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RECONNAISSANCE TRAVERSE ACROSS THE EASTERN CHUGACH MOUNTAINS, ALASKA

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This report is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature

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Introduction

The eastern part of the Chugach Mountains, south and east of the Bremner district, is one of the largest geologically unexplored areas in Alaska. That these mountains are complexly folded Mesozoic and Paleozoic strata, intruded in places by granitic rocks, was known from the reports of Moffit (1914 and 1938), who mapped the western and northern boundaries of the area. The purpose of the present investigation was to make a traverse perpendicular to the structural trend of the eastern Chugach Mountains to determine: (1) the lithologic character, stratigraphic relations, and age of the bedded rocks; (2) the general structural pattern of these rocks; and (3) the nature of the intrusive rocks and associated mineralization, if any. The investigation will also assist in the planning of future geological exploration in the unmapped portions of these mountains.

The area described in this report is a strip approximately 5 miles wide and 48 miles long, across the Chugach Mountains at meridian 142° 30' W. (fig. 1). The topography of the map area and adjoining districts is shown on the Bering Glacier and McCarthy quadrangles, scale 1:250,000, 1950 and 1951 editions, respectively.

The present investigations began in August 1958 when Miller photographed and observed the outcrops along the proposed traverse route from the air. During the spring of 1959, the U. S. Geological Survey compiled a planimetric map and profile from vertical aerial photographs taken in 1957. This map and the photographs were used to plot the geology in the field and for final compilation of the geologic map.

The field party consisting of the writers and A. L. Kimball, geologic field assistant, left Cordova, Alaska by airplane on June 30, 1959 and established a base camp at Ross Green Lake. From this lake and the nearby dry lake bed on Granite Creek, the party was moved by ski-wheel and float airplane to other parts of the traverse area. The field work was completed August 29.

Rock terms in this report generally follow those of Williams and others (1954). Color nomenclature is from the Rock-Color Chart of Goddard and others (1948).

Bedrock geology

Description of the rocks

The bedded rocks in the traverse area are divided into two successions separated by the Bagley Ice Field. Both successions are thought to decrease in age southward, the rocks exposed in Barkley Ridge being in part younger and possibly in part equivalent to the rocks exposed north of the Bagley Ice Field. Marble, limestone, sandstone, argillite, and semischist exposed in the northernmost part of the traverse area are provisionally referred to the Strelna formation of Mississippian age. This formation is overlain unconformably to the south by the Valdez group, comprising argillite and graywacke of Mesozoic age. The Valdez group grades southward into metamorphic rocks, chiefly schist and gneiss, which are subdivided into four units. The oldest(?) of these units is the metamorphosed equivalent of part of the Valdez group, and the other three units probably represent bedded rocks of Mesozoic age that were regionally metamorphosed. Volcanic rocks of Mesozoic age are exposed south of the Bagley Ice Field and east of the map area are in depositional contact with the Yakutat group, chiefly argillite and graywacke, of Late Cretaceous age. The Yakutat group is thrust over sedimentary rocks of early Tertiary age near the southern boundary of the traverse area. Quartz diorite and related plutonic rocks, probably in part of metasomatic origin, occur mainly in the Strelna formation in the northern part of the map area, but smaller masses of plutonic rocks and dikes cut the Valdez group, the metamorphic rocks, and the volcanic rocks.

Strelna formation

The northernmost exposures of this formation, and possibly the oldest rocks in the map area, are thin-bedded to massive, pink, white, and variegated marble. These recrystallized limestones crop out at the sharp bend in the Kiagna River, near its junction with the Chitina River. Bedrock is concealed by surficial deposits for 2-1/2 miles south of this locality, but exposures farther up the canyon of the Kiagna River and east of the covered interval appear from the air to consist of marble and other bedded rocks. The Strelna is again exposed in a band approximately 2 miles wide between plutonic rock masses, just north of Slender Lake. Here it is well-bedded sandy limestone and poorly sorted limey sandstone, seemingly interbedded with grayish green semischist (possibly chloritized sandstone) and quartz-biotite schist. Some of the calcite in the limey rocks has been altered to tremolite.

In a narrow band trending northwest through the southern end of Slender Lake, rocks assigned to the Strelna are moderate-red, pale-olive, and grayish-black argillite and slate interbedded with grayish-green semischist. The red color of some of these rocks is due to disseminated hematite.

A few pods of argillite, limey sandstone and schist occur in the band of quartz diorite south of Slënder Lake. Between this pluton and strata assigned to the Valdez group, the Strelna consists predominantly of massive grayish-green semischist that may be chloritized sandstone and argillite, or perhaps altered tuffaceous rocks. The schist has some interbeds of grayish-black argillite, dark-gray limestone, poorly sorted gray sandstone and siltstone (graywackes), and a few nodules of moderate-red, grayish-green, and dark-gray chert.

The stratigraphic relations at the contact between the Strelna formation and the Valdez group are not clear. In places these units appear accordant and even gradational, but at other localities the lowest beds of the Valdez seem to fill channels in and to truncate the uppermost beds of the Strelna. Moreover, the change from relatively unaltered argillite of the Valdez to semischist and limey rocks of the Strelna is abrupt, when one considers that these units are probably several thousand feet thick. Therefore, the Strelna and Valdez may represent different systems, perhaps even different eras.

No fossils were found in the northern part of the map area. Correlation of the rocks exposed there with the Strelna formation and Valdez group is based on lithologic similarity and on photoidentification of the contact described above with the Strelna-Valdez contact mapped in the Hanagita

River area (Moffit, 1914, pl. 2; 1938, pl. 2). The contact was traced from the map area to the Tana River valley 6 miles south of the crest of Towhead Mountain, where the photoidentification was confirmed in the field, and thence northwestward through Goodlata Peak, across Monahan Creek at a point 6 miles southwest of the junction of Monahan Creek and the Chakina River, and into the contact mapped by Moffit (1938, pl. 2) at the head of the Hanagita River. The Strelna formation is assigned to the Mississippian on the basis of crinoid stems and corals found west of the Hanagita River, and on more diagnostic fossils found elsewhere in the Chitina Valley (Moffit, 1938, p. 26-28).

Valdez group

The rocks of this group are predominantly indistinctly stratified grayish-black argillite, most of which has a poorly developed cleavage. In the vicinity of the lakes at the head of Martin Creek, the argillite is laminated and is interbedded with poorly sorted gray sandstone and siltstone (graywackes) and a few thin beds of conglomerate. Most of the clasts in the conglomerate are rounded or angular pebble-size fragments of argillite, whereas the principal constituents of the sandstone are quartz, plagioclase,feldspar, and as much as 50 percent silt and clay matrix. Muscovite and pyrite are common constituents of all the rocks; the pyrite weathers to limonite and gives a speckled appearance to the rock. Calcite cements some of the strata, and in one thin section it has partly replaced the quartz and feldspar. Quartz and feldspar are also partly replaced by chlorite in a thin section of a specimen from another locality, but this replacement is not so extensive as to give a greenish cast to the rock.

The name "Valdes series" was given by Schrader (1900, p. 408-410, 413) to varied rocks that crop out in the vicinity of Port Valdez, 125 miles west of the traverse. The age of these relatively unfossiliferous deposits is uncertain, but they seem to belong to a belt of eugeosynclinal sediments that farther west are, at least in part, Cretaceous. Moffit (1938, p. 89) points out, however, that the Valdez group may include rocks of Older Mesozoic or even Late Paleozoic age. The strata mapped as Valdez in the area of this report are provisionally referred to the Mesozoic and are considered to be most likely of Jurassic age because: (1) they are in the northern part of a succession of rocks that seems to become progressively younger to the south; and (2) rocks of Jurassic age and of similar lithologic character are widespread in adjoining areas of southern Alaska, but rocks of Triassic age are limited in extent and are mainly limestone and volcanic rocks (Payne, 1955). Irrespective of their age, the argillite and associated rocks in the northern part of the traverse area are similar to and are probably co-extensive with the type "Valdes series". Schrader mapped this unit to the mouth of the Bremner River, and Moffit (1938) mapped the Valdez group eastward to the present traverse.

Metamorphic rocks

Schist and gneiss predominate in the central part of the traverse area. Presumably they represent sedimentary and mafic intrusive or extrusive rocks that were regionally metamorphosed. Four distinctive metamorphic units that may correspond to facies of the parent rock sequence from which they were derived are differentiated on the map and described here. The units are described from north to south in what may also be chronological order from oldest to youngest, as the rock succession seemingly decreases in age southward in the traverse area.

Unit A.--Biotite-quartz-feldspar schist predominates in Unit A. The schist consists of approximately 40 percent reddish-brown biotite, 30 percent sand-size quartz grains, and 30 percent plagioclase feldspar. These minerals are in medium gray bands less than one inch thick, separated by light-gray quartz. A few pale-red crystals of andalusite were found in the schist near the contact with unit B.

Unit A grades northward by decreasing metamorphism into argillite of the Valdez group, and southward by increasing metamorphism into the gneiss of unit B. These gradational contacts are best observed six miles west of the traverse area and along the east bank of the Tana River, where the Tana Glacier has scraped the bedrock clean. The contacts of unit A can also be seen in the vicinity of the notch 5 miles due north of the mouth of Twelvemile Creek, and near the head of the glacier 2 miles west of this creek. Both the gradation from schist to argillite and the abundance of biotite in the schist support the inference that unit A is the metamorphosed equivalent of part of the Valdez group.

Unit B.--This unit of quartz-feldspar-biotite gneiss is best exposed in glaciated knobs on the floor and sides of the valley of Granite Creek, and is probably the source of the name given to this creek by prospectors. Most of the gneiss is medium-grained, gray on fresh surfaces, and light-brown on weathered surfaces. Some of the gneiss is fine-grained, brownish black, and rich in biotite. The contacts of the more mafic bands with the typical gneiss are sharp, parallel to the foliation, and are believed to correspond to changes in lithologic character of the original bedded sequence. Hence, bedding symbols are shown on the map for these contacts.

Most of the quartz grains in the gneiss are sand-size, and in thin section appear strained. The feldspar is predominantly albite, although a sodium cobaltinitrite stain test showed that small amounts of potash feldspar are also present. The biotite is reddish brown.

Quartz-feldspar-biotite laminae alternate with quartz-feldspar laminae relatively free of biotite, giving the gneiss a pronounced foliation. Few of these folia can be traced more than a few inches. Quartz lenses, as much as a foot thick, also occur in the gneiss and are parallel to the foliation. Some of these lenses can be traced a few tens of feet. Both the quartz lenses and the smaller folia are drag folded at many localities.

The gneiss of unit B is interlayered with the schist of unit A at their contact. This relationship and the relative abundance of quartz and feldspar in the gneiss suggest that unit B is a metamorphosed sandstone sequence that overlaid conformably the argillite of the Valdez group.

Unit C.--This unit consists of amphibolite and quartz-feldspar-biotite-garnet schist and gneiss. The gneiss resembles that of unit B; the schist and amphibolite resemble those of unit D.

Unit C seems to grade into unit B on the north slope of Thompson Ridge. The contact is placed arbitrarily between relatively fine-grained biotite- and hornblende-rich schist to the south, and predominantly medium-grained felsic gneiss of unit B to the north. The contact between units C and D is tentatively placed at the western end of the ridge east of Juniper Island where generally coarser-grained and more gneissic appearing rocks of unit C are in contact to the south with low-grade metamorphic rocks showing relic sedimentary structures. Some relic bedding was seen in the rocks of unit C north of this contact, however. The uppermost(?) 200 feet of unit C resembles diorite, and contains oriented inclusions of schistose rocks, some as much as 2 feet long, that are similar to the schists of unit D.

Unit D.--Quartz-feldspar-biotite-garnet schist and amphibolite predominate in unit D. The schist forms most of Juniper Island and the western tip of the ridge to the east. The amphibolite crops out chiefly in the southeastern and southwestern parts of Juniper Island, but it also alternates with schist at a few other places on this nunatak.

The schist is composed of quartz, albite, brown biotite, pink almandite garnet, and brown chlorite. The quartz occurs as disseminated grains and also as lenses, most of which are a few inches long and as much as one-half inch thick. At many localities laminae of quartz and albite alternate with laminae of biotite and garnet. The foliation resulting from these mineral segregations probably represents original stratification, since the foliation is too regular and too extensive laterally to be wholly a product of metamorphism. Chert nodules and relic cross-beds in the schist support this interpretation. These relic sedimentary features and the composition of the schist suggest that the parent rock was a well-bedded sandstone and siltstone sequence that had a few nodules of chert.

The schist is medium to light gray on fresh surfaces, and reddish brown or light gray when weathered. It has a pinkish cast when the garnet content is high. The quartz lenses give outcrops of schist a dappled appearance that is conspicuous at a distance.

Most of the amphibolite is greenish-black, and consists of approximately 80 percent hornblende, in crystals about 1/4-inch long, and 20 percent plagioclase feldspar. The hornblende crystals are in parallel arrangement, and give the rock a well-defined lineation. Some of the amphibolite is speckled, and has white laths of plagioclase in a matrix of greenish-black hornblende. Its texture resembles the subophitic texture in gabbro, diabase, and basalt. The texture and the interlayering of the amphibolite and schist suggest that the amphibolite is metamorphosed basalt. If so, unit D may be the transition between the volcanic rocks outcropping near Natural Arch and the metamorphosed sedimentary sequences north of the Tana and Jefferies Glaciers.

Volcanic rocks

Lava flows and flow breccias of dusky purple and grayish-green amygdaloidal basalt or andesite, and possibly some tuffaceous rocks compose this unit. They crop out in the vicinity of Natural Arch, along a ridge at the southern boundary of the Bagley Ice Field. Stratification of these volcanic rocks is generally not well defined, but at some localities individual flows a few feet thick can be distinguished. No pillow structures were found. All of the volcanic rocks are partly chloritized.

The volcanic rocks extend west of the map area and seem to form most of the central and northern part of Waxell Ridge. Near the northeastern part of this ridge, the volcanic rocks are in fault contact with sedimentary rocks of Tertiary age. East of the map area, a nearly vertical contact between the volcanic rocks to the north and the Yakutat group to the south can be seen on the northwest face of Mount Miller. From an airplane, the units appear to be accordant and in depositional contact at this locality.

No evidence was found in the traverse area to indicate definitely whether the volcanic rocks are younger or older than the Yakutat group, except that the volcanic rocks are more highly altered. Farther east, in the Malaspina district (Plafker and Miller, 1957) and in the Yakutat Bay region (Tarr and Butler, 1909, p. 150-152), volcanic rocks or greenstone probably derived at least partly from volcanic rocks lie unconformably below the Yakutat group. The volcanic rocks in the map area are considered to be older than the Yakutat group, but probably not much older and almost certainly of Mesozoic age. The relationship of the volcanic rocks on Barkley Ridge to the rocks mapped north of Bagley Ice Field is not known, but the possibility that part of the volcanic unit is equivalent to the metamorphic rocks unit D is suggested by the presence of amphibolite on Juniper Island and the presence of sedimentary rocks interbedded with purple and green rocks, almost certainly volcanic, on two nunataks 9 miles due west of Juniper Island.

Yakutat group

The Yakutat group in the traverse area comprises argillite and poorly sorted fine-grained sandstone and siltstone (graywackes). The argillaceous rocks are medium dark gray to grayish black, and usually have a well-developed fracture cleavage. Most of the sandstone and siltstone is medium gray, and weathers pale reddish brown or light brown. At a few places the sandstone is chloritized, and has a greenish cast. The constituents of one sandstone specimen are quartz, plagioclase feldspar, plagioclase-rich fragments of volcanic rocks, and less than 1 percent microcline, biotite, and muscovite.

Lenticular calcareous concretions a few inches long occur in the argillite at a few localities. They weather light gray where they are nearly pure calcite, and pale yellowish brown where they are chiefly argillite. Many of these concretions were broken open and a few were dissolved in acid, but fossils were found in them at only one locality.

Bryozoans, pelecypods, a turreted gastropod, and worm trails were found in the Yakutat group along a spur extending north from Barkley Ridge (see localities 59ABa 291 and 59AMr 436 on map) but they are too poorly preserved to date the beds. A foraminifer from argillite at the northwestern end of Barkley Ridge (locality 59AMr 453) was identified by Ruth Todd of the U. S. Geological Survey as Nodosaria affinis Reuss, indicating that the beds there are Upper Cretaceous or Paleocene. A Late Cretaceous age is more likely, since the Yakutat group is in fault contact to the south in the Yakataga district with less altered rocks at least as old as Eocene and possibly of Paleocene age (Miller, 1957). Furthermore, the Yakutat group in the Malaspina district is overlain with marked angular contact by coal-bearing beds of the Kulthieth formation, of Eocene age (Plafker and Miller, 1957).

The argillite and graywacke here assigned to the Yakutat group extend west of the traverse area to the southern part of Waxell Ridge. They have been traced on aerial photographs 20 miles east of the traverse area to the central part of Barkley Ridge where the strata seem to be truncated to the south and east by crystalline rocks and the Chugach-St. Elias fault. The Yakutat group crops out again 35 miles east of the traverse area, near Mount St. Elias, and has been traced southeastward on the south side of the Chugach-St. Elias fault to the type area in the Yakutat Bay region (Plafker and Miller, 1957). The age of the argillite-graywacke sequence first named the Yakutat "system" by Russell (1891, p. 167-170) and later called the Yakutat group (Tarr and Butler, 1909, p. 152-157) is not definitely established even in the type area. Plafker and Miller believe that the group is Cretaceous and probably largely or entirely Late Cretaceous. The strata mapped as the Yakutat group in the traverse area are also tentatively considered to be Late Cretaceous in age.

Lower Tertiary sedimentary rocks

Rocks mapped as Tertiary include conglomerate, sandstone, siltstone, argillite, and coal. The conglomerate forms a few thin beds at the southwestern end of Barkley Ridge. It contains well-rounded pebbles of quartz, argillite, and volcanic rocks. The sandstone is a thin-bedded to massive, olive-gray, medium- to fine-grained subfeldspathic lithic arenite that commonly contains biotite laminae and argillite chips. A stain test and thin section of one sandstone specimen shows approximately 60 percent quartz, 15 percent lithic fragments, 10 percent potash feldspar, 10 percent plagioclase feldspar, and 5 percent biotite, muscovite, and sphene. Several of the quartz and feldspar grains are partly replaced by chlorite. The lower Tertiary sandstone is distinguished from sandstone in the Yakutat group by its lighter color and larger percentage of potash feldspar, but the argillites in these two units are similar in appearance. Coal crops out only in the southernmost part of the map area. The coal and associated sandstone and siltstone were previously mapped as part of the lower Tertiary sequence in the Yakataga district (Miller, 1951, p. 13-15, fig. 1). All of the unweathered lower Tertiary rocks along Barkley Ridge are dense and relatively impermeable.

An oyster and poorly preserved Foraminifera found in beds assigned to the Tertiary at the western end of Barkley Ridge (59ABa 307 and 59AMr 466 on map) are not more closely determinable than forms of probable late Mesozoic or early Tertiary age. The sequence is similar in lithologic character to parts of the Kulthieth formation of Paleocene(?) and Eocene age in the adjoining Yakataga district to the south (Miller, 1957).

Plutonic rocks

Plutonic rocks in the traverse area are predominantly quartz diorite. Most of the quartz diorite crops out in the vicinity of Slender Lake, where it alternates with bands of the Strelna formation. The contacts shown on the map between the bands of quartz diorite and Strelna formation are generalized. Pods and bands of the Strelna formation occur in quartz diorite, and vice versa.

The average composition of seven quartz diorite specimens is approximately 50 percent plagioclase feldspar, 35 percent hornblende, 10 percent quartz, and 5 percent biotite and accessory minerals. Three additional specimens from the northernmost band of plutonic rocks in the traverse area contain nearly equal amounts of plagioclase and potash feldspar, suggesting that the quartz diorite grades into monzonite. The quartz diorite also grades with increasing hornblende content into gabbro and hornblendite. These mafic rocks seem most abundant in the bands of quartz diorite and Strelna formation from Slender Lake northward, but gabbro was also found in the southernmost band of the Strelna and in the volcanic rocks along Waxell Ridge, 5 miles west of the traverse area.

Three thin sections of the quartz diorite show some alteration of the quartz, feldspar, and hornblende to chlorite. In outcrops of quartz diorite two miles south of Slender Lake, and at other nearby localities, chloritization is so extensive that the rock is grayish green.

Several features seen in the field suggest that part of the quartz diorite has formed by metasomatic processes. Sill-like bodies of quartz diorite found at a few places in undisrupted sequences of Strelna rocks contain inclusions of limestone and seem to grade into the adjoining sedimentary rocks. The stratification of the limestone inclusions is parallel to that of the adjoining beds of the Strelna formation. These relationships suggest that the limestone inclusions were not incorporated in a moving silicate melt, but instead are relics of a selectively metamorphosed sedimentary sequence. Another feature that suggests metasomatism of a sedimentary sequence is the alternation of quartz diorite and gabbro in bands parallel to the regional sedimentary stratification. Such banding is found mainly near contacts between the quartz diorite and the Strelna. Some of the quartz diorite has a foliation that is parallel to the regional stratification of the Strelna formation and to the foliation of the metamorphic units in the vicinity of Granite Creek. The foliation is due to a concentration of hornblende crystals in laminae and perhaps reflects differences in composition of a parent bedded sequence. Similar relationships are described for diorite thought to have been derived largely from bedded sedimentary and volcanic rocks in the Geikie Inlet area, Alaska (Seitz, 1959, p. 81-101), and for diorite of probable metasomatic origin on Chichagof Island (Rossman, 1959, p. 172-176).

Some of the diorite is clearly intrusive. Irregular apophyses of quartz diorite extending from the plutons into the Strelna formation and across the stratification were found at a few localities. Quartz diorite dikes, probably related to the plutons, also cut across the stratification or foliation of the Valdez group and metamorphic units A, B, and C.

The age of the quartz diorite and related plutonic rocks in the traverse area is not well established. They are probably Mesozoic, but older than Late Cretaceous, inasmuch as they cut the volcanic rocks and the metamorphic rocks but not the Yakutat group. Similar plutonic rocks are considered to be post-Early Cretaceous in the St. Elias Mountains less than 100 miles to the east (Sharp and Rigsby, 1956), and on Chichagof Island in southeastern Alaska (Rossman, 1959, p. 177-179).

Dikes and veins

The Valdez group and units A and B are cut by coarse- to fine-grained quartzo-feldspathic dikes. Most of these dikes are light colored, but a few are greenish gray, due probably to partial replacement of the quartz and feldspar by chlorite.

Felsic pegmatite dikes penetrate the plutonic rocks, the Strelna formation, unit B and unit C. All the dikes observed are less than 2 feet thick. Those cutting the plutonic rocks are composed of quartz, plagioclase feldspar, and hornblende, the last in crystals as much as 7 inches long. Some of these pegmatite dikes fill fractures that offset alternating bands of diorite and gabbro. One pegmatite dike cutting across the foliation of the gneiss in unit B consists of quartz, feldspar, and book muscovite. Pegmatite dikes in unit C near the crest of Thompson Ridge were observed at a distance, and fragments of the rock were found in the moraine of a valley glacier on the ridge. These pegmatites differ from the others in that they contain black tourmaline crystals as much as 2 inches long.

Quartz veins cut the volcanic rocks, the stratification of the Strelna formation and Valdez group, and the foliation of metamorphic units A and B. The largest vein seen is approximately 4 feet thick and at least 50 feet long, but most are less than a foot thick. Some quartz veins are in parallel arrangement, and are easily mistaken for bedding at a distance.

Dikes and veins are not shown on the map. Intrusion of most or all of the dikes probably was contemporaneous with or closely followed the intrusion of the plutonic rocks, but preceded the deposition of the Yakutat group.

Structure

Folds

The regional trend of stratification and foliation in the map area is approximately N. 70° W. All of the bedded rocks are thought to be tightly folded, but this pattern of folding was clearly seen on a regional scale only in the well stratified part of the Yakutat group. Closely spaced, nearly isoclinal folds in the Yakutat group, and also the relationship between axial plane cleavage and bedding, are best exposed in the valley walls of the glacier that crosses the profile line 1.9 to

2.4 miles north of the southern boundary of the map. Isolated folds were recognized at a few other places where beds could be traced across a crest or trough, and were tentatively identified at some places from a reversal in dip indicated by cross-bedding or other sedimentary structures, from a change in the pattern of drag folds, or from a change in the angular relationship between cleavage and bedding. North of Bagley Ice Field the axial planes of most of the folds are vertical or dip steeply to the north. Near the southern margin of the map area, however, many of the folds in the Yakutat group have southward-dipping axial planes, and some of these folds are overturned to the north.

Faults

The Chugach-St. Elias fault, which crosses the southern part of the map area, is one of the major structural features of southern Alaska. It has been traced for a distance of 180 miles along the southern front of the Chugach and St. Elias Mountains, from the delta of the Copper River to Yakutat Bay (Miller and others, 1959, p. 42, pl. 5). The surface trace of the fault is easily identified at the southeastern corner of the map area, where the prevailingly dark-colored argillaceous rocks of the Yakutat group have been thrust southward and over light-colored sandstone of Tertiary age. The location of the fault is less evident farther west, where the Tertiary rocks are mainly dark-colored argillite similar in appearance to the Yakutat group. The fault trace was previously thought to lie beneath the glacier at the southwest corner of the map area (Miller, 1951, fig. 1; 1957, fig. 2), but during the present investigation the fault was found at one locality on the west end of Barkley Ridge, a few hundred feet above the surface of the Bering Glacier. The fault at this locality is a 2- to 5-foot wide zone of extensively fractured rocks and a little gouge, dipping about 50° N. The dip of the fault farther east, as estimated from oblique photographs, is between 40° and 55° N. on the spur at the profile line, and between 35° and 55° N. just beyond the southeast corner of the map.

A few northward-trending steeply dipping faults offset schist layers in unit D on the south side of Juniper Island. These faults and other minor faults seen farther north in the traverse area are not shown on the map.

Economic geology

Minerals of possible economic interest seen in the reconnaissance traverse are meager in both amount and variety, considering that bedded rocks, including limestone, are cut by large masses of plutonic rocks and by dikes. Copper minerals, graphite, pyrite, and hematite were found at several localities, but not in a quantity suggesting deposits of commercial value. A scintillation counter was carried on nearly all traverses north of the Bagley Ice Field and was used to test the radioactivity of most common types of rocks and mineralization found in the map area. The results indicate an absence of large fields of radioactivity or of significant concentrations of radioactive minerals. A trace of gold was found in one quartz vein in the Valdez group.

Most of the mineralization is in the bedded rocks of the Strelna formation or in the associated plutonic rocks. The most extensive mineralization seen is in a zone averaging about 20 feet wide, exposed in deep gullies on the west valley wall of Bearhole Creek, 1 mile north of Slender Lake. The mineralized zone is conspicuous at a distance because it is a lighter color and more yellowish brown than the country rocks. Graphite and pyrite comprise about 20 percent of one vein from this zone; the gangue minerals are altered quartz and feldspar. Graphite and pyrite were found also on the opposite valley wall, indicating that the zone may extend across the valley of Bearhole Creek. Disseminated pyrite was seen at many other localities in the Strelna formation.

The band of Strelna argillite that passes through the southern part of Slender Lake is partly hematized. The hematite is disseminated in the rock and concentrated along fractures. The mineralization is more pronounced in the northern part of the band, and extends at least the width of the traverse area. Hematite was also found in quartz veins that cut the Valdez group and Strelna formation, and along fractures in the quartz diorite.

A small amount of native copper was found in the volcanic rocks a few miles north of Barkley Ridge. Malachite and azurite occur in quartz veins that cut this volcanic sequence. These copper carbonates were also observed along fractures and disseminated in the quartz diorite, in unit D, and in the hematized band of Strelna rocks. Some chalcopyrite was found in unit D, in quartz veins that cut the Valdez group, and associated with pyrite and graphite in the zones north of Slender Lake.

Many of the dikes and quartz veins in the Valdez group were examined in the field, inasmuch as these rocks are known to be gold-bearing at Golconda Creek, about 35 miles to the northwest, and also at other places in the Bremner district (Moffit, 1914, p. 44-51; 1937, p. 99-102).

No free gold was seen under the hand lens, but a trace was recovered from a quartz dike that cuts the Valdez group near the southern end of the smaller of the two lakes 8 miles south-southeast of Slender Lake. One 500-gram sample of the quartz yielded a flake of gold weighing less than 0.0001 gram. Although this amount is not of commercial value, more systematic sampling must be done before the deposit can be properly evaluated.

The larger streams from Granite Creek north in the map area were probably tested for placer deposits of gold by the prospectors who began to explore this area in the early 1900's (Moffit, 1918, p. 77-78). There was a miniature stampede to the Kiagna River area during the fall and winter of 1914-1915, but according to Moffit, the quantity of gold recovered was too small to encourage further work. Some of the smaller creeks, such as Martin Creek, Twelvemile Creek, and unnamed creeks draining the outcrop area of gold-bearing Valdez rocks, may be better prospects. Bench deposits formed during and following the last major glaciation are now being dissected along the lower part of these creeks under conditions similar to those resulting in placer gold deposits on Dan and Chititu Creeks in the Nizina district to the north, and in the Bremner district (Moffit, 1938, p. 128-129).

Quaternary deposits and glacial history

by Don J. Miller

Glaciers and the meltwater streams draining from them are chiefly responsible for the unconsolidated deposits of Quaternary age in the map area. Other kinds of surficial deposits that are thin or of small areal extent in the map area are the stratified deposits laid down in the intermittent lake at the mouth of Granite Creek; talus rubble at the base of steep slopes; alluvial fan deposits of the many small clear streams draining the walls of the larger valleys; and landslide debris. The surficial deposits are shown on the map only where they conceal the bedrock over large areas, chiefly on the floors and lower slopes of the larger valleys. The various kinds of surficial deposits are not differentiated.

Evidence of two major glacial advances, presumably of Wisconsin age, and of two or possibly three minor glacial advances of Recent age is recognized in the northern part of the map area, between the valley of the Chitina River and the south flank of Thompson Ridge. On Juniper Island and south of the Bagley Ice Field, however, no evidence was found for a glacial advance more extensive than a Recent advance recorded by fresh lateral moraines standing at most places no more than 100 feet above the present ice surface.

The oldest major glacial advance is recorded in the northern part of the map area by faceted bedrock spurs and other ice-sculptured features that are limited to the upper part of the valley walls and are extensively dissected by stream erosion. This is the most extensive glaciation now recognizable in the traverse area from Granite Creek north to the valley of the Chitina River, and is presumed to represent the maximum stand of glaciers in the northern Chugach Mountains east of the Copper River during the Wisconsin stage. No deposits of this advance were definitely identified in the map area, though erratics found up to an altitude of 6,000 feet or more on the north side of the Chitina Valley, opposite the mouth of the Kiagna River (Moffit, 1918, p.46), probably are of this age.

The youngest major glacial advance is recorded in the northern part of the map area by extensive deposits and by ice-sculptured features that are limited to the lower part of the valley walls and are little dissected by stream erosion. At the culmination of this advance the ice stood about 700 feet higher than the present surface of the Tana Glacier on the south flank of Thompson Ridge and it filled the lower parts of the larger valleys to the north, to a height of about 2,500 feet in Granite Creek and the lower part of Twelvemile Creek, and to a height of 500 feet on Bearhole Creek just north of Slender Lake. The glaciers in the valleys of the Tana and Kiagna Rivers were about 2,000 feet thick where they joined the trunk glacier stream in the valley of the Chitina River, the ice standing at the present altitude of about 3,500 feet on the north end of the ridge south of the mouth of the Kiagna River. This glacial advance is believed to be of latest Wisconsin age, and is tentatively correlated with an advance of the glaciers down the Chitina River valley to an end moraine near the mouth of the Chokosna River (Coulter, H. W., and others, committee for a glacial map of Alaska, written communication), about 70 miles beyond the present front of the Chitina Glacier. No evidence for this major advance of late Wisconsin age was found on Juniper Island and Barkley Ridge, in the southern part of the map area.

One, or possibly two minor advances of Recent age are recorded by heavily vegetated end moraines at distances ranging from 1,800 feet to at least 10,000 feet beyond the present fronts of many small glaciers in the northern part of the map area. Some glaciers have one, and others two vegetated end moraines. Where two moraine systems are recognizable, they show little difference in the stage of vegetation growth or degree of dissection, and hence may represent either an advance followed by a stillstand during retreat, or two advances separated by a short interval of time. The single or double advance recorded by the vegetated end moraines is correlated with the advance of glaciers on the south flank of the eastern Chugach Mountains and adjoining part of the St. Elias Mountains at different times during an interval between 670 and 1,360 years ago (Plafker and Miller, 1958; Kachadoorian, 1960). Measurements made for nine glaciers less than 5 miles in length, in the area from Granite Creek north to the Chitina Valley, indicate that the outermost vegetated moraines of Recent age represent an increase in the length of these glaciers ranging from 14 percent to at least 120 percent, and averaging about 60 percent. The large glaciers in the southern part of the map area undoubtedly increased in size also during this period, but the resulting lateral moraines evidently either coincide with or were exceeded by the moraines formed during the latest advance.

A minor glacial advance culminating within the past 300 years, and followed by recession continuing to the present, is recorded by bare or sparsely vegetated moraines bordering nearly all of the glaciers in the map area. The end moraines formed during this latest advance by the smaller glaciers in the northern part of the map area lie within the vegetated moraines of the earlier Recent advance or advances, and record a rather uniform increase in the length of these glaciers, ranging from 6 percent to 33 percent and averaging about 24 percent. The fresh lateral moraines deposited at the margins of the larger glaciers during this advance are the only evidence recognized for more extensive glaciation on Juniper Island and Barkley Ridge, in the southern part of the map area. The latest general advance of glaciers in the coastal region of the eastern Chugach Mountains and the St. Elias Mountains culminated between 1700 A.D. and 1791 A. D. in the Malaspina district (Plafker and Miller, 1958), and probably about 1700 A.D. in the Katalla district (Kachadoorian, 1960). Trees growing on the highest of several lateral moraines above Hanna Lake, at the eastern margin of the Bering Glacier (observed by the writer in 1946) indicate that the glaciers draining from the Bagley Ice Field began to retreat from their last maximum stand about 120 years ago.

The lack of evidence for late Wisconsin glaciation more extensive than the glacial advances of the past 1,400 years or less was noted previously at the margins of the Bering Glacier and other large glaciers draining south from the eastern Chugach Mountains and the adjoining part of the St. Elias Mountains (Miller, 1958; Plafker and Miller, 1958; Kachadoorian, 1960). The present reconnaissance traverse extends the area of seemingly anomalous late Wisconsin glacial conditions northward into the Chugach Mountains, and suggests that the area may be bounded by a hinge line or fault lying beneath the Jefferies Glacier and the upper part of the Tana Glacier. A lateral moraine containing many foreign rocks, believed to represent the last major glacial advance in late Wisconsin time, was found on the south side of Thompson Ridge, about 700 feet above the present surface of the Tana Glacier and 600 feet or more above the lateral moraine formed during the latest Recent advance. Juniper Island, only 6 miles to the southeast, is encircled by the equivalent lateral moraine of Recent age, standing generally less than 100 feet above the present surface of the Jefferies Glacier and Bagley Ice Field, but no erratics or other evidence of any older, more extensive glacial advance was found on the higher part of this nunatak.

As a possible explanation for the seemingly anomalous glacial history of this area the writer suggests that continuing uplift of the Gulf of Alaska Tertiary province and adjoining part of the eastern Chugach Mountains and St. Elias Mountains in late Quaternary time caused a gradual southward shift of optimum conditions for ice accumulation. Rates of uplift ranging from 2 feet to 3.7 feet per century during the past 8,100 to 10,800 years are indicated by radiocarbon dates on marine terraces in the coastal area (Heusser, 1959); uplift of the Chugach-St. Elias Mountains arc along the bordering system of high-angle thrust faults (Miller and others, 1959, p. 42, pl. 5) probably was even more rapid. Evidence of southward movement of ice over divides on the south side of the Chitina Valley was cited by Moffit (1914, p. 39-40) in support of his suggestion that the Wrangell Mountains were a more important center of ice accumulation than the Chugach Mountains during a glaciation which probably correlates with the older of the two major glacial advances recognized in the northern part of the traverse area.

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