THE CHAKACHAMNA-STONY REGION

By STEPHEN R. CAPPS

INTRODUCTION

LOCATION AND AREA

The region considered in this report lies along the axis of the Alaska Range due west of the upper end of Cook Inlet and includes areas that drain eastward to Cook Inlet through the Chakachatna River and westward by way of the Stony River to the Kuskokwim River and Bering Sea. The crest of the range at Merrill Pass is 56 miles west of Cook Inlet at Trading Bay. In this region the axis of the range has a north-south trend. The geography and geology of the region in the vicinity of Mount Spurr and extending from Cook Inlet to the headwaters of the Chakachatna River have been described in a previous report.[1] The present report deals with the region lying immediately west of the Mount Spurr region and extending across the Alaska Range to and including the headwaters of the Stony River, between parallels 61° and 61° 40′ and meridians 153° and 154° 20′. This region comprises about 1,000 square miles, all of which was previously unsurveyed and had been little visited by white men.

EXPLORATION AND PREVIOUS SURVEYS

The history of exploration in this part of Alaska dates back to the middle of the eighteenth century, for by 1762 the Russian fur traders had reached Kodiak Island, and no doubt within the next few years they penetrated Cook Inlet. The first accurate information of record, however, was obtained by the British navigators Capt. James Cook, who in 1778 charted Cook Inlet as far northward as Point Possession, and Capt. George Vancouver, who in 1794 mapped Turnagain and Knik Arms. For the next 100 years little was done in the way of systematic survey or exploration in this region. During the period of the Russian occupation up to 1867 the sphere of influence of the Russian trading posts was extended,

[1] Capps, S. R., The Mount Spurr region: U. S. Geol. Survey Bull. 810, pp. 141–172, 1929.

and some crude knowledge of the courses of the major rivers was obtained, but no accurate mapping was done.

Modern history of this region began about 1894, when gold was first discovered at several places in the upper Cook Inlet area, mainly on the streams draining into Turnagain Arm. These discoveries brought an influx of prospectors into this part of Alaska, but the real stimulus to systematic exploration in Alaska came in 1898, when the discovery of rich gold placer deposits in the Klondike stirred the imagination of adventurers throughout the civilized world and brought about a tardy realization of the potential value of this northern territory.

Among a number of expeditions launched in 1898 and 1899 by the United States Army and the United States Geological Survey and in later years by the Geological Survey, only those will be mentioned here that contributed to the exploration of the region north and west of Cook Inlet.

The first exploration to penetrate the Alaska Range west of the Susitna River and to bring out an accurate survey of the route traversed was the expedition of the Geological Survey in charge of J. E. Spurr [2] and W. S. Post, who in 1898 ascended the Susitna, Yentna, and Skwentna Rivers in canoes, crossed the range through a high pass at the head of Portage Creek, and thence descended the Kuskokwim to Bering Sea, returning to the Pacific shore by way of Bristol Bay and across the Alaska Peninsula to Katmai village. In this remarkable journey they completely encircled the south end of the Alaska Range and obtained important geologic and geographic information about a great area that was previously unknown.

The next expedition of importance was that of Brooks,[3] in 1902, which with pack horses left Tyonek in the early spring, crossed the range at Rainy Pass, traversed the north flank of the range to the Nenana River, and proceeded thence northward to the Yukon. Among the fruits of this exploration was first knowledge of the geography and geology of a large area of the Alaska Range. Between 1902 and 1921 a number of geologic and geographic explorations were made by the Geological Survey around the west, south, and east sides of the Alaska Range, all of which added greatly to knowledge of the range, but there still remained a great area lying between Cook Inlet on the east, Lakes Clark and Iliamna on the south, the Mulchatna-Stony-Kuskokwim lowland on the west and the Skwentna on the north about which accurate geographic and geologic

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

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

information was entirely lacking and into which few white men had penetrated. The Geological Survey had for years had under consideration plans to carry surveys into this region, but demands for work elsewhere and lack of funds had delayed these projects.

In 1926, however, a series of expeditions, planned to explore this unknown area, was begun, and a combined geologic and topographic party in charge of S. R. Capps,[4] geologist, and K. W. Trimble, topographic engineer, ascended the Skwentna River to its head and mapped the headwaters of that basin, as well as some country tributary to the South Fork of the Kuskokwim River. In 1927 a second expedition, in charge of Mr. Capps,[5] with R. H. Sargent, topographic engineer, approached the region from the west shore of Cook Inlet, east of Mount Spurr, and explored and mapped most of the basin of the Chakachatna River, as well as a large area of the coastal region between Cook Inlet and the mountains.

PRESENT INVESTIGATIONS

The Chakachamna-Stony region adjoins to the southwest the area covered during the two preceding seasons. It includes part of the western headwaters of the Chakachatna River, most of the basin of the Necons River, and the upper, mountainous portion of the valley of the Stony River, all previously unsurveyed and largely unexplored. The lack of knowledge of this area was due mainly to its difficulty of access.

The eastern front of the mountains is separated from Cook Inlet by a belt of swampy lowland and of rolling brushy ridges, crossed by torrential glacial streams. In summer the lowland offered a serious obstacle to travel, and in winter the rugged mountains with their heavy snows and high winds presented little attraction to the prospector or trapper. Approach to this region from the southwest and west was also difficult, involving a long journey either from Bristol Bay or from the Kuskokwim River over a country devoid of trails, or up rivers that narrow canyons and rapids make difficult to navigate even by poling boat or canoe. Under the conditions that prevailed until within the last few years a prospecting or trapping expedition to the west front of the Alaska Range in this region was considered to be a 2-year undertaking, the first summer being used to transport the necessary supplies by poling boat to the head of navigable waters, from which supplies were taken by dog sled to the chosen field after the freeze-up in the fall. The winter was spent in trapping, building cabins, and opening trails, and the following summer could be devoted to prospecting. Few men have so far cared

[4] Capps, S. R., The Skwentna region: U. S. Geol. Survey Bull. 797, pp. 66–98, 1929.
[5] Capps, S. R., The Mount Spurr region: U. S. Geol. Survey Bull. 810, pp. 141–172, 1929.

to undertake such an expedition into this region. Mr. R. M. White had spent some time trapping on the headwaters of the Stony River, and he furnished a rough sketch map of the drainage with which he was familiar. During the last two or three years, however, the Geological Survey has surveyed considerable portions of this hitherto unexplored area, and in the winter of 1927–28 several men took advantage of the establishment of a commercial airplane service from Anchorage to fly into the headwaters of the Chakachatna and Stony Rivers to trap and prospect, and without doubt others will follow.

In the expedition of which this report is an account it was planned to utilize airplane transportation, in addition to pack train, in order to expedite the freighting of supplies and personnel to the field of operations and so lengthen the season of productive work. Arrangements were made in advance for the transportation of the three technical members of the party and about a ton of supplies and provisions by airplane from Anchorage to the head of Kenibuna Lake, in the Chakachatna Basin. This was accomplished on May 10 and 11, 1928. Meanwhile, the pack train and remaining supplies, with the two packers and the cook, were transported by launch and an open barge to Trading Bay, just east of Mount Spurr, and there put ashore to join the airplane party by way of the trail established the preceding summer. As a result of the bad condition of the trail, much snow on the ridges above timber line, rainy weather, and absence of adequate grass for horse feed due to the late spring, the pack-train party was three weeks on the way from Anchorage to the base camp, to which the other members had gone by air in a little more than an hour. Upon the arrival of the pack train at the head of Kenibuna Lake, on June 30, the expedition proceeded westward toward the crest of the range. The personnel included, in addition to the writer, who was geologist of the expedition, Gerald FitzGerald, topographic engineer; William A. Spurr, recorder; C. C. Tousley, packer; R. A. Francis, assistant packer; and Jim Brown, cook. To all these men the writer wishes to express his earnest appreciation of their faithful service during a season of trying weather conditions and difficult trail.

After leaving Kenibuna Lake the expedition proceeded westward to the head of Another River, toward Merrill Pass, a pass across the crest of the range which was discovered from the air by Russell H. Merrill, pilot of the Anchorage Air Transport Co., and which it was hoped would be feasible for pack horses. This pass is low, having an altitude of 3,180 feet, and is approached from both east and west by easy grades. The pass itself, however, is obstructed by coarse granite talus slides that extend down from the cliffs on both sides and that in three places meet along the valley axis. In their natural

state these accumulations of coarse blocks offered little difficulty to the passage of a man on foot but were entirely impassable for pack horses. Several days' work by all members of the expedition were required to fill in the interstices with fine material and to grade out trail on steep slopes before the horses could be taken through. A part of the trail so constructed will be fairly permanent, but on certain unstable slopes slides are sure to occur, and more trail work will be necessary before horses can again be safely taken across the pass.

Once across the crest of the range the party proceeded westward down a tributary valley to the Necons River and down that river to Two Lakes. From the head of Two Lakes a well-traveled game trail was followed westward across a high ridge to the valley of the Stony River, and that stream was ascended to its head, where an easy pass was found leading northward into the basin of some northward-flowing stream, possibly the Hartman River. Unfortunately, the lateness of the season prevented the exploration and mapping of this northward-flowing drainage system. From the head of the Stony River the party turned back and returned to Cook Inlet at Trading Bay by the trail followed in the spring. In spite of much trail work and an unusually rainy season, an area of about 1,000 square miles was mapped topographically and geologically, and much information was gained as to the interrelations of the drainage systems that carry the waters from this mountain mass to the sea by way of the Skwentna, Chakachatna, and Kuskokwim Rivers and Lake Clark. On the accompanying geologic map the geologic units portrayed are shown in a generalized way only. The difficulties of travel, unusually rainy weather during the field season, and the desire to cover as large an area as possible in the short time available prevented the tracing out of many of the geologic boundaries and made impossible any attempt to subdivide certain groups of deposits into smaller units. In this region fossils are extremely scarce, only a single invertebrate fossil having been found during the entire summer, so that the age determinations of most of the formations mapped are rather indefinite and have been made largely by correlation with similar formations in adjoining areas.

The thin sections of rocks collected during this expedition have been studied by J. B. Mertie, jr.

GEOGRAPHY

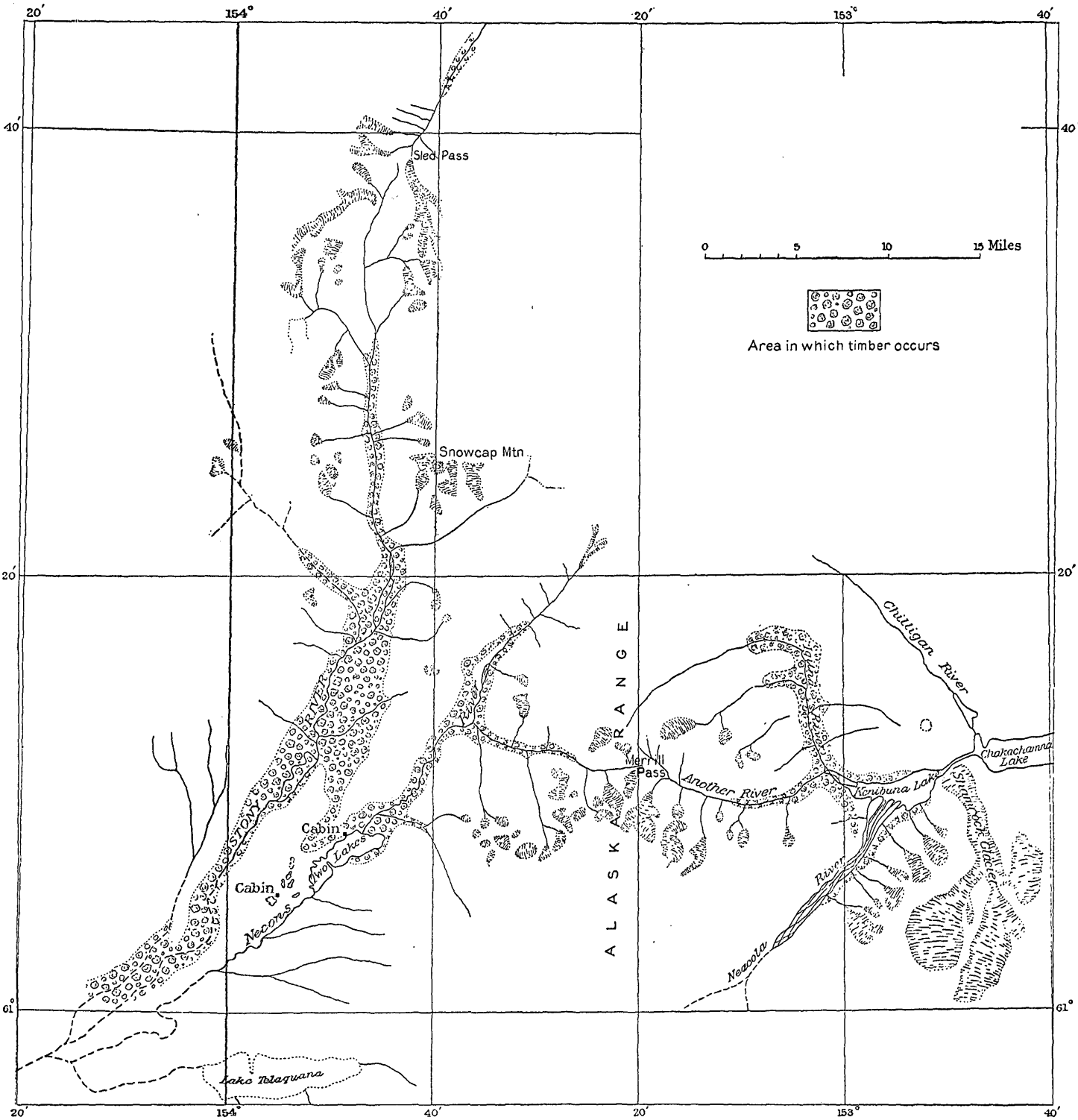
Drainage.—The drainage systems of the area discussed in this report include part of the extreme westward headwaters of the Chakachatna Basin and part of the headwaters of the Stony River. The greater part of the Chakachatna Basin was explored and mapped

in 1927 and is described in a report on the Mount Spurr region.[6] In that report it is stated that Chakachamna Lake and its westward extension beyond Shamrock Glacier is 23 miles long, but at that time it was not known whether there is a single lake, constricted near its middle by Shamrock Glacier, or two separate lakes, separated by a short stream flowing along the margin of Shamrock Glacier. In the expedition of 1928, however, the technical members traveled by airplane up Chakachamna Lake and found that Shamrock Glacier actually separates two distinct lakes. The upper of these is called Kenibuna Lake and lies at an altitude about 100 feet higher than Chakachamna Lake, to which it drains through a turbulent river 2 miles long that flows along the north margin of Shamrock Glacier. Except in its northeastern portion Kenibuna Lake is very shallow, and it is rapidly being filled by sand from the glacial streams that join it from the southwest and northwest and by drainage from Shamrock Glacier itself. Its average area is 5 or 6 miles, but the lake is subject to a fluctuation of level of 6 feet or more, and low water exposes several square miles of sand beaches and bars that are covered in periods of high water. The Neacola River, the large glacial tributary that enters Kenibuna Lake from the southwest, was not ascended, though good views up it for 12 miles or more showed the extensive sand and gravel bars characteristic of glacial rivers.

The valley of Another River, which joins Kenibuna Lake from the west, was followed to Merrill Pass. Another River can be crossed on foot at a few places in ordinary stages of summer flow, but in many places its swift current and the coarse boulders over which it flows makes it dangerous to ford, even with horses, in ordinary stages of water, and during periods of high water it is a roaring torrent, impossible to ford. Fortunately either side of the valley can be followed by pack train, the north side offering the less difficulty, so that crossing this river is unnecessary in order to reach the pass.

The drainage on the west slope of the Alaska Range in the region here described is tributary to the Stony River. In its lower course this river flows west-northwestward to join the Kuskokwim about 50 miles above Georgetown. Its headward portion, within the high mountains, however, flows in a southerly direction, not swinging to the westward until it has emerged from the mountains onto the Kuskokwim lowland. In the area surveyed the Stony receives two large tributaries, West Fork, which enters from the northwest and only the lower portion of whose basin was mapped, and the Necons River, which for most of its length flows in a course roughly parallel with the Stony. At the face of the mountains the Necons River empties into a large double lake, known as Two Lakes, below which its course gradually converges with that of the Stony. These streams

[6] Capps, S. R., The Mount Spurr region: U. S. Geol. Survey Bull. 810, pp. 141–172, 1929.



SKETCH MAP OF THE CHAKACHAMNA-STONY REGION, ALASKA

Showing areas in which timber occurs

join in the lowland many miles below Two Lakes. The largest tributary of the Necons enters it from the east and receives the drainage from the main crest of the range for some distance north and south of Merrill Pass.

Another large lake, known to the natives as Telaquana Lake, lies some miles southwest of Two Lakes and drains into the Necons River. It was seen only from a distance, and neither its exact outline nor its area is accurately known.

At the head of the main Stony River there is an easy pass, entirely feasible for pack horses, that leads northward into the head of some northward-flowing stream, probably one of the headwater tributaries of either the South Fork of the Kuskokwim River or the Hartman River. Further exploration will be necessary to determine this question.

Relief.—The Chakachamna-Stony region, as the term is here used, is almost exclusively an area of rugged mountains and deep valleys, though it is bordered on the southwest by an area of much milder topography, the upland edge of the great Kuskokwim-Mulchatna lowland. Part of this lowland was seen at a distance, but the route followed by the Geological Survey party lay entirely within the mountains.

In that part of the Alaska Range here described the range is of extraordinary width from its eastern to its western front. The distance measured in a straight east-west direction from the Cook Inlet face of the range to the mountain front of Two Lakes is 50 miles, and that width is increased 20 miles northwest of Two Lakes by the western bulge of the mountain front beyond the Stony River. Throughout this wide belt the range consists of an unbroken area of rugged mountains and steep-walled valleys, and views from the air at an altitude of 7,000 to 8,000 feet give the impression of an endless sea of sharp crags and ridges. The highest mountains of the region lie along the ridge of which Mount Spurr is the southern point, and many peaks on that ridge rise to altitudes of 11,000 feet or more. Farther west the summits are lower, though no less rugged in character. From Kenibuna Lake to the west front of the range most of the higher peaks reach altitudes of 7,000 to 7,500 feet, with a few mountains attaining 8,000 to 9,000 feet. All these mountains show the effects of severe glaciation in the past, and in many valley heads active glaciers still survive. To reach the crests of most of the interstream ridges requires alpine climbing of considerable difficulty, and hundreds of peaks are almost or entirely unscalable. The granitic rocks that occupy much of the region take on extremely rugged forms under the influence of glacial erosion and yield scenery of impressive grandeur.

The main valleys throughout this region are deeply carved and lie at altitudes of 1,100 to 2,500 feet. Kenibuna Lake is 1,250 feet above sea level, Merrill Pass 3,180 feet, and the Necons River at the mouth of its main eastern tributary about 1,400 feet. Two Lakes lie at 1,270 feet, only a little higher than Kenibuna Lake. The valley of the Stony River west of Two Lakes is at 1,350 feet, and the grade of that river for the next 20 miles upstream averages only about 12 feet to the mile. In the lower portion of the part of the Stony River shown on the accompanying map that stream is only moderately swift and meanders through a rather flat-floored valley in a single channel bordered by timbered banks. Farther upstream the river is swifter, flows in many branching channels over gravel bars, and has the characteristics of heavily loaded glacial rivers. Travel along any of the larger valleys by pack train offers no unusual difficulties, though at many places some trail cutting is necessary. The presence of well-traveled moose trails greatly facilitates travel in many brushy areas, and by following them one may avoid much chopping and be assured of fairly good footing.

Climate.—No reliable records of temperature and rainfall are available for the part of the Alaska Range here under discussion. The nearest point at which accurate weather observations are taken is Anchorage, and as Anchorage has entirely different surroundings with respect to mountains and ocean and different prevailing winds, its weather is quite unlike that of the Alaska Range. Any generalizations made here are therefore based on the experience of the Geological Survey parties of 1927 and 1928 during the periods between June 1 and September 15. Both of those summers are reported to have been unusually cloudy and rainy in the Cook Inlet region in general, and they may therefore not represent the average conditions in the Chakachatna and Stony Basins. In 1927, between June 11 and September 13, there were 70 days on which there was some rain. In 1928, in the corresponding season, there were 60 days that were rainy in the part of Chakachatna and Stony Basins in which the party happened to be, and on many other days there was low-lying fog. The summer temperatures are generally mild, though some rainy days were rather chilly and some clear days were oppressively hot. Nothing definite can be said about the climate during the winter further than that it is probably much like that of the other mountain provinces that border Cook Inlet. Such evidence as could be obtained from the attitude of the brush indicates that the snowfall is moderate. High winds are likely to prevail in the mountain valleys and passes.

Vegetation.—Within the portion of the Alaska Range here described timber grows only in narrow strips along the lower valley slopes to altitudes of not more than 2,500 feet, and even at lower

levels there are many areas in which no trees grow. Plate 1 shows the areas in which timber occurs in the region, although in parts of the areas so shown the trees are scattered, and there are irregular marshy tracts without trees. Practically none of the trees are large enough or clear enough to have any value as merchantable timber, but they serve well for the local uses of the trapper and prospector. Spruce is the most abundant tree, and some specimens 2 feet or more in diameter at the butt were seen. Some birch occurs on well-drained slopes. Cottonwood grows in places on the stream flats, and a few groves of quaking aspen were seen.

Within the timbered areas there is nearly everywhere some brushy undergrowth that includes alders, willows, and various shrubs, so that some trail cutting is necessary for the passage of pack animals, and in many places on the mountain slopes above timber line alders grow in such dense stands that they are almost impassable, even for a man on foot. Willows large enough for tent poles and for the camp fire are generally to be found in the valleys for considerable distances above the last timber.

Grass is fairly well distributed throughout the region, though it is necessary to have the question of forage in mind when choosing a camp site, as there are considerable areas in which grass is scanty. The commonest grass is a variety known as redtop, which locally grows in lush, luxurious stands. There is also some bunch grass and in places some vetch known as "pea vine." The leaves of certain types of willows are also eagerly sought by horses. As most of the types of forage plants are nutritious only during the growing season, the time during which pack animals can subsist properly on what they can obtain by grazing extends only from about the early part of June to the middle of September.

Game.—This portion of the Alaska Range is fairly well stocked with large game animals, though in fewer numbers and smaller variety than in some other parts. Both black and grizzly bears are common, more than 60 bears being seen by the party during the summer of 1928, and they are equally numerous in the adjoining areas surveyed during the two preceding years. As these bears have had little experience with man, they show little fear, and the black bears especially are bold and are likely to raid any provisions left unguarded. Wolverines are also common, and precautions must be observed to keep them out of caches.

In the western part of the Chakachatna Basin, in the valley of the Necons River, and in most of the Stony Basin sheep and caribou are scarce, though a little sign was observed. Moose, however, are plentiful, and well-traveled moose trails may be found along all the valleys. As the head of the Stony was approached caribou began to appear, and still farther upstream a few sheep were seen. The pass

between the head of the Stony and the northward-flowing stream that drains the north side of the pass is the summer range of a considerable number of caribou, and sheep sign was more abundant there than elsewhere in this region.

The fur-bearing animals that are to be found in this area include beaver, in the Stony Basin, and some lynx, mink, fox, and wolverine. Except for beaver, upon the trapping of which there are restrictions from time to time, the region is said to offer no exceptional inducements to the trapper.

Among the small game animals rabbits were seen only in moderate numbers, though in favorable years they are no doubt abundant here, as elsewhere in Alaska. Ptarmigan, like the rabbits, vary greatly in abundance from year to year. In 1928 only a few were seen. A few spruce hens were observed in the timbered areas.

As all the larger streams receive glacial waters and are muddy in the summer, they are unfavorable for fishing. Here and there are clear-water creeks and lakes that contain trout, grayling, and pickerel, and these fish are a welcome addition to the camp larder. Salmon run up the Necons as far as Two Lakes and also up the main Stony and are caught and dried by the natives on both of these streams.

Routes of travel.—The Chakachamna-Stony region is difficultly accessible, and until the last few years it could be reached only after a long and arduous journey. The Chakachatna Basin was virtually unknown and unexplored until it was mapped by the Geological Survey during a series of expeditions, the third of which is described in this report. No trails had been opened by which to approach it overland, and the Chakachatna River is too swift for boating in the summer and probably does not freeze solidly enough to provide a sled route in the winter. As a result, the upper basin of this river had been visited by not more than two or three white men, and the Cook Inlet natives, who formerly hunted in this basin, have avoided it for the last 30 years. In 1927 the Geological Survey party cut out and graded a passable trail from the beach of Cook Inlet at Trading Bay to the foot of Chakachamna Lake, and thence by way of the Nagishlamina and Chilligan Rivers to the headwaters of the Igitna River. In 1928 the pack train came in by this same route, and the trail was extended down the Igitna to Kenibuna Lake, up Another River to Merrill Pass, down the westward-draining valleys to Two Lakes, and thence northward to the extreme head of the Stony River. The pack train returned to Cook Inlet over the same route. This trail is well blazed from Cook Inlet to Chakachamna Lake and can be followed, but its course lies through much soft ground, and in places fallen timber adds to its difficulties. Horses can still be taken over it, but anyone attempting this trail with

horses should realize that it is a slow, difficult trail, with many stretches of soft ground that horses find barely passable. From the foot of Chakachamna Lake westward the trail offers no serious difficulties until it reaches Merrill Pass, where a party with horses should be prepared to do considerable pick and shovel grading in order to cross the pass. A considerable part of the grading done by the Geological Survey party was on unstable ground, and parts of the trail will surely slump off or be filled by slides from time to time. On the Kuskokwim side no unusual difficulties are to be encountered other than those incident to travel in any new country.

This region has been approached from the west by two distinct routes, one leading from the Kuskokwim River up the valley of the Stony, and the other from Lake Clark to Telaquana Lake and thence to Two Lakes. The route by way of the Stony River is said to be difficult in summer, as there are several canyons on the Stony through which boats can not be taken, and some of the portages around the canyons are reported to be several miles long. That route can be followed by dog sled in winter, but the trip is long from any base of supplies on the Kuskokwim.

It is reported that an old Indian trail leads from Lake Clark along the west face of the Alaska Range to Telaquana Lake and Two Lakes. It seems likely that this route would be feasible for pack horses, though none have yet been taken over it, and no description of this trail has been obtainable. In view of the length and probable character of the trail, there seems to be little choice between the route from Trading Bay to Two Lakes and that from Iliamna Bay to Two Lakes by way of Lake Clark.

With the establishment of a commercial aviation service at Anchorage the problem of transporting passengers and freight to points in this region has been wonderfully simplified, and a number of trappers have used this service in taking outfits into the Chakachatna and Stony Basins. In 1928 the charge for this service was about $1 per plane-mile, the capacity of the plane was a pay load of about 700 pounds, and landings were made with pontoons on some of the numerous lakes. This service was used by the Geological Survey party in taking part of the personnel and part of the supplies from Anchorage to the upper end of Kenibuna Lake, but the pack horses necessary for the prosecution of the work had to be taken in overland from Trading Bay.

GEOLOGY

GENERAL OUTLINE

The areal distribution of the rocks of the Chakachamna-Stony region is shown in Plate 2 in so far as the formations have been

differentiated. Before the expedition on which this report is based the region was unexplored and unmapped. Only reconnaissance mapping was attempted on the expedition of 1928. The time available for field work was only about 60 days, during much of which the efforts of all members of the party were required in building or cutting trails. Bad weather also handicapped the prosecution of the geologic and topographic surveys. A still further obstacle to the careful mapping of the geologic boundaries arose from the fact that the topographic mapping was carried on concurrently with the geologic mapping, and the completed topographic base map was not available until several months after the field work had been finished. All these difficulties are present in some degree in any surveys carried out in a new country remote from transportation facilities, and because of these difficulties and of the reconnaissance character of the work, the geologic boundaries shown on the accompanying map are only approximate.

The geologic units shown on the map include five rock groups, of which two are intrusive igneous rocks and three are bedded and mainly of sedimentary origin. There are in addition two units that represent unconsolidated materials. All these units have been described in reports on adjoining areas, and only brief descriptions of their character, occurrence, structure, and age will be given here, with references to more complete descriptions published elsewhere.

Probably the oldest rocks in this area are a group that includes fragmental volcanic material now consolidated into tuff, lava flows, and associated clastic sediments, all considerably metamorphosed. This group has yielded no fossils in this region but is believed to be Mesozoic and probably of Lower Jurassic age. It is associated with and overlain by metamorphosed sediments that were originally sand and mud, but are now altered to argillite, slate, graywacke, and quartzite. These rocks are probably of Jurassic or Cretaceous age. A third group, younger than those already mentioned, consists largely of black argillite and slate, with minor amounts of graywacke. The rocks of this group have locally been severely metamorphosed to form black fissile schist penetrated in all directions by long andalusite crystals. From this group a single fossil was collected that indicates an Upper Cretaceous age.

A large proportion of the Alaska Range in this region is composed of granitic rocks. To the north, west, and southwest of Kenibuna Lake the granitic materials show a pronounced gneissic character, and these granitic or dioritic gneisses may be older than the surrounding unaltered granite, though definite proof of this was not obtained. The alternate view is that the granitic gneisses are of the same age as the associated unaltered granite, but that they were

changed to gneisses through fairly local metamorphism. There is evidence that granitic intrusion has taken place in this part of the Alaska Range during more than one period. Nevertheless, the great bulk of the granitic rocks are believed to have been intruded in late Mesozoic time, for they cut rocks believed to be of Upper Cretaceous age and have nowhere been seen to cut rocks of known Tertiary age.

Tertiary sediments are present on the east flank of the Alaska Range in this latitude and are known to occur on the north and northwest flank north of this region. No Tertiary beds were observed in the present investigation.

Unconsolidated materials of Pleistocene and Recent age are widely distributed in this region, particularly in the valley of the Stony River. These materials include glacial morainal deposits, alluvial fans, talus accumulations, and the gravel, sand, and silt of the present streams. The entire region shows evidence of the presence of great glaciers during the last glacial period, and the topography within the mountains is typical of a heavily glaciated mountain region. Many active glaciers still exist in the higher mountain valleys and supply débris to the rivers during the summer.

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

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

Tertiary: No Tertiary deposits have been recognized in this area, though it is likely that Eocene beds may occur on the west flank of the Alaska Range.

Mesozoic: Granitic intrusions; granite and diorite gneiss (possibly in part older than Mesozoic); black slate, shale, and graywacke, locally altered to schist, believed to be in part at least of Upper Cretaceous age; metamorphosed sediments, including slate, argillite, graywacke, and quartzite, of probable Jurassic or Cretaceous age; andesite, dacite, rhyolite, and basalt tuffs and flows, probably Lower Jurassic.

Pre-Mesozoic: Possibly the granite and diorite gneiss near Kenibuna Lake is pre-Mesozoic.

GRANITE AND DIORITE GNEISS

On the north, west, and southwest sides of Kenibuna Lake the prevailing rocks consist of granular intrusive materials that have undergone varying amounts of metamorphism. They range from fairly coarse quartz diorite, with incipient foliation, through banded gneiss, to finely foliated and fissile biotite schist. All gradational phases may be found from the little-altered material through rocks in which biotite becomes more abundant and a parallelism of the crystals begins to appear to banded gneiss in which little-foliated, sinuous bands of light-colored diorite alternate with darker, somewhat fissile

bands. This rock in turn grades into highly fissile mica schist, in which biotite is very abundant, all the minerals are recrystallized, and a suite of minerals not present in the original unaltered rock appear. Within the area of gneissic rocks there are numerous later intrusive bodies, also so metamorphosed that their original composition is not readily determinable. Among these is an altered dacite or quartz latite which originally contained plagioclase, quartz, possibly orthoclase, and accessory minerals, as well as ferromagnesian minerals that are now altered to epidote. Much secondary quartz is also present.

The age of these gneissic rocks is not definitely known. Time was not available to trace out the boundaries accurately, even if those boundaries are sharply defined. If the gneiss can be shown to be a distinct unit, not related to the surrounding granite, its degree of metamorphism would indicate that it is older than the unaltered granite. Fragments of granitic rocks within the tuff formation, to be described later, show that there were granitic rocks in this region before the intrusion of the prevailing granite. It is entirely possible that the gneissic rocks are much older than the sediments and tuffs in this area and than the prevailing granite, but the possibility should be kept in mind that the gneiss may be the result of local metamorphism of the prevailing granitic rocks and of the same age.

In the valley of the Nagishlamina River, about 20 miles east-northeast of Kenibuna Lake, there are schistose rocks[7] that include hornblende schist, as well as altered banded rocks that are probably metamorphosed sediments, which are considered to be older than the granite and the sedimentary and tuffaceous rocks of that region. Possibly the gneiss near Kenibuna Lake may be related to the schistose rocks of the Nagishlamina Basin, though this is only a suggestion. The age of the gneissic rocks near Kenibuna Lake is still uncertain. They may be older than Mesozoic, or they may be late Upper Cretaceous, like most of the associated granitic rocks.

MESOZOIC ROCKS

With the possible exception of the gneissic rocks in the vicinity of Kenibuna Lake, already described, all the hard rocks of the Chakachamna-Stony region are believed to be of Mesozoic age. These rocks include four units that have been differentiated on the accompanying geologic map. In ascending order they are (1) a group composed mainly of volcanic tuffs and lava flows, with some included and associated sedimentary rocks; (2) a group of undifferentiated rocks, including some of the tuff and lava of group 1 but consisting mainly of metamorphosed sediments—argillite, chert, slate, gray-

[7] Capps, S. R., The Mount Spurr region: U. S. Geol. Survey Bull. 810, pp. 155–156, 1929.

EXPLANATION

SEDIMENTARY AND BEDDED VOLCANIC ROCKS

Recent	Gravel, sand and silt of present streams	QUATERNARY
Recent and Pleistocene	Glacial morainal material and outwash gravel, terrace gravel, alluvial fans, and talus	QUATERNARY
Upper Cretaceous	Black argillite, slate and graywacke, locally schistose	JURASSIC AND CRETACEOUS
Probably Lower Jurassic to Upper Cretaceous	Undifferentiated complex, consisting mainly of altered sediments, including slate, graywacke, altered sandstone, etc., but with some volcanic tuff and lava	JURASSIC AND CRETACEOUS
Probably Lower Jurassic and younger	Undifferentiated complex, consisting mainly of tuff and lava, but containing also some metamorphosed sediments and some granite	JURASSIC AND CRETACEOUS

IGNEOUS ROCKS

Upper Cretaceous	Granitic intrusives with some later dikes	CRETACEOUS? CRETACEOUS
Upper Cretaceous or older	Gneissic granitic rocks with some later dikes	CRETACEOUS? CRETACEOUS

Scale 1/250,000

0 5 10 15 Miles

GEOLOGIC MAP OF THE CHAKACHAMNA-STONY REGION, ALASKA

Geology by S. R. Capps. Base prepared by Alaskan branch from surveys by Gerald FitzGerald

1930

wacke, and quartzite, with a little limestone; (3) a group composed mainly of black argillite and graywacke, which have locally been metamorphosed to schist; and (4) the granitic intrusive rocks that form the most conspicuous element in this part of the Alaska Range. All these rocks are cut by dikes and sills, but so far as is known these intrusive rocks, which are of considerable variety but of minor quantity, are of Mesozoic age also. None of the rock groups listed above carries fossils in sufficient abundance to serve as a reliable guide in stratigraphic work. In three successive field seasons in this general region careful search has resulted in the finding of only two determinable fossils, one a plant and the other an invertebrate. Both of these were found in the upper shale-argillite-graywacke group, and both suggest an Upper Cretaceous age for that group. The determination of the age of the underlying rocks is therefore somewhat uncertain, depending on correlation with other formations of known age some distance away.

TUFFS, LAVAS, AND ASSOCIATED SEDIMENTS

Character and distribution.—Probably the oldest bedded rocks in the area here considered are included in a group composed of andesite, dacite, and rhyolite porphyry and basalt flows, tuffs and agglomerates of the same materials, and minor amounts of metamorphosed sediments that were originally shale, sandstone, and limestone. In this region these rocks are present on the east fork of the Necons River, 5 or 6 miles west of Merrill Pass, and are abundant on the main east fork of the Stony River, where they predominate over the other rocks. Similar rocks have been observed in adjacent regions, including the valleys of the Skwentna River [8] and of the Igitna River [9] in the Chakachatna Basin. The rocks here included in this group will doubtless some time be subdivided, but at present information on which such a subdivision could be made is lacking.

The most characteristic phase of this predominantly volcanic group of rocks consists of a great variety of tuffs and agglomerates interbedded with porphyritic lava flows. The tuffs range in color from dark gray or almost black through lighter gray, pink, and various hues of green, purple, and brown. The included fragments are angular to subangular or rounded and range in size from microscopic particles to pieces 8 inches or more in diameter. They are composed for the most part of andesite, dacite, rhyolite, and basalt, but there are in some places abundant pieces of shale and argillite, and a few pebbles and fragments of granitic rock were seen. These tuffs are

[8] Capps, S. R., The Skwentna region: U. S. Geol. Survey Bull. 797, pp. 82–86, 1929.
[9] Capps, S. R., The Mount Spurr region: U. S. Geol. Survey Bull. 810, pp. 156–160, 1929.

interbedded with lava flows that include andesite, rhyolite, dacite, and basalt, and with some altered sedimentary materials such as argillite, graywacke, black chert, and a little limestone. Some of the lava beds are finely banded and show flow structure.

Structure and thickness.—Structurally the tuffs and lavas show various attitudes, but in general they form a group of competent rocks that are less deformed than the associated sediments. In many places they are only mildly folded, and their structure is relatively simple. Elsewhere they are closely folded and crumpled and are intricately faulted, particularly near some of the contacts with the intrusive granite, which cuts the lavas and tuffs and which has sent many dikes and apophyses into them. The areas of the tuff and lava group are separated from one another by patches of sedimentary rocks and by granitic intrusive rocks, so that precise correlation between parts of the group at different places is difficult, but the group as a whole has such characteristic lithology that a general correlation of the several patches of these rocks is open to little question.

The maximum thickness of the lava-tuff group in this region is not known. Its intricate structure, the obscurity of the bedding in places, and the lack of complete sections all add to the difficulty of determining the thickness. All that can now be said is that probably the group as a whole is at least 2,000 feet thick, and it may be much thicker.

Age and correlation.—No precise evidence of the age of this tuff-lava group has been procured in this region. No fossils have been found in it, and as the associated metamorphosed sediments are also unfossiliferous its assignment to any time period must be based on its correlation with similar rocks in neighboring regions where more positive evidence of age is available. The only older rocks that have been recognized in this part of the Alaska Range are the schists of the Nagishlamina Valley, northwest of Mount Spurr,[10] and possibly the gneisses near Kenibuna Lake, described on pages 109–110. The age of neither of these formations is definitely known, although the schist is thought to be of pre-Mesozoic age and possibly the gneisses are also. The age of the group of metamorphosed sedimentary rocks that is associated with and in part overlies the lava-tuff group is also not definitely known. The still younger group, composed of black argillite and graywacke and their schistose equivalents, is believed to be Upper Cretaceous. From direct fossil evidence, therefore, it is known only that the lava-tuff group is considerably older than Upper Cretaceous.

[10] Capps, S. R., The Mount Spurr region: U. S. Geol. Survey Bull. 810, pp. 155–156, 1929.

By correlation on the basis of lithology and of general stratigraphic position, however, a more definite age assignment is obtained. The discussion of the age of these rocks has been fully presented in the reports on the Skwentna and Mount Spurr regions already cited and will be briefly reviewed here.

There can be little doubt that the lava-tuff group of rocks observed in the basin of the Stony River is to be correlated with similar rocks in the Chakachatna Basin, to the east, and with similar lavas and tuffs in the basin of the Skwentna River, where they also lie beneath argillite and slate that have yielded Upper Cretaceous plant remains. This whole assemblage of volcanic rocks appears to be most closely related to a similar group of rocks that occurs in the valley of the Matanuska River, to the east, where it was described as the Talkeetna formation by Martin[11] and assigned by him to the Lower Jurassic on the basis of fossils found in it. Whether or not all the lavas and tuffs of this group in this part of the Alaska Range are correlative with the Talkeetna formation, and, if so, how much of the associated sediments are also of Lower Jurassic age are not yet known, and those questions must remain unanswered until more fossil evidence is obtained from these very scantily fossiliferous rocks.

UNDIFFERENTIATED METAMORPHIC SEDIMENTS

Character and distribution.—Within the basin of the Stony River, especially in the basin of the Necons River, its largest tributary from the northeast, there is a group of undifferentiated rocks that includes some lavas and tuffs, which may, upon more detailed study, be grouped with the lava-tuff group already described, and a series of metamorphosed sediments, at least a part of which may eventually be grouped with the Upper Cretaceous argillite-graywacke-schist group. These metamorphosed sediments are best developed on the Necons River north of Two Lakes and extend up that stream as far as the mapping was carried. They include a great variety of rock types, among which are coarse graywacke, some of which contains more or less rounded fragments of shale or argillite; finely banded and ribboned siliceous graywacke; dense rusty quartzite; and some black chert. All these rocks are cut by large and small siliceous dikes and by the prevailing granitic rocks of the region. Both graywacke and dike rocks contain disseminated pyrite, which, along with the secondary silica, is the result of igneous metamorphism. Over considerable areas the oxidation of the pyrite has given these rocks a rusty color.

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

Structure and thickness.—Little can be said of the general structure or the thickness of this group of metamorphosed sediments. Their structure is known to be complex in detail, with much minor folding and faulting and locally with intimate intrusion. In the main this group is believed to overlie the lava-tuff group already described, though the presence of tuffs along with these sediments suggests that it may be the upper continuation of the tuff-lava group and so may represent the waning of volcanic deposition with a consequently greater proportion of normal sedimentary material in the section. The maximum thickness of the rocks is likewise not known, though they are doubtless several thousand feet thick in places.

Age and correlation.—If the conclusion is correct that this group of metamorphosed sediments is younger than the lava-tuff group and older than the argillite-slate-graywacke group, described below, and if the age determinations of those groups are correct, then the age of this group of rocks must be somewhere between the Lower Jurassic and the Upper Cretaceous. So far no fossils have been found in these rocks, and their age must remain uncertain within the limits above set forth until diagnostic fossils are discovered or until their correlation is made more definite than it is at present.

ARGILLITE-SLATE-GRAYWACKE GROUP

Character and distribution.—In the valley of the Necons River, in the vicinity of Two Lakes, and along that part of the valley of the Stony River that is included in this investigation there is a group of black argillite and slate and dark-gray graywacke that appear to be distinct from the metamorphosed sediments and tuffs described above, and they are indicated by a separate pattern on Plate 2. They are characterized by their prevailing black color, in contrast to the rusty and brownish shades of the other sedimentary group, and their comparative freedom from igneous intrusive rocks.

In the vicinity of Two Lakes these rocks comprise black slabby argillite and gray siliceous graywacke. The proportion of argillite to graywacke varies from place to place. In one section a hundred feet or so of argillite, with little coarser material, gives place gradually to an intimately banded alternation of argillite with graywacke in layers an inch or less thick, and this in turn, by the increase in thickness of the graywacke bands and a decrease in thickness of the argillite bands, to a massive graywacke, with beds several feet thick separated by only thin partings of argillite. Locally the argillite shows slaty cleavage, and the graywacke is silicified and becomes an impure quartzite.

This same group of rocks appears to occupy a considerable area in the mountains bordering the valley of the Stony River west

and southwest of Two Lakes, although that area was seen only from a distance. On the Stony River above Two Lakes the argillite-graywacke group crops out first on one side of the valley and then on the other but occupies only a narrow north-south belt, bordered by granitic intrusive rocks and by the older sedimentary and volcanic rocks. Apparently these sedimentary rocks have formed a line of weakness through an area of more resistant rocks and have determined the course of the Stony River.

As the main forks of the Stony River are approached from the south, the argillite-graywacke rocks show increasingly the effects of igneous metamorphism from the intrusion of the granitic rocks. Secondary mica and silica become more abundant, and a schistose cleavage appears. Still farther north these sediments become very schistose, the coarser phases becoming impure quartzite schist and the argillite being altered into a black fissile carbonaceous schist characterized by a remarkable development of needle-like andalusite crystals that lie parallel to the planes of schistosity but point in all directions within those planes. Secondary pyrite appears as scattered cubes throughout both coarse and fine phases of these rocks. Still farther north, near the pass at the head of the Stony River, these rocks again become less schistose, and normal argillite and graywacke prevail.

Structure and thickness.—The structure of the argillite-graywacke group of rocks appears to depend, in considerable degree, upon the size of the areas in which they occur. South and east of Two Lakes, where this group occupies an area of many square miles, the beds have a fairly uniform monoclinal dip of 15°–20° NE. Similarly, on the west side of the Stony River, west and southwest of Two Lakes, the bedding as seen from a distance seems to be only mildly deformed. By contrast, in those belts along the Stony Valley where the argillite-graywacke rocks occur in narrow areas bordered by granitic intrusives, the beds have steep dips, in many places approaching the vertical. Near the head of the Stony River, where these rocks again occur in large areas, their structure is simpler and the dips are less steep.

No accurate measurements of the thickness of the argillite-graywacke group have been made, for nowhere has the complete section been studied. All the areas of this group that were seen are bordered on at least one side by granitic intrusive rocks, and as these are the youngest hard rocks of the region, the uppermost beds have suffered erosion wherever they are exposed. On the mountains east of Two Lakes at least 3,000 feet of beds of this group are exposed, and a similar thickness is present east of the extreme head of the Stony River. The group is therefore at least 3,000 feet thick and may be considerably thicker.

Age and correlation.—The argillite-graywacke group is believed to be in part, at least, of Upper Cretaceous age. A single shell collected from these rocks in 1928 was identified by T. W. Stanton as an *Inoceramus*, which he believed to be Cretaceous and probably Upper Cretaceous. A single fossil leaf collected in 1926 on the upper Skwentna River, from what is believed to be the same group of rocks, was identified by Arthur Hollick as a dicotyledonous angiosperm of Cretaceous or Tertiary age. Inasmuch as the only rocks in this part of Alaska that are definitely known to be Tertiary are the coal-bearing sediments correlated with the Kenai formation, of Eocene age, and as these Eocene rocks are undoubtedly younger than the argillite-graywacke group here under discussion, the evidence seems definite that the argillite-graywacke group is in part, at least, Upper Cretaceous. The fossils noted above, however, were found at neither the top nor the bottom of this thick group of rocks. In the writer's opinion it is likely that all these rocks above the horizons at which the fossils were found are of Upper Cretaceous age, but there is no assurance that some portions of this group below the fossil horizons are not older. For the present, however, it seems best to classify this entire group in the Upper Cretaceous.

TERTIARY ROCKS

No Tertiary rocks have been found in the Chakachamna-Stony region, though Tertiary rocks are extensively developed in the lowlands east of the Alaska Range, from Cook Inlet to Broad Pass, as well as on the north and northwest flank of the range from the Delta River at least as far westward as Muldrow Glacier. These Tertiary rocks form a characteristic and easily recognizable series of shale, sandstone, and conglomerate, usually containing some lignitic coal. Their chief economic value lies in the coal, which in many places occurs in thick beds and which, though generally of too low grade to warrant commercial development at the present time, nevertheless constitutes an important fuel reserve. No detailed description of these rocks will be given here, but attention is called to the possibility that the coal-bearing formation may be present on the west slope of the Alaska Range in the lowlands or in the foothills flanking the main mountains.

INTRUSIVE ROCKS

A brief description of the gneissic rocks in the vicinity of Kenibuna Lake is given on pages 109–110. It is uncertain whether they are older than the Mesozoic tuffs, lavas, and sedimentary rocks or whether they represent only a local, metamorphic phase of the prevailing granitic rocks.

The most conspicuous single group of rocks in this region comprises the granitic intrusives, which occupy a large area, as shown on Plate 2, and to which is largely due the rugged character of this part of the Alaska Range. Throughout the width of the range in this latitude, from its eastern face near Mount Spurr to the edge of the Kuskokwim lowlands on the west, this great mountain mass is composed predominantly of granitic intrusive rocks. Furthermore, granitic rocks are known to constitute a large part of the range from Iliamna Lake northward to and beyond Mount McKinley.

The granitic rocks have commonly a gray color, though some are pink. Microscopic examination shows that these rocks are mainly to be classified as granite, though diorite is also present. They range in texture from fine-grained sugary rocks to coarse granite with orthoclase phenocrysts 2 inches or more long. As is usual where granite occurs in large areas, there is a wide range in color, from almost pure white through various hues of pink and gray to nearly black, the color depending upon the proportions of the different minerals present and upon the segregation of certain minerals within the granitic mass. All these rocks, however, have the granitic habit, and although a careful microscopic study would result in their classification into a large number of rock types, until such a systematic study is made they may well be included under the general term granitic rocks.

Dikes and sills in considerable variety cut the granitic rocks, and also the tuffs and sediments of the region. They include rhyolite and diorite porphyry and more basic types such as augitite, pyroxenite, diabase, basalt, and basalt porphyry. Although post-granite dikes, obviously younger than the rocks into which they are intruded, are common, their bulk as compared with the rocks into which they are injected is small, and they are not shown on the geologic map.

From information obtained in this part of the Alaska Range during the last three years the age of the main bulk of the granitic intrusives has been determined within fairly narrow limits. In 1926, in the valley of the upper Skwentna River, a fossil leaf was collected from shale cut by granite that is directly connected with and a part of the great intrusive mass here under discussion. That leaf was determined to be of Upper Cretaceous or Tertiary age. On the Stony River a single fossil shell from the argillite-graywacke group was identified as of Cretaceous age, probably Upper Cretaceous. The argillite and graywacke are also cut by the granitic intrusives, which must be younger than the sediments and therefore at least as young as Upper Cretaceous. On the other hand, there are in many

places along the flanks of the Alaska Range beds of Eocene age, lying close to the granite but, so far as is known, nowhere cut by the granite. It seems fairly certain, therefore, that the intrusion of the main bulk of the granite of this portion of the Alaska Range occurred after these Upper Cretaceous sediments were laid down but before the beginning of Tertiary sedimentation in this region. These granitic rocks must therefore be of late Upper Cretaceous or early Tertiary age.

This age assignment refers to the great bulk of the granitic rocks that are so extensively developed between the Chakachatna and Stony Basins and Mount McKinley. It is recognized, however, that there are older granite pebbles in the tuff of probable Lower Jurassic age, and that there were earlier intrusions of granite in this part of Alaska, though the areas in which these older granites occur are not known. Possibly they are represented by the gneissic granite near Kenibuna Lake.

QUATERNARY DEPOSITS AND HISTORY

PREGLACIAL CONDITIONS

The Quaternary period of geologic time includes all the geologic events that have taken place during the great ice age (the Pleistocene epoch) and the time since the ice age (the Recent epoch). In the high mountains of Alaska the distinction between Pleistocene and Recent events is difficult to make, for here the final withdrawal of the great glaciers, which in many parts of the world marked the end of the Pleistocene and the beginning of Recent time, has been delayed, and great glaciers, the direct descendants of the Pleistocene glaciers, still exist. Pleistocene conditions have therefore merged gradually into present conditions, and glacial deposits are even now being laid down.

In a reconnaissance survey, such as that upon which this report is based, a large part of the effort and time of the party is consumed in travel to and from the field of work and in overcoming the difficulties of travel in a trailless country. As the purpose of the expedition was to survey as large an area as possible in a short working season, many details of geologic and physiographic interest had to be passed over hastily, to await more careful study in the future. Nevertheless, enough is known of the Pleistocene and Recent history of the region to justify a general statement outlining the more important events of this time.

At the end of Tertiary time the Alaska Range had the same position and general shape that it has to-day, and its summit peaks were probably even higher than they are now. Great valleys had been carved in it in about the same positions as the present valleys. In

the details of topography and in the general appearance of the region, however, this part of the Alaska Range was very different then from what we see now. The mountain valleys, developed by running water, without the aid of valley glaciers, were more nearly V-shaped in cross section; their gradients were very different, and many of the tributary streams followed courses quite different from those we now find. Such lakes as Chakachamna, Kenibuna, Telaquana, and Two Lakes did not then exist, and the extensive mantle of morainal material and glacial outwash now present along the Stony and Necons Valleys and extending westward into the Kuskokwim lowlands had not yet been laid down.

GLACIAL EPOCH

Pleistocene time in Alaska, as in many other parts of the world, was characterized by a remarkable development of glaciers and is often spoken of as the great ice age. It is possible that the higher mountains of the Alaska Range harbored valley glaciers in preglacial times, as they do now, but these glaciers were small compared with the tremendous ice fields that overwhelmed this part of Alaska in Pleistocene time. At the beginning of the glacial epoch a change of climate took place by which the mean annual temperature was lowered, the winters became longer and more severe, and the summers became shorter, so that such small valley glaciers as may have been present in the higher mountains grew and lengthened, and in other valleys previously unglaciated snow banks remained unmelted through the summer, thickened year by year, and eventually became glaciers that lengthened and moved down the valleys. With continuing growth the glaciers from the many tributary valleys joined in the trunk valleys to form large ice streams with many branching heads, and these in turn pushed farther and farther down their basins. In the Cook Inlet-Susitna region so vast a mass of glacial ice advanced from the surrounding mountains that the entire Susitna Basin was buried beneath several thousand feet of moving ice, and this great glacier pushed down Cook Inlet at least as far as the forelands and possibly much farther. On the west and north front of the Alaska Range the precipitation was probably much lighter than on the Cook Inlet-Susitna slope, and the glaciers, although reaching a thickness of thousands of feet within the mountains, spread out into great spatulate lobes at the mountain flank, and most of them did not push out to any great distance into the Kuskokwim lowland.

In the north-central part of the United States, where the glacial deposits have been studied in great detail, it has been shown that during the glacial period there were several distinct stages during which the glaciers grew and expanded, and these stages were sepa-

rated by interglacial stages during which the ice edge retreated far to the north and the glaciers may have disappeared altogether. In Alaska the sequence of glacial advances and retreats is not so well worked out, for the last great glaciers obliterated much of the evidence of their predecessors. Nevertheless, at a number of places in Alaska definite proof has been found that there were great ice advances long before the last great forward thrust of the glaciers, and it is probable that here also there were several stages of vigorous ice advance, separated by periods of deglaciation, and quite likely these glacial stages corresponded in time with those elsewhere on the continent.

In the Chakachamna-Stony region the erosive power of the thick streams of moving ice during the glacial epoch is well shown by the shapes of the valleys as we now see them. These valleys are straight or follow sweeping curves; their floors are relatively broad, and the walls rise steeply to the bordering peaks; and the mountain spurs between tributary streams have been cut away so that one's view is unobstructed for miles up or down these valleys. The smoothed and truncated valley walls show plainly that the glaciers scoured the sides of their walls to a height of as much as 3,000 feet above the bottom, and a view of the region at the height of the glacial epoch would have revealed only lines of ragged peaks and ridges projecting above a sea of ice. At that time the glacier surface was continuous through many low divides from one drainage basin to another, and whenever the snowfall in one basin was unusually heavy for a period of years, ice from that basin crowded across the borders of the basin through any low passes that existed and by its grinding action on those passes lowered them still more. In this way such low, broad passes as Merrill Pass and the pass at the head of the Stony River were formed.

GLACIAL DEPOSITS AND BENCH GRAVEL

While the glaciers were growing and during their period of greatest expansion they picked up and carried with them all the soil and loose materials over which they moved and used these rock fragments as tools with which to grind down their beds still further. Thus a vast amount of detritus was carried out of the mountains to the lowlands and there deposited as moraines or supplied to the rushing streams to be sorted by them and laid down as stream deposits or carried to the sea. As the ice retreated, however, it left behind extensive deposits of morainal materials, and the streams, reworking the ice-brought materials, built up wide and thick gravel beds. These deposits of moraine and of outwash gravel, the latter now generally intrenched by the streams to form benches or terraces,

are shown on the geologic map (pl. 2) wherever they are sufficiently thick to conceal the underlying rock formations over considerable areas. They generally form narrow strips along the lower slopes of the valley walls, but they cover large areas in places where the valleys widen out near the flanks of the range.

At the time of the maximum glaciation the ancient glacier that flowed down the Stony Valley extended some 50 miles beyond the mountain front into the lowland.[12] The topography of the lowlands, as seen from the ridge between Two Lakes and the Stony River, indicates that this glacier spread out in a spatulate, piedmont lobe. Extensive terraces, cut from glacial outwash gravel, are widely developed in the Stony Basin below the main forks and east and south of Two Lakes. Two Lakes and the many small lakes near by lie in depressions in morainal material, and the low ridge that constricts Two Lakes is a moraine ridge. Probably Telaquana Lake also is dammed behind a glacial moraine. Kenibuna Lake owes its origin to the damming of its valley by Shamrock Glacier, a vigorous ice stream that pushes northward across the great east-west valley drained by the Chakachatna River. A farther advance of that glacier would deepen and enlarge Kenibuna Lake, by raising the barrier around which its outlet must pass. Chakachamna Lake, into which Kenibuna Lake drains, just east of the terminus of Shamrock Glacier, is similarly impounded by Barrier Glacier.

PRESENT STREAM DEPOSITS

The deposits of the present streams, as shown on Plate 2, include only those materials on the stream flats that are even now submerged at periods of unusually high water. In general these deposits lie in narrow strips, extending only a short distance back from the streams on either side. In the upper courses of some of the larger glacier-fed rivers, however, the heavily loaded streams have developed wide gravel flats over which the streams flow in many branching channels. The gravel in each of these valleys is coarsest near the glaciers in which the river heads and becomes progressively finer downstream; as the coarse gravel is dropped the gravel flats narrow and the stream flows in a single channel between well-defined banks. Thus the Stony River below the mouth of its main west fork flows in a single well-defined channel, whereas above that point it is a braided stream. Likewise the Necons River has extensive bare gravel bars above Two Lakes but is confined to a single channel below them. The Neacola River flows in many channels over a wide stream flat as far as Kenibuna Lake, into which it empties. The

[12] Smith, P. S., The Lake Clark-central Kuskokwim region, Alaska: U. S. Geol. Survey Bull. 655, pp. 85–96, 1917.

lower valley of that stream is a wide sandy plain, built in part as a river plain and in part as a delta into Kenibuna Lake. Considerable areas of this sand plain are overflowed by Kenibuna Lake during periods of high water but are exposed when the lake is low.

MINERAL RESOURCES

No mineral resources, either metallic or nonmetallic, have been developed in the Chakachamna-Stony region, and almost no prospecting has been done there, so that little is known of its possibilities. No coal deposits were seen during this investigation, and none have been reported from the area considered.

In an area as remote from transportation as this the only mineral deposits that would offer a likelihood of profit to the prospector are those of the precious metals, and gold placers have the greatest appeal, for by the use of simple equipment that can be made on the ground the placer miner can exploit his discoveries, accurately gage their value, and carry the product of his mining out with him. Therefore the first inquiry that the prospector makes concerning a new country is as to the possibility that it may contain placer gold. That part of the Chakachatna and Stony Basins here described does not hold out much promise as a field for placer-gold prospecting. Such panning as was done by members of the Geological Survey party yielded no gold at all on Another River and in the basin of the Necons River, and none on the Stony except at a point about 10 miles below the head of that stream, where a few fine colors were obtained. The severe scouring to which this country was subjected by the glaciers during the ice age resulted in the removal of all rock waste and stream gravel, and the ice no doubt ground away much of the bedrock also, so that any concentrations of placer gold that may have existed in preglacial time are likely to have been removed and scattered. The geologic conditions, however, are not unfavorable for the existence of gold-bearing veins, for the extensive granitic masses have mineralized the bordering sediments. Pyrite is abundantly present as scattered specks in the argillite and graywacke in many places, and numerous rusty patches on the mountain slopes result from the oxidation of the pyrite. It is quite possible that veins bearing gold, silver, copper, lead, and zinc may be found in this region, for these minerals are commonly present in veins associated with granitic rocks.

In this general region placer gold in encouraging amounts has been found at several places where the rock formations are similar to those here described. Some years ago there was a small stampede to a part of the Stony Basin some distance southwest of Two Lakes, but the results of prospecting there were disappointing, and no con-

siderable amount of gold was recovered. In the basin of the Styx River, a tributary of the South Fork of the Kuskokwim River, at a point only 25 miles northeast of the pass at the head of the Stony River, coarse gold was found about 15 years ago, and a small amount was recovered, but no ground rich enough to justify mining under the existing conditions was located. In view of these occurrences of placer gold in this general region, it seems possible that some of the smaller and less heavily glaciated valleys on the west flank of the Alaska Range, both north and south of the Stony River, and in the adjacent foothills might offer promise of containing workable gold placers, and prospecting in such favorably situated places would be justified.