THE MOUNT SPURR 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 side of Cook Inlet, in latitude 60° 50′ to 61° 30′ north, longitude 151° to 153° 20′ west. Mount Spurr, a prominent snow-clad peak of 11,000 feet altitude that is plainly visible from Cook Inlet, lies almost centrally in the region. As can be seen from the coast, the region to the west consists of a piedmont belt, beyond which lies a rugged snow-capped range, with great glaciers extending down the valleys to the mountain front. Heretofore this region, except for a part of the piedmont belt, has been almost entirely unexplored, yet existing knowledge of surrounding areas indicated that within it lay the headwaters of several large rivers, including streams that drain eastward to Cook Inlet, southward to Lake Clark and Bristol Bay, westward to the Kuskokwim and Bering Sea by way of the Stony River and the South Fork of the Kuskokwim, and northward through the Skwentna River to the Susitna. Inquiries which have been made for many years of prospectors, trappers, and hunters had failed to bring to light any information about the mountainous portion of this region, though vague accounts from the natives indicated that there was some sort of difficult route by which it was possible to go on foot well back into the mountains somewhere west of Tyonek.

PREVIOUS SURVEYS

Although the Russian fur traders had pushed eastward along the Alaska Peninsula as far as Kodiak Island by 1762, they had made no permanent settlements on the American continent at that time. The earliest accurate information about this part of Alaska was that obtained by the British navigator Capt. James Cook, who in May, 1778, discovered the inlet that bears his name and soon afterward sailed northward up it as far as Point Possession, charting its shores as he proceeded. A second British expedition, in charge of George

Vancouver, returned to the inlet in 1794 and completed the charting of its upper end, including Turnagain and Knik Arms.

From 1794 until the transfer of Alaska from Russia to the United States, in 1867, the Russians had gradually extended their trading posts to this part of Alaska but apparently carried on no systematic surveys. The Russian charts of that time add little to the surveys of Cook and Vancouver, except that they show in a general way the courses of the Susitna and Matanuska Rivers.

From 1867 until the discovery of gold in the upper Cook Inlet region, in 1894, there was a general apathy concerning this part of Alaska, and though in the next four years there was a large influx of prospectors and miners into the Cook Inlet region, most of them left no written record of their explorations.

The discovery of bonanza gold placer deposits in the Klondike was the stimulus that brought about a tardy recognition of the value of this frontier territory, and appropriations were made by the Federal Government for systematic surveys. Among the agencies chosen to do this work was the United States Geological Survey, which in 1898 had members on several expeditions that radiated west, north, and east from the head of Cook Inlet. Two of these expeditions ascended the Matanuska and Susitna Rivers, respectively, but the one that had most bearing on the region here under discussion was that in charge of J. E. Spurr[1] and W. S. Post, who ascended the Susitna, Yentna, and Skwentna Rivers to the mouth of Portage Creek, proceeded up that creek to a high pass across the Alaska Range, and thence descended the Kuskokwim to its mouth, returned by canoe eastward to the Alaska Peninsula, and terminated their exploration at Katmai Village. Thus on this trip they traveled entirely around the region here described. As a result of this extraordinary trip they obtained geographic and geologic information concerning a large area, including a section directly across the Alaska Range.

The next expedition to procure definite topographic and geologic information in this general region was that conducted by Alfred H. Brooks[2] in 1902. The Brooks party landed at Tyonek and proceeded by pack train northward to the Skwentna River and thence westward across the Alaska Range at Rainy Pass, from which their course lay northward along the face of the range. The expedition yielded an astonishing fund of information about a great area that had previously been unexplored, but it left untouched the great mountainous region south of the Skwentna.

[1] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 43–264, 1900.

[2] Brooks, A. H., The Mount McKinley region, Alaska; U. S. Geol. Survey Prof. Paper 70, 234 pp., 1911.

Later explorations of the Geological Survey that reduced the unmapped area of that part of the Alaska Range that lies south of the Skwentna were made by G. C. Martin [3] on the shore of Cook Inlet between Tuxedni and Iniskin Bays in 1903 and 1904; by Martin, Katz, Witherspoon, and Giffin in the Iliamna-Lake Clark region in 1909; by P. S. Smith [4] and R. H. Sargent in their expedition from Lake Clark to the Kuskokwim in 1914; and with more detailed mapping by F. H. Moffit [5] and associates on the coast of Cook Inlet in 1921.

All these expeditions procured invaluable geologic and geographic data from the areas that they traversed, but there still remained a great region of about 15,000 square miles, roughly outlined by Spurr's route along the Skwentna River on the north, by Snug Harbor, the Iniskin-Chinitna Peninsula, and Cook Inlet on the southeast and east, by Lakes Clark and Iliamna on the south, and by the Kuskokwim-Mulchatna lowland on the west, that was entirely unmapped and virtually unexplored. Plans had been under consideration for many years by the Geological Survey to enter this region, but lack of funds forced the postponement of these projects. In 1926, however, a party in charge of the writer [6] ascended the Skwentna River to its head and mapped a considerable area on the north edge of this region.

PRESENT INVESTIGATION

The expedition of 1927, here described, was planned for the purpose of still further reducing the unexplored portion of this part of the Alaska Range and of studying its geology, in order to determine its mineral resources. In spite of the extended inquiries that had been made, no information was available as to the easiest route of approach to the mountainous area or as to the possibility of taking pack horses from Cook Inlet westward to and beyond the face of the forbidding mountain range that could be seen from the coast. There were vague reports that many years ago the natives were accustomed to cross the mountains to the head of the Skwentna to hunt caribou, but the route that they traveled was not known. The only clue as to the location of a route into the range was the break in the mountain front just south of Mount Spurr, which could be seen from a distance and which offered the only possible entry into the mountains, the other valleys all being occupied by vigorous glaciers.

[3] Martin, G. C., and Katz, F. J., A geologic reconnaissance of the Iliamna region, Alaska: U. S. Geol. Survey Bull. 485, 138 pp., 1912.

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

[5] Moffit, F. H., The Iniskin-Chinitna Peninsula and Snug Harbor district, Alaska: U. S. Geol. Survey Bull. 789, 71 pp., 1927.

[6] Capps, S. R., The Skwentna region, Alaska: U. S. Geol. Survey Bull. 797, pp. 67–98, 1929.

There was also considerable doubt as to whether horses could be taken from the shore of Cook Inlet westward to the mountains, for the coastal belt, from 15 to 35 miles wide, was known to contain large marshy areas and to have great areas of dense alder thickets through which trail must be chopped tediously and laboriously.

A careful consideration of all the information available indicated that the most promising line of attack was to land on the west side of Cook Inlet a few miles south of the native village of Tyonek and to proceed thence westward to the mountain front just south of Mount Spurr, with the hope that at that place a possible route would be found westward into the mountains. Accordingly the party was organized at Anchorage during the first week of June, 1927. The writer was in charge and was responsible for the geologic mapping. R. H. Sargent, topographic engineer, was to carry on the topographic surveys, assisted by Ray C. Russell, recorder. C. C. Tousley and G. W. Pearson were employed as packers, and Edgar Brooker as cook. An excellent pack train of 15 horses was leased from W. N. Beach, of New York. By the courtesy of Noel W. Smith, general manager, a gasoline launch and a large open scow were chartered from the Alaska Railroad, and every possible facility was provided for the transfer of the party to its point of debarkation and for its return in the same way to Anchorage at the end of the field season. The writer wishes here to acknowledge his deep obligation to the members of the party for faithful services performed throughout a difficult journey; to Mr. Noel W. Smith for his hearty cooperation with the facilities of the Alaska Railroad; and to Mr. and Mrs. E. L. Everett and Mr. R. H. Koch for their unfailing hospitality at their fishing site near Nicolai Creek.

On June 10 the party of 6 men, with 15 horses and supplies and provisions for 100 days, sailed from Anchorage and landed that same day on the open beach of Trading Bay, about 2 miles northeast of the mouth of Nicolai Creek and 65 miles southwest of Anchorage. The point chosen for departure from the beach proved most fortunate, for there a piedmont slope rises gradually from the shore toward the mountains, offering comparatively solid footing for horses, whereas immediately to the southwest is a great marshy lowland drained by Nicolai Creek and the Chakachatna and McArthur Rivers, and this lowland is utterly impassable for horses in the summer. The first 12 to 15 miles of the journey toward the mountains lay along a ridge at an altitude of only 200 to 300 feet above sea level, through spruce, birch, and hemlock timber and around the edges of irregular marshes. Considerable trail cutting was necessary, but forward progress of about 5 miles a day could be made. Still farther west the height of the ridge increased, and as timber line was approached, at an altitude of about 1,200 feet, the country became more open and afforded excellent travel through grassy meadows and along mossy ridges.

At a point about 18 miles by trail from the beach the ridge followed rises to an altitude of 1,700 feet and swings somewhat to the north. It therefore became necessary, in order to ascend the large valley to the south of Mount Spurr, to drop down into the brushy lowlands. There for many miles the expedition encountered dense alder thickets that required laborious trail cutting before horses could be taken through them. In places the efforts of the entire party could open less than a mile of trail in a day. The route followed led southwestward toward a large river that could be seen to emerge from an extensive valley that cuts the mountains on the south flank of Mount Spurr. When this river, the Chakachatna, as it was known to the natives, was reached it was found to be a roaring torrent, far too deep and swift to be crossed with horses, and bordered on the north for several miles by rock cliffs several hundred feet high, against the foot of which it flowed. It was therefore necessary to return to the high bench north of the river and cut trail for several miles through dense alders to a point above these rock bluffs. That accomplished, it was found possible to ascend the valley on the north bank of the river, though cut bluffs and thick brush still required much trail building and cutting.

Upon ascending the Chakachatna Valley about 15 miles into the mountains, at a distance of 35 miles from the beach, a glacier was encountered that descended from the southwest slope of Mount Spurr and pushed entirely across the valley of the Chakachatna, completely blockading the valley and impounding a superb lake, Chakachamna Lake. For its lower 3 miles this glacier is generally covered by coarse morainal material from a few feet to several feet thick, though in many places the ice shows through. The edges of the moraine are heavily clothed with large alder brush, and smaller alders have found a footing over the more stable portions of the moraine-covered ice. This glacier offers no serious obstacle to passage on foot, but the cutting and grading of a trail passable for pack horses across it required the equivalent of 20 days' work for one man.

Chakachamna Lake is about 23 miles long and lies in a deep glacial valley whose walls rise so abruptly from the water's edge that it has no beach upon which travel is possible except at the mouths of tributary streams, where small deltas have been built out into the lake. Travel with horses along the lake was obviously impossible, but a route was found around the northeast corner of the lake into the valley of the Nagishlamina River, a stream that flows southeastward into the lake. Up this valley the party proceeded, but only with difficulty, for the brush is heavy and the flat of the stream so strewn with great boulders that it was barely possible to take horses through. By dint of much trail cutting and some grading a route was opened to a point 6 miles above the lake, where a second glacier from the northeast blockaded the valley, and several days of trail work was necessary to cross it. About 4 miles farther to the northwest a third glacier crossed the valley, but this was passed with less delay. Above this third glacier a broad, open valley leads to the low pass into the head of the Skwentna, and here travel was easy. From the head of the Nagishlamina the party crossed a high but easy pass, at an altitude of 3,700 feet, into the basin of the Chilligan River, and thence southwestward across another easy pass to the Igitna, where the lateness of the season forced the party to turn back. So far as could be seen, no unusual difficulties other than considerable brush would be encountered in traversing the valleys of the streams that flow into Chakachamna Lake from the northwest, west, and southwest.

The return trip to the coast, over the trail already established, offered no difficulties other than some very soft going, for much of the route traveled earlier in the season was over ground that was still frozen a short distance below the surface, and by the end of the summer this ground had thawed, so that the trail, especially in some stretches that were cut through alder thickets, was so soft as to be barely passable even with lightly loaded horses. The launch and scow that had been arranged for in the spring arrived at Trading Bay on September 13, the date agreed upon, and the expedition arrived at Anchorage on the morning of September 14. After the return to Washington the thin sections of the rock specimens collected were examined by J. B. Mertie, jr., who has made the petrographic determinations mentioned in the discussion of the rock formations.

The area mapped during the expedition is shown on Plate 3.

GEOGRAPHY

DRAINAGE

Reference has already been made to some of the major drainage features of the region. Until the expedition of 1927 the only geographic features of this part of Alaska that were correctly shown on existing maps were the coast line of Cook Inlet; the mouths of the McArthur River and Nicolai Creek, which had been accurately located by the Coast and Geodetic Survey; and Mount Spurr, the position and altitude of which had been pretty well determined by the Brooks expedition in 1902 and later by the Coast and Geodetic

Survey. Some unofficial maps had been published on which a number of rivers and lakes were shown, but these were drawn from imagination and had little or no relation to the facts. Actual surveys had been made only of the lower mile or two of Nicolai Creek and the McArthur River. From the coast the view up the great lowland from which the McArthur River emerges shows the snout of a great glacier that pushes northeastward to the mountain front, and it was presumed that this glacier was the principal source of the river. It was determined, however, that another large stream, the Chakachatna, drains a large basin in the heart of the range and emerges from a valley just south of Mount Spurr to join the McArthur River only a few miles from the coast. Although the part of the McArthur River above the Chakachatna was not seen at close range, it is almost certain, from the size of the drainage basins of the two streams, that the Chakachatna supplies more water to the McArthur River than the glacier at the head of that stream. For the lower 25 miles of its course the Chakachatna flows through a marshy lowland at a comparatively low gradient and probably with a current of only moderate swiftness. Within the mountains it has a fall from 1,170 feet at its source in Chakachamna Lake to 400 feet at the western edge of the lowland and is a roaring torrent that through considerable distances has a current estimated at 15 miles an hour. The Chakachatna receives a number of tributaries from the north, all of which carry the drainage from the glaciers that radiate from Mount Spurr, and a few short tributaries of moderate size from the south, all of which head in glaciers in the granite mountains south of the river.

Chakachamna Lake, in which Chakachatna River has its source, lies in a great east-west glacial valley, the headward portion of which is damned by Barrier Glacier, a vigorous ice stream that descends the southwest slope of Mount Spurr. To ascend the Chakachatna Valley along the north side of the river to the lake (the south side being impassable for horses), it is necessary to cross the moraine-covered portion of Barrier Glacier, and this can be accomplished with little difficulty on foot, though for horse travel much trail building is necessary. The lake is a superb body of water, 23 miles long and on the average 2 miles wide, inclosed on all sides by steep, rugged, and lofty mountains that rise precipitously from the shores. The members of the expedition saw the lake from its lower end and from a number of points north and northwest of it. At a point 15 miles above its lower end the lake is constricted by a large ice tongue, Shamrock Glacier, that flows into it from the south. Above Shamrock Glacier there is another area of lake, but its exact shape and whether or not it is continuous with the lower lake could not be positively determined. Several glaciers from tributary valleys descend into the lake, or almost to it, and nearly every valley of the surrounding mountains contains a glacier at its head. The water of Chakachamna Lake is slightly turbid in summer, for all the streams that flow into it are glacial streams. The steep cliffs that form the shores of the lake on its north and south sides render land travel along the lake difficult or impossible, though by boat all points on the lake could be reached with ease.

The only tributaries of the lake visited by the expedition were those that enter it from the north. The easternmost of these streams, the Nagishlamina, which joins the lake near its northeast end, was ascended to its source. This river is a large turbulent stream during the summer, too swift and deep in its lower course to be fordable with horses, and carries such coarse boulders that the bars are difficult to traverse with pack animals. At a point 6 miles above the lake this valley is blockaded by Pothole Glacier, which descends from the range north of Mount Spurr and has built a great moraine across the stream valley. This glacier forms an obstacle to travel along the valley, which, though not so difficult to pass as Barrier Glacier, nevertheless required the equivalent of 8 or 10 days' work for one man to build a passable trail across it. About 4 miles farther upstream a similar glacial obstruction is encountered, but this can be largely avoided by crossing the river to its northwest side and skirting the edge of the glacier. Beyond Harpoon Glacier, the second glacier in the Nagishlamina Valley, travel is easy through a wide-floored glacial trough up to the broad pass that separates this drainage basin from the head of the Skwentna River. The extreme headward tributary of the Nagishlamina from the west may be followed without difficulty to a pass at an altitude of 3,600 feet that leads into the valley of the Chilligan River, 13 miles above the point where that stream flows into Chakachamna Lake.

The Chilligan River is the longest of the northern tributaries of Chakachamna Lake. It heads in the high mountains in which lies the divide between the Skwentna and the South Fork of the Kuskokwim, flows eastward and then southeastward, and empties into the lake 15 miles above its lower end. Its total length is about 35 miles. The Igitna River lies southwest of the Chilligan River, receives a number of eastward-flowing tributaries from the main crest of the Alaska Range, and empties into the upper lake, or the upper part of Chakachamna Lake.

There are many other tributaries of Chakachamna Lake from the west and south, but these were not visited. Most of them are known to be short and to head in the glaciers that lie in the heads of practically all the valleys.

Two other streams that deserve mention are the Straight River, which heads in a vigorous glacier on the east flank of Mount Spurr and flows into the lowland to join the Chakachatna 20 miles above its mouth, and Nicolai Creek, which flows along the north edge of a swampy flat and receives drainage from the flat itself and from tributaries that drain the rolling ridge north of the flat. Nicolai Creek is a clear stream and empties into Cook Inlet 11 miles northeast of the mouth of the McArthur River.

RELIEF

As already stated, the Mount Spurr region may be divided into two distinct provinces—a coastal belt, of low or moderate relief, and a mountainous belt. The coastal belt may be subdivided into the swampy flat, of low relief, that extends from Nicolai Creek southward to and beyond the McArthur River, and the rolling ridge north of Nicolai Creek. This ridge, which starts at the beach of Cook Inlet in a bluff about 150 feet high, gradually increases in altitude as the mountains are approached and reaches 3,000 feet at the point where it passes into the mountains proper. Its surface has been modeled by glacial scour to rolling, gentle slopes, with some stream-developed terraces along its south edge and a few steep, intricately eroded gulches, where southward-flowing streams with steep gradients have cut through the veneer of glacial materials and into the underlying Eocene sediments.

The mountain province includes all of the area here considered that lies west of the coastal belt. These mountains rise steeply from the coastal belt to the highest peaks in this part of the range. Mount Spurr has an altitude of 11,000 feet, and other points in the range to the north of Mount Spurr are almost as high. This ridge, though lofty and heavily charged with glacial ice, maintains a high average altitude, and no individual peaks stand up conspicuously above their fellows. Vigorous glaciers flow eastward from it to the lowland and supply the greater part of the water to the Beluga and Straight Rivers, and southward and westward flowing glaciers drain to the Chakachatna both directly and by way of Chakachamna Lake and the Nagishlamina River. Still other westward-flowing glaciers from this same mountain ridge supply waters to the head of the Skwentna.

West of the high ridge on which Mount Spurr stands is a wide area of rugged mountains and glacial valleys comprising the headward portion of the Chakachatna Basin. Many mountains reach altitudes of 7,000 to 9,000 feet, and especially in those areas of granitic rocks the ridges and peaks are ragged and steep and form scenic features of impressive grandeur. The valleys, however, show the scouring effects of the glaciers that formerly occupied them and are fairly wide and of moderate gradients, so that travel through them is not difficult, except as it may be impeded by heavy brush.

CLIMATE

No observations on the climate of this region are available except for the period in 1927 during which the Geological Survey party was in the field. That year between June 11 and September 13 there was some rain on more than 70 days at the points where the party happened to be, but the summer of 1927 was unusually rainy throughout the Cook Inlet region, and the area near Mount Spurr probably also received more than an average amount of precipitation. To judge from the general position of this region with respect to the ocean, the prevailing winds, and the topography, it is likely that the average summer is mild, with a considerable number of cloudy or rainy days on the face of the mountains toward Cook Inlet, but that precipitation is less as the crest of the range is approached, and that within the mountain province the winters are severe with moderate snowfall, the quantity of snow increasing from the crest of the range toward Cook Inlet. In short, the yearly climate is probably not far different from that of the other mountain areas that border Cook Inlet. The attitude of the brush on the Cook Inlet piedmont area indicates a fairly heavy snowfall, whereas within the mountains the indications point to less heavy snows in the winter.

VEGETATION

The piedmont and coastal plain province of this region is characterized by a fairly continuous stand of spruce, birch, and some hemlock and cottonwood below an altitude of 1,200 to 1,500 feet in those areas that are not too wet to permit the growth of forest trees. The great lowland along the courses of the McArthur and Chakachatna Rivers and Nicolai Creek is generally marshy and supports timber only in narrow strips bordering the streams or scrubby trees in a few areas that are relatively well drained. The remainder of the lowland is clothed only with brush and marsh plants. The rolling piedmont ridge that stretches from the coast to the mountains north of the marshy lowland is generally forested up to an altitude of 1,200 feet, though there are many marshy openings that have no trees and are covered with moss and low brush. Within the timber there is generally brushy undergrowth, including alders and high-bush cranberry, which makes travel somewhat arduous, and near timber line the alders flourish in places in dense stands through which it is necessary to chop trail continuously in order to make a way for horses. In general it may be stated that the largest trees grow on the best-drained ground. Spruce trees 2½ feet in diameter were seen, and birch trees 12 to 18 inches in diameter are common in places. The writer noted the presence of some hemlock of fair size. This tree grows abundantly on Kenai Peninsula and around Turnagain

Arm but is absent farther north, and this is the first time he has seen hemlock on the west side of Cook Inlet. Within the mountains timber is found only along the valley bottoms and lower slopes. Timber, which is limited to altitudes of 1,500 feet or less in the piedmont area, is found up to 2,300 feet in the mountain valleys, though by no means all of the surface below that altitude is forested. Alders, which may be burned green, grow to altitudes of 2,000 to 2,600 feet, and large willows occur considerably higher. Willows large enough for tent poles were found in favorable places up to altitudes of 3,000 feet or more. The areas in which timber occurs are shown on Plate 4.

Grass for horses can generally be procured throughout the region, though there are some areas in dense alders or in the timber where none is obtainable. Large areas of luxuriant redtop grass are found on the rolling ridge between Mount Spurr and the beach and just above timber line, and that region should be capable of supporting much livestock during the summer.

Within the mountains patches of grass sufficient for a moderate number of animals for a few days may be found here and there, but there are many places where forage is scant. In open valleys above timber line, such as the broad valley near the pass between the head of the Nagishlamina and the Skwentna, there is fine forage, including redtop, bunch grass, and other vegetation, but within the timbered areas of the Chilligan and Igitna Rivers grass is scarce. As a whole, however, this region is well supplied with forage for pack animals, and if some consideration is given to the choice of camping places with the matter of forage in mind, horses will do well in the country from early June until late in September.

GAME

Within the piedmont area between Cook Inlet and the face of the mountains the only large wild animals that are at all abundant are bears. Black bears are abundant within the timbered and brushy areas, and they are particularly bold in molesting any provisions that are not protected by being placed in a high, bear-proof cache. At and above the upper limit of timber and brush grizzly bears are common, but they seem more fearful of the presence of man than the black bears. In the mountainous part of the region, also, bears are numerous, and 65 of them were seen during the summer, about equally divided in numbers between blacks and grizzlies. It is doubtful if most of these bears had ever before seen a human being, and though they seemed little concerned by the presence of the party, they showed no inclination to attack it. On many occasions bears came into camp and attempted to carry off provisions, so that constant watchfulness was necessary. The same care was required to protect food supplies from the wolverines, which were surprisingly numerous throughout the region. Eighteen of these animals were seen during the summer, and wolverine tracks were everywhere.

Several beaver colonies were observed in the piedmont area, both on the high ridge north of Nicolai Creek and in the lowland tributary to the Chakachatna. Several families of land otters were seen, and there were less abundant signs of fox and mink.

Above Chakachamna Lake the tributary valleys from the northwest are occupied by caribou and moose in moderate numbers, and some fairly recent sheep sign was seen, though no sheep were actually observed. In the country above the foot of the lake there was much less evidence of the presence of fur-bearing animals other than wolverines than in the piedmont area east of the rugged mountains.

Among the small game animals the rabbits, in places so abundant in Alaska, were seen only in moderate numbers, and ptarmigan, though present within the higher mountains, were not plentiful.

This region can not be considered a good country for the fisherman. A few of the small, clear streams contain Dolly Varden trout of small size. No grayling were seen. A very few salmon run up the Chakachatna, possibly as far as the lake, but the run is very small and of no commercial value.

ROUTES OF TRAVEL

The approach to the Mount Spurr region is made by water, as the region is bordered on the southeast by the west shore of Cook Inlet. The only settlement on this part of the inlet is the native village of Tyonek, about 40 miles west of Anchorage. No regular boat service is maintained to Tyonek or to any other point in the Mount Spurr region, though small boats ply between Cook Inlet points at irregular intervals. During the summer, when the salmon are running, however, boats from Anchorage call at the fish traps every day or two to collect the fish, and transportation can be obtained on these boats.

The expedition landed on the open beach of Trading Bay, 3 miles northeast of the mouth of Nicolai Creek, at a cabin owned by Koch & Everett, who operate fish traps there, and discharged horses and equipment from a scow directly onto the beach. Such a procedure would be possible only in calm weather, for the shore there is unprotected from easterly or southerly winds. During stormy weather a pilot thoroughly familiar with these waters might manage to enter the mouth of Nicolai Creek at high tide and thus obtain shelter, but otherwise there are no protected waters hereabout.

Once ashore, there are no well-established routes of travel inland, although it is possible to follow the beach except at extreme high tide. It is said that there is an old but scarcely discernible Indian trail leading from Tyonek back to the mountains, but no evidences of such a trail were seen by the expedition, and its route and destination are not known to the writer. The older natives report that 30 years ago members of this tribe were accustomed to make hunting expeditions into the mountains northwest of Chakachamna Lake, and they doubtless had some feasible route of travel, but since that time they have given up these expeditions, and as the younger generation knows nothing of the back country, their hunting and trapping is confined to a rather narrow area in the piedmont belt.

With the exception of a few trappers who maintain trap lines within the piedmont area, the country back from the beach is entirely uninhabited. These trappers take supplies to their headquarters either by small boat during the season of open water or by dog sled over the marshy lowlands after the streams are frozen in the fall. They have established no summer trails from the beach. In the expedition here described, therefore, the party had no semblance of trail to follow except where game trails could be utilized, and it was necessary to establish a trail as the party proceeded. The general route followed has already been described (pp. 144–146), and that route will be open for pack-train travel for a few years, or until the brush grows over it. In some soft ground, however, the passage of the pack train out and back reduced the trail to a quagmire, and it may be found necessary to chop detours around some of the softest places. Some pick and shovel work will also be necessary to recondition the trail across the moraine-covered glaciers, but for many years the route followed by the expedition of 1927 will be discernible, and the amount of work necessary to make it passable will be much less than to establish a new trail.

GEOLOGY

GENERAL OUTLINE

The areal distribution of the rock formations in the Mount Spurr region is shown on the accompanying geologic map, in so far as the formations have been differentiated. The region here shown was heretofore entirely unexplored, and the field work done in 1927 was of reconnaissance character only. Furthermore, on account of the difficulties encountered in travel, a considerable part of the time during the short field season was spent in building trail, often in areas of dense brush where rock exposures were scarce or lacking. The geologist worked under the further disadvantage that the preparation of the topographic base map was carried on concurrently with the geologic work, so that the completed map was not available at the time the field work was done, nor until the writing of the report was in large measure completed. As a consequence of these difficulties, all of which are more or less inherent to exploratory or reconnaissance surveys, the outlines of the rock groups that are differentiated on the accompanying geologic map (pl. 3) are only approximate.

No identifiable fossils have been found in the Mount Spurr region, and any age determinations here given are based upon correlations with similar rocks in adjacent regions or upon stratigraphic relations.

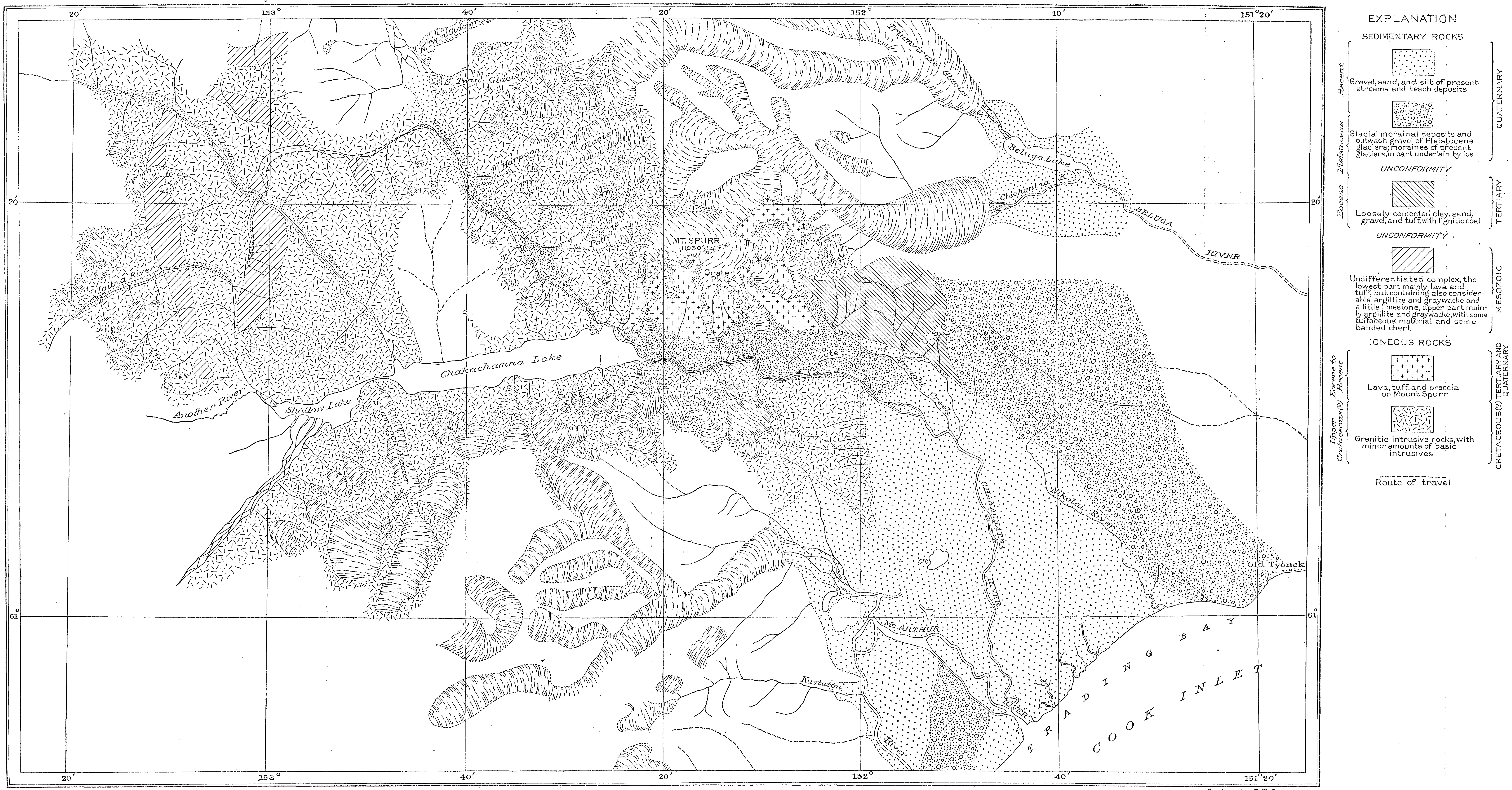
The geologic units shown on the accompanying map, with the exception of the lavas and tuffs of Mount Spurr, have all been described elsewhere in reports on contiguous areas, and elaborate descriptions are unwarranted here. In the following pages a brief description of each subdivision is given, with as definite a correlation as can safely be made and with references to more complete descriptions published elsewhere.

Probably the oldest rocks of the region are certain banded schistose rocks that occur on the mountain ridge 6 or 8 miles northwest of Mount Spurr and between the crest of that ridge and the Nagishlamina River. These rocks were not seen in place and are not represented on the geologic map, but their general location is known because of their abundance on the moraines of the southwestward-flowing Harpoon Glacier, which terminates in the Nagishlamina Valley 11 miles above the mouth of that stream. The age of these schists is not known, but they are believed to be of pre-Mesozoic age. Next younger is a group that comprises basaltic flows, andesitic, dacitic, and basaltic tuffs, and metamorphosed sedimentary rocks that include banded schists and rocks that were formerly shale, sandstone, and limestone. The rocks of this group are unfossiliferous but are believed to be Mesozoic and are probably of Jurassic and Cretaceous age.

A large part of the area here considered is occupied by granitic rocks that form a notable element of the Alaska Range from Lake Clark northward to Mount McKinley and beyond. Quite possibly granites of several ages are represented, but in the Mount Spurr region there is evidence for the belief that the major intrusions took place in late Mesozoic time, though earlier granites are present also.

Tertiary sedimentary rocks of Eocene age are present in the widespread deposits between the east flank of the mountains and the coast. These rocks include clay, sandstone, tuff, and lignitic coal.

The volcanic rocks of Mount Spurr range in age from early Tertiary to Recent. Tuffs and beds of lava pebbles included in the



Base prepared by Alaskan Branch from surveys by R. H. Sargent

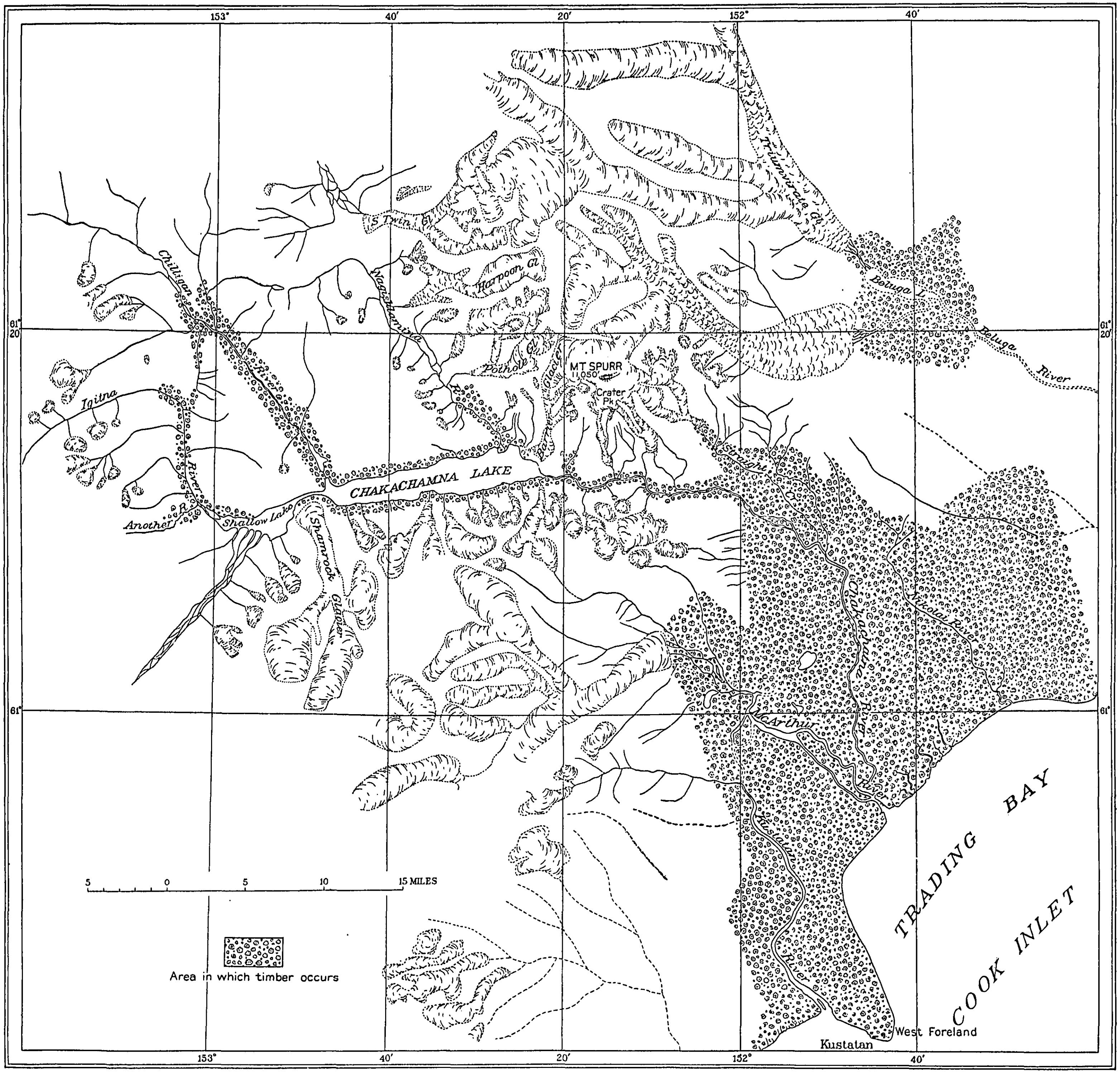
GEOLOGIC MAP OF MOUNT SPURR REGION, ALASKA

Geology by S. R. Capps

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

0 5 10 15 Miles

1929



MAP SHOWING DISTRIBUTION OF TIMBER IN THE MOUNT SPURR REGION

Eocene sediments indicate that this volcano was active in Eocene time, and lava beds interbedded with glacial deposits, deposits of volcanic ash, and fumaroles that still exist on the mountain give evidence of at least intermittent activity up to the present time.

A widespread mantle of glacial till and boulders over the piedmont area and the deeply excavated glacial troughs within the mountains testify to the great development of glacial ice within the region in Pleistocene time, and the remnants of those ancient glaciers are still vigorous ice streams that occupy the higher mountain valleys. Post-glacial erosion has been active in cutting valleys within the relatively soft Eocene sediments and the older glacial deposits and in forming steep wave-cut cliffs along the shores of Cook Inlet. The sediments derived from this erosion have been deposited in Cook Inlet, as shown by beaches, bars, and extensive mud flats.

The stratigraphic sequence for this district, in so far as it has been determined, is shown below.

Quaternary.—Beach sand and gravel, bars, and mud flats; gravel, sand, and silt of present streams; talus accumulations; peat and impure organic deposits or muck; soil and rock disintegration products in place; deposits of existing glaciers; terrace and bench gravel, in part of glaciofluvial origin; morainal deposits, presumably of Wisconsin age; lava and volcanic ash and tuff from Mount Spurr.

Tertiary.—Eocene sediments, generally light-colored soft sandstone and moderately indurated clay, locally containing lignite. Contain tuff beds, largely made up of pebbles of volcanic rocks from Mount Spurr, which was probably active when these beds were laid down.

Mesozoic.—Granitic intrusive rocks. Probably some, at least, of the masses of metamorphosed shale, sandstone, and limestone surrounded by granite are of late Mesozoic age. Andesite and basalt tuff and basalt and dacite flows, probably of lower Jurassic age.

Pre-Mesozoic.—Hornblende schist and associated contact-metamorphic rocks.

STRATIGRAPHY

SCHISTOSE ROCKS

What are probably the oldest rocks in this region occur somewhere in the range north of Mount Spurr. They were not seen in place, but their presence is known from numerous boulders and blocks that have been brought down the Nagishlamina Valley by Harpoon Glacier, the upper of the two glaciers that push down into this valley from the northeast. These rocks include hornblende schist that consists essentially of green hornblende and quartz, with epidote, pyrite, and iron oxides as accessory minerals. In places the hornblende schist has flowed around knots and irregular lenses of dense siliceous material, which itself has locally been drawn out and interlaminated with the hornblende material. Associated with the schist, which appears to have been originally a basic igneous rock, are banded contact rocks that are composed of alternating bands of quartz and biotite, quartz and epidote, and nearly pure quartz, as well as some more massive graywackes. Both these contact rocks, which probably are contact-metamorphosed sedimentary rocks, and the hornblende schist itself locally contain scattered specks of pyrite and on weathered surfaces show oxidation stains.

No direct evidence concerning the age of these schistose rocks was obtained. Without doubt they are older than the unmetamorphosed granite with which they are associated, for fragments of the schist were found as inclusions in the granite. They also appear to be much older than the Mesozoic tuffs, lavas, and associated sediments, which are described below. Possibly they are to be correlated with the mica schist of the Willow Creek district,[7] but this is only a suggestion and as yet not capable of proof. At any rate they appear to be much older than any known Mesozoic rocks in this general region and are here classified broadly as pre-Mesozoic.

MESOZOIC ROCKS

Character and distribution.—In the basins of the Chilligan and Igitna Rivers occurs a group of rocks that includes basaltic lava flows; andesite, dacite, and basalt tuff and agglomerate; and metamorphosed sedimentary rocks that were originally shale, sandstone, and limestone. They occur in considerable masses within an area that is mainly granitic, and the volcanic and associated sedimentary rocks form irregular areas that are entirely or nearly surrounded by the granite. The main areas of this group of rocks are shown on the accompanying geologic map (pl. 3), but the group, which is capable on detailed study of being subdivided into a number of units, is here undifferentiated.

As the volcanic and sedimentary rocks occur in somewhat isolated patches that are engulfed within the surrounding granite, it has so far been impossible to carry stratigraphic correlations from one area to another. Perhaps the best area for study, though it may not be typical, is the mass that lies between the lower Chilligan and lower Igitna Rivers. Only the north end of this mass was examined, but there the lowest rocks exposed consist of an alternation of dacite, basalt, and basalt porphyry with andesitic and basaltic tuff and agglomerate. These rocks are succeeded above by metamorphosed sediments that include argillite, graywacke, and limestone and contact-metamorphic derivatives of all these rocks.

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[7] Capps, S. R., The Willow Creek district, Alaska: U. S. Geol. Survey Bull. 607, pp. 26–30, 1915.

The most conspicuous element of the lower, volcanic part of this group consists of several kinds of tuff and agglomerate. These rocks range in color from dark to light gray and shades of green and purple. The included fragments are angular to subangular or rounded and range in size from tiny bits the size of sand grains to pieces 8 inches or more in diameter. Most of the fragments consist of andesitic, dacitic, and basaltic lavas, though fragments and pebbles of granite and other granular intrusive rocks, as well as of slate and argillite, are also present. These tuffs are interbedded with lava flows that include dark hornblende basalt, basalt porphyry, and light porphyritic dacite, and there are present also some black argillaceous rocks that look like metamorphosed mudstones.

The upper portion of this group of rocks at the locality described above contains, in addition to volcanic rocks, a considerable amount of contact-metamorphosed sedimentary material that includes dense argillite and graywacke, thin beds of gray crystalline limestone, and banded contact rocks in which bands of calcite and zeolite alternate with bands of a mixture of hornblende, chlorite, and quartz. All these altered sediments contain disseminated pyrite.

At other places within this region there are areas of sedimentary rocks surrounded by granite, and these have been included in the same group with the volcanic and associated sedimentary rocks described above, although without definite evidence that they are of the same age. North of the pass between the head of the Nagishlamina River and the Chilligan River there are areas of such sedimentary rocks, which consist mainly of argillite and graywacke. Just south of that pass lies a narrow belt of rock, bordered to the east and west by granite, which consists of finely banded chert, showing zones of recrystallization into interlocking quartz crystals, simulating a quartzitic fabric. Much of the regrown quartz is cloudy, and some of it is sericitized, suggesting igneous metamorphism. Some of these beds of chert, which are blended in layers only a fraction of an inch thick, show straight, parallel zones, but others are intricately contorted and folded.

West of the Igitna River, in a region that was seen only from a distance, there is a large area of dark rocks cut by granite, presumably another area of sedimentary and associated volcanic rocks. Many similar areas were mapped by the writer in 1926 in the region directly north of that here described.[8]

Structure and thickness.—As a result of the mountain-building forces that have affected this whole region and of the profound intrusion of tremendous masses of granite that surrounded and

[8] Capps, S. R., The Skwentna region, Alaska: U. S. Geol. Survey Bull. 797, pp. 82–86, 1929.

engulfed many areas of sedimentary and volcanic rocks, these beds exhibit a wide range in the degree of disturbance that they have suffered. In places, like the locality south of the pass between the Chilligan and Igitna Rivers, the beds are not greatly deformed and show a general monoclinal dip of 10°–15° NW. The banded cherts in the pass between the Nagishlamina and Chilligan Rivers, however, have high dips and show intimate distortion and crumpling. The separate patches of sedimentary rocks, now isolated by intruded granites, have little structural relation to one another, and, with the cursory field examination that has so far been given it has been impossible to trace the structure from one area to another or to correlate definite horizons in separate areas. Quite possibly detailed field studies might succeed in such an undertaking, though the complete lack of fossils would necessitate correlations on the basis of lithology only. In general, the beds of this group are commonly folded and faulted, and the folding is in the main more severe near the edges of the granite. Where the relatively competent lavas and tuffs form a large portion of the section the folding is likely to be less severe than where only argillite and graywacke are present. Many faults of small or unknown displacement were observed, and some of large displacement probably exist. For example, it is likely that the contact between this group of bedded rocks and the granite in the pass between the Chilligan and Igitna Rivers is marked by a fault that has a displacement of 2,000 feet or more. No reliable estimate can yet be made of the thickness of the beds included in this group. At one place in the Igitna Basin the series is certainly 2,500 feet or more thick. Farther north, in the basin of the Skwentna, the writer[9] estimated the beds to be at least 4,000 to 5,000 feet thick and possibly much more.

Age and correlation.—No precise evidence of the age of this group of volcanic and sedimentary rocks was obtained during the investigation here described. No fossils were found in them, and their assignment to any period must be based on their geologic relations and on lithologic resemblance to similar rocks of known age in other areas. Unfossiliferous argillite, shale, and graywacke make up a large element in the Alaska Range from the Mount Spurr region northward to and beyond Broad Pass, and in the Skwentna region they are associated with basic lava and tuff. These rocks are definitely older than the Eocene coal-bearing beds, which in places lie unconformably above them, and are older than the Cantwell formation farther north in the Alaska Range, which has been classified as Eocene but may be Upper Cretaceous. They are also known to be

[9] Capps, S. R., op. cit., p. 84.

younger than certain Middle Devonian limestones with which they are associated farther north in the Alaska Range.

The position within the range of these rocks in the Mount Spurr region leaves little doubt that they belong to the group of similar rocks in the Skwentna region,[10] immediately to the north. In the upper portion of this group the writer found a fossil leaf that was determined to be of Upper Cretaceous or Tertiary age. Still farther north in the range, and along the strike of this group of sediments, Brooks[11] found fossils near Rainy Pass that were of Middle Jurassic age. In the Yentna region Mertie[12] obtained a fossil of probable Upper Cretaceous age. Still farther north, in the basin of the West Fork of the Chulitna River, the writer[13] found a series of shale, argillite, and graywacke, presumably related to the beds here under discussion, that lay above a Triassic limestone and below the Cantwell formation. Thus all the localities in which fossils have been found in this widespread group of rocks indicate that the beds are of Mesozoic age and younger than Triassic.

The lower part of this group, in which basic lava and tuff predominate, is believed to be the correlative of the Skwentna group described by Spurr[14] and later by Brooks.[15] These writers made a definite separation of the Skwentna group, a volcanic series, from the Tordrillo "series," a sedimentary series. In the upper Skwentna region, however, the writer found that sedimentary and volcanic rocks were so intermingled that no such complete separation was possible in reconnaissance studies, and he therefore placed them together in a single undifferentiated group, and the same procedure is here followed for the Mount Spurr region. Brooks recognized the probable equivalence of the volcanic rocks to a similar assemblage of rocks in the Matanuska Valley named by Martin the Talkeetna formation and assigned by him[16] to the Lower Jurassic on the basis of its fossils. There is considerable ground for the belief that the lavas and tuffs of this group in the Mount Spurr region are the equivalent of the Skwentna group of Spurr and Brooks and of the Talkeetna formation of Martin, and the lower part of the group is considered to be of Lower Jurassic age. The upper part of the group, which con-

[10] Capps, S. R., op. cit., pp. 84–86.

[11] Brooks, A. H., The Mount McKinley region, Alaska: U. S. Geol. Survey Prof. Paper 70, p. 90, 1911.

[12] Mertie, J. B., jr., Platinum-bearing gold placers of the Kahiltna Valley: U. S. Geol. Survey Bull. 692, p. 237, 1919.

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

[14] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898; U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 149–155, 1900.

[15] Brooks, A. H., op. cit., pp. 75–90.

[16] Martin, G. C., The Mesozoic stratigraphy of Alaska: U. S. Geol. Survey Bull. 776, p. 219, 1926.

sists mainly of shale, argillite, and graywacke, is believed to be in part Upper Cretaceous. Whether or not beds of Middle and Upper Jurassic and of Lower Cretaceous age are present or whether there are great unconformities within the group has not yet been determined. It is a remarkable fact, of which there is still no adequate explanation, that this great group of Mesozoic sedimentary rocks is almost devoid of fossils in that part of the Alaska Range between Mount Spurr and Broad Pass, whereas in the area from Snug Harbor southwestward along the Alaska Peninsula and in the Talkeetna Mountains to the northeast the Mesozoic succession is remarkably complete and is fossiliferous throughout. The difficulty of subdividing the Mesozoic sediments of this part of the Alaska Range and of giving definite age assignments to the subdivisions is due mainly to this lack of fossils, and unless fossils are eventually found the geologic history of this region during Mesozoic time will be very difficult to decipher. At present all that can safely be said is that there is an undifferentiated group of volcanic and sedimentary rocks that probably range in age from Lower Jurassic to Upper Cretaceous.

TERTIARY ROCKS (EOCENE)

Character and distribution.—Eocene coal-bearing rocks are present in the Mount Spurr region only within the piedmont belt between the face of the mountains and Cook Inlet, and throughout most of that area they are concealed beneath a cover of glacial deposits or of vegetation and muck. These beds were first described by Spurr[17] as the Tyonek beds, and by Eldridge[18] as the Kenai formation, and their observations and his own were later summarized by Brooks,[19] who also published a cross section of the formation, which was not seen by the present writer. Brooks states that Eldridge observed about 1,000 feet of strata, striking N. 10°–15° E. and dipping 15°–60° SE. The beds consist of friable standstone, fine conglomerate, shale, and lignitic coal. There are 24 coal beds, ranging in thickness from 1 to 15 feet. Along the shores of Trading Bay for several miles east of the mouth of Nicolai Creek the bluffs are composed of glacial till and the Eocene beds are not exposed, although they are probably present beneath the glacial deposits. Farther west, in the piedmont belt between the inlet and the mountain front, no outcrops of this formation were seen for a distance of 18 miles from the beach, but still farther west, in the basin of the Straight River, there are many exposures of these beds, and fragments of lignite are common along the bars of the Straight River.

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[17] Spurr, J. E., op. cit., pp. 171–172.

[18] Eldridge, G. H., A reconnaissance in the Sushitna Basin and adjacent territory, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 16–17, 21–22, 1900.

[19] Brooks, A. H., op. cit., pp. 94–103.

The route traveled did not permit a careful study of the Eocene section exposed along the mountain front, though from a distance a series of exposures of beds that are certainly many hundreds of feet thick could be seen. At one locality, about a mile west of the point where the trail leaves the high piedmont ridge to descend to the valley of the Straight River, a section of this formation was examined. This section, given below, is far up in the formation and is underlain by many hundreds of feet of beds that from a distance seem to consist mainly of friable sandstone and shale. The general structure of the formation at that place is a strike about due north and a dip of 15° E. This dip is greater than the eastward slope of the piedmont ridge, so that the Eocene outcrops near Tyonek would appear to be higher in the formation than the section given herewith. The thicknesses stated are approximate only.

Section of Eocene beds 19 miles northwest of the mouth of Nicolai Creek

	Feet
Volcanic ash and soil	5
Glacial boulders and lava blocks	5
Glacial till	50
Poorly exposed, but mainly sandstone and shale; a thin bed of impure lignite near top	100
Coarse sandstone and pebbly sandstone	40
Coarse gray sandstone and fine conglomerate	10
Sandstone containing boulders, mainly granitic	15
Gray grit and fine white sandy clay	30
Purple, brown, and gray grit and tuff, with boulders 2 feet or less in diameter; pebbly beds with the pebbles mainly of volcanic materials	30
Unconformity.	
Gray, brown, and purple grit and tuff, with beds containing boulders, including lava blocks as much as 3 feet in diameter	50
Gray sandstone and white clayey sandstone	30
Unexposed.	
Total thickness exposed	360

The unconformity shown in this section is an angular unconformity, but there is evidence of the presence of coal beds both above and below it. The areal extent and stratigraphic significance of this unconformity are not known, but in a section containing so much coarse material it is likely that the break may be of only local significance and the unconformity only an intraformational one.

Earlier explorations have shown that beds of this formation extend from Tyonek northward across the Beluga and Skwentna Basins, occupy much of the lowland of the Susitna Basin, and occur in numerous outcrops almost entirely around the borders of Cook Inlet.

There is good reason to suppose that a great part of the Cook Inlet depression, from the Alaska Range on the west to the Kenai Mountains on the east, is underlain by beds of this formation, although in much of that region they are overlain and concealed by deposits of glacial till and glacial outwash gravel. In nearly every place in which these beds are extensively exposed they are found to contain lignitic coal, and in many places coal beds occur at a number of places in the formation and are fairly thick. At the present time these Cook Inlet coals are of too low grade to command other than local markets, but without doubt the quantity present in this basin is very great, and at some time in the future the coal will be valuable.

Structure and thickness.—The Eocene beds in the extensive exposures north of the lower end of the Straight River Glacier show a general eastward dip of about 15°, and this dip continues eastward to the point where these beds pass beneath the glacial deposits. It is possible that gentle monoclinal eastward dips continue to the coast. At the Tyonek exposures, described above, the dips are also eastward but steeper, ranging from 25° to 60°. This difference indicates that if the beds at Tyonek extend westward to the mountain front, as is probable, they are either folded or faulted. Otherwise such steep eastward dips, extending over a distance of 25 or 30 miles, would give a section much thicker than has been observed elsewhere in this formation. So much of the area occupied by Eocene rocks in this region is covered by younger deposits, however, and the exposures so far examined are of such small extent that at the present time no safe conclusions can be made about the general structure in this region. Likewise any estimates of the thickness of this formation are of minimum rather than of maximum thickness. Brooks[20] states that the Tyonek section exposes about 1,000 feet of beds. The exposures on the upper Straight River, as seen from a distance, appear to show as much as 2,000 feet or more of beds that probably belong in this formation. It is therefore probable that the formation in this region is at least 2,000 feet thick and it may greatly exceed that figure.

Age and correlation.—The Eocene rocks were laid down in fresh water as estuarine, river flood plain, or marsh and swamp deposits. They have yielded no invertebrate fossils but contain abundant plant remains in the form of coal, carbonized twigs, and leaf imprints, and from these a large number of plant forms have been identified. In spite of this abundance of organic material, however, it has been possible to collect determinable fossils only at a relatively

[20] Brooks, A. H., op. cit., p. 95.

few places, for the matrix in which the plants are found is generally poorly consolidated and too fragile to stand shipment. All the fossil collections from this formation have been determined to be of Eocene age. From the widespread occurrence of outcrops of this formation around the Cook Inlet Basin, in the valleys of the Susitna River and its tributaries, it is known that during Eocene time a great lowland that corresponded in general size and shape to the present lowland was in existence and was receiving deposits of sediments from surrounding higher lands. Also during that period there were recurring intervals during which, at many places within this lowland, organic material accumulated as peat or bog deposits, which were later transformed to lignitic coal. From our present knowledge of these coal beds it appears that no single bed is continuous over large areas and that at no one time was coal-forming material laid down over the entire basin. It is more likely that at any particular time vegetation was accumulating over rather local areas while sand and clay were being laid down elsewhere. In other words, the conditions of sedimentation at any one time differed greatly from place to place throughout the basin, and it is therefore difficult to correlate accurately a section exposed at one locality with that at another locality some distance away, but the general correlation of the scattered outcrops to a single formation can be made with little uncertainty. The significance of such intraformational unconformities as that shown in the section described above, however, is not yet known. So far as is known, therefore, all the exposures of the coal-bearing formation in the area of the Cook Inlet-Susitna lowlands are to be correlated with the Kenai formation and are of Eocene age.

QUATERNARY DEPOSITS AND HISTORY

Preglacial conditions.—The Quaternary history of this region includes all geologic events that have taken place there from the beginning of the great ice age, the Pleistocene epoch, to the present. In a geologic sense the Quaternary deposits are young, though in years the time is long, as the earliest events of the Quaternary took place at least several hundred thousand years ago. In reconnaissance field work it is inevitable that many details of this history should escape notice, but enough facts have been recognized here and elsewhere in Alaska to justify a general statement of the most noteworthy events of this time. Thus we know that by the end of Tertiary time or the beginning of the Quaternary the Alaska Range had reached about its present area and height, the main river valleys had been established in it, and the distribution of mountains and lowlands was about that of to-day. In detail, however, there were many differences. The mountain valleys, instead of being of the wide-floored, U-shaped type, were more nearly V-shaped in cross section; their gradients were very different from those of to-day; and many tributaries had quite different courses from those shown on the present map. The large lakes now found in the Beluga lowland and those in the mountains, such as Chakachamna Lake, did not then exist; the lowland between Cook Inlet and the mountains had an entirely different appearance, and the shore line of Cook Inlet was doubtless far different from the present one. Mount Spurr, long an active volcano, had probably already grown to about its present height, though its top was a great crater 3 or 4 miles across.

The glacial epoch.—The Pleistocene or glacial epoch—the first major division of the Quaternary—was characterized in Alaska and in many other parts of the world by a remarkable development of glaciers. Quite possibly there were mountain glaciers in the higher parts of the Alaska Range before Pleistocene time, as there are to-day, but they were small as compared with the great Pleistocene ice flood that overwhelmed the region. This great growth of glaciers was brought about by the more severe climate at that time, probably the result of a lowering of the mean annual temperature, and possibly also by an increase in precipitation, so that each winter more snow fell than was melted during the succeeding summer. This condition resulted in the formation of small glaciers, at first only in the protected gulches in the higher mountains, but later on these smaller ice streams lengthened and joined into great, many-branching valley glaciers that filled the mountain valleys and poured out from the mountains into the Cook Inlet lowland, there to join the great glacier that pushed down from the north. At the time of the greatest glaciation the great southward-moving ice mass in the Cook Inlet lowland filled that basin to a height, opposite Mount Spurr, of at least 3,000 feet. As a consequence, the surface of the tributary ice streams that joined this glacier from the mountains to the west also had at that time an altitude at the mountain front of 3,000 feet, and that surface sloped upward toward the valley heads. At the foot of Chakachamna Lake the ice level at one time reached a height of about 4,200 feet, or about 3,000 feet above the present level of the lake, and still farther toward the valley heads the glacier surface reached even greater altitudes, so that only the higher peaks and ridges projected above its surface. At that time a continuous glacier extended from the upper valley of the Nagishlamina River across the divide into the head of the Skwentna, and at the pass its surface stood at an altitude of 6,000 feet, so that the glacial ice was more than 3,000 feet thick at the pass. No doubt the direction of flow of the glacier through the pass was at times northward into the Skwentna Basin, and at other times southeastward into the Nagishlamina, depending upon which basin received the heavier snowfall. Similarly, glacial ice moved through other passes between the Chakachatna Basin and the Skwentna to the north and the Kuskokwim to the west. Thus the mountainous part of this region was so heavily glaciated that the valleys were filled with ice to a depth of several thousand feet. This ice in its movement followed the drainage lines and in the region here discussed pushed down into the valley of the Chakachatna River and thence eastward toward the Cook Inlet lowland, joining the great ice tongue that moved down that lowland from the north. As already stated, the west margin of the Cook Inlet glacier stood against the east flank of Mount Spurr at an altitude of at least 3,000 feet, and that glacier therefore must have pushed southward down the lowland a long distance beyond Mount Spurr. Just how far southward this great glacier extended we do not know, but there can be no doubt that it reached a considerable distance beyond the constriction formed by East and West Forelands, and it is possible that it filled the entire inlet and pushed eastward into the Gulf of Alaska between Kenai Peninsula and Afognak Island.

The long occupancy of these valleys by glacial ice, probably at several separate times during the Pleistocene epoch, resulted in profound changes in the topography of the country. A thick glacier, shod with abundant rock fragments and boulders, is admirably equipped to wear down the bed over which it moves, and all the valleys in these mountains show plainly the effects of erosion by glaciers. The steep-walled, troughlike valleys, with wide floors, point unmistakably to the scouring action of former glaciers. The valley walls, smoothed and fluted up to the height reached by the ice, contrast with the sharp, ragged ridges and peaks that stood above the ice surface.

Glacial deposits and bench gravel.—During the final shrinkage of the glaciers to their present dimensions many of the valleys were freed from ice, and the normal processes of stream erosion became effective. The valley floors left by the glaciers, however, were in many places out of adjustment to stream drainage, and the streams commenced the task, still far from completed, of reestablishing normal gradients. At many places the bedrock floor had been oversteepened by the ice, and the streams, flowing swiftly in those places, developed sharp canyons cut in bedrock. At other places overdeepened stretches became lakes, and the streams at once began to fill these depressions with sand, gravel, and silt brought from higher portions of their basins.

During some stage in the retreat of the ice lobe up the Chakachatna Valley the glacier terminated somewhere near the lower end of Chakachamna Lake, and at that time an extensive gravel filling was laid down along the Chakachatna Valley to and beyond the mountain front. With a further retreat of the main glacier and the formation of Chakachamna Lake behind the dam formed by Barrier Glacier, the load of gravel and sand brought down by the headward tributaries of the Chakachatna was trapped in the lake, and the river below the lake, freed from this burden of sediments, was able to intrench itself into the gravel filling of the valley and locally into the bedrock. As a result a fine series of terraces was developed in the valley for many miles below the lake, especially on the north slope of the valley. The upper and most prominent terrace stands about 100 feet above the river, and in places three or four lower terraces can be seen at levels 20 feet or so apart.

Terraces are also developed along the south slope of the piedmont ridge that extends from Cook Inlet back to the mountains just north of Nicolai Creek. These terraces are for the most part covered with heavy timber and brush and are not conspicuous, but one well-developed terrace, at an altitude of 100 to 150 feet above sea level, was traced back for several miles from the beach.

In the headward valleys of many tributaries of Chakachamna Lake there are deposits of terrace or bench gravel, but these are in general related to incidents that occurred during the retreat of the glaciers in those valleys and are of local rather than of general significance.

Present stream gravel.—Virtually all the larger streams in this region have fairly extensive gravel and sand flood plains in places, for all are glacier-fed and carry heavy loads of detritus during the summer, when the ice fields are melting. The flood plains are not continuous, however, for they are interrupted from place to place by rock canyons, by lakes, and by glaciers that push down across the larger valleys. Thus the McArthur and Chakachatna Rivers have extensive gravel flats in the lowland east of the mountains, but within the mountains the valley of the Chakachatna is constricted at a number of places by rock bluffs, by high terrace deposits, and just below Chakachamna Lake by Barrier Glacier. The Nagishlamina River has a delta at its mouth, built out into Chackachamna Lake, and for several miles above the lake flows through a wide-floored valley paved with coarse boulders. At 5 miles above its mouth the valley is narrowly constricted by rock bluffs, and a mile farther upstream by a vigorous glacier, which pushes out from a tributary valley from the east and across the main valley of the Nagishlamina. Above this glacial dam is a wide flat 3 miles long and a mile wide, occupied by a lake and by fine sands at its lower end and by gravel at its upper end. Above this flat the valley is again constricted by a second glacier from the east. On the upstream side of this second glacier is a wide, gravel-floored valley, which extends northwestward to the pass at the head of the Skwentna and down that stream for many miles.

The Chilligan River has in its upper reaches a broad, bare gravel floor over which the river flows in many channels. For the lower 8 miles of its course, however, its flood plain is narrower and flanked by terraces from a few feet to 15 or 20 feet high. The Igitna River likewise has a wide gravel floor in its upper valley, but for 7 miles above its mouth it flows through a series of short rock canyons alternating with wider stretches in which there is a narrow gravel flood plain.

Chakachamna Lake at present receives and retains a large amount of sand, gravel, and silt brought down to it by a great number of glaciers and glacial streams. The coarse materials are dropped at the mouths of the tributaries to form delta deposits, but the finer silt is carried farther from shore and laid down over the entire bed of the lake. Should the Barrier Glacier retreat a short distance, or the moraine at its lower end be trenched by the Chakachatna River so as to drain the lake, there would no doubt be found a large volume of lake beds in the area now covered by the lake.

Volcanic ash.—At many places throughout this region where fresh exposures are available a bed of volcanic ash may be observed on top of the deposits left by the old glaciers but beneath a layer of vegetal material and turf. The depth of the ash differs from place to place, as does the thickness of the soil and turf under which it lies. There are places on the piedmont ridge, northeast of the Straight River and above the altitude to which brush grows, where persistent snow banks have prevented the growth of moss or heather and where considerable patches of volcanic ash mixed with soil are exposed at the surface. On the southeast side of the Straight River, 3 miles below the glacier, the terrace face shows as much as 6 feet of volcanic ash overlain by 12 to 18 inches of vegetal material and soil, on the surface of which stands a forest of large spruce trees.

On the surface of the moraine of the Harpoon Glacier, in the Nagishlamina Valley, volcanic ash that ranges from 2 to 4 feet in thickness was seen beneath a foot of turf. Still farther west, in the pass between the Chilligan and Igitna Rivers, 4 feet of pale-buff to brown volcanic ash was seen immediately below the turf.

Similar occurrences of ash were observed in 1926 at several localities in the Skwenta Basin.[21] At that time it was not known that Mount Spurr is an active volcano, and the source of the ash was not determined. The observations in that year, however, together with those in 1927, show that a relatively recent fall of ash covered a large area to the west, north, and east of Mount Spurr and probably to the south also. No other volcano from which the ash could have come is known nearer than Redoubt Peak, 60 miles south of this area, and as Mount Spurr is still active and lies about in the center of the area of the ash, it seems almost certain that an explosion from that volcano supplied the ash in the surrounding region.

The ash is geologically very recent. It occurs on the surface of moraines in the Nagishlamina Valley that were not laid down until the main glacier in that valley had disappeared, and it now lies on surfaces that have suffered little erosion since the ash fell. It is buried by a few inches to a foot or two of soil, and on this soil grow trees that must be at least 200 years or more old. Apparently the ash was ejected several hundred but probably less than a thousand years ago.

IGNEOUS ROCKS

The rocks of igneous origin in the Mount Spurr region include relatively old gneisses and schists, lava flows, and tuffs of Mesozoic age, late Mesozoic granitic intrusive rocks, and the lavas, breccias, and eruptive volcanic materials from Mount Spurr, which range in age from Eocene almost to the present. The gneisses and schists have already been described (pp. 155–156), and the Mesozoic lavas and tuffs, which are interbedded with sedimentary materials, have been described in connection with the Mesozoic sediments.

GRANITIC ROCKS

The most conspicuous single group of rocks in this region, on account of its widespread distribution and of the rugged topographic forms produced from it by erosion, is that which includes the granitic intrusive rocks. Granitic rocks occupy much the larger portion of the mountain province in this region and belong to the great group of intrusive rocks that extends from Iliamna Lake northward to and beyond Mount McKinley and constitutes a conspicuous element in

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

the Alaska Range. The mountainous portion of the region here considered is entirely made up of granitic rocks except for the more recent volcanic rocks of Mount Spurr and certain relatively small areas of gneiss and of Mesozoic sediments, lavas, and tuffs. The great intrusive masses of granitic material are commonly gray, though more rarely of a pink hue. Thin sections cut from a dozen specimens from different parts of the region show only one rock that would be classed as a diorite, and the others are all granites. Later dikes that cut the granites include both rhyolite and diorite porphyry, and still later are more basic types that include augitite, pyroxenite, diabase, basalt, and basalt porphyry. These basic dikes, although their dark colors are conspicuous in contrast to the lighter colors of the granite, are not quantitatively abundant.

The granites have a considerable range in color, texture, and composition. Specimens collected within a few hundred yards of one another range from a fairly coarse dark-gray hornblende granite containing quartz, orthoclase and plagioclase, hornblende, apatite, zircon, and iron oxides through finer-grained light-gray biotite granite containing quartz, orthoclase, acidic plagioclase, biotite, ilmenite, and titanite to a nearly white sugary-textured aplitic granite containing quartz, orthoclase, and acidic plagioclase but with a very small proportion of muscovite and biotite or other dark minerals. In places, as in the extreme headward basin of the Nagishlamina River, a common phase of the granite is a coarse-grained pinkish-gray granite porphyry that is studded with prominent orthoclase phenocrysts. Many of the phenocrysts are euhedral and attain a greatest diameter of 2 inches or more. In the same vicinity occur hornblende phases in which the proportion of hornblende ranges from 25 to 90 per cent.

No positive evidence of the age of the granitic intrusive rocks was obtained during this investigation, but it is certain that granites have been intruded into this general region during at least two periods in its history, for granitic pebbles were observed in the tuffs of probable Lower Jurassic age and these tuffs were later cut by other granites. Most of the granite of the region is believed to be of late Mesozoic age. In the upper Skwentna region [22] these granites cut shale from which was collected a fossil leaf that was identified as of Upper Cretaceous or Tertiary age and are directly continuous with the same great intrusion that brought in most of the granites of the Mount Spurr region and are probably a part of it. In the basin of the Igitna River the granite cuts the tuffs and sediments that are classi-

[22] Capps, S. R., op. cit., p. 89.

fied as of Mesozoic age and contains blocks and fragments of the still older schists of the Nagishlamina Basin. It is older than the Eocene beds, and it was through this granite that the volcanic vent of Mount Spurr broke its way to the surface. The best evidence available therefore points to a late Mesozoic age for the bulk of the granites of this region.

VOLCANIC ROCKS OF MOUNT SPURR

Mount Spurr is a volcanic mass that lies on the east face of the Alaska Range and so far as is known is the northernmost of a long line of craters that extends down the Alaska Peninsula to the Aleutian Islands and includes Mount Spurr, Redoubt Peak, Iliamna Peak, Mount St. Augustine, Mount Katmai, Mount Peulik, Aniakchak Crater, and many others. It is thus one of the conspicuous series of volcanoes that border the Pacific Ocean, and many of these mountains are still active. The mass of which the highest peak is called Mount Spurr consists of a great outer crater, now breached by the valleys of a number of glaciers that flow radially from it, and a central cone within this older crater, the highest peak of the mountain, from vents near the top of which steam still issues. One small subsidiary crater, now occupied by a small glacier, was recognized on the south rim of the old, outer crater.

As has already been shown, volcanic activity at this place began at least as long ago as Eocene time, the vent having been formed through the somewhat older granitic rocks. It is likely that this mountain, like other volcanoes, has been active intermittently, the active periods alternating with periods of relative quiescence. Volcanic ash is widely scattered in this region and is found immediately beneath the turf, indicating that the last violent explosion, probably from Mount Spurr, took place within the last few centuries. At present a moderate steam plume is the only indication of activity.

The rocks of which Mount Spurr is composed include breccia, tuff, and lava flows, together with minor amounts of dikes and sills. They range in composition from diorite porphyry, which occurs in minor amounts, to basalt porphyry, which makes up the bulk of the mountain. A thin section of a quartz-bearing pyroxene diorite porphyry showed phenocrysts of plagioclase, basaltic hornblende, and augite in a holocrystalline groundmass of plagioclase, augite, basaltic hornblende, biotite, magnetite, and apatite. The commonest type of basalt porphyry consists of a glassy to microcryptocrystalline matrix containing phenocrysts of plagioclase and augite, with small amounts of apatite and iron oxides. Another type consists of a holocrystalline groundmass of labradorite, titaniferous augite, magnetite, and apatite, with phenocrysts of labradorite and augite.

MINERAL RESOURCES

Metallic minerals.—The Mount Spurr region has been so little visited by white men that only the most superficial prospecting has been done, and little definite information is available about its mineral resources. The few white men who have entered the region have doubtless done some panning for placer gold, but without success. Members of the Geological Survey expeditions of 1926 and 1927 also did some panning but found scarcely a color of gold. This failure, however, is scarcely surprising, for the valleys have been so recently occupied by great glaciers and were so severely scoured out by the ice that there has been too little weathering and decomposition of the rocks to release a new supply of placer gold to the streams, even if the rocks were gold bearing. Furthermore, all the large and most of the smaller streams are supplied by glaciers, carry great quantities of gravel, sand, and silt, and are building up extensive gravel flats. This process does not tend to concentrate any heavy metallic content into a sharply defined channel or pay streak. It therefore seems unlikely that extensive or continuous placer channels will be found in the rugged portions of this region.

The possibilities of the presence of valuable lode deposits in this part of the Alaska Range are somewhat better. The extensive masses of granite intruded into sediments of different ages have been the cause of the mineralization of some of the intruded rocks, as can be seen from the rusty color of those rocks at many places and from the presence of scattered pyrite at many localities. No deposits of more valuable metals were actually observed, but the association of lodes carrying gold, silver, lead, copper, and zinc with granitic intrusive bodies is so common that any region where such intrusives are present and in which iron sulphides are abundant deserves at least a careful scrutiny for more valuable minerals.

Coal.—The Tertiary formations of the Cook Inlet depression, between the beach and the mountain front, are known to contain lignite, and in the vicinity of Tyonek a section about 1,000 feet thick shows 24 coal beds ranging in thickness from 1 to 15 feet. This formation is known to crop out at many places throughout the piedmont area and is probably present in most of it, though generally covered by glacial deposits, gravel, and vegetation. Too little is known of the section or of the structure of the beds to warrant any estimate of the amount of coal present, but it is undoubtedly large and may be a valuable reserve of fuel at some distant time. At present this coal has no value for other than strictly local use. Much better coal is now being mined in the Matanuska Valley and in the Nenana field, and numerous exposures of coal are known around Cook Inlet and in the Susitna Basin that are more accessible to transportation and probably of equally good or better quality. Recently developed methods of manufacturing liquid fuels for internal-combustion engines from low-grade coals, however, suggest the possible future value of such coals.

INDEX

SELECTED LIST OF GEOLOGICAL SURVEY PUBLICATIONS ON ALASKA

[Arranged geographically]

All these publications can be obtained or consulted in the following ways:

1. A certain number of copies are delivered to the Director of the Geological Survey, from whom they can be obtained for a limited period free of charge (except certain maps) on application.

2. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at the price indicated. No copies are available of those marked with an asterisk (*); they may be consulted at many public libraries.

3. Copies of all Government publications are furnished to the principal public libraries throughout the United States, where they can be consulted by those interested.

The maps whose price is stated are sold by the Geological Survey and not by the Superintendent of Documents. On an order for maps amounting to $5 or more at the retail price a discount of 40 per cent is allowed.

GENERAL

REPORTS

* The geography and geology of Alaska, by A. H. Brooks. Professional Paper 45, 1906, 327 pp.

The Alaskan mining industry in 1927, by Philip S. Smith. In Bulletin 810, 1928. Free on application. The preceding volumes in this series are Bulletins 259, 1904, 15 cents; 284, 1905, 25 cents; 314, 1906, 30 cents; 345, 1907, 45 cents; 379, 1908, 50 cents; 442, 1909, 40 cents; 480, 1910, 40 cents; 520, 1911, 50 cents; 542, 1912, 25 cents; 592, 1913, 60 cents; 622, 1914, 30 cents; 642, 1915, 35 cents; 662, 1916, 75 cents; * 692, 1917; * 712, 1918; * 714, 1919; 722, 1920, 25 cents; 739, 1921, 25 cents; 755, 1922, 40 cents; 773, 1923, 40 cents; 783, 1924, 40 cents; 792, 1925, 25 cents; 797, 1928. Free on application.

Railway routes from the Pacific seaboard to Fairbanks, Alaska, by A. H. Brooks. In Bulletin 520, 1912, pp. 45–88. 50 cents.

Geologic features of Alaskan metalliferous lodes, by A. H. Brooks. In Bulletin 480, 1911, pp. 43–93. 40 cents.

The mineral deposits of Alaska, by A. H. Brooks. In Bulletin 592, 1914, pp. 18–44. 60 cents.

Alaska coal and its utilization, by A. H. Brooks. Bulletin 442–J, reprinted 1914, pp. 47–100. 10 cents.

The preparation and use of peat as a fuel, by C. A. Davis. In Bulletin 442, 1910, pp. 101–132. 40 cents.

* Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Bulletin 263, 1905, 273 pp.

* Geographic dictionary of Alaska, by Marcus Baker (second edition, prepared by James McCormick). Bulletin 299, 1906, 690 pp.

Tin mining in Alaska, by H. M. Eakin. In Bulletin 622, 1915, pp. 81-94. 30 cents.

Antimony deposits of Alaska, by A. H. Brooks. Bulletin 649, 1916, 67 pp. 15 cents.

The use of the panoramic camera in topographic surveying, by J. W. Bagley. Bulletin 657, 1917, 88 pp. 25 cents.

The mineral springs of Alaska, by G. A. Waring. Water-Supply Paper 418, 1917, 114 pp. 25 cents.

The future of Alaska mining, by A. H. Brooks. Bulletin 714–A, pp. 5–57. 25 cents.

Preliminary report on petroleum in Alaska by G. C. Martin. Bulletin 719, 1921, 83 pp. 50 cents.

The Mesozoic stratigraphy of Alaska, by G. C. Martin. Bulletin 776, 1926, 487 pp. 75 cents.

In preparation

The Upper Cretaceous flora of Alaska, by Arthur Hollick, with a description of the Upper Cretaceous plant-bearing beds, by G. C. Martin.

Tertiary flora of Alaska, by Arthur Hollick.

Igneous geology of Alaska, by J. B. Mertie, jr.

TOPOGRAPHIC MAPS

Map of Alaska (A); scale, 1:5,000,000; 1927. 10 cents retail or 6 cents wholesale.

Map of Alaska (C); scale, 1:12,000,000; 1916. 1 cent retail or five for 3 cents wholesale.

Map of Alaska, showing distribution of mineral deposits; scale, 1:5,000,000; 1925. 20 cents retail or 12 cents wholesale.

Index map of Alaska, including list of publications; scale, 1:5,000,000; 1927. Free on application.

Relief map of Alaska (D); scale, 1:2,500,000; 1923. 50 cents retail or 30 cents wholesale.

Map of Alaska (E); scale, 1:2,500,000; 1923. 25 cents retail or 15 cents wholesale.

SOUTHEASTERN ALASKA

REPORTS

The Juneau gold belt, by A. C. Spencer, pp. 1-137, and A reconnaissance of Admiralty Island, by C. W. Wright, pp. 138-154. Bulletin 287, 1906, 161 pp. 75 cents.

Reconnaissance on the Pacific coast from Yakutat to Alsek River, by Eliot Blackwelder. In Bulletin 314, 1907, pp. 82-88. 30 cents.

The Ketchikan and Wrangell mining districts, by F. E. and C. W. Wright. Bulletin 347, 1908, 310 pp. 60 cents.

The Yakutat Bay region, Alaska, by R. S. Tarr and B. S. Butler. Professional Paper 64, 1909, 183 pp. 50 cents.

Occurrence of iron ore near Haines, by Adolph Knopf. In Bulletin 442, 1910, pp. 144–146. 40 cents.

Geology of the Berners Bay region, by Adolph Knopf. Bulletin 446, 1911, 58 pp. 20 cents.

The Eagle River region, southwestern Alaska, by Adolph Knopf. Bulletin 502, 1912, 61 pp. 25 cents.

The Sitka mining district, by Adolph Knopf. Bulletin 504, 1912, 32 pp. 5 cents.

The earthquakes at Yakutat Bay, in September, 1899, by R. S. Tarr and Lawrence Martin. Professional Paper 69, 1912, 135 pp. 60 cents.

A barite deposit near Wrangell, by E. F. Burchard. In Bulletin 592, 1914, pp. 109–117. 60 cents.

Geology and ore deposits of Copper Mountain and Kasaan Peninsula, by C. W. Wright. Professional Paper 87, 1915, 110 pp. 40 cents.

*The structure and stratigraphy of Gravina and Revillagigedo Islands, by Theodore Chapin. In Professional Paper 120, 1918, pp. 83–100.

*The geology and mineral resources of the west coast of Chicagof Island, by R. M. Overbeck. In Bulletin 692, 1919, pp. 91-136.

The Porcupine district, by H. M. Eakin. Bulletin 699, 1919, 29 pp. 20 cents.

Notes on the Unuk-Salmon River region, by J. B. Mertie, jr. Bulletin 714–B, 1921, pp. 129–142. 10 cents.

Marble deposits of southeastern Alaska, by E. F. Burchard. Bulletin 682, 1920, 118 pp. 30 cents.

Water-power investigations in southeastern Alaska, by G. H. Canfield. In Bulletin 722, 1922. 25 cents. Similar previous reports in Bulletins 642, 1916, 35 cents; 662, 1917, 75 cents; *692, 1919; *712, 1920; 714–B, 1921, 10 cents.

Ore deposits of the Salmon River district, Portland Canal region, by L. G. Westgate. In Bulletin 722, 1922, pp. 117–140. 25 cents.

Mineral deposits of the Wrangell district, by A. F. Buddington. In Bulletin 739, 1923, pp. 51–75. 25 cents.

Mineral investigations in southeastern Alaska in 1924, by A. F. Buddington. In Bulletin 783, 1927, pp. 41–62. 40 cents. Similar report for 1923 in Bulletin 773, 1925, pp. 71–139. 40 cents.

Aerial photographic surveys in southeastern Alaska, by F. H. Moffit and R. H. Sargent. In Bulletin 797, 1928, pp.———. Free on application.

In preparation

Geology and ore deposits of the Juneau district, by H. M. Eakin.

Geology and mineral deposits of southeastern Alaska, by A. F. Buddington and Theodore Chapin. Bulletin 800.

Geology of Hyder and vicinity, with a reconnaissance of Chickamin River, southeastern Alaska, by A. F. Buddington. Bulletin 807.

TOPOGRAPHIC MAPS

Juneau gold belt, Alaska; scale, 1:250,000; compiled. In Bulletin 287, 1906. 75 cents. Not issued separately.

Juneau special (No. 581A); scale, 1:62,500; 1904, by W. J. Peters. 10 cents retail or 6 cents wholesale.

Berners Bay special (No. 581B); scale 1:62,500; 1908, by R. B. Oliver. 10 cents retail or 6 cents wholesale. Also contained in Bulletin 446, 1911, 20 cents.

Kasaan Peninsula, Prince of Wales Island (No. 540A); scale, 1:62,500; by D. C. Witherspoon, R. H. Sargent, and J. W. Bagley. 10 cents retail or 6 cents wholesale. Also contained in Professional Paper 87, 1915, 40 cents.

Copper Mountain and vicinity, Prince of Wales Island (No. 540B); scale, 1:62,500; by R. H. Sargent. 10 cents retail or 6 cents wholesale. Also contained in Professional Paper 87, 1915, 40 cents.

Eagle River region; scale, 1:62,500; 1912, by J. W. Bagley, C. E. Giffin, and R. E. Johnson. In Bulletin 502, 25 cents. Not issued separately.

Juneau and vicinity (No. 581D); scale, 1:24,000; 1918, by D. C. Witherspoon. 20 cents retail or 12 cents wholesale.

Hyder and vicinity; scale, 1:62,500 (No. 540C); 1927, by R. M. Wilson. 10 cents retail or 6 cents wholesale.

CONTROLLER BAY, PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS

REPORTS

Geology of the central Copper River region, by W. C. Mendenhall. Professional Paper 41, 1905, 133 pp. 50 cents.

Geology and mineral resources of Controller Bay region, by G. C. Martin. Bulletin 335, 1908, 141 pp. 70 cents.

Mineral resources of the Kotsina-Chitina region, by F. H. Moffit and A. G. Maddren. Bulletin 374, 1909, 103 pp. 40 cents.

Mineral resources of the Nabesna-White River district, by F. H. Moffit and Adolph Knopf, with a section on the Quaternary, by S. R. Capps. Bulletin 417, 1910, 64 pp. 25 cents.

Reconnaissance of the geology and mineral resources of Prince William Sound, by U. S. Grant and D. F. Higgins. Bulletin 443, 1910, 89 pp. 45 cents.

Geology and mineral resources of the Nizina district, by F. H. Moffit and S. R. Capps. Bulletin 448, 1911, 111 pp. 40 cents.

Headwater regions of Gulkana and Susitna Rivers, with accounts of the Valdez Creek and Chistochina placer districts, by F. H. Moffit. Bulletin 498, 1912, 82 pp. 35 cents.

Coastal glaciers of Prince William Sound and Kenai Peninsula, by U. S. Grant and D. F. Higgins. Bulletin 526, 1913, 75 pp. 30 cents.

The McKinley Lake district, by Theodore Chapin. In Bulletin 542, 1913, pp. 78–80. 25 cents.

Geology of the Hanagita-Bremner region, Alaska, by F. H. Moffit. Bulletin 576, 1914, 56 pp. 30 cents.

Mineral deposits of the Yakataga district, by A. G. Maddren. In Bulletin 592, 1914, pp. 119–153. 60 cents.

The Port Wells gold-lode district, by B. L. Johnson. In Bulletin 592, 1914, pp. 195–236. 60 cents.

*The geology and mineral resources of Kenai Peninsula, by G. C. Martin, B. L. Johnson, and U. S. Grant. Bulletin 587, 1915, 243 pp.

The gold and copper deposits of the Port Valdez district, by B. L. Johnson. In Bulletin 622, 1915, pp. 140–188. 30 cents.

The Ellamar district, by S. R. Capps and B. L. Johnson. Bulletin 605, 1915, 125 pp. 25 cents.

*A water-power reconnaissance in south-central Alaska, by C. E. Ellsworth and R. W. Davenport. Water-Supply Paper 372, 1915, 173 pp.

Copper deposits of the Latouche and Knight Island districts, Prince William Sound, by B. L. Johnson. In Bulletin 662, 1917, pp. 193–220. 75 cents.

The Nelchina-Susitna region, by Theodore Chapin. Bulletin 668, 1918, 67 pp. 25 cents.

The upper Chitina Valley, by F. H. Moffit, with a description of the igneous rocks, by R. M. Overbeck. Bulletin 675, 1918, 82 pp. 25 cents.

*Platinum-bearing auriferous gravels of Chistochina River, by Theodore Chapin. In Bulletin 692, 1919, pp. 137–141.

*Mining on Prince William Sound, by B. L. Johnson. In Bulletin 692, 1919. Similar previous reports in Bulletins 592, 1914, 60 cents; 622, 1915, 30 cents; 642, 1916, 35 cents; 662, 1917, 75 cents.

*The Jack Bay district and vicinity, by B. L. Johnson. In Bulletin 692, 1919, pp. 153–173.

*Nickel deposits in the lower Copper River valley, by R. M. Overbeck. In Bulletin 712, 1919, pp. 91–98.

The Kotsina-Kuskulana district, by F. H. Moffit and J. B. Mertie, jr. Bulletin 745, 1923, 149 pp. 40 cents.

The metalliferous deposits of Chitina Valley, by F. H. Moffit. In Bulletin 755, 1924, pp. 57–72. 40 cents.

The occurrence of copper on Prince William Sound, by F. H. Moffit. In Bulletin 773, 1925, pp. 141–158. 40 cents.

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Geology of the Chitina quadrangle, by F. H. Moffit.

Geology of upper Nizina River, by F. H. Moffit. In Bulletin 810.

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Central Copper River region; scale, 1:250,000; by T. G. Gerdine. In Professional Paper 41, 1902, 50 cents. Not issued separately. Reprint in Bulletin 498, 1912, 35 cents.

Headwater regions of Copper, Nabesna, and Chisana Rivers; scale, 1:250,000; by D. C. Witherspoon, T. G. Gerdine, and W. J. Peters. In Professional Paper 41, 1905, 50 cents. Not issued separately.

Controller Bay region (No. 601A); scale, 1:62,500; 1907, by E. G. Hamilton and W. R. Hill. 35 cents retail or 21 cents wholesale. Also published in Bulletin 335, 1908, 70 cents.

Latouche Island, part of; scale, 1:21,120; by D. F. Higgins. In Bulletin 443, 1910, 45 cents. Not issued separately.

Chitina quadrangle (No. 601); scale, 1:250,000; 1914, by T. G. Gerdine, D. C. Witherspoon, and others. Sale edition exhausted. Also published in Bulletin 576, 1914, 30 cents.

Nizina district (No. 601B); scale, 1:62,500; by D. C. Witherspoon and R. M. La Follette. In Bulletin 448, 1911, 40 cents. Not issued separately.

Headwater regions of Gulkana and Susitna Rivers; scale, 1:250,000; by D. C. Witherspoon, J. W. Bagley, and C. E. Giffin. In Bulletin 498, 1912, 35 cents. Not issued separately.

Prince William Sound; scale, 1:500,000; compiled. In Bulletin 526, 1913, 30 cents. Not issued separately.

Port Valdez district (No. 602B); scale, 1:62,500; 1915, by J. W. Bagley. 20 cents retail or 12 cents wholesale.

The Bering River coal field; scale, 1:62,500; 1915, by G. C. Martin. 25 cents retail or 15 cents wholesale.

The Ellamar district (No. 602D); scale, 1:62,500; by R. H. Sargent and C. E. Giffin. In Bulletin 605, 1915, 25 cents. Not issued separately.

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Upper Chitina Valley; scale, 1:250,000; by International Boundary Commission, F. H. Moffit, D. C. Witherspoon, and T. G. Gerdine. In Bulletin 675, 1918, 25 cents. Not issued separately.

The Kotsina-Kuskulana district (No. 601C); scale, 1:62,500; 1922, by D. C. Witherspoon. 10 cents. Also published in Bulletin 745, 1923, 40 cents.

In preparation

Prince William Sound region; scale, 1:250,000; by J. W. Bagley, D. C. Witherspoon, and others.
Valdez and vicinity; scale, 1:62,500; by J. W. Bagley and C. E. Giffin.

COOK INLET AND SUSITNA REGION

REPORTS

Geologic reconnaissance in the Matanuska and Talkeetna basins, by Sidney Paige and Adolph Knopf. Bulletin 327, 1907, 71 pp. 25 cents.
*The Mount McKinley region, by A. H. Brooks. Professional Paper 70, 1911, 234 pp.
A geologic reconnaissance of the Iliamna region, by G. C. Martin and F. J. Katz. Bulletin 485, 1912, 138 pp. 25 cents.
Geology and coal fields of the lower Matanuska Valley, by G. C. Martin and F. J. Katz. Bulletin 500, 1912, 98 pp. 30 cents.
The Yentna district, by S. R. Capps. Bulletin 534, 1913, 75 pp. 20 cents.
*Geology and mineral resources of Kenai Peninsula, by G. C. Martin, B. L. Johnson, and U. S. Grant. Bulletin 587, 1915, 243 pp.
The Willow Creek district, by S. R. Capps. Bulletin 607, 1915, 86 pp. 25 cents.
The Broad Pass region, by F. H. Moffit and J. E. Pogue. Bulletin 608, 1915, 80 pp. 25 cents.
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A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, by P. S. Smith and H. M. Eakin. Bulletin 449, 1911, 146 pp. 30 cents.

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Seward Peninsula, northeastern portion, reconnaissance map (No. 655); scale, 1:250,000; 1905, by D. C. Witherspoon and C. E. Hill. 50 cents retail or 30 cents wholesale. Also in Bulletin 247, 1905, 40 cents.

Seward Peninsula, northwestern portion, reconnaissance map (No. 657); scale, 1:250,000; 1907, by T. G. Gerdine and D. C. Witherspoon. 50 cents retail or 30 cents wholesale. Also in Bulletin 328, 1908, 70 cents.

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