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THE LAKE CLARK-MULCHATNA REGION ALASKA

BY

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THE LAKE CLARK-MULCHATNA REGION, ALASKA

By Stephen R. Capps

INTRODUCTION

LOCATION AND GENERAL CHARACTER OF THE REGION

The region here considered lies in south-central Alaska, on the west flank of the Alaska Range between latitude 60° 15′ and 61° 5′ north and longitude 153° 40′ and 155° 10′ west, and includes the western face of the range and a part of the foothills in a belt that ranges from 15 to 25 miles in width and extends from Lake Clark northeastward to the basin of the Stony River. It is therefore an intermediate belt, bordered on the east by the high, rugged, snow-capped mountains of the Alaska Range, which reach altitudes of 8,000 to 9,000 feet or more, and on the west by the headwater basins of the Mulchatna River, a tributary of the southward-flowing Nushagak River, and the Hoholitna and Stony Rivers, tributaries of the Kuskokwim. These basins are characterized by wide, level lowlands broken by more or less isolated hills and ridges of mature slopes that rise 1,000 to 3,000 feet or more above the adjacent valleys. The existence of a large lake at approximately the position of Lake Clark, at the south edge of the region here described, has been fairly well known since the early days of the Russian occupancy. The area north of Lake Clark, although it has been visited by a considerable number of white prospectors and trappers during the last 30 years, has remained one of the little-known parts of Alaska. Only crude sketch maps have been available to show the courses of the main rivers, and these maps differed so much among themselves that little reliance could be placed upon them.

PREVIOUS EXPLORATIONS AND SURVEYS

From the time of Bering's discovery of Alaska, in 1741, many navigators sailed along the coast of southern and southwestern Alaska, and its shore lines were fairly well known by the end of the eighteenth century, when Cook, Dixon and Portlock, and Vancouver had made rather complete charts of the shores of Cook Inlet and the Russians had explored the shores of southwestern and western Alaska. Inland

explorations into the region between Cook Inlet, Bristol Bay, and the headwaters of the Kuskokwim River came more slowly. An unpublished manuscript by Alfred H. Brooks outlines many details of the early explorations in this region, and a condensed statement of Brooks's findings has been given by P. S. Smith,[1] so that only a brief summary will be given here.

The first inland exploration of importance was made in 1818 by Korasakorsky, who traveled from Cook Inlet to Bristol Bay by way of Iliamna Lake. In 1829 Vasilief and Lukeen journeyed from Bristol Bay up the Nushagak and thence to the Kuskokwim at the mouth of the Holitna, and in 1832 Kolmakof and Lukeen followed the same route and established Lukeen's Fort, on the Kuskokwim a hundred miles below the Holitna. This settlement was partly burned by the natives in 1841 but was soon replaced by a new one named Kolmakof's Redoubt, a few miles below. This is the site of the present village of Kolmakof. Other explorations of the Russians in this region that are worthy of mention are Glazanof's trip some 50 miles up into the basin of the Stony River, in 1834, and Zagoskin's journey in 1844 from Lukeen's Fort up the Kuskokwim to the Takotna.

Martin and Katz[2] report that some of the early Russian maps indicated a large lake in the general region of Lake Clark, and the presence of such a lake had long been vaguely known, but the first definite account of its existence resulted from an exploration of A. B. Schanz and J. W. Clark, who in 1891 ascended the Nushagak and Mulchatna and possibly traversed a part of the area considered in this report.

In 1898 J. E. Spurr and W. S. Post, of the Geological Survey, made a notable expedition from Cook Inlet across the Alaska Range by way of the Skwentna River, descended the Kuskokwim to its mouth, and thence made their way partly overland and partly along the coast to the head of Bristol Bay and across the Alaska Peninsula to Katmai Bay. They thus made a complete circuit around the Lake Clark-Mulchatna region, though they did not set foot within 100 miles of it.

Osgood[3] and Maddren, of the Biological Survey of the United States Department of Agriculture, in 1902 roughly mapped the route from Cook Inlet to Lake Clark and thence by the Chulitna, Mulchatna, and Nushagak Rivers to Bristol Bay. In 1901 and for several succeeding years an exploration for a railroad line from Iliamna

[1] Smith, P. S., The Lake Clark-central Kuskokwim region, Alaska: U. S. Geol. Survey Bull. 655, pp. 12–16, 1917.

[2] Martin, G. C., and Katz, F. J., A geologic reconnaissance of the Iliamna region, Alaska: U. S. Geol. Survey Bull. 485, p. 24, 1912.

[3] Osgood, W. H., A biological reconnaissance of the base of the Alaska Peninsula: U. S. Dept. Agr. Biol. Survey North American Fauna, No. 24, 86 pp., 1904.

Bay to Anvik, on the Yukon, was carried on intermittently, and a route was selected; but so far as is known only a crude exploration survey was made, and that only as far as the Mulchatna River. Apparently this route ran westward from Lake Clark up the valley of the Chulitna River. No construction work was done.

About 1912 reports of important discoveries of placer gold brought about a small stampede to the upper basin of the Mulchatna River. The focus of activity was in the neighborhood of the canyon of Bonanza Creek, a tributary that rises in the foothills west of the area directly concerned in this report. A large number of claims were staked and a little gold was recovered, but no ground was found that could be worked at a profit under the conditions then prevailing, and no serious mining has since been done there. As a result of this stampede a good many men prospected the headwaters of the Mulchatna, but they left no record of their explorations.

The first accurate survey in this region, of which a published record was made, was that of the United States Geological Survey in 1909, when D. C. Witherspoon, topographic engineer, and G. C. Martin,[4] geologist, with 10 other technical and camp men, surveyed an area between Iliamna Bay and Lake Clark. Their published report included topographic and geologic maps of the area covered, and their observations and conclusions in respect to the geology of that area, which is directly south of the region here under discussion, has been of great help in preparing this report.

In 1914 another expedition from the Geological Survey, in charge of R. H. Sargent, topographer, with P. S. Smith as geologist, landed at Iliamna Bay with pack horses and proceeded to the foot of Six-mile Lake, a southwestward continuation of Lake Clark, where the field work began. From that point they traveled in a northwestward direction, eventually making their way to the Kuskokwim and thence to Iditarod. This expedition also resulted in the publication of a valuable report, including geologic and topographic maps of the route traversed.[5] As the area included in that survey directly adjoins on the southwest and west the region treated in this report and as several rock groups are present in both areas, Smith's report has been freely drawn upon by the present writer, who here gives rather brief descriptions of formations that have already been adequately described elsewhere.

It will thus be seen that as a result of the exploratory expeditions of Spurr in 1898 and Brooks in 1902 and of the reconnaissance surveys of Martin, Witherspoon, and their associates in 1909 and Sargent and Smith in 1914 a great area in the southern part of the Alaska

[4] Martin, G. C., and Katz, F. J., op. cit.

[5] Smith, P. S., The Lake Clark-central Kuskokwim region, Alaska: U. S. Geol. Survey Bull. 655, 162 pp., 1917.

Range has been surrounded by surveys, but there remained a rather compact block of rough, mountainous country bordered by the Skwentna River on the north, the Iliamna-Lake Clark region on the south, Cook Inlet on the east, and the Mulchatna-Kuskokwim lowland on the west, which had been visited by few white men and about which little was known. Plans for exploring and mapping this region had been under consideration by the Geological Survey for many years, and in 1926 a series of expeditions in charge of the writer was begun. The first of these expeditions, in which K. W. Trimble was topographer, in 1926 ascended the Skwentna River and mapped its headward basin, together with some contiguous country on the Kuskokwim slope of the Alaska Range. In 1927 the writer, with R. H. Sargent as topographer, penetrated into the basin of the Chakachatna River from the east and connected with the preceding year's work in the Skwentna Basin. In 1928 the writer, with Gerald FitzGerald as topographer, took up the work in the head of the Chakachatna Basin and carried it westward across the range to include the headward basin of the Stony River.

PRESENT EXPEDITION

The expedition of which this report is an account, the fourth in the series carried out in this general region, had as one of its main purposes the connecting of the earlier surveys carried west and northwest from Iliamna Bay with those carried into the region in preceding years by way of the Skwentna River and from Trading Bay on Cook Inlet. This purpose was successfully accomplished. The party, in charge of the writer as geologist, with Gerald FitzGerald as topographer, included four other men—Fred M. Bullard as recorder, G. W. Pearson and L. W. Oules as packers, and Thomas Owens as cook. To all these men the writer wishes to express his appreciation for able and faithful services. With 15 pack horses and the necessary equipment and provisions for the summer, the party was landed from the steamship at the mouth of Iliamna Bay upon an open barge in tow of a launch, supplied through previous arrangement by the Alaska Railroad. There are no regular landing facilities at Iliamna Bay. On landing the party proceeded over the trail and road to Iliamna Village, on the Iliamna River some 4 miles above the point where that stream flows into Iliamna Lake. From the village most of the supplies and three of the men traveled by boat to Severson's trading post, at the foot of the portage to the Newhalen River, while the pack horses were taken around the north shore of Iliamna Lake to the same point. From Severson's post the party went to the foot of Sixmile Lake, where the horses were swum across the head of the Newhalen River. At that point a

man was hired to take several hundred pounds of provisions, the supplies for the last half of the season, up Lake Clark to be stored at Carlson's cabin, a few miles above the mouth of the Kijik River. The pack train proceeded northwestward to the Chulitna River along an old Indian trail, and field work was begun in the hills just north of Long Lake, connecting with the 1914 surveys of Sargent and Smith. From Long Lake the party followed a northeasterly course through the foothills and along the face of the range to Telaquana Lake, at which the work was tied in to the 1928 surveys by Capps and FitzGerald, in the basin of the Stony River. The return trip was made from Telaquana Lake to Lake Clark over the Indian trail known to the natives as the Telaquana trail, and from Carlson's cabin, a few miles northeast of the mouth of the Kijik River, the pack train and three men followed the northwest shore of Lake Clark and Sixmile Lake to the head of the Newhalen River, while the other three members of the party traveled down the lakes by boat. The writer wishes to express his thanks to Mr. Brown Carlson for sheltering and caring for provisions left with him during the summer and for conveying personnel and supplies from his camp to the Newhalen portage in the fall.

From the head of the Newhalen portage the party followed the same route back to Iliamna Bay as that taken in the spring. Arrangements having already been made through the courtesy of the Alaska Railroad for a launch to meet the party at Iliamna Bay in the fall, the party proceeded to Anchorage, where it was disbanded.

As a result of this expedition an area of some 1,400 square miles of previously unmapped and little-known country was mapped, both topographically and geologically, the position and headward courses of the eastern tributaries of the Mulchatna River were determined, and a connecting link was obtained between the surveys of 1909 and 1914 and those of 1926 to 1928 that were carried westward to the west slope of the Alaska Range by way of the Skwentna, Chakachatna, and Stony Rivers.

The microscopic examination of the thin section of rocks described in this report was made by J. B. Mertie, jr.

GEOGRAPHY

RELIEF

The area here referred to as the Lake Clark-Mulchatna region includes a strip from 20 to 30 miles in width that stretches northward from Lake Clark to the Stony River. This strip includes the basin of the Koksetna River and crosses several of the headward tributaries of the Mulchatna River. At the time the field work was done

it was hoped that the mapping could be carried to the heads of these streams and so include a considerable area in the high, rugged portion of the Alaska Range, but bad weather so retarded the work that this was impossible. The Chilikadrotna, Mulchatna, and Telaquana Rivers all head in the high snowy peaks of the range and have considerable glaciers at their heads. These glaciers were formerly much larger than they are to-day, and glacial ice from the higher mountains pushed westward into the foothill region, surmounted and smoothed off all the lower groups of hills, and deposited great quantities of morainal material. By both erosion and deposition, these former glaciers had a profound effect upon the topography, and glaciated mountain forms, moraines, and outwash gravel are still conspicuous features of the landscape.

The long mountain spurs that extend southwestward from the main range between Lake Clark and the Little Mulchatna River have rather high relief, and summit altitudes of 4,000 feet or more are common, yet these spurs are cut at intervals by broad, open passes, so that travel from one stream valley to another is not difficult, and when the time comes that road and trail construction is necessary fairly direct routes with moderate gradients can be found.

West, northwest, and southwest of the area here described is a great lowland that includes on the north the lower basins of the Stony and Hoholitna Rivers, and on the west and southwest the Mulchatna-Nushagak lowland. These lowlands are characterized by more or less isolated groups of hills and ridges of moderate height, separated by broad alluvium-filled valleys that are occupied by lakes and rather sluggish streams. Through this great lowland, which stretches from Bristol Bay northward to the Kuskokwim River, travel in the winter by dog team is fairly easy, for the broad valleys can be followed and the hills avoided. In the summer, however, travel on foot or with horses is difficult, for the valley floors are in many places swampy, lakes are numerous, and many streams are too large to ford easily.

The high portion of the Alaska Range, bordered on the west by the region here under discussion, on the east by Cook Inlet, on the north by the Chakachatna Basin, and on the south by Lake Clark, is unexplored, although the eastern face of the range is visible from Cook Inlet and something is known of its geography. Probably the largest valley within that unmapped area is that of the Tlikakila River, or Big River, as it is locally called, a stream that enters the head of Lake Clark from the northeast. This valley is said to extend some 60 miles to the northeast, and a glacier-filled pass at its head is reported to lead to the valley of the Kustatan River and afford a possible winter route from Lake Clark to Cook Inlet. With the exception of the Tlikakila Basin and its tributary valleys it

seems certain that the remainder of this mountainous region is drained by the tributaries of the Kijik, Mulchatna, and Stony Rivers on the south and west and by a number of rivers of moderate size that flow eastward to Cook Inlet.

DRAINAGE

The drainage systems of the region here described include streams that flow to Lake Clark, thence by the Newhalen River to Iliamna Lake, which in turn drains through the Kvichak River to Bristol Bay; several of the eastern headwaters of the Mulchatna River, which joins the Nushagak about 100 miles above the point where that stream flows into Bristol Bay; and the Telaquana River, which flows into the Stony River, a tributary of the Kuskokwim. Of the Lake Clark tributaries, the largest within this region are the Chulitna River and its main northern tributary, the Koksetna. The Chulitna drains a great lake-dotted lowland between the Mulchatna and Lake Clark and for most of its length is sluggish and too deep to ford with horses. It is said that the only feasible ford is that used by the Geological Survey party, just south of the center of Long Lake. At that point a riffle was found with water only 3 feet deep in late June. The Chulitna is easily navigable for shallow-draft power boats for many miles above Lake Clark, and there would probably be no serious difficulty in ascending it at least as far as the Nikabuna Lakes. The Koksetna follows a peculiar course, flowing first north, then making an irregular curve to the southwest, south, and east, and finally reversing its direction to a southwest trend where it joins the Chulitna. This unusual drainage pattern is the result of the former severe glaciation of the area and the succeeding deposition of heavy accumulations of outwash gravel in all the valleys near the ice margin. This scour and fill brought about many changes in the courses of the streams, and the present Koksetna River has no doubt a quite different pattern from that of the streams that drained this area in preglacial time. The present basin contains many small lakes, some of which are of glacial origin and some formed behind beaver dams.

The only other important tributary to Lake Clark in this area is the Kijik River, which enters the lake from the northwest 17 miles below the head of the lake. The Kijik heads in rugged mountains, and although the extreme head of its basin was not mapped, its cloudy waters show that there are active glaciers at its head. The low pass northeast of Ingersoll Lake that gives access to the valley of the Tlikakila (Big) River indicates that the upper part of the Kijik Basin once drained to that stream but was diverted to the southwest by a great glacier that filled the Tlikakila Valley.

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The headward tributaries of the Mulchatna River, including an unnamed stream just north of the Kijik River, the Little Mulchatna, the Chilikadrotna, and the main head of the Mulchatna, with the Telaquana River, a tributary of the Stony, drain the remainder of this area. All head at the face of or within the high mountains of the Alaska Range and flow southwestward through broad gravel-filled valleys. The Chilikadrotna, the Mulchatna, and the Telaquana head in glaciers and have large glacial lakes at the points where they emerge from the range into the foothill belt. All these lakes are impounded behind glacial moraines, and their waters are slightly cloudy with glacial silt. These streams vary greatly in volume from time to time. All of them are ordinarily fordable on foot, but after heavy rains they become so swollen that crossing even on horseback is hazardous.

CLIMATE

No reliable records of temperature or rainfall are available for this part of Alaska. The nearest points at which accurate weather observations are kept are on the coast of Cook Inlet and of Bristol Bay, and at these points the climate is obviously affected by the influence of the ocean waters and is unlike that of the interior region here under discussion. In general, it may be said that the winters are cold, with moderate snowfall, and the summers cool and rainy. Between June 13 and September 11, 1929, there were 45 days during which rain fell in the places where the Geological Survey party happened to be, and on many other days there was low-lying fog or a heavily overcast sky. A wide range in the number of rainy days may occur within short distances, however, and the year 1929 was said to be unusually clear and fine on Iliamna Lake. It appears that there is much more rain in the areas of high mountains than in the lowlands to the west. Late spring and early summer weather is likely to be clearer than that of middle and late summer. Frost may be expected in the mountains in any month during the summer, though along the shores of Lakes Iliamna and Clark vegetables do well and summer frosts are infrequent.

VEGETATION

The distribution of timber within the region here described is largely determined by the altitude. In general, the upper limit to which trees grow is about 2,000 feet, although in a few places scattered trees may be found above this altitude, and there are large areas below 2,000 feet that have little or no timber. Figure 5 shows the areas in this region in which timber occurs. The gradually decreasing altitude of timber line southward along the Alaska Range

is an anomaly for which no entirely satisfactory explanation has yet been advanced. Timber would naturally be expected to grow at successively higher altitudes on these mountains southward from the northern part of the range, near Mount Hayes, but this is not the case. Along the range from the international boundary past Mount McKinley and as far southwestward as the basin of the Stony River

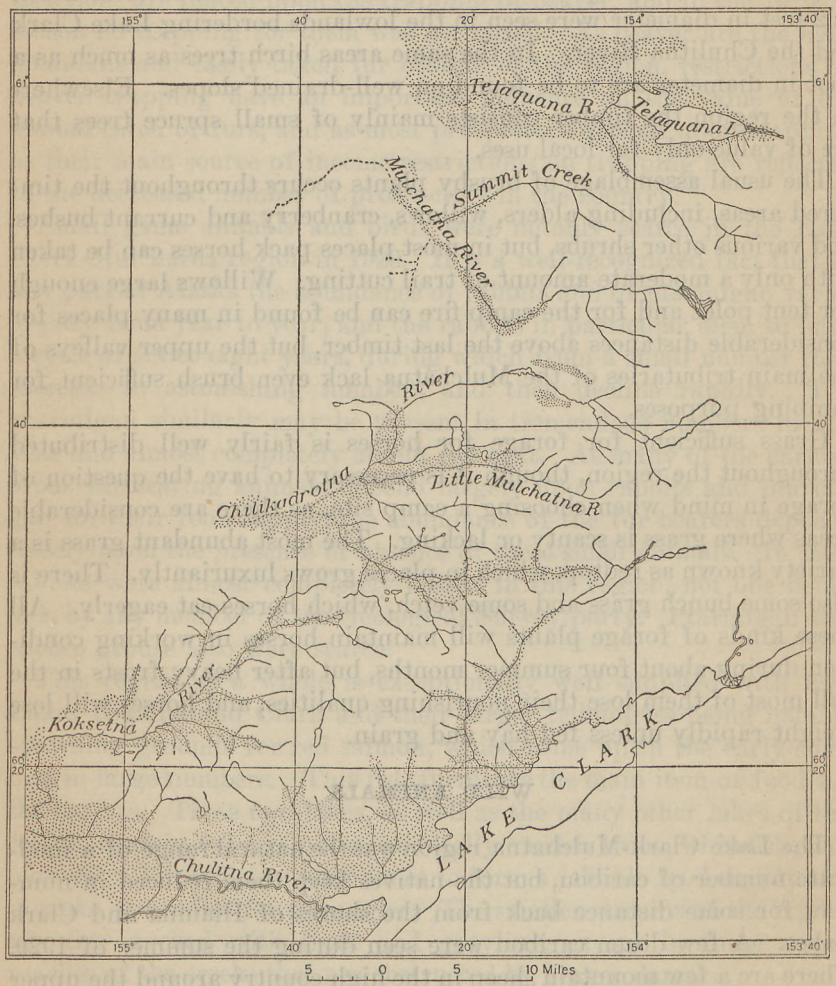

FIGURE 5.—Areas in which timber occurs in the Lake Clark-Mulchatna region

timber line lies at 2,500 to 3,000 feet above sea level, with scattered trees and patches of timber at altitudes of 3,500 to almost 4,000 feet From the Stony River southward, however, the conditions for the growth of trees become rapidly less favorable. The lowlands bordering the lower part of Iliamna Lake have only scattered, small trees, although they stand only 200 to 1,000 feet above sea level. Still

farther south groves of trees become more scattered, and the Alaska Peninsula from Becharof Lake southward is timberless.

In the Lake Clark-Mulchatna region trees of sufficient size to yield saw logs occur only along the shores of Lake Clark and in the lower valley of the Chulitna River. The commonest tree is the spruce, which in places reaches a diameter of 18 inches to 2 feet, but there are only small areas of spruce of that size. Cottonwood trees as much as 2 feet in diameter were seen in the lowlands bordering Lake Clark and the Chulitna River. In the same areas birch trees as much as a foot in diameter are to be found on well-drained slopes. Elsewhere in the region the timber consists mainly of small spruce trees that are of value only for local uses.

The usual assemblage of brushy plants occurs throughout the timbered areas, including alders, willows, cranberry and currant bushes, and various other shrubs, but in most places pack horses can be taken with only a moderate amount of trail cutting. Willows large enough for tent poles and for the camp fire can be found in many places for considerable distances above the last timber, but the upper valleys of the main tributaries of the Mulchatna lack even brush sufficient for camping purposes.

Grass sufficient for forage for horses is fairly well distributed throughout the region, though it is necessary to have the question of forage in mind when choosing a camp site, as there are considerable areas where grass is scanty or lacking. The most abundant grass is a variety known as redtop, which in places grows luxuriantly. There is also some bunch grass and some vetch, which horses eat eagerly. All these kinds of forage plants will maintain horses in working condition during about four summer months, but after heavy frosts in the fall most of them lose their nourishing qualities, and horses will lose weight rapidly unless fed hay and grain.

WILD ANIMALS

The Lake Clark-Mulchatna region was the natural range of a moderate number of caribou, but the natives keep them reduced in numbers for some distance back from the shores of Iliamna and Clark Lakes. A few dozen caribou were seen during the summer of 1929. There are a few mountain sheep in the high country around the upper end of Lake Clark, and probably also in the rough country at the heads of the tributaries of the Mulchatna River. One band of sheep was seen near the head of Telaquana Lake.

Both black and grizzly bears are present, and some of the grizzlies are large. From the experience of the Geological Survey parties during the years 1926 to 1929 in this general part of Alaska, bears are less common in the upper basins of the Mulchatna and Stony Rivers

than farther north in the range. Moose may be found throughout this region, but are more abundant in the valleys of the northern tributaries of the Mulchatna and in the Stony Basin than farther south.

The fur-bearing animals that are most abundant in this area are beaver, fox, otter, lynx, mink, and muskrat. From time to time restrictions are placed upon the trapping of beaver, and in the 1929–30 season no trapping for them was permitted. As beaver are the most abundant and easily taken fur bearers of the region, restrictions on beaver trapping have an important influence on the value of the annual catch of furs, and as most prospectors depend upon trapping as their main source of income restrictions on trapping are reflected in the decreased number of prospectors in the country.

Small game animals and birds were notably scarce in the Lake Clark-Mulchatna region in 1929. It is a well-recognized fact that in any part of Alaska the abundance of rabbits and of ptarmigan varies greatly from year to year, and the rabbits in particular seem to have a cycle of six to eight years, during which from a small number they increase to astonishing numbers and then decline rapidly. The ptarmigan similarly may be present in tremendous numbers in one year and almost completely absent the next. As many of the carnivorous fur-bearing animals depend largely upon rabbits and ptarmigan for their food supply, the abundance of the fur bearers depends closely upon the presence or absence of these small animals. In 1929 rabbits were almost completely absent in this region, not one being seen by any member of the Geological Survey party. Ptarmigan and spruce grouse also were scarce.

This region as a whole is exceptionally well supplied with fish. Lakes Iliamna and Clark and their larger tributaries being notable spawning grounds for red salmon, which come up in the early summer in large numbers. This fish furnishes the main item of food for the natives. These two lakes, as well as the many other lakes of the region, contain lake, rainbow, and dolly varden trout, whitefish, and pickerel, all in sufficient abundance to form a reliable food supply and to make a paradise for the angler. The smaller streams of the region are also stocked with trout and grayling, except in those upper reaches of the creeks that are obstructed by beaver dams.

ROUTES OF TRAVEL

So few white men have visited the region between Lake Clark and the Stony River that there are no established routes of travel in it. The Geological Survey party in 1929 approached the region from Iliamna Bay, between which and Iliamna Village, on the Iliamna River 4 miles above the mouth of that stream, an old native trail

has long existed. This trail has been improved during recent years by the Alaska Road Commission, and parts of it have been widened and graded to form a passable wagon road. Plans are under way to continue this improvement, and it was expected that by the end of 1930 a light wagon could be taken across the entire 12 miles of this route from Cook Inlet to the navigable waters of the Iliamna Lake-Kvichak River drainage basin. During 1929 a gasoline launch made calls at intervals of about two weeks at Iliamna Bay, landing mail, perishable goods, and light freight, and a small pack train was operated between Iliamna Bay and Iliamna Village. From Iliamna Village westward practically all summer travel goes by boat and winter travel by dog sled, so that only faint trails or none lead overland. Pack horses, however, can be taken along the north shore of Iliamna Lake at least as far west as the foot of the Newhalen portage, at Severson's trading post, though the trail is poor and travel slow. In summer power launches are able to ply between Iliamna Lake and Bristol Bay by way of the Kvichak River, and most of the supplies for this region come in by that route. A trading post with a small stock of goods is operated at Iliamna Village, and a larger trading post, at which supplies of all kinds can be purchased, is maintained on the north shore of Iliamna Lake about 4 miles northeast of the mouth of the Newhalen River. From that point an old portage trail leads northwestward to a point above the upper rapids of the Newhalen. This portage trail is soft for a mile or so from Iliamna Lake but is hard and well worn beyond. From the head of this portage the Newhalen River is navigable to Sixmile Lake and Lake Clark, and the Chulitna River, tributary to Lake Clark from the west, is also navigable by small boats for many miles above its mouth. There were in 1929 no work animals other than dogs in the region except the three or four horses used between Iliamna Bay and Iliamna Village. As a consequence all materials that pass back and forth between Iliamna Lake and Lake Clark are taken across the Newhalen portage mostly on men's backs, though in lesser part by dog sled in winter. In this way are carried all the supplies for the Indian village of Nondalton and for the white trappers and prospectors on Lake Clark, including such heavy materials as gasoline and dried salmon.

North of Lake Clark the region is almost devoid of well-marked trails. A faint Indian trail leads from Nondalton in a northwesterly direction to a ford across the Chulitna River, and another dim trail leads northeastward from that village along the shore of Lake Clark. This trail follows the lake beach much of the way but is plain across most of those places where rock cliffs along the lake shore make beach travel impossible.

An old Indian trail, known as the Telaquana trail, leaves the shore of Lake Clark at the site of an abandoned native village at the mouth of the Kijik River and leads northward across several stream valleys to Telaquana Lake, where there was formerly a native settlement. This was a well-traveled native trail and can be followed without difficulty for the first 20 miles or so, but in the basin of the Mulchatna River it is indistinct in many places. Although very steep where it ascends from the valley of the Kijik River to the divide leading into the Mulchatna Basin and somewhat marshy in a few places, throughout most of its length it is entirely feasible and affords good footing for horses.

With the exception of the primitive native trails described above, there are no established routes of travel in this little-visited region. Nevertheless the country is open and fairly free from brush and thick timber, and except in certain marshy areas in the stream valleys and the more rugged mountains of the main range a pack train can be taken almost anywhere without more difficulty than is to be expected in any unsettled part of Alaska.

POPULATION

Except for one white man on the north shore of Lake Clark, about 5 miles above the mouth of the Kijik River, there are no permanent inhabitants in the region described in this report. There were formerly native villages at the foot of Telaquana Lake and at the mouth of the Kijik River, and a few native houses along the north shore of Lake Clark, but all of these are now abandoned. The nearest settlement of any size is Nondalton, on the west shore of Sixmile Lake, where some 60 or 80 natives and one white man live. There are perhaps half a dozen white men prospecting or trapping on Lake Clark. Although most of the natives of this region have their homes at Nondalton, many of them visit different parts of this region to trap during the midwinter months and move to temporary fishing camps in the summer, so that the inhabitants of the village are rarely all present there at the same time.

On Iliamna Lake and on the lower Iliamna River there are about a dozen white men and two native villages. Iliamna Village, on Iliamna River, 4 miles above its mouth, is inhabited by 60 or 70 natives of the Kenai tribe. Another village a few miles below the mouth of the Newhalen River is occupied by Aleuts. A herd of about 500 reindeer has been maintained by the natives for many years near the south end of the Newhalen portage.

It will thus be seen that although the Iliamna-Lake Clark region has been known to white men for many years and is fairly easy of access both from Cook Inlet and from Bristol Bay, its development

has been very slow, and the few white men in it live by trading, trapping, and prospecting.

GEOLOGY

GENERAL OUTLINE

The areal distribution of the rocks of the Lake Clark-Mulchatna region is shown on Plate 2 in so far as the formations have been differentiated. Prior to the expedition upon which this report is based this region was unmapped and only partly explored, and except for a few scattered observations along the northwest shore of Lake Clark nothing was known of its geology. The expedition of 1929 attempted only reconnaissance mapping. Of the 91 days spent between the arrival at Iliamna Bay in June and the return to that place in September 40 days was required in getting to and from the field of work, so that only 51 days was available for actual mapping in a new area, and during even that short field season rainy weather greatly interfered with the work. A further handicap to the close mapping of geologic boundaries arose from the fact that the topographic mapping was carried on concurrently with the geologic field work, and a completed topographic map as a base for the geology was not available until several months after the end of the field season. As a consequence of these difficulties the geologic boundaries as shown on the map are only approximate, but they represent the best information obtainable during the short season.

The geologic units shown on Plate 2 include four rock groups and a fifth comprising all the relatively young unconsolidated materials. All these units have been described in reports on adjoining areas, and only brief descriptions of their salient characteristics will be given here, with references to the more complete descriptions already published.

The oldest rocks in this area comprise a group of volcanic materials with which are associated large quantities of sediments, all more or less metamorphosed. These rocks occupy the foothills northwest of Lake Clark and are present near the face of the Alaska Range as far north as the basin of the Stony River. The volcanic rocks include andesite and basalt flows and large volumes of water-laid fragmental volcanic materials that may be included under the general term "tuff." Interbedded with the tuff there is locally much sedimentary material that was originally mud and impure sand but is now indurated and metamorphosed to form shale, argillite, and graywacke. It is believed that the lower part of this group is composed dominantly of medium basic to basic lava flows, with fragmental volcanic material and sediments increasing in abundance toward the upper limit of the group. The age of this undifferentiated group of

EXPLANATION

BEDDED ROCKS

Pleistocene and Recent	Q — Sand, gravel, and silt of present streams; glacial morainal material and outwash gravel; terrace gravel, alluvial fans, and talus	QUATERNARY
	Trb — Rhyolite and basalt	TERTIARY
Probably in part Upper Cretaceous	Ks — Mainly black argillite, shale, slate, and graywacke with minor amounts of intrusive material	MESOZOIC
Probably Lower Jurassic to Cretaceous	Kl — Undifferentiated complex consisting mainly of medium basic to basic lava and tuff, but containing locally considerable amounts of metamorphosed sediments and some intrusive rocks	MESOZOIC

INTRUSIVE ROCKS

Upper Cretaceous	Kgr — Granitic intrusives with some later dikes	CRETACEOUS

GEOLOGIC MAP OF THE LAKE CLARK-MULCHATNA REGION, ALASKA

rocks is somewhat uncertain, but it is here tentatively assigned mainly to the Lower Jurassic, though it may include materials as young as Upper Jurassic or even Cretaceous.

The next younger rocks in this region consist of a series of argillites and graywackes, cut by numerous dikes and sills, but containing only minor amounts of lava and tuff, that occurs west of the Koksetna River and in the vicinity of Telaquana Lake. These rocks lie along the strike of a similar series of rocks in the Stony Basin, from which a fossil has been determined as probably of Upper Cretaceous age. A third group, composed almost exclusively of lava flows and tuff of andesitic, rhyolitic, and basaltic composition covers a considerable area of the foothill region in the upper basin of the Chilikadrotna River. These rocks are locally faulted and mildly folded but in general are not greatly deformed and are obviously younger than the Upper Cretaceous sediments. They are no doubt of Tertiary age, though it is as yet impossible to determine to what part of the Tertiary system they belong.

Granitic rocks form a prominent element in the Alaska Range from Iliamna Lake northward to and beyond Mount McKinley, being present in bodies of large area and also in smaller outliers. In the Lake Clark-Mulchatna region granitic rocks occur both as small outliers and as part of the larger masses that are present in the main range, though it happens that the region here covered lies a little too far west to include extensive areas of granite. Such an area occurs, however, not far east of this region, and studies in the Iliamna-Lake Clark area and in the Chakachatna Basin, farther north, indicate that much of the main range is composed of granitic rock. Still farther north, in the Stony and Skwentna Basins, these granites are found to cut Upper Cretaceous sediments, though they are nowhere known to intrude Eocene sediments, and they are therefore thought to be of late Mesozoic age.

Unconsolidated materials of Pleistocene and Recent age are abundantly present in this region and include conspicuous glacial moraine deposits, glacial outwash gravel, and the deposits of the present streams. Almost the entire foothill belt was formerly buried by glaciers that moved out from the high range and spread over the lowlands. This area is characterized by wide gravel-floored valleys, whose filling, in part at least, has been derived from the outwash left behind by the Pleistocene glaciers during their retreat. In many places the gravel has been partly removed by the streams, and the remnants now occupy terraces at various heights above the present flood plains. Active glaciers still exist in the rugged, unsurveyed portion of the range, and the draining streams carry much glacial débris. Most of the present glacial outwash, however, is trapped

in the lakes that occur in all the main valleys, and the waters of these lakes and of the streams that drain them, while slightly opaque, nevertheless are much clearer than glacial streams usually are.

The geologic sequence for the region, so far as it has been determined, is as follows:

Quaternary.—Gravel, sand, and silt of present streams; volcanic ash; lake deposits of sand and silt; talus accumulations; peat and impure organic deposits, or muck; soil and rock-disintegration products in place; terrace and bench gravel, in part of glaciofluvial origin; moraine deposits of Wisconsin and pre-Wisconsin age.

Tertiary.—Andesite, rhyolite, and basaltic lavas and tuffs.

Mesozoic.—Granitic intrusive rocks, probably of late Upper Cretaceous age; black shale, argillite, slate, and graywacke cut by dikes and sills, probably in part of Upper Cretaceous age; slate, argillite, graywacke, medium basic to basic lavas, and fragmental volcanic material, in part water-laid, all more or less metamorphosed, probably of Lower Jurassic and later age.

STRATIGRAPHY

Of the four rock groups in this region shown on Plate 2 one is in part sedimentary but contains much lava and fragmental material, one is dominantly sedimentary, and one is composed entirely of lava and fragmental volcanic material. All three of these groups, however, are stratified and presumably in part water-laid, and therefore they occupy definite positions in the stratigraphic column. In this discussion groups containing bedded lavas and tuffs as well as the ordinary sediments will be discussed in order of their age. The fourth group consists of deep-seated intrusive rocks.

MESOZOIC ROCKS

Three of the groups of hard rocks are believed to be of Mesozoic age. Beginning with the oldest, these are (1) an undifferentiated complex consisting mainly of medium basic to basic lava and tuff but containing locally considerable amounts of sedimentary materials and some intrusive rocks; (2) a group consisting mainly of black argillite, slate, and graywacke, with minor amounts of intrusive material; and (3) granitic intrusive rocks, which are present in this region only in small areas but which farther east form a conspicuous element in the Alaska Range. All these rocks are cut by dikes and sills, some of which are probably of Mesozoic age, but some no doubt are to be correlated with the Tertiary lavas. None of these rocks have yielded fossils in the region here described, and in adjacent regions fossils are so rare as to be of little aid in stratigraphic work. It is only by correlation with similar rocks in other regions that the

age of these rock groups can be even tentatively determined. From such unsatisfactory evidence it is believed that the lower complex is in part, at least, of Lower Jurassic age; that the argillite, shale, slate, and graywacke group is of Upper Cretaceous age; and that the granites cut Upper Cretaceous rocks but do not cut the Tertiary volcanic rocks.

COMPLEX OF LAVAS, TUFFS, AND METAMORPHOSED SEDIMENTS

Character and distribution.—The oldest group of rocks in the region here considered includes an undifferentiated complex of basic to medium basic lava, tuff, and associated argillite, slate, and graywacke, all more or less metamorphosed. These rocks dominate in the foothills immediately northwest of Lake Clark and extend northwestward to the Koksetna River and the southernmost tributary of the Chilikadrotna River. In the main range they occur near the western face of the mountains from Lake Clark northward to the Mulchatna, north of which they are interrupted by granitic intrusive rocks. As only the front face of the main range has been surveyed in this region, the areal distribution of the rocks of this group within the range is not known. Martin and Katz [6] found the porphyry and tuff of this group to give way toward the east to greenstone, slate, chert, crystalline limestone, gneiss, and quartzite schist of probable Paleozoic age, which are cut off on the east by granitic rocks. In the present investigation the Paleozoic rocks described by Martin and Katz were not seen, though they may be present farther back in the range. Apparently the western boundary of the main granitic core of the range, which at the head of Lake Clark has a northeasterly trend, swings westward in the region here described and comes to the face of the mountains near Telaquana Lake. It is thought likely that the greater part of the region east of the area here discussed and west of the granitic core of the range is composed of rocks of this group of lava, tuff, and metamorphosed sediments.

In composition this rock group is composed of a lower portion that consists almost exclusively of porphyritic lava and tuff and an upper portion that consists mainly of argillite, slate, graywacke, and tuff, with minor amounts of lava. The lower lava and tuff portion has been described rather fully by Martin and Katz [7] and by Smith,[8] and a brief review of its salient characteristics will suffice here. South of Lake Clark the igneous portion of this group includes rocks, commonly of porphyritic texture, that range in compostion from rocks containing quartz and alkali feldspar to augite andesites and tuffs of similar composition. All are more or less

[6] Martin, G. C., and Katz,, F. J., op. cit., pl. 11.
[7] Idem, pp. 50–56.
[8] Smith, P. S., op. cit., pp. 104–112.

metamorphosed, and such alteration products as calcite, chlorite, secondary quartz, epidote, and iron oxides are common. Little opportunity was afforded for the study of these rocks immediately northwest of the upper end of Lake Clark, but in the headward tributaries of the Chilikadrotna River rocks that are thought to belong to this group include olivine basalt porphyry, now much chloritized and serpentinized; andesite greenstone, also much altered; and basaltic greenstone.

Farther southwest, in the area drained by the eastern tributaries of the Koksetna River, the porphyry and lava are less abundant, and the rocks consist mainly of clastic materials that range from argillite and slate to tuff in which most of the fragments are of volcanic origin but which also contain some fragments of sedimentary rock and to graywacke containing mainly normal sedimentary material. In composition the graywacke and tuff grade into one another in such a way that it is impossible to draw a sharp line of distinction between them, and in the field it is impracticable to make such a distinction. Apparently during the deposition of these beds there were times of little volcanic activity during which normal sedimentation took place, but at other times volcanic activity yielded considerable fragmental material that was intermingled and deposited with the clastic detritus and so built water-laid beds containing variable proportions of fragments of igneous origin. The eastern basin of the Koksetna River was apparently so far removed from the areas of volcanic activity that relatively little volcanic material fell there, but farther east and northeast volcanic materials greatly preponderate.

The beds of this group have suffered considerably from regional metamorphism. The lava and tuff are much altered and full of secondary minerals. The sediments are faulted, folded, and metamorphosed, the mudstone having become hard argillite and in places even slate and the graywacke and tuff having been cemented with secondary silica to form hard, impure quartzitic beds. Locally the group contains some black or gray chert. In general the bedding stands at rather high angles, and locally care must be exercised to avoid confusing the slaty cleavage with the true bedding, which is obscure.

On Plate 2 only a few granitic bodies are mapped as cutting the rocks of this group, but dikes and sills intruding them are common, and no doubt more detailed work will outline other granitic areas of sufficient size to be shown on a map of this scale.

No reliable estimate can be made of the thickness of this group. Northwest of Lake Clark mountains 4,000 feet or more in height are composed entirely of these rocks, and although it is recognized that faulting and folding have been active and in places may have made

the section appear thicker than it normally is, nevertheless it is difficult to imagine that less than 4,000 to 5,000 feet of beds are involved in the group. The thickness certainly varies greatly from place to place, however, for it depends to a considerable degree upon the amount of igneous material present, and individual lava flows vary greatly in thickness from place to place.

Age and correlation.—No information was obtained in the region that warrants a precise definition of the age of this rock group. No fossils have been found in it, and its approximate age can be determined only by correlation with similar rocks in neighboring areas, where the age relations are more definite. Thus Martin [9] suggests that the volcanic rocks of this group near Iliamna and Clark Lakes may possibly be correlated with beds at Seldovia that have similar lithology and sequence and that have been assigned to the Lower Jurassic. Similarly the writer [10] considers the lava and tuff to be correlative with similar rocks observed in the Stony, Chakachatna, and Skwentna Basins that he tentatively assigned to the Lower Jurassic. Certainly the volcanic rocks in those regions underlie Upper Cretaceous shale, and the evidence given for their assignment to the Lower Jurassic seems fairly conclusive. The slate-argillite-graywacke-tuff portion of this group appears to overlie the dominantly volcanic portion and therefore to be younger. It also appears to underlie the shale-argillite-graywacke group west of the Koksetna, and, as will be shown, that group is probably, in part at least, of Upper Cretaceous age. This entire group of sedimentary and volcanic rocks therefore appears to occupy the interval between the Triassic and the Upper Cretaceous and to be in part Lower Jurassic. Some of the upper sedimentary beds may be as young as Upper Jurassic or possibly even Lower Cretaceous.

ARGILLITE, SHALE, SLATE, AND GRAYWACKE GROUP

Distribution and character.—West of the Koksetna River and in the vicinity of Telaquana Lake there are areas in which the prevailing bedrock is composed mainly of metamorphosed sediments that were originally laid down as mud and impure sand but have now been consolidated to form argillite, shale, and graywacke, and these rocks have locally been further altered through faulting and folding to form slate. The areas of this formation, as shown on Plate 2, are widely separated, but it is likely that the sediments are fairly continuous from those localities through the region to the west of

[9] Martin, G. C., and Katz, F. J., op. cit., pp. 58–59.

[10] Capps, S. R., The Chakachamna-Stony region, Alaska: U. S. Geol. Survey Bull. 813, pp. 111–113, 1930; The Mount Spurr region, Alaska: U. S. Geol. Survey Bull. 810, pp. 156–160, 1929; The Skwentna region, Alaska: U. S. Geol. Survey Bull. 797, pp. 82–86, 1929.

that in which geologic observations have been made. Smith,[11] in a traverse from Lake Clark to the Kuskokwim, found shale and sandstone of this group to be the dominant rocks from the Chulitna River northward to and beyond the Hoholitna and eastward nearly to Whitefish Lake, and there is reason to believe that these rocks predominate from Smith's route eastward to the area here under discussion. Still farther north, in the basin of the Stony River, a continuation of this rock group has been traced to the head of the Stony.

The isolated mountain mass lying west of the Koksetna River and between it and the Mulchatna and the Chilikadrotna is composed entirely of sediments of this group, cut by minor amounts of intrusive rocks of various sorts. The eastern flank of these mountains was traversed by P. S. Smith, who describes the rocks rather fully under the designation "Mesozoic shales south of the Kuskokwim," so that only a brief description will be given here. The rocks consist of a monotonous succession of dark shale or argillite and impure sandstone or graywacke, the relative amounts of these two types of sediment varying from place to place. Locally the shale and argillite predominate, and little graywacke is present. Elsewhere the graywacke is much more abundant than the mudstones.

Both argillite and graywacke locally show the effects of contact metamorphism in the neighborhood of bodies of intrusive rocks, with the formation of secondary mica and other contact minerals such as chiastolite, cordierite, and andalusite. Locally, too, the sediments have suffered from dynamic metamorphism also, and pronounced schistosity and slaty cleavage have been developed. In general, however, the sediments are moderately altered shale, argillite, and graywacke.

The sediments exhibit a wide variation in structure. West of the Koksetna River the prevailing strike of the bedding is east-northeast, with generally steep dips both northwest and southeast. Near Telaquana Lake the sediments have been much sheared, faulted, and crumpled; the folds trend nearly east, and the prevailing dips are about 50° S. Still farther north, in the upper part of the Stony Basin, the beds strike nearly north, dip steeply, and are highly schistose. In many places both coarse and fine sediments of this group contain scattered cubes of secondary pyrite and on weathering take on a conspicuous rusty color.

Age and correlation.—No fossils have been found in this group of sediments in the region here described, nor did Smith find fossils in his traverse over these sediments between Lake Clark and the Hoholitna River. By correlation and by inference Smith con-

[11] Smith, P. S., op. cit., pp. 63–72.

cluded that these rocks were of Mesozoic age and that in part they were to be assigned to the Middle Jurassic, though he suggested that some beds might be younger and some older than that. In 1928 the writer found a fossil invertebrate in the basin of the Stony River, in beds that are lithologically like those here described and that lie directly along the strike of this group and only 10 or 15 miles northeast of the area of these rocks at Telaquana Lake. That fossil was determined to be an *Inoceramus* of Cretaceous, probably Upper Cretaceous age. Still farther north, in the basin of the Skwentna River, the writer had earlier found in similar beds a fossil leaf that was identified as of Upper Cretaceous or Tertiary age. As the containing rocks were much older in appearance than any known Tertiary beds in this part of Alaska the plant was assumed to be Upper Cretaceous. That determination, supported by the fossil from the Stony Basin, seems sufficiently definite to warrant the conclusion that at least a large part of the argillite-shale-slate-graywacke group on the west side of the Alaska Range, between Lake Clark and the South Fork of the Kuskokwim River, is of Upper Cretaceous age. Neither of the fossils upon which this determination is based was found at the top or at the bottom of this group of beds, and as the group is several thousand feet thick it is entirely possible that some beds older and some younger than Upper Cretaceous may be included. The known Tertiary rocks of this part of Alaska, however, are different in lithology and are younger in general appearance than the rocks of this group, and the writer considers it doubtful that any of this group is younger than Upper Cretaceous. On the other hand, it appears quite likely that some Jurassic beds are included in it.

TERTIARY VOLCANIC ROCKS

Distribution and character.—A considerable area in the upper basin of the Chilikadrotna River is occupied by lava and tuff that are younger than any of the Mesozoic rocks described above. These rocks occur mainly in the foothills and in general form rounded hills or mountains that rise 1,000 to 2,500 feet above the bordering valleys, though just south of the large lakes in the upper reaches of the Chilikadrotna, where the foothills merge into the main range, mountains of these lavas rise 3,000 feet above the lakes. Rocks of this formation have been noted by Martin and Katz [12] on the southeast shore of Lake Clark and on Chulitna Bay, and by Smith [13] on the mountains immediately west of Sixmile Lake. In none of those places does this lava occupy continuous areas of more than a few

[12] Martin, G. C., and Katz, F. J., op. cit., p. 76.
[13] Smith, P. S., op. cit., pp. 122–127.

square miles. In the upper basin of the Chilikadrotna, however, there is an area of over 200 square miles that is occupied almost exclusively by these rocks, though they are overlain and concealed in places by unconsolidated surface deposits.

This volcanic group is composed of lava and tuff of sharply contrasting appearance and composition. The predominant rocks range in color from white through cream-colored to pink, red, and brown and consist of rhyolite and andesite flows and tuffs. Especially conspicuous are certain areas of nearly white rocks that in the field appear to be well-laminated volcanic glass but under the microscope prove to be very fine grained rhyolite tuff, probably derived from the consolidation of beds of volcanic ash. Elsewhere black obsidian occurs. Associated with these acidic volcanic materials are almost equally conspicuous black diabase and basalt flows, some showing columnar structure. In general the basaltic flows appear to occur near the upper part of the series, though in places basalt flows were seen overlain by several hundred feet of the more acidic lavas.

Structure and thickness.—As a rule the Tertiary lavas lie more nearly horizontal and are less deformed than any of the other hard rocks of the region. In the outlying foothills they show little folding or tilting, though nearer the main range mild folding and both normal and thrust faults of considerable displacement were observed. Their freedom from metamorphism is also apparent in the thin sections, which show the rocks to be fairly fresh and unaltered. In areas where these rocks lie nearly horizontal and there is no evidence of duplication by folding or faulting the series is certainly 2,000 to 2,500 feet in thickness, with a possible maximum of 3,000 feet.

Age and correlation.—No close age assignment for this group of volcanic rocks is possible at present. They carry no fossils, overlie unconformably the older Lower Jurassic (?) group of volcanic and sedimentary rocks, and are themselves overlain only by Pleistocene and Recent unconsolidated materials. Martin[14] assigns the basalt flows and tuff of Iliamna Lake and east of Lake Clark to the late Tertiary, his conclusion being based in part on some poorly preserved fossils of probable Tertiary age that he found in sandstone underlying the basalt on Iliamna Bay. Martin, however, separated the basalt of this group from the more acidic associated lava and tuff, considering that the andesite and rhyolite belonged to the group of Lower Jurassic volcanic rocks and the basalt to be Tertiary. Smith[15] later found rhyolite, overlain by basalt, lying unconformably on older, much decomposed andesite, and recognized the fact

[14] Martin, G. C., and Katz, F. J., op. cit., p. 82.
[15] Smith, P. S., op. cit., pp. 125–126.

that the younger group of lavas comprises both acidic and basic flows and tuffs. Observations in the Lake Clark-Mulchatna region support the view taken by Smith, for these basaltic lavas were found interbedded with more acidic flows, though in general the basaltic phases were near the top of the series. Smith accepted the assignment of these lavas to the Tertiary. This age determination is strengthened by the later evidence as to the Upper Cretaceous age of at least a part of the argillite-shale-slate-graywacke group west of the Koksetna River, for those sediments are certainly older than this group of lavas. As the lavas are younger than part of the Upper Cretaceous rocks and older than Pleistocene, they fall somewhere in the late part of Upper Cretaceous time or in the Tertiary, but no more accurate assignment is possible from the evidence now at hand. It is suggested that they may be the surface, effusive phase of the granite intrusions, but that seems hardly likely, for the lavas are little deformed, whereas the granites and the sediments they intrude are much deformed and appear to be older than the lavas.

INTRUSIVE ROCKS

Granitic rocks form an abundant element in the Alaska Range from its south end, south of Iliamna Lake, northward to and beyond Mount McKinley, and in those areas that have been mapped much of the higher and more rugged portion of the range is carved from granitic materials.[16] Within the area here described, however, granitic rocks occur in less abundance. In the basin of the Koksetna River a few granitic outliers occur, but in the upper Mulchatna and Telaquana Basins the main granitic mass of the range projects farther west and actually reaches the face of the range. On Plate 2 granitic rocks are shown as having no very broad distribution, but it should be remembered that not far east of the area mapped the range is predominantly granitic, the contact between the granitic rocks and the Mesozoic lavas and sediments stretching through unsurveyed country from the head of Lake Clark to the face of the range at Telaquana Lake. No doubt the proportion of granular intrusive rocks to lavas and sediments would have been found to be much larger if the mapping had been extended to the extreme headwaters of the Mulchatna and Telaquana Rivers.

The rocks here described under the inclusive term "granitic rocks" include a considerable variety of coarsely crystalline, deep-seated

[16] Capps, S. R., The Chakachamna-Stony region, Alaska: U. S. Geol. Survey Bull. 813, pp. 109–110, 1930; The Mount Spurr region, Alaska: U. S. Geol. Survey Bull. 810, pp. 140–172, 1929; The Skwentna region, Alaska: U. S. Geol. Survey Bull. 797, pp. 67–98, 1929; The Yentna district, Alaska: U. S. Geol. Survey Bull. 534, p. 75, 1913. Brooks, A. H., The Mount McKinley region, Alaska: U. S. Geol. Survey Prof. Paper 70, p. 234, 1911.

intrusive materials, of varying color, texture, and composition. Gray colors predominate, though pink granite is present, and the range is complete from nearly white rocks with almost no ferromagnesian minerals to black hornblende rocks that have little quartz and feldspar. In some localities true granite prevails; elsewhere quartz diorite and diorite predominate. The outlying masses in the basin of the Koksetna River are less coarsely crystallized than the typical granite of the main range and might properly be termed granite porphyry.

The age of at least part of the granitic intrusive rocks of this region can be assigned within certain limits, though the evidence is not so conclusive as could be desired. Martin and Katz[17] placed some of the granites on the shores of Cook Inlet rather definitely as later than Triassic and earlier than Upper Jurassic and considered them as, in part at least, of Lower Jurassic age. In the region north of Lake Clark the granitic rocks in the Koksetna Basin certainly cut tuffs and sediments that are believed to be in part of Lower Jurassic age and possibly in part younger. So far as known they do not cut the lavas and tuffs that are thought to be of Tertiary age. In the Chakachamna-Stony region, adjoining this area on the north, and in the upper Skwentna Basin, still farther northeast, the writer found granite cutting argillite and shale that carry Upper Cretaceous fossils. The granite has nowhere in the range been found to intrude the Eocene coal-bearing formation. From these facts it may be stated that at least part of the granitic rocks of the Alaska Range are as young as Upper Cretaceous and are probably older than the part of the Eocene represented by the coal-bearing beds of that age.

QUATERNARY DEPOSITS AND HISTORY

Preglacial conditions.—The youngest hard rocks in the Lake Clark-Mulchatna region are the Tertiary volcanic materials in the Mulchatna Basin. The part of Tertiary time represented by these volcanic rocks is not known, but the lavas and tuffs were probably laid down as terrestrial deposits, and so far as the sedimentary record shows this region finally emerged from the sea at the end of Upper Cretaceous time and has remained a land area ever since. The end of the Mesozoic era was here marked by pronounced folding, faulting, and warping of the preexisting rocks, and after the Tertiary volcanic rocks were laid down there was still some regional metamorphism, which also involved folding and faulting, though these movements were less severe than those at the end of the Mesozoic.

During all of Tertiary time, therefore, this region was exposed to erosion by streams and by all the agencies that are at work upon

[17] Martin, G. C., and Katz, F. J., op. cit., pp. 76–77.

exposed land surfaces. Mature drainage patterns were developed upon it, and mature stream valleys were carved. It is believed that at the end of the Tertiary period the mountains had approximately their present relief and the rivers followed much the same courses that they do to-day. The general aspect of the country, however, must have been quite different from that we now see. The mountain forms, developed mainly by stream erosion, were less rugged than at present, the valley walls in the high mountains were less steep, and the stream gradients from the valley heads to the great lowlands on the west were more uniform than they now are. The widespread mantle of unconsolidated gravel and of glacial deposits, now so conspicuous in the foothills, was absent, as were the many lakes that form so striking a feature of the present landscape.

Glacial epoch.—Neither the beginning nor the end of the glacial epoch is so sharply defined in Alaska as it is in the lower latitudes in the United States. The high mountains of Alaska to-day nourish vigorous glaciers, and it is likely that this was true also in Tertiary time. Thus the higher valleys in this part of the Alaska Range have probably been continuously glaciated for a very long period, perhaps since some time in the Tertiary. At the beginning of Pleistocene time, however, there came a gradual change in climate, with a decreasing mean annual temperature, so that the existing glaciers grew in size, and in many valley heads that had been previously free of glaciers snow and ice accumulated year by year to form ice tongues. These separate valley-head glaciers slowly grew larger and longer, pushed down their separate troughs to join in the main stream valleys, and ultimately stretched down to the westward beyond the mountain front and far out onto the lowland, there to coalesce with ice streams from adjoining mountain basins. In this way all the mountain valleys became filled with ice, so that at the times of maximum glaciation only the higher ridges and peaks projected above the surface of the glaciers. Each mountain valley sent its ice flood out onto the lowland, and these streams, coalescing in the lowlands, formed a piedmont glacier that filled the valleys in the foothill belt and surmounted most of the isolated groups of hills there. On the shale-graywacke hill west of the Koksetna River the glacial ice stood up to an altitude well over 3,000 feet. In the upper Mulchatna Basin practically all the lava ridges below 4,000 feet were surmounted by ice, and the surfaces of the ice streams in the Telaquana, Mulchatna, and Chilikadrotna Valleys stood at a height of about 4,000 feet at the points where they emerged from the main range into the more open valleys of the foothill belt.

The western margins of these glaciers, at the time of their last great development, lay west of the region here described. Smith [18] has outlined approximately the outer margins of the glaciers that moved westward from the Alaska Range into the Mulchatna, Hoholitna, and Stony Basins during the last great ice advance and shows that they moved well down into the Mulchatna Valley and that a lobe pushed down some 15 or 20 miles beyond Whitefish Lake into the Hoholitna Valley and down the Stony to a point within about 40 miles of the mouth of that stream. This distribution corresponds closely with what could have been predicted from observations made on the height reached by the ice along the flanks of the main range. At the south border of this region the ice that moved southwestward along the great valley now occupied by Lake Clark was moving into an open lowland country that included the broad flat basin of the Chulitna River and the great lowland of lower Iliamna Lake. In these lowlands the mountain glaciers could expand laterally, and the surface of the ice became correspondingly lower, so that at the mouth of the Nondalton River the glacier was only 1,200 to 1,400 feet thick.[19]

Glacial erosion and deposits.—The influence of the Pleistocene glaciers upon the topography of this region was tremendous. By the abrading action of enormous masses of moving ice, shod with innumerable rock fragments, the loose materials upon the surface were rapidly removed, and later the bedrock itself was worn down in places to great depths. Within the narrow valleys in the mountains the ice was deepest, its movement was most rapid, and its power to deepen and widen its troughs was greatest. As a result, each mountain valley now carries conspicuous evidences of the former presence of great glaciers, such as steep headward cirques, clifflike side walls, broad, troughlike valleys free from projecting spurs and ridges, and glacial lakes. The processes of glacial erosion are still active in those valleys which harbor glaciers to-day.

Beyond the face of the mountains, in the piedmont area, the results of past glaciation are equally striking, though different. There the ice could expand laterally as the valleys widened, its thickness and its rapidity of movement decreased, and although projecting ridges and hills over which it passed were attacked by ice erosion, the glaciers could deposit in this area of more sluggish movement much of the material picked up above. Thus in the high mountains the action of the glaciers was mainly erosive, but within the foothills and in the lowlands to the west the glaciers modified the appearance of the country mainly by deposition. The most conspicuous of the accumulations of ice-deposited débris are the great lateral moraines

[18] Smith, P. S., op. cit., pp. 85–94.
[19] Martin, G. C., and Katz, F. J., op. cit., pp. 82–88.

that border the north side of the valley of the Chilikadrotna and both sides of the Mulchatna and Telaquana Valleys at the places where those streams emerge from the mountains. The surface of the moraine north of the Chilikadrotna, at the point where it abuts against the mountain face, stands 2,000 feet above the valley floor, reaching an altitude of 4,000 feet, but descends rapidly toward the west, so that 7 miles west of the mountain face it has an altitude of only about 2,100 feet and is only 300 feet above the valley floor. Similarly, on both sides of the large lake in the upper Mulchatna Basin lateral moraine ridges rise to altitudes of 4,000 feet at the mountain face some 1,500 feet above the surface of the lake. Telaquana Lake is likewise flanked on the north and south by great lateral moraine ridges that at their highest points stand 3,600 to 3,800 feet above sea level, or 2,400 to 2,600 feet above the lake surface. Some of these moraine ridges certainly consist of a thick veneer of glacial débris over a preexisting rock spur, and possibly all of them are so constituted. Nevertheless, postglacial gulches cut in some of these lateral moraines show that in places the morainal material is at least several hundred feet thick.

Between the north lateral moraine on the Mulchatna and the south lateral moraine on the Telaquana there is an area some 6 or 7 miles wide and 10 miles or more long that has mild relief and comprises a high rolling plain. It appears to be composed entirely of gravel deposits and is probably an outwash plain which, during the early stages of retreat of the last great glaciers, formed a basin between two large glaciers, from each of which heavily loaded streams discharged gravel into this basin.

A characteristic feature of the foothill belt in this region and of the hill-dotted lowland to the west consists of the wide gravel-floored valleys with their many lakes and generally low gradients. All these valleys were occupied by ice during the last great ice advance, and during the retreat of the glaciers they were aggraded by great quantities of glacial outwash gravel, sand, and silt. In places the present streams have cut through this filling to the underlying bedrock, but in general they flow over a gravel fill and are flanked by gravel terraces. In all likelihood the outwash gravel extends westward down the Mulchatna, Hoholitna, and Stony Valleys beyond the border reached by the ice during its farthest westward stand.

As a result of the extensive aggradation of the lowland valleys of this region and of glacial erosion in the more mountainous areas, many changes in drainage have resulted during and since glacial time. Thus the upper Koksetna probably once drained into the Chilikadrotna. Quite possibly the present Lake Clark Basin had its preglacial outlet to the Mulchatna by way of the Chulitna Valley. The present head of the Mulchatna might well have flowed into the

Chilikadrotna at the low pass 8 miles southwest of the lake. Without much doubt College Creek and Ingersoll Lake formerly drained eastward through a low pass to the Tlikakila (Big) River, and many other drainage changes, small and large, resulted from the occupancy of this region by glacial ice. Most of the lakes owe their origin either to glacial erosion or to damming by glacial deposits, or both, though many small lakes and ponds have been formed behind beaver dams.

Older glaciation.—It has long been known that throughout the northern United States there were repeated advances and withdrawals of glacial ice during the Pleistocene epoch, each advance being separated from the others by a long interval during which the ice melted back and a milder climate prevailed. Information is gradually accumulating to show that Alaska also has been the scene of repeated glaciations during Pleistocene time. At several places glacial deposits have been observed which either underlie the débris left by the last great glaciers or which in stage of oxidation, weathering, or induration indicate plainly that they are much older than the materials left during the last great glacial stage. A deposit of this type was observed in the upper basin of the Chilikadrotna River, about 2 miles north of the outlet of the lower of the two large lakes, where there is an exposure of rounded and subangular boulders and pebbles and of fragments of a wide variety of rocks, embedded in a clayey matrix. Boulders, pebbles, and rock fragments are somewhat decayed, and their original surfaces are lost. No striae were found, but few pebbles were sound enough to have retained striae, even if they had once been present. The matrix and the included rocks are oxidized to a conspicuous reddish color, in contrast to the blue color and unoxidized and undecayed character of the more recent till by which this deposit is overlain. The fresh overlying till is a part of the lateral moraine left by the ice during the last great ice advance, in Wisconsin time. The oxidized and decomposed till beneath is believed to be morainal material left by the ice during a pre-Wisconsin stage of the Pleistocene. There is too little information at hand to justify the correlation of this older glacial deposit with any particular stage of Pleistocene glaciation.

Present stream gravel.—The deposits of the present streams, which on Plate 2 are included in a single pattern with the other unconsolidated deposits of the region, are of rather scanty development in the area here described. In most parts of the Alaska Range the streams that head in the high mountains, especially those that rise in glaciers, have broad flats built up of the detritus received from the glaciers or eroded from the steeply sloping mountain basins. The region here discussed includes only the outer face of the main range. Farther

east many of the streams have extensive gravel flats and wide flood plains. As it happens, most of these streams have large lakes in their basins at the points where the valleys pass from high mountains to the foothill belt. This is true of the Telaquana, Mulchatna, and Chilikadrotna Rivers, and Ingersoll Lake lies in the mountain valley of the Kijik River. Above these lakes the rivers are characterized by broad outwash trains of gravel through which the streams flow in many branching channels. The lakes, however, act as traps in which the streams drop all of their heavy débris, and the rivers that drain the lakes, while somewhat cloudy with fine glacial silt, nevertheless carry little gravel and sand. As a consequence they have developed only narrow flood plains and flow in single, well-defined channels through the lowlands. They are only moderately swift, and on most of them places at which horses can ford can be found in normal stages of water. It is not known whether or not the Telaquana River is fordable below the lake. In fairly high stages the Kijik River is said to be a dangerous stream to cross, even with horses, but in July and August, 1929, an easy ford was found a short distance below the point where the Telaquana trail meets the river.

Volcanic ash.—At several places within this area, as throughout the region from Lake Clark northward to the Skwentna River, there is a layer of volcanic ash just beneath the turf. The ash ranges from a few inches to several feet in thickness, and apparently was scattered by an eruption from some volcanic vent that cast ashes over an area of many thousands of square miles in the southern portion of the Alaska Range. In the Mount Spurr region [20] ash, apparently from this same fall, attained 6 feet in thickness, and in the Skwentna region [21] the deposit was from an inch or so to more than 3 feet thick. In general the ash is thickest in the region around Mount Spurr, a volcanic mountain that still shows signs of mild activity. It therefore seems probable that this mountain was the vent from which the ash was ejected. Mature spruce trees growing on top of the ash indicate that it fell at least 100 or 200 years ago.

MINERAL RESOURCES

The Lake Clark-Mulchatna region has been so little visited by white men and is still so incompletely prospected that no fair judgment as to its mineral resources can yet be made. Mining has been limited to small gold placer-mining operations on some of the

[20] Capps, S. R., The Mount Spurr region, Alaska: U. S. Geol. Survey Bull. 810, pp. 167–168, 1929.

[21] Capps, S. R., The Skwentna region, Alaska: U. S. Geol. Survey Bull. 797, pp. 95–96, 1929.

tributaries of Lake Clark. The most ambitious attempt to develop the gold placer deposits on any one stream took place in 1910 to 1912 on a creek locally known as Portage Creek, which flows into Lake Clark from the northwest some 10 miles northeast of the mouth of the Kijik River. A number of men worked for three summers on the lower four claims on that stream, and it is reported that the total value of the gold recovered was about $2,000. Desultory mining has been done at a few other localities near Lake Clark, but the results were discouraging, and in 1929 no placer mining was in progress in this region.

It is reported that a small gold-placer stampede took place about 1912 to what was then known as "the Stony River country." The focus of interest was at the canyon of Bonanza Creek, a tributary of the Mulchatna that flows westward from the foothills that lie west of the part of the Chilikadrotna Basin shown on the plate, some distance west of the region here under discussion. Some gold placer prospects were found, but only a few dollars' worth of gold was recovered. It is said that there is some ground on Bonanza Creek that might be profitably worked if the region were less remote and the cost of hauling in supplies and equipment not prohibitive.

In the region between Lake Clark and Iliamna Lake there are reported to be several gold and copper prospects that show considerable mineralization. These prospects occur in rocks similar to those that have been mapped in the present investigation. This occurrence and the fact that many areas near the contacts of granitic rocks with sediments, especially those of the smaller granite masses, are sites of mineral deposits give some hope that further prospecting will result in the discovery of valuable lode deposits in this region. The outlook for the finding of profitable gold placer deposits in this region is less promising, though possibly small areas of workable ground occur there. The severe glacial erosion within the high mountains is likely to have removed any extensive preglacial accumulations of placer gold that may have existed, and the thick deposits of gravel in the valleys in the foothill belt make it difficult to sink to bedrock and so determine whether or not paying ground is present.

As for nonmetallic mineral deposits of value, little can be said. No coal-bearing beds are known in this region and there is probably no coal here. There is also no likelihood that the rock formations here represented are oil bearing. Certainly the granite and other igneous rocks offer no hope, and the Mesozoic sediments are so highly metamorphosed and so lacking in organic material that the chance that they contain oil pools is remote.