Reconnaissance Geology of Northern Baranof Island, Alaska

By H. C. BERG *and* D. W. HINCKLEY

CONTRIBUTIONS TO GENERAL GEOLOGY

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A stratigraphic and structural study to provide a basis for geologic mapping of Baranof and southern Chichagof Islands

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By H. C. Berg and D. W. Hinckley

ABSTRACT

The rocks of northern Baranof Island range in age from Paleozoic (?) to Mesozoic; they are tightly folded, intricately faulted, and regionally metamorphosed. They are also contact metamorphosed near the borders of dioritic intrusive rocks that are probably related to the Coast Range batholithic complex. To the west, on Kruzof Island, rocks of Mesozoic age are unconformably overlain by volcanic rocks that were extruded from Mount Edgecumbe and other vents during Quaternary time. On Baranof Island the strike of most of the contacts, bedding, and mineralogical layering, as well as the trend of the lineations, is northwest; however, between Rodman Bay and Saook Bay where strata of Triassic (?) age show two episodes of folding, the rocks commonly strike north and east. Fieldwork combined with the study of aerial photographs shows that many well-defined lineaments are probably faults and shear zones.

For mapping purposes the bedded rocks are herein divided into seven lithologic-stratigraphic units. Although no fossils have been found in or reported from the rocks of northern Baranof Island, the ages of many of the units are tentatively established by lithologic correlation with rocks that are better dated elsewhere in the region, particularly those on Chichagof Island.

INTRODUCTION

Baranof Island is located in the west-central part of southeastern Alaska, about 70 miles south-southwest of Juneau (fig. 1). The purpose of this investigation was to gain an understanding of the stratigraphy and structure of northern Baranof Island in advance of reconnaissance geologic mapping of all of Chichagof and Baranof Islands. The structural grain of the country trends northwest, and the rocks are best exposed along the beaches; hence, we traversed 300 miles of the northern shoreline of Baranof Island, approximately two-thirds in detail. We also examined the rocks on many of the smaller adjacent islands.

Fieldwork started June 1 and ended August 29, 1960. About half the mapping was done from base camps in Kelp Bay and Nakwasina Sound. Base of operations for the rest of the work was the U.S. Geological Survey MS *Stephen R. Capps*.

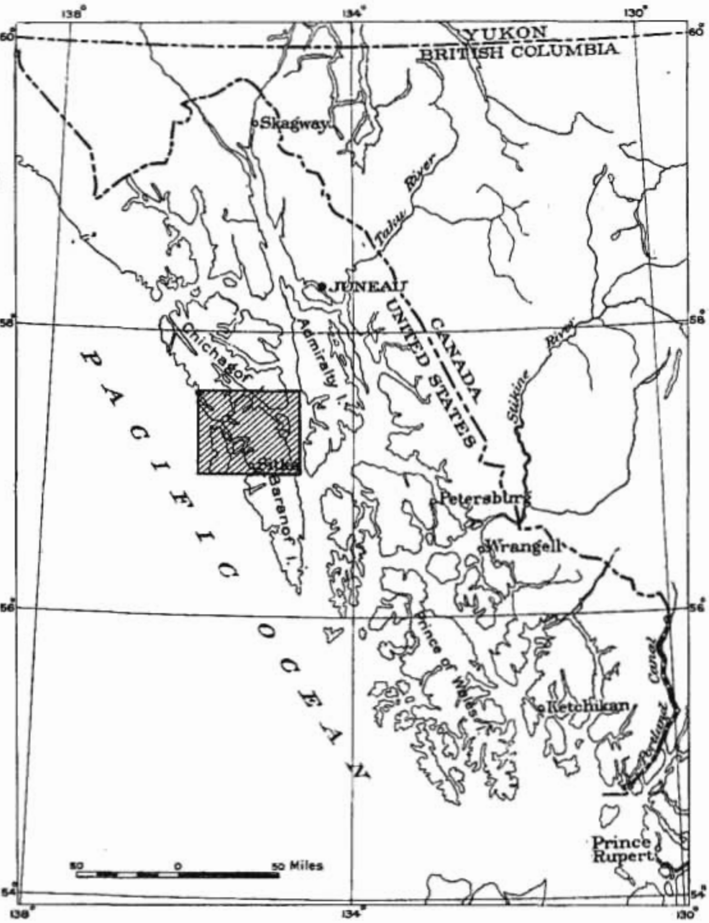

FIGURE 1.—Index map of southeastern Alaska showing the location of northern Baranof Island.

Most of the field data for this report were obtained at or near the shorelines; the geology of inland areas is in part extrapolated from these data and in part interpreted from aerial photographs (pl. 1). In areas east of Sitka and Silver Bay and near Mount Edgecumbe, the geology is adapted from published works and unpublished field data of previous workers of the U.S. Geological Survey (pl. 1).

Many of the rocks were studied by means of the petrographic microscope and were classified following the system used by Williams, Turner, and Gilbert (1954).

Of the previous geologic investigations in the region, one of the earliest reconnaissance studies was made in 1895 and 1896 by G. F. Becker (1898, p. 78–80), who examined the geology of the coastal region near Sitka and described the gold lodes of Silver Bay. In 1899 members of the Harriman Alaska Expedition (Emerson and others, 1910, p. 18–19, 44–48, 92) briefly studied the rocks and mineral prospects near Sitka and Silver Bay. The first general examination of Baranof Island was undertaken by F. E. and C. W. Wright. Brief preliminary accounts of their investigations were published (Wright and Wright, 1905, p. 57–59; 1908, p. 38, 42, 56–57; Wright, 1907, p. 48–49, 59–60), but detailed reports were not prepared. In 1904 F. E. Wright examined many shoreline exposures around the island, traversed inland areas east and south of Sitka, visited Mount Edgecumbe, and studied the mines and prospects in the vicinity of Silver Bay. In 1903, 1905, and 1906, C. W. Wright made reconnaissance trips along the east coast of Baranof Island and investigated the regions near Fish Bay and Rodman Bay. The Wrights (1908, p. 38, 56–57) compared the rocks of western Baranof Island with those near Juneau and concluded that the areas were geologically analogous. In 1910 Adolph Knopf (1912, p. 7–17, 26–30) examined Baranof Island from Peril Strait to Silver Bay and described the geology and mineral deposits of the Sitka mining district. In 1941 J. C. Reed (*in* Kennedy and Walton, 1946, p. 63–64) investigated a nickel-copper prospect near Herring (Salmon) Cove in Silver Bay, and in 1950 W. S. Twenhofel (1951, p. 3) examined the rocks along Sawmill Creek from Silver Bay to Blue Lake.

We wish to acknowledge the able field assistance of Roger L. Taylor, geologic field assistant, and to thank Robert D. Stacey and John Muttart, master and crewman, respectively, of the U.S. Geological Survey MS *Stephen R. Capps*, for their help in transporting our party during the summer. Particular thanks are due to Mr. Glenn Morgan of Sitka, who generously allowed us to use his cabin in Silver Bay.

GEOLOGY

BEDDED ROCKS

GNEISS AND SCHIST

Gneiss and schist derived mainly from sedimentary and volcanic rocks form most of the shore of Peril Strait from the vicinity of Fish Bay to about 4 miles northwest of the mouth of Rodman Bay. Most of these rocks are well layered or strongly schistose and contain variable proportions of quartz, feldspar, mica, amphibole, and garnet. Next in abundance are interbedded micaceous quartzite, which probably is recrystallized chert, and weakly to moderately schistose metavolcanic rocks; both crop out on the point northeast of Louise Cove and for about 2 miles northeast of Point Siroi, and are thought to be less highly metamorphosed parts of the schist and gneiss unit.

Beds of brown-weathering white and gray calcite marble crop out 1.4 miles west of Haley Point, near the head of Fish Bay, and at Middle Point. The marble beds probably average 150 feet thick; they are commonly intercalated with gneiss and schist, or with faulted, schistose metachert and metavolcanic rocks. Near its contact with a quartz diorite intrusive body at the head of Fish Bay, the marble is intercalated with pink and green calcsilicate rock that consists of diopside, garnet, quartz, sphene, and minor calcite. Calcsilicate rock is also interbedded with marble near Middle Point.

Several bodies of slightly to moderately foliated granitoid rock intrude and are gradational with the gneiss and schist unit, but only a few of these are large enough to show on the map. Small dikes of quartz diorite, of quartz monzonite, and of granite cut the unit at Pogibshi Point, at Middle Point, and near the north end of Deadman Reach, respectively. A large body of quartz diorite cuts gneiss and schist in Fish Bay. Well-foliated diorite grades into well layered paragneiss along Deadman Reach, and pegmatitic rocks, composed of hornblende and calcic plagioclase, crop out in a few places about 2 miles northeast of Pogibshi Point.

The contact relations between the gneiss and schist unit and younger rocks are complicated by folding, faulting, igneous intrusion, and metamorphism. Moreover, because contact zones are likely to be zones of weakness they are commonly obscured by stream-channel deposits or tidal flats. Northwest of Rodman Bay a well-defined northeast-trending lineament, interpreted as a fault, separates gneiss and schist from younger metasedimentary rocks. In Louis Cove sill-like bodies of diorite and a probable fault separate gneiss and schist from less metamorphosed sedimentary and volcanic rocks of probable Triassic age, herein named Kelp Bay Group (p. O10).

The stratigraphic thickness of the gneiss and schist unit cannot be closely estimated because the rocks are highly deformed and lack persistent marker beds; however, the unit is probably very thick because the rocks crop out almost continuously along about 10 miles of coastline, dip moderately to steeply, and strike nearly at right angles to the trend of the shore.

Small siliceous flakes and chips of possible organic origin are common in some of the marble beds, but no identifiable fossils were found in the unit.

The gneiss and schist unit of Peril Strait is provisionally considered to be of Paleozoic age. It is lithologically and structurally similar to, and probably correlative with, part or all of a marble-gneiss sequence on northwestern Chicagof Island which Rossman (1959, p. 149–156) thinks is at least partly of Silurian age. However, recent investigations (R. A. Loney, oral communication, 1961) indicate that the rocks on which Rossman based this age assignment may also include strata as young as Devonian in age, therefore, the gneiss and schist unit in the area of this report might be of Silurian or Devonian age.

AMPHIBOLITE AND METACHERT

Dark-green and dark-gray amphibole-rich rocks, interlayered with small amounts of metachert and subordinate marble, crop out on the southwest coast of Catherine Island and form most of Dead Tree Island and part of the southwest shore of Portage Arm. The sequence forms a northwest-trending belt about a mile wide that is bounded on the southwest and possibly on the northeast by faults. On the southwest, the unit is separated from younger rocks by a zone of intense crushing and shearing several hundred feet wide; on the northeast, it is in contact with quartz diorite.

The amphibolite is a weakly to moderately foliated granular hornblende-plagioclase rock. It occurs in tabular layers a few tens of feet thick and is locally interbedded with small amounts of thinly laminated schist that contains variable amounts of chlorite, calcite, mica, hornblende, and feldspar. The amphibolite is cut by many quartz veins and lenses, some of which contain small concentrations of sulfide minerals.

Bedded metachert and marble probably compose less than 5 percent of the exposed part of the amphibolite and metachert unit. About 100 feet of brown and green metachert, interbedded with white and gray marble, underlies or is intercalated with amphibolite about a mile north of North Point, near the southwest tip of Catherine Island. Much-faulted metachert and marble, possibly the same beds as those north of North Point, crop out on the west side of Echo Cove, about 0.6 mile from its mouth. In general, the metachert beds, which average 3 feet thick, are more common than the marble beds, which average 6 inches thick. About 100 feet of thin-bedded metachert and marble crop out near the head of Portage Arm, where they are flanked by intensely sheared and brecciated amphibolite to the northeast, and are in fault contact with contorted and crushed sediments to the southwest. A small amount of marble is interbedded with shattered amphibolite near the northwest corner of Catherine Island.

No fossils were found in the amphibolite and metachert of Catherine Island. The unit is tentatively correlated with similar rocks, thought to be of Paleozoic age, that crop out near Sitkoh Bay on southeastern Chichagof Island (F. E. Wright, unpublished data, 1904; Bur-

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chard, 1914, p. 101). Recent investigations (E. H. Lathram, oral communication, 1961) indicate that the rocks on southeastern Chicagof Island are probably of Silurian or Devonian age.

NAKWASINA GROUP

A complex group of rocks, herein named the Nakwasina Group, crops out along the western shoreline of northern Baranof Island from St. John Baptist Bay southward to Katlian Bay, and forms most of Halleck Island. The Nakwasina Group is well exposed in cross section on the shores of Nakwasina Passage and Nakwasina Sound, from which the group is named, and which area is herein designated the type area.

The group is made up largely of metachert, volcanic rocks, and greenstone; marble, volcanic breccia, graywacke, argillite, phyllite, calcareous siltstone, schist, and hornfels occur locally.

Only the marble and volcanic breccia are differentiated on the geologic map (pl. 1). The marble, which is in beds and lenses that range in thickness from about 10 feet to 60 feet, forms distinctive brown-weathering pitted outcrops; it is not common, but its areal distribution may be important in interpreting the structure of the Nakwasina Group. In a few places greenschist is intercalated with the marble. Volcanic breccia crops out for about a mile south of Allan Point on Halleck Island and on the east side of Nakwasina Sound about 1½ miles from its head. The breccia seems to form a northwest-trending lens about 1,500 feet thick and at least 1 mile long. The lens may be cut by a fault along Nakwasina Sound, but there is no evidence of displacement. The breccia is made up principally of blocks of scoriaceous volcanic rock, as much as 2 feet in largest dimension, in a matrix composed of calcite and of small fragments of argillaceous and volcanic rocks. Pods and blocks of marble as much as 10 feet in diameter are particularly abundant near the base of the breccia on the east side of Nakwasina Sound, where the volcanic rocks conformably overlie thick-bedded marble. It is likely that these textures and relations originated from the flow of lava over or into limy mud.

Because of structural and stratigraphic complexities, only the general areal distribution of other rock types can be given. The bulk of the Nakwasina Group consists of folded and faulted interbedded metachert, basaltic or andesitic volcanic rocks, and greenstone. The metachert is a fine-grained white and light-greenish-gray rock that is granular to slightly foliated and consists of quartz and subordinate amounts of feldspar, sericite, chlorite, and epidote. The volcanic rocks have diabasic, felty, and granular textures; they are fine grained and dark green and are composed of pyroxene, plagioclase (andesine?), epidote, chlorite, sericite, prehnite, quartz, calcite, and unidentified fine-grained material. The greenstone is a fine-grained granular to slightly schistose metamorphic rock whose original textures are not known; it commonly contains amphibole, sodic(?) plagioclase, chlorite, epidote, sericite, prehnite, quartz, and calcite.

Metachert, volcanic rocks, and greenstone constitute most of the strata on the north and east sides of Halleck Island and on the east side of Nakwasina Sound. Near the contact of a large gabbroic intrusive body, the volcanic rocks and greenstone are metamorphosed to amphibole hornfels, coarse amphibolite, and gneissose amphibolite. Interbedded argillite and metachert are common along the northeast shore of Olga Strait on Halleck Island. The rocks from Neva Point to St. John Baptist Bay are sheared thin- to medium-bedded greenstone, metachert, argillite, slate, siltstone, and greenschist. Crumpled and foliated marble, metachert, siliceous greenschist, phyllite, and slaty argillite crop out at the east end of the small cove east of Neva Point. Highly faulted thin- to medium-bedded massive to schistose greenstone, metachert, phyllite, greenschist, marble, siltstone, argillite, graywacke, and fine-grained conglomerate make up the bedded rocks of the Nakwasina Group along the shores of Nakwasina Passage. Brecciated gray metachert crops out near the north end of the east side of Nakwasina Sound, about 1.5 miles S. 60° E. of Allan Point. Sheared, contorted thin-bedded black calcareous chert, gray metachert, and greenstone crop out near Halleck Point. Highly faulted interbedded argillite, fine-grained volcanic rocks, metachert, siltstone, and graywacke form the bedded rocks of Lisianski Peninsula and the south side of Katlian Bay. Pods and veinlets of calcite and quartz are common in many of the rocks.

The Nakwasina Group is cut by a multitude of fractures of all scales. In places the rocks are complexly folded, but characteristically they are shattered. The degree of crushing varies from place to place owing to differences in composition of the rocks and to probable differences in direction and amount of stress. Recemented tectonic breccia, in which angular blocks of rock tens of feet in largest dimension grade downward in size to a fine-grained matrix of crushed, rubbly fragments, forms much of the shoreline of Lisianski Peninsula and Katlian Bay. Some of the blocks show small-scale crumpling, which indicates, at least in part, that a period of folding preceded widespread brecciation. Most of the rock fragments are argillite and siltstone, but blocks of graywacke, chert, volcanic rock, greenstone, amphibolite, and gabbro are not uncommon. In the finer matrix, the material is so comminuted that identification of original rock types is not possible. In St. John Baptist and Katlian Bays, and in places in Nakwasina Sound, the rocks have been so finely milled that cohesive specimens can be obtained only with difficulty. The original nature of this material is no longer discernible; what remains after milling is a poorly cemented powdery rock that weathers directly to gritty dust.

The rocks of the Nakwasina Group were probably deformed in at least two different environments: originally, the rocks were subjected to stress at depth and yielded plastically, producing mostly folds and some faults; later, at shallower depths, the rocks yielded mainly by rupture. The length of time that separated the episodes of deformation is not known.

The stratigraphic thickness of the Nakwasina Group cannot be closely estimated because the rocks are highly deformed and lack persistent marker beds; the group is probably many thousands of feet thick.

The Nakwasina Group is commonly separated from younger rocks by faults, so that stratigraphic relations are difficult to interpret. North of the mouth of St. John Baptist Bay a shear zone several hundred feet wide separates beds of the Nakwasina Group from younger rocks of Triassic(?) age herein assigned to the Kelp Bay Group (p. O10). At the head of Nakwasina Sound, about 1.5 miles east of Allan Point, the contact between the Nakwasina Group and overlying rocks of the Kelp Bay Group is covered, but the units seems to be structurally discordant. If the ages assigned in this report to these two groups are correct, the apparent unconformity represents a considerable interval of time. Near Old Sitka, an intrusive body separates sheared and brecciated rocks of the Nakwasina Group from younger and less deformed rocks which are questionably assigned to the Kelp Bay Group of probable Triassic age.

The contact between the Nakwasina Group and the underlying gneiss and schist unit was not seen. However, the lithologic assemblages of the two units are of distinctly different metamorphic grade and there is no evidence of a metamorphic transition or large-scale faulting between them. These facts, coupled with the likelihood that there is a hiatus between the units, suggest that they are separated by an unconformity.

Fossils have not been found in the rocks of the Nakwasina Group; consequently, little is known of its age. Some of the marble beds contain scattered bits of resistant siliceous rock that may be organic in origin, but are not identifiable as such.

F. E. and C. W. Wright (1908, p. 38, 56–57) and Knopf (1912, p. 13), correlated the rocks of northern Baranof Island with deposits of late Carboniferous age in the Juneau district, particularly those in the vicinity of Taku Harbor, 21.5 miles southeast of Juneau. The results of the present investigation neither confirm nor deny such a correlation. In this report the Nakwasina Group is tentatively considered to be of Paleozoic age, and to be younger than the metamorphosed bedded rocks of Peril Strait and Catherine Island.

The Nakwasina Group, as mapped, may contain infolded or infaulted wedges of younger rocks that are not distinguishable, particularly in some of the areas of extreme deformation described above.

UNDIVIDED SEDIMENTARY AND METAMORPHIC ROCKS

The rocks on the northwest side of Baranof Island near the southwest contact between rocks of probable Paleozoic and Mesozoic ages are so complexly folded, faulted, and metamorphosed that the features that distinguish stratigraphic units are generally destroyed or recognized only with difficulty. Deformation along the contact has resulted in juxtaposition of small tracts of rocks of different ages that cannot be mapped separately. Such undivided rocks form parts of the Siginaka Islands and of the northeast sides of Krestof and Partofshikof Islands.

In this undivided unit, rocks that resemble those of the Nakwasina Group are: chert; interbedded metachert, greenstone, and volcanic rocks; argillite, amphibole hornfels, and volcanic siltstone; and breccia that consists of shreds of siliceous greenstone in an argillite matrix. Rocks that are similar to those of the Kelp Bay Group (p. O10) are: fissile quartzose greenschist and phyllite, black calcareous and quartzose slate, bedded chert, calcareous siltstone, and granular-appearing moderately platy siliceous greenschist that ordinarily is interbedded with argillite but in a few places contains small lenses of jasper. Rocks like those of the Sitka Group (p. O12) are: fine- to coarse-grained conglomerate that consists mostly of rounded pebbles of chert and volcanic and dioritic rocks in an argillite or graywacke matrix, and interstratified graywacke and argillite.

On southeastern Krestof Island, near the contact of a quartz diorite intrusive body, undivided sedimentary and volcanic rocks are metamorphosed to chlorite-epidote rock, fine-grained biotite schist and hornfels, mafic gneiss, and migmatite. In the cove about 0.5 mile southwest of Eastern Point, bodies of massive to gneissose diorite and gabbro crop out, but they are too small to show on the geologic map.

On the map (pl. 1) the contacts between the undivided rocks and younger rocks of the Kelp Bay and Sitka Groups are drawn approximately where the younger rocks become sufficiently persistent in outcrop to show at the map scale.

KELP BAY GROUP

The complex group of rocks herein named the Kelp Bay Group is the most widespread bedded unit on northern Baranof Island. This assemblage and its metamorphic equivalents form the shoreline from north of Rodman Bay to Kasnyku Bay and from Louise Cove to north of the mouth of St. John Baptist Bay. Rocks that are assigned to the Kelp Bay Group crop out at the head of Nakwasina Sound; those that are questionably assigned to the group crop out in the central part of Baranof Island about 15 miles east of Sitka, near Old Sitka, near the mouth of Silver Bay, and in the vicinity of the mouth of Blue Lake. The group also forms parts of Krestof Island and most of the northeast half of Partofshikof Island.

The Kelp Bay Group is best exposed along the shores of Kelp Bay, herein designated the type area, for which the assemblage is named. The stratigraphic thickness of the group cannot be closely determined because the rocks are intricately folded and cut by many faults; the unit is probably many thousands of feet thick.

The Kelp Bay Group is composed of a variety of predominantly fine-grained thin- to medium-bedded rocks. Present in about equal amounts are: fissile quartzose greenschist and phyllite; graywacke, slate, and sheared conglomerate; calcareous and quartzose slate that contains scattered lenses of metachert and volcanic rock; and granular-appearing, moderately platy siliceous greenschist that commonly contains layers and lenses of jasper or is interbedded with slate or argillite. Less common are beds of greenish- or reddish-gray chert, calcareous siltstone, pillow basalt, and thick beds of moderately schistose green rocks that probably are metamorphosed lava flows or pyroclastic deposits.

Limestone is rare in the Kelp Bay Group on northern Baranof Island, but Reed and Coats (1941, p. 25, 38) and Overbeck (1919, p. 97) noted several lenses or beds of it in probably correlative rocks on western Chichagof Island.

The jasper-bearing beds, which have been differentiated on the geologic map (pl. 1), form brightly colored outcrops of layered red and green strata, particularly where they are exposed to wave erosion along the coastline. The distinctive appearance of the jasper-bearing sequence, which is probably not more than 200 feet thick, made it useful in correlating beds of the Kelp Bay Group in widely separated parts of northern Baranof Island and in adjacent islands northwest of Sitka. In addition, its outcrop pattern from Appleton Cove to Hanus Bay outlines fold structures in the group.

Greenschist (greenstone schist of Guild and Balsley, 1942) and phyllite, chert, quartz-biotite schist, and small amounts of limestone were mapped by Guild and Balsley (1942, p. 174–175, pl. 21) about 15 miles east of Sitka. Phyllite, graywacke, metachert, and greenschist crop out near Old Sitka and near the mouths of Silver Bay and Blue Lake. These rocks are lithologically similar to those of the Kelp Bay Group and it is on this basis that they are questionably assigned to the group.

Near the contact of a large body of quartz diorite south of Kelp Bay, the rocks of the Kelp Bay Group have been metamorphosed to schist that contains variable amounts of quartz, feldspar, biotite, chlorite, amphibole, staurolite, and garnet. From South Point to Kasnyku Bay the beds are increasingly recrystallized; near Kasnyku Bay, they are cut by veins of granitoid rock. South of Kasnyku Bay, schist, migmatite, and gneiss are in contact with quartz diorite that locally contains large inclusions or xenoliths of what are probably metamorphosed sedimentary rocks. In Louise Cove, quartz diorite intrudes and is faulted against contact metamorphosed beds of the Kelp Bay Group.

In the description of the Nakwasina Group (p. O6), it was pointed out that the Kelp Bay Group apparently unconformably overlies the older Nakwasina Group of Paleozoic(?) age.

Despite the fact that the strata of the Kelp Bay Group and the Sitka Group (p. O12) are intricately folded (p. O21–O22), with but one exception they were found to be structurally conformable. On the northwest side of Sound Island in Krestof Sound a conglomerate bed, probably at the base of the Sitka Group, overlies with apparent angular discordance thin-bedded rocks of the Kelp Bay Group. On the southeast side of the island, however, strikes and dips of the conglomerate beds are nearly parallel to those of the older rocks. On Partofshikof and Krestof Islands beds of the Kelp Bay Group underlie those of the Sitka Group, apparently without strong angular discordance. Probable faults separate the Kelp Bay Group from the Sitka Group near Old Sitka and near the mouths of Blue Lake and Silver Bay.

Because there is evidence of a hiatus (p. O12, O14) between the Kelp Bay Group and the overlying Sitka Group (p. O12) and because of the structural relations indicated, we believe that a disconformity generally separates the units, but that locally the unconformity may be angular.

Early workers (C. W. Wright, 1907, p. 59–60; C. W. Wright and F. E. Wright, 1908, p. 38, 56–57; Knopf, 1912, p. 13), by analogy with deposits near Juneau and Taku Harbor, concluded that all the rock units, including those of the Kelp Bay Group of this report, that underlie the graywacke (see Sitka Group) in the Sitka district are of Paleozoic age.

Berg examined the rocks near Juneau and Taku Harbor and in the Chichagof mining district, about 50 miles northwest of Sitka, and found that the rocks of the Kelp Bay Group within the area of this report most closely resemble the rocks of the Chichagof district, particularly those of the "schist unit" of Reed and Coats (1941, p. 24–30) and Rossman (1959, p. 163–166). In addition, the Kelp Bay Group in the Sitka district is overlain by a clastic sequence (Sitka Group) that is probably correlative with the graywacke unit that overlies the schist unit in the Chichagof district. Hence, on the basis of similarities in lithology and in structural and stratigraphic relations to younger rocks, the Kelp Bay Group of northern Baranof Island is herein correlated with the schist unit of northwestern Chichagof Island.

The age of the schist unit in the Chicagof mining district is not definitely known. Overbeck (1919, p. 99–100) tentatively correlated the unit with rocks of Late Triassic or Jurassic age on Gravina Island, near Ketchikan. On the basis of somewhat doubtful fossil determinations, Reed and Coats (1941, p. 29–30, 49) considered at least part of the unit to be of Late Triassic age. They also believed that an unconformity separates the schist unit from the overlying graywacke (ibid., 1941, p. 32). Rossman (1959, p. 166–167) concluded that the schist and graywacke units are conformable and tentatively regarded the schist unit as being of Jurassic age.

According to Reed and Coats (1941, p. 30, 35, 49–50), Triassic(?) fossils were reportedly found on the north shore of Mud Bay on Kruzof Island. We were unable to confirm this occurrence, however, and believe that the fossils were not found in place.

We believe that the rocks of the Kelp Bay Group are more similar to those of Triassic age than to those of Jurassic or Cretaceous age elsewhere in southeastern Alaska (Martin, 1926, p. 65–95, 245–262, 375–383; Barker, 1957; Lathram and others, 1960). This comparison, coupled with the meager fossil evidence found by Reed and Coats in the Chichagof district, serves as our basis for provisionally assigning a Triassic age to the Kelp Bay Group.

SITKA GROUP

A thick sequence of slate, graywacke, and conglomerate, herein named the Sitka Group for its exposures in the type area in the vicinity of Sitka, forms a discontinuous belt along the southwest sides of Chichagof and Baranof Islands. It crops out from Old Sitka southeastward to Silver Bay, forms large parts of Krestof, Partofshikof, and Kruzof Islands, and makes up many of the smaller islands near

Sitka. On Chichagof Island it was called the "graywacke formation" by Reed and Coats (1941, p. 33–35) and the graywacke unit" by Rossman (1959, p. 167).

The principal rock types in the Sitka Group are thin- to medium-bedded interstratified graywacke and argillite and slaty argillite. Massive graywacke, conglomerate, and breccia are widespread but less abundant. Beds and lenses of volcanic rocks, commonly with massive or bedded chert, form a minor part of the unit, and greenschist interstratified with slate crops out in a few places. The rocks of the group are ordinarily dark gray and weather dark brown and dark green. Some of the massive varieties weather light gray and light brown. The petrology of the rocks herein assigned to the Sitka Group has been described by Reed and Coats (1941, p. 32–35) and by Rossman (1959, p. 167–168).

Thin- to medium-bedded graywacke and argillite compose most of the Sitka Group on Partofshikof, Krestof, and Kruzof Islands and form most of the shoreline of Silver Bay. The Gavanski Islands, Crow, Middle, and many of the smaller islands near Sitka also are formed mostly of interbedded graywacke and argillite. The beds range in thickness from 1 inch to about 10 feet. Sedimentary structures such as graded bedding and small-scale crossbedding are common in the interstratified graywacke and argillite on Crow, Middle, and the Gavanski Islands. Beds of massive graywacke, conglomerate, and breccia, as much as 50 feet thick, form conspicuous outcrops from near Old Sitka to Sitka, and lenses and beds of conglomerate make up a small part of the group in many other places. Sheared argillite, graywacke, and small amounts of conglomerate crop out along the southwest and southeast sides of Partofshikof Island.

Lenses and layers of sheared volcanic rocks, greenschist, and massive to thin-bedded chert crop out in several places along the shoreline of Silver Bay.

The Sitka Group is at least several thousand feet thick but is too highly deformed to permit a close estimate of its thickness.

The Sitka Group strikes generally northwest and dips steeply southwest; locally the beds are vertical or dip steeply northeast. On southeastern Partofshikof Island and on the larger of the Gavanski Islands, the beds dip gently to moderately southward and are probably near the axes of folds that trend northwest and plunge southeast.

The group is cut by many steep faults, most of which strike northwest nearly parallel to the average strike of the beds. This fact and the lack of marker beds make it difficult to determine direction and amount of movement on the faults. A few north-, northeast-, and east-striking faults also cut the strata, and locally a conspicuous set of nearly vertical joints strikes northeast. Foliation or cleavage planes commonly are nearly parallel to the bedding but are locally divergent; near fold hinges cleavage and bedding intersect nearly at right angles. Overturned beds were recognized on Crow and Middle Islands.

On Kruzof Island flat-lying or gently dipping volcanic rocks of Quaternary age (p. O14) unconformably overlie steeply dipping beds of the Sitka Group. Near the contacts of intrusive igneous rocks on Kruzof and Krestof Islands, rocks of the Sitka Group have been recrystallized to hornfels and schist that contain variable proportions of feldspar, chlorite, amphibole, biotite, garnet, and quartz; from Herring Cove to Bear Cove in Silver Bay, parts of the group have been metamorphosed, probably by nearby intrusive rocks, to hornfels and quartz-biotite schist.

Contact relations between the Sitka Group and older rocks have already been discussed (p. O9, O11).

Quartz and quartz-calcite veins that contain small amounts of sulfide minerals fill many faults and joints in the Sitka Group; in Silver Bay some of the veins are reported to be gold-bearing (Becker, 1898, p. 78–80; F. E. and C. W. Wright, 1905, p. 57–59; Knopf, 1912, p. 26–29).

Of the fossils collected on Kruzof Island (Reed and Coats, 1941, p. 35, 49–50) it is highly probable that the lot containing *Terebellina palachei* and *Aucella crassicolis* came from rocks herein assigned to the Sitka Group (R. R. Coats, oral communication, 1961); if this is so, then at least part of the group is of Early Cretaceous age.

The fossils collected by Overbeck (1919, p. 108) from Slocum Arm probably came from rocks that are correlative with the Sitka Group. Although Overbeck believed the rocks to be of probable Late Jurassic age, he quoted T. W. Stanton's informal report, which indicated that the distinction between fossils of Late Jurassic and Early Cretaceous age was in this case not entirely satisfactory.

We believe that the Sitka Group includes rocks of Early Cretaceous age and probably some of Late Jurassic age.

EDGECUMBE VOLCANICS

The south half of Kruzof Island is formed almost entirely of postglacial basaltic and andesitic lava and pyroclastic debris extruded from Mount Edgecumbe and nearby vents. These rocks are herein named the Edgecumbe Volcanics from Mount Edgecumbe, now a dormant volcano which may have been active in historic time (Becker, 1898, p. 13; Knopf, 1912, p. 14).

Geographic distribution of the formation was interpreted mainly from aerial photographs, supplemented by fieldwork and by unpublished data of previous investigators. (See pl. 1.)

Mount Edgecumbe is entirely unglaciated and ash from it and nearby vents lies on top of the most recent glacial deposits. The dips of the lava flows are probably original.

The petrography of the unit has been described by Knopf (1912, p. 14–15).

Flat-lying to gently dipping lava flows unconformably overlie vertical beds of the Sitka Group on the north shore of Mud Bay and near Port Krestof, and lie nonconformably upon quartz diorite of Jurassic or Cretaceous age on the south shore of Mud Bay and probably on some of the Magoun Islands. The age of the Edgecumbe Volcanics is assigned to the Recent Epoch.

UNCONSOLIDATED SEDIMENTS

Unconsolidated sediments on northern Baranof Island consist of alluvium, glacial debris, and volcanic ash. Deposits of sand, silt, and gravel occur in many of the streams that drain the island. Most of the deposits are small and only the largest, mapped in part by interpretation of aerial photographs, have been shown on the map (pl. 1). Near the mouths of the larger rivers and at the heads of some of the bays, deposits of alluvium up to several hundred feet thick form deltas. Alluvial deposits too small to show on the map are common on the beaches.

Glacial deposits near the beaches characteristically consist of scattered erratic blocks as much as 20 feet in largest dimension. Locally a thin veneer of apparently glacially derived detritus caps the cliffs adjacent to the shore. Some of the areas of alluvium consist of reworked glacial debris.

Volcanic ash from volcanoes on Kruzof Island is widely distributed on the western parts of Baranof and Chichagof Islands. At one time the ash may have formed a blanket several inches thick over much of the area, but Recent erosion has removed or redistributed most of the material. On northwestern Chichagof Island the average thickness of the ash is about 6 inches (Reed and Coats, 1941, p. 47); in the vicinity of Sitka the ash is more abundant and in places is as much as 10 feet thick; on Mount Edgecumbe, ash deposits probably attain thicknesses of 20 feet or more (F. E. Wright, unpublished data, 1904). The petrography of the volcanic ash has been described by Reed and Coats (1941, p. 47–48).

PLUTONIC ROCKS

GABBRO

A band of gabbro about 2 miles wide and at least 15 miles long extends from the south shore of Katlian Bay to the north shore of Nakwasina Passage. Smaller bodies, each exposed over less than a square mile and probably apophyses of the main body, occur on the east shore of Starrigavan Bay, in the Siginaka Islands, on the east side of Partofshikof Island, and on the north side of Nakwasina Passage. Sill-like bodies of granitoid rocks that are probably gabbro in part crop out southwest of Blue Lake, at the head of Bear Cove, and in Herring Cove.

Structural relations of the gabbro with the surrounding bedded rocks are rarely well displayed. Some contacts, such as those on the Siginaka Islands, are clearly faults. F. E. Wright, unpublished data, 1904, saw gabbro dikes, probably apophyses of the main gabbro, that intrude the amphibolite and greenstone of the Nakwasina Group near the northeast contact of the two units, on the east side of Halleck Island. In most places, however, the contact is obscured by the intense fracturing that has affected the gabbro as well as the other rocks of the Nakwasina-Katlian area.

The gabbro is a fine- to medium-grained granular rock that weathers dark gray or dark brown. In some outcrops, layers that differ in grain size and in content of dark minerals are conspicuous. In many outcrops, and perhaps in most, the gabbro is intensely sheared, so that blocks of the little-altered rock are encased in a matrix of material that is finely ground and much altered. Veinlets of quartz, epidote, and serpentine fill many of the cracks in the gabbro, and veins of prehnite are especially common.

Microscopically the gabbro shows an allotriomorphic-granular texture, except where the original texture has been destroyed by shearing and alteration. Few grains exceed 5 mm in length, and the average grain diameter is generally less than 1 mm. The plagioclase ranges from labradorite to bytownite; zoning is uncommon. Nearly all of the plagioclase has undergone some degree of saussuritization.

Clinopyroxene (augite or diallage) is the most common mafic mineral. Hypersthene also occurs in about half the sections that were examined, and in a few of these sections it exceeds clinopyroxene. Thus some of the rock is norite and some of it (where the plagioclase is bytownite) is eucrite. The hypersthene is replaced, wholly or partly, by serpentine, generally bastite. Some of the serpentine may be pseudomorphic after olivine, but the gabbro contains no olivine now. Most of the samples also contain hornblende, some of which has replaced pyroxene.

The accessory minerals of the gabbro are magnetite, ilmenite, pyrite, pyrrhotite, apatite, and sphene. Serpentine, chlorite, quartz, epidote, and leucoxene are the most widespread secondary minerals.

The gabbro is younger than the Nakwasina Group of Paleozoic (?) age, and thus it may be approximately coeval with the more widespread quartz diorite of Late Jurassic or Early Cretaceous age.

QUARTZ DIORITE

Quartz diorite makes up most of the plutonic rocks on northern Baranof Island. Closely associated with the quartz diorite are lesser amounts of granodiorite, diorite, and olivine-bearing gabbro, which are not shown separately on the geologic map.

The largest intrusive body apparently spans Baranof Island near the south edge of the map (pl. 1) and extends southward for an unknown distance. At its northern contact in Kasnyku Bay it intrudes schist and phyllite of the Kelp Bay Group.

Another quartz diorite pluton forms most of Catherine Island and all or part of several small islands in Peril Strait. Its contact with the metamorphic rocks along Portage Arm was not seen and may be a fault throughout its length.

The large quartz diorite stock at Fish Bay may be connected at depth with the smaller body exposed at Louise Cove, where apophyses of quartz diorite intrude slate and graywacke of the Kelp Bay Group. A discontinuously exposed body crops out on Krestof Island, on the Magoun Islands, and at Mud Bay on Kruzof Island. It has contact metamorphosed rocks as young as those of the Sitka Group, which it intrudes. A small body crops out at the head of Kalinin Bay on Kruzof Island and another, of much-altered rock, at the head of Nakwasina Sound.

The quartz diorite is a light-gray medium-grained gray- or tan-weathering granitic rock that commonly is slightly foliated, but is well foliated in some locations at Fish Bay and Catherine Island. The body of quartz diorite on Catherine Island is distinguished also by elongate inclusions or segregations of darker fine-grained rock of about the same composition as the surrounding medium-grained rock.

The quartz diorite has a hypidiomorphic-granular texture and consists of plagioclase (chiefly andesine), hornblende, biotite, quartz, and minor amounts of apatite, zircon, sphene, pyrite, magnetite, and potassic feldspar. Some of the biotite replaces hornblende. Quartz, prehnite, epidote, sericite, and chlorite are common secondary minerals.

The quartz diorite is thought to be part of the Coast Range batholithic complex (Knopf, 1912, p. 15; Overbeck, 1919, p. 109–110; Buddington and Chapin, 1929, p. 252–253) which was emplaced in Late

Jurassic or Early Cretaceous time. The fact that the Sitka Group is cut by the quartz diorite and also contains pebbles of quartz diorite suggests that deposition of sediments of the Sitka Group began before the intrusion and continued until some of the quartz diorite was unroofed and eroded, or that at least one of the plutons is older than the whole Sitka Group.

HYPABYSSAL ROCKS

The hypabyssal rocks of northern Baranof Island may be divided into three groups which are easily distinguished in the field: ultramafic rocks, lamprophyric dikes, and felsic dikes, all of which are too small to show on the geologic map.

Ultramafic rocks consisting of peridotite and pyroxenite were noted in two places on the southwest side of Catherine Island. The size of the bodies and their relation to the surrounding amphibolite are uncertain, but they appear to form one or more tabular bodies which strike about parallel to Portage Arm and may be connected. The fact that the ultramafic rock seems to be relatively undeformed and the surrounding rocks complexly folded suggests that the ultramafic rocks were intruded into the amphibolite after its metamorphism, which is thought to have occurred in Late Jurassic or Early Cretaceous time.

Of two specimens examined microscopically, one is an apparently protoclastic peridotite composed mainly of magnesian olivine with interstitial tremolite and chlorite and a little fine-grained opaque material, biotite, and talc. The other is a pyroxenite that consists mainly of diallage and subordinate amounts of olivine and plagioclase, all poikilitically enclosed in large crystals of hypersthene. Pyrite and chalcopyrite are accessories; hornblende, biotite, and serpentine are alteration products.

The lamprophyric dikes generally dip steeply and range in thickness from 2 inches to 10 feet. An exception is a layered, subhorizontal body about 5 feet thick on the point between Middle and South Arms of Kelp Bay. This body is concordant with the invaded greenschist, slate, and graywacke where their bedding is flat lying and discordant where it is steep.

Many dark fine-grained lamprophyric dikes cut the gabbro and the rocks of the Nakwasina Group in Katlian Bay and on the west side of Lisianski Peninsula and the undivided rocks and quartz diorite on the south side of Krestof Island. Most of them strike north to northeast and are vertical or nearly so. They are cut by joints and by northwest-striking faults but are much less deformed than the country rocks that they intrude. They were not found in contact with the Sitka Group, but the fact that they are relatively undeformed suggests that they are younger than the Sitka Group.

The lamprophyres are very fine- to medium-grained black- or gray-weathering gray to green rocks, many of which show flow banding. They are made up largely of randomly oriented euhedral hornblende prisms, sodic plagioclase, and secondary serpentine or epidote; some contain a little quartz and orthoclase or sanidine. Magnetite, pyrite, and sphene are common accessories. Alteration products, besides serpentine and epidote, include calcite, prehnite, and chlorite.

The felsic dikes are fine grained, gray and greenish gray, and porphyritic. They are as much as 50 feet thick and are widespread, but, like the lamprophyric dikes, they are particularly abundant in Katlian Bay, on the west side of Lisianski Peninsula, and on the south side of Krestof Island. Many felsic dikes also cut the rocks of the Sitka Group on the north side of Kruzof Island. Like the lamprophyric dikes, they have not been affected by the folding and shearing that deformed the country rocks. The relation between the felsic dikes and the lamprophyric dikes is not known because they were not seen in contact, but they probably are of about the same age.

Sodic plagioclase and quartz are the principal minerals of the felsic dikes although a little orthoclase occurs in some and a few contain hornblende phenocrysts. In most dikes, the phenocrysts and the mafic minerals of the groundmass have been replaced by biotite, chlorite, epidote, and calcite. Most of the feldspars are sericitized to some degree. Apatite, sphene, and opaque minerals are accessories.

STRUCTURAL GEOLOGY

The outcrop pattern of the stratigraphic units suggests that the rocks of Baranof and adjacent smaller islands (excluding Catherine Island) form two broad structural features—an anticlinorium that trends north-northwest through Katlian and Fish Bays and a synclinorium that trends north-northwest through Point Benham and Saook Bay. Rocks of probable Paleozoic age form the core of the anticlinorium which is flanked on the southwest by rocks of the Kelp Bay Group of Triassic(?) age and the Sitka Group of Jurassic and Cretaceous age. The prevailing strike of the Mesozoic rocks is northwesterly, and the dips, particularly in exposures of the Sitka Group, are mostly steep to the southwest or vertical. The northeast part of the anticlinorium consists of rocks of Triassic(?) age that also form the southwest part of the synclinorium. The beds in the southwest (heads of Nakwasina Sound and Rodman Bay) and northeast parts (Portage Arm and Pond and Crow Islands) of the synclinorium strike northwestward. In the axial region of the structure they strike northeastward (Rodman Bay) and eastward (Appleton Cove to Saook Bay). Steep northwest, north, and northeast dips are prevalent from Rodman Bay to Kelp Bay; southerly dips are rare, but a few were recognized in Kelp and Rodman Bays.

Although the outcrop pattern of the sedimentary units indicates that the major structural features apparently plunge southeastward, most of the small folds measured in the field plunge north and northwest, and a few plunge northeast. We cannot explain the anomalous relation between the plunges of the small folds and those of the apparent regional structures, and it seems that solution of this structural problem must await additional field studies.

The Paleozoic rocks of Catherine Island evidently are not part of the Baranof Island geological province; the islands are separated by a fault, probably of large displacement, that may account for the bedded rocks of Catherine Island being more like those of southeastern Chichagof Island than those of the northeast part of Baranof Island.

The Edgecumbe Volcanics of Kruzof Island are undeformed.

The northeast and southwest sides of northern Baranof Island are marked by two great northwest-trending lineaments that probably are the traces of major faults (Twenhofel and Sainsbury, 1958, p. 1436). The lineaments are developed along zones of intense crushing and shearing that are as much as half a mile wide on Baranof Island. The fault that separates Catherine Island from Baranof Island can be traced for about 85 miles across the length of Chichagof Island (Rossman, 1959, p. 195, 196). Relative movement on the fault is not known, but because it brings rocks of apparently different geologic provinces together, the displacement may be great. The other fault passes through Silver Bay and Slocum Arm and can be traced for about 60 miles. Relative movement and amount of displacement on the fault in the mapped area are not known; in the Chichagof mining district similar faults are right lateral (Reed and Coats, 1941, p. 67) and apparent right-lateral displacements of as much as 5,000 feet have been estimated along northwest-striking faults on Chichagof Island (W. H. Condon, oral communication, 1961). Twenhofel and Sainsbury (1958, p. 1440, 1442) suggest that the distribution of mineral deposits in the Sitka district, particularly in Silver Bay, is related to the position of this fault.

Small-scale structural features of intense deformation are present nearly everywhere on northern Baranof Island. The area is characterized by complexly interrelated folds, faults, and joints.

Second- and third-order small folds, some of which show incongruous "drag" patterns, characterize strata of pre-Cretaceous age.

Composite folds, those that show evidence of more than one deformation, are outlined by jasper-bearing beds of the Kelp Bay Group from Appleton Cove to east of Point Kennedy. The beds were first isoclinally folded and overturned to the south; the folds were later bent about steep northward-plunging axes. The later folds vary from minute kink folds to broad open warps hundreds of feet in wave length and several tens of feet in amplitude. Strain-slip cleavage developed parallel to the axial planes of the later folds. In this area the strain-slip cleavage planes are shear surfaces that commonly intersect the first foliation nearly at right angles. If strain-slip cleavage develops approximately perpendicular to the direction of principal compression, then the fact that the poles to the cleavage in figure 2 form

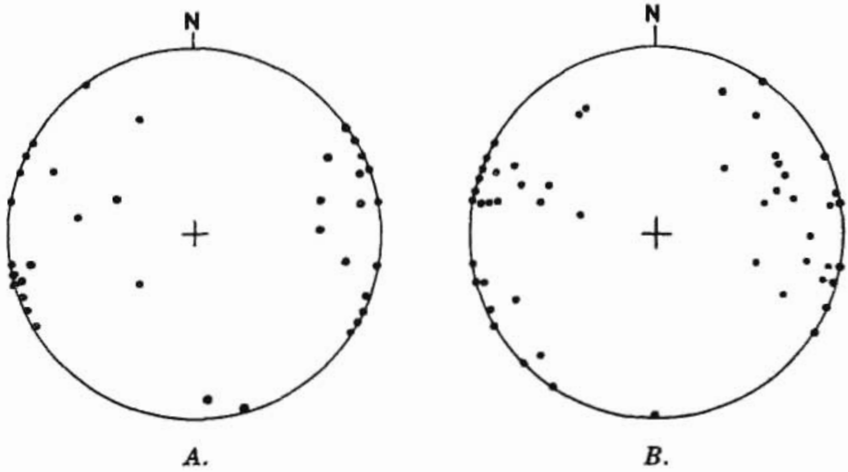

FIGURE 2.—Stereographic plot of (A) 36 poles to strain-slip cleavage in shoreline exposures from Rodman Bay to Hanus Bay and (B) 51 poles to strain-slip cleavage in Kelp Bay. Data are projected to lower hemisphere.

rough maximums around east and west shows that the principal compression during the second (younger) deformation acted along nearly east-west lines. A second interpretation of the stereograms is that the distribution of the poles shows submaximums that suggest that the strain-slip cleavage forms a conjugate system whose sets strike north-northwest and north-northeast. If the acute angle between the sets is bisected by the direction of maximum compressive stress, then the principal compression during the second deformation acted along nearly north-south lines. In either case, the orientation of the folds and possible stress orientations in the Appleton Cove to Point Kennedy area are at variance with the dominant northwesterly trend of regional folds in southeastern Alaska, which are probably the result of northeast-southwest compression. It seems likely that the composite folds resulted from at least two periods of compression but the length of time that separated the episodes of deformation is not known.

In the Kelp Bay area, multiple deformation is not apparent from the outcrop pattern on the map because of the lack of persistent marker beds. However, strain-slip cleavage, kink folds, and warps superimposed upon isoclinal, overturned older folds indicate that the style of deformation in Kelp Bay is like that in the vicinity of Point Benham.

The configuration of folds in the gneiss and schist unit in the vicinity of Nismeni Point is similar to that of the folds in the Kelp Bay Group near Point Benham. Evidence for two episodes of deformation in the rocks of the Nakwasina Group on Lisianski Peninsula and the north shore of Katlian Bay has already been given (p. O7–O8).

In the Sitka Group, steep, vertical, and overturned beds, and the development of slaty cleavage in the argillaceous layers, indicate that the unit is strongly deformed. Locally, cleavage-bedding relations, overturned bedding, and axial planes of small folds show that the rocks have been compressed into northwest-trending isoclinal folds with axial planes dipping steeply southwest. Small folds, however, are not common in the Sitka Group, owing either to its greater competency or to its having been deposited after the deformation of older rocks.

Only a few of the myriad smaller faults that cut the rocks of northern Baranof Island have been plotted on the map (pl. 1). Some of these are fractures and shear zones that probably are complementary to the major faults described above. Most of the small faults are nearly vertical, but, owing to the lack of marker beds, the relative movement and amount of displacement on most of them could not be determined. Zones of intense shearing and brecciation in the vicinity of St. John Baptist and Katlian Bays, and of Nakwasina Passage and Sound were discussed earlier (p. O7–O8); many of these zones strike northwestward and most dip vertically. It seems likely that many reverse faults are present, but few were recognized because of the lack of marker beds.

The rocks of Baranof Island are commonly jointed. The most conspicuous and numerous joints strike northeast and ordinarily dip vertically. A less widespread set strikes northwest and a few joints strike east. Because joints are most likely to form in competent rocks, they are plentiful and well developed in the graywacke beds of the Sitka Group and in the plutonic bodies. Nearly all of the joints are planar. No joints of tectonic origin were observed in the

Edgecumbe Volcanics on Kruzof Island—only polygonal joints caused by contraction during cooling of the lava.

The planar structure of the tectonic joints and the fact that they cut rocks of Jurassic and Cretaceous age but not rocks of Quaternary age suggest that they formed late in the tectonic history of Baranof Island, but before the deposition of the Edgecumbe Volcanics. In many places the northeast-striking joints are filled by lamprophyric and felsic dikes as much as 50 feet wide. Dike concentrations occur on the southwest side of Lisianski Peninsula, along the shores of Katlian Bay, and on the north and south sides, respectively, of Kruzof and Krestof Islands.

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