EXPLANATION UNCONSOLIDATED DEPOSITS Muskeg deposits Alluvial-gravel deposits Beach deposits Swamp deposits Outwash deposits End, lateral and ground moraine deposits Terrace deposits BEDROCK Sedimentary rocks pTm Metamorphosed rocks Axis of overturned anticline Contact Dashed where indefinite, inferred, gradational, or indefinite boundary of surficial deposits Maximum extent of 600 A.D.—900 A.D. glacial advance Dashed where inferred Dashed where indefinite; dotted where concealed Maximum extent of youngest glacial advance (1700 A. D. advance) Strike and dip of beds Dashed where inferred Strike and dip of overturned beds Abandoned drainage channel of Kushtaka Lake Horizontal beds 90 Location of sample shown on Figure 2 Strike of vertical beds Unknown depth of muskeg deposits overlying Axis of anticline showing direction of plunge terrace deposits -4-+---Axis of syncline showing direction of plunge 8 feet of muskeg deposits overlying terrace deposits

INTRODUCTION A geologic examination of the Katalla area, Alaska, was made by the U.S. Geological Survey during the summer of 1955 at the request of and in cooperation with the Alaska Road Commission (now Bureau of Public Roads). The Katalla area lies in the Cordova A-1, A-2, B-1, and B-2 quadrangles (fig. 1) and encompasses most of the area considered as the Controller Bay region or Katalla district by previous investigators. This report describes the engineering geology of the Katalla segment of a proposed highway from Mile 39 on the Copper River Highway to Icy Bay, approximately 110 miles east of the small town of Katalla. The completion of this segment of the highway and the Copper River Highway from Mile 39 to Chitina will connect the Katalla and Cordova areas with the Alaska Highway system and the Alaska Railroad. Previous geologic work in the Katalla district was directed primarily toward investigations of oil and coal resources. The Katalla district as defined by Miller (1951) "... extends from the valley of the Copper River eastward about 40 miles to the western margin of Bering Glacier, and from Kayak Isla id northward about 55 miles to the southern front of the Chugach Mountains." A systematic investigation of this district was begun in 1903 by G. C. Martin and carried out through 1906, and in 1917 by Martin and other geologists of the Geological Survey. The Katalla district was investigated more recently by D. J. Miller, D. L. Rossman, and C. A. Hickcox in 1944, and by Miller in 1945 and 1951. The primary objective of their investigation was to obtain geologic information useful in appraising the oil possibilities of the

The present geologic examination of the Katalla area was made in 1955 by a Geological Survey party consisting of Reuben Kachadoorian, David D. Smith, and A. Peter Haupert. Nelson C. Fellows was assigned as bulldozer operator to the party by the Alaska Road Commission. Field mapping consisted of a series of boat and foot traverses during which geologic information was gathered and plotted on vertical aerial photographs of 1:40,000 scale, and transferred later to a topographic map of 1:40,000 scale. Areas not visited on the ground were mapped by reconnaissance from a light airplane, and by Areas east of the Bering River, north of the Martin River, northwest of Ragged Mountain, and Fox, Kanak, Kayak, and Wingham Islands were not visited on the ground. They were, however, visited by Martin and Miller and information on such areas was obtained from Miller (1951, and oral communication, 1957). Information and criteria established in the areas traversed on foot and by boat were used to extend the lithologic units into the above areas Field work and logistic support were greatly facilitated by the cooperation of numerous Alaska Road Commission (now Bureau of Public Roads) employees. Of particular value was the cooperation of Lawrence C. Hough and

The mechanical analyses in this report were made by the Valdez District of

the Alaska Road Commission (now Bureau of Public Roads) and the Geolog-

ical Survey in Menlo Park, Calif. GEOGRAPHY

feet to 4,000 feet.

James W. Kassen, Alaska Road Commission engineers.

The Katalla area lies on the south flank of the Chugach Mountains and is bounded on the south by the Gulf of Alaska. Major topographic features include northward-trending mountains and ridges interspersed with lakes, glaciers, valleys, swamps, and broad lowland areas. About one-fourth of the map area consists of mountains, one-fourth of sea and tidal lowlands, and the remaining one-half is comprised of approximately equal proportions of lakes, lowlands, valleys, and glaciers: The mountains rise abruptly from the lowland areas to a maximum elevaion of about 3,315 feet in Ragged Mountain, south of the Martin River. North of the Martin River the mountains rise from an altitude of about 100

VEGETATION Two major floral zones are represented in the Katalla area. The coastalforest zone extends from sea level to an altitude of approximately 1,700 feet. Areas above this altitude have alpine-tundra vegetation. Within the coastal-forest zone swamps, Qs, and muskegs, Qm, are covered with grasses, sedges, mosses, and small colonies of shrubs. Willow, alder, and limited patches of Sitka spruce or western hemlock are restricted to higher ground bordering the water courses of the swamps and meadows. Vegetation on the alluvial-gravel deposits, Qag, of the fans consists of willow, alder, Sitka spruce, and western hemlock. On the fans in the east and west sides of Katalla Valley, vegetation is chiefly alder and willow with scattered small stands of spruce and hemlock. The spruce and hemlock occur in the better drained upslope part of the fans. The undergrowth on these fans consists chiefly of devilselub and salmonberry. Spruce and hemlock, some as much as 3 feet in diameter, are the dominant trees on the fan that divides Katalla Valley and Bering Lake. Devilsclub, salmonberry, and scattered patches of alder and willow form the undergrowth on this fan. Sitka spruce and western hemlock predominate in the denser forests. They grow on the better drained lowlands, and on the slopes up to an altitude of 1,700 feet. The largest stands of spruce and hemlock are on (1) moraines, Qmo, and outwash, Qo, south of Kushtaka Glacier, west of Martin River Glacier, and south of Lake Charlotte (2) on bedrock along Trout Creek, and (3) along the shore holes ranging from shallow panlike depressions 10 feet deep and 100 feet wide between Redwood Bay and the mouth of Bering River. Trees in these areas to steep-walled pits 50 feet deep and 100 to 500 feet across are common. Lakes are as much as 5 feet across and average 3 feet in diameter. The forest floor is mantled by a thick growth of devilsclub, salmonberry, and blueberry. In the alpine-tundra zone, above timberline, the upper slopes and summits of the hills and mountains are covered by a thick mat of moss, sedges, and herbs. Shrubs and stunted Sitka spruce and mountain hemlock grow in sheltered localities along the lower margin of the alpine zone. Vegetation-

The climate of the Katalla area is characterized by heavy rainfall, cloudy weather, and by low summer and moderate winter temperatures. Complete climatological data are not available for the Katalla area. The data for Cordova Airport, approximately 55 miles northwest of Katalla, and the CAA station, Yakataga, about 70 miles east of Katalla, are shown on tables 1 and 2, respectively (U.S. Weather Bureau, 1956).

free bedrock is common in areas of very steep slopes and on the higher summits.

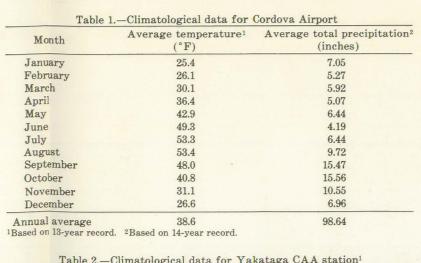


Table 2.—Climatological data for Yakataga CAA station¹ Average temperature Average total precipitation March

During the 1955 summer field season numerous snowslides were heard in the Katalla area. Nels Larson, a resident of Katalla reported (oral communication 1955) that snowslides are abundant in the area and occur most frequently during the late spring and early summer. He stated that the largest slides occur on the east slope of Ragged Mountain and on the west slope of the mountains forming the eastern boundary of Katalla Valley. Areas that are subject to snowslides are distinguished by slopes containing chutelike scars, vegetation-free slopes, and slopes supporting relatively young vegetation. Such areas should be considered and evaluated in the ocation of the highway alignment.

age, and unconsolidated sediments of glacial and nonglacial origin of Quater-

ROCKS OLDER THAN TERTIARY (pTm) The sedimentary and volcanic rocks of pre-Tertiary age are slightly to moderately metamorphosed and are exposed on Ragged Mountain, Wingham Island except the extreme southeastern part, and in the Chugach Mountains north of the Martin River (see geologic map). The rocks consist of metamorphosed silty and sandy sediments (sandstone, graywacke, shale, and slate) with greenstone, graywacke, and minor amounts of chert, limestone, and intrusive igneous rocks (Martin, 1908, Miller, 1951). The sandstone and graywacke are massive and generally fracture into blocks 2 to 5 feet across. Locally, however, they fracture into blocks less than 1 foot across. The greenstone is massive and fractures into blocks 5 to 8 feet across. The shales and slates have well-developed cleavage and break into thin slabs. The rocks are intensely jointed and complexly faulted and folded; they are in fault contact with the Tertiary rocks on Wingham Island, on the south flank of the Chugach Mountains northwest of the mapped area, and on the east flank of Ragged Mountain. The age of these rocks has not been clearly established. The degree of

deformation and alteration, the structural relationship to the Tertiary rocks exposed in the area, and the lithologic similarity to more accurately dated rocks in adjacent areas of Alaska indicate that the bedded metamorphosed rocks of the Katalla area are of Mesozoic age (Miller, 1951, p. 12).

ROCKS OF TERTIARY AGE (Tss)

Sedimentary rocks of Tertiary age underlie most of the Katalla area. They extend from the east flank of Ragged Mountain to the eastern boundary of the mapped area and from the Martin River and Martin River Glacier south to the Gulf of Alaska. They also crop out on the west side of Ragged Mountain and on Wingham Island. The sedimentary rocks consist chiefly of sandstone, shale, argillite, siltstone, and conglomerate (Miller, 1951) and are subdivided into several mappable units. Since the engineering characteristics of most of the various units are essentially similar, however; the sedimentary rocks are considered as one unit in this report. The sedimentary rocks considered to be of Tertiary age in this report consist of the Stillwater, Kushtaka, Tokun, and Katalla formations of Eocene to Oligocene and possibly Miocene age, and undifferentiated sequences of probable early Tertiary age (Miller, 1951, p. 13-23).

The Tertiary rocks are locally metamorphosed in areas of contact with the metamorphosed sediments of pre-Tertiary age. West of Ragged Mountain the sandstone is massive, hard, fine- to medium-grained and interbedded with argillite, siltstone, and conglomerate that contains cobbles and boulders. In the area between Martin Lake and Bering Lake the rocks are shale with minor amounts of mudstone, siltstone, and claystone and fine-grained calcareous sandstone interbedded with shale and siltstone. The rocks exposed on the northeast shore of Bering Lake are chiefly coarse arkose. Massive, thick-bedded, medium- to coarse-grained sandstone interbedded with finegrained, thin-bedded sandstone is exposed at Split Creek south of Bering Lake. On Burls Creek, about 8½ miles east of Katalla, the rocks are chiefly massive gray shale and associated dense, massive glauconitic sandstone, tuff, and Joints in the thick- and thin-bedded sandy and shaly sediments locally are 4 to 8 inches apart. More commonly the joints in these rocks are spaced 2 to

DEPOSITS OF QUATERNARY AGE With the exception of glacial outwash, Qo, and glacial moraine, Qmo, the unconsolidated deposits in the Katalla area are of nonglacial origin. Deposits associated with two minor glacial advances of Recent age are recognized in the area; a few small deposits of till-like material on the northeast side of Whale Island may represent a third, much older glacial advance, but other evidence of such an advance is inconclusive, and the material is mapped as Recent terrace deposits. Outwash and morainal complexes (end, lateral, and ground moraines) are restricted to areas within 5½ miles of present glaciers. The nonglacial sediments, however, vary widely in composition and

re scattered throughout the Katalla area. End, lateral, and ground moraines (Qmo).—End, lateral, and ground moraines are common in the Kushtaka Lake, Lake Charlotte, and the Martin River areas. Kushtaka Lake is encircled by a large, well-developed end moraine approximately 100 feet high. Another well-developed end moraine restricts the Martin River channel approximately 2 miles west of the terminus of the Martin River Glacier. Numerous smaller lateral moraines occur on the high slopes of the mountains between Kushtaka Lake and Lake Charlotte. Most of the morainal complex consists of end and lateral moraines. There are, however, small patches of ground moraine in the mapped area. Ground moraines occur along Stillwater Creek about half a mile east of Kushtaka Lake, and in a small area between the 600 A.D.-900 A.D. and the 900 A.D.-1700 A.D. glacial advances in front of the terminus of the Martin River Glacier. Areas of ground moraine and end or lateral moraines are similar lithologically Topographically, however, the ground moraine areas are slightly more subdued than the areas of end and lateral moraines. The morainal complexes are areas of rough topography consisting of ridges are common in the kettle holes and in depressions dammed by till that was plastered at the base of moving ice, or dumped without reworking at the point

where ice finally melted. End and lateral moraine complexes are formed at the fronts and sides of glaciers. The larger ridges may represent (1) material plowed up during periods when the glaciers were advancing, (2) material dumped without much reworking by meltwater, and (3) material dumped during periods when the glaciers were receding. Smaller sand and gravel hillocks consist of material washed into tunnels and crevasses along the margins of the ice. The kettle holes represent the sites of isolated ice blocks that melted away within the moraines or melted away after being buried in gravel by meltwater streams. Sandy till is generally the predominant material comprising moraine complexes and consists of 58 to 72 percent gravel, 24 to 36 percent sand, and less than 6 percent silt and clay (fig. 2, curves D and E). It is present everywhere in the moraines at depth, and crops out at the surface in long ridges that are the dominant element in the morainal topography. The dominant exposed material of the moraine that dams Kushtaka Lake, however, is not sandy till but is cobbles and boulders. Boulders as much as 10 feet across are common and one boulder 25 feet across was noted. Sandy till may be present at depth. Rocks in the morainal complexes consist chiefly of subangular to angular cobbles and boulders of granite, sandstone, metamorphic rocks, and volcanic rocks. Most of the large boulders are granite. The outer margins of the end and lateral moraines are generally well drained

and are relatively favorable areas for road building where considerations of grades and alignments permit. Outwash (Qo).—Outwash is glacial debris that has been reworked and deposited by meltwater streams. It consists of well-sorted sand and gravel, commonly stratified. Areas of outwash large enough to be mapped separately are found west of the Martin River and Bering River Glaciers, north and south of Kushtaka Lake, and south of Lake Charlotte. The surficial swamp, Qs, and alluvial-sand deposits, Qas, east of the Bering River may be underlain by outwash deposits. In many places, outwash and alluvial-sand deposits intergrade. Topography underlain by outwash is characterized by nearly flat surfaces

with local relief of 3 to 15 feet consisting of low escarpments, bars, and swales marking the courses of ancient stream channels. The outwash deposits are similar to, but coarser than, the modern alluvium, Qas, in nearby streams and consist principally of well-rounded pebble and cobble gravel, sand, and silt and clay. A sample of outwash material deposited by the Kushtaka Glacier consisted of about 65-percent well-rounded pebble and cobble gravel, 30-percent clean washed sand, and less than 5 percent silt and clay (fig. 2, curve F). Drainage conditions vary widely in outwash areas. The outwash is coarse and permeable and thus generally has good drainage. Many of the outwash areas, however, have low gradients and are indented below the surrounding terrain, thereby collecting drainage from large areas. The outer margins of the outwash plains are generally marshy or swampy. Terrace deposits (Qt).—Terrace deposits are confined to the western portion

of the Katalla area. They occur west of the town of Katalla, along the southern end of Ragged Mountain, west of Martin Lake, on Fox and Whale Islands, and in a small area north of the Martin River on the west flank of a spur of the Chugach Mountains. The terraces on Fox and Whale Islands, west of Katalla, and along the southern and western margin of Ragged Mountain were formed by marine deposition and erosion. Terraces north of the Martin River and west of Martin Lake may have formed either by marine deposition and erosion or by glacial scouring. The terraces are in large part mantled by swamp, Qs, and muskeg, Qm, deposits 3 to 10 feet thick. The terrace west of Martin Lake is completely covered by muskeg deposits 3 to 6 feet thick. Measured thicknesses of terrace deposits range from 3 feet west of Katalla to 46 feet on Whale Island. Sediments comprising terrace deposits consist of about 35 to 58 percent

angular to rounded gravel, 25 to 54 percent sand, and 7 to 40 percent silt or clay (fig. 2, curve T-T'). Beach deposits (Qbd).—All constructional shoreline deposits, built principally by marine waves and longshore currents and consisting of sand, pebbles, and boulders, are considered beach deposits in this report. Under beach deposits are discussed barrier beaches, spits, bay-mouth bars, and cuspate forelands. Kanak Island, a barrier beach, was formed by waves breaking some distance The rocks exposed in the Katalla area consist of metamorphic rocks and offshore on the gently shelving offshore area. The waves churned up the

GEOLOGIC UNIT

GENERAL DESCRIPTION

Masses of rock that have loosened

and slipped down slopes. Land-

slides generally slip to bottom of

Loose rock pried from bedrock cliffs

by frost action and other weather-

hill or slope.

principally of coarse- to fine-grained sand with minor amounts of pebbles. Okalee Spit, Softuk Bar, and the spit at Katalla Bay are being formed by arrents flowing in a northwesterly direction around bedrock headlands (Cape

Martin, Suckling Hills, west of map area, and Cave Point, respectively), and tail off into deep water. The past history of Katalla Valley indicates that several such spits formed in Katalla Bay in the past. As these former spits and barrier beaches grew they nearly or completely closed the entrance to Katalla Bay, thereby forming a bay-mouth bar. Several distinct former bay-mouth bars can be noted on the geologic map. The oldest bay-mouth bar in the valley is about 4 miles north of the spit now developing at the mouth of the valley. Therefore, the bay at one time extended into Katalla Valley at least 4 miles and the development of a series of spits into bay-mouth bars has forced the bay to its present location. Bay-mouth bars in Katalla Valley range in composition from about 68-percent gravel, 30-percent sand, and less than 2-percent silt and clay at the head of valley to about 10-percent gravel, 85-percent sand, and less than 5-percent silt or clay at the mouth of the valley (fig. 2, curves A and B). Palm Point, south of the town of Katalla, is a cuspate foreland formed by rrents from Katalla Bay and from the direction of Martin Islands. The point was built at a time when Katalla Bay extended farther into the Katalla Valley. At the present time the point is being eroded by the current that is building the spit across Katalla Bay. From Palm Point northward to a point approximately three-eights of a mile south of Katalla the beach is being eroded. Locally, the waves have undermined a 50-year-old railroad grade that was originally located approximately 100 feet inland. More commonly,

years. Elsewhere in the Katalla area, erosion of the coastline is of much Alluvial-gravel deposits (Qag).—Included in alluvial-gravel deposits are alluvial fans and stream gravel of numerous nonglacial streams. Many alluvial fans occur in the Katalla area. Extensive areas of fans are (1) on the east, south, and west slopes of the mountains bounding Katalla Valley, (2) between Katalla Valley and Bering Lake, and (3) south of Martin Lake. Smaller fans have developed along Redwood, Burls, Mary, Puffy, Dick, Stillwater, and Locally, the fans have relatively little relief and stand only a foot or two higher than their stream channels. Trenches a few feet deep represent old abandoned stream channels and channels occupied only during floods. The heads of the fans are generally well drained, and the water table lies 10 to 15 feet below the surface. At the toes, however, seepages are numerous, and Alluvial fans consist of interfingering lenses of clean, washed gravel and sand, with a few cobbles. The average grain size of the deposit decreases with increasing distance from the mountain slopes or sources of the material. A sample collected midway between the toe and head of the alluvial fan on the east flank of Ragged Mountain consists of approximately 55-percent

however, the beach has retreated between 25 and 35 feet in this span of 50

gravel, 43-percent sand, and 2-percent silt or clay (fig. 2, curve C). Muskeg deposits (Qm).—Extensive areas of muskeg form in poorly drained areas and occur (1) in the Katalla Valley, (2) west and southwest of Martin Lake, and (3) along the southern margin of Ragged Mountain. Small, scattered muskegs occur locally on the upper slopes of the mountains. Muskegs consist of 1 foot to 10 feet of spongy material made up of grasses, sedges, mosses, fine sand, and silt. Although the material is very absorbent and generally dry on the surface, local swampy areas are abundant in the lowlying muskegs. Deep, steep-sided small pools are characteristic of the muskeg areas. With the exception of those on the mountain slopes, the muskegs are generally underlain by 3 to 12 feet of sand and gravel. On the high mountain slopes they are underlain by bedrock. The muskeg deposit west of Martin Lake ranges from 2 to 5 feet in thickness. The deposit that underlies the abandoned railroad grade in Katalla Valley has an average depth of at least Swamp deposits (Qs).—Large swamp deposits are scattered throughout the Katalla area and are especially abundant south of Kushtaka Lake, southeast

of Bering River, and west of the Martin River Glacier. The features considered and mapped as swamp deposits in this report consist of large areas in which drainage is impeded so that the soils are saturated hroughout the year, tidal flats, and low-lying coastal areas occasionally inundated by the highest tide. Standing water a few inches deep covers much of the surface. Many areas mapped as swamp deposits do not generally contain any standing water. They do, however, become marshy and contain water 2 to 3 inches deep after a few days of rain. Therefore, such areas are considered and mapped as swamp deposits in this report. Swamp deposits consist of peat, muck, and silt as much as 3 feet thick. West of the Martin River and Bering Glaciers, swamp deposits are underlain by outwash sand and gravel. Elsewhere they are underlain by muskeg, alluvial sand, and alluvial-gravel deposits. Alluvial-sand deposits (Qas).—Extensive areas of alluvial sand underlie the

The alluvial-sand deposits of the large glacial rivers (the Gandil, Nichawak, Bering, Copper, and Martin Rivers) and Shepherd Creek are 1 foot to 10 feet thick and consist of clean, washed fine- to coarse-grained sand locally interbedded with gravel. The fine- to coarse-grained sand is underlain by an unknown thickness of sandy gravel. During construction of a segment of the

pherd Creek is of the same order of magnitude. amounts of silt. Gravel was not observed in the sand and silt.

Talus deposits (Qta).-Talus deposits are found along the front of the The talus consists of loose rock pried from bedrock cliffs by frost action t or more in diameter. Some of the talus deposits are as much as 50 feet tion. The thickness of this talus is unknown but is believed to be 5 to 10 feet Landslides (QIs).—Large landslides have developed in metamorphosed sedi-

The earliest geologic event recorded in the Katalla area is the deposition evidence for such an advance is inconclusive. reenish-gray sediment

Although the sediments on Whale Island and the shape of Katalla Valley suggest that a glacial advance may have extended beyond the clearly defined Ridge, no glacial deposits have been found on the mountain slopes or on the associated intrusive rocks of pre-Tertiary age, sedimentary rocks of Tertiary bottom sand and built the island. Barrier beaches and sand bars consist low hills that would justify postulating an extensive glacial advance at this

time. It is most improbable that erosion would remove all the morainal debris that would result from an advance extensive enough to leave deposits on Whale Island. Martin River Glacier would have to advance at least 22 miles, and the glaciers in the Copper River valley would have to advance a minimum of 38 miles to cover the island. If the Martin River Glacier had advanced 22 miles and ice from the Copper River valley 38 miles, it would be reasonable to assume that Bering Glacier, immediately east of the Katalla area, would also have advanced in the same order of magnitude. If Bering Glacier did advance this amount there is no evidence of it in the field. Miller reports (oral communication, 1955) that he did not find any glacia debris on Suckling Hills, 2 miles in front of the present position of the Bering Glacier ice. He also did not find any glacial debris on Nichawak Mountain, Gandil Mountain, and Mount Campbell, which are adjacent to the ice front. Miller does state, however, that there is a well-defined moraine deposited by Bering Glacier approximately 100 to 300 feet above the present ice and beyond the limits of the recent end moraines along the slopes of Mount Campbell around Hanna Lake, and along the north margin of Bering Glacier. Bering Glacier has deposited a well-defined moraine up to 500 feet above the present ice on Nichawak Mountain. The above evidence would indicate that the Bering Glacier did not have an advance comparable in extent to the advance that would be necessary for the Martin River Glacier or ice from the Copper River valley to deposit glacial debris on Whale Island. To explain the lack of extensive morainal debris in the Katalla area, Martin (1908, p. 50-52) proposed that the land was elevated during the maximum glaciation of the area and that large glaciers went out through valleys now submerged or filled with alluvium. If the land were elevated 1,000 feet, snowline would fall a corresponding distance and local glaciers would form in the now abandoned local glacial cirques. The reservoir area of the larger glaciers would increase, thereby increasing the flow of the glaciers, and the ice would rise to about the altitude indicated by the highest moraines bordering the Martin River Glacier. The valley tongues of the glaciers would extend into the valleys and flow out to the sea. During subsequent depression of the area, the debris left by the glacier beyond the moraines that can now be observed would be buried by river deposits. The broad alluvial flats are known to be filled with unconsolidated deposits exceeding depths of 280 feet in the Katalla

Valley, and 580 feet on the east shore of Bering River. The total depth of these unconsolidated deposits is unknown. Martin (1908) suggested that the ice rose to levels of the highest lateral moraines observed in the area. If these moraines were deposited by the extensive advance proposed by Martin, they would have to extend beyond the points where the recent lateral moraines descend rapidly to the end moraines. The high lateral moraines are continuous, however, with the end moraines and do not exist above the point where the lateral moraines descend. Thus, it is likely that the glacial advance proposed by Martin (1908) was not extensive, but probably was similar to the later advances of the Martin River Glacier The maximum clearly established glacial advance younger than the advance discussed above, is represented south of the Martin River Glacier by the moraine that extends up to an altitude of 1,300 feet on Cunningham Ridge, descends into the valley of Stillwater Creek, encircles and forms the south shore of Kushtaka Lake, then rises to an altitude of approximately 1,500 feet on the east flank of Charlotte Ridge. The moraine then descends along the west flank of Charlotte Ridge and extends about half a mile south of the Lake Charlotte outlet, rising again along the west shore of the lake to an altitude of about 1,000 feet. The moraine continues westward, along the mountain wall, descends into the Martin River valley and crosses the valley approximately 3 miles west of the present front of the Martin River Glacier. North of the Martin River Glacier, the moraine is on the south flank of the Chugach Mountains, descending westward from an altitude of 1,000 feet to 800 feet,

tributary lobes, and an unnamed glacier. The moraine encircling Kushtaka Lake was deposited by the Kushtaka Glacier, a lobe of the Martin River Glacier. The moraine in the valley along the south flank of the Chugach Mountains was deposited by a small unnamed glacier. The age of the glacial advance that deposited this clearly defined morainal complex has not been determined accurately. However, a tentative date is here proposed on the following evidence: (1) The moraines are relatively fresh, without any soil profile developed upon them. The lack of a soil profile, however, may be the result of the bouldery character of the morainal debris, which is not conducive to the development of a soil profile. (2) A second generation growth of a mature forest of hemlock and spruce occupies the moraine encircling Kushtaka Lake. Boring of the trees indicated that some of the larger trees were about 500 years old. Assuming that the first generation trees also attained an age of 500 years would make the age of the moraine at least 1,000 years. (3) Miller collected a wood sample in a moraine at Icy Bay (about 100 miles east of the Katalla area) that was dated by radiocarbon techniques. The material was determined to be 1,200±160 years old (Plafker

The above evidence suggests that the morainal complex is at least 1,000 years old. It is believed that the glacier that deposited this morainal complex advanced at approximately the same time as the glacier that deposited the Icy Bay moraine described by Plafker and Miller (1958). Therefore, a tentative age of from 600 A.D. to 900 A.D. for this glacial advance is proposed. youngest advance in the Katalla area is represented south of the Mart River Glacier, by a moraine that descends from an altitude of 900 feet on the west flank of Cunningham Ridge to an altitude of 100 feet along the northeast shore of Kushtaka Lake, crosses the lake approximately in the middle and rises again to an altitude of 900 feet along the east flank of Charlotte Ridge. North of Charlotte Ridge, on Hill 1400, the moraine rises to altitude of approximately 1,100 to 1,200 feet. The moraine then descends into the Lake Charlotte valley. crosses the valley approximately one-eighth of a mile south of the lake outlet, rises again along the west shore of the lake to an altitude of 500 feet. The moraine then continues westward and descends into the Martin River valley about half a mile west of the present ice front of the Martin River Glacier. The moraine cannot be found in the valley because it has been covered by outwash debris from the present wasting ice. North of the Martin River Glacier this glacial advance is represented by a moraine that descends westward along the south flank of the Chugach Mountains from an altitude of 700 feet to an altitude of 500 feet. The moraine

wash debris from a small unnamed wasting glacier on the south flank of the Chugach Mountains. The moraines that represent this glacial advance are not as well defined as e that represent the 600 A.D.—900 A.D. glacial advance. The age of this glacial advance has not definitely been established. There is, however, evidence to tentatively assign a date to this advance. On the south shore of Kushtaka Lake is an abandoned channel 23 feet above the present lake level. This channel passes through the 600 A.D.-900 A.D. morainal complex encircling Kushtaka Lake, is 50 to 60 feet wide in the morainal complex and as much as 100 feet wide, and 6 to 7 feet deep in the outwash plain beyond the moraine. The channel and the lake shore below the altitude of the channel are now occupied by first generation hemlock and spruce trees. Several trees were cored in the channel and along the shore of Kushtaka Lake, within 3 feet of the present water level. All the core samples indicate that the largest trees are about 250 years old. As the trees are 250 years old and as very little if any time elapsed after the retreat of the ice before the trees started to grow, it is proposed that the age

is not found in the Martin River valley because it has been covered by out-

of this glacial advance is at least 250 years, or about 1700 A.D., but not as old SEISMIC ACTIVITY The Katalla area lies in a zone of major seismic activity. Moderate and severe earthquakes have been reported at Katalla, at Cordova, west of Katalla,

and at Yakataga, east of Katalla (Tarr and Martin, 1912). On May 14, 1908,

with its epicenter at Katalla. Tarr and Martin report the description of the

an earthquake with an intensity of VII on the Rossi-Forel scale was reported

earthquake taken from the Katalla Herald (May 16, 1908) as follows: "Two earthquake shocks occurring in quick succession at 11:07 o'clock Thursday night, set every building in town rocking, moved furniture about rooms, knocked dishes from shelves, and caused many of the people in town, many of whom had retired, to take to the streets. 'According to the statements of a number of people, the shocks of which there were two in almost instantaneous succession, lasted from 10 to 17 seconds. No damage was done. The shocks were accompanied by a vibratory motion pretty nearly north and south. In the Herald office the machinery and fixtures swayed perceptibly, while the building rocked as if it had been struck by a cyclone." Recent earth movement in the area is indicated by a 30-foot displacement of the talus deposits along the fault on the eastern flank of Ragged Mountain.

Recurrence of earthquakes of intensities as great as that of the 1908 earthquake is probable in the Katalla area. Therefore, manmade structures in the area should be made earthquake resistant. REFERENCES

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ENGINEERING GEOLOGY

Unsuitable as road foundation.

Unsuitable as road foundation

because deposit is generally in

source of riprap. Good source of

coarse borrow material if crushed. Poor to fair as road foundations

and as source of borrow. The

flood plains of the Gandil,

Nichawak, Bering, Copper, and

Martin Rivers generally fair for

road foundation because they are

underlain by sandy gravel. Al

other areas are poor to fair for

Unsuitable as road foundations

where underlain by sand and silt.

May offer fair foundation where

underlain by sand and gravel, if

swamps are drained. Generally

foundations.

row material.

Alaska, in September 1899: U. S. Geol, Survey Prof. Paper 69.

DESCRIPTION OF GEOLOGIC UNITS IN THE KATALLA AREA, ALASKA DRAINAGE NATURAL SLOPE THICKNESS Large slides have developed along the east flank of Ragged Moun-Broken surfaces containing | Surface drainage gentain, north of Martin River, and erally good; subsur- Slides are subject to recurrent benches, ridges, and depresn the east flank of Charlotte face drainage gen- movement. Poor source of borsions. Slopes range from Ridge. Numerous smaller slides nearly flat to steep. occur throughout mapped area. May be as much as 100 feet thick Generally smooth surfaces except at bottom of deposit flank of Ragged Mountain, and Slopes range from gentle to from 5 to 50 feet in thickness.

ing processes and deposited as aprons and cones on gentle slopes Large deposits lie along the east below. The rocks are angular, insorted, and range from a few inches to 10 feet or more in Clean, washed, fine- to coarselie the flood plains of the Gandi grained sand with minor amounts Nichawak, Martin, Bering, and Nearly flat marshy surface of silt interspersed with gravel. Katalla Rivers, and the Copper | crossed by a few winding Alluvial sand deposited by large River delta. Smaller amounts sloughs and minor streams. glacial rivers is underlain by occur along the tributaries of these Lakes, muskeg areas, and sandy gravel; alluvial sand deposrivers. Alluvial sand deposits ited by the Katalla River and vary from 1 foot to 15 feet in minor streams is underlain by fine sand and silt. Areas in which drainage is impeded so that soils are saturated all year. of Ragged Mountain, (3) south o Standing water a few inches deep the Bering River, and (4) south of covers much of the surface. Kushtaka Lake. Small swamps Deposit consists of peat, muck, are scattered throughout the and silt generally underlain by mapped area. Tidal flats are silt and fine sand. Southeast of also mapped as swamps. Deposit Bering River the deposit is underare as much as 3 feet thick in lain by sand and gravel. ontidal areas. In tidal areas Spongy material made up of grasses sedges, mosses, fine sand, and silt. Locally muskegs are swampy Extensive deposits are (1) in Katalla valley, (2) west and southand contain deep, steep-sided Generally flat and gently east of Martin Lake, and (3) along small pools. sloping surfaces. Locally on top of low mountains Alluvial gravel consists of interand on moderate slopes of fingering lenses of clean, washed deposits on upper slopes of sand, pebbles, and cobbles. Rocks mountains. Deposits range from are subangular to rounded. 1 foot to 8 feet in thickness. Average grain size of rocks decreases with increasing distance

a poor source of borrow. Unsuitable as road foundation and source of borrow. Good as road foundation. Selecsouth, and west slopes of mou from slopes or source of material. tive borrowing will yield usable tains bounding Katalla valley, (2) Fans have relatively little sand and gravel for fills. Depth Constructional shoreline deposits between Katalla valley and Bering relief and stand only a foot of borrow pits will be controlled consisting of barrier beaches, Lake, and (3) south of Martin or two higher than their by the water table, which ranges sand bars, spits, cuspate fore-Lake. Smaller fans are along stream channels. Slopes in depth from a few inches at lands, and bay-mouth bars. numerous small creeks in the area. are gentle. the toe of the fans to 10 or 15 Deposits consist of clean, washed Deposits are as much as 15 feet feet at the head of the fans. sand, pebbles, and boulders. Little if any fines. Deposits are along shoreline and in Excellent as road foundation. How-Marine deposition and erosion sur-Katalla valley. Thickness of Smooth, flat, gently sloping ever, deposit has insufficient fine faces in large part mantled by deposit is unknown but may be surfaces. material for road surfacing. swamp deposits, Qs, and muskeg from 25 to 75 feet thick. deposits, Qm. Terrace deposits eposits lie (1) west of Katalla consist of gravel, sand, silt, and) along south and west flanks Good as road foundation in the well of Ragged Mountain, (3) west of Generally good. Locally drained areas. Fair in areas of Glacial debris reworked by melt-Martin Lake, (4) on Fox and locally poor drainage. In areas water streams. Outwash deposits Whale Islands, and (5) north of Smooth surfaces flat or gently overlain by a thin mantle of consist chiefly of well-rounded Martin River on west flank of the sloping. silt- or clay-size swamp or muskeg deposits, good pebble-cobble gravel, clean Chugach Mountains. Measured as road foundation if swamps or washed sand, and minor amounts hicknesses of deposits range from meadows are removed. of silt and clay. 3 feet west of Katalla to 46 feet Moraines generally consist of 35 to 70 percent gravel, 25 to 50 percent sand, and less than 6 percent silt Drainage varies from Well-drained areas offer good road Martin River Glacier; (2) west | Nearly flat surfaces with local or clay. Moraine south of Kushof Bering River Glacier, (3) north relief of 3 to 15 feet conpoor to good. Low, foundation. Poorly drained areas taka Lake consists chiefly of will also offer good road foundation if adequately drained. Source

and south of Kushtaka Lake, (4) sisting of low escarpments, cobbles and boulders at the sursouth of Kushtaka Lake, and (5) bars, and swales marking the outer margins of face. Boulders as much as 10 outwash plains are of small quantities of good boralong west flank of the Chugach the course of ancient stream feet across are common and a poorly drained. mountains. Thickness unknown channels. boulder 25 feet across was noted. out may be as much as 50 feet. Rocks are subangular to angular Ioraines are restricted to Kushtaka granite, sandstone, metamorphic Lake, Charlotte Lake, and Martin Areas of rough topography rocks, and volcanic rocks. Outer margins gener ally well drained. In-Chiefly thin- to thick-bedded sandness of moraine is unknown. feet high, separated by stone, shale, argillite, siltstone, However, the moraine encircling swales and undrained deand conglomerate with minor Kushtaka Lake is at least 125 pressions. Slopes are gento well drained. amounts of mudstone and clayfeet thick and may be as thick as erally moderate to steep. stone. Rocks locally metamorphosed. Rocks moderately jointed, Mountainous terrain with with joints generally spaced 2 to gentle to steep slopes 4 feet apart. Exposed extensively throughout Mountain tops generally Slightly to moderately metamorrounded with locally sharp phosed silty and sandy sediments with greenstone and minor Mountainous terrain with amounts of chert, limestone, and Exposed on Wingham Island, on gentle to steep slopes. intrusive igneous rocks. Rocks Ragged Mountain, and in the Mountain tops generally

End, lateral, and ground moraine deposits are complexly faulted, folded, Chugach Mountains. and intensely jointed.

and crosses the valley. This morainal complex was deposited by the Martin River Glacier, its dis-

flood plains of the Gandil, Nichawak, and Bering Rivers west of the Bering Glacier; the Martin River west of the Martin River Glacier; the Katalla River; and Shepherd Creek which flows into Bering Lake. Smaller areas of alluvialsand deposits are along the numerous tributaries of these streams. The flood plains underlain by alluvial sand are nearly flat, marshy surfaces, crossed by a few winding sloughs and minor streams. Lakes, meadows, and swamps

Copper River Highway in similar deposits west of the Copper River, the Bureau of Public Roads (Alaska Road Commission) engineers state (oral communication, 1955) that as much as 30 feet of gravel was encountered beneath the alluvial sand. It is reasonable to assume, therefore, that the hickness of sandy gravel underlying the alluvial-sand flood plains of the Gandil River, Nichawak River, Bering River, Copper River, Martin River, and The alluvial-sand deposits of the Katalla River and minor streams are 3 to 10 feet thick and consist chiefly of fine- to coarse-grained sand with minor Drainage of areas underlain by alluvial-sand deposits varies from poor to

mountains and in the steep-walled valleys within the mountains. Large talus deposits occur on the east flank of Ragged Mountain. and other weathering processes and deposited as aprons and cones on the gentler slopes below. The angular unsorted blocks may be as much as 10 thick, but, more commonly they are 25 to 30 feet thick. The talus deposit along the east shore of Martin Lake is mantled by a thick growth of vegetaand locally as much as 15 feet. No large blocks of talus debris were noted. ments of pre-Tertiary age along the east flank of Ragged Mountain, north of Martin River on the south flank of the Chugach Mountains, and on the east flank of Charlotte Ridge. Numerous smaller slides are common throughout the Katalla area in rocks of pre-Tertiary and Tertiary age.

during pre-Tertiary time of sediments and volcanic rock (Martin, 1908, p. 61). he pre-Tertiary rocks were subjected to early Tertiary or older diastrophism as well as late Tertiary or Quaternary diastrophism that affected the youngest exposed Tertiary rocks of the Katalla area (Miller, 1951, p. 11). According to Martin (1908), the sedimentary deposits of Tertiary age are marine and nonmarine in origin. Folding of the rocks took place in late Tertiary or Quaternary time and was probably accompanied by local igneous intrusion. The folding was accompanied by or immediately followed by uplift, which has probably continued to Recent time (Martin, 1908, p. 63-64). Two recent minor glacial advances can be clearly established in the Katalla area. Unconsolidated deposits overlying bedrock on Whale Island may possibly be remnants of a third much older and more extensive advance, but other The deposits on Whale Island that indicate a possible older glacial advance comprise 29 feet of greenish-gray till-like material, overlain by 17 feet of light olive-gray till-like sediments. The dark greenish-gray material consists of approximately 40-percent angular to subangular, locally subrounded gravel, 20-percent coarse- to fine-grained sand, and 40-percent silt or clay. The overlying light olive-gray sediments consists approximately of 45-percent angular to subangular gravel, 32-percent coarse- to fine-grained sand, and 23-percent silt or clay. Several subrounded small granite pebbles were noted in the dark The shape of Katalla Valley may be considered evidence of an extensive glacial advance. Although the valley is filled with river deposits of an unknown thickness and the shape of the valley cannot be determined by surface observations, the probability that the valley is U-shaped is not a remote

morainal complex encircling Kushtaka Lake, there is contradictory evidence. If there were an extensive glacial advance in the Katalla area, there should be evidence of this advance on the sides of mountains and on top of the lower hills. With the exception of a few rocks that may be erratics that lie approximately 200 feet above the recent lateral moraines on the east flank of Charlotte

ALASKAFIGURE 1. INDEX MAP SHOWING LOCATION OF KATALLA AREA, ALASKA 0 10 20 30 40 50 100 150 Miles EXPLANATION -A-B-. Beach deposits Alluvial fan --D---E-Moraine Outwash errace deposits. Area includes size-frequency curves of sam ples T_1 , T_2 , T_3 , and T_4 Samples A. B. C. E. F. T., and

analyzed by Alaska Road Public roads). Samples D, and T2 analyzed by U.S. Geological Survey Silt or clay

FIGURE 2. CUMULATIVE SIZE-FREQUENCY CURVES OF DEPOSITS IN THE KATALLA AREA, ALASKA

DECLINATION, 1960

ENGINEERING GEOLOGY OF THE KATALLA AREA, ALASKA

Reuben Kachadoorian SCALE 1:63 360 1 ½ 0 1 2 3 4 M CONTOUR INTERVAL 100 FEET DATUM IS MEAN SEA LEVEL DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOWER LOW WATER SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER THE AVERAGE RANGE OF TIDE IS APPROXIMATELY 8 FEET 1960

Geology mapped in 1955 by Reuben Kachadoorian assisted by D. D. Smith

material.

row material.

Well-drained moraines generally

good as road foundations. Poor

to good source for borrow material.

Excessive boulders on Kushtaka

moraine would require crushing

Excellent as road foundation. Fair

as riprap. Locally overbreakage

during blasting will occur in the

Excellent as road foundation. Good

source for riprap. Overbreakage

may result from blasting. Insuf-

ficient fines for good borrow

thin-bedded units.

of material from this moraine.

Base from topographic maps U. S. Geological Survey, 1953