several feet in length. Some of the limestone fragments contain fossils. The conglomerate does not occur at the contact of the Permian with the Mesozoic rocks, where it might be expected, but at a variable distance from it, at no place less than 2 miles. It possibly signifies an unconformity within the Mesozoic sequence and represents the erosion of a land surface which was at least in part made up of rocks of probable Upper Triassic age. The thickness of the conglomerate reaches several hundred feet in places, but this includes interstratified sandstone beds as much as 30 feet thick as well as the coarse conglomerate. At one such locality, 5 miles southwest of Suslota Pass, the overlying rocks are sandstone and fine conglomerate, in which the well-rounded pebbles are smaller and much more sparingly distributed than in the older basal conglomerate and include little, if any, limestone.

Limestone is the least common of the rocks that make up the Mesozoic sediments. No persistent bed, such as might be used as a horizon marker in studying the structure and distribution of the formations, was found, but disconnected and isolated masses were seen at various places throughout the area, mostly south of the valley from Mentasta Pass to Tuck Creek. They attain a maximum thickness of 100 feet or more and probably lie at different horizons, possibly having been laid down at different periods of time. Local deposition or unconformity may account for part of their irregular distribution and form, although it is certain that folding and faulting are also involved.

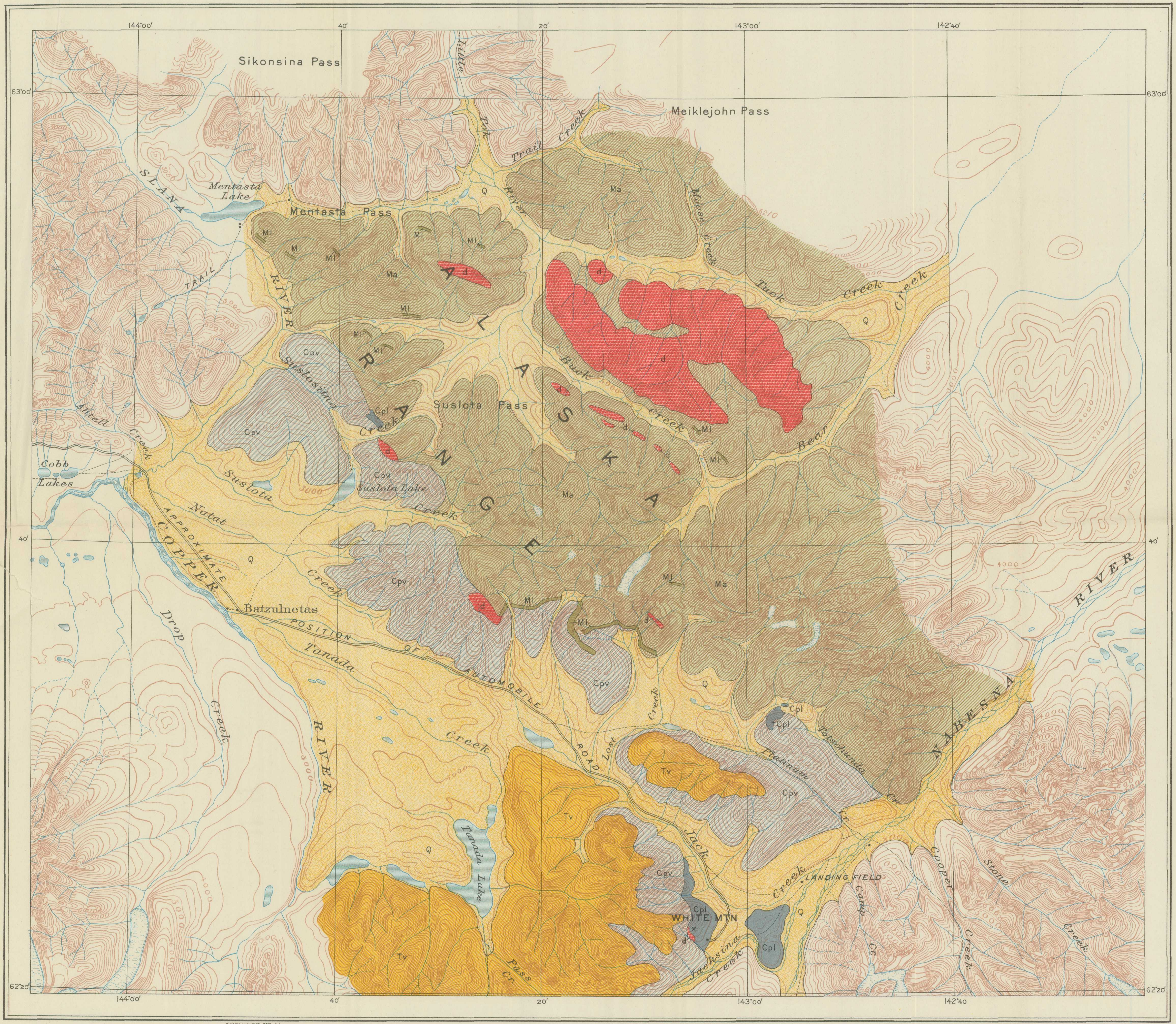
The Mesozoic rocks were intruded by igneous rocks in the form of dikes, sills, and large irregular masses that form extensive mountain areas and will be mentioned again in later paragraphs.

A somewhat fuller description of the Mesozoic rocks that occur in several localities will help to give a clearer picture of their distribution and character and possibly of their structure.

At the forks of the first branch of Platinum Creek west of Totschunda Creek the Permian limestone overlies amygdaloidal lava flows that are exposed in the canyon walls of the creek. The lavas and limestone are succeeded on the north by 75 feet of black slate, 25 feet of basalt, and then more black slate, which is regarded as of Mesozoic age. At 800 feet north of the forks lies another basalt flow in the black slate, and at 3,000 feet banded argillite begins and continues along the creek for more than 2 miles, or as far as the beds were followed. The dip is steep to the north at the forks and diminishes upstream. A conspicuous feature, which gives rise to the Indian name Totschunda (red stone), is the coloring of crushed zones in the argillite that results from oxidation of pyrite.

In ascending the next branch of Platinum Creek to the west the first rock exposed is banded argillite that continues to the head of the creek, where sandstone and quartzite beds appear and also a thick bed of conglomerate, which is probably the limestone conglomerate already mentioned. The next stream on the west, which is the most easterly branch of Jack Creek, crosses the outcrop of the Mesozoic (?) limestone, which is overlain on the north by black slate containing a bed of feldspathic sandstone 75 feet thick that rests on cherty beds. At 200 yards north of the limestone the feldspathic sandstone is overlain by banded argillite that dips north and continues northward to the top of the mountain. These beds are cut by numerous porphyritic dikes and sills, which have whitened the limestone and hardened the clay rocks but which are too small to show on the map. Banded argillite immediately follows on the north of the limestone near the head of the next fork of Jack Creek, and the presence of the conglomerate is shown by numerous boulders along the creek bed. On the tributary of Jack Creek that heads against the extreme eastern part of Suslota Creek the beds overlying the limestone consist of argillite, but they have the ribbon banding less well developed.

In the narrow valley (not shown on the topographic map) which leads east from a low divide between Suslota and Suslositna Creeks to the main headwater tributary of the Little Tok River the succession of deposits from south to north, or in ascending order, is black slate or argillite, ribbon-banded argillite, massive conglomerate beds containing much limestone debris and interstratified with sandstone, and finally sandstone and quartzite with fine grit beds. The total thickness of beds exposed is many hundreds of feet, but as previously mentioned it may not represent a continuous succession of sediments,



EXPLANATION

BEDDED ROCKS

Q — Silt, sand, and gravel deposited by streams and lakes, and morainal material (QUATERNARY)

Tv — Lava flows and tuffs (TERTIARY)

Ml — Limestone of Mesozoic age but possibly including some Permian limestone (MESOZOIC)

Ma — Banded argillite, sandy argillite, sandstone, quartzite, and conglomerate (MESOZOIC)

Cpl — Massive and thin-bedded bluish-gray limestone, in places marmorized or altered by intrusive rocks (CARBONIFEROUS, *Permian*)

Cpv — Bedded volcanic rocks including altered tuffs and lava flows and undifferentiated granular intrusives (CARBONIFEROUS, *Permian*)

INTRUSIVE ROCKS

d — Granular intrusive rocks dominantly diorite but including both more acidic and more basic types (MESOZOIC OR TERTIARY)

Gold mine

Topography by T. G. Gerdine and D. C. Witherspoon, 1902.

Geology by Fred H. Moffit, 1931.

GEOLOGIC RECONNAISSANCE MAP OF THE SUSLOTA PASS DISTRICT, UPPER COPPER RIVER REGION, ALASKA

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

5 0 5 10 15 Miles

5 0 5 10 15 20 Kilometers

1933

Contour interval 200 feet

Datum is mean sea level

a possibility suggested by the limestone conglomerate. The banded argillite is prominent in the mountains west of Suslota Pass, but the massive limestone conglomerate was not identified with certainty. Northward and eastward from Suslota Pass the banding of the argillite is less conspicuous and the bands or beds increase in thickness. In the south slopes of the mountain west of the mouth of Buck Creek the individual dark-gray or black beds reach a thickness of 10 inches, and the whole mass of sediments is indurated by the intrusion of igneous rocks. Similar alteration, by which the argillites were indurated and silicified, took place in the lower slopes of the mountain east of Buck Creek, and in addition the rocks are colored by the oxidation of iron sulphides. In places the siliceous rocks are cherty. The intrusion of diorite or subsequent metamorphism in the vicinity has also given a schistose or subschistose structure to the sediments locally. These alterations, however, have not wholly obliterated the banding of the original argillites.

A change in the character of the sedimentation is indicated by the rocks in the mountains east of the Little Tok River and north of Tuck Creek. The slope of the mountains forming the northeast wall of the valley from Trail Creek to Bear Creek shows a succession of lava flows alternating with sedimentary deposits that include slate, banded argillite, cherty and quartzose beds, and a few thin beds of limestone. The sedimentary members between the lava flows are commonly not over 50 feet thick, and the lava flows are of similar thickness. These rocks all dip northeast, and the spurs extending southwestward from the divide between this valley and the drainage toward the Tetling Lakes show a succession of knobs, representing the resistant lava flows, separated by smooth grassy slopes that mark the place of the sediments. Along the divide occur finely banded black slate, with good cleavage, and quartzite beds. These beds are succeeded on the northeast by light-colored quartzite beds with little slate, which are more extensively developed there than in any other part of the area visited during the summer. The succession shows a few beds of quartzose graywacke or sandstone. In places a platy cleavage or even a schistose structure is seen. There is probably not less than 1,000 feet of these light-colored siliceous beds, and the thickness may be much greater, for they were not followed into the valleys north of the divide.

Thickness and structure.—It is not possible with the information at hand to state the thickness of the Mesozoic sediments in any but indefinite terms. These sediments are believed to have been deposited unconformably on the older Permian rocks, but as the beds adjacent to the boundary line show considerable variation in composition it is possible, if not probable, that the boundary drawn on the geologic map represents a fault contact. Some further support for this suggestion is found in the Chisana River district, 30 miles southeast of the Nabesna River, where, as stated by Capps,[9] the Mesozoic and Permian rocks are separated by a great fault, which probably extends westward beyond the Chisana River. If the contact in the part between the Nabesna and Slana Rivers is the result of faulting, the true base of the Mesozoic sediments may not be exposed in this vicinity. To complicate the matter further, the top of the succession is not known, one if not two structural unconformities within it are probable, and both the Upper Triassic and Lower Cretaceous series of beds which are present are too little known to justify the assignment to them of even an approximate thickness. It is, nevertheless, safe to say that the thickness of all the deposits is measured in thousands of feet rather than hundreds, for the high mountains at the head of Platinum Creek indicate a thickness of at least 4,000 feet, even if no consideration is given to the northerly dip of the beds. Moreover, this locality is believed to represent only part of the total thickness and does not include an unknown amount of younger beds. It is wholly possible that the total may exceed 10,000 feet.

The Mesozoic sediments are folded and much faulted. The folding, however, does not appear to be intense in this area, and where schistosity occurs it is not regional but seems to be due to local causes, such as intrusion by igneous rocks or faulting. Overturned folds were not recognized. The general trend of the folds is northwest. The prevailing dips throughout most of the area are to the northeast, although the opposite dip was noticed. Near the boundary of the Permian and Mesozoic rocks at the "soda springs", on the east branch of Platinum Creek, the slate beds dip 60° NE. This dip decreases to about 25° upstream and at a point 1½ miles from the boundary gives place to steep southwesterly dips for a short distance, beyond which the northeasterly dip is resumed. Probably more detailed work would reveal many such reversals of dip, for otherwise the thickness of the Mesozoic beds in this part of the Alaska Range would be almost incredible. All the rocks examined in the area east of the Little Tok River and north of Tuck Creek have northeasterly dips, but the eastern boundary of the Mesozoic deposits is beyond the limits of the area studied and was not seen. As a whole, the Mesozoic sediments appear to constitute a broad, shallow synclinorium made up of minor secondary folds compressed to a moderate degree.

[9] Capps, S. R., The Chisana-White River district, Alaska: U.S. Geol. Survey Bull. 630, p. 50. 1916.

Age and correlation.—Fossils were collected from 12 localities within the area mapped as occupied by Mesozoic rocks. Most of the localities are within 10 miles of the belt of Permian rocks, and none are in the northeast side of the range—that is, the fossils appear to be from the lower rather than from the higher beds. The Mesozoic deposits in which fossils were found contain a much less abundant fauna than the Permian limestone. Fossils are not numerous in any locality where they were discovered by the writer and are rare in most of the area.

Two periods of Mesozoic time are recognized with certainty in the collections—the Upper Triassic and Lower Cretaceous. Definite evidence for the intermediate Jurassic period is lacking, although rocks of this age are recognized in the southeastern extension of the Mesozoic belt in the Chisana River district. This lack of Jurassic fossils in the collections made in 1931 should not be regarded as indicating the absence of Jurassic deposits until more evidence has been collected.

The limestone beds containing Upper Triassic fossils are adjacent to the Permian boundary line, and from general considerations involving the occurrence of Upper Triassic sediments in parts of the Copper River Basin it is suspected that they represent the lowest of the Mesozoic sediments overlying the Permian rocks in this district, although on the evidence of fossil shells of the pelecypod *Pseudomonotis subcircularis* (Gabb) they are to be correlated with the beds high in the Upper Triassic deposits of the Chitina Valley, where, as stated by Martin,[10] " the most complete known section of Triassic rocks in Alaska " is found. The lower beds are not known to have been deposited on the north side of the Wrangell Mountains or elsewhere in the Copper River Basin. At present the only rocks in the district known to be of Upper Triassic age consist of limestone. Whether slates or other argillaceous rocks corresponding to the McCarthy shale of the Chitina Valley are present has not been determined.

The following table contains a list of Mesozoic fossils collected in the Suslota Pass district. In commenting on these collections Mr. Reeside says of locality 16266: " This fauna is wholly new and of a facies not recorded in North America before. It seems surely to be Triassic and probably Upper Triassic, but none of the familiar species are present."

[10] Martin, G. C., The Mesozoic stratigraphy of Alaska: U.S. Geol. Survey Bull. 776, p. 6, 1926.

Mesozoic fossils collected from the Suslota Pass district

[Determinations by John B. Reeside, Jr.]

	Upper Triassic	Probably Upper Triassic								Lower Cretaceous		Age undetermined	
	16086	16261	16262	16264	16265	16266	16267	16268	16269	16259	16085	16261	16263
Astrocoenia n. sp						×							
Dielasma? n. sp						×							
Terebratula, 2 sp., probably new						×							
Cyrtina? n. sp						×							
Spiriferina cf. S. yukonensis Smith						×							
Spiriferina n. sp						×							
Spiriferina? n. sp						×							
Conucardia n. sp						×							
Dimyopsis n. sp						×	×						
Cassianella? sp						×							
Monotis sp						×							
Pseudomonotis subcircularis Gabb	×												
Aviculopecten? sp						×							
Omphaloptycha? sp						×							
Entolium sp												×	
Phillipiella? sp												×	
Buchia (Aucella) crassicollis (Keyserling)										×	×		
Turbo? sp						×			×				
Fragments of gastropods and pelecypods suggesting the fauna of no. 16266			×										
Undetermined organism, spherical bodies as much as 1½ inches in diameter with granular cortex preserved in silica		×		×	×		×	×	×				
Undeterminable forms suggesting the fauna of no. 16266													×

16085. Head of the first branch of Jack Creek west of Platinum Creek.
16086. Near the head of the tributary that joins Jack Creek 1½ miles below Jack Creek Lake. This stream heads against Suslota Creek. See locality 16267.
16259. Talus near the head of the west branch of the first large stream **southwest** of Buck Creek, 10 miles east of the outlet of Suslota Lake.
16260. Northern tributary of Suslota Creek, about 5½ miles from Suslota Lake.
16261. South side of the pass between the head of Suslositna Creek and the west branch of the large creek southwest of Buck Creek, 6 miles east of the head of Suslota Lake.
16262. Near locality 16261.
16263. Head of the middle fork of Platinum Creek, on the north side of the valley near the glacier.
16264. Head of the tributary of Jack Creek that lies directly south of the Bear Creek glacier (Lost Creek?). There is confusion in the use of the name Lost Creek.
16265. Near locality 16264.
16266. Near locality 16264.
16267. Near the head of the tributary that joins Jack Creek 1½ miles below Jack Creek Lake. This stream heads against Suslota Creek.
16268. Near locality 16267.

UNCONSOLIDATED DEPOSITS

The unconsolidated deposits of this district include unsorted material from the weathering of both igneous and sedimentary consolidated rocks, stream and bench gravel, and glacial deposits of various kinds. The unsorted waste is present on all slopes not too steep to hold it and in general represents the most recent product of weathering. It usually has not traveled far and is little worn. Although it represents the first state of the loose material that makes up the other classes of unconsolidated deposits and is present practically everywhere, it is not the material to be given consideration here. Stream gravel and glacial deposits, however, will receive attention. No distinction is made on the geologic map between stream and glacial deposits, for in many places no distinction can be made without detailed work. The term "stream deposit" is used for the sand and gravel of the present stream channels and flood plains. As a rule, stream gravel and bench gravel are different states of the same kind of deposit. The bench gravel in most places is stream gravel of older flood plains into which the present stream has carved a new channel at a lower level, leaving benches or terraces of the older material. In places the bench gravel is a marginal deposit formed along the edge of the glacial ice.

Glacial deposits are of many forms and represent the material transported by ice and freed from it at the time of melting. Probably most of the stream and bench deposits of this district were once glacial deposits.

Stream gravel is found on all the streams throughout the area but has its widest development on the lowlands adjacent to the Copper River, where it is in many places associated with unmodified glacial deposits. Field evidence shows that the Wrangell Mountains were once a center for ice accumulations, from which the ice moved radially in all directions. Ice filled the valley of the upper Copper River to a depth of several thousand feet and spilled out through the lower parts of the divide between the Copper and Tanana drainage basins. Cobbles of scoriaceous lava from the Wrangell Mountains are present in the gravel of the upper tributaries of the Little Tok River, and well-rounded gravel of foreign origin is found on mountain tops 2,000 feet above the Copper River lowland. Probably only the higher mountains on the Copper River side of the Suslota Pass district were above the ice surface at the time of maximum glaciation. Immense amounts of rock debris were deposited over the lowlands of the Copper River. These deposits have been reworked by streams in part and appear as stream and bench gravel, but wide areas of typical glacial deposits remain and are particularly noticeable about the heads of Tanada, Jack, and Platinum Creeks. Where the streams from the melting ice spilled over into the Little Tok drainage great quantities of gravel were deposited. The upper part of Suslositna Creek was filled practically to the level of the passes between that stream and Suslota Creek. The present stream channel is cut through this gravel deposit to bedrock and is bordered on both sides by remnants of the original gravel, which on the south side forms a continuous high terrace 2 miles long, sloping gently northeastward, toward Suslota Pass. The west end of the pass that leads east from the head of Suslositna Creek to the principal headwater tributary of the Little Tok River is marked by high terraces, which were probably formed when a stream of ice moving northward into Suslositna Creek blocked the drainage from the east and impounded the gravel. High gravel terraces similar to those on the head of Suslositna Creek are present lower on the creek, north of Suslota Lake. They, too, were probably formed by a stream flowing into the Tanana River drainage basin from the Copper River side of the divide.

The small basin into which the upper tributaries of the Little Tok River flow before uniting to form the main stream is filled with unconsolidated deposits which are in part unmodified glacial debris but are chiefly outwash gravel of glacial origin and reworked glacial material. The streams have not cut into them deeply in the central part of the basin, and bedrock exposures are lacking.

The valleys of the Little Tok River and Tuck Creek are typical glacial valleys of broad U-shaped cross section, but glacial deposits are less noticeable than on the Copper River side. Possibly the streams have had more opportunity to rework the glacial debris, and probably, as on the Copper River side, more recent stream deposits and talus material have covered the older glacial deposits in part. Many of the small streams, overloaded with waste from the rapidly weathering argillite and slate of the Mesozoic areas, have spread their burden in the form of broad, fan-shaped deposits as diminishing grade compelled them, especially where they emerge into the larger open valleys, and have buried earlier deposits, diverted streams, or modified the land surface in other ways. The headwater tributaries of Jack and Platinum Creeks have produced large deposits of this type.

IGNEOUS ROCKS

Intrusive rocks.—Igneous rocks comprise about one quarter of the rock formations, exclusive of unconsolidated deposits, shown on the geologic map. They may be considered under three classes—lava flows and tuffs, which make up most of the pre-Mesozoic rocks; intrusive masses in Mesozoic and pre-Mesozoic rocks; and post-Mesozoic volcanic rocks. The pre-Mesozoic lava flows and tuffs have been considered in connection with Permian sediments (pp. 144–148) and will not be described again further than to repeat that they form a narrow belt of metamorphosed rocks extending along the southwest side of the range from the Slana River to the Nabesna River and in places include a small proportion of sedimentary beds, mostly limestone. In a few places also they are cut by the intrusive rocks next to be considered.

The Permian volcanic rocks and the Mesozoic sediments are intruded by different kinds of igneous rocks which for the most part are coarsely granular and porphyritic. They are commonly of a light color in the hand specimen but look dark or even black when viewed from a distance, owing to the black lichens which cover them. Undoubtedly this association expresses the fact that the rock furnishes some constituent favorable to the life and growth of the lichen. The intrusive rocks in general are members of the diorite family, although granite is present, as well as other varieties more basic than the diorite. Locally the intrusive rocks are pegmatitic and show large crystals of feldspar and hornblende.

The largest area of diorite lies between Buck and Tuck Creeks. All the higher part of this mountain mass is composed of diorite, which appears to form a cap overlying or folded into the Mesozoic sediments. Diorite also forms much of the mountain south of Buck Creek and caps the mountain west of the Little Tok River. The other larger areas of dioritic rocks are on Suslositna Creek and at the head of the northern tributaries of Jack Creek. No attempt was made to map many of the dikes and sills which cut the sediments in different parts of the district.

Some of the granular intrusive rocks are altered chemically or mechanically or both, and it is evident that they have taken part in at least some of the folding which the district has undergone. It is evident also that the intrusion of the diorite altered the host rock, producing features like schistosity and introducing or forming by chemical changes new minerals not present originally. One interesting phase of the diorite is a porphyritic form that occurs along the north side of the area south of Tuck Creek. This rock has a light-gray granular groundmass which contains vast numbers of large crystals of orthoclase feldspar. Each crystal, apparently a single individual, is made up of two crystals joined together in the form known to petrographers as a carlsbad twin. These twins are of nearly equal dimensions in one plane and are about half as thick as long. They range from less than an inch to more than 2 inches in greatest diameter.

Practically no sedimentary rocks are included in the area north of Buck Creek mapped as intrusive rocks, but the rocks on the south side of its valley appear to comprise numerous sills or irregular bodies of diorite intruded into the argillite that forms most of the mountain and the area to the south, and the boundaries shown on the map merely indicate that those areas are made up dominantly of the intrusive rocks. Although the intrusive rocks are largely light-colored and coarse-grained, they include phases that are of medium grain and dark color and are without phenocrysts.

The intrusive rocks near the head of Jack Creek include several irregular masses of no great extent, as is shown on the geologic map. Dikes and sills, however, are numerous and probably have played a part in the mineralization of the argillite beds in that vicinity. Here, as well as at White Mountain, and elsewhere in the upper Nabesna River Valley, they have brought about marked changes in the composition and appearance of the intruded rocks, especially the limestone beds—changes which include leaching, silicification, and the formation of new minerals.

Little evidence on which to base a definite age determination for the granitic intrusive rocks was discovered during the course of the summer's work. From the degree of alteration, it seems probable that some of the intrusive masses in the Permian rocks are earlier than Upper Triassic or older than the oldest of the known Mesozoic sediments. Others, because of lesser alteration and also because of their lithologic similarity to the intrusive bodies that cut the Mesozoic sediments, are believed to be younger. Most of these intrusive rocks are probably of Cretaceous or later age, as they appear to cut all the sediments that are thought to be of Mesozoic age. It is possible that some of the intrusive bodies in the Mesozoic rocks may be older than Cretaceous—that is, either Upper Triassic or Jurassic—but no evidence for or against the possibility was recognized. As the results of field observation in many parts of the Alaska Range accumulate, it becomes more and more evident that the time which includes the late Mesozoic or early Tertiary period was a time of widespread intrusion of acidic rocks into the Mesozoic and older rocks. It therefore seems probable that most of the coarse-grained granitic and dioritic intrusive rocks shown on plate 2 are either of late Cretaceous or of early Tertiary age.

Tertiary and recent lava flows.—Lava flows which occur at the margin of the Wrangell Mountain area are the youngest rocks so far recognized in the district. These flows are gray vesicular basalts, commonly iron-stained and having the vesicles filled with quartz or other material. In places tuffaceous beds are present. They form most of the mountains west of Jack Creek and cap the north end of the mountain between Jack and Totschunda Creeks. The younger lava flows of White Mountain form the top of the mountain and rest on older lava flows above the limestone. From that point they slope gently north or north and east to the level of Jack Creek. In the mountain east of Lost Creek the base of the younger lavas is about 800 feet above the stream. Remnants of the younger lavas are found in the lowlands north of Jack Creek Lake. It is evident that the valley of Jack Creek is cut through the younger volcanic rocks into the older volcanic rocks and the limestone.

Outpourings of amygdaloidal basalt began in the Wrangell region some time after the Cretaceous sediments had been deposited, elevated, and subjected to a period of erosion and have continued practically to the present time. These lavas accumulated to a depth of several thousand feet over an area of many hundreds of square miles. Their sources may have been somewhat centralized, yet the flows probably came to the surface in large part through an intricate system of fissures rather than through a central vent. Without doubt other vents than that of the present Mount Wrangell have existed at different times. Mount Drum and Mount Sanford are such vents.

The age of the younger lavas that are exposed in the vicinity of Jack Creek was not determined from evidence collected during the summer but from the field work of previous years. These lavas are correlated with flows of like character which make up a large part of the Wrangell Mountains and are well exposed on the north side of the Chitina Valley. In the Skolai Basin, at the head of the Nizina River, they overlie Cretaceous and older rocks unconformably and accumulated to a thickness of many thousands of feet on an old land surface. In a few places thin deposits of fresh-water sediments containing plant remains were found beneath the flows, and on the basis of this evidence the beds were assigned to the Eocene. The late period of volcanic activity in the Wrangell Mountains began in Eocene time and has continued with interruptions to Recent time. The age of the younger volcanic rocks can therefore be determined within much narrower limits than that of the intrusive rocks.

MINERAL RESOURCES

That part of the Alaska Range proper which has been described above has never been fully prospected, but the area shown on the geologic map contains one gold mine, in the Wrangell Mountains, which came into production in 1931. Although the area between the Slana and Nabesna Rivers is now without mines, evidence of mineralization is present, and a little prospecting has been done, the signs of which are chiefly in abandoned tools, old cuttings, and a few ruined cabins. Several shafts were sunk, as on Moose Creek, a tributary of Tuck Creek, in an attempt to reach bedrock and find placer gold. The search for lode deposits was not neglected, and the country at the head of Jack and Platinum Creeks received particular attention. An application for patent of one property was made but was not carried through because of the outbreak of the war. In 1931, prospecting for placer gold was done on the tributary of Jack Creek that heads against Suslota Creek, and a group of claims was staked. Prospects were found in the surface gravel, but no development work was done in the summer, and it was the intention of the owners to sink holes during the coming winter to determine the value of the claims.

The success of the Nabesna Mining Corporation in its work on the Nabesna River, together with easier access resulting from the construction of the highway, stimulated interest in the district and brought in several men with supplies and the intention to prospect during the winter and coming summer.

Gold lode of the Nabesna Mining Corporation.—Only one productive mining property is situated in the district under consideration. This property is a gold mine 5 miles west of the Nabesna River on White Mountain, between Jacksina and Jack Creeks, which belongs to the Nabesna Mining Corporation. A wagon road leads from Jack Creek to the mine, and a summer trail, suitable only for pack horses, connects it with the aviation field at Brown's homestead on the Nabesna Bar. The mine is between 1,700 and 1,800 feet higher than the bars of the Nabesna River and 1,000 feet above the mill and camp that have been built at the foot of the steep mountain slope. It is less than half a mile east of the old gold property of the Royal Development Co.,[11] on which a small mill was installed and a little mining was done in 1906.

The ore body was discovered by Carl Whitham, for many years a prospector and miner in the district, who organized a company with local capital and finished the installation of the mill and tram in time to begin mining operations in July 1931.

The east side of White Mountain shows at least 1,000 feet of bluish-gray limestone overlain by over 500 feet of thin-bedded impure limestone, which in turn is overlain by lava flows. The lava flows appear to be of two periods—probably the older Permian volcanic rocks and the more recent flows from the Wrangell Mountains. The volcanic rocks have no known connection with the deposition of the gold.

The limestone in the vicinity of the mine is not strongly folded but is faulted and intruded by large irregular masses of diorite which locally have altered it profoundly. This alteration is most marked in the thin-bedded limestones, where it resulted in extensive silicification and garnetization. Garnet was also formed in the massive limestone but is less abundant than magnetite in the vicinity of the mine. The massive limestone at one point near the mine also contains specular hematite and fibrous hornblende and in places is recrystallized, so that the weathered surface breaks down into coarse sand.

The ore body was formed along a nearly vertical northward-trending contact surface between diorite on the west and massive limestone on the east. The contact is not a plane surface but one of considerable irregularity. In general it trends east of north and dips high to the west. Accurate measurement of dip and strike was not attempted, however, for it was found that the presence of magnetite in many places makes the reading of compass bearings unreliable.

The discovery outcrop is on the top of a small spur extending from the main mountain toward the Nabesna River. The ore body is in the massive limestone just below the base of the overlying thin-bedded limestone, which is wholly removed from the top of the spur, on the crest of which the ore crops out and across which extends the contact between the diorite and limestone. A displacement of unknown amount took place along the contact, for the top of the

[11] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska: U.S. Geol. Survey Bull. 417, p. 58, 1910.

massive limestone appears to be elevated with reference to the thin-bedded limestone on the crest of the spur a short distance west of the fault. The contact has been traced in both directions from the discovery point on the spur through a horizontal distance of many hundred feet and is exposed for a vertical distance of at least 300 feet.

The ore body was crushed by the movement along the fault zone between the diorite and limestone, and the ore now being taken out is a mass of frozen angular quartz and country rock, which breaks like a solid rock in the tunnel and stopes but slacks down to a loose material resembling the product of an ore crusher when exposed to the warm air at the ore bin. The ore consists chiefly of pyrite, iron-stained mineralized quartz, and silicified limestone of variable thickness, possibly as much as 8 feet, as is indicated by the width of the stopes. It is brightly colored by the iron oxides and in places shows copper staining.

An open cut was made on the vein at the discovery point, and a shaft was sunk, connecting with a winding tunnel 98 feet below, which was driven from the south along the contact about 200 feet. This part of the ore body is known as the Bear vein and is developed by two stopes, from which the mill ore is taken. The tunnel extends almost to the north side of the spur but was not holed through because it is desirable to keep the warm air away from the frozen ore. A second tunnel 164 feet lower had been driven 280 feet to tap the Bear vein at a lower level but had not reached it at the time of visit.

The metallic minerals recovered from the tables in the mill are gold, lead sulphate, pyrite, a little chalcopyrite, and magnetite. Galena has not yet been found in the ore and is uncommon in the district. The silver content is low. Gypsum is one of the nonmetallic minerals contained in the gangue but is less common than garnet.

Power for drilling in the mine is furnished by a gasoline engine of 60 horsepower and a compressor capable of supplying necessary air to three drills. The mine is connected with the mill by a single-span double-wire tram 1,900 feet long, with a rise of 1,000 feet. The two buckets are operated in balance. The mill has a capacity of 35 tons a day and includes a crusher, a Hardinge ball mill, a classifier, and five tables from which is obtained a "bullion cut", containing gold and lead sulphate; a concentrate, which in 1931 was shipped out to Copper Center by airplane; a second concentrate, which was saved at the mill; and a tailings cut, which was impounded for possible further treatment at some future time. About 15 tons of ore a day of 10 hours was being treated at the time of the writer's visit, and the recovery was approximately $1,000. A process for extracting the gold from the lead sulphate cut, containing about 2 or 3 percent of lead, was installed but was not successful and therefore was given up. It will be replaced by another process in the future.

Power for the mill is furnished by a gas engine. Water for milling and camp use is brought from Cabin Creek immediately west of the mine by a wooden flume three quarters of a mile long. The supply from this source was adequate for the needs in 1931 and could be increased slightly by extending the flume, but it fails after cold weather comes and thus definitely limits the length of the operating season. An increased continuous water supply and water power for the mill and mine are among the plans contemplated for the future. A shortage of gasoline in 1931 threatened to stop operations in late summer, but this trouble was averted by an arrangement with the Gillam Airways under which gasoline was brought by airplane from Copper Center to the landing field on Nabesna Bar and concentrates were taken out on the return trip, thus greatly reducing the cost of transportation. Twenty men were employed on the property during most of the season of 1931, but this number was later reduced to 18. All supplies and equipment except those required in emergencies are brought by sled in winter, but the efficiency of this method is increased by using tractors in place of horses. The highway along Copper River from the Richardson Highway near Gulkana and the construction of the bridge across the Slana River have already been of benefit to the mine as well as to prospecting in other parts of the district, and when it is completed between the Slana and Nabesna Rivers it will still further reduce the difficulty and expense of bringing freight, mail, and men from the outside.

Placer-gold prospects.—Placer gold has not yet been produced in the Suslota Pass district. In early days gold prospects were found near Mentasta Lake, and a search for placer gold was made in the gravel of different streams in several parts of the district but with little success. Claims were staked in 1931 by N. P. Nelson and E. G. LaBell on the tributary of Jack Creek that heads against Suslota Creek. Prospects had been found in the surface gravel near the head of the stream during the summer, but no development work had been done when the locality was visited by the writer in August, although he learned later from Mr. Nelson that it was planned to sink holes in the coming winter.

The claims lie partly on the main stream and partly on an eastern tributary coming from a small glacier. As no holes had been sunk, neither the content nor the depth of the gravel was known, yet it would appear from the character of the valley and from such outcrops of country rock as can be seen near the stream that the depth of gravel on the main stream is not great and that it is considerably greater on the tributary, especially near the mouth.

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