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THE CURRY DISTRICT, ALASKA

BY

RALPH TUCK

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THE CURRY DISTRICT

By RALPH TUCK

ABSTRACT

The Curry district lies on the south flank of the Alaska Range, on the southeast side of Mount McKinley. Most of it is west of the Alaska Railroad. The eastern portion can be easily reached from several points along the railroad route, but the western portion is much more difficult of access, owing to the numerous glacial streams and the rugged topography. The relief of the area is great, the elevation ranging from 500 feet along the Chulitna River to 20,300 feet at Mount McKinley. The Chulitna River, a tributary of the Susitna River, drains the larger part of the area described. It flows in a broad valley in the eastern part of the district, and here the maximum relief is about 3,000 feet. The western part of the district is very rugged, with numerous peaks over 6,000 feet in elevation which have sheer slopes and almost unscalable pinnacles. Winding down through this maze of rugged mountains are four major valley glaciers—Eldridge, Buckskin, Ruth, and Tokichitna—and many tributary and smaller glaciers. Practically the entire district, with the exception of the higher peaks and ridges, has been glaciated. Timber grows along the main streams and extends to an elevation of 2,000 feet, but a large portion of the district lies above that elevation.

The oldest rocks consist of slate, graywacke, schist, argillite, and phyllite, with lesser amounts of chert, quartzite, limestone, conglomerate, tuff, and breccia. These rocks are divided into three groups, which range in age from Paleozoic to late Mesozoic. Tertiary sand, gravel, and clay, which contain some coal seams, are present. The Quaternary is represented by glacial and stream deposits. Intrusive into the Paleozoic and Mesozoic metamorphic rocks are granitic sills, dikes, stocks, and batholiths. These intrusives form a large part of the rock outcrops in the district and in some places extend almost unbroken from the Chulitna River to the south peak of Mount McKinley. The granite is believed to be of late Mesozoic or early Tertiary age. The regional strike of the metamorphic rocks is northeast and parallels the trend of the Alaska Range in this locality. Details of structure are in many places difficult to determine, owing to the high degree of folding in the older rocks.

The area has been but little prospected, and only one lode discovery has been made; it consists of several small gold-quartz veins on the north side of the Hidden River. These veins cut across the metamorphosed sediments, and, although they contain high-grade ore, the present exposures are too small to be of commercial value. In the vicinity are strong fissure veins that have not yet proved to contain valuable deposits, although their genetic relationship with the small veins is encouraging. Quartz veins are numerous in the sedimentary rocks at a distance of several thousand feet from the margin of the granite, but immediately adjacent to the contact the chief action of the intrusive has

been to silicify the sediments. No evidence of mineralization has been found in the granite, which is usually fresh and massive. The most favorable prospecting ground appears to be in the metamorphic rocks in the vicinity of Eldridge Glacier and the Hidden River. In the same locality there is evidence of lead and copper mineralization.

Small amounts of placer gold have been recovered from the bars of the Chulitna River, but it is extremely doubtful if in this highly glaciated area there are placers that will yield any commercial production.

The coal that occurs at several localities along the Chulitna River and its tributaries is of lignitic rank and of value only locally as fuel.

INTRODUCTION

LOCATION AND AREA

The district here described receives its name from the settlement of Curry, a division point on the Alaska Railroad and the place at which practically all its through trains stop over night. The district lies southeast of Mount McKinley (fig. 4). The part of this area which has been examined in most detail is bounded by Eldridge Glacier on the north, the divide between the Susitna and Chulitna Rivers on the east, and Tokichitna Glacier and River on the south and southwest. The divide lying east of the Chulitna River was not examined with any thoroughness in the course of the work described in this report. The district lies between latitude 62°35′ and 63° and longitude 149°40′ and 150°50′. The area studied in most detail covers about a thousand square miles.

PREVIOUS INVESTIGATIONS

The major part of the district was heretofore unmapped, and little was known of the details of the topography and drainage or of the character of the formations. A few prospectors and trappers have visited the region; but owing to its difficulty of access, the failure to locate any deposits of economic importance, and the small number of fur-bearing animals that live there, it has been but little frequented.

A large part of the surrounding country has been covered in a reconnaissance manner by members of the United States Geological Survey, and their reports have greatly facilitated the present work. The explorations and surveys in contiguous areas which have a bearing on this report and the known prospecting in the area itself are outlined below.

In 1898 G. H. Eldridge[1] made a reconnaissance of the Susitna Basin, and a part of his traverse was along the eastern edge of the area that is included in this report. In 1902 a Geological Survey

[1] Eldridge, G. H., A reconnaissance in the Sushitna Basin and adjacent territory, Alaska, in 1898: U.S. Geol. Survey 20th Ann. Rept., pt. 7, pp. 1–29, 1900.

party under the direction of Alfred H. Brooks[2] made a traverse from Cook Inlet northwestward across the Alaska Range and thence northeastward along the north side of Mount McKinley. Although

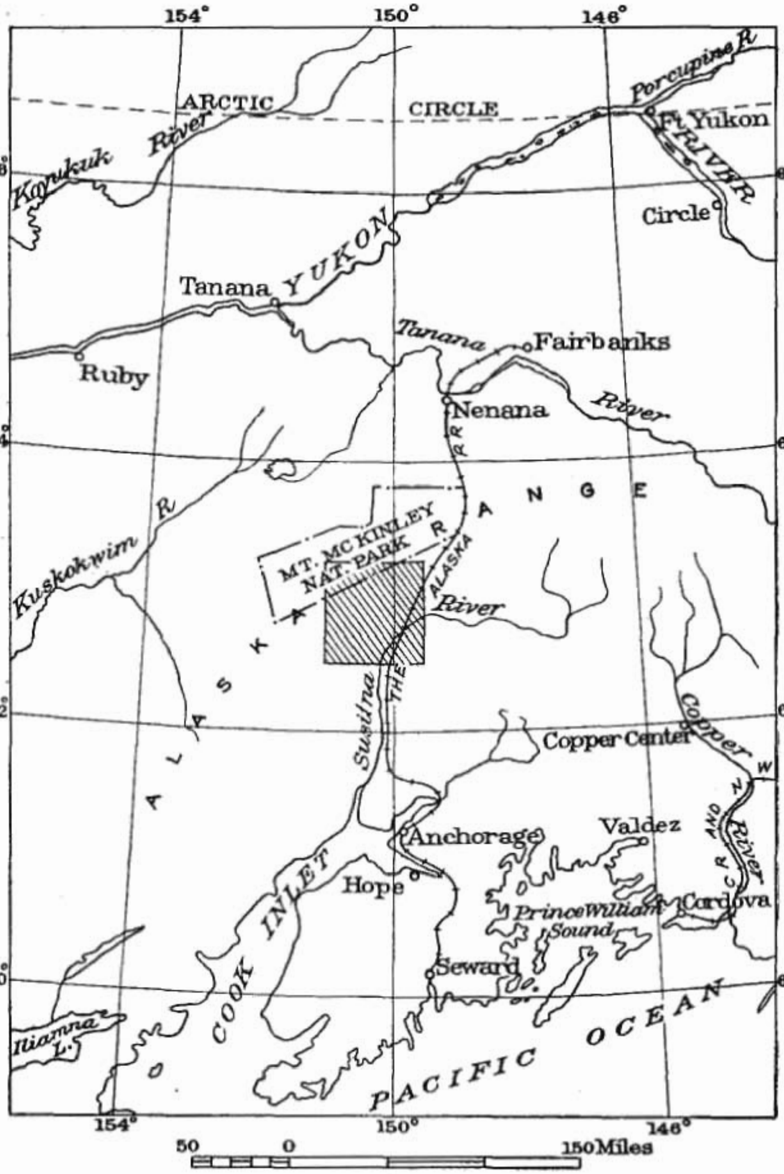

FIGURE 4.—Index map showing the location of the Curry district.

his field work did not touch the Curry district, many similar formations were encountered; his report also contains an account and sum-

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

mary of all the explorations and scientific work to that date, thereby including areas contiguous to the Curry district.

In 1906 a private expedition under the leadership of Dr. F. A. Cook[3] was organized for the purpose of climbing Mount McKinley. The attempt was made from the south side by way of Ruth Glacier. R. W. Porter, topographer of the expedition, mapped a large area, the northern portion of which borders on the area examined by the writer and includes parts of the Tokichitna and Ruth Glaciers.

In 1910 Belmore Browne[4] and Herschel Parker explored the southeast side of Mount McKinley in an attempt to climb the mountain, and their account contains some information concerning the general nature of the country, particularly in the vicinity of Ruth Glacier.

In 1911 S. R. Capps[5] made a study of the Yentna district and used parts of Porter's map as a base for some of his geologic mapping.

A prospector, Gene Bartholf, reports that in 1915 he made a prospecting trip into the southern part of the area and found some rich gold-quartz float on Whistler Creek. Later he made a number of other trips into the district.

In 1917 Capps[6] investigated the mineral resources and mapped in a reconnaissance way the upper Chulitna region, which lies adjacent to the Curry district on the northwest.

In 1929 Elmer and Roy Boedeker prospected in the vicinity of Eldridge Glacier and the Hidden River and located gold-bearing quartz veins on the north side of the river. During 1931 and 1932 they were engaged in the further development of these veins.

In 1930 Capps[7] continued the geologic mapping on the West Fork of the Chulitna and extended it across the Alaska Range into previously mapped districts on the north side.

In 1931 a prospecting party organized by Gene Bartholf traversed part of the area lying west of the Chulitna River. This party cut a large amount of trail and obtained considerable general information which greatly facilitated the mapping and geologic work during the summer of 1932.

In 1931 C. P. Ross[8] mapped in detail and reported on the mineral resources of the West Fork of the Chulitna River, which lies immediately north of the district described in this report.

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[3] Cook, F. A., To the top of the continent, New York, 1908.

[4] Browne, Belmore, The conquest of Mount McKinley, G. P. Putnam's Sons, 1913.

[5] Capps, S. R., The Yentna district, Alaska: U.S. Geol. Survey Bull. 534, 1913.

[6] Capps, S. R., Mineral resources of the upper Chulitna region: U.S. Geol. Survey Bull. 692, pp. 207–232, 1919.

[7] Capps, S. R., The eastern portion of Mount McKinley National Park: U.S. Geol. Survey Bull. 836, pp. 219–300, 1932.

[8] Ross, C. P., Mineral deposits near the West Fork of the Chulitna River: U.S. Geol. Survey Bull. 849–E, 1933.

PRESENT INVESTIGATION

The present investigation was conducted by the United States Geological Survey with funds provided by the Alaska Railroad through its special authorization to investigate the mineral resources adjacent to its route. The discovery of gold-bearing veins during the last few years in this unmapped and little-known area had aroused much interest, and there was a demand for further information regarding these discoveries and the area in general. The objects of the work were to ascertain of what importance they might be as a future source of revenue to the railroad, to map the area as an aid to prospecting, and, if possible, to delimit the more favorable portions so as to facilitate future exploration and development. To accomplish these objects a joint topographic and geologic party was formed, with C. P. McKinley as topographer and the writer as geologist. Other members of the party were E. J. FitzGerald, recorder, and C. C. Tousley, H. Sagers, and J. Waddell, camp hands. Ten horses were used for the packing of equipment and supplies, and in addition arrangements were made to have an airplane land at Spink Lake during the middle of the summer with additional supplies, as the ruggedness of the country prevented heavy packing.

The party left the Alaska Railroad at mile 276.5 June 13, 1932, and the field work started immediately. The route from that point was westward to the cable crossing of the Chulitna River near the mouth of Coal Creek, across the foot of Eldridge Glacier, and then in a general southwesterly direction across the drainage lines of the region to the foot of the Tokichitna Glacier. The Tokichitna River, which marked the western limit of the new surveys made in the course of the field work, was crossed September 5. From that point the party went up Ramsdyke Creek, thence to the Peters Creek trail and by that trail and the wagon road, reaching Talkeetna (mile 222 on the Alaska Railroad) September 10.

The topographic and geologic mapping was done in the field on a reconnaissance scale of 1: 180,000, or about 3 miles to 1 inch.

GEOGRAPHY

DRAINAGE

The Susitna River receives all the drainage of the Curry district. The drainage pattern is decidedly asymmetric, however, owing to the location of the district on the south flank of the Alaska Range. The Susitna flows across the southeastern part of the district; the Chulitna River, about 10 miles west of the Susitna, has a parallel course and joins the Susitna at the town of Talkeetna, which lies a few miles south of the district. Almost all the surface waters from the west discharge directly into the Chulitna River. The major western tributaries of the Chulitna that drain the area are, from north to south, Ohio Creek, the Fountain River, the Hidden River, the Coffee River, and the Tokichitna River with its tributaries Alder Creek and the Ruth River. All these streams have a general south and southeast course. The eastern tributaries of the Chulitna in this area are Pass Creek, Troublesome Creek, and several other small streams that head in the ridge between the Susitna and Chulitna Rivers. The Susitna and Chulitna have a south-southwesterly course, which has been determined in part by the structure of the underlying rocks.

The Chulitna River is a swift stream whose course alternates between canyon-like stretches in which it flows in a single channel between rock walls and more open stretches where the river emerges as a braided stream onto flood plains a mile or more in width. Small power boats can navigate on the Chulitna except during very low stages. As many of the tributary streams rise in glaciers, the Chulitna River carries a large amount of silt, particularly during times of high water, and is constantly shifting its course, cutting into its banks or forming bars and flood plains. On both sides of the flood plain of the Chulitna are gravel and rock walls several hundred feet high that form benches representing the floor of a broader older valley. This old valley is larger and more mature than the old valley of the Susitna and suggests that the Chulitna at one time may have been the master stream, although at present the Susitna has a greater volume of water. An explanation of this anomaly is suggested by Moffit,[9] who states that probably as a result of glacial damming the Nenana River was able to capture the headwaters of the Chulitna. At the present time the Chulitna River rises in Broad Pass, and it is probable that in preglacial time its source was at least 50 to 60 miles farther east, in Monahan Flats. The geomorphic development of the Susitna and Copper River Basins has been profoundly affected by their repeated invasion by glacial ice during Pleistocene time, and many great changes in drainage have resulted. It is possible that at some time in the past large areas of what is now the Copper River Basin drained to the Susitna River by way of the Chulitna.

The Fountain River flows 8 miles from Eldridge Glacier before joining the Chulitna River. A part of the water emerges from the base of the glacier as a fountain 3 to 10 feet in height, throwing ice and boulders as large as 6 inches in diameter. The fountain is the outlet of almost all of the Eldridge Glacier drainage, and it is constantly changing its position, sometimes breaking out on one

[9] Moffit, F. H., The Broad Pass region, Alaska: U.S. Geol. Survey Bull. 608, pp. 72–73, 1915.

side of the glacier and then on the other. Below the glacier the Fountain River flows on a treeless flood plain about 2 miles in width. On this flood plain the river is constantly changing its channel, often breaking up into a number of small streams. Partin Creek is the largest tributary of the Fountain River. It originates in several small glaciers north of Eldridge Glacier and flows through a narrow glacial valley for about 10 miles before cutting into the ice and moraine of Eldridge Glacier. Two miles before it reaches the glacier it flows into a narrow gorge with vertical walls several hundred feet in height. After reaching the glacier it flows along the north edge of the ice and finally emerges on the flood plain of the Fountain River.

The source of the Hidden River is a small lake that lies on the moraine-covered lower end of Buckskin Glacier. From the lake it cascades over the terminal moraine and follows a narrow glacial valley within which it has a shifting course upon a flood plain only a few hundred yards in width. Ten miles from the foot of the glacier the river enters a low-walled granite gorge through which it flows for several miles to join the Chulitna River a short distance below the mouth of the Fountain River. At high water lightdraft boats can be taken up the river for a few miles, to a point where the stream emerges from the granite gorge.

The Coffee River is about 20 miles in length and has its source in a number of hanging glaciers. It is similar in general features to the Hidden River except that it has a smaller volume of water.

Alder Creek, whose basin lies between that of the Coffee River and Ruth Glacier, receives part of its water from several small hanging glaciers and is about 18 miles long, joining the Tokichitna River 2 miles above its mouth. In the upper part of its course it is confined to a narrow U-shaped valley. It reaches Ruth Glacier about 12 miles from its source and flows along the north side of that glacier for about 4 miles to its terminus, at which it debouches onto the outwash plain of the glacier.

The Ruth River emerges from the moraine on the south side and near the foot of Ruth Glacier and flows turbulently for about 4 miles, to its junction with the Tokichitna.

The Tokichitna River originates at the terminus of the Tokichitna Glacier and flows 25 miles before it joins the Chulitna. In its upper course it is a swift braided stream, but 4 or 5 miles below its source the gradient becomes gentle, and the stream is sluggish and meandering and is confined to one channel. It is probable that at one time the Tokichitna flowed directly southeastward to the Chulitna, but, possibly owing to glacial damming, its course was changed, and it now enters the Chulitna by a circuitous route. The Tokichitna

River is navigable by small power boats from its mouth up to Home Lake, a distance of about 15 miles.

Each of the major streams of the district has glaciers as its source, and all are typical glacial streams in that during periods of high water they carry enormous quantities of silt and are constantly changing their channels. Periods of high water occur in the spring and summer, when with warm weather the snow and ice are rapidly melted. Heavy warm rains are also effective, and during the summer of 1932 a few hot days followed by several weeks of rain turned even the small streams into torrents and swelled the Chulitna River into a wide stream reaching from bank to bank where ordinarily there are long stretches of bars and gravel. In the fall, with the oncoming of freezing weather, the melting of the ice ceases and the volume of all the streams is lowered, a condition which lasts all winter. As a result of the extreme changes in water level, all the stream valleys are similar in that they exhibit broad flood plains on which the streams build up or cut down according to local conditions.

TOPOGRAPHY

The topographic map of this area shows a greater amount of relief than any other Alaska map of a comparable area. The Chulitna River, in the southeastern part of the area, has an elevation of 500 feet, and Mount McKinley (the highest peak in North America), in the northwest corner, has an elevation of 20,300 feet. (See pl. 1.) Within a distance of 35 miles there is thus a relief of nearly 20,000 feet.

Viewed from a distance the western part of the district is a chaotic mass of peaks and is awe-inspiring in its grandeur. Not only is the regional relief great, but even within short distances great differences in elevation are encountered. Sculptured by erosion, glaciation, and extreme changes in temperature, sheer granite walls rise from 2,000 to 4,000 feet and are surmounted by innumerable unscalable pinnacles. Unnamed peaks 5,000 to 11,000 feet high, rising 4,000 to 8,000 feet above their bases, are common; and within this maze of imposing mountains, glaciers wind downward from the culminating and dominating point, Mount McKinley (pl. 2, *B*). The topography of a large part of the area has been glacially modified, and cirques, aretes, U-shaped valleys with oversteepened slopes, and truncated spurs are common.

The eastern half of the area, including the Chulitna River, the lower parts of its tributaries, and the divide between the Susitna and Chulitna, is of a different aspect, as it was entirely overridden by the Pleistocene glaciers. The slopes are smooth and rolling and do not culminate in pinnacles, and the valleys are wide with broad flood plains. The elevation of this portion of the area ranges from 500 to 3,500 feet.

CLIMATE

The Pacific coast region of south-central Alaska is characterized by cool, moist summers and moderate winters. The annual precipitation is heavy, and the range in temperature during the entire year is small. In contrast with this climate the interior of Alaska has cold winters and dry summers, its annual rainfall is small and its yearly range in temperature great. Lying 200 miles inland from the Pacific Ocean and yet on the south side of the Alaska Range, the Curry district has a climate that is intermediate in character between these two extreme types. The rainfall is heavy but not as heavy as in the typical Pacific coast region, and in winter the Pacific Ocean has a tempering effect and the extreme low temperatures of the Yukon Valley are not encountered.

No climatic records have been made in the Curry district. The nearest point at which records have been kept is the town of Talkeetna, which is about 20 miles south of the area, at the confluence of the Susitna and Chulitna Rivers, and has an elevation of only about 400 feet. Records over several years show that Talkeetna has an average rainfall of 30.31 inches. September has the greatest monthly precipitation with an average of 5.1 inches. The mean annual temperature is 33.6° F.; July is the warmest month, with an average temperature of 57.8°, and January is the coldest, with an average of 9°. The climate of the Curry district is probably similar to that of Talkeetna except that the precipitation is greater.

During the summer of 1932, from June 19 to September 11, a total of 85 days, there were 46 days which were partly or entirely rainy, 19 days were clear, and 20 were cloudy. As 1932 was an extremely wet season throughout central Alaska, this record cannot be considered a fair average. Capps [10] reports that in the region to the south, which climatically is similar, during the summer of 1906 it rained 50 out of 110 days.

The winters are about 7 months long, extending from October to April, and the active prospecting season is limited to a season of about 4 months, from June to September. The rivers and streams are usually free of ice by the middle of May. Snow remains at the lower elevations until May, but in the higher regions there are large areas of perpetual snow. On sheltered slopes the snow line in summer is around 5,000 feet, whereas on exposed southern slopes it lies much higher. Snowstorms were encountered at elevations of 5,000 and 6,000 feet in July and August, and around Mount McKinley blizzards and snow flurries are common throughout the year. A

[10] Capps, S. R., The Yentna district, Alaska: U.S. Geol. Survey Bull. 534, p. 17, 1913.

member of the Lindley-Strom Mount McKinley expedition in 1932 states that from the time they climbed the mountain in May until they returned in July, it had snowed and drifted about 10 feet on Muldrow Glacier at an elevation of about 10,000 feet.

Most of the clear days during the open season occur in May and June. July, August, and September are usually rainy, with poor visibility and only occasional clear days. The weather is particularly unfavorable in the vicinity of the glaciers, and it is probable that locally these ice masses influence the climate, because often when the weather is bad in the vicinity of the glaciers it is good a few miles away.

ROUTES AND TRAILS

The Alaska Railroad follows the east bank of the Susitna River, and the part of the district that lies between the railroad and the Chulitna River is easily accessible. Old trapper trails can occasionally be found on the long ridge lying between the Susitna and Chulitna Rivers, but the only developed trail is a short one between Curry (mile 248.5 on the Alaska Railroad [11]) and the top of the ridge between the two rivers, a distance of 4 miles. The trail ends at a shelter or observation house called Curry Lookout. Both the shelter and the trail were built and have been maintained by the Alaska Railroad as a scenic attraction, for on clear days the lookout affords an excellent view of Mount McKinley and the Alaska Range.

The western part of the area, west of the Chulitna River, is much more difficult of access and can be reached only from the north and south. The southern point of entry is Talkeetna (mile 226.7), and the northern point is Chulitna station (mile 273.8). The route from Talkeetna is by boat across the Susitna River, where it is necessary to swim horses. From the west bank of the Susitna a road built and maintained by the Alaska Road Commission leads to the mining districts of Cache and Peters Creeks. From the Peters Creek district two routes are practicable—either up Willow Creek and down Ramadyke Creek to the Tokichitna River or up Poorman Creek and down the south slope of the Tokichitna Valley. Old trails exist on both routes. Both the Tokichitna and Ruth Rivers must be crossed in order to reach the heart of the Hidden River country, but both of these glacial streams can be forded with horses near the glaciers, except during periods of exceptionally high water. Farther downstream difficulty with soft ground may be encountered.

An alternative and more direct route than by the Peters Creek trail would be to proceed up the west bank of the Chulitna River after crossing the Susitna River at Talkeetna. No trail has been

[11] Mileage is measured from Seward, the southern terminus of the Alaska Railroad.

opened over that route, however, and it is likely that heavy brush, soft ground, and deep streams would offer considerable difficulty to its use.

The route from the north, which was followed by the Geological Survey party of 1932 and over which horses were taken without great difficulty, was to leave the railroad at mile 276.5 and follow the trail westward to the Chulitna River near the mouth of Pass Creek. The trail thence leads down the east bank of the river to a point near the mouth of Coal Creek, where there is a cable crossing. Here it is necessary to swim horses across the river, although it is reported that at some seasons of the year the stream is easily forded. From the western terminal of the cable considerable cutting has been done on a trail that leads west to the front of Eldridge Glacier. Here the Fountain River is easily forded, or it may be avoided by persons on foot, who can cross on the moraine of the glacier. Thence the trail strikes over the low ridge between the Fountain and Hidden Rivers and up the north side of the Hidden River to Swift Creek, where the Boedeker brothers have a short trail leading to their prospect. A tram at this point crosses the river, which is easily forded with horses. From the Hidden River a route to the southwest that runs transverse to the drainage is the only one that can be taken with horses. It follows a narrow belt of metamorphosed sediments that affords several low passes over divides that elsewhere are sharp granitic ridges. The Coffee River and Alder Creek are easily forded, and the route crosses the lower end of Ruth Glacier and thence leads to Talkeetna by way of the Peters Creek trail.

An alternative route from the north is to leave the Alaska Railroad at Honolulu (mile 288.7). Two miles to the south there is a bridge that crosses the Chulitna River. It is reported that from that point a trail leads to the southwest along the high bench ground on the west side of the river.

Spink Lake, 1½ miles in length, a few miles north of the Coffee River, is an ideal landing point for airplanes; from it a large part of the area can easily be reached.

Light power boats can ascend the Chulitna River, and a large part of the district can be reached in that manner. The Tokichitna River is also navigable for about 15 miles. It is probable that prospectors or trappers can reach the district more easily and cheaply by boat from Talkeetna than by any other means.

VEGETATION

As soon as the snow melts in the spring vegetation grows with remarkable rapidity at the lower elevations. Although the growing season is usually not more than 100 days in length, its shortness is compensated by the amount of daylight, as in June the days are over 20 hours long. Before the snow has entirely melted, the trees are budding and soon after it has left the ground the grass has attained a growth of several inches. Late in the summer the vegetation is so profuse along the river valleys that it is almost tropical in aspect, and considerable trail cutting is necessary in order to travel with a pack train. In places, as in the vicinity of the front of Ruth Glacier, the growth is so junglelike that four men can cut only a mile or two of trail a day.

White spruce, birch, and cottonwood grow in the well-drained areas along all the major streams and on the hillsides up to elevations of 1,800 feet. Diameters of 3 feet are attained by many of these trees. Stunted black spruce are the only trees in the poorly drained areas below timber line, and sphagnum mosses cover the muskegs and swamps. Timber does not end abruptly but merges almost imperceptibly into a zone of thickly growing alders, or, in the poorly drained parts, into willow thickets. This alder and willow zone extends up to an elevation of about 2,500 feet and is often almost impenetrable even to one on foot, so that cross-country traveling is very difficult. Because much of the area lies above timber line (see fig. 5) green alders are often the only available fuel. The so-called sweet and sour willows are not limited to areas above timber line but grow in many places along the streams. Above the upper limit of the alder and willow, only buckbrush, mosses, and heatherlike plants are found. In many places the mosses grow in dome-shaped clumps, or "niggerheads", a foot in diameter and 8 to 10 inches high.

Feed for stock is abundant throughout the summer. The commonest variety of grass is one called red top (*Calamagrostis*). It grows luxuriantly in open parks along the valley bottoms and hillsides up to elevations of 2,500 feet, and it often attains a height of 5 or 6 feet. Late in the summer, when it attains maturity and is beaten by the winds, it becomes matted, so that progress through it is slow and fatiguing. It is excellent forage from the time it appears in the spring until after the first heavy frost in the fall, although gradually decreasing in nutriment as the season progresses. Ordinarily it has acquired a sufficient growth to be of value to stock by June 10 and will sustain pack animals until the early part of September in favorable localities in the valley bottoms and on low hillsides.

In the valleys as well as up to an elevation of several thousand feet, bunch grass is abundant and of great value as horse feed. A jointed rush (*Equisetum*) and a wild vetch, locally known as "pea vine ", both of which grow chiefly on gravel bars along the rivers, also furnish excellent forage for stock.

In the northern part of the area edible berries are few, but in the southern part currants, blueberries, and cranberries are common.

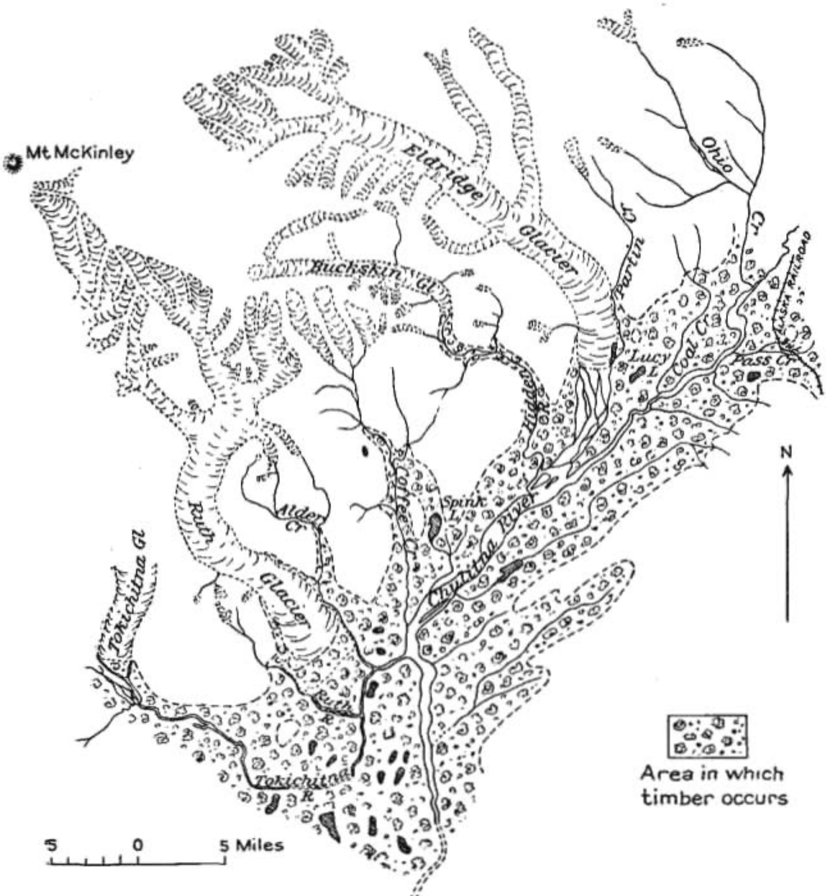


FIGURE 5.—Sketch map showing the distribution of timber in the Curry district.

GAME

There are few large game animals in the part of this area that lies west of the Chulitna River. In the northern part of the district caribou are occasionally seen, but they seldom reach the southern part. A few moose live along the Susitna and Chulitna Rivers, but they rarely travel up the western tributaries of the Chulitna. Even the brown and grizzly bears that are common in other parts of the Alaska Range are scarce here. During the summer of 1932 only four were seen by the Geological Survey party, though their tracks are common near the headwaters of the Tokichitna River, where there is a considerable run of salmon during the spawning season. No mountain sheep or goats were seen, although sheep are very abundant a few miles to the north, in Mount McKinley National Park.

Of the smaller game, beaver are especially abundant along the Chulitna River and its tributaries, the Tokichitna River, Alder Creek, the Coffee River, and the Hidden River, and many ponds show fresh beaver cutting. In fact, the beaver dams have turned almost all of the valley bottoms adjacent to these streams into countless swamps, making parts of the country almost inaccessible in the summer. Other fur-bearing animals, such as otter, mink, marten, muskrat, wolverine, and fox are present in scanty numbers in the territory adjacent to the major streams.

Game birds such as ptarmigan and grouse were found only infrequently.

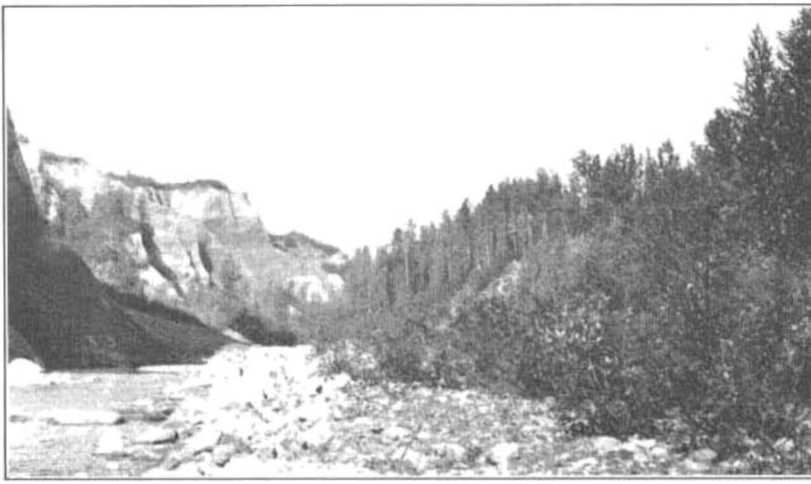
In most of the clear-water streams grayling and rainbow trout occur in small numbers. At Spink Lake, which is accessible by airplane, rainbow trout are very abundant, and many of them measure over 20 inches in length. Fish also occur in Pass, Coal, Partin, and Alder Creeks and in Lucy Lake.

Naturally, the animal life is restricted mainly to the area that supports some vegetation. The extreme western part of the district is so high that it is either covered with perpetual snow and ice, or only steep, barren rock slopes are visible.

SETTLEMENTS AND INDUSTRIES

With the exception of the stations along the railroad there are no permanent settlements in the district. The stations from which the railroad maintenance is carried on are, from south to north, Curry, Sherman, Gold Creek, and Canyon. At each of these places from two to eight men are employed, depending on the season, as in the winter no improvements can be made and only work which is directly concerned with keeping the line open is carried on. At Curry a roundhouse and hotel are maintained, as the trains from Seward to Fairbanks use that station as an overnight stop. The census of 1930 gives Curry a population of 91. In addition to the railroad employees, there are several fur farmers and a few prospectors who winter along the railroad, and these together constitute what might be called the permanent population. In the western part of the district a few men trap along the rivers in winter, but in summer there have never been more than a few prospectors at work, so that there is practically no permanent population in the portion of the district that lies west of the Chulitna River.

The nearest permanent settlement other than those maintained by the railroad is Talkeetna, which lies outside the southern limit



A. EOCENE COAL-BEARING ROCKS (ON LEFT) AND VEGETATION-COVERED MORAINE OF RUTH GLACIER (ON RIGHT).

B. RUGGED GRANITIC MOUNTAINS ON THE EAST SIDE OF MOUNT McKINLEY.

RUGGED TOPOGRAPHY ALONG ELDRIDGE GLACIER.

Typical granite slopes in left foreground; smooth slopes of slate, graywacke, and schist in middle foreground and on right.

BUCKSKIN GLACIER, WITH MOUNT McKINLEY IN THE BACKGROUND.

of the district. The census of 1930 gives Talkeetna a population of 89. It has several stores and is the railroad point of entry to the placer-mining districts of Cache and Peters Creeks.

Practically no freight is furnished to the Alaska Railroad by this district. The trapping of wild fur supports only a few men and will never be a potent factor in the settlement of the region. Several fur farms could be supported, but they also would offer only a small amount of business to the railroad, and there are many other places that are more advantageously located for such enterprises. Agriculture will probably never be important, as the tillable ground is confined to the stream bottoms and is therefore of small extent and of value only locally for gardens.

On the other hand, the district offers unusual scenic possibilities, for from a number of easily accessible places along the railroad superb views of Mount McKinley and the Alaska Range can be obtained. Opportunities also might be made for longer trips by pack train into this rugged glacier-filled country, but the scarcity of big game makes it unattractive to the hunter.

GEOLOGY

PRINCIPAL FEATURES

The areal distribution of the surface rocks and their division into lithologic units is shown on plate 1. The field work upon which this report is based was of a reconnaissance nature only, and although it is believed that the mapping of the formations is accurate within the limits of the scale used (1 inch equals 4 miles), nevertheless detailed work will no doubt make possible the more accurate mapping of the contacts of the various formations and a separation of the members of the metamorphosed sediments that have here been classified as one series into a number of separate formations.

The oldest rocks consist of thin-bedded chert, quartzite, and argillite that are exposed in only a small part of the area. Lying unconformably on these rocks is a volcanic formation composed of tuff and agglomerate, exposed only in the northern part of the area. Later another series of sediments, now exposed as chiefly slate, graywacke, and schist, was deposited, and all the rocks were folded, faulted, and changed to their present highly metamorphosed condition. Subsequent to the regional metamorphism, or as its last phase, the district was invaded by a granitic batholith that now occupies its greater part. This igneous intrustion further altered the metamorphic rocks and along its margin sent acidic dikes and sills ramifying into the surrounding sediments. The last phase of igneous activity was the intrusion of a few basic dikes that cut the granite as well as the metamorphosed sediments. The formation of the ore deposits in the district was probably associated with the granitic intrusion, in that the vein minerals were brought in by the granite magma and were liberated during its crystallization.

The intrusion of the granite batholith was followed by a long period of erosion, in which a topography with a general similarity to that of today was carved into the metamorphosed sediments and granite. At the end of this period much of the region, particularly what are now the valleys, was a low-lying region close to sea level, with many swamps. In this low region vegetation grew rank for long periods of time. Then followed periods of rapid deposition which resulted in the covering of the vegetation by clay, sand, and gravel. This cycle recurred several times, as is indicated by the different coal seams, separated by deposits of clay, sand, or gravel. After the deposition of the coal-bearing rocks was completed a sheet of gravel many hundreds of feet thick completely covered the coal series. At the end of this period of active sedimentation an uplift of the land mass slightly tilted the coal-bearing rocks and rejuvenated the streams, which once more began to erode actively. After a long period of erosion climatic changes resulted in the accumulation of large amounts of ice at several centers in the higher parts of the Alaska Range. From these centers the ice moved down the valleys and modified the earlier stream-carved topography. Still later, with a return to milder climatic conditions, the glaciers retreated, leaving behind morainal material liberated by the melting ice. Most of the morainal material has since been removed by erosion, but a great thickness of glacial outwash gravel remains in the valleys in the form of well-defined terraces. Still more recently the present streams have been engaged in transporting and depositing silt, sand, and gravel. Many of these recent deposits, as well as the glacial deposits, are too small to be shown on the accompanying map.

In this report formation names have not been given to the various rock groups, as the data as to their age, subdivision, and correlation are incomplete; instead they are here separated into divisions based on rock types and stratigraphic relations.

SEDIMENTARY ROCKS

PRE-PERMIAN (?) QUARTZITE, CHERT, AND ARGILLITE

Distribution and character.—The oldest rocks that have been recognized in the Curry district occur in its northeastern part in the vicinity of the front of Eldridge Glacier, from which they extend northeastward for several miles. They are also present on the west side of the lower end of the glacier, and they form the walls of the steep gorge that Partin Creek cuts before reaching Eldridge Glacier, as well as the prominent ridge that separates Partin Creek from the headwaters of Coal Creek. South of the front of Eldridge Glacier these rocks are not exposed, and if they are present there they underlie the silt, sand, and gravel in the valleys of the Fountain and Chulitna Rivers.

Most of these rocks are dark gray to black on fresh surfaces. Weathered surfaces are sometimes light gray, but more commonly a rusty red-brown, owing to the alteration of the disseminated pyrite that they contain. In many places the beds range in thickness from 1 to 12 inches and so give the outcrops a banded appearance. Fine-grained quartzite, chert, and cherty argillite constitute the major parts of the series. In a few places tuff and small bodies of massive serpentinized rock are interbedded, the serpentinized rocks possibly having been derived from the metamorphism of impure sediments or bzsic igneous rocks. All the rocks are highly metamorphosed, and parts of them show a great deal of silicification. In addition to containing disseminated pyrite, they are cut by numerous small veinlets carrying quartz, sericite, and pyrite, sericite in small oriented flakes being a common accessory constituent of the quartzite. Most of the cherts also contain sericite and considerable kaolin. The argillite usually includes large amounts of carbonaceous material. Basic dikes that occur in places are difficult to distinguish in the field from the metamorphosed sediments and are usually composed predominantly of andesine, which is highly altered, and chlorite, which has probably been derived from a pyroxene mineral.

Structure and thickness.—Locally the strike of these rocks ranges from north to east, but the average or regional trend is about N. 25°-30° E. Their dip also varies greatly, ranging from 45° either northwest or southeast to vertical. Repeated close folds are the most common type of structure, and their intricate character, the absence of recognizable horizons, and the lack of time prevented the working out in detail of any of them. Many of the rocks have well-developed cleavage that parallels the bedding. Only minor faults were observed; but as the beds are intensely folded, it is probable that faults with large displacements are present.

The thickness of this group of rocks is not definitely known, as neither the base nor the top of the series was recognized. Outcrops along Eldridge Glacier indicate a thickness of 5,000 feet, but inasmuch as close folding and faulting have resulted in a repetition of beds this figure may be excessive.

Age and correlation.—Early Tertiary (Eocene) deposits that occur nearby are almost flat-lying and are but slightly consolidated, and the interbedded coal is only of lignitic rank; so that it is apparent that these highly metamorphosed sediments at the base of

Eldridge Glacier are much older than the Tertiary. No exposure of the actual contact of this formation with the slate, graywacke, and schist immediately to the west was found, and although the presence of a definite unconformity between them can only be surmised, nevertheless it is believed to be present, for the chert-quartzite series is lithologically dissimilar to the slate, graywacke, and schist group and has suffered a greater degree of folding and metamorphism.

During the present investigation a few fossils were collected from a calcareous shale on a small eastern tributary of Partin Creek that heads against Little Shotgun Creek. J. B. Reeside, Jr., identified the material as follows:

Pecten sp.
Cardinia sp.
Arniotites, several species.
Fragmentary ammonites, undetermined.

He states that "This fauna has never been adequately studied, and few names can be given to the species. There is no doubt, however, that it is of early Jurassic age (lower Liassic)." The fossiliferous shale at this locality is conformably overlain by shaly slate and underlain by agglomerate and red tuff. In turn the agglomerate and tuff are underlain by the chert, quartzite, and argillite, so that apparently the latter are of pre-Jurassic age.

Immediately north of the area where these rocks occur, Ross [12] found on Ohio Creek a formation that from his description is in general similar to that here under discussion, except that it has considerable calcareous material with the cherty rocks. It is not definitely established that these formations are continuous; in the Curry district this formation has been traced from Eldridge Glacier several miles up Partin Creek, and the formation described by Ross was traced southward to a point near the mouth of Shotgun Creek, thus leaving a gap of about 8 miles. The probability that the rocks continue through this unmapped area is apparent, as they occur on the same strike. On the West Fork of the Chulitna River the overlying Permian beds rest with angular unconformity on these calcareous and cherty rocks; hence Ross considers them pre-Permian and, owing to their lithologic similarity to fossiliferous Devonian limestones in the Broad Pass district, probably Devonian. Capps [13] in an earlier report calls the same rocks pre-Triassic, as overlying rocks contain Triassic fossils.

The evidence in the Curry district itself indicates a pre-Jurrassic age for these metamorphosed sediments, and tentative correlation

[12] Ross, C. P., Mineral deposits near the West Fork of the Chulitna River: U.S. Geol. Survey Bull. 849–E, 1933.

[13] Capps, S. R., Mineral resources of the upper Chulitna region: U.S. Geol. Survey Bull. 692, p. 216, 1919.

with formations exposed north of the district suggests that they are pre-Permian.

PERMIAN(?) TUFF AND AGGLOMERATE

Distribution and character.—A few exposures of volcanic rocks occur in a narrow band on a small northeastern tributary of Partin Creek that heads against Little Shotgun Creek. No other exposures of this formation were recognized in the district, and although it is probable that they may occur farther up Partin Creek, the field work was not carried beyond the locality mentioned. These volcanic rocks consist of varicolored breccias or agglomerates made up chiefly of angular fragments of fine-grained igneous rock with a tuffaceous matrix. Interbedded with and locally grading into the agglomerates are beds that are composed entirely of red tuff. The exposures at this locality suggest a distinct formation, largely of volcanic origin, although the presence of a few shaly members indicates that a part of it may have been waterlaid.

Structure and thickness.—The few exposures show but little structure, as both the agglomerates and the tuffs are massive. At one locality the bedding strikes northeast and dips steeply to the northwest—an altitude that conforms in general with that of the overlying formation, which is predominantly shale. The thickness of the volcanic formation at this locality is about 300 feet.

Age and correlation.—The volcanic rocks overlie the quartzite, chert, and argillite series that has tentatively been referred to as pre-Permian. Overlying the agglomerate and tuff are calcareous shales that contain Lower Jurassic fossils, so that it is evident the volcanic rocks are older than Lower Jurassic. Similar formations a few miles to the north have been mapped by Capps,[14] who has referred to them as Triassic or pre-Triassic. Later and more detailed work by Ross[15] proves that at least a part of the volcanic rocks are of Permian age, so that it appears probable that the agglomerates and tuffs on Partin Creek are Permian.

MESOZOIC ROCKS

Distribution and character.—A thick group of sedimentary rocks, predominantly slate and graywacke but with intermediate and more highly metamorphosed phases, has a wide distribution within this district. (See pl. 1.) It is quite possible that this group is composed of several formations, but data for subdivision are lacking. They extend from the north and the northeast side of the area to

[14] Capps, S. R., Mineral resources of the upper Chulitna region: U.S. Geol. Survey Bull. 692, pp. 215–217, 1919.

[15] Ross, C. P., Mineral deposits near the West Fork of the Chulitna River: U.S. Geol. Survey Bull. 849–E, 1933.

the southern margin and also underlie a large part of the Chulitna Valley. Farther west they occur in a northeastward-striking belt that is almost entirely surrounded by granite. This belt is nearly continuous from the Yentna district, where it was previously mapped, to the upper Chulitna region, where it has also been recognized. The major part of the moraine of Eldridge Glacier is composed of these rocks, suggesting that the greater part of the Eldridge Glacier basin is underlain by them. The moraine of Buckskin Glacier consists mainly of granitic debris, but one long moraine ridge of slate and graywacke fragments extends for 15 miles up the glacier, indicating that an isolated mass of metamorphosed sedimentary rocks occurs in the granite near the base of Mount McKinley. Although this series of rocks forms a large part of the Alaska Range and of south-central Alaska, its stratigraphic limits are only imperfectly known. Its character is so uniform and beds that can be traced continuously over considerable distances are so rare that it is exceedingly difficult to work out the structural details. Moreover, fossils are almost lacking, so that the age limits of the group are still obscure.

The rocks of this sedimentary series include a wide range of metamorphic materials that originally were shale and impure sandstone. Regional metamorphism, as well as contact metamorphism due to the intrusion of granite has changed them to slate, argillite, phyllite, schistose graywacke and arkose, and a wide variety of schists. Definite evidence, either lithologic or paleontologic, that would justify the subdivision of the series is lacking, and on plate 1 all the metamorphosed sediments are mapped as a unit. However, on the basis of their distribution and their megascopic and microscopic differences, it is simpler here to discuss them as two subdivisions. One extends from Ruth Glacier northeastward to Eldridge Glacier and forms the western portion of the metamorphosed sedimentary group. This part consists predominantly of schist, phyllite, argillite, slate, and graywacke. Thin beds of limestone, conglomerate, serpentine, and quartzite are interbedded in places, particularly in the vicinity of Eldridge Glacier. Most of the rocks are fine to medium grained and dark gray to black. They weather into smooth slopes composed of small shaly fragments, although beds of graywacke, which are subordinate in amount to the other types, are more resistant. This series is easily distinguishable, even at a distance, from the intrusive granite, which is cream-colored and on weathering forms a rough, precipitous topography. (See pl. 3.) In some places the series is thin-bedded, and in others it is massive. Cleavage and schistosity may or may not be well developed and where present are usually parallel to the bedding.

As determined by microscopic study, andalusite, cordierite, biotite, sericite, and hornblende schists are abundant, particularly near the granite contacts. Quartz, feldspar, and kaolin are also abundant, with lesser amounts of chlorite, epidote and magnetite. In places along the western margin of this band of sediments, where they are very argillaceous, and immediately adjacent to the granite contact, there is a well-defined belt of andalusite schist. This schist contains disseminated phenocrysts of andalusite and chiastolite as much as an inch in length and a quarter of an inch in diameter. Carbonaceous material is present in many of the rocks, and some of the slates and graywackes are slightly calcareous. Under the microscope almost all the rocks have a well-defined schistosity, with a parallel orientation of the component minerals, although in the hand specimens this schistose character is not always evident, owing to the fineness of the grain.

A typical section of the metamorphosed sediments in the northern part of the area is shown by good exposures on the north side of Buckskin Glacier.

Section of rocks on north side of Buckskin Glacier 1 mile west of terminus

	Feet
Fine-grained dark-gray slate	500
Graywacke, sheared conglomerate, and quartzite	80
Thin-bedded shaly sericite schist with small lenses of serpentine	350
Fine-grained black phyllite	200
Fine-grained black andalusite schist	150

All these beds are conformable, with a dip of 50°–70°SE. The andalusite schist is in direct contact with the intrusive granite, and the two grade into each other.

At the contact with the granite the sediments are as a rule highly metamorphosed into a dense silicified rock that contains a fine-grained mass of quartz, biotite, muscovite, andalusite, cordierite, and garnet. Medium-grained biotite and hornblende schists border the granite, and in places there is a thickness of several inches of biotite flakes at the margin of the granite.

Quartz veins occurring both as tiny veinlets and also as large fissure veins are found throughout the series. Many of the veins contain small amounts of pyrite, chalcopyrite, and free gold. As a rule the veins are larger and better defined 1,000 feet or so away from the granite than at the contact, as immediately adjacent to the intrusive the chief action of the granite has been to silicify the sediments.

The other subdivision of the metamorphosed sediments occurs just south of the front of Ruth Glacier and is a continuation of at least a part of the slate and graywacke of the Yentna district. These rocks are also exposed along the Chulitna River in the vicinity of Pass Creek and Chulitna Butte, and they border the granite mass that lies between the Susitna and Chulitna Rivers. They are dark gray and fine to medium grained. Sheared graywacke and arkose with lesser amounts of slate form the predominant rock types. Microscopically they are composed of subangular grains of quartz and feldspar and small fragments of quartzite, argillite, and fine-grained igneous rocks. The groundmass usually contains kaolin and sericite, with but little carbonaceous material. The rocks south of the front of Ruth Glacier have in many places disseminated pyrite crystals half an inch across, and on weathered surfaces only the cavity and iron stain are left by the oxidation of the pyrite. The bedding is difficult to determine, as in the vicinity of Pass Creek the rocks are massive, and farther south they are highly sheared.

The metamorphosed sediments, in addition to being intruded by the granite, are cut by both acidic and basic dikes. As a result of the small scale of the map no attempt has been made to map the dikes separately, and they have been included with the sediments.

Structure and thickness.—All the metamorphosed sediments are highly folded. The strike of the beds ranges from east to north but is usually about N. 45° E., paralleling the trend of the Alaska Range. The dip ranges from vertical to 20°, either to the northwest or to the southeast. At the headwaters of Alder and Whistler Creeks the rocks dip northwest. In the vicinity of Buckskin Glacier the prevailing dip is to the southeast. On the north side of Eldridge Glacier and on the Chulitna River north of Pass Creek it is to the northwest. At many other localities there is close folding, with the beds vertical. In the district here described there is probably not a regional dip; instead there are a number of folds. Structure and lithologic similarity suggest that the axis of one such anticline probably strikes across Ruth and Buckskin Glaciers. This fold was intruded by granite, which cut across the axis at an acute angle, and a remnant of the west limb is preserved at the heads of Alder and Whistler Creeks and a part of the east limb at the foot of Buckskin Glacier. South of this district Capps[16] found a great variance in the direction of dip, due to the small folds, but in general it is to the southeast. To the north Ross[17] found a general northwest dip.

Only faults of small displacement were recognized, but it is probable that with the high degree of folding large faults are present.

[16] Capps, S. R., The Yentna district, Alaska: U.S. Geol. Survey Bull. 534, pp. 26–27, 1913.

[17] Ross, C. P., Mineral deposits near the West Fork of the Chulitna River: U.S. Geol. Survey Bull. 849–E, 1933.

The uniform character of the sediments makes it difficult to detect faults as well as to decipher the major folding. Cleavage and schistosity are developed to some degree in almost all the rocks, and microscopically they are very apparent in the alinement and orientation of the rock-forming minerals.

The thickness of the series is great. At the fronts of both Whistler Glacier and Buckskin Glacier 4,000 feet of sediments are exposed without any apparent repetition. The exposures of graywacke and slate in the Chulitna Valley are not as good, but it is probable that these rocks are there at least several thousand feet thick, and as a conservative estimate it appears probable that in this district there are over 6,000 feet of metamorphosed sediments. Capps [18] believes that an estimated thickness of 3,000 feet is warranted for a similar series in the Yentna district.

Age and correlation.—The scarcity of fossils in this series is a serious handicap to any determination as to its age. Stratigraphic evidence is also inadequate. Lignitic coals of Eocene age lie unconformably on these older sediments, so that direct evidence from this district can do but little more than point to a pre-Tertiary age. During this investigation a few Lower Jurassic fossils were collected on a small tributary of Partin Creek that heads against Little Shotgun Creek. These fossils were found in a shaly slate which may be a part of the series that occurs on the Hidden River. Field work in adjacent areas affords a basis for correlation and an approximate age determination of these sediments. Similar formations have a wide distribution in south-central Alaska and have long furnished a difficult geologic problem.

In the eastern part of this district Eldridge [19] noted a series of slates along the Susitna River, but he made no statement as to their age. In the Yentna district, which lies immediately south of the Tokichitna River, Capps [20] mapped a series of highly folded slates and graywackes that continue into the Curry district. Lacking conclusive evidence, he provisionally assigned the series to the Paleozoic or Mesozoic. Capps further correlated the rocks in the Yentna district with a series that occurs in the Kichatna Valley, described by Brooks [21] as a series of slates, and on structural and stratigraphic grounds tentatively placed in the Paleozoic, although with the reservation that it was by no means impossible that they might be Mesozoic. More definite information as to the age of the slate and graywacke

[18] Capps, S. R., The Yentna district, Alaska: U.S. Geol. Survey Bull. 534, p. 27, 1913.

[19] Eldridge, G. H., A reconnaissance in the Sushitna Basin and adjacent territory in 1898: U.S. Geol. Survey 20th Ann. Rept., pt. 7, pp. 15–16, 1900.

[20] Capps, S. R., The Yentna district, Alaska: U.S. Geol. Survey Bull. 534, pp. 24–28, 1913.

[21] Brooks, A. H., The Mount McKinley region, Alaska: U.S. Geol. Survey Prof. Paper 70, pp. 67–68, 1911.

of the Yentna district was obtained by Mertie,[22] who discovered fossils of probable Upper Cretaceous age on Long Creek, a tributary of the Tokichitna River.

Directly north of this district, Capps [23] noted a group of rocks that are predominantly black argillite with minor amounts of graywacke and some fine conglomerate. His conclusion as to their age was that they are younger than a part of the Triassic and older than Eocene. During a later investigation in the same district Capps [24] collected fossils of late Jurassic or early Cretaceous age from the same rocks. Still later Ross [25] mapped the argillite as Triassic but stated that part of it might be of a later Mesozoic age. Farther north, in the Broad Pass district, a group of rocks consisting predominantly of slate, with lesser amounts of graywacke, conglomerate, and limestone, has tentatively been placed in the Jurassic by Moffit [26] and correlated with similar rocks in the Susitna Valley, Yentna and Kichatna districts, and other localities in the Alaska Range.

From the foregoing summary it is apparent that there is a large group of rocks in adjoining and nearby districts that are lithologically and structurally similar and can be traced along the strike almost without a break for at least 200 miles, from the Yentna River to the Broad Pass district, and that form one of the dominant lithologic units of the south slope of the Alaska Range. For the most part recent estimates as to the age have assigned the series to various parts of the Mesozoic (Triassic to Cretaceous). In view of the wide areal extent and varied nature of the sediments and the conflicting fossil evidence, it is doubtful if a definite period can be assigned to the entire group. Instead, it is probable that throughout the Mesozoic era the area was subjected to fluctuating conditions of sedimentation, which varied from place to place, so that there was an overlapping of formations, with the result that a large part of Mesozoic time is represented.

No direct information as to age was gained in this district other than that the series was pre-Tertiary. Mertie's discovery of Cretaceous fossils on Long Creek indicates that the slate and graywacke near the front of Ruth Glacier and along the Chulitna River are probably Cretaceous. Whether the rocks on the Hidden River are the same, or younger, or older, is not proved, so that provision-

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[22] Mertie, J. B., Jr., Platinum-bearing gold placers of the Kahiltna Valley: U.S. Geol. Survey Bull. 692, pp. 236–237, 1919.

[23] Capps, S. R., Mineral resources of the upper Chulitna region: U.S. Geol. Survey Bull. 692, pp. 217–218, 1919.

[24] Capps, S. R., The eastern portion of Mount McKinley National Park: U.S. Geol. Survey Bull. 836, pp. 260–263, 1932.

[25] Ross, C. P., Mineral deposits near the West Fork of the Chulitna River: U.S. Geol. Survey Bull. 849–E, 1933.

[26] Moffit, F. H., The Broad Pass region, Alaska: U.S. Geol. Survey Bull. 608, pp. 32–38, 1915.

ally they are assigned to the Mesozoic and are believed to belong possibly to the Jurassic or Cretaceous.

Mesozoic sediments of similar character are not confined to the areas mentioned on the south slope of the Alaska Range but are widespread throughout south-central Alaska—on Kenai Peninsula,[27] in the Turnagain-Knik River [28] and the Knik River-Matanuska River [29] districts, and in parts of the Talkeetna Mountains.[30] Moffit [31] has also suggested their correlation with a great thickness of Mesozoic beds of similar character in the Nutzotin Mountains, which form the eastern part of the Alaska Range.

EOCENE COAL-BEARING ROCKS

Distribution and character.—Deformation and a long period of erosion followed the deposition of the slate and graywacke series, as is shown by a pronounced unconformity between the highly folded metamorphic rocks and the overlying slightly indurated and almost flat coal-bearing rocks. At the time of the deposition of the coal-bearing series the topography had already acquired the major features that it now exhibits. The principal features of the Alaska Range had already been formed, and the drainage was essentially along the same lines as at present. In the Susitna and Chulitna Valleys vegetation flourished and accumulated for long periods of time, after which it was covered with sand, gravel, and clay from streams that headed back in the mountains. This cycle was repeated several times, as is indicated by the alternation of beds of coal with beds of clay, sand, and gravel.

The wide-spread deposition of the coal-bearing rocks is indicated by the outcrops and float from that formation throughout the Susitna and Chulitna Valleys. Exposures of this coal series were found in several localities in the Curry district. The largest and best exposure is south of the front of Ruth Glacier, where it forms a part of the ridge between the Ruth and Tokichitna Rivers. A few exposures occur on Alder Creek near the point where it flows along the moraine of Ruth Glacier. Farther north exposures are found along the Chulitna River in the vicinity of Little Coal Creek. It is also reported that coal occurs on Troublesome Creek, the large eastern tributary of the Chulitna opposite the front of Ruth Glacier. Float occurs at several localities along the Chulitna River and the

[27] Martin, G. C., Johnson, B. L., and Grant, U. S., Geology and mineral resources of Kenai Peninsula, Alaska: U.S. Geol. Survey Bull. 587, p. 33, 1915.

[28] Capps, S. R., The Turnagain-Knik region: U.S. Geol. Survey Bull. 642, pp. 155–161, 1916.

[29] Landes, K. K., Geology of the Knik-Matanuska district: U.S. Geol. Survey Bull. 792, pp. 56–57, 1927.

[30] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna Basins, Alaska: U.S. Geol. Survey Bull. 327, pp. 11–12, 1907.

[31] Moffit, F. H., op. cit. (Bull. 608), p. 38.

lower parts of many of its tributaries. As the float is lignitic coal, which breaks down rapidly when exposed to the weather, it is evident that the coal outcrops occur not far from the places where the float is found, and the formation is probably widespread beneath the younger gravel. A short distance beyond the eastern limit of the district several exposures occur along the Susitna River above its junction with the Chulitna. Concerning these outcrops Eldridge [32] says:

> The third coal field along the main river [Susitna], 4 to 10 miles above the Chulitna, appears to outcrop for a distance of 6 or 7 miles and is, perhaps, the exposed portion of an extensive area. The strata form bluffs 100 to 300 feet high and consist of clays and sandstones, the former predominating, with coal seams from 6 inches to 6 feet thick. There are perhaps 10 or 15 coal beds exposed in the entire length of the outcrop. Their general dip is 5° to 15° SSE. with undulations. The thickness of the series is perhaps 50 feet.

Where the writer observed these exposures they were essentially the same as those on the south side of Ruth Glacier.

No doubt at some time during the Eocene the Chulitna and Susitna Valleys and the lower parts of their tributary valleys were covered with the coal-bearing series. Subsequent erosion by these streams has resulted in the removal of a larger part of the series, so that only remnants are left in the lowlands or in protected localities.

Good exposures of the coal-bearing series are rare, for the rocks are but slightly consolidated and quickly erode to gentle slopes covered with vegetation; where clay predominates in the series, the beds stand up as bluffs. Along the south side of Ruth Glacier a good section is exposed at a place where a small creek that flows at the contact of the coal-bearing series and the moraine has cut into the coal-bearing formation. (See pl. 2, *A*.) This section shows a series of interbedded, slightly indurated layers of clay, sand, and gravel, with lenticular lignitic coal seams from a few inches to 6 feet thick. The sands are usually buff and friable, and the clays are yellow or gray and very plastic. Where the clay directly underlies the coal it is commonly rusty-colored, suggesting that it may represent the top-soil zone upon which vegetation grew, but there was no other evidence of the residual origin of the coal; instead, the lenticular nature of the lignite seams and the associated material suggests that the vegetable material may have been transported. Much of the gravel shows cross-bedding and is composed of slate, graywacke, and granite pebbles and boulders as much as 10 inches in diameter. The lignite contains carbonized fragments of bark, twigs, and limbs and breaks down quickly on exposure to weather. In the northern part of the district, along the Chulitna River, the series is represented chiefly by coaly shale beds.

[32] Eldridge, G. H., op. cit., p. 22.

Structure and thickness.—In detail the section shows lenticular beds and much cross-bedding, suggesting a rapid deposition of at least a part of the formation and fluctuating conditions of sedimentation. In places there is a suggestion that the material was deposited as the delta of a stream. Except for the cross-bedding the formation is almost horizontal or has a slight southeast dip. The greatest inclination observed was 12° SW. As a rule the series has been but little disturbed.

Near the southern edge of the moraine of Ruth Glacier about 500 feet of unconsolidated sediments are exposed. The coal-bearing portion occurs in the lower part of the section. Several hundred feet of gravel lies conformably upon the coal-bearing portion, and the conformable relations suggest that the gravel may be a part of the coal formation. Exclusive of the gravel there is a thickness of more than 300 feet of the coal-bearing series exposed in this section. At other localities throughout the Cook Inlet and Susitna region, the thickness of similar coal-bearing rocks ranges from 100 to 10,000 feet.

Age and correlation.—Geomorphic evidence in the Curry district shows that this formation has suffered considerable erosion and has been glaciated and is thus of pre-Pleistocene age. Fossil plant remains in similar rocks south of the Tokichitna River and also throughout the Chulitna and Susitna Valleys and Cook Inlet region [33] indicate an Eocene age for the coal-bearing formation; and there is every likelihood that the series in this district also is of that age.

TERTIARY GRAVEL

On the ridge between Ruth Glacier and the Tokichitna River the coal-bearing formation is overlain by coarse stream-washed gravel, which is probably a continuation of gravel deposits in the area south of the Tokichitna River, described by Capps.[34] No other exposures of this gravel were found in the district, but possibly it may continue to the north beneath a cover of younger gravel and vegetation.

The gravel consists of well-rounded pebbles and boulders as much as 10 inches in diameter. Slate, graywacke, conglomerate, and various types of igneous rocks are represented in it. The boulders are partly cemented in a plastic clay and are usually oxidized and partly decomposed. The few exposures examined show that the

[33] Capps, S. R., The Yentna district, Alaska: U.S. Geol. Survey Bull. 534, pp. 28–33, 1913; The Skwentna region, Alaska: U.S. Geol. Survey Bull. 797, pp. 86–88, 1929. Eldridge, G. H., op. cit., pp. 16–17. Brooks, A. H., The Mount McKinley region, Alaska: U.S. Geol. Survey Prof. Paper 70, pp. 94–103, 1911. Capps, S. R., Mineral resources of the upper Chulitna region: U.S. Geol. Survey Bull. 692, pp. 219–220, 1919. Martin, G. C., and others, Geology and mineral resources of Kenai Peninsula, Alaska: U.S. Geol. Survey Bull. 587, pp. 67–89, 1915.

[34] Capps, S. R., op. cit. (Bull. 534), pp. 33–36.

gravel has a thickness of at least 300 feet. A greater thickness is probable, as the boulders are found covering the ridges at much higher elevations.

So far as could be ascertained the gravel lies conformably on the coal-bearing rocks, with no time break indicated. The gravel is believed to represent an uninterrupted continuation of the sedimentation that produced the coal-bearing series. In the Bonnifield district, on the north side of the Alaska Range, Prindle [35] and Capps [36] found similar deposits of gravel overlying coal-bearing rocks of similar age.

Large granite glacial boulders, some of them 20 feet across, lie on the gravel and indicate that the gravel has been glaciated and is older than Pleistocene. Correlation with similar gravel in the Yentna district also indicates that it is Tertiary and possibly of Eocene age.

QUATERNARY DEPOSITS

GLACIAL DEPOSITS

Moraines.—True glacial deposits are not abundant in the Curry district. Terminal moraines are entirely lacking except those at the present termini of the living glaciers, and these are being removed by the glacially fed streams as rapidly as the glaciers retreat. A few lateral moraines are still preserved, a conspicuous one lying on the north side of the lower portion of Eldridge Glacier, where long parallel ridges, composed mainly of large angular boulders, rise several hundred feet above the present surface of the ice. These ridges are partly covered with vegetation and are separated from the living glacier by another more recent lateral moraine that is still bare. The hummocky character of the ridge between the Fountain and Chulitna Rivers suggests that it may be composed, at least in part, of morainal material, perhaps from a medial moraine formed by the coalescing of Eldridge Glacier with the glacier that formerly occupied the valley of the Chulitna. Similar topographic conditions exist on the lower ends of the ridges between the Fountain and Hidden Rivers, Hidden and Coffee Rivers, Coffee and Tokichitna Rivers, and Ruth and Tokichitna Rivers. It is highly probable that these areas also are paved with morainal material, but the heavy mantle of vegetation made it difficult to ascertain this fact definitely. Ground moraine is probably present in all the valleys but is overlain by later gravel and vegetation. On the Hidden and Coffee Rivers it covers the valley floor for several miles below the present fronts of the glaciers. Glacial till, con-

[35] Prindle, L. M., The Bonnifield and Kantishna regions: U.S. Geol. Survey Bull. 314, pp. 221–222, 1907.

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

sisting of boulders and clay, is present in a few localities; but for the most part, as the glaciation was of the valley type and as the district lies in an area where ice accumulation was taking place, the glacial work was erosive, and upon the retreat of the glaciers the valleys were swept clean by water from the melting ice or covered with stream-washed material.

Bench gravel.—In almost all the valleys, particularly those of the Susitna and Chulitna Rivers, large deposits of gravel are common. With the gradual retreat, by melting, of the glaciers that occupied all the valleys, a large amount of water was liberated, which reworked much of the glacial debris and deposited it as sand, gravel, and silt. This glacial outwash material, which was formed beyond the terminus of the ice, occurs as benches or terraces above the present stream levels. In some localities, as on the Chulitna River, these benches lie several hundred feet above the present river and generally slope gently toward the center of the valley and downstream.

RECENT DEPOSITS

As all the major streams have their sources in glaciers, they carry large amounts of gravel, sand, and silt and gradually deposit it downstream. This outwash material is coarsest near the glaciers, and becomes progressively finer downstream, as a result of the decrease in gradient and therefore in velocity. The Chulitna, Tokichitna, Hidden, Coffee, and Ruth Rivers all have wide flood plains, which are composed of these recent deposits of sand, gravel, and silt. Another type of recent deposits is the slide rock or talus formed from the disintegration of the rocks on steep slopes and its downward movement by gravity. These deposits are unimportant in the low country but are common and in places of considerable extent in the higher country.

IGNEOUS ROCKS

Distribution and character.—The distribution of the igneous rocks is shown on plate 1. They constitute most of the rock outcrops in the district, forming a part of the ridge east of the Chulitna River, as well as a large part of the west wall of the Chulitna Valley, and extending almost continuously to the top of Mount McKinley. The south face of the mountain is composed of granite, and the contact of this rock with the sedimentary series probably strikes between the north and south peaks, as from a distance of a few miles it is plainly evident that the north peak is composed of sedimentary rocks. In addition to these major masses of igneous rock, small isolated masses or stocks occur as intrusives into the metamorphosed sedimentary series. A few such smaller masses are found on Crystal and Cloud Creeks, on the north side of Buckskin Glacier, and on the Chulitna River at the cable crossing near the mouth of Coal Creek.

In detail the margin of the intrusive igneous rock is not always as smooth as it is depicted on the geologic map; instead it is in places very irregular, with dikes and sills ramifying into the surrounding sediments, but these smaller features cannot be shown on a map of this scale. On plate 1 the contact has been drawn at the margin of the major mass of the igneous rock. The west margin of the intrusive that forms the mass immediately west of the Chulitna River is irregular in detail yet in general follows the strike of the adjoining sedimentary rocks. Farther west the eastern margin of the main batholith that extends to Mount McKinley is comparatively straight and vertical, with but few branching dikes, and it also follows in general the strike of the intruded rock. It is highly probable that locally the intrusion has been controlled by the regional structure of the metamorphosed sedimentary rocks. The igneous mass that forms the ridge between the Chulitna and Susitna Rivers also suggests the local structural control of the intrusion, for it follows the regional strike of the metamorphosed sediments. At other localities the intrusive rock cuts directly across the sediments.

Granite and granodiorite form the greater part of the intrusive igneous masses. Generally they are medium to coarse grained, and the individual minerals can easily be seen with the naked eye. Here and there porphyritic varieties contain feldspar crystals several inches in length. The predominance of feldspar and quartz gives the rock a light-gray to cream color. Upon weathering, which in this district is largely mechanical, owing to extreme changes in temperature, the granitic rocks break down into coarse granular sand of feldspar and quartz, with bronze-colored flakes of bleached biotite. The weathering of the granite also results in a characteristic rugged topography of sheer cliffs and pinnacles.

Microscopically the granodiorite is composed of quartz, feldspar, and biotite. In places it contains such accessory minerals as hornblende, zircon, and tourmaline. The commonest feldspar is albite, but orthoclase may also be present. Microcline is developed in places along the margin of the intrusive. Zonal growth of feldspar is common.

Although the intrusive is largely acidic—that is, it contains a high percentage of silica, as is shown by the quartz, albite, and orthoclase—there are more basic phases. On the ridge between the Coffee River and Slide Creek a basic differentiate, a diorite porphyry, is composed largely of andesine with some pyroxene that has altered to chlorite, epidote, and biotite. Small basaltic dikes cut the granite as well as the sedimentary rocks. These dikes are fine-grained and are composed of labradorite, pyroxene, and magnetite. Such secondary minerals as epidote, calcite, and chlorite are present. The acidic dike rocks and sills, offshoots of the batholith, are very abundant in the sedimentary rocks but have not been mapped separately. They are essentially of the same composition as the parent rock but are usually finer-grained.

The coarse texture of the intrusive rocks suggests that they crystallized at a considerable depth below the surface. Later erosion has stripped off much of the overlying rock, exposing the granite. The similarity in chemical composition indicates that the isolated masses of granite are connected with one another beneath the surface, and that the bands of sediments are roof pendants of the batholith and if removed would show granite underneath. There is little evidence of extensive hydrothermal alteration in the intrusive rock, though some of the feldspars are partly altered to sericite, paragonite, and kaolin by weathering.

Structure.—The intrusive igneous rocks are generally massive. In places sets of widely spaced joints have been developed, but shearing and gneissic structure are absent. The presence of vertical jointing in the granite has contributed to the development of sheer cliffs by erosion. In some localities, such as the ridge between the Coffee River and Slide Creek, a combination of vertical joints and sheeting that dips 20° S. has produced several northward-facing escarpments. Faults have not been observed, and if present they would be difficult to detect in a rock so uniform in character as the intrusive.

Age and correlation.—The precise determination of the age of the intrusives in the Curry district as well as in adjacent districts is of great economic importance, for some of these igneous rocks have been the means by which the valuable minerals have been brought into the region. Geologic work in the future may show that only intrusives of a certain age or ages have been the cause of the introduction of valuable mineral deposits, so that intrusives of a later age would be barren of valuable minerals. These facts would greatly facilitate prospecting and development work, for areas underlain by postmineral intrusives could be eliminated from consideration in the search for ore deposits.

During the present investigation definite evidence as to the age of the igneous intrusions was not found. They are intrusive into the slate, graywacke, and schist series and are thus younger, but the age of the metamorphosed sediments is not definitely known, although they may be Cretaceous in part. As the intrusives have suffered little or no deformation and even the dikes that extend from the main igneous mass are undeformed, it is apparent that the granite was intruded after the folding of the sediments had been completed, or as the very last phase of the regional metamorphism. The igneous rocks were not found to intrude the Eocene coal-bearing series. It therefore appears that they were intruded after the deposition and folding of the metamorphosed sediments and before the deposition of the coal-bearing series and thus may be of late Mesozoic or early Eocene age.

Correlation with similar intrusives in adjacent districts throws some light on the age of the intrusives in this district. Rocks of granitic character form a large part of the Alaska Range, extending from Iliamna Lake to and beyond Broad Pass and making up the major part of the Talkeetna Mountains. In all of this area the intrusive rocks are similar to those in this district—that is, they are predominantly acidic, with granite and granodiorite prevailing. Whether or not they all represent parts of the same intrusion has not been determined, but they are evidently from a common underlying source.

In the past determinations of the age of the granites of the Alaska Range and of south-central Alaska have usually been based on correlation with similar intrusives in the eastern part of the Talkeetna Mountains and in the Iliamna district. In the Talkeetna Mountains [37] quartz diorite intrudes lower Middle Jurassic formations, and granitic material is abundant in Upper Jurassic conglomerates; hence it is inferred that the intrusions are of Middle to Upper Jurassic age. In the Iliamna district [38] granitic rocks cut Lower Jurassic rocks but are not known to intrude Middle Jurassic formations. Furthermore, the Upper Jurassic conglomerates contain granitic material, and the conclusion is that at least some of the granitic rocks are Lower or Middle Jurassic. As a result of these determinations it has generally been assumed that a large part of the intrusions of the Alaska Range and south-central Alaska are Jurassic. Later work, however, indicates that at least a part of the intrusions are younger.

South of the Tokichitna River Capps [39] found granitic rocks that can be traced into this district. The evidence in that area indicates that the granites are later than the period of metamorphism of the sediments they intrude and are older than the coal-bearing Tertiary beds. With this evidence, and on the basis of correlation with similar intrusives in the Iliamna and Talkeetna regions, Capps provisionally assigned the granites to the Lower or Middle Jurassic.

[37] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna Basins, Alaska: U.S. Geol. Survey Bull. 327, pp. 19–20, 1907.

[38] Martin, G. C., and Katz, F. J., A geologic reconnaissance of the Iliamna region, Alaska: U.S. Geol. Survey Bull. 485, pp. 74–77, 1912.

[39] Capps, S. R., The Yentna district, Alaska: U.S. Geol. Survey Bull. 534, pp. 45–47, 1913.

At a later date, in the Skwentna region, which lies directly south of the Yentna district, Capps [40] found a continuation of the granites. There they intrude formations that contain plant remains of late Upper Cretaceous or early Eocene age, and inasmuch as they do not intrude the coal-bearing series he concluded that they are probably late Cretaceous or early Eocene.

Brooks [41] mapped similar granites on the north slopes of Mounts McKinley, Foraker, and Russell. He states that the granites of the Alaska Range are in part Middle Jurassic but suggests the possibility of an Upper Cretaceous age. The granites forming parts of Mounts McKinley, Foraker, and Russell are probably a part of the same granitic batholith that occurs in the Curry, Yentna, and Skwentna regions, as the granite strikes uninterruptedly across the range.

On the east side of Broad Pass Moffit and Pogue [42] mapped many of the granites as Tertiary, inasmuch as they intrude Eocene sediments. They also recognized the possibility of a succession of intrusions ranging from Jurassic on into the Tertiary. In the area drained by the West Fork of the Chulitna both Capps [43] and Ross [44] recognized the possibility of a Tertiary age for some of the granite intrusions. Capps [45] believes that many of the granitic rocks in the eastern part of Mount McKinley National Park are Eocene, inasmuch as they cut the Cantwell formation, which is believed to be early Eocene.

The more recent work on the slate and graywacke series has indicated that parts of it are probably Cretaceous. It is apparent that, if this determination is correct, much of the granite of the Alaska Range is late Cretaceous or early Eocene. The granite that forms the ridge between the Susitna and Chulitna Rivers may be of the same period, and the lithologic similarity of the batholith of the Talkeetna Mountains further suggests that it also may be late Mesozoic or early Tertiary.

INFLUENCE OF ROCK TYPE ON TOPOGRAPHY

Although the topography has been modified by active glaciation, the underlying rock has had a profound influence on the detail of the

[40] Capps, S. R., The Skwentna region, Alaska: U.S. Geol. Survey Bull. 797, pp. 88–90, 1929.

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

[42] Moffit, F. H., and Pogue, J. E., The Broad Pass region, Alaska: U.S. Geol. Survey Bull. 608, p. 59, 1915.

[43] Capps, S. R., Mineral resources of the upper Chulitna region: U.S. Geol. Survey Bull. 692, pp. 220–221, 1919.

[44] Ross, C. P., Mineral deposits near the West Fork of the Chulitna River: U.S. Geol. Survey Bull. 849–E, 1933.

[45] Capps, S. R., The eastern portion of Mount McKinley National Park: U.S. Geol. Survey Bull. 836, pp. 284–286, 1932.

surface features. The rocks that crop out in the district can be divided into two broad classes—granite and metamorphosed sediments. Almost invariably the granitic areas show pointed peaks, sheer slopes, sharp divides, and pinnacles on the slopes and summits. In contrast the areas underlain by the metamorphosed sediments exhibit smoother and less precipitous slopes and summits and broad, low divides. This is largely a result of the relative difference in resistance that the granite and sediments offer to weathering and erosion. (See pl. 3.)

This topographic expression of the rock type greatly facilitates the geologic mapping and prospecting, as from a high point the contact between the granite and the sediments can be followed with the eye for miles. In addition to the difference in topography, the granite is cream-colored and the sediments are gray to black; and as the area is largely above timber line and therefore has little vegetation, this color difference greatly aids any reconnaissance mapping.

At lower elevations the surface expression of the type of rock has been modified to a greater extent by glaciation. The parts of the granitic slopes that have been overridden by the glaciers have been smoothed off and, where overgrown with vegetation, resemble the slopes underlain by the metamorphosed sediments. The ridge lying between the Susitna and Chulitna Rivers is partly granite, yet it exhibits smooth features, for, lying between elevations of 2,000 and 3,000 feet, it was completely covered by ice and therefore severely glaciated.

GLACIATION

HISTORY

Climatic changes during Pleistocene time that included an increased annual snowfall caused the gradual accumulation of ice in the Alaska Range. As this ice increased in thickness to thousands of feet, it took the paths of least resistance—the then existing valleys—and slowly moved down them. As the ice flowed, it picked up rock fragments, and with these as tools it ground and eroded the country over which it moved. Thus many ice tongues, moving down separate tributary valleys, coalesced in the main valleys and so formed great, many-branching ice streams. The glacier that moved down the Chulitna Valley was joined by ice masses from Eldridge, Hidden River, Coffee River, Ruth, and Tokichitna Glaciers. Ultimately the Chulitna ice stream joined a similar one in the Susitna Valley at the present site of Talkeetna and formed a single mighty ice tongue that moved down into Cook Inlet. At places the ice attained a thickness of 3,000 feet, so that the ridges and hills were covered partly or completely.

At the end of Pleistocene time another change in climate occurred, possibly brought about by a lowering of the elevation by a sinking of the land mass, a decrease in precipitation, or other causes, with the result that the ice ceased to form in excess of melting, and gradually the ice tongues retreated by melting at their fronts. As the ice had been carrying a large amount of rock debris, the melting released it as morainal material. Much of it was transported by water from the melting ice and redeposited as glacial outwash or bench gravel in the valleys. As the ice retreated the land so bared showed a topography that had been modified from the one that existed prior to glaciation. The preglacial valleys had been V-shaped in cross section, with interlocking spurs and many sharp ridges. As a result of glaciation the valleys had been straightened by the truncation of spurs and the overdeepening of the valley bottom and given a U-shaped cross section. Many of the tributary valleys were left hanging. The general effect in the lower regions was to smooth off the topography, and ridges that had been overridden now showed smooth, rolling tops. A large part of the ridge lying east of the Chulitna River had been so glaciated. Glaciation not only smoothed and polished the tops of many of the ridges but left numerous large erratics or boulders that are foreign to the country rock. In the areas of great relief, such as that lying west of the Chulitna, many of the ridges and peaks, although they were the gathering grounds for the ice that formed the glaciers, were never covered by moving ice and do not exhibit smooth, round, glaciated surfaces. Nevertheless, the ice in many places undercut and plucked these slopes, leaving sharp ridges and rounded amphitheaterlike basins (cirques).

The upper limit of glaciation depended on the thickness of ice and the height and relief of the surface and is therefore extremely variable in the Curry district. In the Susitna and Chulitna Valleys it attained elevations of 3,500 to 4,000 feet or more. West of the Chulitna River, toward the summit of the Alaska Range, it reached a much greater elevation, and on Mount McKinley it was over 19,000 feet.

PRESENT GLACIERS

All the larger glaciers in the district originate in the snow fields on or near the slopes of Mount McKinley and extend radially outward. There are four large glaciers—Eldridge, Buckskin, Ruth, and Tokichitna—and almost innumerable small tributary and hanging glaciers.

Eldridge Glacier has a length of about 35 miles and is about 2½ miles wide at its terminus. Ten miles above its lower end it forks, the main part heading to the west, near the foot of Mount McKinley, and two branches heading to the north, against the Alaska Range northeast of Mount McKinley. The lower 10 miles of the glacier is covered with moraine, and the ice is exposed only on the margins where it is cut by streams or in fissures extending through the moraine. The moraine of Eldridge Glacier differs from that of the other major glaciers in that it does not support any vegetation. This lack of vegetation suggests that in recent times glacial movement has been active, although the glacier front may not have advanced, melting at the front having kept pace with or exceeded the forward movement. No terminal moraine exists beyond the front of the glacier, and apparently the volume of water from the melting ice has been sufficient to remove the morainal material as fast as it accumulated. Old lateral moraines are found several hundred feet above the present glacier on its north side along Partin Creek, and some of them are completely covered with vegetation. They are relics of the time when Eldridge Glacier was much larger than it is at present.

Buckskin Glacier has a sinuous course of about 15 miles from a source close to the east side of Mount McKinley. (See pl. 4.) It is about a mile wide at its lower end. About 10 miles from its terminus a branch joins it at a right angle from the north and northeast, and at its head, a short distance farther west, only a low saddle separates it from the upper part of Ruth Glacier. Its lower 3 or 4 miles is covered with a moraine of cream-colored granite, from the color of which the glacier derives its name. A terminal moraine at its front is covered with vegetation, which suggests a stable condition of equilibrium at the present time. For a distance of 3 or 4 miles below the terminus the valley bottom is covered with ground moraine which the Hidden River has not yet been able to remove. It is probable that before it reached the present stable condition the glacier retreated very rapidly and so left this accumulation of ground moraine unremoved by the draining stream.

Ruth Glacier is the largest one on the southeast side of Mount McKinley. Originating near the base of the mountain, it winds its way to the southeast for a distance of about 30 miles and is 4 miles wide at its front. The lower 6 miles is covered with moraine, and of this moraine the lower 2 miles carries a thick growth of vegetation with spruce and birch 2 feet in diameter not unusual. It is thus apparent that the glacier beneath this moraine has been stagnant long enough for soil to form and trees to grow to such a size.

Tokichitna Glacier, which has already been described by Capps,[46] is formed by the union of two glaciers, the larger of which appears to head on the east side of Mount Hunter and probably also on the

[46] Capps, S. R., The Yentna district, Alaska: U.S. Geol. Survey Bull. 534, p. 42, 1913.

south slope of Mount McKinley. The lower 6 miles of the glacier is covered with moraine. Large spruce trees directly below the terminus indicate that its front is now as far advanced as it has been for many years.

The glaciers of this district have many common characteristics, but in spite of these similarities there are differences that must be due to different conditions in their respective feeding basins.

The accumulation of large amounts of moraine on the lower portions of all the major glaciers is due to two factors—(*a*) the falling of debris upon the ice and its transportation downward by slow movement at a period when the glacier is active or advancing; (*b*) in conjunction with this a melting at the front of the glacier, so that although the ice itself is advancing the front of the glacier may be retreating, stationary, or advancing more slowly than the movement of the ice. As a result of the interrelations of these two factors the amount of moraine on the different glaciers varies. Eldridge Glacier has the greatest amount, its lower 10 miles being moraine-covered, thus indicating that there has been a heavy supply of detrital material in the upper basin of the glacier.

On three of the glaciers considerable amounts of vegetation cover the moraine which overlies the ice, indicating that recently the ice front has remained nearly stationery. Eldridge Glacier has no vegetation on its moraine and so appears to have been recently more active than any of the other glaciers.

Only one glacier, Buckskin, has marked deposits of moraine below the present ice front. In view of the fact that the size of the stream as compared with the size of the valley is practically the same for all the glaciers, it is probable that Buckskin Glacier, before its recent state of stability was reached, had retreated rather rapidly for 2 or 3 miles and that the Hidden River has been unable to keep pace with it in removing the debris.

ECONOMIC GEOLOGY

None of the mineral resources of the Curry district have been developed or even thoroughly examined. The inaccessibility of parts of the district has no doubt contributed largely to this lack of development, although there are large areas that appear unfavorable for future prospecting. Undoubtedly large parts of the more accessible sections of this country were scrutinized for mineral deposits, particularly for gold placers, in that period of successive gold discoveries from 1898 to 1910, but no record of this work is known, and it is probable that the region was quickly passed by for more favorable prospecting ground.

Since 1915 eight or ten parties have prospected in the region, most of these during the last 5 years. The known mineral discoveries are few. In 1915 Gene Bartholf found some rich quartz float on the upper part of Whistler Creek. Since then several efforts to find the bedrock source from which the float came have failed. In 1929 Roy and Elmer Boedeker found gold quartz veins on the north side of the Hidden River, and since that date they have attempted to develop these veins. Other small quartz veins have been located, but superficial examination of them has failed to disclose any value worthy of note.

Owing to the small amount of actual development work that has been done, this discussion of the mineral resources will be chiefly confined to suggestions as to what appear to be the more favorable areas for lode prospecting, although in a reconnaissance examination of this type there is danger that such observations may lead to conclusions that in the light of more detailed work will require modification. It must therefore be kept in mind that many of the following statements are to be regarded as suggestive and not conclusive.

In addition to the lode prospecting, some placer prospecting has been done. There has been no notable placer production, however, and it is extremely doubtful if economically important placer concentrations occur in the district. Prospecting in the past has shown that gold exists in some of the gravel, but this gravel is very meager in extent and low in value. It is reported that some gold has been taken periodically from the bars of the Chulitna River, but that it was surficial and did not go down into the underlying sand and gravel, so that it afforded opportunity for only small operations.

LODE PROSPECTING

In a general way there are two major formations in the district—(*a*) a series of highly folded and faulted metamorphosed sediments, (*b*) phases of a granitic batholith that is intrusive into these sediments.

The granite, which underlies the greater part of the area and extends from the Chulitna River in an almost unbroken belt to Mount McKinley and also forms a part of the ridge between the Susitna and Chulitna Rivers (see pl. 1), is not known to be mineralized. Where exposed the granite, with the exception of a few joints, is invariably massive. Even minor faults are uncommon, and neither gneissic nor schistose phases were observed, all of which indicates that, in the area examined, the granite has suffered but little deformation and that structural features suitable for ore deposition are few. Moreover, little evidence of hydrothermal alteration was seen. As granites are susceptible to alteration, evidences of hydrothermal alteration would suggest the likelihood of the presence at one time of ore-bearing solutions. Pannings from the small streams draining only granitic areas ordinarily do not yield any colors of gold, whereas pannings from streams that drain areas underlain by the metamorphosed sediments usually yield a few fine colors.

All the evidence above set forth suggests that the granite in the western part of the area is in general unfavorable for prospecting. However, in view of the fact that mineral deposits occur in granite in the Talkeetna Mountains and other localities and that granitic intrusives are believed to have been the cause of mineralization in a great number of districts, the evidence so far discovered in the Curry district cannot be considered conclusive. The gold quartz veins in the Willow Creek district are in granite which is a part of the Talkeetna Mountain batholith, and although this granite shows greater deformation than that in the Curry district, there is as yet no conclusive evidence that it is of different age. The difference in the degree of deformation could be explained as a result of local conditions, for even the Tertiary coal beds adjacent to the Willow Creek district show considerable deformation, whereas the coal-bearing formations in the vicinity of Ruth Glacier, which are probably of the same age, are comparatively undisturbed.

The contact of the intrusive rock, which is in many districts a favorable prospecting ground, did not indicate strong mineralization in the area examined, the chief effect of the intrusive being to silicify the invaded rock. Most of the veins appeared to be several thousand feet from the granite contact.

The area underlain by the metamorphosed sediments appears to be more favorable prospecting ground than the granite. The discoveries so far made have been in this formation, which has been highly deformed and so offers the possibility of providing structural features suitable for the deposition of minerals in commercial quantity. Usually the sand and gravel of streams draining the area underlain by the metamorphosed sediments yield at least a few colors of gold and so indicate that there has been some mineralization in the sediments themselves.

As the south-central and western portions of the district are predominantly granite, with only a few small belts of slate and graywacke, it is probable that most of the more favorable prospecting ground occurs in the area that lies north of the Hidden River, where the granitic outcrops are subordinate in amount to the metamorphosed sediments. However, one discovery of rich gold quartz float has already been noted in the southern part of the district, on Whistler Creek, and quartz veins are numerous in the metamorphosed sediments between the Coffee and Hidden Rivers.

North of the Curry district, in the basin of the West Fork of the Chulitna, there is a series of mineralized tuff, lava, chert, and argillite that has been described by Capps[47] and Ross.[48] Several prospects of merit are located in this belt of base-ore mineralization, which also contains, in some places, high values in gold. As the district here described is on the continuation of the strike of these same rocks, it was thought that a continuation of this belt of mineralization might be found. The field work has proved that it does not continue any farther south than Eldridge Glacier, in the vicinity of which it apparently lenses out.

The area in the vicinity of Eldridge Glacier and the Hidden River seems to offer the most encouragement for prospecting, for the metamorphosed sediments are much more abundant there than farther south. Several small but rich veins carrying free gold have been found, and strong fissure veins, which so far have not been found to contain metals in commercial amounts, are known to exist close by. In the vicinity of Eldridge Glacier many small veinlets carrying pyrite, pyrrhotite, chalcopyrite, and sphalerite were found. It has also been reported that galena float occurs on the moraine of the glacier, about 10 miles north of its front.

BOEDEKER CLAIMS

The only known prospects on which any development of gold lodes has so far been done are the Boedeker claims nos. 1 and 2, located and held jointly by Roy and Elmer Boedeker. The claims are on the north side of the Hidden River a short distance east of Swift Creek, at an elevation of 4,000 feet, or about 2,800 feet above the floor of the Hidden River Valley. The discovery was made in the fall of 1929, and the development work was done in 1931 and 1932. The developments consist of several open cuts, a 30-foot tunnel which was driven a few feet below several small flat-lying veins, and several open cuts on a large vein that lies about 100 feet down the hill from the small veins.

As the slope of the hill at this point is about 35°, there is a large amount of surface creep. Snow and rock slides have caused the caving of many of the pits soon after they were opened up and have also given false inclinations to the veins and country rock, so that in many places it is difficult to ascertain the true geologic conditions. The country rock consists of foliated slate and fine-grained schist, graywacke, and argillite that locally have variable attitudes but in general strike N. 30° E. and are vertical. Numerous veins cross the structure of the country rock. One group consists of several small irregular veins that strike N. 20° W. and lie flat or locally dip

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[47] Capps, S. R., Mineral resources of the upper Chulitna region: U.S. Geol. Survey Bull. 692, pp. 216–217, 1919; The eastern portion of Mount McKinley National Park: U.S. Geol. Survey Bull. 836, pp. 257–260, 1932.

[48] Ross, C. P., op. cit. (Bull. 849–E).

10°–20° W. They range in width from 2 to 10 inches, and none of them are persistent for more than 100 feet. The vein material consists of quartz that is tightly "frozen" to the graywacke walls. In addition to the quartz there is a very small amount of fine disseminated pyrite, a few flakes of sericite and galena, and considerable free gold. The gold in the veins is erratically distributed, barren places alternating with exceedingly rich spots.

About 60 feet vertically below the small veins, there is a large vein which has a strike similar to that of the small veins (N. 20° W.) but which dips about 70° E. This vein can be traced along its strike for over 800 feet and has a width of 3 to 12 feet. In the pit below the tunnel the vein walls are well defined and the quartz is separated from the country rock by seams of gouge. The vein is predominantly quartz, but it includes some gouge and several small slate horses, which suggest a postvein movement. The quartz at the surface is stained with limonite and appears to be identical with that in the small rich veins above, but the large vein does not carry any ore. Small amounts of finely disseminated pyrite and arsenopyrite can occasionally be seen in the vein material. Six samples taken at the most favorable places along the large vein assayed only traces of gold and silver.

To the northwest the large vein disappears under a cover of slide rock, but before that point is reached the vein material is but little iron-stained and the quartz loses its similarity to that in the small veins and appears barren. To the southeast the large vein apparently pinches out, as it cannot be located on a small ridge that offers good exposures. At several points along the large vein there are small offshoot veins extending up the hill in a manner similar to that of the small rich vein already described and seeming to have similar relationships. However, little indication of valuable minerals in these small offshoot veins has been found.

It is probable that there is a relationship between the small gold quartz veins and the large fissure vein directly adjacent to them, for their proximity and the similarity in strike and in the nature of the vein material are strongly suggestive of a close genetic association. If they are genetically the same, it is possible that further development on the large vein might disclose ore shoots of value.

The veins so far found that carry free gold are too small in extent and number to warrant successful mining, although if they were more accessible, it is highly probable that some gold could be profitably extracted from them.

COAL

Lignitic coal of poor to medium grade occurs in the district. Outcrops and coal float have been found at several localities, notably on Little Coal Creek, Alder Creek, and Bluff Creek (on the south side of Ruth Glacier). The lignite is dark brown to black, light in weight, and very woody and disintegrates quickly on exposure to the weather. It is probably of little value except for local use. As there have been no attempts at opening up any of it, all the material seen was badly weathered. The best outcrops occur on Bluff Creek, where about a dozen beds, ranging in thickness from a few inches to 6 feet, were seen in a 200-foot section. The section showed that the beds were lenticular. An analysis of an air-dried sample of the woody lignite, by M. L. Sharp, Bureau of Mines, Anchorage, Alaska, is as follows:

Moisture	14.10
Volatile matter	45.76
Fixed carbon	33.54
Ash	6.60
Sulphur	.05
	100.05
British thermal units	9,210

CONCLUSIONS

The immediate future of the Curry district seems to rest entirely on the possible development of its gold lode deposits. Under present economic conditions, largely because of the prevailing low prices of metals and the difficulties of transportation from the district to the railroad, it is doubtful whether even if base-metal deposits should be found in the district, unless they were of unusual richness and size, they could be profitably worked. However, some galena float has been found in the northern part of the district, and it might be worth while to ascertain the site and extent of the deposit from which it came.

The gold prospects so far discovered are 20 miles from the railroad, yet gold deposits if of sufficient size and richness can be worked in almost any locality, and inasmuch as gold is known to be present, it would appear that further prospecting is justified, particularly in the northern part of the district and around the margin of the granite intrusive.

The present trail and tram across the Chulitna River, though sufficient for prospecting, would be inadequate for any larger developments, and the cost of building a serviceable road and bridges across the Chulitna and Fountain Rivers is not justified at present. Heavy freight for prospecting and developing mining properties can be moved into the district more cheaply by sled in winter than by any means in summer, and until more promising properties are discovered that would appear to be the logical way of bringing in supplies.

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