Reconnaissance Geology of Chichagof, Baranof, and Kruzof Islands, Southeastern Alaska

By ROBERT A. LONEY, DAVID A. BREW, L. J. PATRICK MUFFLER,
and JOHN S. POMEROY

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SOUTHEASTERN ALASKA

Rugged interior of Baranof Island west of Carbon Lake; note Sitka Sound and Mount Edgecumbe in upper right.

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ABSTRACT

The region described in this report encompasses a land area of about 4,000 square miles in southeastern Alaska that comprises the westernmost islands of the Alexander Archipelago, principally Chichagof, Baranof, and Kruzof Islands. The islands are generally mountainous, and the lower slopes of these mountains are densely forested. Baranof Island has the most rugged topography, and the highest peaks rise to more than 5,000 feet in altitude. The islands are much indented with fiords and bays, some of which penetrate deeply into the interior. During the Pleistocene an ice sheet covered all but the highest elevations of the region. Today, glaciers are restricted to the highest parts of Baranof Island and to a single locality on Chichagof Island.

The rock formations range from Ordovician or Silurian to Quaternary; outcrops of Paleozoic rocks are confined to Chichagof Island. The oldest rocks are the Ordovician or Silurian (460 m.y.) syenitic plutonic rocks in southeastern Chichagof Island. These rocks are depositionally overlain by a thick, largely marine section that includes from the base upward: graywacke, slate, limestone, and conglomerate of the Upper(?) Silurian Point Augusta Formation (new name); reef limestone of the Silurian and(or) Devonian Kennel Creek Limestone; interbedded graywacke and limestone of the Middle and Upper Devonian Cedar Cove Formation; thick andesitic, basaltic, minor rhyolitic volcanic rocks, and associated sedimentary rocks of the Upper Devonian Freshwater Bay Formation; and limestone, chert, and shale of the Lower and Upper Mississippian Iyoukeen Formation.

Mesozoic sedimentary and volcanic rocks make up a large part of Baranof Island, Kruzof Island, and the western third of Chichagof Island. The Mesozoic section is poorly documented by fossils, and many of the age assignments are tentative. A unit of chert, limestone, sandstone, and greenstone is considered to be of Paleozoic or Mesozoic age. This unnamed unit is overlain by the Kelp Bay Group which is divided into five formations on Chichagof Island. From bottom to top these are: the Goon Dip Greenstone, the Whitestripe Marble, the Pinnacle Peak Phyllite, the Waterfall Greenstone, and the Khaz Formation (new name). The lower four formations are Triassic(?); the Khaz Formation, which consists of a chaotic melange of all rock types found lower in the Triassic(?) section, is Triassic and(or) Jurassic. Only the Khaz Formation could be mapped separately in southern Chichagof Island and Baranof Island. This formation is overlain by the Upper Jurassic and Lower Cretaceous Sitka Graywacke, a thick sequence of graywacke and argillite with minor conglomerate, greenstone, and limestone.

Mesozoic plutonic rocks are widely distributed on Chichagof Island, absent on Kruzof Island, and very minor on Baranof Island. The oldest known Mesozoic plutonic rocks are Jurassic (144–164 m.y.) adamellites and diorites in the Freshwater Bay and Peril Strait areas. Next youngest are the mainly granodioritic plutons of Early Cretaceous age (103–117 m.y.) that underlie extensive areas of Chichagof Island. The ultramafic rocks of Red Bluff Bay and the serpentinites of central Baranof Island probably were emplaced as cold, tectonic intrusions during the Mesozoic. Two small bodies of gabbro on central Baranof Island may have been emplaced in the Cretaceous or possibly in the early Tertiary.

Tertiary and Tertiary(?) plutons are scattered throughout the map area. The oldest plutons of known Tertiary age are the largely tonalitic Eocene (42–48 m.y.) plutons on Baranof and Kruzof Islands. The youngest dated pluton is the Oligocene and Miocene (24–31 m.y.) granodiorite at Gut Bay on Baranof Island. Many of the plutons along the northwest coast of Chichagof Island are of probable Tertiary age, although there are no radiometric ages.

Tertiary sedimentary and volcanic rocks are not present in the map area. Quaternary sedimentary deposits include alluvium, colluvium, glacial sediments, and volcanic ash and lapilli. The Quaternary igneous rocks are represented principally by the prominent Mt. Edgecumbe volcanic field, a series of high-alumina, calc-alkaline flows and pyroclastics on Kruzof Island. The prehistoric Edgecumbe Volcanics is largely post-glacial, but the eruptions began in late Pleistocene time. A widespread ash deposit has been dated at about 9,000 years.

The pre-Tertiary section has been extensively affected by both regional and contact metamorphism. The extensive, largely Cretaceous plutons of Chichagof Island have metamorphosed the middle Paleozoic rocks into hornfels, granofels, and marble of the low-pressure hornblende hornfels facies. Along Peril Strait, between Chichagof and Baranof Islands, arnphibolite, schist, and marble of the amphibolite facies appear to have been derived from greenstone-rich parts of the Kelp Bay Group. In eastern Baranof Island, the Kelp Bay Group is metamorphosed into the prehnite-pumpellyite-metagraywacke and greenschist facies. Superimposed on this low-grade regional metamorphism are aureoles surrounding the Tertiary plutons. The metamorphism of the aureoles progresses inward from the upper albite-epidote hornfels facies to a high-temperature, intermediate-pressure facies that is intermediate between the hornblende hornfels and the amphibolite facies. In pelitic rocks, this facies is characterized by staurolite, almandine, and sillimanite. On western Baranof Island and on Kruzof Island, Tertiary plutons produced contact aureoles in the Sitka Graywacke. In pelitic rocks, these aureoles are characterized by hornfels and schist that contain cordierite, staurolite, andalusite, and sillimanite. Although variable from

place to place, the metamorphism of the broad aureoles in both the Kelp Bay Group and the Sitka Graywacke suggests an increase in pressure as well as temperature towards the plutons. The coexistence of staurolite-andalusite-sillimanite in the higher grade zones suggests a depth of intrusion of at least a few kilometers.

The pre-Tertiary rocks generally are intensely folded and faulted. In northeastern Chichagof Island folding is moderately intense, and fold axes trend northwest. In western Chichagof Island and in Baranof Island, where folding is more intense, fold axes trend north-northwest to north, and at least two generations of folds are recognized. In places the two generations are homoaxial, but in other places, the axes are widely divergent. Most of this folding occurred after deposition of the Late Jurassic and Early Cretaceous Sitka Graywacke but before intrusion of the Eocene plutons.

Most faults are high-angle ones; the most important of these are the Chatham Strait fault and the faults of the Fairweather fault system. Movement has taken place throughout the Tertiary and Quaternary. The Chatham Strait fault is a zone 2–15 miles wide and over 265 miles long that has had right-lateral movement of 100–120 miles and vertical uplift of the west side of over a mile. The Peril Strait fault of the Fairweather fault system shows right-lateral movement of up to 36 miles and appreciable uplift of the northeast side. Historic seismicity has occurred on the Fairweather fault northwest of the map area. Other older and less important fault systems include the subvertical northwest-striking Tenakee fault system, a northeast-striking, high-angle fault system and two thrust faults.

Gold and silver were mined before 1945 from lodes in western Chichagof and Baranof Islands. The lodes are quartz fissure veins in fault zones that mainly cut low-grade metasedimentary and metavolcanic rocks of Mesozoic age; the lodes contain pyrite, arsenopyrite, chalcopyrite, galena, and sphalerite. The mineralization appears to be related to Tertiary granitic rocks rather than to the more abundant Mesozoic rocks. Gypsum was mined before 1923 from the Mississippian Iyoukeen Formation in northeastern Chichagof Island. In addition, there are prospects of nickel, chromium, copper, molybdenum, tungsten, iron, potash feldspar, palygorskite, and andalusite.

INTRODUCTION

LOCATION

The area of this report includes the westernmost islands of the Alexander Archipelago of southeastern Alaska (pl. 1). Chichagof, Baranof, and Kruzof Islands comprise a total land area of more than 4,000 square miles between lat 56" and 58° 20′N. and long 134'30' and 136°40′W. The islands are bordered by the Pacific Ocean on the south and west and by Chatham Strait on the east; they are separated from the mainland to the north by Cross Sound and Icy Strait. The area lies within the Tongass National Forest.

PREVIOUS INVESTIGATIONS

One of the earliest geologic studies in the area of this report was conducted in 1895 and 1896 by Becker (1898, p. 13, 43, 78–80), who investigated the Sitka–Silver Bay area, Baranof Island. Members of the Harriman Alaska Expedition examined the same general area in 1899 (Emerson and others, 1910, p. 18–19, 44–48, 92). In 1904 F. E. and C. W. Wright (1905, p. 57–59) made a reconnaissance study of the shoreline of northern Baranof Island and the west coast as far south as Whale Bay (Knopf, 1912, p. 7). A year later C. W. Wright examined the shoreline of Chichagof Island and eastern Baranof Island. He reported the discovery of gold on Chichagof Island (F. E. and C. W. Wright, 1906, p. 45–46) and spent the following field season visiting the claims. In a later report (1907, p. 59–61) C. W. Wright briefly described the general geology and prospects of Chichagof and Baranof Islands. Fossils from the Freshwater Bay area, Chichagof Island, were collected and discussed by Kindle (1907, p. 314–337). In 1910 Knopf (1912) studied the geology of the Chichagof mining district and the Sitka area. In 1913 Burchard (1920, p. 45–48) investigated the marble areas along Tenakee Inlet and in Basket Bay, Chichagof Island. Waring (1917, p. 26–41, 91) visited and discussed several mineral springs on Chichagof, Baranof, and Kruzof Islands. In 1917 Overbeck (1919, p. 91–136) examined the outcrops along the west coast of Chichagof Island and along Peril Strait to the head of Hoonah Sound; considerably more geologic information is available in Overbeck's report than in earlier reports. Kirk (1918) discussed the possibility of Paleozoic glaciation based partly on observations in the Freshwater Bay area of Chichagof Island. In 1923 Buddington (1925, p. 95–125) investigated nickel-copper claims on Yakobi Island, Tenakee Inlet (Chichagof Island), and Snipe Bay (Baranof Island). Further studies of fossils from the Freshwater Bay area were made by Kirk (1927a, b). In 1928 the gypsum deposits of Iyoukeen Cove, Chihhagof Island, were examined by Stewart (1932).

Reconnaissance studies throughout southeastern Alaska were carried out by A.F. Buddington and Theodore Chapin between 1915 and 1925 and were published in a major work (Buddington and Chapin, 1929) that summarizes the geology and mineral deposits then known. Although this work concentates on the inner islands of the Alexander Archipelago, some information on Baranof and Chichagof Islands is presented, and incidental observations of early visitors are summarized.

During the field seasons of 1938 and 1939, Reed and Coats (1914) systematically mapped the Chichagof mining district; a geologic map at a scale of 1:62,500 and several mine and prospect maps are included in the report, On Baranof Island the Red Bluff Bay area was examined briefly by Reed and others in 1939 (Guild and Balsley, 1942, p. 173). Guild and Balsley (1942) later mapped the Red Bluff Bay ultramafic body and prepared a reconnaissance map of part of central Baranof Island. During the period 1939–44, miscellaneous mineral prospects on Chichagof Island were investigated (Twenhofel and others, 1949, p. 20–28). In 1940 Reed and Dorr (1942, p. 105–138) mapped the nickel deposits of Bohemia Basin and vicinity on Yakobi Island. Pecora

(1942) conducted further studies related to the nickel-copper deposits of the west coast of Chichagof Island. In 1942 and 1943 Kennedy and Walton (1946a) continued investigations on Yakobi Island and the west coast of Chichagof Island.

Nickel-copper prospects at Snipe Bay and near Sitka, Baranof Island, were visited by Reed and Gates (1942) and by Kennedy and Walton (1946a, p. 63–64). Kennedy and Walton (1946b, p. 72–75) reexamined the Red Bluff Bay ultramafic body and areas inland. In 1946 Flint and Cobb (1953) studied the gypsum deposits near Iyoukeen Cove. From 1946 to 1948 Rossman (1959) mapped northwestern Chichagof Island and Yakobi Island at a' scale of 1:63,360. In 1949 West and Benson (1955, p. 47–50) conducted radioactivity investigations at Goddard Hot Springs and in the Chichagof mining district. The Blue Lake area near Sitka was briefly investigated by Twenhofel (1951) in 1950. During short periods in 1953 and 1954, Sainsbury (1957, p. 141–152) examined pegmatite deposits near Redfish Bay, Baranof Island. In 1956, Soward (1961) studied the geology of proposed powersites at Baranof and Carbon Lakes. Twenhofel and Sainsbury (1958) included Baranof and Chichagof Islands in their discussion of linear trends in southeastern Alaska. Wanek and Callahan (1969) studied proposed powersites at Deer Lake and Kasnyku Lake, and Callahan (1970) investigated a proposed powersite at Takatz Creek.

Lathram and others (1958, 1959) prepared reconnaissance geologic maps of that part of northeastern Chichagof Island included in the Juneau (1:250,000) quadrangle. Detailed stratigraphic and structural information gathered in the Freshwater Bay area in 1956 and 1957 (Loney, Condon, and Dutro, 1963) facilitated the reconnaissance mapping of all of Chichagof Island. More recently, Berg and Hinckley (1963) examined the shoreline of northern Baranof Island. All of their maps, and those of Rossman (1959) and Reed and Coats (1941) have been incorporated into plate 1 of this report.

Important modern mapping and studies of nearby areas include the reconnaissance work (Lathram and others, 1960, 1965) and detailed studies (Loney, 1963, 1964, 1965) on Admiralty Island to the east; reconnaissance and detailed mapping in the Keku Strait area to the southeast (Muffler, 1967); reconnaissance and detailed mapping in the Glacier Bay area to the north (Rossman, 1963a, 1963b, unpub. data; Seitz, 1959); and reconnaissance mapping in Glacier Bay and the Chilkat Range to the north (Lathram and others, 1958, 1959; MacKevett and others, 1971).

PRESENT INVESTIGATION

The previously unmapped part of Chichagof Island, some of northern Baranof Island, and part of Kruzof Island were mapped during the 1961 field season (Loney, Berg, Pomeroy, and Brew, 1963). The area covered by the map of Reed and Coats (1941) was visited only along its eastern and southern boundaries. The area of Rossman's (1959) map was studied briefly along its eastern boundary and along Icy Strait. A large part of Baranof Island was mapped during the 1962 field season (Loney and others, 1964). Brew and Muffler completed the geologic mapping of the remainder of the island during a short period in 1963. The use of the Geological Survey motor vessel *Stephen* R. Capps and of a helicopter facilitated the reconnaissance mapping. Geologic data were accumulated from a combination of shoreline and ridge traverses. Shoreline exposures are generally excellent, and ridges above timberline afford maximum outcrops during the middle and late summer.

ACKNOWLEDGMENTS

We are indebted to our colleagues H. C. Berg, W. H. Condon, D. W. Hinckley, and E. H. Lathram for their contributions to this report, made both through actual mapping and through discussion. We are particularly indebted to Berg and Lathram for helpful technical reviews. We also thank R. R. Coats for clarification of several points pertaining to his earlier mapping in the Chichagof mining district.

J. L. Kulp, when at the Lamont Geological Observatory, visited the project on Baranof Island and sampled both igneous and metamorphic rocks for radiometric age determination. The data Professor Kulp has contributed are discussed in the section on igneous rocks together with information from our colleagues M. A. Lanphere and G. D. Eberlein, who sampled igneous rocks from Chichagof Island and provided critical radiometric ages. T. W. Stern, U.S. Geological Survey, provided important corroborative lead-alpha dates from several igneous masses. R. A. Marvin contributed an important potassium-argon age.

Study of the rocks of Paleozoic age on Chichagof Island was aided by fossil determination made by the following U.S. Geological Survey paleontologists: J. T. Dutro, Jr., C. W. Merriam, Helen Duncan, and E. L. Yochelson. The few Mesozoic forms found were classified by D. L. Jones, Helen Duncan, and N. J. Silberling, Jr. No fossils were found on Baranof or Kruzof Islands.

We are also indebted to Capt. Robert D. Stacey, Master of the M/V Stephen R. Capps, and to John Muttart, cook-seaman, both of whom gave responsible and effective support during the fieldwork.

GEOGRAPHY

Chichagof, Baranof, Kruzof, and adjacent smaller islands form a 150 mile-long, wedge-shaped land mass that narrows southeastward. The two major islands are separated from each other by Peril Strait. They are also dissected by many major bays, inlets, and fiords, but the irregular shoreline with steep-sided valleys and fiords is best developed in southern Baranof Island.

Chichagof and Kruzof Islands are fairly mountainous and of moderate relief, and Baranof Island features the most rugged topography of any island in southeastern Alaska. On Chichagof Island, the major peaks reach a height of less than 4,000 feet, whereas on Baranof Island, the highest peaks exceed 5,000 feet in altitude. Many peaks on Baranof Island are partly ice and snow covered the year around owing to the extraordinarily heavy snowfall at the higher elevations during the winter months.

Streams on the islands are numerous but short and commonly have moderate to steep gradients. Their flow is highly variable throughout the year.

Glaciation has been the most significant factor in modifying the landscape. Only one present-day glacier has been recognized on Chichagof Island, but glaciers are common in east-central and north-central Baranof Island. The rugged and scenic region behind Carbon Lake and the high country bordering the headwaters of Glacial River are especially noteworthy for their glaciers and permanent snowfields (see frontispiece).

During the Pleistocene Epoch, an ice sheet from the north and northeast covered all but the highest elevations of the islands. Minimum elevation of the ice cover was generally between 2,400 and 2,700 feet on Chichagof Island and a few hundred feet less on Kruzof and Baranof Islands (Coulter and others, 1965). Evidence of younger local glaciation is seen in the many cirques, horns, arêtes, U-shaped valleys, erratics, percussion marks, and striae. The Pleistocene glaciers scoured out basins which are now the sites of lakes, some of which bottom well below present sea level. At Deer Lake on southern Baranof Island, the deepest observed point is 877 feet, or 503 feet below sea level (Johnson, 1963, p. 176–179). Baranof, Carbon, Kasnyku, and Takatz Lakes have also been sounded (Johnson, 1963, p. 176).

Dense forest stands and undergrowth are characteristic of the lowlying areas. Hemlock and spruce are the dominant forest trees. Alder, devilsclub, and berry bushes, the dominant undergrowth, are nearly impenetrable in places. The altitude of timberline varies throughout the islands. Generally it ranges from 2,000 to 2,600 feet on Chichagof, Kruzof, and northern Baranof Islands and from 1,500 to 2,100 feet on central and southern Baranof Island.

The typically maritime climate of the area is characterized by relatively moderate temperatures and heavy precipitation. Mean minimum temperatures range from 24" to 28°F. in January and from 48" to 50°F. in July. Mean maximum temperatures range from 34" to 38" in January and 60" to 64" in July. The southernmost part of Baranof Island receives the greatest recorded annual average precipitation in Alaska, with Little Port Walter receiving slightly over 221 inches of precipitation during the average year (Watson, 1959, p. 3). Sitka and Chichagof Island receive an average of 100 inches. The rainfall is usually heaviest in October and lightest in May or June. These scant meteorological data come from a few stations located at sea level. Greater extremes of temperature and precipitation would be expected inland.

Sitka (including the adjoining community of Mount Edgecumbe) is the only large town within the mapped area. Port Alexander, Baranof, and Goddard are small settlements on Baranof Island; Tenakee, Hoonah, Chatham, Pelican, and Elfin Cove are small permanent settlements on Chichagof Island. Lumber camps at Rodman Bay, Katlian Bay and elsewhere provide logs for the paper mill at Sitka. Paved roads exist only in the Sitka area. Maintained trails are scarce.

All the communities noted above serve as stops for scheduled and chartered flights.

STRATIGRAPHY

Bedded rocks ranging in age from Silurian to Quaternary crop out on Chichagof, Baranof, and Kruzof Islands (pl. 1, fig. 1). These units have been briefly described by Loney, Berg, Pomeroy, and Brew (1963) and by Loney, Pomeroy, Brew, and Muffler (1964). Some generalized paleogeographic conclusions have been advanced by Brew, Loney, and Muffler (1966). Detailed information concerning the Silurian to Mississippian rocks in the Freshwater Bay area of Chichagof Island is found in Loney, Condon, and Dutro (1963, p. 6–37).

In this discussion of stratigraphy, the various map units are described from oldest to youngest. In order to provide a better basis for paleogeographic conclusions, those units that are essentially metamorphic are discussed together with their unmetamorphosed equivalents. Consideration of detailed metamorphic characteristics is deferred to a later section of this report.

The stratigraphic nomenclature that is used by previous workers and by the present group of investigators in earlier reports is shown graphically in figure 2.

We have attempted to correlate most of the map units throughout the region, but our efforts have been hindered by insufficient paleontologic or physical data. Although many Paleozoic fossil collections were made during the years 1956 and 1957, most are as yet unstudied. The taxonomic reports by the paleontologists of the U.S. Geological Survey some day will undoubtedly aid in elucidating stratigraphic relations.

SYSTEM OR SERIES		UNIT			DESCRIPTION
QUATERNARY		Unconsolidated sedimentary deposits; Edgecumbe Volcanics			Unconsolidated deposits. Include alluvium, colluvium, glacial drift, and ice-marginal deposits, and minor volcanic ash. Edgecumbe Volcanics are basalt flows, silicic plugs and ash, lapilli, and tuff breccia.
CRETACEOUS	Lower Cretaceous	Sitka Graywacke			Lithic and feldspathic graywacke with locally abundant argillite; minor conglomerate, limestone, and greenstone.
JURASSIC	Upper Jurassic				
TRIASSIC AND (OR) JURASSIC		Kelp Bay Group	Schist unit of Reed and Coats, 1941	Khaz Formation	Greenstone, greenschist, graywacke, metachert, phyllite and minor limestone; chaotically mixed.
TRIASSIC(?)				Waterfall Greenstone	Greenstone, lesser amounts of graywacke, greenschist, radiolarian chert, and marble.
				Pinnacle Peak Phyllite	Thinly laminated siliceous gray phyllite.
			Whitestripe Marble		Light-gray and white massive marble with minor greenstone interbeds.
			Goon Dip Greenstone (base not exposed)		Greenstone, volcanic breccia, greenschist, and rare limestone.
PALEOZOIC OR MESOZOIC		Chert, limestone, sandstone, and greenstone			Thin-bedded chert and black shale at top, thin-bedded limestone in middle, sandstone and siltstone at base.
MISS.	Lower and Upper Mississippian	Iyoukeen Formation			Upper member: cherty fossiliferous limestone; middle member: shale and shaly limestone; lower member: dark-gray limestone.
DEVONIAN	Upper Devonian	Freshwater Bay Formation			Andesite and basalt flows, volcanic breccia, tuff, minor graywacke, and limestone.
	Middle and Upper Devonian	Cedar Cove Formation	Limestone member		Very thick bedded to thin-bedded fossiliferous limestone.
			Clastic member		Thin-bedded argillite with local limestone, graywacke, and conglomerate.
SILURIAN AND (OR) DEVONIAN		Kennel Creek Limestone			Limestone, minor dolomite, limestone breccia, and shale.
SILURIAN	Upper (?) Silurian	Point Augusta Formation			Arkosic, feldspathic, and lithic graywacke; argillite; subordinate conglomerate, siltstone, and limestone.

FIGURE 1.— Generalized stratigraphic section for Chichagof, Baranof, and Kruzof Islands.

SILURIAN ROCKS

POINT AUGUSTA FORMATION

The Point Augusta Formation is here named for the widespread map unit previously called "graywacke and argillite" (Lathram and others, 1959; Loney, Berg, Pomeroy, and Brew, 1963), or "unnamed argillite and graywacke" (Loney, Condon, and Dutro, 1963). The formation crops out on Chichagof Island in two main belts. The southern and more extensive belt stretches from near the mouth of Tenakee Inlet northwesterly to Icy Strait. The northern belt is exposed along the northeast shore of Chichagof Island from False Bav northwestward to a few miles west of the mouth-of Port Frederick. The type locality of the Point Augusta Formation is exposed in the nearly continuous cliffs that extend west from Point Augusta along Icy Strait to Whitestone Harbor and south from the point along Chatham Strait to False Bay. The widespread calcareous facies of the Point Augusta Formation is typically exposed in the cliffs along Icy Strait from Point Adolphus southwest nearly to Mud Bay.

Metamorphic rocks derived from the Point Augusta

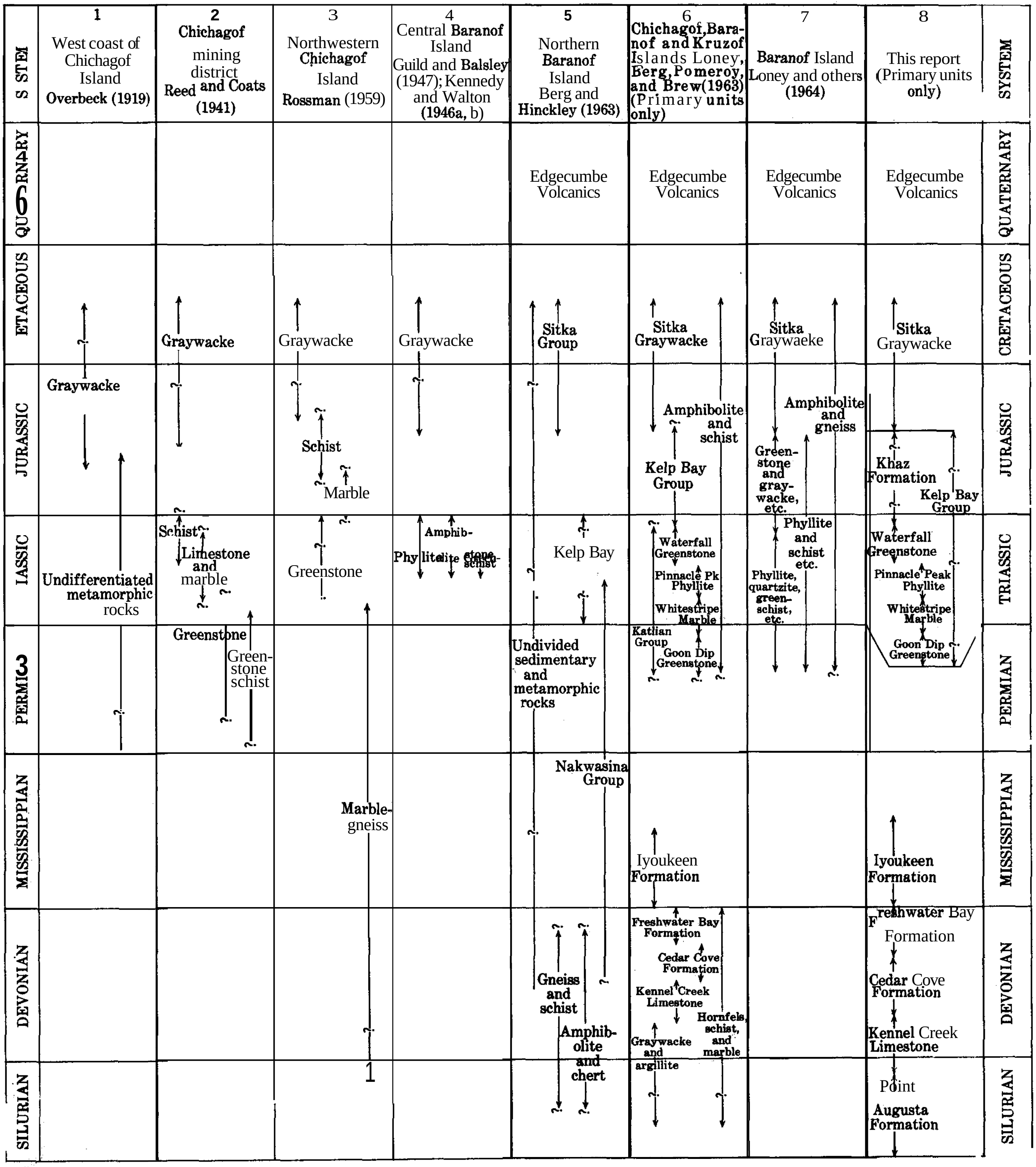


FIGURE 2.—Nomenclature used in previous reports concerning the stratigraphy of Chichagof, Baranof, and Kruzof Islands.

Formation are exposed over a large area in central and west-central Chichagof Island as a complex of marble, schist, gneiss, and amphibolite.

The Point Augusta Formation, the oldest formation in the Chichagof-Baranof-Kruzof area, underlies the Kennel Creek Limestone of Silurian and (or) Devonian age. The nature of the contact is not known, but it is interpreted to be unconformable. No fossils have been found in the Point Augusta Formation in the map area. Probably at least 5,000 feet of the formation is exposed, but structural complexities and a lack of marker beds make thickness estimates uncertain; the base of the sequence has not been recognized.

The Point Augusta Formation consists primarily of interbedded graywacke and argillite and has a uniform appearance over much of northeast Chichagof Island (fig. **3).** The thin-bedded graywacke is commonly medium to fine grained and ranges from arkosic to lithic in composition. Graded bedding, crossbedding, convolute bedding, and load casts occur locally, but no systematic study of the sedimentary structures has been made. The argillite is dark gray, thin bedded to laminated, and devoid of sedimentary structures. It is locally calcareous, and in many outcrops it is intricately folded or intensely sheared. In areas of intensive folding, the argillite has a well-developed slaty cleavage, and the weathered surfaces have a slight micaceous sheen.

Graywacke predominates over argillite throughout most of the outcrop area, but argillite dominates along parts of Icy Strait and near the entrance to Port Frederick. Northwest of Pinta Cove, the sedimentary structures and bedding characteristics are like those elsewhere, but the strata are actually limestones and limy graywackes.

Thin-bedded light-gray medium-grained limestone occurs as isolated beds intercalated with argillite and graywacke throughout the map area. These strata weather gray or brown. Thin- to thick-bedded dark-gray limestone occurs as mappable units up to several hundreds of feet thick north of Tenakee Inlet and near the head of Port Frederick (fig. 4). These thick limestone lenses commonly are intricately folded.

Less abundant rock types such as conglomerate, slate, and siltstone are locally intercalated with the dominant graywacke and argillite of the Point Augusta Formation. Conglomerate and pebbly graywacke are particularly abundant southwest of Freshwater Bay (Loney, **Condon,** and Dutro, **1963).**

Microscopically, the graywacke consists of angular to subangular grains of quartz, plagioclase, argillite, siltstone, graywacke, and limestone set in an abundant matrix that is composed largely of calcite and chlorite. The relative amount of calcareous and chloritic matrix is variable; at Point Augusta the two types of matrix are mixed together, whereas at False Bay thin calcareous and chloritic layers alternate. Calcareous matrix is predominant at Point Sophia in both graywacke and argillite, which in places grade into impure limestone, as noted above.

Although no recognizable fossils have been found in the rocks of the Point Augusta Formation, we consider it to be of Late(?) Silurian age on the basis of lithostratigraphic correlation with fossiliferous rocks of probable Late Silurian age to the north in the Chilkat Range and in Glacier Bay and to the southeast on Kuiu, Heceta, and Tuxekan Islands. The formation was considered to be Silurian(?) or Devonian(?) by Loney, Con-

FIGURE 3.—Sole markings in graywacke of Point Augusta Formation, False Point, Chichagof Island.

FIGURE 4.—Very thin to thin-bedded platy weathering dark-gray limestone of Point Augusta Formation, east side of Port Frederick, Chichagof Island. Photo by W. H. Condon.

don, and Dutro (1963), but no fossils of Devonian age have been found in rocks that correlate with the formation. We therefore consider the Devonian(?)assignment unwarranted and assign a Late(?) Silurian age to the unit.

The rocks of the Point Augusta Formation are lithically similar to a widespread argillite, graywacke, and limestone unit to the north in the Chilkat Mountains and are probably physically continuous with that unit. Graptolites (*Monograptus*) indicating a Middle or Late Silurian age (Loney, Condon, and Dutro, 1963, p. 13) were collected near St. James Bay and Boat Harbor on the east side of the Chilkats from a black slate section that appears to be in the lower part of the unit. Corals collected from a correlative limestone unit in the vicinity of Mount Young, farther to the north in the Chilkat Range, were determined by W. A. Oliver, Jr. (written commun., 1959) to indicate a Silurian age. Diagnostic forms noted include Favosites sp., Halysites sp., Heliolites sp., Alveolites sp., Arachnophyllum sp., Amplexoides sp., and *Zelophyllum*(?) sp. Although this unit was assigned a Silurian(?) to Devonian age by Lathram, Loney, Condon, and Berg (1959), the new fossil evidence makes the Devonian assignment unwarranted. Late Silurian graptolites have also been reported from equivalent strata at the south end of the Chilkat Mountains and in Glacier Bay National Monument (Michael Churkin, Jr., oral commun., 1964, 1966).

The rocks of the Point Augusta Formation are also lithically similar to those of the Tidal Formation in the Glacier Bay area that are assigned to the Late Silurian on meager evidence (Rossman, 1963b, p. 12–16). The Tidal Formation consists principally of well-indurated fine-grained calcareous argillite interbedded with minor graywacke. A thin-bedded limestone member (Rossman, 1963b, p. 15) lies between dominantly argillaceous sections. The rocks of the Tidal Formation are similar to and probably continuous with Silurian rocks of the Chilkat Range mentioned in the previous paragraph.

Rossman (1963b) also mapped separately two limestones: the Pyramid Peak, which overlies the Tidal Formation, and the Willoughby, which he considered to underlie the Tidal although its stratigraphic position is uncertain and it has not been seen in normal contact with any of the other formations of the Glacier Bay section. We feel that Rossman's field data are subject to another interpretation and we suggest that the lithologically different Pyramid Peak and Willoughby Limestones, set up by Rossman as separate map units at different stratigraphic levels, are lateral facies variations of the same limestone unit. The Willoughby Limestone is a massive probable reef-type limestone that is lithically similar to the Kennel Creek Limestone in parts of northern Chichagof Island (Loney, Condon, and Dutro, 1963, p. 16–17), and it also contains the large pelecypod, Pycinodesma, which is common in the Kennel Creek. On the basis of this fossil, the Willoughby was assigned to the Late Silurian (Kirk, 1927a). The Kennel Creek Limestone overlies the Point Augusta Formation of Chichagof Island; thus, if the tentative correlations of the Kennel Creek, Willoughby, and Pyramid Peak Limestones are correct, the Point Augusta Formation is probably equivalent to the Tidal Formation, and both are older than the Willoughby.

Paleogeographic information is scant, but the greater ratio of graywacke to argillite on Chichagof Island than on Glacier Bay indicates that a source area might have existed to the south. The local increase in the proportion of calcareous matrix probably has little regional significance.

To the east, along the west coast of Admiralty Island, a regionally metamorphosed sequence of Silurian or Devonian age (Lathram and others, 1959) might represent in part the equivalent of the Point Augusta Formation on Chichagof Island.

The Point Augusta Formation is probably also correlative with the Bay of Pillars Formation of Late Silurian age on northern Kuiu Island (Muffler, 1967). Graptolites from the Bay of Pillars Formation clearly indicate a Late Silurian age, and the rocks are lithically similar to those of Point Augusta on Chichagof Island. The Point Augusta Formation probably also correlates with part of the thick Silurian section in the Heceta-Tuxekan area of Prince of Wales Island (Eberlein and Churkin, 1970; Condon, 1961).

SILURIAN AND (OR) DEVONIAN ROCKS

KENNEL CREEK LIMESTONE

The type section of the Kennel Creek Limestone, as originally defined by Loney, Condon, and Dutro (1963, p. 13), crops out at the mouth of Kennel Creek on the south side of Freshwater Bay. They mapped it north of the bay and northwestward as far as Port Frederick. To the south of Freshwater Bay and northwest of Port Frederick, the Kennel Creek correlates with a prominent limestone unit that forms a continuous belt along Chatham Strait from Peninsular Point to Basket Bay and that trends northwestward to the vicinity of Game Creek. Farther northwest the outcrop pattern is irregular. This limestone unit was described previously (Lathram and others, 1959; Loney, Berg, Pomeroy, and Brew, 1963) as a member of an unnamed limestone and clastic unit. In this report, the name Kennel Creek is extended to include the apparently correlative strata outside the area in which it was previously mapped.

The Kennel Creek Limestone is made up of thin to very thick bedded limestone and a few beds ofdolomite and limestone breccia. Medium-grained thick-bedded to very thick bedded limestone is characteristic of the lower part of the unit in the type area. Outside the type area subordinate thin-bedded calcareous shale and siltstone and a few layers of conglomerate are interbedded in the lower part of the section. Conglomerate layers contain angular and rounded fragments of syenite, leucocratic granite, mafic volcanic rock, chert, graywacke, and limestone. The upper part of the formation consists of thin-bedded limestone with very thin siliceous tuffaceous partings.

The formation ranges from 2,200 to 5,000 feet in thickness in the type area and forms prominent ridges. The thickness diminishes to about 800 feet northwest of Port Frederick, and the unit becomes locally obscure. It grades upward into the Cedar Cove Formation; the contact is placed at the base of the lowest interbedded limestone and clastic unit.

The absence of diagnostic fossils in the Kennel Creek Limestone precludes assignment to a specific time division. The available evidence from correlative strata outside the map area favors a Silurian age, but the stratigraphic position below rocks of established Middle Devonian age makes a Devonian age possible. For these reasons we assign a Silurian and (or) Devonian age to the formation.

The Middle Devonian age originally assigned by Dutro (Loney, Condon, and Dutro, 1963, p. 16–17) is based on the occurrence of a favositid–rugose coral assemblage from an unspecified unit in an unspecified locality outside the type locality at Kennel Creek. The Kennel Creek Limestone itself is not dated directly; the only fossils known in rocks mapped as Kennel Creek Limestone in its type locality are the stromatoporoid Amphipora and the large pelecypod Pycinodesma. Both of these forms are known in Silurian strata (Loney, Condon, and Dutro, 1963, p. 17).

On the ridge north of Kook Lake, the stromatoporoid *Amphipora*(?) sp. and tabulate corals Favosites sp. and Thamnopora sp. occur in a highly fractured fine-grained thin-bedded limestone mapped as Kennel Creek. A Middle or early Late Devonian age has been suggested by W. A. Oliver, Jr. (written commun., 1962), for this collection. Field relations support correlation of this limestone with the Kennel Creek Limestone in its type locality.

Pycinodesma is found in thick-bedded to massive limestone units that closely resemble the Kennel Creek both in lithology and in stratigraphic position at Glacier Bay (the Willoughby Limestone, Rossman, 1963b) and in the Heceta-Tuxekan area (Eberlein and Churkin, 1970). The Pycinodesma-bearing limestone units in these areas are considered to be Silurian.

Limestone that is lithically similar to the Kennel Creek and which contains Amphipora and *Pycinodesma* also occurs in the William Henry Bay–Boat Harbor area on the east side of the Chilkat Range. The Kennel Creek Limestone may correlate with limestones from Admiralty Island that have been assigned a Silurian or Devonian age (Lathram and others, 1960) and with the Late Silurian Kuiu Limestone of northern Kuiu Island (Muffler, 1967). Recently, Ovenshine and Webster (1970) show that the range of *Amphipora* and Pycinodesma in the [Heceta] Limestone of the Sea Otter Sound area of southeastern Alaska extends into the Silurian. Eberlein and Churkin (1970, p. 21) point out that on Heceta Island Amphipora occurs with *Zelophyllum,* considered by many workers to be restricted to the Silurian.

DEVONIAN ROCKS

CEDAR COVE FORMATION

The Cedar Cove Formation, as originally defined (Loney, Condon, and Dutro, 1963, p. 17), is exposed along the south side of Freshwater Bay, near the head of Iyouktug Creek, and on both sides of Port Frederick. The best exposures occur in Freshwater Bay. To the northwest and south, the formation correlates with rocks referred to in previous reports (Lathram and others, 1959; Loney, Berg, Pomeroy, and Brew, 1963) as unnamed limestone and clastic units. In this report, the name Cedar Cove is extended to include the correlative strata outside the type locality that crop out along Chatham Strait, on the north shore of Tenakee Inlet, in the Hoonah area, and throughout the region between Port Frederick and Icy Strait. The upper limestone member (see below) is exposed only in the Port Frederick–Icy Strait area.

This formation consists of a lower clastic member and an upper limestone member. The clastic member is composed mainly of thin-bedded argillite with thin limestone and graywacke beds near the base and lesser amounts of graywacke and conglomerate throughout. The limestone member contains a very thick bedded limestone at the base that is overlain by thin-bedded fossiliferous limestone containing minor thin siliceous beds.

The formation is about 2,700 feet thick at the type section. The lower clastic member is thin in the eastern part of Chichagof Island but thickens to a maximum of 3,000 feet to the northwest at the expense of the underlying Kennel Creek Limestone. Conglomerate is an abundant rock type and is interbedded with dark-gray graywacke, siltstone, shale, argillite, limestone breccia, and minor amounts of dark-gray limestone. These rock types interchange laterally and vertically within short distances.

The upper limestone member is thin to medium bedded and irregularly bedded; it contains minor shaly layers. The maximum thickness of the member is about 2,500 feet; it is thinner or absent in these places where it was eroded prior to the deposition of the overlying volcanic rocks of the Freshwater Bay Formation.

The graywacke in the clastic member is dark-greenish-gray well-indurated medium- to coarse-grained arkosic lithic sandstone. Large pink grains that can be seen in hand specimen are mostly K-feldspar. In thin section, the graywacke consists of rounded to subrounded grains of plagioclase, K-feldspar, quartz, pyrite, and volcanic rock fragments embedded in a matrix composed of chlorite, epidote, muscovite, secondary albite and quartz, and iron-ore minerals. The matrix usually constitutes about 30 percent of the rock.

The conglomerate consists of clasts of volcanic rock, granite, alaskite, syenite, graywacke, quartz, chert, and limestone in a matrix of fine conglomerate or graywacke. Generally, the conglomerate is intensely brecciated and sheared. The limestone breccia consists of blocks of limestone as much as 6 feet long in a graywacke or fine conglomerate matrix.

Granitic cobbles from the conglomerates were collected at several localities for age dating. Although most of the cobbles proved unsuitable, two were not; one was analyzed by the potassium-argon method and the other by the lead-alpha method. The potassium-argon age of 247±10 m.y. (million years) obtained from hornblende in a quartz diorite boulder collected at South Passage Point has been discussed in detail by Lanphere, Loney, and Brew (1965). A lead-alpha age of 330±40 m.y.[1] was calculated for zircon from a pink coarse-grained granitic cobble collected about 5 miles east-southeast of the head of Mud Bay on northern Chichagof Island. Taking into consideration the limitations of the lead-alpha method and the probable post-emplacement history of the potassium-argon dated sample, these two dates indicate a middle Paleozoic age for the granitic debris. The presence of accompanying syenite clasts and the proximity to the syenite complex of Silurian or older age south of Tenakee Inlet suggest that the complex was the source of the granitic debris (Lanphere and others, 1965).

The Cedar Cove Formation at the type locality was considered to be of Middle and Late(?) Devonian age. This age was based on a large assortment of rugose and tabulate corals and stromatoporoids which were collected at various horizons (Loney, Condon, and Dutro, 1963, p. 22). A trilobite that was collected near the type locality by C. W. Merriam in 1961 was identified as *Dechenella?* sp. of Middle Devonian age (R. J. Ross, Jr., written commun., 1964). At Port Frederick, the limestone member contains corals in the basal and middle parts of the unit and brachiopods in the upper part. J. T. Dutro, Jr. (written commun., 1958), considers the faunas to be most closely related to the Frasnian (early Late Devonian). C. W. Merriam (oral commun., 1961) has suggested that some fossils in the lower part at Port Frederick suggest a Middle Devonian age.

South of Pinta Cove a clastic sequence of dark red and greenish-gray sandstone and argillite that underlies the upper limestone member contains a *Cyrtospirifer*-molluscan fauna of Frasnian age (Dutro, written commun., 1958). Elsewhere the major part of the clastic member is apparently stratigraphically lower in the section and is inferred to be Middle Devonian in age.

This evidence supports a revision of the age of the Cedar Cove Formation to Middle and Late Devonian. The fossil evidence indicates that the lower part of the Cedar Cove Formation is probably coeval with the Black Cap Limestone of the Glacier Bay region (Rossman, 1963b, p. 22) and possibly part of the Rendu Formation. At least parts of the Black Cap and the Cedar Cove are definitely Middle Devonian and both overlie units whose age is poorly known, but which probably are mainly Silurian. In the Chilkat Range, near Boat Harbor, there are Devonian limestones of about the same age (Lathram and others, 1959), but their correlation with the Cedar Cove Formation is uncertain. The Cedar Cove may also correlate with Devonian (Gambier Bay Formation) limestone and other strata on Admiralty Island (Lathram and others, 1960, 1965; Loney, 1961, 1964) and with limestones in the northern Kuiu-Kupreanof Islands area (Muffler, 1967).

Abrupt facies changes are present within the Cedar Cove Formation and its correlative units. In general, the amount of detrital clastic debris increases in a southwesterly direction, and the amount of carbonate strata decreases correspondingly. This evidence suggests that the Middle and Late Devonian strandline trended north-northwest and may have been only tens of miles southwest of the Freshwater Bay area. The evidence cited earlier for the local source of the granitic detritus supports this suggestion.

FRESHWATER BAY FORMATION

Rocks of the Freshwater Bay Formation (Loney, Condon, and Dutro, 1963, p. 23–32) crop out in the Freshwater Bay–Port Frederick area, and extend northwestward to Icy Strait near Flynn Cove. The formation also occurs at Corner Bay in Tenakee Inlet. The outcrop belt is widest in the vicinity of Port Frederick. Unlike the ridge-forming Kennel Creek limestone, the Freshwater Bay Formation is not especially resistant to erosion and therefore usually underlies valleys and low ridges.

The Freshwater Bay Formation consists predomi-

[1] The data for this age determination are as follows: Field No. 57ALy196a; lat. 58°9′39″ N., long. 135°49′54″ W.; α/mg-hr: 241; Pb (ppm): 33; suggested probable age range: middle Paleozoic. Analyst: T. W. Stem, U.S. Geological Survey.

nantly of andesite and basalt flows, breccia, and tuff (fig. 5), and minor amounts of interbedded conglomeratic volcanic graywacke, grayish-black argillite, and dark-gray limestone. The volcanic rocks vary widely in color, composition, and thickness. They are characterized by widespread epidotization, chloritization, and albitization.

In the immediate vicinity of its type locality at Freshwater Bay, the formation can be divided into a lower greenstone (altered basaltic) member, a middle rhyolitic member, and an upper andesitic member. North of Freshwater Bay the formation consists predominantly of massive porphyritic andesite flows with minor amounts of flow breccia. Northwest of Freshwater Bay the lower part of the formation is mostly basalt, and the upper part is mainly andesite. Clastic rocks of volcanic origin, some of which are ash flow tuffs, are interlayered with the flow rocks in the Port Frederick area. At Corner Bay, the formation is a heterogeneous accumulation of red and green porphyritic flows and tuffs, coarse volcanic conglomerate and breccia, and minor thin-bedded graywacke and shale. The formation is about 6,000 feet thick and rests unconformably on diverse older strata. It is overlain by the Iyoukeen Formation of Mississippian age; the contact is an angular unconformity.

The Freshwater Bay Formation is considered to be Late Devonian in age on the basis of fossil assemblages from interbeds of sandstone at Port Frederick. The brachiopods (including *Cyrtospirifer*), mollusks, and corals indicate a Frasnian age (J. T. Dutro, Jr., written commun., 1958).

The rocks of the Freshwater Bay Formation are similar to the basalt and andesite flows, agglomerates, and tuff of Devonian(?) age in the north-central Chilkat Range (Lathram and others, 1959, map unit 13a). They may possibly also correlate with metavolcanic rocks in the Gambier Bay Formation (Devonian) and Retreat Group (Devonian) on Admiralty Island (Lathram and others, 1960, 1965).

MISSISSIPPIAN ROCKS

IYOUKEEN FORMATION

The Iyoukeen Formation (Loney, Condon, and Dutro, 1963, p. 3237) crops out along Iyoukeen Peninsula, in Iyoukeen Cove, and in ridges extending northwestward almost to Port Frederick. The formation is the youngest one exposed in the Freshwater Bay synclirie. The dominant lithologies in the Iyoukeen Formation are limestone and shale. The limestone commonly contains abundant shell debris, and some beds are composed entirely of shell debris.

In the Freshwater Bay area, the formation is divided into three members. The lower limestone member consists of dark-gray thin- to medium-bedded limestone and sparse dark-gray chert beds. The middle member is characterized by dark-gray noncalcareous to calcareous shale which grades northwestward into dark-gray yellow-weathering shaly limestone. The upper limestone member consists mainly of dark-gray thin- to thick-bedded limestone and dark-gray nodular chert lenses (fig. 6) and is generally thicker bedded than the lower member. Gypsum occurs at the top of the upper limestone member.

FIGURE 5.—Blocky weathering, massive andesitic volcanic rocks of the Freshwater Bay Formation, Port Frederick, Chichagof Island.

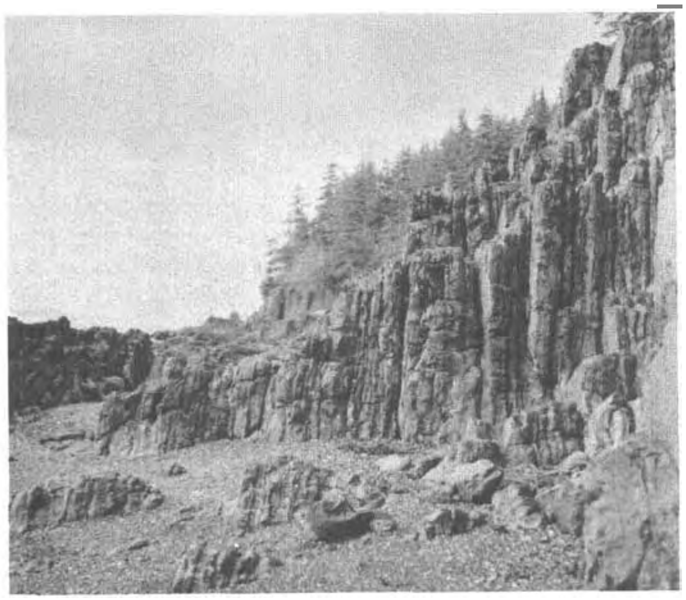


FIGURE 6.—Very thin to medium-bedded cherty limestone of the upper member of the Iyoukeen Formation, southwest side of Iyoukeen Peninsula, Chichagof Island.

The total exposed thickness cannot be measured at any one locality, but it is probably about 4,000 feet. The exposed thickness decreases to the northwest. Neither the base nor the top of the formation has been found.

The lower and middle members of the formation are of Early Mississippian age, whereas the upper member is Late Mississippian in age (Loney, Condon, and Dutro, 1963, p. 36–37). The lower member has yielded the coral *Syringopora,* spiriferoid and chonetid brachiopods, and gastropods. The middle member is characterized by the same fossils in addition to solitary rugose corals and productoid brachiopods including *Leptagonia analoga* (Phillips). Lithostrotionoid corals and large horn corals are ubiquitous in the upper member. Large gigantoproductid brachiopods, including *Striatifera,* are widely represented.

The Iyoukeen Formation correlates with the lower part of the Saginaw Bay Formation of Kuiu Island (Muffler, 1967) and with Mississippian limestones along the west side of Prince of Wales Island, which are assigned to the Peratrovich Formation (Eberlein and Churkin, 1970, p. 49).

PROBABLE PALEOZOIC METAMORPHIC ROCKS ASSOCIATED WITH THE CHICHAGOF PLUTONIC COMPLEX

DISTRIBUTION AND CORRELATION

Metamorphic rocks associated with the Chichagof plutonic complex comprise the. interbedded hornfels, granofels, marble, schist and amphibolite that occur in relatively small bodies in and around the predominantly plutonic rock of the complex. Most of the complex lies between the northwest-striking Peril Strait fault and the Sitkoh Bay fault (pl. 4), but the outer fringes locally extend northeast and southwest beyond the faults. In northwestern Chichagof Island, the complex bends northward and passes beneath Icy Strait in the vicinity of Idaho Inlet.

These metamorphic rocks were probably derived mainly from sedimentary and volcanic rocks of Silurian, Devonian, and possibly Mississippian age. Although fossils are lacking, the abundant thinly layered calc-silicate hornfels, calcareous granofels, and marbles were very likely metamorphosed from the calcareous middle Paleozoic rocks of northeastern Chichagof Island rather than from the rare calcareous Mesozoic rocks of western Chichagof and Baranof Island. More specifically, these rocks probably were mainly derived from the slate, graywacke, and limestone of the Point Augusta Formation. The abundant hornfels and amphibolite were possibly derived from volcanic flows and sediments of the Freshwater Bay Formation, but the intervening Kennel Creek Limestone was not recognized. Rossman's (1959, p. 149–156) marble-gneiss sequence in northwestern Chichagof Island is the continuation of the metamorphic rocks of the plutonic complex. Rossman thought this sequence was older than the Mesozoic rocks to the west of it; however, it is possible that some Mesozoic rocks are present in the complex, especially because its southwestern and western boundary in western Chichagof Island is somewhat indefinite and borders on a terrane of sedimentary and volcanic rocks of probable Mesozoic age.

METAMORPHIC FACIES

Except for the intense cataclasis and retrogressive metamorphism along the Peril Strait fault, the metamorphic rocks studied from the complex are of high metamorphic grade and contain only slight and scattered retrogressive metamorphism. No broad metamorphic zonation could be recognized. The zone of transition from nonmetamorphic or low-grade metamorphic rocks at the borders of the complex must be narrow, although the details of this transition were not obtained in the present reconnaissance work.

In general, the mineral assemblages indicate the hornblende hornfels facies of contact (low pressure) metamorphism (Turner, in Fyfe and others, 1958, p. 205–211; Hietanen, 1967). In the present study, this facies is distinguished from the amphibolite facies of regional metamorphism by the extreme sparsity of epidote, almandine, and staurolite. The cataclasites of the Peril Strait fault contain mineral assemblages indicative of the albite-epidote hornfels or greenschist facies. Elsewhere, there is only minor chloritization of mafic minerals in the high-grade rocks.

HORNFELS, AMPHIBOLITE, AND SCHIST

Hornfels are here distinguished from the foliate amphibolite and schist by a granoblastic texture that shows no noticeable preferred orientation of minerals. The hornfels layering is probably the original sedimentary bedding; in most places it ranges from 1 to 10 centimeters in thickness. Commonly the layering is defined by alternating light-gray to light-green feldspathic or diopsidic layers and dark-gray to dark-reddish-gray hornblendic or biotitic layers. In most hornfels, both hornblende and biotite are present, and there appears to be a complete gradation from biotite hornfels to hornblende hornfels. Generally the hornfels are fine grained, but their grain size is variable, and in places they grade into coarser grained granofels of the same composition.

Amphibolite and schist show a distinct planar preferred orientation of minerals and are commonly lineated as well as foliated. There is a complete gradation between hornfels and foliated rocks, and rocks showing only incipient foliation are common. The present data indicate that foliated rocks in general have the same range in mineral composition as the hornfels. However, plagioclase-hornblende rocks without biotite and commonly without quartz are much more common among the amphibolites than among the hornfels. These amphibolites are especially abundant north of Hoonah Sound, where they occur in thick rather homogeneous units that are cut in places by networks of gabbro veins and dikes.

The following chief mineral assemblages are found in the hornfels, amphibolite, and schist; minerals are listed in order of decreasing abundance:

quartz-andesine-biotite-hornblende
andesine-hornblende-biotite
andesine-hornblende
quartz-andesine-hornblende-diopside
quartz-oligoclase (or andesine)-biotite

The hornblende is mostly bluish green (Z), but green (Z) hornblende is also present. The biotite is brownish red (Z). Actinolite occurs in hornfels at a few places. Common accessory minerals are sphene, apatite, and magnetite or ilmenite.

QUARTZO-FELDSPATHIC GRANOFELS AND SCHIST

Quartzo-feldspathic granofels and schist are conspicuous but only locally abundant. They are medium to coarse grained and generally contain more than 75 percent quartz and feldspar. Some of these granofels show granoblastic textures, but most quartzo-feldspathic granofels and schists show variously modified igneous textures. The schist commonly has lenses of relict igneous rock in a granulated, porphyroblastic, foliated groundmass. The foliation is defined by the planar preferred orientation of biotite and minor muscovite.

The abundance of relict granitic minerals in these rocks made identification of new-formed metamorphic mineral phases often uncertain. In general, obvious metamorphic mineral phases in most rocks are quartz, microcline, oligoclase-andesine, brownish-red (Z) biotite, and minor muscovite. Obvious relict igneous minerals are quartz, oligoclase, and microcline. It is often difficult to distinguish metamorphic and relict microcline. Almandine garnet is a very minor constituent in some quartzo-feldspathic schists, but whether it is igneous or metamorphic is uncertain. Apatite and magnetite-ilmenite are common accessory minerals.

CALCAREOUS GRANOFELS AND MARBLE

Most of the calcareous granofels occur in thick calcareous sections that grade into marble. Thin layers of calcareous granofels occur in the layered hornfels sections; these granofels grade into calc-silicate granofels and hornfels. In general, the calcareous granofels are light-gray to greenish-gray medium-grained rocks in which layering ranges from 1 to 15 cm in thickness. The marbles are dark gray to white and fine to medium grained; the layering ranges from less than 1 cm to several meters in thickness; the marbles characteristically weather medium gray.

Generally the calcareous granofels have granoblastic textures and are coarser grained counterparts of the calc-silicate hornfels. Tactites are an exception to this texture, and are composed of a complex of poikiloblastic calc-silicate minerals and mosaic calcite. The marbles commonly consist of an interlocking mosaic of anhedral calcite crystals, through which are scattered calc-silicate minerals, either in clusters or singly. The calcite crystals tend to be equant and to contain well-developed deformation lamellae, some of which are lenticular. In places, the calcite is clouded with fine carbon particles, which tend to be concentrated in layers that are probably bedding.

The following mineral assemblages were found in the calcareous granofels and marble:

calcite-diopside
calcite-diopside-grossularite-wollastonite (tactite)
calcite-serpentine-brucite-spinel-scapolite
calcite-cummingtonite

The unmistakably orthorhombic forms of the serpentine-brucite masses, which average about 5 mm long, indicate that the original mineral was probably either forsterite or enstatite. The presence of brucite strongly suggests forsterite rather than enstatite (Page, 1967), and the following reaction, after Turner (in Fyfe and others, 1958, p. 209), is probable:

$$\underset{\text{forsterite}}{2Mg_2SiO_4} + H_2O \rightarrow \underset{\text{serpentine}}{H_4Mg_3Si_2O_9} + \underset{\text{brucite}}{Mg(OH)_2}$$

CATACLASITES

Although retrogressive metamorphism is shown in widely scattered places throughout the Chichagof plutonic complex by minor chloritization of mafic minerals, the only important area of intensive retrogression occurs along the Peril Strait fault. There granitic and high-grade metamorphic rocks of the complex have been subjected to intense cataclasis that produced phyllonitic low-grade rocks of the albite-epidote or greenschist facies. The following mineral assemblages and rock types occur in the cataclasites:

quartz-albite-chlorite-calcite greenschist
quartz-albite-muscovite phyllite

PALEOZOIC OR MESOZOIC ROCKS

AMPHIBOLITE, GNEISS, SCHIST, AND MARBLE

High-grade metamorphic rocks of uncertain age crop out in an irregular belt extending from Lisianski Inlet south-southeast across Chichagof and Baranof Islands to the vicinity of Fish Bay (pl. 1). Where well exposed along the west arm of Peril Strait, these rocks consist of intensely folded amphibolite, schist, and minor marble. The outcrops scattered along Hoonah Sound are mainly cataclastic schist and hornfels. The part of Rossman's (1959, p. 149–155) marble sequence that extends from Lisianski Inlet southeast along the northeast side of Stag Bay is here included in the belt of high-grade metamorphic rocks.

The correlation of these high-grade metamorphic rocks is uncertain. They may represent metamorphosed probable Paleozoic rocks (as in the Chichagof plutonic complex) or metamorphosed Kelp Bay Group rocks. In the area around the west arm of Peril Strait, the high-grade metamorphic rocks lie between Jurassic to Tertiary plutonic rocks on the west and low-grade metamorphic rocks of the Kelp Bay Group on the east. This relationship suggests that the high-grade metamorphic rocks were derived through metamorphism of the Kelp Bay Group by the plutons. This conclusion is supported by the similar bulk composition of the Kelp Bay Group (greenschist, greenstone, phyllite, graywacke, and marble) and the Peril Strait high-grade metamorphic rocks (amphibolite, quartzo-feldspathic schist, biotite schist, and marble). On the other hand, zonation is apparently lacking in the high-grade metamorphic terrain, and no gradation is observed between the low-grade fine-grained rocks of the Kelp Bay Group and the high-grade coarser grained Peril Strait rocks. The contact, where exposed along the northeast arm of Peril Strait, is a fault; but contact relations elsewhere are uncertain. Because of scattered exposures, a transition zone of as much as one-third mile might be undetected.

AMPHIBOLITE AND SCHIST

Along Peril Strait, the dominant metamorphic rocks are hornblende-bearing and range from andesine-hornblende amphibolite to quartz-andesine-hornblende-biotite schist. Next most abundant are hornblende-free, quartzo-feldspathic biotite-schists; pelitic mica schists were not found. The amount of quartz and feldspar in these rocks varies markedly from layer to layer, giving them a strikingly banded appearance in which light quartzo-feldspathic layers (generally 0.5–10 cm thick) alternate with dark mafic layers. The rocks show a pronounced foliation that is defined by the planar preferred orientation of micaceous and prismatic minerals. Lineation, mostly in the form of mineral elongation, is generally present but not conspicuous.

The most abundant rock is a schist that contains hornblende, biotite, and commonly pink almandine garnet. Almandine was not found in the less abundant biotite-free amphibolites. The chief mineral assemblages are as follows:

quartz-andesine-biotite-hornblende
andesine-hornblende
quartz-oligoclase-biotite-hornblende-almandine
quartz-oligoclase-biotite-almandine

Biotite generally occurs as ragged, elongate flakes that are pleochroic as follows: X=pale yellow, Y and Z=reddish brown. Hornblende occurs most commonly as elongate poikiloblastic subhedral prisms that show the following pleochroism: X=pale yellow, Y=olive, Z=blue green. Quartz and plagioclase are generally equant anhedra in mosaics that occur in layers and lenses parallel to the foliation. Common accessory minerals are apatite, pyrite, and sphene. Epidote occurs only in a few rocks that show signs of alteration, chiefly seritization of plagioclase. These altered rocks also contain cataclastic textures.

MARBLE AND CALC-SILICATE GRANOFELS

Thin units (generally less than a few meters thick) of marble and calc-silicate granofels crop out at a few places on the west side of Peril Strait. The thickest section is located at the mouth of Deep Bay. The marble is white, medium grained, and equigranular; it is generally almost pure calcite. In the single thin section examined, the following assemblage was identified:

calcite-brucite-plagioclase

The granofels is a medium- to coarse-grained equigranular rock that occurs mostly in 1–10 cm layers. Thicker masses of very coarse grained calc-silicate rock, probably a tactite deposit, crop out at the mouth of Deep Bay. The granofels has a granoblastic texture with a slight tendency for elongation parallel to the foliation. The following mineral assemblages were found:

bytownite-diopside-clinozoisite (granofels)
quartz-calcite-diopside-grossularite (tactite deposit)

Calcite, pyrite, and sphene are accessory minerals in the calc-silicate granofels.

METAMORPHIC FACIES

These high-grade metamorphic rocks seem best assigned to a facies transitional between the hornblende hornfels and amphibolite facies. The presence of amphibolite composed of hornblende and plagioclase that is more calcic than albite is characteristic of both facies. The restriction of epidote to calc-silicate rocks and to retrograded rocks suggests the hornblende hornfels facies (Turner, 1968, p. 223). The widespread occurrence of almandine, however, suggests the amphibolite facies, but its presence may not be diagnostic, for Turner (1968, p. 223) indicates that almandine may be more an index of rock composition (high FeO/MgO) than of pressure.

CHERT, LIMESTONE, SANDSTONE, AND GREENSTONE

Slightly metamorphosed sedimentary and igneous rocks of uncertain age occur at the base of the western Chichagof Mesozoic section in two localities. The first locality is a 16-mile-long belt extending more or less continuously from just south of Stag Bay southeastward to the Black River, and the second locality is a 6-mile-long belt southwest of Ushk Bay (pl. 1). To the southwest the unit is bordered in places by the Goon Dip Greenstone (Triassic?); to the northeast it is everywhere in contact with igneous rocks.

The northwestern half of the first belt consists of highly folded slightly metamorphosed sedimentary rocks that Rossman (1959) included in his marble-gneiss sequence. He considered these rocks to unconformably underlie his greenstone unit (here referred to the Goon Dip Greenstone) because of their greater deformation and the irregularity of the contact. Rossman divided these rocks into three lithologic subunits: an upper unit of thin-bedded chert interbedded with black shale, a middle unit of thin-bedded limestone, and a lower sandstone and siltstone unit. The upper unit is 20–500 feet thick and consists of slightly metamorphosed thin-bedded chert in the upper part and thin-bedded chert and interbedded graphitic shale in the lower part. The middle unit is about 700 feet thick and consists of white, gray, or tan thin-bedded limestone interlayered with thin siliceous beds. Some graphitic shale occurs in the upper part, and unidentifiable fossil fragments were found in the limestone. The lower unit is 500–1,000 feet thick, is conformable with the middle unit, and consists of thick to very thick bedded yellowish- to dark-brown sandstone and siltstone. Some greenstone bodies occur stratigraphically below the lower unit but are enclosed entirely within igneous rock.

Reed and Coats (1941) described the southeastern end of the first belt as the lower part of their "greenstone-schist" unit. This lower part is extensively intruded by igneous rock but appears to consist mostly of diabase and gabbro sills interlayered with light-colored schistose and granulose metavolcanic and metasedimentary rocks. The original rocks are interpreted to have been basalts, calcareous sandstones, and sandy limestones. In general, the rocks are more metamorphosed than in the area studied by Rossman. Reed and Coats believed that this unit was conformable beneath the upper part of their "greenstone-schist" unit (here referred to the Goon Dip Greenstone) but pointed out that the relations were obscured by the abundant igneous bodies.

The second belt of the chert, limestone, sandstone, and greenstone unit was originally mapped as part of a Mesozoic amphibolite and schist unit by Loney, Berg, Pomeroy, and Brew (1963). The present mapping suggests that these rocks were originally continuous with those of the first belt but have been interrupted by subsequent intrusions. The rocks of the second belt resemble those described by Reed and Coats (1941) from the southeast end of the first belt and occupy the same relation to the Goon Dip Greenstone.

The rocks are dominantly red-weathering greenstone with prominent zones of folded white-weathering metachert and minor siliceous graywacke, siltstone, and cherty argillite layers. The metachert zones consist of very thin bedded "ribbon" chert 10–50 feet thick. The fine- to medium-grained greenstones are massive, are dark greenish gray on fresh surfaces, and contain relict amygdules that are now quartz. No calcareous strata occur in the unit here, but marble surrounded by granitic rock just east of the north end of this southern belt may represent carbonates originally interlayered with the greenstone and chert.

There is no evidence of an unconformity between the rocks of this southern locality and the Good Dip Greenstone to the west. To the east the unit is in contact with hornblende-rich tonalites of inferred Jurassic age.

No determinable fossils have been found in the chert, limestone, sandstone, and greenstone unit, and its age cannot be established by other available evidence. Rossman (1959) considered the rocks to be the youngest in his marble-gneiss sequence of Paleozoic age on the basis of their unconformable position below his "greenstone unit" of Triassic(?) age. Rossman tentatively correlated some marble units elsewhere and apparently lower in the marble-gneiss sequence with limestone north of Tenakee Inlet which is now considered to be Devonian and (or) Silurian in age (see section on "Kennel Creek Limestone"). Reed and Coats (1941) considered their "greenstone-schist" unit, of which these rocks constitute the lower part, to be pre-Triassic(?) in age, but they thought that the upper part might be Triassic. Loney, Berg, Pomeroy, and Brew (1963) mapped the unit as Mesozoic in age, because they included it with other rocks interpreted to be the metamorphic equivalents of the Mesozoic section.

The chert, limestone, sandstone, and greenstone unit south of Lisianski Inlet is here considered to be of Paleozoic or Mesozoic age. The unit's relation to the structurally overlying Goon Dip Greenstone of Triassic(?) age suggests an early Mesozoic or older age. The unconformity between these units that is described by Rossman favors a pre-Mesozoic age. If the unit is Paleozoic in age, the rocks are not like the middle Paleozoic rocks elsewhere on Chichagof Island but resemble some of the Permian rocks of Admiralty and Kuiu Islands (Loney, 1964; Muffler, 1967).

TRIASSIC AND (OR) JURASSIC ROCKS

KELP BAY GROUP

The Kelp Bay Group is here redefined to include the Goon Dip Greenstone, Whitestripe Marble, Pinnacle Peak Phyllite, Waterfall Greenstone, Khaz Formation, the schist unit of Reed and Coats (1941) on western Chichagof Island; the Khaz Formation, and three unnamed units: a phyllite unit, a greenschist and greenstone unit, and a graywacke semischist unit on Baranof Island. In parts of Baranof Island, the group is not subdivided. Also mapped on Baranof Island are two unnamed higher grade contact metamorphic units that are adjacent to Tertiary plutons: a biotite schist and gneiss unit, and an amphibolite and greenschist unit (see section on "Contact Metamorphism around Tertiary Plutons").

The name Kelp Bay Group was originally proposed by Berg and Hinckley (1963, p. 10) for a bedded unit known from shoreline exposures on northern Baranof Island. Loney, Berg, Pomeroy, and Brew (1963, p. 4) used the name in a restricted sense for rock here referred to as the Khaz Formation.

The redefinition of the Kelp Bay Group in this report is necessitated by new field data that indicate that the usage proposed by Loney, Berg, Pomeroy, and Brew (1963), if extended to cover all the interior of northern Baranof Island, would exclude Berg and Hinckley's type area from the group. In addition, correlations based on the completed mapping show that Berg and Hinckley's original Kelp Bay Group includes the lateral equivalents of the Goon Dip Greenstone, Pinnacle Peak Phyllite, and Waterfall Greenstone. For these reasons, the group is redefined to include almost all of Berg and Hinckley's original unit and the correlative units on Chichagof Island. A new name, Khaz Formation, is proposed for the unit called Kelp Bay Group by Loney, Berg, Pomeroy, and Brew (1963) (fig. 2).

The Katlian Group of Loney, Berg, Pomeroy, and Brew (1963) is here abandoned because completed studies show that, although a mappable unit, it consists if intensely deformed cataclastic rocks. derived from phyllite, greenschist, and metachert that are correctly referred to the Kelp Bay Group. Tectonic lenses composed of these rock types, clearly recognizable in the field as typical of the Kelp Bay Group, occur thoughout the cataclasites.

The Nakwasina Group of Berg and Hinckley (1963, p. 6) was incorporated unchanged in the preliminary map of Loney, Berg, Pomeroy and Brew (1963), even though its equivalence to the Katlian Group and Kelp Bay Group (usage of Loney, Berg, Pomeroy, and Brew, 1963) was already recognized. Subsequent study has confirmed this correlation, and Loney, Pomeroy, Brew, and Muffler (1964) discarded the name Nakwasina Group and applied the terminology used for the equivalent rocks. The name Nakwasina Group is synonymous with the term Kelp Bay Group (as herein defined) and therefore is here abandoned.

On the basis of very scanty fossil evidence, the Kelp Bay Group is considered to be of Triassic and (or) Jurassic age. Fossils of doubtful Triassic age were found by Reed and Coats (1941, p. 24, 29–30) in a boulder that may have come from the Whitestripe Marble (see section on "Whitestripe Marble"). A coral of Triassic or Jurassic age was found near the top of the Khaz Formation (see section on "Khaz Formation"). The Goon Dip Greenstone, the Waterfall Greenstone, and the Pinnacle Peak Phyllite are apparently unfossiliferous; likewise, no fossils were found in any of the units of the Kelp Bay Group on Baranof Island.

Throughout most of their extent, the rocks of the Kelp Bay Group have undergone low-grade metamorphism. The dominant phyllite, graywacke (commonly semischist), metachert, greenstone, and greenschist generally contain the following metamorphic mineral assemblages: albite-chlorite-epidote, quartz-albite-chlorite-muscovite, and albite-epidote-actinolite-chlorite. Prehnite occurs commonly as vein fillings in graywacke and greenstone south of Gut Bay in eastern Baranof Island and in western Chichagof Island. In the latter area, fine pumpellyite crystals were found on plagioclase clasts in graywacke. These assemblages indicate a regional metamorphism that probably ranged from the prehnite-pumpellyite-metagraywacke to lower greenschist facies (Turner, 1968, p. 266–270). Locally, especially near Tertiary plutons, these assemblages are replaced by higher grade ones that contain biotite and hornblende (see section on "Contact Metamorphism around Tertiary Plutons").

GOON DIP GREENSTONE

The Goon Dip Greenstone crops out in an essentially continuous belt more than 30 miles long on western Chichagof Island between Kakul Narrows at the southwest tip of the island and the Lake Elfendahl area to the north. The formation also crops out on Yakobi Island and on the Inian Peninsula.

The name was proposed for a metamorphic sequence of greenstone, greenschist, and minor marble several thousand feet in thickness (Loney, Berg, Pomeroy, and Brew, 1963). Before metamorphism the sequence probably consisted mostly of basaltic flows, mafic sills, and perhaps some tuffs. The type section is in the upper valley of the Goon Dip River east of Portlock Harbor.

The formation is equivalent to the "greenstone unit" of Rossman (1959, p. 157–161) on northwestern Chichagof Island and is also largely equivalent to both the "greenstone-schist" and "greenstone" units mapped by Reed and Coats (1941, p. 14–22) in the Chichagof mining district. We were not able to differentiate these two units southeast of the area mapped by Reed and Coats.

Intrusive rocks obscure the lower contact relationships of the Goon Dip Greenstone. The relations of the formation with the chert, limestone, sandstone, and greenstone unit of Paleozoic or Mesozoic age have been described previously. At the type locality the formation is overlain by the Whitestripe Marble, but to the southeast it is largely overlain by the Pinnacle Peak Phyllite. On Yakobi Island, the Goon Dip Greenstone is overlain by the "schist" unit of Reed and Coats (1941) and Rossman (1959). In general, the Goon Dip Greenstone and the overlying formations appear to be structurally concordant; however, intense folding, faulting, and the absence of marker beds make the exact nature of the upper contact problematical.

The predominant greenstone in general is massive rather than schistose. Layering is difficult to discern in most localities. The rock is generally dark green, but weathered surfaces are usually a lighter shade of green or gray. The greenstone consists of altered, commonly amygdaloidal, basaltic flows and sills. A basaltic origin is confirmed by rare relict labradorite and augite crystals. Lesser amounts of volcanic breccia, greenschist, and minor limestone are interbedded with the flows. Rossman (1959, p. 159–161) states that most of the greenstone unit between Idaho Inlet and Port Althorp Bay is a massive or banded amphibolite.

Epidote and actinolite are the dominant minerals in most of the greenstone specimens studied petrographically. The original minerals of the greenstones have largely been replaced by albite, epidote, chlorite, actinolite, prehnite, calcite, pyrite, and sphene. The amygdules commonly are composed of quartz, prehnite, epidote, and minor amounts of copper-bearing sulphides. The copper-bearing sulphides are most common in the upper part of the unit. Rossman (1959, p. 159) reports amygdules composed of quartz and epidote as large as 1 inch in diameter.

Fissile albite-chlorite-epidote greenschist is common in the area south and east of Ford Arm. One thin section of a greenschist contained the following: epidote (40 percent), actinolite (30 percent), chlorite (20 percent), and plagioclase, quartz, and iron oxide (10 percent). In some of the massive-appearing "greenstones" a foliation is discernible, so that these "greenstones" are technically greenschists.

Reed and Coats (1941, p. 19, 22) assigned a Triassic(?) age to their "greenstone" unit because of its assumed conformity with the overlying "limestone and marble" and "schist" units of Triassic(?) age. A "pre-Triassic(?)" age was given to the underlying "greenstone schist" unit. Rossman (1959, p. 157) assigned a Triassic(?) age to his "greenstone" unit, which includes both the "greenstone" and "greenstone schist" units of Reed and Coats (1941).

The Goon Dip Greenstone was considered to be Permian(?) and Triassic(?) in age by Loney, Berg, Pomeroy, and Brew (1963). Fossil evidence is entirely lacking. Loney, Berg, Pomeroy, and Brew (1963) followed Reed and Coats' usage but suggested that the "pre-Triassic(?)" designation might be modified to "Permian(?)". Subsequent review of the available information concerning rocks of established Permian and Triassic age elsewhere in northern southeast Alaska indicates that volcanic rocks are abundant in the Triassic but relatively rare in the Permian; therefore, the tentative lithogenetic correlation of the dominantly volcanic Goon Dip Greenstone with the Permian is unwarranted. For this reason the Goon Dip Greenstone is now considered to be of Triassic(?) age.

WHITESTRIPE MARBLE

The Whitestripe Marble crops out continuously for about 18 miles on Chichagof Island from Lake Morris southward to the Rust Lake area where it is abruptly terminated by a fault. Southeast of Rust Lake the formation is represented by a few scattered thin lenses of marble. North of Lisianski Inlet on Inian Peninsula, the formation occurs as a narrow band of marble. Small bodies of Whitestripe Marble also crop out between Stag Bay and Lake Elfendahl.

The name Whitestripe Marble was proposed for the prominent light-gray marble along the west coast of Chichagof Island by Loney, Berg, Pomeroy, and Brew (1963). The type locality is at Whitestripe Mountain, about 4% miles east of Portlock Harbor.

Reed and Coats (1941, p. 22) mention that the unit reaches a maximum thickness of 1,500 feet in the Chichagof mining district. It averages several hundred feet in thickness elsewhere. In the southern part of its extent, it commonly is considerably less than 100 feet thick. Rossman (1959, p. 161) reports that the marble north of Lisianski Inlet has an average thickness of about 100 feet.

The marble is a white to light-gray, massive, and generally fine-grained rock composed of nearly pure calcite. It weathers to a medium-gray rugged deeply etched surface, and karst topography is developed in many places. Rossman (1959, p. 162) reports that garnet and wollastonite have developed where the marble has undergone high-grade metamorphism.

Reed and Coats (1941, p. 23) believed that the lower and upper contacts were conformable. The contact with the underlying Goon Dip Greenstone appears to be conformable, because greenstone and marble are interlayered above and below the contact. The contact with the overlying tightly folded Pinnacle Peak Phyllite is of uncertain nature and may be tectonic.

The Whitestripe marble is considered Triassic(?) in age. No fossils have been found in place. Fossils of doubtful Triassic age were collected from a large limestone boulder in the Goon Dip River (Reed and Coats, 1941, p. 24, 29–30). The boulder could have come either from this marble unit or from a marble lens in the overlying schist unit, and Reed and Coats thought the latter possibility more likely.

The Whitestripe Marble may correlate with limestone in the Late Triassic Hyde Formation of Admiralty Island (Loney, 1964), and in the Hyd Group of the Keku Straits area (Muffler, 1967), but it seems certain that the units were never physically continuous. No correlative rocks were found on Baranof Island.

PINNACLE PEAK PHYLLITE

On Chichagof Island the Pinnacle Peak Phyllite crops out in a continuous belt for about 20 miles from Pinnacle Peak southeastward to Kakul Narrows.

The name Pinnacle Peak Phyllite was proposed by Loney, Berg, Pomeroy, and Brew (1963) for the thinly laminated siliceous phyllite that crops out near the west coast of Chichagof Island. The premetamorphic rock types are interpreted to have been mostly fine grained detrital clastics with possible minor thin chert beds.

The Pinnacle Peak Phyllite is underlain by the Whitestripe Marble in the northern part of its outcrop area and is generally underlain by the Goon Dip Greenstone in the southern part. It is overlain by the Waterfall Greenstone. The phyllite is intensely folded, and the exact natures of the lower and upper contacts are not understood. Its thickness is not known.

The phyllite is generally a dark-gray fine-grained rock that contains abundant light-gray and yellowish-gray siliceous laminae; the laminae range in thickness from 1 to 25 mm. The rock is characterized by intense crenulations and abundant lineations. The phyllite displays a well-developed lustrous foliation or cleavage which, in general is approximately parallel to the siliceous laminae, but which more accurately is parallel to the axial planes of isoclinal folds in the laminae. Figure 24 illustrates this relation in similar phyllite from the Khaz Formation. Quartz and plagioclase make up about 50 percent of the rock; there are lesser amounts of muscovite, actinolite, epidote, hornblende, and carbonaceous material. The foliation is commonly defined by elongate wisps of carbonaceous dust and by the planar preferred orientation of the micaceous minerals. The lenticular siliceous laminae consist of fine mosaics of quartz and albite around which the foliation bends. The groundmass commonly contains abundant fine needles of pale actinolite and interstitial chlorite that show no preferred orientation.

No fossils have been found in the phyllite. The unit is considered to be Triassic(?) in age, based on the questionable faunal evidence discussed in the section on "Whitestripe Marble".

North of Pinnacle Peak the phyllite unit correlates with the basal part of the "schist" unit of Reed and Coats (1941, p. 24–30) and Rossman (1959, p. 163–166). The Pinnacle Peak Phyllite also correlates with the unnamed phyllite unit of the undivided Kelp Bay Group on Baranof Island.

WATERFALL GREENSTONE

The Waterfall Greenstone crops out on western Chichagof Island from Rust Lake southward to Slocum Arm in the vicinity of Cobol. The unit also is present on the Khaz peninsula.

The name Waterfall Greenstone was proposed by Loney, Berg, Pomeroy, and Brew (1963) for a sequence consisting predominantly of greenstone but also containing lesser amounts of graywacke, greenschist, radiolarian chert, and marble. Typical exposures, considered the type locality, crop out on the ridge immediately east and north of Waterfall Lake. Before metamorphism, the predominant rock type was basalt or andesite.

The Waterfall Greenstone is underlain by the intensely folded Pinnacle Peak Phyllite. The exact nature of this contact is not known, but it could be tectonic. The unit is probably transitional both upward and laterally into the Khaz Formation; it appears to wedge out to the southeast by intertonguing with the Khaz Formation near Cobol on Slocum Arm. But, considering the melange character of the Khaz Formation, this wedging-out and intertonguing may be tectonic.

The greenstone is a generally unfoliated reddish-brown weathering altered intermediate or mafic volcanic rock in which the original minerals have been largely replaced by epidote, chlorite, albite, calcite, and prehnite. Relict euhedral phenocrysts of plagioclase (An_{20-30}) and augite occur sparsely. Nontronite locally forms as much as 40 percent of the rock. Some of the greenstone is intensely brecciated and has cataclastic textures. Locally, it grades into greenschist with pronounced cataclastic foliation.

The graywacke is fine to medium grained and consists of angular to subrounded clasts of plagioclase (An_{20-30}), quartz, greenstone, and chert embedded in an abundant matrix composed largely of chlorite, prehnite, epidote, calcite, muscovite, and clay minerals. Sporadic faint and irregular foliation surfaces cut the rock at various angles, and brecciation and mylonitization have occurred along these surfaces.

The radiolarian chert is thin bedded, weathers white, and on fresh surfaces ranges from light gray to medium greenish gray. It commonly is recrystallized to very fine grained quartzite containing scattered chlorite and albite. Bands of folded thin-bedded chert, as much as 3 m thick, form distinctive outcrops.

A sizeable body of light-gray weathering marble occurs within the Waterfall Greenstone in the highlands of Khaz peninsula. Thin bodies of phyllite and volcanic rock are locally infolded with the marble.

No fossils have been collected from the unit, but it is considered Triassic(?) in age on the basis of the fossils in the limestone float collection discussed in the section on "Whitestripe Marble."

Because Waterfall Greenstone was not differentiated by previous workers in the region north of Rust Lake, it is included in and correlates with part of the "schist" unit of Reed and Coats (1941, p. 24–30) and Rossman (1959, p. 163–166). It is also tentatively correlated with parts of the unnamed greenstone and greenschist unit and the graywacke semischist unit of the undivided Kelp Bay Group on Baranof Island.

KHAZ FORMATION

The name Khaz Formation is here proposed for the chaotic terrane composed largely of greenstone, greenschist, graywacke, and phyllite that crops out on Khaz Peninsula and in the area east of Slocum Arm on Chichagof Island. Discontinuous exposures have also been mapped on Kruzof Island, on the islands north of Sitka Sound, and on Baranof Island as far south as Gut Bay.

This unit was earlier termed the Kelp Bay Group as restricted by Loney, Berg, Pomeroy, and Brew (1963), but with our futher revision of the Kelp Bay Group (see section on "Kelp Bay Group"), the unit became only the uppermost of the several formations of the group. The new name, Khaz Formation, is taken from the Khaz Peninsula, the type area. The formation is particularly well exposed across the peninsula at the latitude of the head of Slocum Arm; this part of the peninsula is designated the type locality. Other good exposures in the same area are at Cobol and at the head of Ford Arm.

The rocks we have mapped as Khaz Formation were included by Berg and Hinckley (1963) in their original Kelp Bay Group on northwestern Baranof Island. We were able to separate these rocks from the rest of the Kelp Bay Group there as well as on southwestern Chichagof, where the stratigraphic sequence of the Kelp Bay Group and related rocks is best known.

The thickness of the Khaz Formation is impossible to estimate accurately owing to its chaotic structure, but the general dip and width of outcrop suggest that it is perhaps thousands of feet thick. The chaotic intermixing of rock fragments common to the underlying units of the Kelp Bay Group is similar to the melange in the Franciscan Formation of California (Hsü, 1967). Although the origin of the melange is as yet unresolved, it is commonly thought to be of tectonic origin.

However, the relations of the Khaz Formation to the underlying and overlying formations, although uncertain because of poor exposures, do not clearly support a purely tectonic origin for it. The following relations have been observed: (1) northeast of Slocum Arm the Khaz Formation pinches out, apparently by intertonguing with the other formations of the Kelp Bay Group; (2) in the Sitka area, the Khaz Formation appears to be conformable with the overlying Sitka Graywacke; (3) at scattered places elsewhere along its extent, both the lower and upper contacts appear to be faults or at least shear zones, and (4) throughout its extent the Khaz Formation maintains its stratigraphic position between the underlying nonchaotic part of the Kelp Bay Group and the overlying Sitka Graywacke, and debris from the Sitka Graywacke has not been observed in the formation.

These features could be explained by a combination of deposition and tectonism: for example, by the deposition during Jurassic time of coarse muddy submarine landslide material along a fault scarp composed of the Kelp Bay Group, followed later by the deposition of the Sitka Graywacke. This coarse deposit would have been intensely deformed along with the rest of the pre-Tertiary rocks during the episode of regional deformation in Cretaceous time after the deposition of the Sitka Graywacke. Folding and faulting could account for the intertonguing contact where the Khaz Formation lenses out at Slocum Arm. The sheared aspect could have been further intensified during Cenozoic fault movements.

The above hypothesis cannot be proved, and no doubt many other interpretations are possible. It is presented because the field evidence, although tenuous, suggests relations that are difficult to explain by the purely tectonic origin generally implied by the term melange.

The Khaz Formation consists mainly of greenstone, greenschist, graywacke, metachert, phyllite, and minor limestone which closely resemble rock types in the Pinnacle Peak Phyllite, the Waterfall Greenstone, and possibly also the Goon Dip Greenstone and Whitestripe Marble. However, in the Khaz Formation, the rock types characteristic of these underlying formations are chaotically intermixed. Typical cataclasites consist of streaked greenschist and phyllite in which lenses of more resistant rock swim in a highly foliated mylonitic matrix. The matrix generally consists of epidote, chlorite, muscovite, sphene, calcite, and angular grains of quartz and plagioclase that grade from a few millimeters in diameter down to dark submicroscopic mylonitic

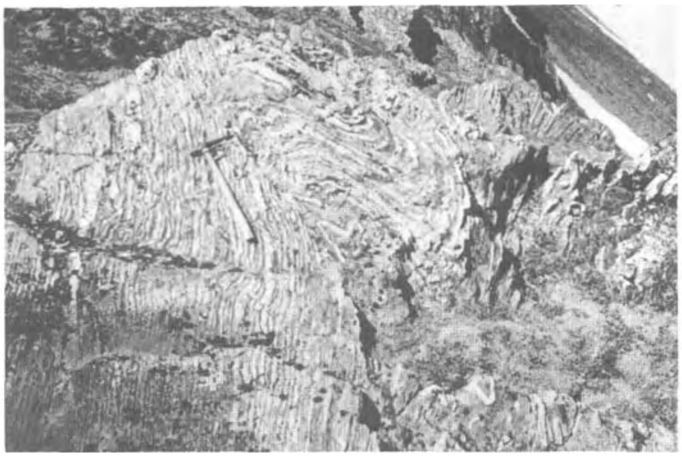


FIGURE 7.—Typical folds in metachert and phyllite of the Khaz Formation west of Indigo Lake, Baranof Island.

material. The resistant lenses are most commonly radiolarian metachert and greenstone (fig. 7).

A suite of rocks that was collected from the northeast shore of the head of Slocum Arm was examined petrographically. Among these rocks, the predominant type is an intensely foliated cataclastic phyllite (phyllonite). The foliation is defined by the preferred orientation of chlorite, muscovite, and elongate grains and mosaics of quartz and plagioclase. The last two minerals usually make up over 50 percent of the rock.

Most exposures of this unit that are mapped south of Slocum Arm, in northern Kruzof Island, and in northwestern' Baranof Island commonly are chaotically intermixed greenstone, graywacke, greenschist, metachert, and phyllite. East of Sitka the exposures of the Khaz Formation show a more regular sequence that consists of alternating layers of graywacke, phyllite, slate, and folded metachert (fig. 7). In this area, the contact between the Khaz Formation and the Sitka Graywacke appears to be gradational.

The Khaz Formation is considered to be of Triassic and (or) Jurassic age on the basis of a fragment of what appears to be a scleractinian colonial coral. The fossil was found in a thin limestone on the northeast shore of Slocum Arm in a section of predominantly graywacke, argillite, and greenstone. This locality is spatially, if not stratigraphically, near the base of the overlying Sitka Graywacke.

Helen Duncan (written commun., 1961) examined the coral and considered a Triassic age assignment the most likely based on what is known of Mesozoic corals in southeastern Alaska, but that a Jurassic age was not precluded, because Jurassic corals are known from the Cook Inlet area. It seems likely that, because of its tectonic character, the Khaz melange is younger than the age of this fossil. However, the melange is probably older than the overlying Sitka Graywacke (Late Jurassic and Early Cretaceous), because no fragments of this formation have been recognized in the melange.

The Khaz Formation is probably represented in the upper part of the "schist" unit of Reed and Coats (1941, p. 24–30) and Rossman (1959, p. 163–166). Similar mixed units have not been reported from the islands to the south and east of Chichagof and Baranof Islands.

SCHIST ON CHICHAGOF ISLAND

The schist unit of Reed and Coats (1941, p. 24–30) and of Rossman (1959, p. 163–166) extends from the southern part of the Fairweather Range south-southeastward to Sister Lake and Ford Arm on Chichagof Island. We have divided the further extension of this unit to the south into the Pinnacle Peak Phyllite, the Waterfall Greenstone, and the Khaz Formation.

The predominant rock type of the schist unit is greenstone interlayered with graphitic schist or phyllite. Massive greenstone, greenschist, phyllite, limestone, graywacke, and chert are subordinate. Generally, massive graywacke and greenstone are more abundant in the southern outcrops of the unit than in the northern. Augite and labradorite are common relict minerals in the greenstone; epidote is abundant in most specimens; pyrite, magnetite, and chalcopyrite are common locally. Lenticular beds of limestone that are similar in color and composition to the Whitestripe Marble also occur.

The thickness of the schist unit probably exceeds 9,000 feet (Rossman, 1959, p. 163), but widespread small-scale folding prevents accurate measurement. Neither Rossman nor Reed and Coats (1941) recognized any unconformity either above or below the unit, although they believed that the intense deformation might have entirely destroyed the evidence.

Reed and Coats (1941, p. 29–30) suggested a Triassic(?) age for the schist unit; this age was based on the fossiliferous limestone float of possible Triassic age (see section on "Waterfall Greenstone") that may have come from a limestone lens in the lower part of the schist unit. During the present mapping, a fragmentary coral suggestive of a Triassic or Jurassic age or both were found in limestone fragments of the Khaz Formation spatially near the contact with the overlying Sitka Graywacke (see section on "Khaz Formation"). These fossiliferous limestone fragments of the Khaz Formation, which were probably derived from the nearby Waterfall Greenstone, probably correlate with the uppermost part of the schist unit. We therefore regard the age of the schist unit to be Triassic or Jurassic or both.

UNNAMED UNITS ON BARANOF ISLAND

Except for the Khaz Formation, the Kelp Bay Group on Baranof Island is not formally subdivided. Three unnamed units have been mapped: a phyllite unit, a greenschist and greenstone unit, and a graywacke semischist unit. Although these units lithologically resemble the named formations of the Kelp Bay Group in western Chichagof Island, intensive folding and shearing has produced a structural complexity in which units are notably broken and lenticular, and in which stratigraphic relations are uncertain. These units grade into one another and have indefinite contacts that are rather arbitrarily shown on the map (pl. 1).

Phyllite

The phyllite unit is predominantly dark-gray phyllite and light-gray thinly laminated fine-grained quartzite that closely resembles the Pinnacle Peak Phyllite. Minor greenschist, greenstone, graywacke semischist, and white-weathering radiolarian metachert are interlayered with the phyllite (fig. 8). The phyllite commonly has abundant siliceous laminae, numerous small folds, lineations, and ac joints (fig. 9). The proportion of phyllite to the other lithologies appears to increase to the south. The phyllite consists mainly of quartz, albite, muscovite, and chlorite. The muscovite and chlorite have a marked orientation, and they define a well-developed lustrous phyllitic foliation or cleavage. Petrographically, the phyllite contains abundant small augen of very fine grained quartzite that apparently have been derived largely from chert. The augen are enclosed in a dark-gray foliated mylonitic matrix composed of newly formed albite, muscovite, chlorite, epidote, prehnite, and angular relict grains of quartz and plagioclase that grade down to submicroscopic mylonitic dust.

FIGURE 8.—Recumbent isoclinal folds in metachert of the unnamed phyllite unit, Kelp Bay Group, on ridge west of the Glacial River, Baranof Island; field of view about 30 ft. across.

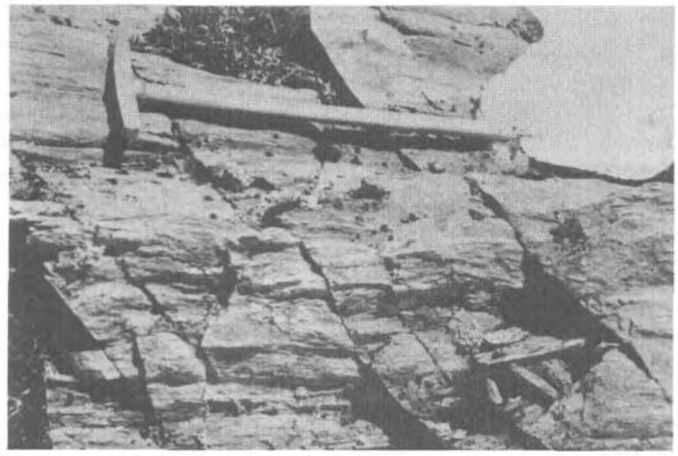


FIGURE 9.—Rodded phyllite outcrop, unnamed phyllite unit in Kelp Bay Group, near Red Bluff Bay, showing well developed *ac* joints and pronounced rodding.

Greenschist and Greenstone

The dominant rock types in the greenschist and greenstone unit represent metamorphosed basaltic flows and tuff. Interlayered with these rocks are minor dark-gray phyllite, graywacke semischist, and white-weathering radiolarian metachert. The unit is similar both to the Goon Dip Greenstone and to the Waterfall Greenstone of Chichagof Island.

Where exposed in a continuous belt from the head of Nakwasina Sound to the mouth of Rodman Bay, the unit is a thinly laminated siliceous greenschist locally interlayered with minor phyllite. The two smaller northwest-trending areas lying just east of the major belt are similar in lithology. Along Peril Strait, the unit contains significant amounts of thick-bedded greenstone. These greenstones are locally interlayered with chert beds less than 200 feet thick (Berg and Hinckley, 1963, p. 10). Similar greenstones with chert beds have also been recognized in the melange northwest of Sitka, but those particular beds are here mapped as part of the Khaz Formation.

Elsewhere on northern Baranof Island, the unit appears to be made up of nearly equal amounts of greenschist and thick-bedded greenstone that in places are interlayered with minor phyllite, metachert, and graywacke semischist.

The greenschist differs from the phyllite only in containing a greater proportion of chlorite relative to muscovite. Like the phyllite, the greenschist has a foliated mylonitic matrix composed of newly formed albite, muscovite, chlorite, epidote, prehnite, and angular relict grains of quartz and plagioclase. The matrix bends around abundant small augen of very fine grained quartzite (metachert).

On southern Baranof Island near Patterson Bay, massive-appearing dark-green- or brown-weathering greenstone is the predominant rock type; relict pillows are discernible in some outcrops. These slightly metamorphosed andesite and basalt flows are rarely foliated. Generally, the rocks display sparse mafic phenocrysts in a fine-grained intergranular groundmass of hornblende or augite and plagioclase. Most of the specimens studied are composed mainly of augite and albite. Hornblende or actinolite, epidote, chlorite, prehnite, and pyrite are less abundant components.

South of Red Bluff Bay, native copper has been reported from amphibolite derived from this unit (P. W. Guild, written commun., 1964). For information about this metamorphic unit, see the section on "Contact Metamorphism around Tertiary Plutons".

GRAYWACKE SEMISCHIST

The graywacke semischist unit consists of predominantly medium-gray thin- to medium-bedded fine- to medium-grained graywacke semischist interbedded with minor dark-gray phyllite and slate, greenschist, and white-weathering radiolarian metachert. Phyllite is more commonly associated with the graywacke semischist than are the other lithologies, and in places the semischist can be seen to grade texturally into phyllite. Locally, graded bedding is discernible in the metagraywacke.

The original graywacke contained subangular grains of quartz, plagioclase, volcanic rock, and low-grade metamorphic rock; in addition it contained about 20 percent matrix. These original components have been affected by low-grade metamorphism and deformation, during which a pronounced, commonly cataclastic foliation was superposed on the clastic textures and structures. Important metamorphic mineral assemblages are quartz-albite-epidote-actinolite-chlorite and quartz-albite-chlorite. In addition, prehnite occurs locally, mainly in veins.

KELP BAY GROUP UNDIVIDED

Two belts of rock on Baranof Island are mapped as undivided Kelp Bay Group. The larger belt extends northwest from central Baranof Island to Kakul Narrows. The smaller belt extends northwest from Kelp Bay to the head of Saook Bay. In both outcrop belts, the rock types are similar to those of the unnamed phyllite, greenstone and greenschist, and graywacke semischist units.

In the northeastern part of Baranof Island, the undivided Kelp Bay Group consists mainly of phyllite with siliceous laminae, greenschist, greenstone, and graywacke semischist. The sequence on the northeast side of Portage Arm (southwest side of Catherine Island) has been intensely sheared.

In northwestern Baranof Island virtually the entire unit has been changed to cataclasite by shearing and crushing. An intense, pervasive foliation has disrupted bedding and preexisting foliation and has precluded any lithologic subdivision. Local lenses of relatively undeformed Kelp Bay type rocks occur within the cataclasite. The undivided Kelp Bay Group in this part of Baranof Island is composed predominantly of intensely foliated fine-grained cataclastic phyllite, greenschist, and graywacke semischist through which are scattered sheared lenses of thinly interbedded white-weathering radiolarian metachert (fig. 10) and reddish-brown-weathering greenstone. Lenses of massive reddish-brown-weathering greenstone are common. A few serpentinite lenses are also present. Phyllite and metachert are considerably more abundant than any other lithology east and northeast of Sitka. In the Nakwasina Sound area, however, the phyllite is subordinate to metachert, volcanic breccia, and greenstone;

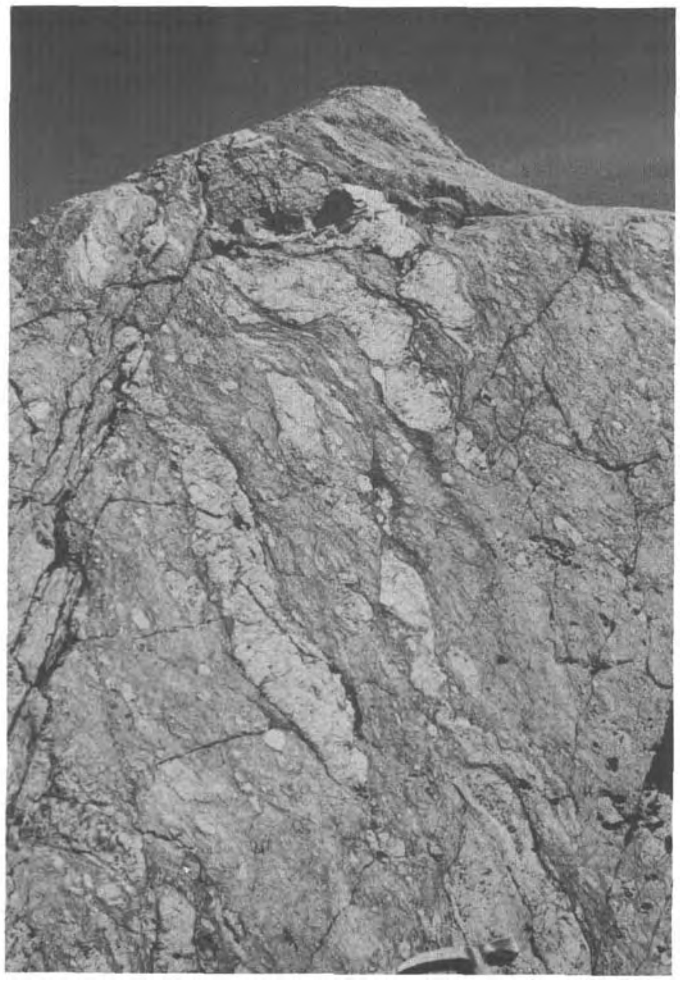


FIGURE 10.—Cataclasite developed from sheared metachert and phyllite of the undivided Kelp Bay Group, north of Blue Lake, Baranof Island.

here marble and hornfels occur locally. North of Nakwasina Sound, phyllite, greenschist, and greenstone are equally abundant.

JURASSIC AND CRETACEOUS ROCKS

SITKA GRAYWACKE

The Sitka Graywacke was named for the exposures near Sitka on the west coast of Baranof Island (Berg and Hinckley, 1963, p. 12). The formation and its metamorphosed equivalents crop out all along the west coasts of Yakobi, Chichagof, Kruzof, and Baranof Islands. The Sitka Graywacke has also been mapped locally in the Hoonah Sound area. The metamorphosed equivalents of the unit have been mapped separately and are discussed in the section on "Contact Metamorphism Around Tertiary Plutons."

Both Reed and Coats (1941, p. 33–35) and Rossman 1959, p. 167) recognized the Sitka Graywacke as a distinct unit but did not name it formally. Berg and Hinckley (1963, p. 12–14) did not consider graywacke to be dominant over argillite in the unit and therefore proposed the name Sitka Group. For the area as a whole, however, the name Sitka Graywacke seems more appropriate (Loney, Berg, Pomeroy, and Brew, 1963), particularly since the unit has not yet been subdivided.

Contact relations between the Sitka Graywacke and the older Khaz Formation have already been discussed (see section on the "Khaz Formation"). No lithologic nor structural break is apparent between the two units. Steeply-dipping graywacke and argillite of the Sitka Graywacke is unconformably overlain by horizontal to subhorizontal basaltic flows and volcanic ash (Edgecumbe Volcanics) of Quaternary age on southern Kruzof Island. Near the mouth of Sawmill Creek and elsewhere near Sitka, the graywacke is also overlain unconformably by volcanic ash.

Two lithic types are about equally common in the Sitka Graywacke. These are: very thick bedded, massive-appearing fine- to coarse-grained light- to medium-gray graywacke with few, if any, argillite partings and no visible sedimentary structures; and very thin to medium-bedded alternating and intergrading units of argillite and fine- to medium-grained graywacke. This latter type has graded beds, minor fine-scale crossbedding, local penecontemporaneous slump features, and rare sole markings. The dark-gray finer grained layers contrast strongly with the lighter colored (light to medium gray) coarser layers. The rocks are classified as turbidites. In many areas, a superposed cataclastic foliation has made the rocks semischistose, but the original rock type is readily discerned.

Less common rock types include dark-gray argillite with rare laminae and very thin beds of graywacke, and minor conglomerate and breccia. Some of the conglomerates contain cobbles and pebbles of silicic volcanic rock, silicic plutonic rock, chert and quartzite. Greenschist, slate, limestone, greenstone, and chert are locally present in small amounts. The interbedded volcanics are abundant only in the area studied by Reed and Coats (1941, pl. 3, p. 34) but are also present in significant amounts on the east side of Baranof Island south of Patterson Bay.

Texturally, the graywackes are poorly sorted fine- to coarse-grained sandstones. The median grain size of most specimens is around 0.35 mm. Most of the poor sorting results from the amount of silt- and clay-size matrix material present (10-20 percent), although the greater-than-silt-size material itself is not well sorted. Most of the matrix has been neocrystallized to quartz, muscovite, albite, chlorite, epidote, sphene, calcite, and locally tourmaline and prehnite. The prehnite occurs as veinlets and irregular masses and is most widespread south of Sitka Sound (pl. 1). Some of this matrix may have developed from the coarser fraction as described by Hawkins and Whetten (1969). In general, mineral assemblages indicate low-grade metamorphism of the prehnite-pumpellyite-metagraywacke facies (Turner, 1968); in places this facies grades into the low greenschist facies.

The clasts in the graywacke were probably derived from a terrane composed dominantly of sedimentary or low-grade metamorphic rocks, but which also contained a significant amount of volcanic rocks. Compositionally, the graywackes are, in order of decreasing abundance, feldspathic, lithic, and arkosic (Gilbert, in Williams, Turner, and Gilbert, 1954). They typically contain 10–30 percent quartz (both strained and unstrained), 3–8 percent potassium feldspar (orthoclase and minor microcline), 5–30 percent plagioclase (oligoclase to andesine), 30–60 percent lithic fragments, and minor amounts of myrmekite, biotite, muscovite, apatite, augite, hypersthene, zircon, garnet, and hornblende. The lithic fragments are dominantly slate, phyllite, argillite, and volcanic rock (from mafic to silicic), along with minor amounts of chert and quartzite.

The interbedded shale or argillite beds are compositionally similar to the graywacke matrix material. Becker (1898, p. 44–45) published a chemical analysis of a graywacke specimen collected at nearby Sitka. Becker was puzzled by the textures of the specimen and classified it as a "pyroclastic diorite." The analysis is reproduced in table 1 together with three new analyses.

Where bedding and cleavage, small folds, and tops of beds are clearly recognized, these features are interpreted as indicating that the Sitka Graywacke is tightly and complexly folded (figs. 11 and 12). Structural attitudes are generally unobtainable from the very thick bedded massive-appearing graywacke. Joints are

TABLE 1.--Chemical and semiquantitative spectrographic analyses of the Sitka Graywacke from *Baranof Island*

[Symbols used are: M = major constituent (greater than 10 percent); 0 = looked for but not detected; < with number = less than number shown (here usual detectabilities do not apply). Also looked for but not detected: Ag, As, Au, Bi, Cd, Ce, Ge, Hf, Hg, In, Li, Pd, Pt, Re, Sb, Sn, Ta, Te, Th, Tl, U, W, and Zn]

Constituents	Specimens			
	172	62ABd147	62ABd149	62ABd152
Chemical analyses[1]				
SiO_2	65.94	66.2	55.5	62.7
Al_2O_3	13.74	14.3	20.0	16.7
Fe_2O_3	.49	1.3	1.0	.83
FeO	5.21	5.4	7.3	4.7
MgO	2.33	2.1	3.8	3.2
CaO	2.87	2.8	2.6	2.5
Na_2O	2.80	2.4	3.9	3.3
K_2O	1.63	2.5	2.5	2.8
H_2O-	.21	.09	.34	.02
H_2O+	2.59	1.3	2.1	1.8
TiO_2	.80	.77	1.1	.80
P_2O_5	.21	.30	.22	.28
MnO	.11	.53	.16	.11
CO_2	.59	.08	.06	.10
BaO	.12	----------	----------	----------
FeS_2	.41	----------	----------	----------
C from carbonaceous material	.20	----------	----------	----------
Total	100.25	100	101	100

Constituents	Specimens			
	172	62ABd147	42ABd149	62ABd152
Semiquantitative spectrographic analyses2				
Si	--------	M	M	M
Al	--------	7.	10.	10.
Fe	--------	5.	7.	5.
Mg	--------	2.	2.	1.5
Ca	--------	2.	2.	2.
Na	--------	1.5	2.	2.
K	--------	2.	2.	2.
Ti	--------	.5	.7	.5
P	--------	0	0	0
Mn	--------	.3	.1	.07
B	--------	.003	0	.002
Ba	--------	.15	.15	.15
Be	--------	.0001	.0015	.0001
Co	--------	.0015	.002	.0015
Cr	--------	.01	.01	.003
Cu	--------	.002	.005	.007
Ga	--------	.002	.002	.002
La	--------	0	0	.003
Mo	--------	0	0	.0005
Nb	--------	0	.0015	0
Ni	--------	.003	.003	<.003
Pb	--------	.003	.0015	.002
Sc	--------	.002	.003	.002
Sr	--------	.03	.05	.05
V	--------	.02	.05	.02
Y	--------	.002	.003	.002
Yb	--------	.0003	.0003	.0003
Zr	--------	.015	.02	.015

'Analysts: Specimen 172, W. F. Hillebrand (Becker, 1898, p. 45); others. Paul Elmore, Sam Botts, Lowell Artis, H. Smith, using rapid rock analysis method.

²Analyst: Chris Heropoulos. Results are reported in percent to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1, etc.; which represent approximate midpoints of group data on a geometric scale. The assigned group for semiquantitative results will include the quantitative value about 30 percent of the time

Specimen descriptions and locations:

172. Graywacke, town of Sitka, Alaska (Becker, 1898, p. 44–45).

62ABd147. Garnet-biotite semischist derived from graywacke, east side of Larch Bay, Baranof Island (Port Alexander A–3 quad).

62ABd149. Garnet-biotite hornfels derived from graywacke, northwest side of Larch Bay, Baranof Island (Port Alexander A–3 quad).

62ABd152. Garnet-biotite semischist derived from graywacke, north side of entrance to Little Puffin Bay, Baranof Island (Port Alexander A–3 quad).

abundant in the graywacke and argillite beds and most frequently occur at a large angle to the bedding. Cleavage, where developed, is commonly subparallel to the bedding but diverges from it in fold hinges (see section on "Southwestern Province"). Locally, shearing parallel to the cleavage has disrupted and transposed the bedding (fig. 13). The formation is at least several thousand feet thick, but the lack of marker beds and the complexity of the structure preclude any reliable estimate of thickness.

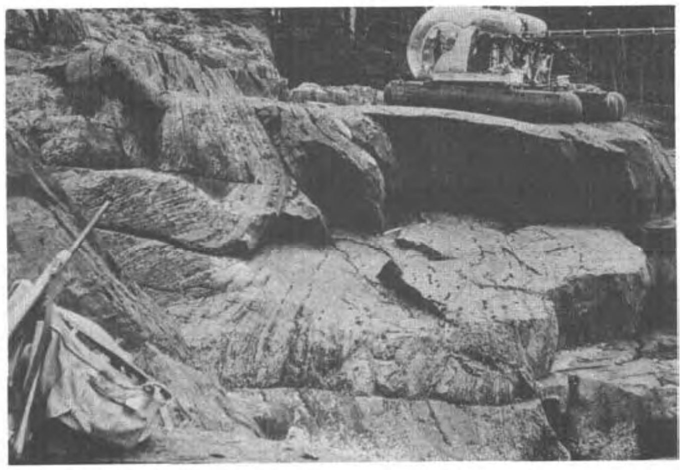


FIGURE 11.—Nearly recumbent folds in thin-bedded graywacke and slate, Sitka Graywacke, west coast Khaz Peninsula, Chichagof Island.

In the vicinity of the Tertiary plutons on Baranof and Kruzof Islands (and probably elsewhere), higher grade contact metamorphism is superposed on the low-grade regional metamorphism. The graywackes and slates are converted into biotite hornfels and, in places on southern Baranof Island, into biotite schist and semischist. The mapped outer margins of the aureoles (pl. 1) are based on the appearance of biotite in hand

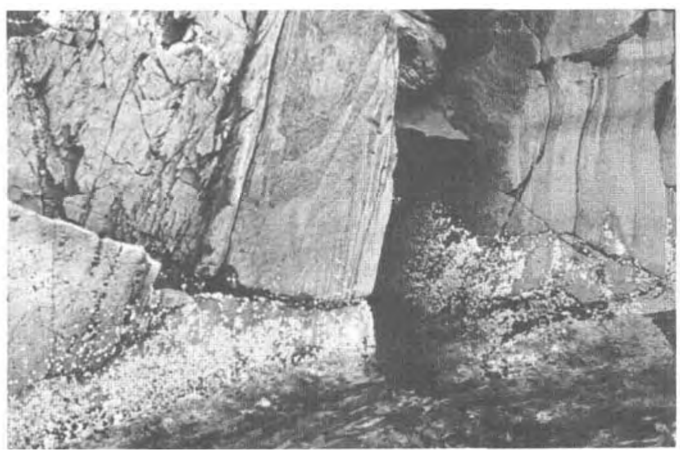


FIGURE 12.-Isoclinal folds in thin-bedded graywacke semischist and slate, Sitka Graywacke, Port Walter, Baranof Island; field of view about 3m across.

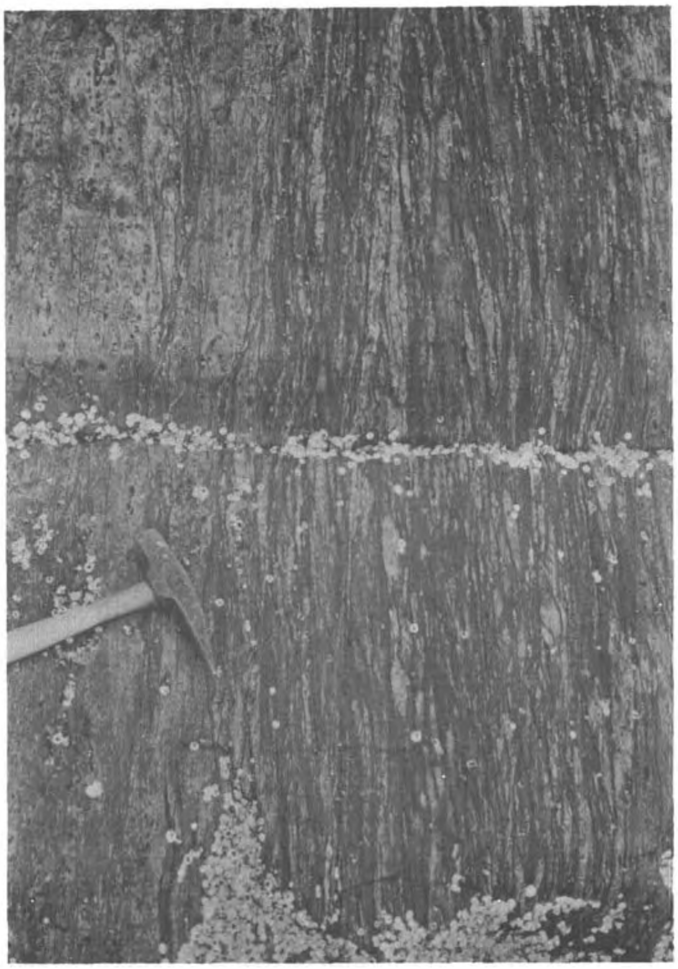


FIGURE 13.—Sheared-out folds and transposed bedding in thin-bedded graywacke semischist and slate, Sitka Graywacke, Pert Walter, Baranof Island.

specimen. Although the metamorphic mineral assemblages vary from aureole to aureole and locally from one part of an aureole to another, the metamorphism generally ranges from upper albite-epidote hornfels facies in outer parts to a facies intermediate between the hornblende hornfels and amphibolite facies (Turner, 1968) in the inner part. The higher grade rocks are generally coarser grained than the lower grade ones and contain staurolite, almandine, and sillimanite; locally they also contain cordierite and andalusite (see section on "Contact Metamorphism Around Tertiary Plutons").

The age of the Sitka Graywacke, Late Jurassic and Early Cretaceous, is determined from a few fossil collections from Chichagof Island. At several localities along the southwest shore of Slocum Arm, fossils were found in lenses of brown-weathering limestone and in fine-grained calcareous graywacke. All the fossils were the pelecypod ***Buchia subokensis*** of Berriasian (Early Cretaceous) age (D. L. Jones, written commun., 1962). However, a small squashed form of ***Buchia piochii***(?), collected by R. M. Overbeck in 1917 in the same area, indicates a possible Tithonian (Late Jurassic) age. ***Inoceramus*** prisms indicative of a Cretaceous or Jurassic age (D. L. Jones, written commun., 1961) were found in calcareous slate interlayered with greenstone, graywacke, argillite, and minor limestone on the southwest side of Emmons Island in Hoonah Sound.

The Sitka Graywacke correlates with the Seymour Canal Formation of eastern Admiralty Island (Loney, 1964; Lathram and others, 1965) and of Keku Strait (Muffler, 1967). It also is correlated with the graywacke and slate from the Juneau area and the Cape Fanshaw-Kupreanof-Mitkof-Etolin-Gravina Islands area (Buddington and Chapin, 1929, p. 157–164, 253–260). To the north, the Sitka Graywacke probably correlates with the unnamed schist and amphibolite units mapped in the Fairweather Range by Rossman (1963a) and Miller (1961).

QUATERNARY ROCKS

ALLUVIAL, COLLUVIAL, AND GLACIAL DEPOSITS

Alluvial, colluvial, and glacial deposits cover lowlands and valleys throughout the map area. In addition, a thin cover of volcanic ash derived from the Edgecumbe volcanic field blankets Kruzof Island, northwestern Baranof Island, and southwestern Chichagof Island. We did not study these unconsolidated sediments in detail and did not distinguish the different types of sediment on the map (pl. 1). Distribution of unconsolidated sediments was determined primarily by interpretation of aerial photographs.

Surficial deposits are most extensive in the rather low-lying, northern part of Chichagof Island, much of which is covered by a mantle of sand, gravel and silt that represent glacial outwash, stream alluvium, and colluvium. To the south, areas of unconsolidated sediments become smaller in size and are usually restricted to small alluvial areas at the heads of bays and lakes.

EDGECUMBE VOLCANICS

Volcanic rocks of Pleistocene and Holocene age (Brew and others, 1969) covering about 260 km^2 of southern Kruzof Island were named the Edgecumbe Volcanics by Berg and Hinckley (1963, p. 014015). These volcanic rocks, consisting of gently dipping flows, composite cones, and air-fall ash and lapilli, are the eruptive products of the Mount Edgecumbe volcanic field that takes its name from Mount Edgecumbe, a nearly undissected composite cone that rises spectacularly above the other eruptive features of the field. The following description is adapted from a more detailed account of the Mount

Edgecumbe volcanic field given by Brew, Muffler, and Loney (1969).

The Edgecumbe Volcanics was largely extruded onto a glacially planed surface underlain by metamorphosed Sitka Graywacke and Tertiary granodiorite; radiometric dating indicates the eruption began in the Pleistocene (Brew and others, 1969). Two radiocarbon dates provide evidence that a major ash and lapilli eruption occurred about 9,000 B. P., spreading ash over a wide area to the northeast. Heusser (1960, p. 97, 184) obtained an age of about 9,000 B. P. from peat underlying this ash near Juneau, and R. W. Lemke (oral commun., 1966) obtained an age of 8,750±300 B. P. from rooted wood in peat that overlies the ash at Sitka. There seem to be no reliable accounts of volcanic activity since Europeans arrived in the area during the 18th century (Becker, 1898, p. 13).

The Edgecumbe Volcanics consists of a succession of flows and pyroclastics that erupted from a northeast-trending line of vents. Nine chemical analyses (Brew and others, 1969, table 2) define a smooth compositional trend from the early basalts through andesites and dacites of intermediate age to young quartz latite. This sequence is interpreted by Brew, Muffler, and Loney (1969) to represent a calc-alkaline magma series that has a close relationship to the high-alumina basalt series.

Gently dipping augite basalt and olivine-augite basalt make up the lowest part of the volcanic pile and form most of the broad platform that underlies the composite cones. Olivine-bearing hypersthene andesite and basaltic andesite overlie the basalts around the composite cone of Mount Edgecumbe and to the southwest; flows and cinder cones that overlie the basalts north of Mount Edgecumbe are known only from photogeologic interpretation. Mount Edgecumbe itself consists of interlayered ash-fall tuffs and flows of augite dacite and hypersthene-augite dacite. Hypersthene-augite dacite also occurs as flows and cinder cones low on the southwest flank of Mount Edgecumbe.

Mount Edgecumbe and the probable remnants of a similar cone at Crater Ridge are cut by augite-bearing quartz latite domes. The site of the inferred Crater Ridge composite cone is now occupied by a caldera 1.6 km in diameter and 240 m deep. Widespread pyroxene-bearing dacite(?) lapilli and ash deposits probably are the result of explosive eruptions during the formation of the composite cones. Cinder cones and flows that appear to be still younger have not been sampled or visited.

LAMPROPHYRIC BASALT ON LISIANSKI INLET

Rossman (1959, p. 186) described three small bodies of igneous rock on Chichagof Island just north of the junction of Lisianski Inlet and Lisianski Strait. He considered these bodies to be extrusive basalt mainly on the basis of outcrop configuration, appearance in hand specimen, and crude columnar jointing in outcrop; however, his petrographic description, suggests that the rock is a lamprophyre. Our reexamination of his thin section indicates that the rock is best classified as a spessartite.

Rossman (1959) interpreted these bodies to be postglacial. He noted that the largest body forms a rounded hill sticking out into Lisianski Inlet, and he therefore concluded that the basalt was not present when glacial erosion formed Lisianski Inlet.

INTRUSIVE IGNEOUS ROCKS

GRANITOID ROCKS

The granitoid rocks of Chichagof and Baranof Island occur in three, northwest-trending, overlapping belts (pl. 2). The northeast belt is a Silurian or older alkalic plutonic complex, 6 miles wide and 30 miles long. The middle belt consists of a terrane underlain dominantly by Jurassic and Cretaceous rocks ranging in composition from gabbro to granite. Within the map area, this belt is 75 miles wide and 115 miles long; it continues north into Glacier Bay National Monument for at least another 66 miles (D.A. Brew, unpub. data, 1971). The southwest belt consists of discrete Tertiary plutons scattered along a belt 40 miles wide and 150 miles long within the map area. The belt continues at least 65 miles northward into the Glacier Bay National Monument (MacKevett and others, 1971; D.A. Brew, unpub. data, 1971). In this southwest belt are included gabbroic rocks of probable Tertiary age that occur on northwest Chichagof and Yakobi Islands (Rossman, 1959) and in the Glacier Bay area (D.A. Brew, unpub. data, 1971).

The density and type of field observations, the number of available samples, and the detail of laboratory investigations vary greatly throughout the map area. The plutons on Baranof Island were studied in the greatest detail, both in the field and in the laboratory. Modal data given for these plutons are based on point counts of all suitable thin sections. The plutons on Chichagof and Kruzof Islands were studied in less detail; modal data are based mainly on visual estimation using comparative charts. Only a few modal data are available for the granitoid rocks mapped by previous workers on Chichagof and Yakobi Islands (Reed and Coats, 1941; Rossman, 1959; Lathram and others, 1959; Loney, Condon, and Dutro, 1963); we have not restudied or remapped these rocks.

The granitoid rocks are classified by a (fig. 14) modified version of Peterson's (1961) descriptive modal system. A simple mineral modifier indicates that the mineral is in excess of 5 percent. A mineral designated as "-bearing" is significant to the classification or pet-

Ratio of alkalic to plagioclase ($>An_{10}$) feldspar: 2 : 1, 1 : 2, 1 : 9, a

>10 percent quartz	Granite	Adamellite	Granodiorite	Tonalite[b,c]	Quartz-norite[d,e,f]	Quartz-gabbro[d,e,f]
	Alaskite: CI <5			Trondhjemite: CI <10		
<10 percent quartz	Syenite	Monzonite	Syenodiorite	Diorite[b,c]	Norite[d,e,f]	Gabbro[d,e,f]

Ratio of orthopyroxene to clinopyroxene: 2 : 1, 1 : 1, 1 : 2

a. An_{47-48} divides diorite field from gabbro and norite.
b. Tonalites and diorites with CI > 40 have prefix "mela."
c. Characteristic hornblende is dark green (z).
d. Characteristic hornblende is medium green, and some is uralitic.
e. Norites and gabbros with CI > 40 have prefix "leuco."
f. Norites and gabbros with from 2:1 to 1:2 orthopyroxene to olinopyroxene ratios may be called augite (etc.) norites and hypersthene (etc.) gabbros, respectively.

FIGURE 14.--Classification of igneous rock types (modified from Peterson, 1961).

rogenesis of the rock but is present in amounts less than 5 percent. The individual intrusive bodies shown on plate 2 are given in table 2, along with the dominant rock type, subordinate rock types, dimensions of outcrop, and any radiometric age data available.

PLUTONS OF SILURIAN OR OLDER AGE

Alkalic plutonic rocks of Silurian or older age underlie approximately 90 mi^2 of southeastern Chichagof Island (Nos. 1–6, pl. 2). The terrane is heavily wooded, outcrops are poor, and access is difficult.

We have provisionally divided this alkalic complex into six plutons on the basis of the dominant rock type represented in the available samples (table 2). Each body is conspicuously heterogeneous (table 3). Rock types range from diorite and trondjhemite to monzonite and alkali syenite; many specimens contain minerals produced by deuteric alteration. Pluton No. 3 contains several unusual alkali rock types; minerals identified include nepheline, sodalite, cancrinite, sodic pyroxene, and possibly kalsilite and kaliophyllite. Relations among rock types are uncertain; there is a tendency for the more alkalic rocks to occur farther from country-rock contacts.

The contacts of the alkalic complex with country rock are poorly exposed, and their nature is uncertain. However, clasts of syenite similar to rocks of the alkalic complex occur in the Point Augusta Formation (Upper? Silurian), in the Kennel Creek Limestone (Silurian and (or) Devonian), and in the Cedar Cove Formation (Middle and Upper Devonian). A 406±16 m.y. date on hornblende from a syenite from pluton No. 2 (62 ALe 15; Lanphere and others, 1964; Lanphere and others, 1965) falls in the Upper Silurian or Lower Devonian (using the time scale of Bottino and Fullagar, 1966), but this is a minimum age (Lanphere and others, 1965, p. B–111). The sum of the stratigraphic and radiometric evidence indicates that the alkalic plutonic complex is Silurian or older.

JURASSIC PLUTONS

KENNEL CREEK PLUTON

A concentrically zoned pluton of Jurassic age crops out near the head of Kennel Creek on eastern Chichagof Island. The central part of the body (No. 8, pl. 2) consists of adamellite, alaskite, monzonite, and granodiorite (table 4). Along the west side of the pluton, we mapped an arcuate border zone (No. 7, pl. 2) of diorite, meladiorite, and syenodiorite. This border zone ranges from 0.4 to 1.6 miles wide along an arc of at least 8 miles. On the east side of the pluton, the border zone may be represented by a heterogeneous zone of constrasting rock types (described by Loney, Condon, and Dutro, 1963). The contact between the border zone and the core is everywhere steep and abruptly gradational. Contacts with the Point Augusta Formation and the Kennel Creek Limestone are likewise steep; the metamorphic aureole appears to be narrow and to reach hornblende hornfels facies (Loney, Condon, and Dutro, 1963).

Data on the age of this pluton consist of lead-alpha determinations on zircons from two samples (180±20 m.y. and 160±20 m.y.) and a potassium-argon determination (144±7 m.y.) on hornblende from the second of the two samples (Loney and others, 1967, tables 1 and 2, Nos. 3 and 4).

TONALITE INTRUSIVES NEAR THE WEST ARM OF PERIL STRAIT

Jurassic plutonic rocks crop out in a north-northwest-trending belt extending 33 miles from Nakwasina Passage on Baranof Island to Patterson Bay on Chichagof Island. These Jurassic Rocks are split into two outcrop areas (Nos. 9 and 11, pl. 2; table 2) by a Tertiary(?) pluton (No. 82, pl. 2).

TABLE 2.--*Major intrusive igneous bodies of Baranof, Chichagof, Kruzof, and Yakobi Islands*

[See pl. 2 for locations]

Body No.	Dominant rock type	Subordinate rock types in decreasing order of abundance	Maximum length (mi)	Maximum width (mi)	Estimated area (sq mi)	Radiometric age[1]	Source of data'
	Silurian or older bodies[3]						
1	Biotite-bearing trondhjemite		4	2	8	----	1,2
2	Biotite syenite	Hornblende syenite, hornblende-bearing biotite monwnite.	12?	3	36	406±16my(KH)	1,2,3
3	Hornblende- and biotite-bearing trondhjemite.	Biotite- and hornblende-bearing monzonite, biotite granite, hornblende adamellite.	10	2	16	----	1,2
4	Sodalite syenite	Sodalite-nepheline syenite, hornblende syenite	7	2	12	----	1,2
5	Hornblende-bearing biotite syenodiorite.	Hornblende-bearing trondhjemite, biotite-bearing adamellite.	7	2	9	----	1,2
6	Hornblende syenite	Biotite syenite, biotite monzonite	8	2	12	----	
	Jurassic bodies[4]						
7	Biotite-hornblende diorite	Biotite-hornblende meladiorite, hornblende syenodiorite and diorite.	6	1.5	8	----	1,2,4
8	Hornblende adamellite	Biotite alaskite, hornblende monzonite, granodiorite.	5	4	15	180±20my(Z) 160±20my(Z)	1,2,4,5
9	Biotite-hornblende tonalite	Biotite-hornblende diorite	13	6	44	164±5my(KH)	1,2,5
10	Hornblende gabbro[5]	"Amphibolite"	----	----	----	----	1,2
11	Hornblende-biotite tonalite	Biotite tonalite, hornblende tonalite	16	4	50	152±4my(KB) 151±5my(KH)	1,2,5,6
	Cretaceous and probable Cretaceous bodies[6]						
12	Hornblende diorite'	Biotite-bearing hornblende diorite, biotite diorite	25	4	75	----	7,8
13	Hornblende diorite		7	1	5	----	7
14	Hornblende diorite[8]		10	1	7	----	7,8
15	Hornblende diorite[9]		----	----	----	----	7
16	Hornblende-biotite albite granodiorite.	Hornblende diorite	2	.5	.8	----	7,8
17	Hornblende-biotite[10] granodiorite.	Biotite-hornblende tonalite, biotite trondhjemite	16	6	64	----	1,2,8
18	Hornblende-bearing biotite tonalite.	Biotite- and hornblende-bearing trondhjernite	8	2	8	----	1,2,8
19	Hornblende gabbro		2	1	2	----	1,2
20	Hornblende diorite[11]	Biotit diorite, aplite	10	.5	3	----	1,2
21	Biotite-hornblende tonalite	Biotite-hornblende diorite, hornblende-biotite tonalite.	11	3	24	----	1,2
22	Muscovite- and biotite-bearing trondhjemite.	Granodiorite?	3	1.5	2	----	1,2
23	Biotite-hornblende tonalite		2	.5	.8	----	1,2
24	Hornblende diorite		12	3	14	----	7
25	Hornblende diorite		17	3	30	----	7
26	Hornblende diorite		5	1	2	----	7
27	Uralitized biotite-pyroxene diorite.	Biotite-hornblende diorite, biotite-hornblende melatonalite.	26	10	100	----	1,7,9
28	Hornblende tonalite	Hornblende diorite	21	6	60	----	7,9
29	Biotite-hornblende diorite	Biotite-hornblende tonalite	4	1.5	4	----	9
30	Uralitized olivine-pyroxene gabbro		3	1	2	----	7
31	Uralitized olivine-pyroxene gabbro		3.5	1	3	----	7
32	Hornblende gabbro[12]	Uralitized leucogabbro, uralitized gabbm and norite.	26	8	80	----	1,7
33	Hornblende tonalite		3	1	2	----	1,7
34	Biotite-hornblende tonalite	Biotite granodiorite, hornblende diorite and gabbro.	20	7	60	210±50my(Z) 111±6my(KH)	1,2,5
35	Hornblende gabbro		1	.5	.5	----	1,2
36	Biotite-hornblende tonalite	Biotite adamellite, uralitized anorthosite	12	4	24	----	1,2
37	Hornblende gabbro	ende diorite, hornblende tonalite	2	1	1	----	1,2
38	Hornblende diorite	hornblende diorite, hornblende rneladiorite.	4	1.5	4	----	1,2
39	Hornblende diorite and meladiorite.	Hornblende gabbro and micmgabbm, hornblende tonalite.	9	1.5	9	----	1,2
40	Biotite-hornblende tonalite	Hornblende and biotite-hornblende diorite, hornblende tonalite.	48	12	280	110±20my(Z) 114±6my(KH) 110±2my(KH) 106±2my(KH)	1,2,5
41	Biotite-hornblende and hornblende tonalite.	Biotite-hornblende granodiorite; hornblende meladiorite.	4	2.5	7	----	1,2
42	Hornblende gabbro	Hornblende diorite	6	1.5	3	----	1,2
43	Chloritized hornblende gabbro		1	.5	.5	----	1,2
44	Hornblende diorite	Hornblende tonalite	5	2.5	7	----	1,2
45	Hornblende gabbro	Hornblende diorite	1.5	1	1	----	1,2
46	Chloritized diorite(?)		1.5	.5	.5	----	9
47	Chloritized biotite-hornblende diorite porphyry		2	1.5	2	----	9
48	Biotitized uralitized augite diorite.		1	1	.5	----	4
49	Hornblende-biotite adarnellite	Diopside- and hornblende-bearing monwnite and diorite.	5	1.5	4	120±20(Z) 150±20(Z) 103±5(KB)	4,5
50	Biotite-hornblende diorite	Hornblende melatonalite	4	1.5	2	----	1,2
51	Hornblende-biotite grancdiorite.	Biotite-hornblende grancdiorite and meladiorite(?)	5	3	10	----	1,2
52	Biotite-hornblende granodiorite.	Biotite- and hornblende-bearing trondhjemite.	2.5	2	4	----	1,2
53	Biotite-hornblende granodiorite.	Biotite-hornblende tonalite and diorite	8	1.5	4	----	1,2,3
	Cretaceous(?) gabbros of Baranof Island						
54	Actinolite-bearing gabbro		.8	>.25	>.2	----	1,12
55	Actinolite-bearing gabbro		.7	.15	.1	----	1,12

TABLE 2.—*Major intrusive bodies of Baranof, Chichagof, Kruzof, and Yakobi* Islands—Continued

Body No.	Dominant rock type	Subordinate rock types in decreasing order of abundance	Maximum length (mi)	Maximum width (mi)	Estimated area (sq mi)	Radiometric age[1]	Source of data[2]
	Probable Tertiary Bodies near head of Tenakee Inlet						
56	Uralitized gabbro and norite	Uralitii leuconorite, uralitized leucogabbro	6	3	15	----------------	1,2
57	Uralitized olivine gabbm	Uralitii troctolite, uralitized leuconorite and leucogabbro.	5	3	10	----------------	1,2
	Probable Tertiary Bodies on Chichagof and Yakobi Islands						
58	Hornblende tonalite		1.5	1	1.5	----------------	7
59	Hornblende tonalite		6	2	8	----------------	7
60	Hornblende tonalite		1	1	1	----------------	7
61	Uralitized(?) gabbro		1	1	1	----------------	7
62	Biotite-hornblende tonalite	Biotite-hornblende diorite	15	6	30	----------------	7,10
63	Uralitized gabbro	Hornblende diorite	3	1	2	----------------	7,10
64	Norite	Augite norite, uralitized norite, gabbro	.5	.5	.25	----------------	7,10
65	Uralitized(?) gabbro		5	2	7	----------------	7
66	Uralitized(?) gabbro		1	.5	.5	----------------	7
67	Uralitized(?) gabbro		4	1	3	----------------	7
68	Hornblende tonalite		3	1	2	----------------	7
69	Hornblende tonalite		2	1	2	----------------	7
70	Hornblende tonalite	Biotite-muscovite granodiorite(?)	3	2	5	----------------	7,8
71	Hornblende tonalite		1	.5	.5	----------------	7
72	Biotite tonalite		4	3	9	----------------	7
73	Hornblende tonalite		4	1	2	----------------	7
74	Hornblende tonalite		2	1	1	----------------	7
75	Hornblende tonalite		1	.5	.5	----------------	7
76	Gabbro	Norite, amphibolite, diorite	2	2	4?	----------------	7,11
77	Norite[13]	Hornblende gabbro, hornblende diorite	1	.5	.5	----------------	7,11
78	Hornblende tonalite		3	1	2	----------------	7
79	Biotite trondhjemite	Hornblende tonalite(?)	13	1	10	----------------	1,2,7
80	Biotite granodiorite[14]	Muscovite- and biotite-bearing alaskite	8	2	8	----------------	2,8
81	Biotite granodiorite		.5	.25	.1	----------------	1,2
82	Garnet- and muscovite-bearing biotite granodiorite.	Biotite granodiorite; hornblende-biotite granodiorite.	7	5	25	----------------	1,2
	Eocene Bodies on Kruzof and Baranof Islands						
83	Chloritized biotite granodiorite.	Chloritized biotite adamellite; muscovite-bearing biotite albite granite.	12	8	32	48.6±1.1(KB)	1,5,6,12
84	Biotite granodiorite		4	2	6	----------------	1,6,12
85	Chloritized biotite-hornblende tonalite.		3	2	4	----------------	1,6,12
86	Hornblende-biotite tonalite	Hornblende-biotite granodiorite, muscovite-biotite trondhjemite.	16	10	10	42.6±1.1(KB) 44.3±1.2(KM) 42.2±0.8(KM) 41.1±0.8(KM) 28.1±1.3(KB) 38.7±0.9(KB)	1,5,12
87	Biotite-hornblende tonalite	Biotite-hornblende granodiorite, hornblende diorite.	8	3	13	47.2±1.3(KB)	1,5,12
88	Biotite granodiorite		4	1.5	3	----------------	1,12
89	Unknown		.5	.5	.25	----------------	1,12
90	Unknown		2	1	1	33.8±0.3(KB) 36.2±0.4(KM)	1,5,12
91	Hornblende-biotite granodiorite and tonalite.[14]	Biotite alaskite	18	4	55	----------------	1,5,12
92	Hornblende-biotite granodiorite.	Hornblende-biotite halite	17	6	60	46.9±0.5(KB)	1,5,12
93	Hornblende-biotite tonalite	Hornblende-biotite granodiorite, alaskite	30	9	160	25.8±0.6(KB) 44.2±1.1(KB) 44.4±0.4(KB) 42.0±0.6(KB) 46.8±3.0(KH)	1,5,12
94	Biotite granodiorite	Biotite adamellite(?)	3	1.5	3	----------------	1,12
95	Biotite granodiorite		2	.5	1	----------------	1,12
96	Gneissose granodiorite[15]		--------	--------	--------	----------------	1,12
97	Hornblende-biotite tonalite	Biotite-hornblende melatonalite, alaskite	11	2	15	43.1±0.9(KB)	1,5,12,13
	Oligocene or Miocene Pluton at Gut Bay, Baranof Island						
98	Hornblende-biotite granodiorite.	Hornblende-biotite tonalite, hornblende gabbro	8	4	19	24.3±1.6(KB) 24.9±0.5(KB) 31.5±0.5(KH)	1,5,12

[1] K indicates potassium-argon age determination.
B following K indicates that Biotite was dated.
M following K indicates that Muscovite was dat
H following Hornblende was dated
W following K indicates that whole rock was dated.
Z indicates zircon was dated by lead-alpha method.

[2] Numbers refer to reports listed below.
1. This report.
2. Loney, Berg, Pomeroy, and Brew (1963).
3. Lanphere, Loney. and Brew (1965).
4. Loney, Condon, and Dutro (1963).
5. Loney, Brew, and Lanphere (1967).
6. Berg and Hinckley (1963).
7. Rossman (1959).
8. Reed and Coats (1941).
9. Lathram, Loney, Condon, and Berg (1959).
10. Reed and Dorr (1942).
11. Pecora (1942).
12. Loney, Pomeroy, Brew, and Muffler (1964).
13. Sainsbury (1957).

[3] Bodies 1–6 constitute the syenite complex of southeastern Chichagof Island.
[4] Bodies 7 and 8 are one pluton; bodies 9, 10, and 11 are probably also one pluton.
[5] Same number is applied to three small gabbmic bodies associated with body no. 9.
[6] Bodies 12–23 are described in text under "Cretaceous plutons southwest of the Peril Strait Fault", bodies 24–45 under "Cretaceous plutons between the Peril Strait Fault and the Sitkoh Bay Fault" bodies 46–53 under "Cretaceous plutons northeast of the Sitkoh Bay Fault."
[7] Connects to south with body no. 17.
[8] Includes small area of younger "unmetamorphosed diorite' near north end.
[9] Same number is applied to three small diorite bodies west of body no. 14.
[10] Connects to north with body no. 12
[11] Body follows outcrop position of Whitestripe Marble.
[12] Body includes small tonalite bo ly [illegible] c surrounded hornfels, schist, and marble unit near south end.
[13] Includes small isolated similar body one mile to southwest.
[14] Largely concealed by water.
[15] Includes four small bodies.

TABLE 3.--*Petrographic data of the alkalic*

[Symbols are as follows: P = present in unspecified amount; T =

Specimen No.	Rock name	Color index	Primary minerals[1]						
			Quartz	Plagioclase	K-Feldspar	Nepheline	Cancrinite	Hornblende	Biotite
	Body no. 1:								
61ABd98	Biotite-bearing trondhjemite	3	41.8	43.8(An13)	11.4(orthoclase)	------	------	0.4	2.0
102b	Biotite-bearing trondhjemite	3	25	45	20	------	------	------	P
	Body no. 2:								
61ABg116	Biotite syenite	7	------	------	75(perthite)	------	------	------	P
61APy47	Hornblende-bearing biotite monzonite	15	------	35	45	------	------	P	P
61ABd99	Hornblende syenite	7	T	25	45(perthite) +20(orthoclase)	------	------	5	------
	Body no. 3:								
61APy165	Biotite-bearing granite	5	P	------	P	------	------	------	P
61ABd197a	Epidote- and biotite-bearing trondhjemite	3	12	68	15(orthoclase) T(microcline)	------	------	------	1
200	Biotite- and hornblende-bearing trondhjemite	5	15	66(An20–32)	11(orthoclase) 4(microcline)	------	------	3	1
201	Biotite-bearing trondhjemite	3	12	60(An20–42)	20(orthoclase)	------	------	------	P
202	Hornblende-bearing adamellite	7	15	43(An15–50)	10(perthite) 16(orthoclase) 4(microcline)	------	------	4	------
204	Epidote- and hornblende-bearing monzonite	5	8	50	35(perthite +orthoclase)	------	------	P	P
206	Hornblende monzonite	15	6	50(An27–47)	13(perthite) 30(orthoclase)	------	------	11	1
207	Hornblende-bearing trondhjemite	4	35	50(An9–37)	12(orthoclase)	------	------	P	------
208	Hornblende-bearing trondhjemite	3	25	55(An15–20)	17(orthoclase)	------	------	1	------
209a	Biotite-bearing monzonite	5	------	30(An15?)	30(perthite) 20(orthoclase)	------	------	------	4
209b	Biotite-bearing cancrinite-nepheline syenite	5	------	15?(<An10?)	30(perthite) 15(orthoclase)	15	15	------	------
	Body no. 4:								
61ABd210	Sodalite syenite	4	------	1?	60(perthite)	P?	5	------	1
61ABg181	Sodalite syenite	2	T?	P?	75(perthite)	------	P	------	P
182	Acmite?-bearing sodalite-nepheline? syenite	2	------	10?(An31)	40(microperthite)	P?	T	------	T
61APy131	Biotite-bearing sodalite-nepheline? syenite	3	------	5	45(perthite)	P?	7	T	3
61APy133	Biotite-bearing syenite	5	T	P	65(microcline) perthite, orthoclase)	------	------	------	P
164	Hornblende syenite	10	------	------	P	P?	------	P	------
	Body no. 5:								
61ABd211	Biotite-bearing syenodiorite	7	3	75(An10?)	10(microantiperthite)	------	------	------	4
212	Hornblende-bearing biotite syenodiorite	11	4	50(An32)	20(microperthite) T(microcline)	------	------	1	7
213	Hornblende-bearing biotite syenodiorite	15	------	50	25(microcline + microperthite)	------	------	P	------
61APy134	Hornblende-bearing trondhjemite	2	12	45	15	------	------	P	P
61ALy147	Biotite-bearing adamellite	2	35	25	35(microcline) T(perthite)	------	------	1	1
	Body no. 6:								
61ALy137c	Hornblende syenite?	40	5	------	55	P?	------	40	------
137d	Hornblende syenite	10	------	------	85	------	------	P	------
138a	Biotite-bearing syenite	3	P?	5	90(perthite)	------	------	------	2
138b	Biotite syenite	15	------	------	65(perthite +orthoclase)	P	------	------	------
153	Aegerinaugite-bearing biotite monzonite	15	------	40(An28?)	35	P?	------	------	7
	Hornblende syenite	---		[illegible]	P(orthoclase)	------	------	P	------

[1]Given in volume percent.

Outcrop area 9 consists primarily of foliate biotite-hornblende tonalite and biotite-hornblende diorite. Several bodies (No. 10, pl. 2) of hornblende gabbro or meladiorite are included in the pluton and, because of their gradational contacts, are interpreted as melanocratic variants of the tonalite magma. Contacts of the pluton with the metamorphic rock are steep, and inclusion-rich zones occur along the west margin and sporadically throughout the pluton at high elevations. The position of the contact with the Cretaceous igneous rocks to the north is uncertain. In the absence of definitive petrographic or geochronologic data, the contact has been arbitrarily drawn to put all the diorite in the Jurassic pluton and all the granodiorite in the Cretaceous pluton.

Outcrop area 11 is dominantly hornblende-biotite tonalite; diorite and gabbro are not present in significant amounts. Contacts are steep, but inclusion-rich zones are present only at the northwest corner. Outcrop area 11 is a part of the wide zone of mechanical deformation that occurs east of the Neva Strait fault and displays widespread cataclastic textures and alteration minerals.

Geochronologic information about outcrop area 9 is limited to a single potassium-argon date (164±5 m.y.) on hornblende from a diorite collected near Ushk Bay (Loney and others, 1967, tables 1 and 2, No. 8). The Jurassic age of outcrop area 11 is established by potassium-argon determinations of 152±4 m.y. (biotite) and 151±5 m.y. (hornblende) on a sample from Schulze Cove (Loney and others 1967, tables 1 and 2, No. 9).

CRETACEOUS AND CRETACEOUS(?) PLUTONS

Cretaceous granitoid rocks are restricted primarily to

intrusive complex, southeastern Chichagof Island

trace. All percent amounts estimated visually unless otherwise **noted]**

Primary minerals[1]—Continued				Secondary minerals						
Epidote	Sodalite	Garnet	Apatite	Biotite	Chlorite	Epidote	Sericite Muscovite	Sphene	Opaques	Remarks
------	------	T	T	------	0.4	0.2	------	T	------	Point counted mode: also T myrmekite.
------	------	T	------	------	P	P	------	------	P	
------	------	------	------	------	P	------	P	------	P	
------	------	------	------	------	P	P	------	P	P	
2	------	------	1	1(after hornblende)	------	------	T	------	T	
------	------	------	------	------	------	------	------	------	------	
3	------	------	T	------	T(after?)	------	T	1	T	Locally cataclastic; **highly** altered;
------	------	------	T	------	1(after hornblende)	1	------	T	1	T zircon, T **perthite; plagioclase** is wned.
------	------	------	P	------	P	P	------	P	------	T **myrmekite;** plagioclase is zoned.
------	------	------	T	1(after hornblende)	------	2	------	1	1	T zircon, 2 **percent** myrmekite; plagioclase is wned
P	------	------	------	------	P	------	------	P	P	P myrmekite also.
------	------	------	T	------	T	T	------	1	2	T myrmekite, T zircon also; plagioclase is zoned.
------	------	------	P	------	P	------	------	P	P	**Plagioclase** is wned.
------	------	------	T	1(after hornblende)	T	T	------	T	1	T zircon, T myrmekite also; plagioclase is wned.
------	------	------	------	------	T	------	10(after K-spar)	------	T	**Very** altered.
------	------	------	------	4(after?)	------	2	------	T	1	
------	25?	------	T	------	------	------	------	2	1	1 percent fluorite, T Na-pyroxene, T **allanite?** also.
------	P	------	------	------	------	------	------	------	P	
------	15	------	T	------	------	T	------	T	T	**20 percent** kalsilite?; 2 percent **acmite?, T zircon**
------	15	------	T	------	------	------	------	T	1	T zircon, **20** percent kalsilite?, 1 percent **scapolite?**
------	------	------	------	------	------	------	P	P	------	**P prehnite.**
------	------	------	------	------	------	------	------	------	------	
------	------	------	T	------	T(after (biotite)	T	T(after K-spar)	1	2	T zircon, T **myrmekite; protoclastic.**
------	------	------	1	------	1	3(after hornblende),	------	1	1	T prehnite, T diopside?, **protoclastic**
------	------	------	P	------	P(after chlorite)	P	------	P	P	
------	------	------	P	------	------	------	------	P	P	T zircon; plagioclase is wned.
------	------	------	------	------	T(after biotite)	------	------	T	------	Plagioclase is wned; **protoclastic?**
------	------	------	------	------	------	P	------	P	------	
------	------	------	------	------	------	P	------	P	------	
------	------	------	------	------	------	------	3?	T	T	T-Na-Pymxene, 1 percent calcite, T **scapolite,**
------	------	------	------	P(after hornblende)	------	------	------	P	P	P zircon, P calcite, P scapolite?
------	------	------	------	------	------	2	------	1	5	2 percent **aegerinaugite,** prehnite?, T calcite, 3 percent **scapolite.**
------	------	------	------	------	------	------	------	P	------	

central Chichagof Island (pl. 2), where they underlie over 80 percent of the outcrop area. This terrane of extensive Cretaceous intrusion (plutons 12–45) is termed the Chichagof plutonic complex. Only a few, small Cretaceous plutons (Nos. 46–53) occur on northeastern Chichagof Island. The only granitoid rocks of possible Cretaceous age on Baranof Island are the two small gabbro masses (Nos. 54 and 55) along the crest of the island just east of the Vodopad River.

Only a few of the plutons shown as Cretaceous on plate 2 have been dated radiometrically. The remaining plutons are inferred to be of Cretaceous rather than Tertiary age through petrographic and megascopic comparison with dated plutons. In general, the Cretaceous plutons are characterized by (1) tonalite or diorite composition, with only minor granodiorite, and (2) moderately to well-developed pervasive foliation parallel to the northwest grain of the regional structure. The Cretaceous plutons intrude rocks ranging in age from Silurian through Jurassic; one pluton (No. 23, on Emmons Island in Hoonah Sound) intrudes the Sitka Graywacke of Jurassic and Cretaceous age.

Data (table 2) on the Cretaceous intrusive rocks of northwestern Chichagof Island (plutons 12–16) are taken from the reports of Rossman (1959) and Reed and Coats (1941). At the boundaries between their areas and the area we mapped (pl. 1), descriptions and nomenclature are not always consistent. Time did not permit us to resolve the discrepancies by reexamining the rocks in their areas; accordingly we have made some arbitrary cartographic decisions that in some cases require that boundaries be drawn within areas shown as single intrusive units by Rossman (1959). All Cretaceous plutons on Chichagof Island are summarized

TABLE 4. — *Petrographic data of the Jurassic*

[Symbols are as follows: P = present in unspecified amount; T = trace; < =

Specimen No.	Rock name	Color index	Texture	Primary minerals: Quartz	Plagioclase	K-Feldspar
						Adamellite-diorite complex
	BODY NO. 7:					
61ALy2	Hornblende diorite	35	hypidiomorphic granular	5	52(An36)	5(microcline)
61APy3	Hornblende syenodiorite	40	hypidiomorphic granular	<10	45	10
8	Biotite-hornblende gabbro(?)	50	hypidiomorphic granular	P	P(An50)	3
10	Biotite-hornblende diorite	27	hypidiomorphic granular	3.6	65.8(An39)	3.0
61ABd14	Biotite-hornblende meladiorite	44	hypidiomorphic granular	3.0	46.8(An31)	1.2(orthoclase)
	BODY NO. 8:					
61APy2	Biotite-bearing hornblende granodiorite	24	hypidiomorphic granular	13.6	53.8(An55–25)	6.6
6	Hornblende monzonite	17	hypidiomorphic granular	7	P	40(orthoclase)
61ABd13	Alaskite	1	allotriomorphic granular	36.2	3.0	55.4(orthoclase)
17	Biotite-and hornblende-bearing adamellite	7	hypidiomorphic granular	21.5	40(An22)	30(orthoclase)
61ABg105	Biotite-bearing alaskite	2	allotriomorphic granular	43.0	5.5(An12)	50.0(orthoclase)
						Tonalite bodies north and south
	BODY NO. 9:					
61APy522	Biotite-hornblende tonalite	20	hypidiomorphic granular	15	65(An30–36)	T
535	Biotite-hornblende diorite	25	hypidiomorphic granular	5	68(An30–34)	------
	BODY NO. 11:					
60AHw340	Biotite-bearing hornblende tonalite	20	hypidiomorphic granular	20	60(An45)	------
61APy545	Biotite? tonal& cataclasite	------	cataclastic	P	P(An45)	------
61ABd592	Hornblende-biotite tonalite	20	hypidiomorphic granular	12	55(An36?)	3
735	Hornblende-chloritized biotite tonalite	25	hypidiomorphic granular	15	40(An20?)	2
738	Hornblende tonalite	35	hypidiomorphic granular	10	50(An35)	2
60ABg350	Hornblende tonalite(?) cataclasite	------	cataclastic	P	P	------
352	Biotite syenodiorite(?)	------	hypidiomorphic granular/cataclastic	P	P	P(microcline)
356	Hornblende-biotite diorite	15	hypidiomorphic granular/cataclastic	------	80	5(microcline)

in table 2, but text descriptions are given only for those rocks we mapped and studied.

CRETACEOUS PLUTONS SOUTHWEST OF THE PERIL STRAIT FAULT

Cretaceous plutonic rocks extend in a continuous belt from northeastern Yakobi Island to Peril Strait (pl. 2). The northwestern part of the belt (No. 12, pl. 2) is dominantly diorite, according to Rossman (1959) and Reed and Coats (1941), whereas our data (table 5) indicate that the central (No. 17) and southeastern (No. 21) parts are composed primarily of granodiorite and tonalite. Foliation is well developed in bodies 12 and 21, but less so in body 17, in part because the more felsic rocks have fewer mafic minerals to define the foliation.

Rocks of diorite and gabbro composition occur sporadically throughout the belt. Body 19 consists of hornblende gabbro that encloses lenses of fine-grained amphibolite; amphibolite inclusions also occur in the surrounding tonalite of body 17. Body 19 may be an almost completely recrystallized large inclusion of country rock. A narrow band of diorite (body 20) follows the stratigraphic position of the Whitestripe Marble. Although shown as a single band on plate 2, body 20 is actually a number of closely spaced sills separated from each other by layers of marble.

Contacts of these Cretaceous plutons with country rock are variable in character. Bodies 17, 18, and 21 show sharp intrusive contacts. The contacts of body 21, however, are gradational in places, and wide zones of migmatitic rocks of the amphibolite or hornblende hornfels facies are present.

A number of the plutons described by Rossman (1959) as Jurassic or Cretaceous in age, we provisionally consider to be of probable Tertiary age. We base our conclusion on petrographic and structural similarities with radiometrically dated plutons to the southeast. These rocks include Rossman's quartz diorite, gabbro, norite, and quartz diorite units. Radiometric dates for these rocks in Rossman's area are not available.

CRETACEOUS PLUTONS BETWEEN THE PERIL STRAIT FAULT AND THE SITKOH BAY FAULT

Over 80 percent of the land area between the Peril Strait Fault and the Sitkoh Bay Fault is underlain by plutonic rocks. These plutons are conspicuously heterogeneous; rock types (table 5) range from hornblende-pyroxene gabbro and diorite through hornblende-biotite tonalite and biotite adamellite to biotite granite. The more felsic rocks are relatively uncommon, and the average rock type appears to be hornblende diorite.

Three general comments apply to all these Cretaceous rocks: (1) the field relations suggest that the gabbros may be older than the diorites and tonalites; in some places diorites and tonalites cut gabbro, but in other places the contacts are gradational; (2) abrupt changes from hornblende gabbro to hornblende diorite or tonalite occur on a hand specimen and outcrop scale; accordingly, our classification of the plutons as mostly one rock type or another is tenuous, and the reader should keep in mind the heterogeneity of the rocks; (3) much of the hornblende in the gabbros, diorites, and tonalites has been called uralite, because it clearly surrounds and replaces pyroxene. Most of this hornblende is pleochroic (Z=dark green, Y=medium to dark green, X=medium green), but some specimens also contain *plutons, Chichagof and Baranof Islands*

less than. All percent amounts estimated visually unless otherwise noted]

(numbers indicate volume percent)					Secondary minerals		Opaques	Remarks
Biotite	Hornblende	Epidote	Sphene	Apatite	Chlorite	Muscovite		
at head of Kennel Creek								
2	27	1.5	1	1	2	1	0.5	1 percent diopside as cores of hornblende.
P	P	--------	P	P	P	P	P	
P	P	P	P	P	P	P	P	Rock is layered.
6.8	18.0	T	T	0.6	0.2	----------	2.0	Point-counted mode.
5.8	38.4	0.2	T	0.8	--------	1.8	1.2	Point-counted mode; T myrmekite.
4.2	18.4	0.8	T	1.0	T	0.2	1.2	Point-counted mode; plagioclase zoned; T myrmekite.
------	P	--------	P	--------	--------	----------	P	
0.4	0.6	T	T	T	T	----------	0.2	Point-counted mode; 1.6 percent microcline, 2.6 percent perthite.
2	3	0.5	0.5	0.5	0.5	0.5	1	
2.0	----------	--------	------	T	T	----------	T	Point-counted mode.
of west arm of Peril Strait								
5	15	T	------	T	T	----------	T	T prehnite as alteration of biotite.
5	17	--------	------	T	--------	----------	2	3 percent cummingtonite altered from hornblende.
4	13	P	1	1	P	1	2	
------	----------	T	------	--------	T	T	T	From isolated body west of main body; prehnite P.
7	5	5	T	T	3	----------	2	Rock is very altered; 7 percent prehnite.
T	10	5	T	T	15	----------	--------	Rock is very altered, 10 percent prehnite.
------	25	2	------	T	5	P	T	5 percent prehnite.
------	P	P	P	P	P	----------	P	Calcite and prehnite P in veins.
P		P	------	P	P	P	--------	Calcite and prehnite P.
10	5	P	------	P	P	P	P	Possible albite in veinlets.

lighter colored amphibole in a similar relationship to the darker amphibole and to the pyroxene. The lighter and darker amphiboles probably formed at different times under different conditions, and the lighter is probably younger. Both types of amphibole are called uralite in table 5, except that the darker is designated simply hornblende if it occurs without demonstrable relations to pyroxene. Thus, a hornblende gabbro and a uralitized gabbro differ only in that the latter contains relicts of clinopyroxene within some of its hornblende crystals.

Significant parts of this belt of Cretaceous rocks may be high-grade, almost completely recrystallized, metamorphic rocks. In particular, some hornblende gabbros may be coarse-grained amphibolites, although the presence of normal zoning of plagioclase in most of the gabbros studied petrographically suggests a magmatic origin. The belt is characterized by a conspicuous foliation marked by variation in mafic mineral content, mafic schlieren, inclusions, and country-rock screens. The nature and origin of these possibly metamorphic rocks in body No. 32 is discussed by Rossman (1959, p. 154, 172, 187–188).

The metamorphic rocks within and around this belt of Cretaceous plutons are all of the hornblende hornfels facies, even at relatively great distances from the plutons. (See section on "Probable Paleozoic Metamorphic Rocks Associated with the Chichagof Plutonic Complex.") This widespread contact metamorphism and the high ratio of intrusive rock to country rock contrast with the situations to the southwest and northeast of the fault-bounded block. These observations, combined with the fault movement history given by Loney, Brew, and Lanphere (1967), suggest that the block between the Peril Strait and Sitkoh Bay faults has been uplifted relative to adjacent blocks and that the exposed rocks represent a deeper crustal level than do the rocks of the adjacent blocks.

The Cretaceous age assignment for these plutonic rocks is based on potassium-argon and lead-alpha age dates from plutons 34 and 40. Hornblende from a muscovite pegmatite dike in body No. 34 gave a potassium-argon age of 11&6 m.y. (Loney and others, 1967, tables 1 and 2, No. 5). Zircon from the same dike gave a lead-alpha age of 210±50 m.y., but this result is suspect because of the low lead content of the sample. Zircon from hornblende tonalite of body No. 40 gave an age of 110±20 m.y. by the lead-alpha method, and hornblende from the same sample gave a potassium-argon age of 114±6 m.y. (Loney and others, 1967, tables 1 and 2, No. 6). Replicate potassium-argon age determinations on hornblende from biotite-hornblende diorite from the east side of Catherine Island were 109.7±1.6 m.y. and 105.8±1.6 m.y. (Loney and others, 1967, tables 1 and 2, No. 7).

CRETACEOUS PLUTONS NORTHEAST OF THE SITKOH BAY FAULT

The terrane northeast of the Sitkoh Bay fault contrasts strikingly with the terrane to the southwest in that less than 5 percent of the area is underlain by Cretaceous plutonic rocks. These rocks crop out as discrete small plutons (Nos. 46–53), the largest of which is only 10 mi^2 in area. Only one of these plutons (No. 49; see No. 2 of tables 1 and 2 of Loney and others, 1967) has been dated radiometrically; (potassium-argon age 103±5 m.y.; lead-alpha age 150±20 m.y.); the remain-

TABLE 5. —*Petrographic data of the*

[Symbols are as follows: P = present in unspecified amount; T = trace; < = less than. All percent amounts estimated visually unless otherwise

Specimen No.	Rock name	Color index	Texture	Primary minerals[1] Quartz	Plagioclase	K-Feldspar	Biotite
				Diorite, tonalite, and granodiorite southwest			
	BODY NO. 17:						
61ALy 359	Biotite-hornblende granodiorite	20	------	15	55	10	7
360	Biotite-hornblende tonalite	25	hypidiomorphic granular.	10	65(An30–35)	------	7
361a	Muscovite-bearing biotite granodiorite	10	hypidiomorphic granular.	20	55(An20–22)	15	7
361b	Muscovite-bearing biotite granodiorite	10	hypidiomorphic granular.	25	52	10(microcline)	10
361c	Hornblende-bearing biotite tonalite	15	hypidiomorphic granular.	20	65(An30–34)	------	13
362	Biotite granodiorite	15	------	25	45	15	15
363	Hornblende-bearing biotite granodiorite	15	hypidiomorphie granular.	20	58(An22–28)	7?	12
367	Biotite granodiorite	15	------	20	55	10	15
61APy410	Biotite-hornblende tonalite	25	hypidiomorphic granular.	10	65(An33)	------	7
413	Altered diorite (?)	--	------	15	15(An6–14)	------	------
416	Biotite-hornblende tonalite	25	hypidiomorphic granular.	10	65(An33)	------	10
424	Biotite-bearing trondhjemite gneiss	5	granoblastic	20	55	20(microcline)	4
438	Chloritized biotite tmndhjemite	5	hypidiomorphic granular:	20	68(An20)	7	------
450	Biotite-hornblende diorite	25	hypidiomorphic granular.	8	67(An30–36)	------	10
462	Hornblende-bearing biotite grancdiorite	10	hypidiomorphic granular.	10	69(An30–36)	10	5
	BODY NO. 18:						
Unknown	Hornblende-bearing biotite tonalite	10	------	25	57(An30–50)	5(orthoclase)	9
Unknown	Biotite- and hornblende-bearing albite trondhjemite	5	------	25	60(An0–10)	10(microcline)	2.5
	BODY NO. 21:						
61ALy437	Biotite-hornblende tonalite	25	hypidiomorphic granular.	15	57(An30)	1	12
447	Biotite-hornblende diorite	25	hypidiomorphic granular.	8	66(An30–35)	T	9
462	Hornblende-biotite tonalite	15	hypidiomorphic granular.	20	63(An30)	T	9
61ABd575b	Biotite-hornblende tondite	15	hypidiomorphic granular.	15	70(An30–35)	T	5
585	Biotite-hornblende diorite	25	hyp~diomorphic granular.	8	67(An30)	T	8
	BODY NO. 22:						
61APy484	Muscovite- and biotite-bearing trondhjemite	5	granoblastic	30	55(An25)	7	4
				Tonalite, diorite, and gabbro between the			
	BODY NO. 27:						
61ABd143	Uralitized biotite quartz-leuconorite	29	------	12	P(An49)	------	8
144	Biotite-hornblende diorite	35	------	5?	P	------	P
145a	Uralitized biotite-augite diorite	37	------	7.5	54(An46)	0.5	14
145b	Hornblende-biotite melatonalite	60	------	P	P(An45)	------	P
146	Uralitized biotite-hypersthene diorite	30	hypidiomorphic granular.	7	P(An47)	0.5	P
155b	Hornblende-biotite diorite	32	------	<10	P	------	P
158	Uralitized biotite-augite diorite	30	------	6	P(An46)	1	P
185	Biotite-hornblende meladiorite	40	------	5	P	------	P
186	Biotite-hornblende melatonalite	40	------	17	P	------	P
	BODY NO. 32:						
61ALy67a	Hornblende gabbro	60	hypidiomorphic granular.	------	P(An68)	------	------
67b	Hblende gabbro	80	hypidiomorphic granular.	------	P(An70–62)	------	------
72	Chloritized uralitized leucogabbro	30	hypidiomorphic granular.	------	P(An64)	------	P
74	Uralitized gabbro and leucogabbro	30(coarse) 70(fine)	hypidiomorphic granular.	------	P(An64)	------	------
75a	Hornblende leucogabbro and hornblende meladiorite	60(fine) 30(coarse)	hypidiomorphic granular.	P	P(An56)	------	------
76a	Uralitiied gabbro	60	hypidiomorphic granular.	------	P(An60)	------	------
78	Serpentinized olivine leucogabbro(?)	30	------	------	P	------	------
80a	Hornblende gabbro	60	hypidiomorphic granular.	------	P(An59)	------	------
81	Uralitized augite norite	50	hypidiomorphic granular.	------	P(An53)	------	------
83b	Uralitized hypersthene gabbm	50	hypidiomorphic granular.	------	P(An52)	------	------
88	Chloritized hornblende gabbm	42	hypidiomorphic granular.	------	P(An61)	------	------
89	Uralitized leuconorite	37	hypidiomorphic granular.	------	P(An57)	------	------
91a	mblende gabbro	45	hypidiomorphic granular.	------	55(An79, 64)	------	------
91b	Hornblende diorite	30	hypidiomorphic granular.	------	P(An45)	------	P
92a	Gamet-bearing muscovite alaskite	3	allotriomorphic granular.	15	35(An11)	45	0.5
92b	Muscovite-biotite alaskite	2	allotriomorphic granular.	30	37	30(perthite)	2
94a	Uralitized leucogabbro	30	hypidiomorphic granular.	------	70(An68)	------	------

See footnotes at end of table.

Cretaceous plutons, Chichagof Island

noted. Uralite is used for all hornblende which rims, surrounds, fringes, or is in any way associated with "cores" of pyroxene]

Primary minerals'--Continued			Primary or secondary minerals'			Secondary minerals'		Opaques	Remarks
Hornblende	Muscovite	Pyroxene	Epidote	Sphene	Apatite	Chlorite	Muscovite		
of the Peril Strait fault									
13	--------	--------	------	------	------	--------	--------	--------	Estimated from stained slab.
15	--------	--------	2	------	T	1	--------	T	T prehnite in biotite; biotite formed from hornblende?
------------	3	--------	------	------	------	--------	--------	--------	T garnet.
------------	3	--------	------	------	------	--------	--------	--------	T garnet.
2	--------	--------	------	------	T	T	--------	T	Crudely foliated.
T	--------	--------	------	------	------	--------	--------	--------	Estimated from stained slab.
2	--------	--------	T	------	------	T	--------	T	T prehnite; foliated,
T	--------	--------	------	------	------	--------	--------	--------	Estimated from stained slab.
18	--------	--------	T	------	------	T	T	T	T prehnite.
------------	--------	--------	40	T	T	10	T	--------	20 percent prehnite.
15	--------	--------	3	T	------	5	T	T	Post-crystallization foliation present.
------------	--------	--------	T	------	------	1	T	T	
------------	--------	--------	1	------	T	4	--------	T	T prehnite; chlorite after biotite probably.
15	--------	--------	------	------	T	--------	--------	T	
3	--------	--------	2	T	T	T	--------	T	Some cataclasis.
1	--------	--------	------	------	T	T	T	3	From Reed and Coats (1941, p. 39); T prehnite.
2.5	--------	--------	T	------	T	T	--------	--------	From Reed and Coats (1941, p. 39); T allanite.
13	--------	--------	2	------	T	T	T	--------	Slight foliation.
15	--------	--------	1	------	T	--------	--------	T	
6	T	--------	1	------	T	--------	--------	1	
9	--------	--------	1	------	T	--------	--------	T	
16	--------	--------	1	------	T	--------	--------	T	
------------	3	--------	1	------	------	--------	--------	--------	T garnet; foliated.
Peril Strait and Sitkoh Bay faults									
12(uralite)	--------	3(augite) 4(hypersthene)	------	------	P	--------	--------	2	
P	--------	--------	------	------	------	P	--------	--------	(2)
20(uralite)	--------	1(augite)	------	------	1	--------	P	2	Augite cores hornblende; some protoclasis.
P	--------	--------	------	------	------	--------	--------	--------	(2)
P(uralite)	--------	P(hypersthene) P(augite)	------	------	P	--------	--------	P	
P	--------	--------	P	------	------	--------	--------	--------	(2)
P(uralite)	--------	P(augite) P(hypersthene?)	------	------	P	--------	--------	P	
P	--------	--------	------	------	------	--------	--------	--------	(2)
P	--------	--------	------	------	------	--------	--------	--------	(2)
P	--------	--------	P	------	P	P	--------	P	Layered; no pryoxene cores in hornblende.
P	--------	--------	------	------	P	--------	--------	P	Layered very fine grained and coarse grained.
P(uralite)	--------	P(augite) P(hypersthene?)	------	------	------	P	--------	P	
P(uralite)	--------	P(augite)	P	P	------	--------	--------	P	Layered; some plagioclase in fine-grained parts is An88.
P	--------	--------	------	------	------	P	--------	P	Layered; plagioclase in fine-grained part is An46.
P	--------	P(augite)	------	P	P	P	--------	P	
P(uralite)	--------	P(augite)	------	------	------	P	--------	P	Highly altered; prehnite after feldspar; antigorite after olivine?
P	--------	--------	------	------	------	--------	--------	P	No pyroxene cores in hornblende; prehnite after feldspar.
P(uralite)	--------	P(hypersthene) P(augite)	------	------	P	--------	--------	P	
P(uralite)	--------	P(augite) P(hypersthene)	------	------	------	P	--------	P	Layered.
P	--------	--------	P	------	------	P	--------	P	
P(uralite)	--------	P(hypersthene) P(augite)	------	------	------	--------	--------	P	Layered.
40	--------	--------	0.5	------	------	--------	--------	5	Hornblende is pseudomorphic after pyroxene.
P	--------	--------	P	------	P	P	--------	P	T prehnite.
------------	3	--------	------	------	------	--------	--------	.5	2 percent garnet; interlayered with diorite/gabbro.
------------	P	--------	------	------	------	P	--------	P	Interlayered with diorite/gabbro; protoclastic.
8(uralite)	--------	1(augite)	1	------	------	16	--------	4	Prehnite veinlet also.

TABLE 5.—*Petrographic data of the Cretaceous*

Specimen No.	Rock name	Color index	Texture	Primary minerals[1]			
				Quartz	Plagioclase	K-Feldspar	Biotite
				Tonalite, diorite, and gabbro between			
61ALy94b	Hornblende gabbm	60	hypidiomorphic granular.	------	39(An76)	------	------
94c	Quartz-bearing hornblende gabbro	50	hypidiomorphic granular.	5	45(An59)	------	------
94d	Hornblende gabbro	70	------	------	29(An60)	------	------
198a	Hornblende leucogabbro	35	------	------	P(An64)	------	------
198b	Biotite tmndhjemite	7	hypidiomorphic granular.	50	43(An30)	------	7
200	Hornblende gabbm	80	------	------	P	------	------
201	Uralitized leucogabbm	25	hypidiomorphic granular.	------	P	------	------
202	Uralitii leucogabbm	30	hypidiomorphic granular.	------	P	------	P
326a	Hornblende gabbro	45	------	------	P	------	------
326b	Uralitized gabbro	45	hypidiomorphic granular.	------	55(An63)	------	------
331	Hornblende gabbro	50	------	------	P(An48)	------	------
333	Hornblende gabbro	60	------	------	P	------	------
61APy373	Uralitized augite norite	50	hypidiomorphic granular.	------	P	------	------
376	Uralitized hypersthene leuconorite	25	hypidiomorphic granular.	------	P	------	------
377	Hornblende gabbm	40	------	------	P	------	------
380	Hornblende gabbro	60	------	------	P	------	------
383	Uralitized olivine? gabbm	40	hypidiomorphic granular.	------	60(An58)	------	------
384	Uralitized olivine-augite leuconorite	36	hypidiomorphic granular.	------	60(An61)	------	------
388	Chloritized hornblende gabbro	50	hypidiomorphic granular.	------	P(An60–47)	2	------
389	Biotite-bearing hornblende granodiorite	17	hypidiomorphic granular..	12	70(An33)	10	4
391	Hornblende meladiorite	50	------	P	P	------	------
406	Hornblende gabbm	50	------	------	P	------	------
61ABd395	Hornblende gabbro	45	------	------	P	------	------
396	Biotite-hornblende tonalite cataclasite	25	cataclastic.	P	P	------	P
397	Hornblende gabbm	60	------	------	P	------	------
398	Hornblende gabbro	50	------	------	P	------	------
408	Uralitized gabbro	40	protoelaatid hypidiomorphic granular	------	P	<0.5	------
409a	Quartz-bearing hornblende leucogabbm	35	------	P?	P(An59)	------	------
409b	Biotitii uralitized leuconorite	35	hypidiomorphic granular.	------	64(An47, 65)	------	5
410a	Biotite hornblende diorite cataclasite	------	cataclastic	P	P	<1	P
410b	Quartz-bearing hornblende leucogabbro	35	------	P?	P	------	------
411	Hornblende gabbro	50	------	------	P	------	------
412	Quartz-bearing hornblende leucogabbro?	30	------	P?	P	------	------
	BODY NO. 34:						
61ALy334b	Biotite alaskite?	5	------	30	P	P?	P
61APy13	Chloritized biotite-bearing hornblende tonalite	20	hypidiomorphic granular.	15	P	5	P
17	Biotite-bearing hornblende tonalite	35	------	20	P	------	P
19	Biotite-bearing hornblende tonalite	35	------	25	P	------	P
84	Uralitized leucogabbm	35	allotriomorphic/ protoclastic.	1	62(An79)	2	------
85	Biotite-hornblende tonalite	40	------	10	P	------	P
89	Biotite granodiorite(?)	15	------	10	P	P	P
109a	Biotite-bearing hornblendite	90	------	------	P	------	P
109b	Hornblende tonalite	30	------	P	P	------	------
114a	Chloritized biotite adamellite	15	hypidiomorphic granular.	25	35(An44)	25	9
114b	Hornblende tonalite	30	------	>10	P	------	------
117	Hornblende diorite	35	------	5	60(An23)	2	------
118	Trachyte or latite porphyry		------	------	------	P	P
392	Biotite-bearing hornblende [illegible]	25	------	12	63(An44)	T	3
61ABd29	Biotite- and hornblen[illegible] bearing t[illegible] it[illegible]	7	hypidiomorphic granular.	17.5	65(An28, 47)	10(microcline)	2.5
30	Biotite-hornblende tonalite	20	------	20	P	------	P
32	Alaskite pegmatite	2	------	P	------	P(orthoclase)	------
35	Biotite-hornblende tonalite	25	hypidiomorphic granular.	15	60(An27–33)	<1	8.5
36	Biotite-hornblende tonalite	30	------	25	P	------	P
37	Biotite-hornblende tonalite	25	------	25	P	------	P
38	Hornblende-biotite granodiorite	20+	------	20	53	7	P
149	Biotite-hornblende tonalite	35	------	15	P	2	P
150	Augite-bearing hornblende-biotite tonalite	25	hypidiomorphic granular.	15	59(An44)	1	11
154a	Augite-bearing hornblende tonalite	30	hypidiomorphic granular.	10	57(An37)	3	1
156	Hornblende-biotite tonalite	30	------	12+	P	2	P
453	Biotite granodiorite	20	------	P	P	------	P
61ABg135a	Biotite-hornblende tonalite	20	------	15	P	------	P
135b	Quartz-bearing? hornblende gabbro	50	------	P	P	------	------
143	Chloritized biotite granodiorite	13	allotriomorphic granular.	40	40(An24)	7	1
144	Biotite adamellite	20	------	20	P	P	P
157	Biotite-hornblende diorite	30	------	5	P	------	P
162	Biotite-hornblende melatonalite	50	------	P	P	------	P
171a	Chloritii biotite tonalite	27	------	15	54(An33)	4	21
	BODY NO. 35:						
61ABg130	Quartz-bearing hornblende gabbm	60	------	P	P(An64)	------	P
133	Hornblende gabbro	80	------	------	P	------	P
	BODY NO. 36:						
61ABd141	Biotite-hornblende tonalite	--	------	P	P	------	P

See footnotes at end of table.

plutons, Chichagof Island—Continued

Primary minerals[1]—Continued			Primary or secondary minerals[1]			Secondary minerals[1]		Opaques	Remarks
Hornblende	Muscovite	Pyroxene	Epidote	Sphene	Apatite	Chlorite	Muscovite		
Peril Strait and Sitkoh Bay faults—Continued									
50	--	--	--	--	1	--	--	10	
45	--	--	2	T	0.5	2	--	0.5	
60	--	--	1	--	--	2	--	7	1 percent prehnite.
P(uralite)	--	--	--	--	--	--	--	P	
--	--	--	--	--	--	--	--	--	T prehnite replacing biotite.
P	--	--	--	--	--	--	--	--	(2)
P(uralite)	--	P(augite) P(hypersthene)	--	--	--	--	--	P	
P(uralite)	--	P(augite)	--	P	P	P	--	P	
P	--	--	--	--	--	--	--	--	(2)
30(uralite)	--	9(augite)	--	--	--	1	--	5	Augite → uralite + opaque
P	--	P?	--	--	--	--	--	--	(2)
P	--	--	--	--	--	--	--	--	(2)
P(uralite)	--	P(hypersthene) P(augite)	--	--	P	--	--	P	
P(uralite)	--	P(augite) P(hypersthene)	--	--	--	--	--	P	Layered.
P	--	--	--	--	--	--	--	--	
P	--	--	--	--	--	--	--	--	
30(uralite)	--	6(augite)	--	--	1	--	--	3	0.5 percent olivine?; prehnite veinlet.
20(uralite)	--	7(hypersthene) 5(augite)	--	--	4	--	--	3	Layered, 0.5 percent serpentine; 0.5 percent olivine.
P	--	--	--	--	P	P	--	P	Layered.
9	--	--	0.5	--	0.5	3	--	1	< 0.5 percent myrmekite.
P	--	--	--	--	--	--	--	--	(2)
P	--	--	--	--	--	--	--	--	(2)
P	--	P?	--	--	--	--	--	--	(2)
P	--	--	--	--	--	--	--	P	Layered.
P	--	--	--	--	--	--	--	--	(2)
P	--	--	--	--	--	--	--	--	(2)
P(uralite)	--	P(augite)	--	--	P	P	--	P	Layered; T prehnite in plagioclase.
P	--	--	--	--	--	--	--	--	(2)
10(uralite)	--	12(hypersthene) 6(augite)	--	--	1	--	--	2	Biotite is altered from hornblende.
P	--	--	--	--	--	--	--	P	Layered.
P	--	--	--	--	--	--	--	--	(2)
P	--	--	--	--	--	--	--	--	(2)
P	--	--	--	--	--	--	--	--	(2)
--	--	--	--	--	--	P	--	--	Dike rock cutting amphibolite.
P	--	--	P	--	--	P	--	P	Foliated.'
P	--	--	--	--	--	--	--	--	Foliated.'
P	--	--	--	--	--	--	--	--	
13(uralite)	--	16(augite	2	0.5	0.5	2	--	1	
P	--	--	--	--	--	--	--	--	(2)
--	--	--	--	--	--	--	--	--	(2)
P	--	--	--	--	--	--	--	--	(2)
P	--	--	--	--	--	--	--	--	Foliated; cut by biotite granodiorite.[2]
<0.5	--	--	--	1	--	4	P	1	
P	--	--	--	--	--	--	--	--	(2)
25	--	<1(augite)	--	--	1	--	P	3	Foliated; so ne An10 plagioclase also.
--	--	--	--	--	--	--	--	--	Porphyritic dik ir ornblende diorite.[2]
12	--	--	1	1	0.5	7	--	1	Biotite and chlorite replace hornblende.
2.5	--	--	0.5	--	0.5	1	P	0.5	
P	--	--	--	--	--	--	--	--	
--	P	--	--	--	--	--	--	--	(2)
15	--	--	--	--	0.5	P	--	1	Prehnite also, replacing biotite?
P	--	--	--	--	--	--	--	--	(2)
P	--	--	--	--	--	--	--	--	(2)
20	--	--	--	--	--	--	--	--	(2)
P	--	--	P	--	--	--	--	--	(2)
8	--	3(augite)	0.5	T	2	1	T	0.5	
16	--	2.5(augite)	3	T	0.5	6	--	1	0.5 percent schorl.
P	--	--	--	--	--	P	--	--	(2)
--	--	--	--	--	--	P	--	--	(2)
P	--	--	--	--	--	--	--	--	(2)
P	--	--	--	--	--	--	--	--	(2)
--	1	--	4	--	1	6	--	1	
--	--	--	--	--	--	--	--	--	Garnet present also.
P	--	--	--	--	--	P	--	--	(2)
P	--	--	--	--	--	--	--	--	
<0.5	--	--	--	--	<0.5	5	--	1	
P	--	--	--	--	--	--	--	--	(2)
P	--	--	--	--	--	--	--	--	(2)
P	--	--	--	--	--	--	--	--	Foliated.[2]

TABLE 5.--*Petrographic data of the Cretaceous*

Specimen No.	Rock name	Color index	Texture	Primary minerals[1]			
				Quartz	Plagioclase	K-Feldspar	Biotite
				Tonalite, diorite, and gabbro between the			
61ABg40	Chloritiied biotite-bearing adamellite	5	Hypidiomorphic granular	24.4	51.2(An30)	19.5(microperthite)	1.2
44	Uralitized anorthosite	7	allotriomorphic granular	0.2	92.0(An63–67)	0.6	------
	BODY NO. 37:						
61APy394	Hornblende diorite	40	------	------	P(An48)	------	P
397a	Hornblende gabbro	50	------	------	P	------	------
397b	Biotite-bearing alaskite	3	------	P	P	P?	P
398	Uralitized gabbro	55	hypidiomorphic granular.	------	45(An77)	------	------
61ABd451b	Hornblende gabbro	60	------	------	P	------	------
451c	Hornblende gabbm	70	------	------	P	------	------
451d	Hornblende tonalite	25	------	10	P	------	------
	BODY NO. 38:						
61ALy324a	Biotite-hornblende diorite	35	------	------	P	------	P
324b	Hornblende microdiorite		------	------	P	------	------
324c	Hornblende diorite	25	------	------	P(An23)	------	------
327	Hornblende tonalite	30		10?	P	------	------
332	Biotite-hornblende tonalite	30	hypidiomorphic granular.	15	53(An42)	2	10
61ABg418	Biotite-bearing hornblende diorite	35	------	------	P(An44)	------	P
419	Hornblende diorite	25	------	5	P	------	------
420	Hornblende diorite	20	------	<5	P	------	------
422a	Hornblende diorite	25	------	------	P	------	------
422b	Hornblende meladiorite	40+	------	------	P	------	------
424	Biotite-bearing hornblende diorite	30	hypidiomorphic granular.	P	P(An43)	------	2
	BODY NO. 39:						
61APy369	Hornblende diorite		hypidiomorphic granular.	P	P	------	------
370	Hornblende microgabbro?	60	------	P?	P	------	------
372	Hornblende meladiorite	45	hypidiomorphic granular.	------	P(An45)	------	------
381	Hornblende meladiorite	42	hypidiomorphic granular.	------	P	------	------
382	Hornblende diorite	30	------	P?	P	------	------
61ABg410	Hornblende micmgabbm	50	------	------	P	------	------
411	Hornblende diorite and meladiorite	25–60	hypidiomorphic granular.	------	P(An40)	------	------
413	Uralitized gabbro	40	hypidiomorphic granular.	------	P	------	------
415	Hornblende gabbro	42	hypidiomorphic granular.	------	P	------	------
416	Uralitii leucogabbro	35	hypidiomorphic granular.	------	P(An48)	------	------
438a	Uralitized hypersthene diorite	20	hypidiomorphic granular.	3	75(An37)	------	
438b	Hornblende diorite	20	------	------	P	------	------
438c	Hornblende gabbro	50	hypidiomorphic granular.	------	P	------	------
438d	Hornblende tonalite and "amphibolite"	30–80	------	P	P	------	------
439	Hornblende diorite and "amphibolite"	25–80	------	------	P	------	------
	BODY NO. 40:						
61ALy129	Uralitized quartz-bearing biotite-augite diorite	25	------	5	P	<1	P
132	Biotite-hornblende granodiorite.	25	hypidiomorphic granular.	17	45	13	10?
176	Uralitized quartz-bearing biotite-augite diorite	30	hypidiomorphic granular.	7	63	<1	P
185	Hornblende-bearing biotit gra[illegible] p[illegible]ry	8	porphyritic.	>20	10	<72	4
187d	Hornblende granodiorite porphyry	20	porphyritic.	> 5	35	5	------
188	Qu[illegible]tz-b[illegible] hornblende diorite	33	hypidiomorphic granular.	5	P	2	------
190b	Hornblende meladiorite	55	hypidiomorphic granular.	------	P(An44)	2	P
191	Biotite adamellite	6	hypidiomorphic granular.	28	35	30	7
61APy32	Biotite-hornblende tonalite	25	------	P	P	------	P
34	Biotite-bearing hornblende granodiorite	15	panidiomorphic granular.	25	40(An30?)	20	3
37	Biotite bearing hornblende gabbm	80	------	------	P	------	P
38	Hornblende gabbm	60	------	------	P	------	------
39	Biotite-hornblende tonalite	40	hypidiomorphic granular.	10?	42(An48)	<2	5
42	Hornblende-biotite tonalite	15	------	20	P	------	P
43	Biotite-hornblende tonalite	20	hypidiomorphic granular.	15	60(An36–48)	1	7.5
44	Biotite-hornblende meladiorite	45	hypidiomorphic granular.	<5	50?(An40)	4	P
166	Hornblende gabbm	40	hypidiomorphic granular.	------	P(An50?)	------	------
169	Biotite-hornblende meladiorite	70	hypidiomorphic granular.	------	P(An46)	1	P
170	Hornblende diorite	30	hypidiomorphic granular.	------	P	------	------
173	Biotite-bearing hornblende tonalite	40	hypidiomorphic granular.	20	P(An45)	<1	P
177	Biotite hornblende tonalite	38	hypidiomorphic granular.	10	P	<1	13
181	Hornblende-biotite diorite	20	------	5?	P	------	P
188	Biotite-hornblende melatonalite	45	hypidiomorphic granular.	10	45(An44)	------	P
190	Biotite-hornblende melatonalite	42	hypidiomorphic granular.	12	P(An42)	2	P

See footnotes at end of table.

plutons, Chichagof Island—Continued

Primary minerals[1]—Continued			Primary or secondary minerals[1]			Secondary minerals[1]		Opaques	Remarks
Hornblende	Muscovite	Pyroxene	Epidote	Sphene	Apatite	Chlorite	Muscovite		
Peril Strait and Sitkoh Bay faults--Continued									
------------	--------	------------	T	T	T	2.5	--------	1.2	Point-counted mode.
1.8	0.2	0.2(hyperstene)	------	------	0.2	4.4	--------	0.4	Point-counted mode; specimen might be from body 55
P	--------	------------	------	------	------	--------	--------	--------	(2)
P	--------	------------	------	------	------	--------	--------	--------	(2)
------------	--------	------------	------	------	------	--------	--------	--------	(2)
20(uralite)	--------	30(augite)	------	------	<.5	--------	--------	5	
P	--------	------------	------	------	------	--------	--------	P	(2)
P	--------	P(hypersthene)	------	------	------	--------	--------	P	(2)
P	--------	------------	------	------	------	P	--------	--------	(2)
P	--------	------------	------	------	------	--------	--------	--------	(2)
P	--------	------------	------	------	------	--------	--------	--------	Chilled margin of dike cutting 61 ALy324a.[2]
P	--------	------------	------	------	------	P	--------	--------	(2)
P	--------	------------	------	------	------	--------	--------	--------	(2)
13	--------	------------	------	0.5	0.5	4	--------	2	Biotite → chlorite + sphene.
P	--------	------------	------	P	P	P	--------	P	Foliated.
P	--------	------------	------	------	------	--------	--------	--------	(2)
P	--------	------------	------	------	------	--------	--------	--------	
P	--------	------------	------	------	------	--------	--------	--------	Foliated.[2]
P	--------	------------	------	------	------	P	--------	--------	(2)
25	--------	------------	P	P	P	P	--------	2	Layered.
P	--------	------------	------	------	P	P	--------	P	Prehnite veinlet also
P	--------	------------	------	------	------	--------	--------	--------	May be meladiorite?
P	--------	------------	------	------	------	--------	--------	P	
P	--------	------------	P	------	P	--------	--------	P	Foliated
P	--------	------------	------	------	------	--------	--------	--------	Foliated.'
P	--------	------------	------	------	------	--------	--------	--------	May be meladiorite.[2]
P(uralite)	--------	------------	------	P	------	--------	--------	P	Banded coarse (C.I. 25) and fine (C.I. 60).
P(uralite)	--------	P(augite)	------	------	------	P	--------	P	
P	--------	------------	------	P	------	--------	--------	P	
P(uralite)	--------	P(augite)	------	------	------	--------	--------	P	Bastite present.
15(uralite)	--------	2(hypersthene)	------	------	1	--------	--------	3	
P	--------	------------	P	------	P	P	--------	P	
P	--------	------------	P	P	------	--------	--------	--------	
P	--------	------------	------	------	------	--------	--------	P	Mixed coarse (C.I. 30) and fine (C.I. 80), garnet?-bearing?
P	--------	------------	------	------	------	--------	--------	--------	Layered coarse (C.I. 25) and fine (C.I. 80).[2]
P(uralite)	--------	P(augite)	------	------	P	P	P	P	Foliated.
15?	--------	------------	------	P	P	P	T	--------	
P(uralite)	--------	(augite)	------	------	P	P	--------	--------	
4	--------	------------	------	------	------	--------	--------	--------	28 percent phenocrysts.
>10(uralite)	--------	------------	------	------	------	--------	--------	P	Myrmekite P; 50 percent phenocrysts.
P	--------	------------	------	P	------	P	--------	P	Foliated.
P	--------	------------	P	P	P	P	--------	P	
------------	--------	------------	P	------	P	--------	P	P	
P	--------	------------	------	------	------	--------	--------	--------	Crudely foliated!
5	--------	------------	------	0.5	------	3	--------	1.5	Biotite replacing hornblende, chlorite after biotite, 1 percent prehnite.
P	--------	------------	------	------	------	--------	--------	P	(2)
P	--------	------------	------	P?	------	--------	--------	--------	(2)
35	--------	------------	------	------	1	--------	--------	P	Biotite replacing hornblende.
P	--------	------------	------	------	------	--------	--------	--------	(2)
10	--------	------------	------	------	0.5	--------	--------	2.5	
P	--------	------------	------	------	P	--------	--------	--------	Biotite replacing hornblende.
P	--------	------------	------	------	P	--------	--------	P	
P	--------	------------	------	------	------	P	--------	P	Hornblende → biotite + opaques.
P	--------	------------	------	P	P	--------	--------	P	
P	--------	------------	------	P	P	P	--------	P	
25	--------	------------	------	------	------	--------	--------	P	
P	--------	------------	------	P	------	--------	--------	--------	(2)
P	--------	------------	P	------	P	P	P	P	
P	--------	------------	------	------	P	P	--------	P	

TABLE 5.—Petrographic data of the Cretaceous

Specimen No.	Rock name	Color index	Texture	Primary minerals[1]			
				Quartz	Plagioclase	K-Feldspar	Biotite
				Tonalite, diorite, and gabbro between the			
61APy199	Biotite-hornblende diorite	35	hypidiomorphic granular.	------	61	4	P
205	Hornblende meladiorite	45	hypidiomorphic granular.	<5	P(An46?)	------	------
208	Hornblende adamellite porphyry	7	porphyritic.	33	35(An45)	25	------
214	Biotite-hornblende tonalite	35	------	20	P(An37)	1	P
221	Biotite-hornblende melatonalite	50	hypidiomorphic granular.	10	P(An46)	3	P
227	Hornblende tonalite	30	hypidiomorphic granular.	10	P(An39)	------	P
229	Hornblende micmgabbm	60?	------	------	P	------	------
230	Hornblende diorite	30	------	P	P	------	------
360	Uralitized quartz-bearing augite leuconorite	35	hypidiomorphic granular.	5?	P(An49)	------	P
363	Hornblende tonalite	38	hypidiomorphic granular.	10	P	------	------
365	Hornblende diorite	35	hypidiomorphic granular.	------	P	------	P
368	Uralitized gabbm	43	hypidiomorphic granular.	PI	P	------	------
61ABd18	Biotite-hornblende tonalite	30	------	20	P	3	P
26	Biotite-hornblende tonalite	20	------	10	P	------	P
41	Hornblende tonalite	10?	hypidiomorphic granular.	10	P(An44)	3	------
245	Uralitized(?) biotite-augite tonalite	35	hypidiomorphic granular.	15	45	5	P
250	Uralitized quartz-bearing biotite-augite diorite	37	hypidiomorphic granular.	8	P	<1	P
261	Biotite-hornblende tonalite	17	hypidiomorphic granular.	40	40	3	P
264	Biotite trondhjemite porphyry	7	allotriomorphic granular.	30	53	10	P
265b	Quartz-bearing biotite-hornblende diorite	35	hypidiomorphic granular.	5	P	2	P
270	Biotite-hornblende tonalite	17	hypidiomorphic granular.	15	65	3	P
272	Biotite-hornblende tonalite	25	hypidiomorphic granular.	20	P	3	P
278	Hornblende-biotite granodiorite	15	hypidiomorphic granular.	15	55	15	P
281	Hornblende-bearing biotite granodiorite	15	hypidiomorphic granular.	15	63	15	P
287	Quartz-bearing hornblende meladiorite	50	hypidiomorphic granular.	5	P(An45)	1?	------
288	Hornblende tonalite	30	hypidiomorphic granular.	12	P	3	P
291	Hornblende diorite	17		<5	P	------	------
298	Biotite-hornblende tonalite	30	hypidiomorphic granular.	12	P	------	P
61ABg32	Chloritized hornblende diorite	35	hypidiomorphic granular.	P	45	20	------
79	Hornblende gabbm	55	------	------	P(An74)	------	P
86	Biotite-hornblende tonalite	25	------	10?	P	------	P
89	Biotite-hornblende tonalite	25	------	30	P	------	P
204	Hornblende diorite	20	------	------	P	------	------
210	Chloritized biotite? alaskite	3	hypidiomorphic granular.	45	35	15	------
214	Chloritized hornblende tonalite	30	hypidiomorphic granular.	10	P	2	------
240	Biotite- and quartz-bearing hornblende meladiorite	50	------	8	P	<1	P
257	Biotite-hornblende tonalite porphyry	20	porphyritic.	P	>40	<3	P
258	Hornblende grancdiorite porphyry	15	porphyritic.	>10	>30	5	------
259	Biotite trondhjemite porphyry	3	porphyritic.	44	50	3	P
266	Biotite-hornblende diorite	30	hypidiomorphic granular.	------	P	2	P
272	Hornblende melatonalite	42	hypidiomorphic granular.	10	46	2	------
273	Muscovite-bearing biotite trondhjemite	8	hypidiomorphic granular.	25	47	20	6
62AMp196	Uralitii olivine-augite gabbm	43	ophitic.	------	57.1(An59)	------	------
199	Biotite-hornblende granodiorite	20	hypidiomorphic granular.	25	41(An26)	10(perthite)	5
202	Tonalite cataclasite	6	cataclastic.	40	40(An3–10)	3	------
347	Biotite-hornblende diorite	27	hypidiomorphic granular.	9.2	63.6(An47)	T	5.8
60ABg590	Biotite-bearing hornblende meladiorite	41	hypidiomorphic granular.	4.5	54.3(An45)	0.3(orthoclase)	2.6
593	Uralitized olivine leucogabbro	31	allotriomorphic granular.	------	68.7(An78)	------	------
60AHw487	Biotite-bearing hornblende tonalite	12	hypidiomorphic granular.	15.0	72.8(An48)	------	3.2
487	Biotite-bearing hornblende meladiorite	50	allotriomorphic granular.	------	48.7(An45–48)	------	1.6
518	Biotite-hornblende quartz leucogabbro	34	hypidiomorphic granular.	20	45(An52)	T	6
518	Hornblende meladiorite	44	allotriomorphic granular.	T	55(An40)	------	T
	BODY NO. 41:						
61ABd20	Biotite-hornblende tonalite	20	------	15	P	------	P
22a	Hornblende gabbm?	50	------	P?	P	------	P
22b	Hornblende gabbro	50	------	P	P	------	------
24	Chloritized hornblende meladiorite	50	------	5	43(An46)	2	------
28a	Hornblende meladiorite	40	------	------	P	------	------
28b	Hornblende meladiorite	40	------	------	P	------	------
28c	Biotite granite?	10	------	P	P(An7)	30	P

See footnotes at end of table.

plutons, *Chichagof* Island—Continued

Primary minerals'--Continued			Primary or secondary minerals'			Secondary minerals[1]		Opaques	Remarks
Hornblende	Muscovite	Pyroxene	Epidote	Sphene	Apatite	Chlorite	Muscovite		
Peril Strait and Sitkoh Bay faults--Continued									
P	--------	------------	------	P	------		--------	P	
P	--------	------------	------	------	P	--------	--------	P	Prehnite P
P	--------	------------	P	P	P	P	--------	P	50 percent phenocrysts.
P	--------	------------	------	------	------	--------	--------	P	
P	--------	------------	------	------	P	--------	P	P	
P	--------	------------	------	------	P	P	--------	P	Prehnite P
P	--------	------------	------	------	------	--------	--------	--------	([2])
P	--------	------------	------	------	------	--------	--------	--------	Foliated.[2]
P(uralite)	--------	P(hypersthene) P(augite)	------	------	P	--------	--------	--------	
P	--------	------------	P	P	P	P	--------	P	Hornblende → epidote + chlorite + sphene.
P	--------	------------	------	P	------	P	--------	P	
P(uralite)	--------	P(augite)	------	------	P	P	--------	P	Foliated.
P	--------	------------	------	------	------	--------	--------	--------	([2])
P	--------	------------	------	------	------	P	--------	--------	([2])
P	--------	------------	P	------	P	--------	--------	P	Foliated.
P	--------	P(augite)	------	------	P	--------	--------	P	
P(uralite)	--------	P(augite)	------	------	P	--------	--------	P	
P	--------	------------	------	------	------	P	--------	P	Foliated.
------------	--------	------------	------	P	------	--------	--------	P	
P	--------	------------	------	------	------	--------	--------	P	
P	--------	------------	------	P	P	P	--------	P	
20	--------	------------	P	P	P	P	P	P	Biotite → chlorite + epidote.
P(uralite)	--------	------------	------	------	------	P	--------	P	
P	--------	------------	------	------	P	--------	--------	P	
P	--------	------------	------	P	P	P	--------	P	Calcite P.
P	--------	------------	P	P	------	P	--------	P	
P	--------	------------	P	------	P	--------	--------	P	
P	--------	------------	------	P	P	--------	--------	P	
------------	--------	------------	P	------	P	P	--------	P	Plagioclase very altered.
P	--------	------------	------	P	------	--------	--------	--------	([2])
P	--------	------------	------	------	------	--------	--------	--------	Foliated.'
P	--------	------------	------	------	------	--------	--------	--------	([2])
P	--------	------------	P	------	P	--------	--------	P	Foliated.
------------	--------	------------	P	------	------	P	--------	P	
25	--------	------------	P	------	P	P	--------	P	Hornblende → chlorite
P	--------	------------	------	------	P	--------	--------	P	
P	--------	------------	------	------	------	--------	--------	P	60 percent phenocrysts.
P	--------	------------	------	------	------	--------	--------	P	45 percent phenocrysts.
------------	--------	------------	P	------	------	P	--------	--------	50 percent phenocrysts.
P	--------	------------	P	P	P	P	--------	P	Foliated.
40	--------	------------	------	P	------	--------	--------	P	
------------	P	------------	------	------		P	--------	P	
36.8(uralite)	--------	3.1(augite)	T	T	------	0.5	--------	2.1	Point-counted mode; foliated; 0.2 percent olivine → serpentine
12	--------	------------	T	T	T	T	T	2	Layered with fine-grained biotite-hornblende tonalite.
------------	--------	------------	2	1	------	3	--------	--------	5 percent calcite; 5 percent prehnite
18.9	--------	------------	T	T	0.4	0.7	--------	1.4	Point-counted mode.
35.6(uralite)	--------	T(augite)	------	T	0.1	--------	P	3.2	Point-counted mode.
10.2(uralite)	--------	7.9(augite)	------	------	T	--------	--------	3.0	Point-counted mode, augite → hornblende; 9.4 percent olivine→, serpentine.
7.0	--------	------------	T	T	0.3	0.4	T	1.3	point-counted mode of light-colored layer.
46.1	--------	------------	------	T	0.8	T	T	2.4	Point-counted mode of dark schliere, T prehnite
25	--------	------------	------	------	1	T	T	3	Coarse layer, T prehnite.
40	--------	------------	T	------	1	T	T	4	Fine layer.
P	--------	------------	------	P	------	--------	--------	--------	Foliated.'
P	--------	------------	------	P	------	--------	--------	--------	([2])
P	--------	------------	------	------	------	--------	--------	--------	([2])
36(uralite)	--------	<0.5(augite)	4	1	1	5	P	1	Hornblende → chlorite, 1 percent calcite
P	--------	------------	------	------	------	--------	--------	--------	Layered very fine and coarse grained.'
P	--------	------------	------	------	------	--------	--------	--------	Layered.
------------	--------	------------	------	------	------	--------	--------	--------	Interlayered with hornblende hornfels.

TABLE 5.—*Petrographic data of the Cretaceous*

Specimen No.	Rock name	Color index	Texture	Primary minerals[1]			
				Quartz	Plagioclase	K-Feldspar	Biotite
				Tonalite, diorite, and gabbro between the			
61ABd47a	Hornblende tonalite	35	--	P	P	--	--
61ABg84	Biotite-bearing hornblende granodiorite	12	--	20	50(An28)	15	3.5
90	Hornblende tonalite	15	--	20	P	--	--
	BODY NO. 42:						
61ALy210b	Hornblende diorite	40	hypidiomorphic granular.	--	P(An47)	--	--
				Granodiorite, adamellite, and diorite			
	BODY NO. 50:						
61APy25	Chloritized biotite-hornblende diorite	23	--	5.6	64.4(An42)	3.2	2.3
61ABd48a	Chloritized biotitized hornblende diorite	31	allotriomorphic granular.	4.7	61.4(An40)	2.8	2.3
48a	Hornblende melatonalite	42	allotriomorphic granular.	10.2	39.6(An38)	4.2	0.2
	BODY NO. 51:						
61APy58	Hornblende-biotite granodiorite	--	--	P	P	P	P
59	Chloritized hornblende-biotite granodiorite	10	hypidiomorphic granular.	31.6	48.2(An46)	9.2(orthoclase)	1.8
61ABd133	Biotite-hornblende granodiorite	23	hypidiomorphic granular.	14	60(An37)	7	7
61ABd136b	Biotite-hornblende meladiorite(?)	45	allotriomorphic cataclastic.	--	P	2	P
	BODY NO. 52:						
61APy136	Biotite- and hornblende-bearing trondhjemite	8	--	15	66(An43?)	10(orthoclase)	2
61ABg190	Biotite-hornblende granodiorite	--	--	P	P	P	P
192	Biotite-hornblende granodiorite	--	--	20	P	P	P
195	Biotite-hornblende granodiorite	--	--	P	P	P	P
226	Biotite-hornblende granodiorite	--	--	P	P	P	P
	BODY NO. 53:						
61ALy155a	Chloritized biotite-hornblende diorite	40	hypidiomorphic granular/protoclastic.	8	50(An35–52)	2(orthoclase)	9
155b	Chloritized biotite-hornblende granodiorite	20	hypidiomorphic granular/protoclastic.	17	40(An30–40)	13	P
156a	Biotite-hornblende granodiorite	--	--	P	P	15	P
156b	Hornblende tonalite	--	--	P	P	<5	--
157	Biotite-hornblende tonalite	--	--	P	P	--	P

[1]Given in volume percent.

ing seven are inferred to be of Cretaceous age by petrographic and structural similarity.

The plutons range in composition from diorite through tonalite and trondhjemite to granodiorite (table 2). They are sharply bounded masses that, in general, are discordant to the regional structure; internal foliation is less conspicuous than in the Cretaceous plutons southwest of the Tenakee Inlet fault. Metamorphic aureoles are only a few tens of feet wide and show assemblages up to the hornblende hornfels facies. Thrust faults marginal to pluton No. 49 are interpreted by Loney, Condon and Dutro (1963) to indicate forcible intrusion. All these factors indicate that the plutons are epizonal according to the classification of Buddington (1959). The block northeast of the Tenakee Inlet fault appears to represent a structurally higher part of the crust than does the block southwest of the fault.

CRETACEOUS(?) GABBROS ON BARANOF ISLAND

Two bodies of gabbro crop out near the center of Baranof Island. The first (No. 54, pl. 2) is 6 miles due east of the head of Silver Bay and about 1% miles southeast of triangulation station "Lacy" (at 5,328 ft., the highest point on Baranof Island); the second (No. 55, pl. 2) is 3 miles east-southeast of the first. Both bodies are in an exceedingly inaccessible part of Baranof Island and are largely obscured by glaciers and snow.

The gabbro bodies intrude phyllite, greenschist, amphibolite and chert of Triassic or Jurassic age. The bodies lie within the metamorphic aureole surrounding the Tertiary Kasnyku pluton and are cut by granodiorite dikes probably related to this batholith. The gabbros show compositional layering defined by variation in grain size and percent of plagioclase. Although this probable cumulate-type layering dips moderately to steeply and one observation of grading suggests overturning, the gabbros are penetratively deformed only locally. The gabbro bodies appear to have been emplaced during the later part of the major Cretaceous(?) deformation, prior to the emplacement of the Tertiary granitic plutons.

The gabbros are gray-green rocks composed dominantly of actinolite, with subordinate plagioclase, bronzite, diopsidic augite, cummingtonite, quartz, and opaque minerals. The actinolite is green to tan in hand specimen and colorless to very pale tan in thin section. It occurs as equant to slightly elongate untwinned crystals averaging 2 mm; in some samples the crystals are as much as 3 cm. It has a Z index of refraction of about 1.643, negative optical sign, and moderate 2V. Using the curves of Deer, Howie, and Zussman (1963, p. 257), the composition is estimated at about 80 percent tremolite end member. The actinolite occurs in a reaction relation to both clinopyroxene and orthopyroxene. The clinopyroxene, a colorless diopsidic augite with a 2V of about 53° (determined on a universal stage), occurs commonly as ragged, corroded remnants with actinolite crystals (fig. 15). The orthopyroxene is a color-

plutons, **Chichagof Island--Continued**

Primary minerals'--Continued			Primary or secondary minerals			Secondary minerals		Opaques	Remarks
Hornblende	Muscovite	Pyroxene	Epidote	Sphene	Apatite	Chlorite	Muscovite		
Peril Strait and Sitkoh Bay faults—Continued									
P	---	---	---	P	---	---	---	---	(2)
7	---	---	---	0.5	---	---	---	1	Foliated; 2 percent myrmekite.
P	---	---	---	P	---	---	---	---	Foliated.[2]
P	---	---	---	---	P	---	---	P	(2)
northeast of the Sitkoh Bay fault									
16.0	---	---	1.8	1.2	0.6	4.2	0.4	0.6	Pointcounted mode.
23.8	---	---	T	0.9	T	3.7	T	0.4	Fine grained layer; point-counted mode.
40.2	---	---	2.0	T	---	1.2	2.2	0.2	Medium grained layer; point-counted mode.
P	---	---	---	---	---	---	---	---	
3.2	---	---	T	0.2	T	4.4	---	0.8	Point-counted mode; T myrmekite.
15	---	---	---	<1	<1	---	---	1	Perthite P.
P	---	---	---	P	---	P	---	P	Mafic clot in granodiorite like 61ABd133.
4	---	---	<0.5	1.5	0.5	<0.5	---	0.5	1.5 percent myrmekite.
P	---	---	---	---	---	---	---	---	(2)
P	---	---	---	---	---	---	---	---	(2)
P	---	---	---	---	---	---	---	---	(2)
P	---	---	---	---	---	---	---	---	(2)
25	---	---	2	0.5	0.5	3	<0.5	---	Foliated.
P	---	---	P	P	P	P	---	P	
P	---	---	---	P	---	---	---	---	(2)
P	---	---	---	---	---	---	---	---	Foliated.[2]
P	---	---	P	---	---	---	---	---	(2)

%formation from binocular microscope study of hand specimen and from grain amounts.

less bronzite with 2Vz of about 83° (determined on a universal stage) and a Z index of refraction approximately 1.683. Bronzite was found only in one specimen, where it occurs as subhedral stubby crystals enclosed in actinolite. A few bronzite crystals are corroded and mantled by actinolite (fig. 15). Plagioclase occurs interstitially to actinolite (fig. 16) and shows no zoning. Plagioclase in samples from the central parts of the bodies is very fresh **bytownite** or labradorite, but in specimens from near the margins is partly or wholly sericitized and can be at least as sodic as andesine. Quartz occurs as an interstitial, primary crystallization product in several samples (fig. 16). No olivine crystals or olivine pseudomorphs were noted. Opaque minerals occur as subhedral equant crystals intergranular to bronzite but enclosed by actinolite and plagioclase.

Many of the specimens show traces of a fine-grained, fibrous, complexly twinned amphibole that both re-

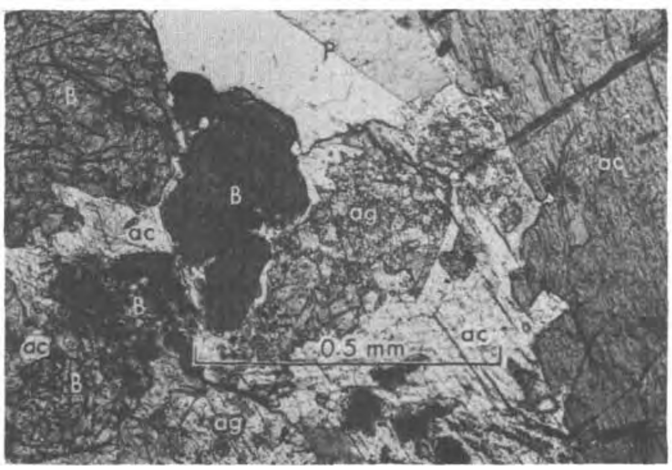


FIGURE 15.—Photomicrograph of actinolite-bearing gabbro. Specimen 62ALy223c. Partly crossed polars. Remnants of diopsidic augite (ag) enclosed in actinolite (ac). Subhedral bronzite (B) partly corroded by actinolite. Interstitial twinned plagioclase (P).

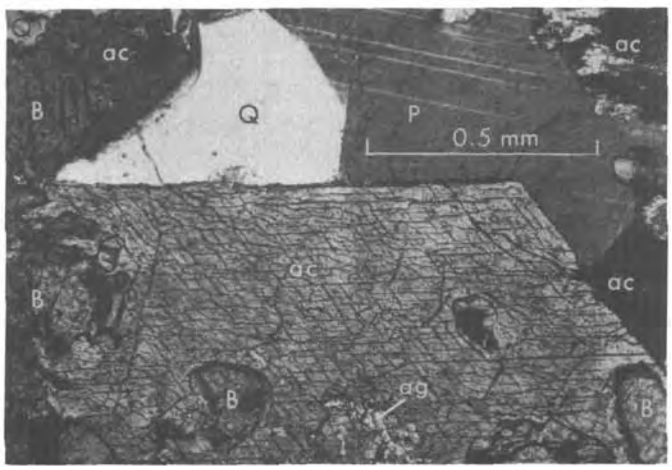


FIGURE 16.—Photomicrograph of actinolite-bearing gabbro. Specimen 62ALy223c. Partly crossed polars. Diopsidic augite (ag) remnants in actinolite (ac). Bronzite (B) enclosed by actinolite. Plagioclase (P) and quartz (Q) interstitial to actinolite.

TABLE 6.--*Petrographic data of the Tertiary(?) layered*

[Symbols are as follows: P = present in unspecified amount; T = trace; < = less than. All percent amounts estimated visually unless otherwise

Specimen No.	Rock name	Color index	Texture	Primary minerals[1]				
				Quartz	Plagioclase	K-Feldspar	Biotite	Hornblende
	BODY NO. 56:							
61ABd147	Uralitii leuconorite	30	------	------	P(An58)	------	------	P(uralite)
148	Uralitized leucogabbro	26	hypidiomorphic granular.	3	71(An49)	------	2	19(uralite)
151a	Hornblende gabbro	70	porphyritic	------	P(An60)	------	------	P
151b	Uralitized olivine(?)-bearing leucogabbro	30	allotriomorphic granular.	------	67(An77)	3	------	15(uralite)
151c	Hornblende tonalite	30	------	P	P	------	------	P
152a	Hornblende gabbro	50	------	------	P	------	------	P
152b	Hornblende gabbro	46	allotriomorphic granular.	------	43.6(An78)	------	------	54.2
153a	Biotite-bearing trondhjemite	3	hypidiomorphic granular.	17	65(An33)	15	2	------
153b	Biotite tonalite(?)	15	allotriomorphic granular.	10	P(An37)	2	P	------
157	Uralitized leuconorite	30	hypidiomorphic granular.	1?	69(An57)	------	3	10(uralite)
161	Uralitii leucogabbro	34	alltromorphic granular.	------	65.8(An76)	------	------	11.3(uralite)
165	Uralitized gabbm	50	hypidiomorphic granular.	------	P(An73)	------	------	P(uralite)
167	Uralitized leuconorite	37	hypidiomorphic granular.	------	62.6(An64)	------	------	6.4(uralite)
169a	Augite leuconorite	35	hypidiomorphic granular.	2	62(An56)	1	1	2(uralite)
169b	Uralitii leucogabbm	35	hypidiomorphic granular.	------	64(An53)	<0.5	1	21(uralite)
170a	H[illegible] br	30/80	------	------	P	------	------	P
170b	Qu[illegible]ing hornblende leucogabbro	35	------	P	P(An60)	------	------	P
172a	Hornblende gabbro(?)	80	granoblastic/ allotriomorphic granular.	------	P(An78)	------	------	P
172b	Quartz-bearing hornblende leuconorite	20	------	12	P(An56)	------	------	P
174	Hornblende leucogabbro	35	hypidiomorphic granular.	------	65(An64)	------	0.5	12.5
176	Uralitized(?) leuconorite	25	------	------	P(An56)	------	------	P
177	Leuconorite	30	------	------	P	------	------	P?
178	Uralitized quartz-bearing leuconorite	30	hypidiomorphic granular.	1	64(An64)	------	------	10(uralite)
179	Hornblende leucogabbm	30	------	------	P(An59)	<0.5	------	------
180a	Augite leuconorite	39	hypidiomorphic granular.	------	60(An78)	------	------	3(uralite)
180b	Hornblende gabbm	85	------	------	P(An64)	------	------	P
182	Hornblende gabbro	42	hypidiomorphic granular/granoblastic.	2	56(An64)	------	------	35
183a	Gabbm	70	hypidiomorphic granular.	------	28(An89)	------	------	1(uralite)
183b	Gabbro	80	------	------	P	------	------	------
183c	Uralitized gabbm	50	hypidiomorphic granular.	<0.5	50(An80)	------	------	15(uralite)
61ABg54(1)	Uralitized leuconorite	30	------	------	P	------	------	P(uralite)
54(2)	Hornblende gabbro	70	------	------	P(An60)	------	------	P
56	Hornblende gabbro	50	hypidiomorphic granular/protoclastic.	------	50(An77)	------	------	38
	BODY NO. 57:							
61APy14	Uralitized augite leuconorite	25	hypidiomorphic granular.	------	75(An64)	------	------	8(uralite)
15	Uralitized olivine(?) gabbro	55	------	------	45(An59)	<1	------	44(uralite)
16	Uralitized leucogabbm	35	hypidiomorphic granular.	------	63(An80)	0.5	------	30(uralite)
61ABg151	Olivine gabbro	55	------	------	P	------	------	P?
152	Uralitized troctolite(?)	10+	allotriomorphic granular.	------	P(An65)	------	------	P
152a	Uralitized troctolite(?)	5	allotnomorphic granular.	------	95(An79)	<0.5	------	2
152b	Uralitized troctolite(?)	25	allotnomorphic granular.	------	74(An80)	------	------	11(actinolite) (uralite)
155	Uralitized troctolite	40	hypidiomorphic granular.	------	50(An84)	------	------	13(uralite)

[1]Given in volume percent.

places actinolite and occurs as sprays and sheaves throughout the rocks. In two specimens from the southeastern gabbro mass, this amphibole forms up to 30 percent of the rock. Whole-rock X-ray diffraction study indicates that it is a cummingtonite. Although precise optical properties could not be determined with confidence owing to the fine grain size, the index of refraction is appreciably greater than that of the actinolite, and obtuse **bisectrix** optical figures indicate that the optical sign is positive.

The available data indicate that these gabbros crystallized as layered intrusive rocks and that actinolite formed as a late-stage crystallization product with a reaction relation to the bronzite and diopsidic augite. The textural relations of the actinolite to the pyroxenes (figs. 15 and 16) indicate that the actinolite can be neither a later metamorphic product nor the product of deuteric uralitization, (which should be expressed as a fibrous actinolite and be accompanied by saussuritization of the plagioclase). The subsequent development of

gabbro near the head of Tenakee Inlet, Chichagof Island

noted. "Uralite" is used for all hornblende that rims, surrounds, fringes, or is in any way associated with "cores" of pyroxene]

Primary minerals[1]--Continued		Primary or Secondary minerals[1]			Secondary minerals[1]		Opaques	Remarks
Muscovite	Pyroxene	Epidote	Sphene	Apatite	Chlorite	Muscovite		
--------	P(hypersthene) P(augite)	------	------	------	--------	--------	--------	(2)
--------	2(augite)	------	------	0.5	--------	--------	2	1 percent myrmekite.
--------	------------------	------	------	------	--------	--------	--------	Could be metamorphic rock?[2]
--------	5(augite)	0.5	------	------	0.5	--------	7	2 percent olivine?; contacts fine-grained hornblende hornfels.
--------	------------------	------	------	------	--------	--------	--------	(2)
--------	------------------	------	------	------	--------	--------	--------	Interlayered fine and very coarse grained.[2]
--------	------------------	------	------	------	0.2	--------	2	Pointcounted mode; foliated.
--------	------------------	------	------	------	1	<0.5	<0.5	
--------	------------------	------	------	------	P	--------	P	P myrmekite; rock may be partly metamorphosed; layered.
--------	10(hypersthene) 4(augite)	------	------	1	--------	--------	3	
--------	16.8(augite)	------	T	------	T	0.3	5.8	Point-counted mode.
--------	P(augite)	------	------	------	P	--------	P	Hornblende → chlorite; veinlets of antigorite.
--------	18.4(hypersthene) 8.0(augite)	------	------	0.2	0.8	--------	3.6	Point-counted mode; T chromite;
--------	18(hypersthene) 10(augite)	------	------	1	--------	--------	3	
--------	10(augite) 0.5(hypersthene)	------	------	0.5	--------	--------	3	0.5 percent myrmekite.
--------	------------------	------	------	------	--------	--------	--------	Layered.[2]
--------	------------------	------	P?	------	--------	--------	--------	(2)
--------	------------------	------	------	------	----------------		P	Foliated; 2nd amphibole also present; granulite?
--------	P(hypersthene)	------	------	------	--------	--------	--------	(2)
--------	------------------	------	------	<0.5	--------	--------	3	Foliated, 20 percent actinolite from hornblende.
--------	P(hypersthene) P(augite)	------	------	------	--------	--------	--------	Foliated.[2]
--------	P(hypersthene) P?(augite)	------	------	------	--------	--------	--------	(2)
--------	18(hypersthene) P(diopside?)	------	------	0.5	--------	0.5	3	1 percent calcite; 2 percent myrmekite.
--------		------	------	------	--------	--------	--------	(2)
--------	20(hypersthene) 13(augite)	------	------	------	--------	--------	3	
--------	P?(hypersthene)	------	------	------	--------	--------	- -	(2)
--------	------------------	------	------	------	--------	--------	7	Foliated; serpentine(?) veinlet.
--------	68(diopside?)	P	------	------	--------	--------	<0.5	3 percent prehnite; possibly granulite.
--------	P(diopside?)	------	------	------	--------	--------	--------	Layered.[2]
--------	28(augite)	------	------	------	--------	--------	7	
--------	P(hypersthene)	------	------	------	------------------------			P olivine(?).[2]
--------	------------------	------	------	------	------------------------			(2)
--------	------------------	1	1.5	------	0.5	--------	2	<0.5 percent prehnite.
--------	9(hypersthene) 5(augite)	------	------	0.5	--------	--------	3	<0.5 percent calcite.
--------	1(augite)	------	1	T	<0.5	--------	4	Foliated, 5 percent olivine(?).
--------	3(augite?)	<0.5	------	0.5	<0.5	--------	1	<0.5 percent calcite; <0.5 percent talc(?).
--------	------------------	------	------	------	------------------------			Olivine P; spinel P.[2]
--------	3(hypersthene)	------	------	------	--------	--------	P	Serpentine P; calcite P; hornblende → olivine.
--------	------------------	------	------	------	--------	--------	1	1.5 percent serpentine; <0.5 percent calcite; talc P.
--------	8(hypersthene)	------	------	------	4	T	2	Serpentine P.; 1 percent talc.
--------	3(hypersthene)	------	------	------	--------	T	10	2 percent spinel; 20 percent olivine; 2 percent cummingtonite(?)

[2]Information from binocular microscopic study of hand specimen and grain mounts.

secondary cummingtonite and saussuritization of plagioclase appear to be caused by the contact metamorphism accompanying the emplacement of the Kasnyku Lake **pluton** (No. 86, pl. 2).

The magnesia-rich and iron-poor nature of the mafic minerals is notable. The textural relations among the pyroxenes and amphiboles would not be exceptional except for the compositions of the amphiboles. Were the actinolite a hornblende, and the cummingtonite an **actinolite,** these gabbros would be readily dismissed as unexceptional, partly altered hornblende gabbros.

TERTIARY AND TERTIARY(?) PLUTONS

TERTIARY(?) LAYERED GABBRO NEAR THE HEAD OF TENAKEE INLET

Two plutons characterized by layered leucocratic gabbro are near the head of Tenakee Inlet (Nos. 56 and 57; pl. 2 and table 6). These bodies contrast with the Cretaceous igneous rock around them, because they are crudely discordant, do not have northwest-trending

TABLE 7.--*Petrographic data of the Tertiary(?)*

[Symbols are as follows: P = present in unspecified amount; T = trace; < =

Specimen No.	Rock name	Color index	Texture	Primary minerals[1]			
				Quartz	Plagioclase	K-Feldspar	Biotite
	Body no. 79:						
61ALy358	Muscovite-bearing biotite trondhjemite	7	hypidiomorphic granular.	20	69(An20–22)	1	7
61APy415	Muscovite- and biotite-bearing trondhjemite	2	hypidiomorphic granular.	20	70(An14–22)	6	2
	Body no. 80:						
61ABg663	Biotite granodiorite	17	----------	30	43(An33–43)	10	15
Unknown	Biotite granodiorite	12	granular	26	49(An30–50)	13(orthoclase)	12
Unknown	Muscovite- and biotite-bearing alaskite	5	granular	24	34(albite)	35(microperthite)	3
Unknown	Muscovite alaskite	1	----------	30	42(albite)	20(microcline)	------
	Body no. 81:						
61ABg686	Biotite granodiorite	20	----------	15	45	10	20
	Body no. 82:						
61ABd559	Muscovite-bearing biotite granodiorite	10	hypidiomorphic granular.	30	40(An33)	17	5
603	Garnet-, muscovite-, and biotite-bearing granodiorite	6	hypidiomorphic granular	42	35(An24?)	12	4

[1]Given in volume percent.

steeply dipping foliation, and are gabbroic rather than dioritic.

The characteristic layering consists of alternating bands of fine-grained gabbro and leucogabbro (or leuconorite). The gabbros have striking allotriomorphic textures in thin section and locally display a complex comblike growth of mafic minerals. The layering is best exposed on several broad ridges in body 56 and in the shoreline exposures of body 57. Some quartz-bearing gabbro, tonalite, and trondhjemite occur in body 56, and troctolite occurs locally in body 57. Both olivines and pyroxenes are commonly rimmed by dark-green uralitic hornblende.

There are no radiometric dates for these plutons. Their relations to the Cretaceous plutonic rock suggest that they intrude the Cretaceous rock and are therefore younger. They may be the same age as the crosscutting Tertiary (?) granitic and gabbroic rocks of northwestern Chichagof Island and Yakobi Island described in the next section.

TERTIARY(?) PLUTONS ON NORTHWESTERN CHICHAGOF ISLAND AND YAKOBI ISLAND

A group of generally leucocratic crosscutting internally almost directionless igneous bodies crops out on western Chichagof Island and on Yakobi Island (pl. 2, Nos. 58–82). Associated with some of these plutons are significant intrusions of gabbroic and noritic composition. None of these plutons has been dated radiometrically; the available field relations indicate only that the intrusions are definitely younger than both the Cretaceous plutonic rocks and the Jurassic and Cretaceous Sitka Graywacke.

Some of these plutons were mapped by Reed and Dorr (1942) and by Pecora (1942), and one body (No. 80) was discussed in detail by Reed and Coats (1941). Most of the plutons occur in the area mapped by Rossman (1959); our original data cover only plutons 79–82 (table 7).

Included in this group of Tertiary(?) plutons are all the bodies that Rossman (1959) mapped as "intrusive rocks associated with nickel deposits" as well as all but one of the bodies he mapped as "quartz diorite." Rossman (1959, p. 170–180) recognized that both of these rock groups crosscut his "diorites" (which are included in this report with the Cretaceous plutons; this age relationship is supported by the absence of regional northwest-striking foliation in the crosscutting plutons. Rossman separated the "quartz diorites" from the "intrusive rocks associated with nickel deposits" by the latter's greater freshness and lack of internal structure. He considered the "quartz diorites" definitely to predate the "intrusive rocks associated with nickel deposits." We interpret both groups to be of probable Tertiary age.

Body 79, is a narrow, elongate pluton that apparently was emplaced along the Peril Strait fault, an occurrence implying that the fault zone existed as a structural element prior to the Tertiary(?) emplacement. Unfortunately, no samples suitable for radiometric dating are available from this pluton.

Body 82 is a complex pluton characterized by conspicuously light-colored relatively unfoliated outcrops of garnet-bearing biotite granodiorite. Much of the complexity results from the incorporation of large volumes of preexisting country rocks along the steep margins and in the north-central part of the pluton where a generally flat-lying roof contact may have been close by.

EOCENE PLUTONS ON BARANOF AND KRUZOF ISLANDS

Several granitic plutons that crop out on Baranof and Kruzof Islands were demonstrated by Loney, Brew, and Lanphere (1967) to be of Eocene age. These bodies are generally light colored and relatively fresh, have few prominent consistent internal structural features, and are discordant to the structures of the enclosing country rock. These criteria are the same ones used to discrimi-

plutons on western Chichagof Island

less than All percent amounts estimated visually unless otherwise noted]

			Primary or secondary minerals[1]			Secondary minerals[1]		Opaques	Remarks
Hornblende	Muscovite	Pyroxene	Epidote	Sphene	Apatite	Chlorite	Muscovite		
----------	1	--------	T	T	T	--------	--------	T	Crude foliation. T prehnite.
----------	2	--------	T	------	------	T	T	--------	T prehnite. Crude foliation possible cataclastic.
P	--------	--------	------	------	------	2	--------	--------	(2)
----------	P	--------	------	------	P	--------	--------	P	From Reed and Coats, 1941 p. 41; mynnekite P.
----------	1	--------	------	1	------	--------	--------	--------	From Reed and Coats, 1941, p. 41; 1 percent allanite.
----------	8	--------	------	------	P	--------	--------	--------	From Reed and Coats, 1941, p. 41; garnet P.
----------	--------	--------	------	------	------	--------	--------	--------	(2)
----------	2	--------	2	------	T	3	T	T	T myrmekite.
----------	3	--------	1	------	------	1	2	T	T garnet; T myrmekite.

[2]Information from binocular microscope study of hand specimen and grain mounts.

nate the plutons of probable Tertiary age on Chichagof and Yakobi Islands. (See section on "Tertiary(?) Plutons on Northwestern Chichagof Island and Yakobi Island".) In Buddington's (1959) classification, the Baranof and Kruzof plutons are mesozonal. For details of contact metamorphism see section on "Contact Metamorphism around Tertiary Plutons," and for effects of intrusion on regional structure see section on "Structural Effects of Tertiary Plutonic Intrusion."

The Baranof and Kruzof Tertiary plutons, the Tertiary plutons of Chichagof and Yakobi Islands, and the Tertiary plutons of Glacier Bay National Monument (D.A. Brew, unpub. data, 1971) compose a Tertiary intrusive belt that follows the Pacific side of the Alexander Archipelago for over 210 miles in a north-northwest direction. This belt was originally recognized as being compositionally distinctive by Buddington and Chapin (1929).

Kruzof Island Pluton

Granitic rock exposed on western and central Kruzof Island (No. 83 of pl. 2) and Krestof Island (Nos. 84 and 85) makes up what is interpreted to be a single pluton. The minimum area of the pluton is 32 mi^2, but considerable additional area is undoubtedly covered by the Edgecumbe Volcanics and the ocean.

The Kruzof pluton is in steep intrusive contact with hornfels and schist derived from the Sitka Graywacke. The highest grade metamorphism in the aureole is interpreted as hornblende hornfels facies. The conspicuous width of the aureole suggests that the cross-sectional area of the pluton at relatively shallow depths is greater than at the surface.

The Kruzof pluton consists mainly of biotite granodiorite, muscovite-bearing biotite adamellite, and muscovite-bearing biotite albite granite (table 8). These rock types are cut by aplitic dikes of biotite-bearing muscovite adamellite and garnet- and biotite-bearing alaskite. Biotite is commonly chloritized, with accompanying pale secondary amphibole in the granodiorite and adamellite. The chloritization was not extensive enough to preclude the potassium-argon dating of one granodiorite; separated biotite gave an age of 48.6±1.1 m.y. (Loney and others, 1967, table 1, No. 10).

Kasnyku Lake Pluton

The Kasnyku Lake pluton (No. 86 on pl. 2) is a complex composite mesozonal intrusion on the east side of Baranof Island slightly north of the latitude of Sitka. About 100 square miles are underlain by igneous rock, and an additional area of unknown extent is covered by the waters of Chatham Strait.

The dominant and most widespread rock type of the Kasnyku Lake pluton is a foliated medium-grained hornblende-biotite tonalite, locally varying to a granodiorite (table 2). Biotite is greatly in excess of hornblende (table 9). A red almandine garnet is a common accessory mineral, particularly near large inclusions of metamorphic rock. The size (up to 4 mm) and the local abundance (up to 5 percent) suggest that this gar-

TABLE 8.—*Averages[1] of visually estimated modal analyses for rocks of the Kruzof Island pluton (in volume percent)*

	Plagioclase	Quartz	K-feldspar	Biotite	Hornblende	Muscovite	Accessories	Alteration	Color index
Granodiorite (3 thin sections)	43 (An_{14-44})	23	19	11	1(?)	0	Trace	3	13
Adamellite (2 thin sections)	30 (An_{20-45})	28	24	12	1(?)	Trace	Trace	5	14
Albite granite (1 thin section)	20 (An_{8-12})	35	33	7	0	2	Trace	3	10

[1]The number of individual modal analyses included in each average does not necessarily indicate the relative importance of the rock type in the batholith; it merely reflects the number of available thin sections suitable for modal analysis.

TABLE 9. — *Averages of modal analyses of rocks from Kasnyku Lake pluton (in volume percent)*

	Quartz	Plagioclase	K-feldspar	Biotite	Hornblende	Muscovite	Accessories[1]	Alteration[2]	Color index
Hornblende-biotite tonalite (10 thin sections)	24	58 (An_{40})	1	14	1	0	1	1	16
Muscovite-biotite trondhjemite (5 thin sections)	35	48 (An_{25})	10	5	0	2	Trace	Trace	5
Hornblende-biotite trondhjemite (2 thin sections)	32	52 (An_{25})	6	6	1	0	Trace	3	10

[1]Includes apatite, zircon, red garnet, opaque mineral (mostly magnetite but some pyrite), and rare sphene and allanite.
[2]Includes chlorite (F/FM > 0.5), epidote, sphene, and sericite.

net may be a contaminant from the pelitic country rock. A few areas show several tonalitic intrusive phases, (for example, the ridge northwest of Kasnyku Lake, where fine-grained tonalite dikes cut medium-grained foliated tonalite that contains elipsoidal schlieren of coarse-grained tonalite). A few bands of gneissose biotite-hornblende tonalite are interlayered with foliated hornblende-biotite tonalite south of Baranof Lake.

Medium- to coarse-grained muscovite-biotite trondhjemite is an abundant and characteristic rock type that occurs as dikes and irregular plutons intruding the hornblende-biotite tonalite in the area west of Takatz Lake and in the area around Kasnyku Bay. Tiny (<0.5mm) red almandine garnets are almost always present among the accessory minerals of this trondhjemite. The trondhjemite has alaskitic border phases, and the more foliated and gneissose varieties contain streaks and schlieren of pegmatite. Pegmatite dikes that were probably derived from the trondhjemite intrude adjacent tonalite and metamorphic rock as well as the trondhjemite itself.

A fine- to medium-grained hornblende-biotite trondhjemite occurs just northwest of Takatz Bay and along Chatham Strait in the vicinity of Warm Spring Bay and may be a separate phase intrusive into the hornblende-biotite tonalite. The trondhjemite in Warm Spring Bay contains appreciable pyrite (from which the red iron stain on the weathered rocks is derived) and is cut by many tonalitic granophyre dikes.

Wanek and Callahan (1969, p. 17–18) discussed the granitic rocks at the Kasnyku Lake damsite, which is in the northeastern part of the pluton. They classified most of their samples as tonalite and provided five chemical analyses of the granitic rocks near Kasnyku Lake (Wanek and Callahan, 1969, table 1).

The country rock is composed of phyllite, greenschist, metachert, and metagraywacke of the Kelp Bay Group (Triassic and (or) Jurassic). The degree of regional metamorphism away from the pluton to the west and north is no more intense than the lower greenschist facies. Near the pluton, the metamorphism attains a grade intermediate between the hornblende hornfels facies and the amphibolite facies.

Contacts are sharp on the scale of a single outcrop, and the igneous rock shows both concordant and discordant relations to structures in the country rock. (See section on "Structural Effects of Tertiary Plutonic Intrusion.") On a larger scale, the contacts are of two general types. To the north and west, the contact has a simple regular trace (see pl. 1) and in general is steep and discordant. To the south and southeast of the pluton, the contact, while still steep, is complex, irregular, and generally concordant, and the intrusion is bordered by a zone several miles wide of mixed granitic and metamorphic rock. The large bodies of country rock in the central part of the pluton display similar contact relations.

The apparent discrepancy between the northern and western contacts (showing characters diagnostic of the upper part of the mesozone) and the central and southern contacts (showing characters diagnostic of the deeper part of the mesozone) is resolved by considering the central and southern contacts as roof contacts. According to Buddington (1959, p. 676), many predominantly mesozonal plutons have parts of the roof that display characters of the catazone (in this regard using the term zone as an intensity term rather than as a strict measure of depth). This interpretation implies that the northern and western contacts of the Kasnyku Lake pluton are wall contacts and that the large metamorphic inclusions in the central part of the pluton are roof pendants (see section on "Aureole of Kasnyku Lake Pluton").

Loney, Brew, and Lanphere (1967, tables 1 and 2, Nos. 11–14) presented six potassium-argon age determinations made on material from the Kasnyku Lake pluton. A biotite-muscovite mineral pair separated from granodiorite gave 42.6±1.1 m.y. and 44.3±1.2 m.y., respectively; two muscovite separates from a pegmatite dike gave 42.2±0.8 m.y. and 41.1k0.8 m.y.; biotite from a highly chloritized biotite granodiorite gave 28.1±1.3 m.y.; and biotite from a hornblende-biotite tonalite gave 38.7±0.9 m.y. These dates are considered to establish its age as late Eocene.

INDIGO LAKE PLUTON

The Indigo Lake pluton (pl. 1; No. 87 on pl. 2) is exposed over about 13 square miles surrounding the highest point (5,390 feet) of Baranof Island. An additional area of 5 square miles is inferred to underlie part of the extensive glacier system found on this part of the island (table 2).

The Indigo Lake pluton intrudes the Kelp Bay Group (Triassic and (or) Jurassic). Potassium-argon analysis of biotite from the pluton gives an age of 47.2±1.3 m.y. (Loney and others, 1967, tables 1 and 2, No. 15). The pluton is discrete, except on the northeast side where a zone of mixed metamorphic and intrusive rock separates the pluton from the Kasnyku Lake batholith. The northwestern part of the Indigo Lake pluton has been displaced about a mile (in a left-lateral sense) along the Medvejie Lake fault.

Along its southeast margin, the pluton is in contact with several bodies of mafic plutonic rock as well as with metamorphic rocks of the Kelp Bay Group. This area is mostly covered by ice and snow, and its bedrock relations are ambiguous.

Medium-grained biotite-hornblende tonalite (see table 10) is the dominant rock type of the Indigo Lake pluton. Near the margins of the pluton and in nearby dikes, this tonalite is fine grained, has a prominent flow foliation, and contains more biotite than hornblende. Biotite-hornblende granodiorite is common in the northwestern part of the pluton, and a medium- to coarse-grained hornblende-biotite tonalite crops out near the center of the intrusion. Hornblende diorite is a minor variant.

TABLE 10.--*Modal analyses of rocks from the Indigo Lake pluton (in volume percent)*

	Medium-grained biotite-hornblende tonalite (average of two thin sections)	Medium- to coarse-grained hornblende-biotite tonalite	Medium-grained biotite-hornblende granodiorite
Quartz	21	22	30
Potash feldspar	0	[1]2	[2]6
Plagioclase	60(An_{35-50})	57(An_{40})	47(An_{20})
Hornblende (including chlorite with F/FM≤0.5)	12	3	10
Biotite (including chlorite with F/FM>0.5)	7	16	7
Apatite, zircon, and opaque minerals	Trace	Trace	Trace
Other alteration products[3]	Trace	Trace	Trace

[1] Orthoclase

[2] Microcline microperthite.

[3] Includes sphene, epidote, sericite, clay(?), and prehnite.

VODOPAD RIVER PLUTON

The upper Vodopad River pluton (pl. 1; No. 88 on pl. 2) is located on the ridge between the Vodopad River and the river draining southeastward into Red Bluff Bay, about 5 miles west of Nelson Bay. The pluton crops out over about 3 square miles (table 2) and on its east side shows intrusive relations to the Kelp Bay Group (Triassic and (or) Jurassic). The western contact is coincident with the trace of the Patterson Bay fault. It is not known whether this fault cuts the Red Bluff–Vodopad pluton or whether intrusion of the pluton was controlled in part by the fault. It is possible that the pluton is a cupola of the Kasnyku Lake pluton.

The pluton is composed almost entirely of medium-grained leucocratic (color index=5–10) biotite granodiorite that in hand specimen shows obvious variability in relative abundance of constituent minerals. Foliation, present only near contacts, consists of alined bands and schlieren of medium-grained biotite tonalite. A few almandine garnet-bearing muscovite alaskite dikes cut the foliated border zone. Along the eastern contact, greenstones and phyllites of the Kelp Bay Group have been metamorphosed to amphibolites and staurolite-biotite-quartz-feldspar schists (see section on "Aureole of Kasnyku Lake Pluton").

Pluton No. 89 is inferred to be an offshoot of the Vodopad River pluton.

Body No. 90 is not a single, discrete pluton but is a part of the zone of mixed metamorphic and igneous rock that extends southeast from the Kasnyku Lake pluton. The body is discriminated separately on plates 1 and 2 because of its very high proportion of granitic and pegmatitic dikes. Muscovite from one of the pegmatite dikes was ,dated at 36.2±0.4 m.y., and biotite from nearby schist gave an age of 33.8±0.3 m.y. (Loney and others, 1967, tables 1 and 2, Nos. 16 and 17).

CRAWFISH INLET PLUTON

The Crawfish Inlet pluton is a composite tonalite and granodiorite body (Nos. 91, 92, and 93 on pl. 2) that extends across the central part of Baranof Island. About 220 square miles of plutonic rock is exposed, and another 55 square miles can reasonably be inferred to be beneath the ocean or lakes. Although the westernmost part of the pluton is covered by the Pacific Ocean, the heterogeneity of intrusive rock types and the great abundance of xenoliths in the Necker Islands suggest that the west margin is not far out to sea. The pluton, a mesozonal intrusive, has been eroded to a moderate depth. Probable remnants of the roof are found primarily in the Necker Islands.

The Crawfish Inlet pluton was emplaced largely in the Sitka Graywacke (Upper Jurassic and Lower Cretaceous); only the eastern extremity intrudes the Kelp Bay Group (Triassic and (or) Jurassic). Potassium-argon ages (table 2) on biotite range from 42.0 to 46.9 m.y. and indicate middle to late Eocene age of intrusion (Loney and others, 1967).

Metamorphic effects vary at different parts of the composite mass (see section on "Southern Baranof Island"). A distinct thermal aureole is present on the northwest and west sides, where rocks of the hornblende hornfels facies occur adjacent to the pluton (metamorphic rocks of the pyroxene hornfels facies occur locally). Country rock to the southeast is regionally metamorphosed at least to the greenschist facies, and the metamorphic mineralogy adjacent to the pluton indicates a facies intermediate between the hornblende hornfels facies and the amphibolite facies.

The contacts of the pluton are of varying character. In detail they are sharp, but on the northeast and southwest sides of the pluton there are zones as much as three-fourths of a mile wide of mixed granitic rock and metamorphic rock (pl. 1). These zones consist of intrusive rock containing metamorphic septa and metagraywacke inclusions of sizes up to one-half a mile long. Migrnatite (as defined by Crowder, 1959, p. 832–833) is only locally present. An extensive area of mixed granitic rock and metamorphic rock that also underlies most of the Necker Islands is possibly near the roof of the pluton. Contact relations on the east side of the plutons are obscured by later cataclastic deformation related to the Patterson Bay fault.

Flow foliation in the granitoid rock is common near the margins of the pluton and in the Necker Islands but is absent in the central part of the pluton. A cataclastic foliation is present in the eastern part of the batholith and increases in intensity toward the Patterson Bay fault. The products of extreme cataclasis are gneissose rocks showing mortar textures in thin section. No lineation was observed in the pluton. Joints are concentrated in two preferred orientations (see Brew and others, 1963) and apparently are related to the regional stresses that produced the similarly oriented joints (and metamorphic foliation) in the country rock.

The outcrop area of the Crawfish Inlet pluton can be divided into three parts (pl. 2). The northeastern part (No. 93) is dominantly homogeneous foliated tonalite, much of which is leucocratic (color index <15), with subordinate granodiorite and minor alaskite. The central part (No. 92) is dominantly nonfoliated medium-grained granodiorite, which commonly is associated with subordinate fine-grained dark-gray tonalite-granodiorite. The variable chronologic relationship of these rock types from one outcrop to the next suggests that they may be two igneous phases of approximately the same age, a suggestion that is supported by the radiometric ages (Loney and others, 1967). The western part (No. 91) of the pluton is a mixture of granodiorite and tonalite, contains many tonalite autoliths and metagraywacke xenoliths, and is cut by numerous alaskite dikes (fig. 17). The western part is subdivided into a northern part dominantly granodiorite and a southern part of mixed granodiorite and tonalite. The central part and the western part are probably separated by a fault along Hot Springs Bay and Windy Passage, but to the southeast both parts show intrusive relations to an intervening septum. The contact between the central and northeastern parts is defined solely on petrographic data and is undoubtedly a gradational boundary.

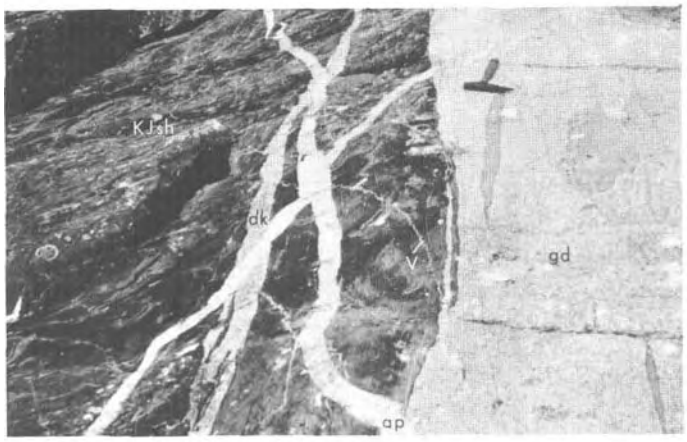


FIGURE 17—Contact between granodiorite (gd) and a large xenolith of schistose hornfelsic Sitka Graywacke (KJsh) at Biali Rock (off the southwest coast of Baranof Island). Granodiorite displays foliation parallel to contact as well as mafic schlieren and inclusions alined in the foliation. Metagraywacke is cut by thin ptygmatic veins (V) of granodiorite and by dikes (dk) of granodiorite. Both granodiorite and metagraywacke are cut by late aplite dikes (ap).

Tonalite, granodiorite, and leucocratic tonalite make up most of the pluton. Although granodiorite is most abundant among the 213 samples collected, this abundance reflects the more detailed sampling in the Necker Islands, which are probably near the margin or the roof of the pluton. It is therefore inferred that the dominant rock type is a tonalite and that granodiorite and leucocratic tonalite are subordinate variants. Adamellite is rare, and trondhjemite occurs only near the northeast margin of the batholith in the vicinity of Gut Bay.

The tonalite, leucocratic tonalite, and granodiorite are all medium-grained seriate granitoid rocks, locally porphyritic, and contain the same primary minerals in varying proportions (table 11). Plagioclase commonly is zoned from An_{45} to An_{25-30}; the average composition appears to be slightly more sodic in the granodiorites than in the leucocratic tonalites and tonalites. Potash feldspar is orthoclase and is only rarely perthitic. Biotite (X=grayish orange, Y=Z=dark reddish brown) greatly predominates over hornblende (X=very light green, Y=light brownish green, Z=moderate green) in almost all specimens. Zircon, apatite, and an opaque mineral are common as accessories; allanite occurs only rarely.

Alaskite occurs as dikes as much as 2 feet thick, as larger irregular masses, and locally as a thin border phase separating granodiorite or tonalite from country

TABLE 11.—*Averages[1] of modal analyses for rocks of the Crawfish Inlet pluton (in volume percent)*

	Plagioclase	Quartz	K-feldspar	Biotite	Hornblende	Muscovite	Accessories	Alteration	Color index
Leucocratic tonalite[2] (6 thin sections)	59 (An_{45})	28	2	9	2	0	Trace	Trace	11
Tonalite[3] (10 thin sections)	58 (An_{44})	21	1	12	7	0	Trace	1	20
Granodiorite (5 thin sections)	45 (An_{40})	35	9	9	1	0	Trace	1	11
Trondhjemite (1 thin section)	48 (An_{22})	35	10	7	0	0	Trace	Trace	7
Alaskite (6 thin sections)	38 (An_{23})	38	19	3	0	1	Trace	1	4

[1]The number of individual modal analyses included in each average does not indicate the relative importance of the rock type in the batholith; it merely reflects the number of available thin sections suitable for modal analysis.

[2]Color index < 15.

[3]Color index > 15.

rock. The alaskite is fine to medium grained and only locally aplitic. Plagioclase shows slight normal and oscillatory zoning and ranges in composition from An_{34} to An_{14}. Potash feldspar is commonly microcline microperthite. Biotite is the only mafic mineral. Primary muscovite is common, and a pink garnet occurs as a characteristic accessory mineral.

Dikes of fine-grained dark-gray granodiorite and tonalite cut the medium-grained light-gray granodiorite and leucocratic tonalite of the batholith in Crawfish Inlet and Necker Bay (similar rocks occur in the same area as a separate phase of the medium-grained batholithic rocks). These dikes, along with the alaskite dikes and rare pegmatite dikes, probably are comagmatic with the Crawfish Inlet pluton and were emplaced very soon after consolidation of the major rock types.

The pluton is also cut by later dacite and alkali-olivine diabase dikes.

Alteration has affected the Crawfish Inlet pluton to varying degrees. Biotite is generally partially altered to chlorite (commonly F/FM>0.5, with anomalous blue birefringence and positive elongation), sphene, opaque dust, and potash feldspar. In the intensely sheared rocks near Patterson Bay, the biotite is completely altered to the above minerals and epidote. The plagioclase of these rocks is altered to albite-oligoclase, clay, sericite, and calcite, and the rocks are cut by masses and veins of prehnite and quartz.

Bodies 94 and 95 (pl. 2) are small cupolalike masses of biotite granodiorite (table 2) that are probably offshoots of the main Crawfish Inlet composite intrusion.

Several small sills and plugs (No. 96 on pl. 2) that are southwest of the pluton in Great Arm of Whale Bay may have been emplaced somewhat earlier than the batholith. The largest sill is dominantly gneissose granodiorite grading into an irregular intensely foliated alaskitic border phase. The alaskite contains quartz, sodic oligoclase, irregularly distributed potash feldspar, abundant secondary (metamorphic?) muscovite, sporadic blue sodic amphibole, and rare pink garnet. It is possible that this body was originally a granodiorite sill cut by alaskite dikes near its contact, was granulated and partly homogenized during continuing deformation of the country rock, and was thermally metamorphosed during the intrusion of the Crawfish Inlet pluton proper.

REDFISH BAY PLUTON

The Redfish Bay pluton (pl. 1, No. 97 on pl. 2) consists of a heterogeneous mass of granitoid rock with abundant inclusions of metamorphic country rock derived from the Sitka Graywacke. The western part of the mass is covered by the Pacific Ocean, so the total outcrop area is not known (table 2).

The granitoid rocks are highly variable compositionally (table 12), and color indices range from nearly 0 to more than 45. The most common granitoid rock type is hornblende-biotite tonalite with a color index of about 20. Many of the darker rocks (color index >40) contain andesite and 10 percent or more quartz and are probably melatonalites. Garnet-bearing biotite-muscovite alaskite is an important subordinate rock type; the alaskites commonly contain oligoclase and greater than 20 percent microcline. Much of the alaskite occurs as dikes closely associated with locally abundant pegmatite~Sainsbury (1957) studied the economic geology of

TABLE 12.—*Averages of visually estimated modal analyses of rocks from Redfish Bay pluton (in volume percent)*

	Plagioclase	Quartz	K-feldspar	Biotite	Hornblende	Muscovite	Accessories	Alteration	Color index
Melatonalite (1 thin section)	45 (An_{58-35})	10	0	13	25	0	7	0	45
Tonalite (2 thin sections)	56 (An_{25-35})	22	4	14	4	0	Trace	Trace	----------
Alaskite (2 thin sections)	45 (An_{25-30})	24	23	1	0	5	2	0	----------

some of these pegrnatites, which contain quartz, albite-oligoclase, microcline, and muscovite.

The metamorphic character of the intruded graywacke, shale, and greenstone is similar to that around the southeastern part of the Crawfish Inlet mass and reaches hornblende hornfels facies.

The compositional similarity of the Redfish Bay pluton to the Crawfish Inlet pluton, the similarity of the metamorphism, the similar age of metamorphism, and the configuration of the metamorphic mineral zones (see section on "Redfish Bay area") all support the hypothesis that the two plutons are connected at shallow depth.

OLIGOCENE OR MIOCENE PLUTON AT GUT BAY, BARANOF ISLAND

The Gut Bay pluton is a heterogeneous intrusive mass that is exposed in an area of about 19 square miles on the east side of central Baranof Island (pl. 1, No. 98 on pl. 2).

Medium-grained hornblende-biotite granodiorite is the dominant rock type (see table 13). The granodiorite commonly contains as much hornblende as biotite, in contrast to the strong dominance of biotite in the granodiorite and tonalite of the Crawfish Inlet pluton. Schlieren of hornblende tonalite, common throughout the Gut Bay granodiorite, vary locally to a tonalite. Hornblende gabbro occurs as large (greater than 500 ft.) masses within the granodiorite and is locally cut by dikes of the granodiorite.

The tonalite schlieren are commonly alined in a prominent flow foliation. Near intrusive contacts, this foliation becomes more intense, parallels the contact, and shows cataclastic features in thin section. No lineation was observed. Contacts are sharp in detail, but zones of mixed igneous and metamorphic rock occur along the periphery of the pluton. Greenstones of the country rock have been metamorphosed adjacent to granodiorite contacts and contain mineral assemblages of either the hornblende hornfels facies or the amphibolite facies. (See section on "Metamorphic Rocks South of Red Bluff Bay.")

The Gut Bay pluton, although contiguous to the Crawfish Inlet pluton, is a separate and younger intrusion. Potassium-argon ages for biotite and hornblende range from 24.3 to 31.5 m.y., indicating middle or late Oligocene to early Miocene age of intrusion (Loney and others, 1967, tables 1 and 2, Nos. 18–19). The two bodies are petrologically distinct because the Gut Bay pluton is dominantly granodiorite rather than tonalite and in part hornblende gabbro; it contains many more mafic schlieren and as much hornblende as biotite. The last two distinctions are particularly striking when the Gut Bay pluton is compared with the adjacent biotite trondhjemites of the Crawfish Inlet pluton.

The Gut Bay pluton probably was emplaced after most of the movement on the Patterson Bay fault. This fault displaces the contacts of the Crawfish Inlet pluton in a right-lateral sense and appears to be related to the intense cataclastic foliation that pervades the eastern part of the pluton. The Gut Bay pluton shows no such pervasive cataclastic foliation. The Patterson Bay fault, where mapped to the south and to the north of Gut Bay, has a prominent physiographic expression; no such expression is present along the projection of the fault across the Gut Bay pluton. The head of Gut Bay, unfortunately, is an area of poor outcrop, and direct contact relations between the Gut Bay pluton and the Crawfish Inlet pluton were not observed.

TABLE 13. —*Average of two modal analyses of granodiorites from the Gut Bay pluton (in volume percent)*

Quartz	26
Potash feldspar	12
Plagioclase (An_{35})	51
Biotite (+ chlorite)	6
Hornblende	5
Opaque mineral	Trace
Zircon	Trace
Apatite	Trace

HYPABYSSAL DIKES

The youngest intrusive rocks in the mapped area are hypabyssal dikes of dacite, andesite, hornblende diabase, and alkali-olivine diabase. Dacite, andesite, and hornblende diabase dikes occur throughout the map area, but alkali-olivine diabase dikes are restricted to the west coast of Baranof Island. All units except the Edgecumbe Volcanics are cut by dike rocks. The dikes range in thickness from 3 inches to 50 feet, are generally discordant to structures in the country rock, and display sharp contacts with country rock.

The following discussion of dike rocks is based primarily on our reconnaissance mapping south of 58" latitude and east of 136° longitude. From this area, 81 thin sections were studied, and in addition, slabs of all thin-sectioned rocks were stained with sodium cobaltinitrite to assure the detection of any alkali feldspar. Dike rocks from northwestern Chichagof Island are described by Rossman (1959, p. 180–186) and by Reed and Coats (1941, p. 42–45). Data on dike rocks from the Freshwater Bay area are given by Loney, Condon, and Dutro (1963, p. 43–45). Information on the nature and distribution of dike rocks from Chichagof Island north of 58° latitude and east of 136° longitude is not available.

We have divided the dike rocks into three broad groups: (1) dike rocks of intermediate to felsic composition (including andesites, dacites, and their deuterically altered equivalents), (2) hornblende diabase, and (3) alkali-olivine diabase.

We were not able to apply the subdivisions used by Rossman (1959). His "aplite" and "brown dikes" probably fall into our category of dike rocks of intermediate to felsic composition; his "aplite" group probably includes andesite and dacite, for he includes in this category rocks with as much as 45% dark minerals (Rossman, 1959, p. 181). His "gray to green porphyritic dikes," "dikes containing blocky hornblende and feldspar phenocrysts," and "fine-grained gray dikes" appear to be varieties of hornblende diabase. His "quartz-feldspar dikes" almost certainly are closely related to the granitic plutons, and his "hornblende-feldspar pegmatite dikes" are probably similar to those pegmatitic dikes we consider to be related to the formation of amphibolite.

Spessartite lamprophyre dikes near Goddard on western Baranof Island are described by Emerson (1904, p. 18; quoted by Knopf, 1912, p. 16, and by Waring, 1917, p. 30). Knopf also states that F. E. Wright found vogesite at the same locality. We did find dikes composed of these rock types but also observed many dikes of alkali-olivine basalt in the vicinity of Goddard.

The lamprophyric dikes of Berg and Hinckley (1963, p. 18–19) correspond to our hornblende diabase dikes, and their felsic dikes correspond to the more altered members of our intermediate and felsic group. Berg and Hinckley (1963, p. 18) describe two fresh "ultramafic dikes" from the southern tip of Catherine Island. We have restudied their specimens but were not able to visit the locality. We suggest that the "dikes" may be melanocratic variants of the Cretaceous plutonic rocks of Catherine Island and may owe their unaltered and undeformed character to fortuitous preservation as a block in the Peril Strait fault zone. Alternatively, the dikes may be Cenozoic intrusive rock of a type not represented elsewhere in the map area.

DIKES OF INTERMEDIATE TO FELSIC COMPOSITION

The dikes of intermediate to felsic composition display wide variation in color, mineralogy, and texture and may represent several petrogenetically distinct associations. Color ranges from medium gray to light greenish gray to white. Some dikes are reasonably fresh and are readily classified as andesite or dacite. Most, however, are deuterically altered to varying degrees, and their position in a common rock classification (for example, fig. 14) is uncertain. In extreme cases, the dikes are completely altered to albite, quartz, and chlorite, and their original magmatic composition is uncertain.

The relatively fresh dikes contain euhedral phenocrysts of acicular reddish-brown hornblende and of zoned andesine in a microcrystalline groundmass of plagioclase, hornblende, quartz, minor K-feldspar, and an opaque mineral. Quartz phenocrysts were noted in only one specimen. The groundmass is characterized by a trachytic alinement of plagioclase laths and hornblende needles.

In the altered rocks, the plagioclase is oligoclase or albite and is partly or wholly replaced by sericite, calcite, and variable quantities of epidote. Hornblende is commonly altered to pseudomorphs of chlorite, sphene, opaque mineral, and calcite; in some rocks the only mafic constituent is chlorite occurring as wisps in the groundmass. Alteration of hornblende did not always proceed concomitantly with alteration of plagioclase; in many specimens one of these minerals is almost completely replaced, while the other is almost wholly fresh. Biotite occurs in a few specimens, commonly as a peripheral alteration of hornblende phenocrysts but sporadically as discrete grains. The original trachytic texture of the groundmass has been obliterated by recrystallization. Up to 25% epidote occurs in a few altered rocks that are low in quartz; altered rocks that are high in quartz consistently have only minor quantities of epidote. Prehnite mats and veinlets occur in a few very intensely altered specimens.

Dikes of andesite and low-quartz altered rock are most commonly found intruding the Kelp Bay Group, particularly in the terrane around Katlian Bay and the Katlian River of northern Baranof Island. A similar concentration of dikes occurs as a belt extending along the west side of Chichagof Island from Waterfall Lake to Lisianski Strait. Loney, Condon, and Dutro (1963, p. 43–44) report a concentration of andesite dikes intruding the Iyoukeen Formation northeast of Freshwater Bay. The andesite and low-quartz altered dikes are found very sporadically within plutonic bodies and in high-grade metamorphic terranes.

The dacites and high-quartz altered dikes are more widely and uniformly distributed than are the andesites and low-quartz altered dikes, although again dikes are concentrated in the Katlian River area. Dacites and high-quartz altered dikes are more common intruding plutonic rocks than are the andesites and low-quartz altered dikes. Dacite dikes are scattered throughout the Crawfish Inlet pluton, and altered high-quartz dikes commonly cut the plutonic complex on Chichagof Island just northeast of the North Arm of Hoonah Sound. This difference in geographic distribution between the high-quartz and low-quartz dike rocks suggests that the dacites may be petrogenetically distinct from the andesites.

The dike rocks of intermediate to felsic composition were emplaced sometime between the Eocene and the Holocene, probably in the Oligocene. These dikes intrude the (Eocene) Crawfish Inlet pluton, but all outcrops have been glaciated. An Oligocene age is suggested for unsheared felsic dikes that cut cataclasites of the Patterson Bay fault, which displaces the (Eocene) Crawfish Inlet pluton but not the (Oligocene to Miocene) Gut Bay pluton (see section on "Fairweather Fault System"). The apparent absence of dikes intruding the Gut Bay pluton may support this Oligocene age of dike intrusion. Alternatively, the apparent absence may be fortuitous or may be due to the insufficient density of our reconnaissance observations.

DIKES OF HORNBLENDE DIABASE

Dikes of dense very fine grained dark-greenish-gray to black hornblende diabase are sparsely but uniformly scattered over Baranof and Chichagof Islands. The diabase has a color index of 35–65 and is characterized by randomly oriented euhedral prisms of dark-reddish-brown hornblende, in general partly altered to chlorite. The hornblende appears to be a primary phenocryst mineral in all specimens except one, in which pale brown clinopyroxene is peripherally altered to hornblende. Plagioclase occurs. as interstitial anhedral grains that partly enclose hornblende in a subpoikilitic texture. When fresh, the plagioclase is labradorite; much plagioclase, however, is altered to albite, to cryptocrystalline semiopaque mats (saussurite?), or to phaneritic epidote. Quartz occurs only sporadically. Prehnite occurs as sprays and veinlets in the more highly altered specimens.

Like the dikes of intermediate to felsic composition, the dikes of hornblende diabase are post-Eocene and pre-Holocene, for they cut the (Eocene) Crawfish Inlet pluton and are in turn glaciated. The relationship (if any) of the hornblende diabase dikes to the Patterson Bay fault zone or to the (Oligocene or Miocene) Gut Bay pluton is unknown.

DIKES OF ALKALI-OLIVINE DIABASE

Numerous dikes of alkali-olivine diabase ranging in thickness from 3 inches to 15 feet cut granodiorite and hornfelsic Sitka Graywacke on the west coast of Baranof Island just northeast of the Windy Passage fault. Similar dikes cut metamorphosed Sitka Graywacke on the south side of the entrance to Snipe Bay on southwestern Baranof Island.

The alkali-olivine diabase is very fine grained to fine grained, black, and locally amygdaloidal. It is composed of fresh euhedral labradorite, fresh granular to subophitic titanaugite, varying amounts of fresh granular olivine, an opaque mineral, and interstitial cryptocrystalline chlorite. Amygdules in several specimens are filled with zeolites (analcime plus an unidentified fibrous species) and calcite.

Contact relations between a diabase dike and granodiorite of the Crawfish Inlet pluton are superbly exposed on the northwest side of Crawfish Inlet just inside the entrance. The dike is subvertical and 4–8 feet thick throughout most of its outcrop but expands at one end to an irregular, bulbous mass about 15 feet in diameter. Microcrystalline chill zones extend 3–13 inches inward from the dike walls, and a zone 1 mm thick adjacent to the granodiorite consists of very dark brown isotropic glass. Within one inch of the dike, the granodiorite is a dark-brown streaky intensely mylonitized and hornfelsed rock that contains about 30 percent alkali feldspar (distinctly more than in the granodiorite away from the dike). The mylonitization of the granodiorite is apparently due to forcible intrusion of the diabase dike.

It is probable that the alkali-olivine diabase dikes just northeast of the Windy Passage fault are comagmatic with the Edgecumbe Volcanics and are of Pleistocene age. The caldera of Mount Edgecumbe lies on the extrapolation of this fault to the northwest, and we suggest that the fault may have provided the access route both for the basaltic magma of the dikes and for the magmas erupted at Mount Edgecumbe. The diabase dikes, however, were emplaced somewhat earlier than any of the Edgecumbe Volcanics now exposed, for all the diabase dikes were glaciated, whereas the Edgecumbe Volcanics as now exposed are entirely post glacial. Either the basalt magma never reached the surface during the Pleistocene, or, alternatively, Pleistocene flows do exist in the Mount Edgecumbe area but have since been covered by Holocene lavas.

ULTRAMAFIC ROCKS

Ultramafic rocks on Baranof Island have two general occurrences: (1) The partially serpentinized peridotite at Red Bluff Bay, and (2) smaller sheared serpentinite bodies that occur in two northwest trending belts northwest of Red Bluff Bay (pl. 1). These occurrences are part of the ill-defined belt of ultramafic bodies described by Taylor and Noble (1960) as lying 60–70 miles west of the main ultramafic belts of southeastern Alaska (fig. 18).

PERIDOTITE AT RED BLUFF BAY

A lenticular body of peridotite about 1 by 2 miles in plan crops out as a conspicuous red hill adjacent to Red Bluff Bay on Chatham Strait on the east shore of Baranof Island. Owing to the sparse vegetation supported by the ultramafic rocks, outcrops are excellent throughout the body.

The peridotite was mapped at 1:12,000 by Guild and Balsley (1942). Kennedy and Walton (1946b) investigated several of the chromite deposits associated with the peridotite and obtained some ground magnetometer data. We visited the pluton briefly in 1962 during the

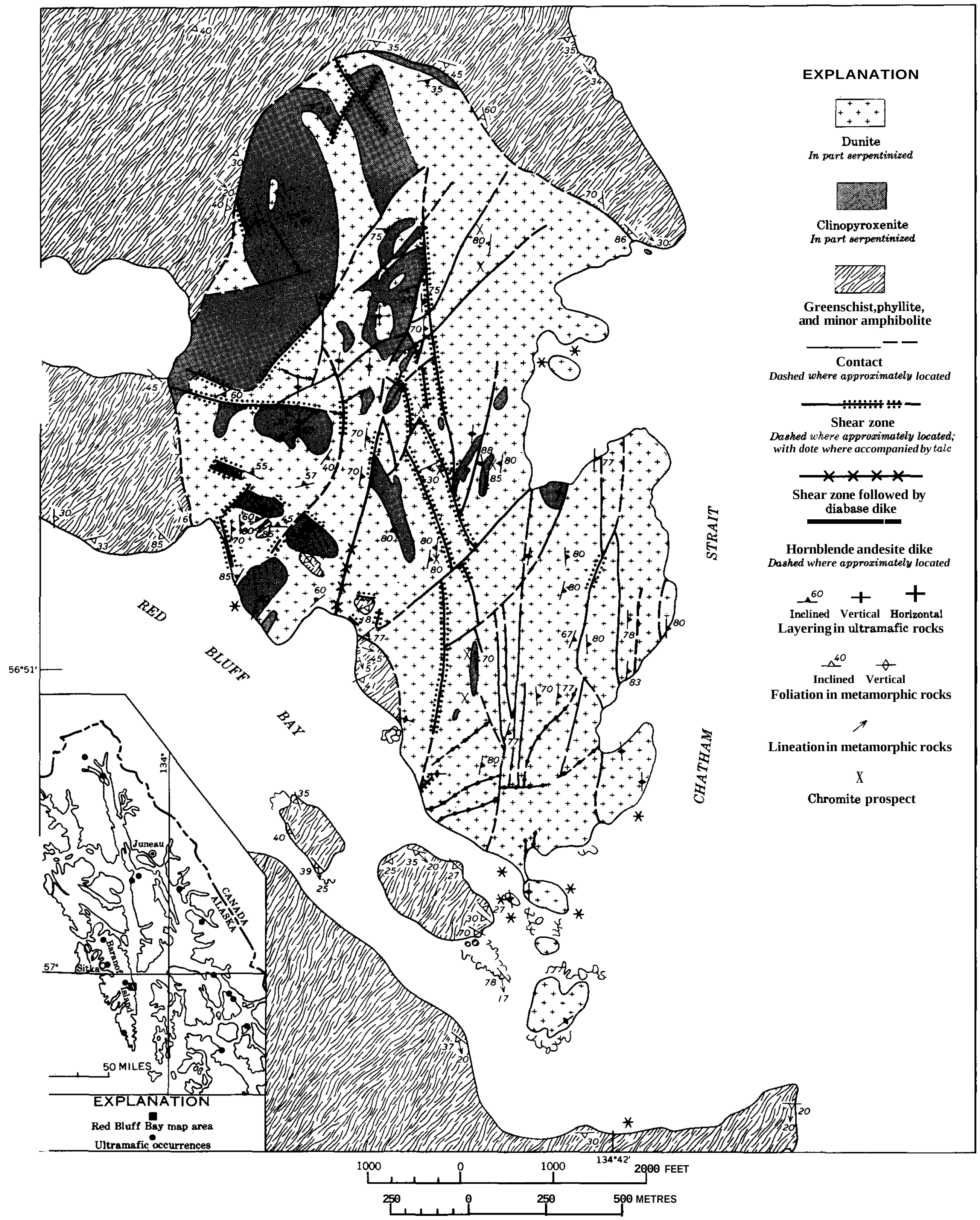


FIGURE 18.—Geologic map of the peridotite at Red Bluff Bay (adapted with modifications from Guild and Balsley, 1942, pl. 22).

course of reconnaissance mapping of Baranof Island. Figure 18 is generalized and adapted from plate 22 of Guild and Balsley (1942) with modifications suggested by our mapping. The mineralogic data given below are based on Guild and Balsley (1942) and on additional petrography and X-ray diffraction studies done by us.

According to Guild and Balsley (1942), the peridotite is composed of dunite and lesser amounts of clinopyroxenite, which occurs as irregular masses, regular layers, and crosscutting veins. None of the samples we collected were pure dunite or clinopyroxenite; in the classification of Jackson (1968), the rocks ranged from olivine-rich wehrlite to olivine-poor wehrlite. All rocks have been affected to varying degrees by serpentinization and talc-carbonate alteration. For a given locality, the olivine-rich rocks are more highly serpentinized. According to Guild and Balsley (1942), the degree of serpentinization is least in the center of the body.

The olivine-rich rocks weather red, giving the peridotite its conspicuous red color from a distance; the olivine-poor rocks weather gray green. Granularity of the dunite is about 1 mm and of the clinopyroxenite is 3–6 mm. Clinopyroxene subpoikilitically encloses olivine. Interlayering of dunite and clinopyroxenite is common throughout the body, with individual bands ranging from 2 cm to 0.5 m. Clinopyroxenite also occurs as large irregular masses in the western part of the pluton (fig. 18) and as veinlets and irregular masses cutting across regular layering. Cataclastic textures are restricted to shear zones and, where present, are superimposed on the original granular texture.

The olivine is extremely magnesian (Fo_{95}), and the clinopyroxene is diopsidic (Guild and Balsley, 1942). Primary chromite occurs as disseminated grains, thin layers, and small lenses, particularly in dunite. (See Guild and Balsley, 1942. p. 178–187 for a description of the chromite ore bodies.) Chromite grains are commonly rimmed by magnetite (possibly a "ehromian magnetite"; compare Chidester, 1962, p. 75). Magnetite also occurs as discrete anhedral grains, probably after chromite, that are interstitial to the silicate minerals and also as dust and veinlets in serpentine. It is probable that the magnetite in both occurrences is a product of serpentinization. This abundant magnetite was not reported by Guild and Balsley (1942), and perhaps accounts for the low Cr:Fe ratios of their samples as well as much of the irregular magnetic data of Kennedy and Walton (1946, p. 75).

Serpentine (primarily antigorite as determined by comparison of X-ray diffraction traces with those given by Francis, 1956, p. 205 and 206) is found in both dunites and clinopyroxenites, in which it appears to have been derived chiefly from olivine. In specimens containing both primary phases, the clinopyroxene is commonly fresh, and the olivine wholly or partly altered to serpentine.

The Red Bluff Bay mass is probably bounded by shear zones (fig. 18). The western contact just north of Red Bluff Bay coincides with a stream and is ambiguously specified on plate 22 of Guild and Balsley (1942), from which figure 18 is adapted. However, because of the peripheral shear zone elsewhere and the likelihood of tectonic emplacement, we feel that this contact is more probably also a shear zone. In addition, subvertical shear zones striking north and northeast are abundant within the body. Many of these shear zones are loci of talc-magnesite or talc-magnesite-dolomite rocks in which chlorite, termolite, and antigorite occur sporadically. The peridotite body appears to consist of two parts that are bounded approximately along the talc-lined shear zones that strike north through the center of the body. To the west, clinopyroxenite and dunite occur in subequal amounts, there are no chromite prospects, and the pattern of shear zones is irregular. To the east, dunite predominates, there are a number of chromite prospects, and the shear zones are preferentially oriented at about N. 5" E. Layering in both parts also shows a subvertical N. 5" E. preferred orientation. This orientation is less well pronounced in the west half where there are some gently dipping layers.

Country rock near the peridotite consists of phyllonite and greenschist derived from sedimentary and volcanic rocks of the Kelp Bay Group. The peridotite appears to have had no contact metamorphic effect on the country rock. The metamorphic grade, which increases northward and southward from Red Bluff Bay to high-grade amphibolites and schists, is related to granitic plutons to the north and south.

The wehrlitic composition of the peridotite resembles the zoned ultramafic complexes of eastern southeastern Alaska (Taylor, 1967), rather than the harzburgitic composition of the major alpine peridotite bodies of the Pacific Coast of the contiguous United States (Ragan, 1963; Himmelberg and Coleman, 1968; Loney and others, 1971). We suggest that the peridotite was originally emplaced as a magma or magmas at a depth below the present level of erosion in a manner similar to that inferred by Taylor and Noble (1960) for the zoned ultramafic bodies. The peridotite body was then caught up in the Late Cretaceous and early Tertiary orogenic activity and was tectonically displaced from its site of crystallization upward into the overlying country rocks. During movement the peridotite probably incorporated water from the country rock (possibly water of hydration driven off during metamorphism) and was partly altered to serpentine. The restriction of completely unserpentinized dunite to a small area near the center of the body (Guild and Balsley, 1942, p. 175) is consistent with this interpretation. During this tectonic intrusion the body was split into two parts; the eastern one was more intensely deformed than the western, as shown by the greater preferred orientation of both layering and secondary structural features.

The talc-carbonate assemblages found along many of the shear zones probably resulted from the action of hydrothermal solutions moving along shear zones subsequent to tectonic emplacement of the peridotite and to serpentinization. The source of these solutions is unknown. We have no evidence that would permit us to choose between connate water driven off during metamorphism of the country rock and magmatic water derived from the granitic plutons of Baranof Island. The presence of antigorite serpentine in the Red Bluff Bay peridotite, which lies in country rocks belonging to the upper greenschist or albite-epidote hornfels facies and higher, is in agreement with the general reported occurrences of antigorite (Page, 1967; Cérny, 1968). According to these authors, antigorite generally occurs in ultramafic rocks that have been subjected to upper greenschist facies and higher metamorphism. It is probable, then, that at least the last major episode of serpentinization of the peridotite took place under the metamorphic conditions related to the Tertiary granitic plutons.

The Red Bluff Bay mass is here interpreted as illustrating a tectonic state transitional between the only slightly altered and deformed ultramafic plutons of the eastern belt of Taylor and Noble (1960) and the intensely deformed, serpentinized, and altered ultramafic masses about 20 miles northwest of Red Bluff Bay. If the Red Bluff Bay body had been forced higher into the country rocks or had been subjected to tectonic intrusion for a longer period of time, all its primary minerals and textures might have been obliterated by alteration and deformation, and it might have been disrupted into a number of smaller masses similar to the serpentinites described below.

SERPENTINITES

The serpentinites of Baranof Island occur in two en echelon belts (pl. 1). The major belt extends northwest from Gut Bay to Katlian Bay and contains at least 28 separate bodies, the greatest concentration of which is just southeast of the Vodopad River. The minor belt trends north-northwest just south of Rodman Creek and contains only three positively identified bodies. The major belt was described briefly both by Guild and Balsley (1942) and by Kennedy and Walton (1946) and is shown by a single locality mark in figure 1 of Taylor and Noble (1960). The minor belt was discovered by us during reconnaissance geologic mapping of Baranof Island in 1962.

These serpentinites occur as lenticular masses concordant to the subvertical north-northwest-striking foliation of the surrounding Mesozoic metamorphic rocks. Individual masses range in size from 10 to 25 feet to 800 by 5,000 feet. They weather dull yellowish orange, orange, and violet, support only a sparse vegetation, and form bare scars that contrast strikingly with the gray- or green-weathering country rock and its common cover of conifers or clubmoss (fig. 19).

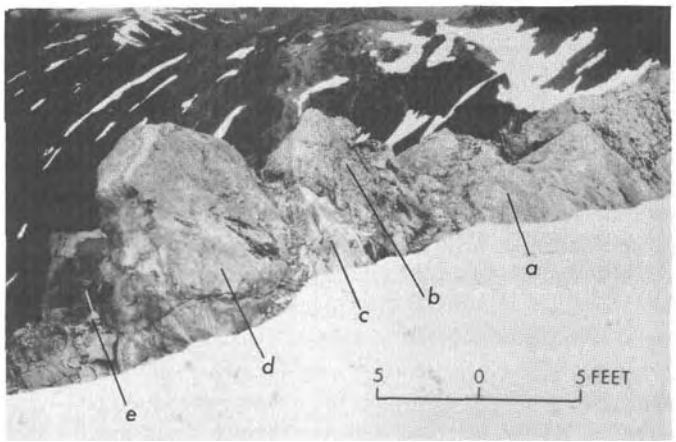


FIGURE 19.—Tectonic contact of metamorphic rocks of the Kelp Bay Group and ultramafic body, illustrating metamorphic differentiation across the contact. *a*=chloritic metachert; *b*=tectonically interlayered metachert and blackwall (chlorite) rock; *c*=talc-tremolite rock; *d*=tremolite-chrysotile-talc rock; *e*=inclusion of schistose tremolite rock. Barren areas on ridge in distance are underlain by ultramafic rock; areas covered by vegetation are underlain by phyllite and greenschist. Photograph looking northwest from the west edge of the glacier 4 miles northeast of Lake Diana. Approximate scale shown by bar.

All these serpentinites are interpreted as tectonic intrusions. The contacts we saw were exclusively shear planes. Foliation within the bodies is pervasive and intense and approximately parallels the regional metamorphic foliation. Weathered surfaces on serpentine or talc-carbonate rock commonly show relic breccia textures, with individual fragments as much as 2 feet in diameter.

Primary minerals are scarce. Kennedy and Walton (1946, p. 73) referred to the rocks as serpentinized dunites with some pyroxene. Clinopyroxene is the only primary silicate we identified, and it was found at only one locality. Chromite occurs as equant grains rimmed and veined by magnetite and is reported by Kennedy and Walton (1946, p. 73) to occur locally as crystal aggregates and as streaks and seams.

The best exposed contact that we saw (fig. 19) shows a zonation attributable to metamorphic differentiation under somewhat different conditions than those under which the more common talc-magnesite rocks were formed. Country rock (a in fig. 19) near the contact is chlorite-bearing metachert. Banding within the metachert is truncated by a 3 foot-thick shear zone (*b*) in which blackwall (chlorite) rock and metachert are tectonically interlayered. The shear zone is in sharp tectonic contact with tough light-gray talc-tremolite rock (*c*) that weathers moderate orange pink. This zone, 6 inches to 2 feet thick, passes gradationally into black tremolite-chrysotile-talc rock (*d*) that weathers dark yellowish orange and contains tectonic inclusions up to 2 feet in diameter of fine-grained medium-green schistose tremolite ($Z=1.635$) rock (e). Foliation in the inclusions commonly is at high angles to foliation in the enveloping tremolite-chrysotile-talc rock. This zone grades inward (within 15–30 feet) into intensely foliated and brecciated medium-gray serpentinite consisting exclusively of antigorite and accessory magnetite. This serpentinite makes up most of the exposed ultramafic body.

This ultramafic contact is comparable with the ultramafic contacts detailed by Chidester (1962); however, the Baranof Island contact differs from the Vermont contacts in that the outermost zone of the body is talc-tremolite rather than talc-magnesite. Phillips and Hess (1936) describe a zonation of talc-actinolite rock adjacent to biotitic blackwall rock and attribute these parageneses to higher temperatures than the talc-magnesite and chlorite parageneses. Extrapolation of this conclusion suggests that the talc-tremolite rock of Baranof Island was produced at higher temperatures and at a deeper level than the now contiguous chloritic blackwall rock and has been displaced upward to its present position during continuing tectonic intrusion of the ultramafic body.

Serpentine minerals are dominant in many of the smaller ultramafic bodies. Both antigorite and chrysotile were identified, but the limited data available permit no generalization about relative distribution or parageneses. Minor secondary magnetite is consistently associated with the serpentine.

Most of the ultramafic bodies show talc-magnesite alteration near their boundaries, and many are completely converted to talc-magnesite. Complementary blackwall (chlorite) zones in adjacent country rock were seen only at a few localities. The common occurrence of talc-magnesite adjacent to unaltered country rock may be due to mechanical separation of complementary talc-magnesite and blackwall zones during recurrence of tectonic intrusion. If this separation occurred, then we may infer (after Chidester, 1962) that the talc-magnesite rocks of Baranof Island were produced by metamorphic differentiation in the presence of CO_2-bearing hydrothermal fluids. Serpentinite in the ultramafic belt near Rodman Creek is in part hydrothermally altered to tremolite-talc-calcite, and irregular grains of calcite are disseminated throughout some of the otherwise unaltered serpentine. Magnesite was not detected in this ultramafic belt.

STRUCTURE

The structure of Chichagof, Baranof, and Kruzof Islands is exceedingly varied and complex. The pre-Tertiary rocks are intensely folded and faulted and extensively intruded by plutonic rock. This combination of folding and faulting has produced a series of northwest-trending belts; some of these belts are bounded by major northwest-striking faults and others by sedimentary contacts. Except for the plutonic rocks, the rocks composing these belts become younger to the southwest. However, the transition from older to younger is complicated by the folding and faulting that have produced widespread repetitions, omissions, and overturning of the stratigraphic sequence on all scales.

Except possibly for a few thrust faults in the middle Paleozoic rocks of eastern Chichagof Island (see section on "Thrust Faults"), it is not possible to correlate episodes of folding with episodes of faulting. The last episode of intense folding ended in early Tertiary time, whereas most of the faulting described in this section took place during the Tertiary, and some movement is continuing today. The folds and faults are therefore described separately.

FOLDS

In order to simplify the presentation of the complex fold structure, the area is divided into three major geologic provinces (fig. 20) as follows: (1) A northeastern province, mainly in northeastern Chichagof Island, that consists largely of rocks of middle Paleozoic age, (2) a southwestern province, mainly in Baranof and western Chichagof Island, that consists largely of rocks of Mesozoic age, and (3) a largely plutonic intermediate province that is informally called the Chichagof plutonic complex. The first two provinces tend to have distinctive tectonic styles. Broad open folds characterize much of the northeastern province, whereas tight folds and axial plane foliation are characteristic of the southwestern province. In general, the different structural styles are probably related mainly to the greater deformation of the southwestern province, but lithologic differences, such as the much greater abundance of carbonate rocks in the northeastern province, are undoubtedly an important influence. The scattered metamorphic remnants in the Chichagof plutonic complex are intensely deformed, but fragmentary knowledge of the general tectonic style is inadequate to make a valid comparison with the other provinces.

In general the provinces are separated from each other by two major northwest-striking faults—the Sitkoh Bay fault and the Peril Strait fault. The provinces, therefore, correspond to the three main belts of plutonic

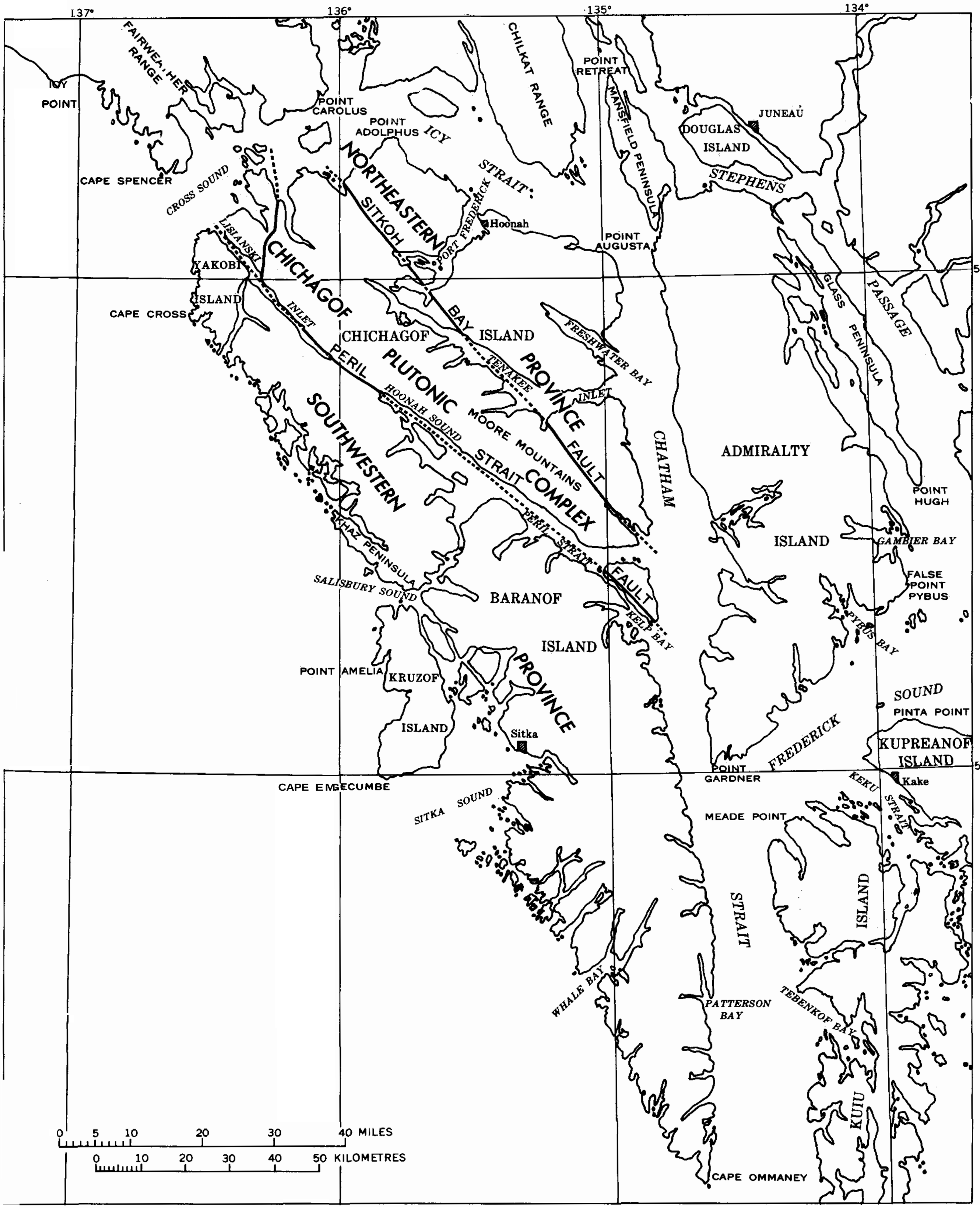


FIGURE 20. —Index map of geologic provinces.

rocks described in the section "Intrusive Igneous Rocks."

NORTHEASTERN PROVINCE

The northeastern province in northeastern Chichagof Island mainly is composed of sedimentary and volcanic rocks that range in age from Silurian to Mississippian. In general, these are gently folded and are metamorphosed only in the vicinity of granitic plutons and near the plutonic complex to the southwest. The structure is dominated by two major folds (see pl. 1, secs. A–A', B–B') that trend northwestward from Chatham Strait to Port Frederick and then northward through a broad arc to Icy Strait. This broad arc is part of a major structural feature also expressed in the map units in northwestern Chichagof Island.

The northeast fold was named the Freshwater Bay syncline by Buddington and Chapin (1929, p. 315; see also Loney, Berg, Pomeroy, and Brew, 1963). It is a broad open symmetrical fold whose axis plunges very gently to the southeast. In places the Kennel Creek Limestone and other formations of middle Paleozoic age are repeated in opposite limbs of the syncline and serve to outline it on the map (pl. 1). The nose of the syncline in the Point Adolphus area is obscured by faulting and later folding about northeast-trending axes.

The southwest fold is an anticline complementary to the syncline; its southwest limb is outlined by the linear outcrop of Kennel Creek Limestone northeast of the town of Tenakee (pl. 1, sec. B–B'). The anticline is much disrupted by plutonic intrusions, and details of its form and orientation are unknown. The anticline is more appressed than the Freshwater Bay syncline, and the larger folds southwest of the anticline, such as the small sharp syncline at the head of Indian River, are of still smaller wavelength. Southwest of this small syncline, the Kennel Creek Limestone is not repeated although the rocks are tightly folded. The marble of Paleozoic(?) age that crops out along the northeast shore of Tenakee Inlet and also in the Chichagof plutonic complex to the southwest is probably correlative with the limestone unit of the Point Augusta Formation. This and other lithologic similarities of the metamorphic rocks of Paleozoic(?) age to the Point Augusta Formation suggest that the rocks southwest of the mapped Kennel Creek exposures are older and that a major anticlinorium or some other type of structural high lies to the south, possibly encompassing Tenakee Inlet and most of the Chichagof plutonic complex (pl. 2 and fig. 20). A study of the faults (see section on "Tenakee Fault System") suggests that the plutonic complex is upthrown relative to the rocks on either side.

Deformation increases to the northeast. In the vicinity of Point Augusta, the typical argillites of the Point Augusta Formation have been converted to intensely folded and lineated slates.

The major folding in the northeastern province occurred probably no later than middle Mesozic time. The plutons in the Freshwater Bay area are generally located in the hinges of major folds and are distinctly later than the folding (Loney, Condon, and Dutro, 1963, p. 45–50). Some of these plutons are Jurassic, and some are Cretaceous (see section on "Intrusive Igneous Rocks").

CHICHAGOF PLUTONIC COMPLEX

The informal term Chichagof plutonic complex refers to a complex of plutonic bodies and much less abundant metamorphic inclusions and pendants. The structural data from both the plutonic rocks and the metamorphic rocks are not abundant enough to attempt a structural analysis. In general, a northwest structural grain, roughly parallel to the regional structural grain, is evident from the strike of foliation and from the trend of folds in the scattered metamorphic rocks; variations of orientation near plutonic contacts are not noticeable. The metamorphic rocks are intensely folded with local development of axial plane foliation, generally in the form of schistosity. However, a large proportion of the metamorphic rock is hornfels and granofels in which bedding is the only visible structural surface other than jointing.

Because of the extensive plutonic intrusive rock, conclusive evidence about the anticlinorium mentioned in the previous section is lacking. The west flank of the "anticlinorium" is represented possibly by the discontinuous belt of Paleozoic(?) marble outcrops along the western margin of the province. The axis trends northwest through the extensive tonalite mass immediately south of Tenakee Inlet and appears to be the axis of maximum plutonism. On the other hand, there is evidence that faulting is at least partly responsible for the present structurally high level of the plutonic complex. (See section on "Tenakee Fault System.")

SOUTHWESTERN PROVINCE

The southwestern province is composed of the Kelp Bay Group and the Sitka Graywacke and includes all of Baranof Island and the western part of Chichagof Island. The province is intruded by several granitic plutons of Tertiary age, with accompanying contact metamorphism but with only minor accompanying deformation. Mesozoic plutons are also present but metamorphism and deformation related to them is unknown.

Throughout most of the province, the strike of the bedding and foliation and the trend of the dominant fold axes is northwest. Large-scale departures from the northwest direction occur in northern Baranof Island, in southwestern Chichagof Island, and in northwestern

Chichagof Island. The rocks generally become younger to the southwest, although the intense folding and faulting have produced many local reversals of this trend. The largest of such reversals is in northern Baranof Island, where the rocks of the Kelp Bay Group crop out in a major antiformal fold in which stratigraphic relations are complex (see section on "Northern Baranof Island").

To the northwest, in the Hoonah Sound area, the antiformal structure is not evident, and rocks that are probably correlative with the Sitka Graywacke and with underlying greenstone units occur in a complexly faulted structure that is intruded by much granitic rock (pl. 1, section *B–B'*). This faulted structure is probably roughly synclinal and complementary to an anticline to the southwest, whose core has been nearly destroyed by extensive granitic intrusions. The anticlinal axis probably trends northwest through the granitic rocks near the head of Patterson Bay, and the southwest limb is represented by the rather uniformly striking map units along the ocean coast.

Reliable marker units and sequences of beds in which the stratigraphic succession is known are rare in the southeastern two-thirds of the southwestern province. For this reason, the study of folds and related structures by conventional stratigraphic means is seldom possible, and statistical graphical methods that represent structural elements on the lower hemispheres of equal area projections have been used instead. These methods, though showing orientation and reflecting style, cannot show size, nature, and location of individual folds. The latter information can be obtained only from conventional field mapping of reliable marker units.

Mesoscopic structural data was obtained from rocks of both the Kelp Bay Group and the Sitka Graywacke. The geometry of the structural elements studied does not reveal significant differences between the two units; the same fold generations were recognized in both. The main difference seems to be in the degree of deformation—the Kelp Bay Group is in general more penetratively deformed than the Sitka Graywacke. The two units, therefore, are generally not distinguished in the following discussion.

Small-scale folds are commonly isoclinal with subvertical axial planes that generally parallel the foliation. More open folds and warps are also common, and kink or chevron folds and strain-slip cleavage are common in thinly layered rocks such as greenschist and phyllite. Superposed folding is indicated in places by the overprinting of two generations of small folds and lineations and also by large-scale departures from the regional fold trend (as in northern Baranof Island).

In southern and eastern Baranof Island, the two generations of folds are nearly homoaxial, but in the vicinity of major bends in the fold belt, such as in southwestern Chichagof Island and northern Baranof Island, the two generations diverge widely.

Most mesoscopic structures in the southwestern province appear to belong to the earlier of the two generations[2]. This earlier generation, here designated F_1, consists of subisoclinal folds (B_1) in bedding (S_1) (fig. 12), axial plane foliation (S_2), and lineation ($L_1=B_1$). Characteristically, larger folds have sharp thick hinges and long, thin, and in places, sheared-off limbs of unequal length; smaller folds in the hinges of larger folds commonly have a more symmetrical open style. The lineations consist of fine crenulations, elongate mineral streakings on foliation, striations on bedding, and mullions. The last three represent or are formed by the intersection of bedding and foliation. All four are subparallel to the axes of the larger (B_1) folds. Lineations and small folds vary greatly in abundance. They are most numerous in thinly layered phyllite and greenschist in areas of more intense metamorphic deformation, such as in southern and eastern Baranof Island. In such terranes, transverse, generally northeast-striking joints (ac) that are approximately normal to the fold axes are especially well developed (fig. 9; see Brew and others, 1963).

The shearing has also produced cataclasis on all scales, and sheared-off lenses of beds and units of beds range in thickness from a few millimeters to several feet (fig. 13). The cataclastic deformation is especially intense and widespread in the Kelp Bay Group east of Sitka (fig. 10). In contrast, little cataclastic deformation seems to have occurred on the west coast of Chichagof Island northwest of Ford Arm, where thin formations, such as the Whitestripe Marble, extend for more than 20 miles with only minor faulting. Southeast of this area, on Chichagof Island and on Baranof Island, the cataclastic deformation has been intense, and the formations are tectonically mixed on a scale too small to map. Much of this chaotically mixed rock, designated the Khaz Formation, resembles the melange described by Hsü (1967) in the Franciscan Formation of California; however, faulting and nosing-out of sharp fold hinges undoubtedly have also contributed to the general lenticularity of rock units in this area.

The S_2 foliation ranges from widely spaced fracture cleavage through slaty cleavage to schistosity and typically shows cataclastic texture in thin section. S_2 is generally subparallel to the bedding (S_1), and a measurable divergence of the two surfaces is rarely seen. In probable hinges of major folds, such as on eastern Baranof Island north of Red Bluff Bay, bedding and

[2]Still earlier folds or warps are suggested by indirect evidence (see section on "Northwestern Baranof Island), but little is known about them, and they do not appear to make an important contribution to the structural picture.

foliation diverge markedly over areas as wide as a few miles. The general subparallelism of bedding and foliation apparently results from a combination of the greater area underlain by the limbs of the isoclinal first folds relative to their hinges and the disruption and transposition in many places of bedding by shearing along foliation planes (fig. 13).

In addition to the F_1 structures, which have deformed bedding, there are later structures, F_2, that have deformed both bedding and S_2 foliation. The F_2 structures consist of folds (B_2), axial plane foliation (S_3), and lineation ($L_2=B_2$). The B_2 folds tend to vary more in style than the B_1 folds, and isoclinality is rare. The S_3 axial plane foliation is developed only locally and ranges from a phyllitic cleavage to a strain slip cleavage. The L_2 lineation is generally fine crenulations in S_2.

Despite the fact that B_2 small folds and L_2 lineations are commonly overprinted on earlier structures, the general trend of B_1 folds is northwestward throughout most of the structural province. Where departures from the northwest trend do occur, such as in northern Baranof Island, the mesoscopic B_2 axes diverge widely from B_1 axes. In most of the terrane where the northwest trend prevails, the mesoscopic B_1 and B_2 axes are subparallel. In a few places, a marked divergence between these axes occurs, but there appear to be no B_2 folds large enough to produce important changes in the regional trend. The F_1 and F_2 structures and their mutual relations are described further on the following pages in detailed analyses of selected areas.

AREAS DOMINATED BY NORTHWEST-TRENDING FOLDS

NORTHWESTERN BARANOF ISLAND

Where not deformed by large-scale F_2 folding about divergent axes, the B_1 folds have northwest-striking subvertical axial planes and axial orientations ranging from a moderate northwest plunge through horizontal to moderate southeast plunge. This general geometry is illustrated by domain I (pl. 3), which represents a large area in predominantly low grade metamorphic rocks in northwestern Baranof Island where plutonic intrusions form a relatively small proportion of the rock. The variation of B_1 axes from a northwest to a southeast plunge lies in the general axial plane of the B_1 folds and thus was probably caused by broad warps in S_1 prior to the F_1 deformation rather than by later deformation. The other scattering in this diagram is probably caused in part by F_2 folding that deformed both S_2 foliation and B_1 fold axes and in part by incorrect identification and inclusion in the diagram of B_2 fold axes and L_2 lineations. Where only one generation of linear structure is present in an outcrop, its identity could seldom be determined with certainty.

The poles of bedding and foliation in the plot of domain I (pl. 3) are concentrated in a single maximum representing an average strike of N. 20" W. and an average dip of 80" to the southwest. This geometry reflects the general steep dip of the limbs and the axial plane foliation of the nearly isoclinal B_1 folds. The scattered poles near the center of the diagram, which represent gentle dips in fold hinges, define a partial girdle whose waxes plunges 45° to the northwest, roughly parallel to the average orientation of small B_1 fold axes and lineations. However, the scatter of poles in the south half of the diagram suggests that in some parts of domain I southeast-plunging π-axes might be defined; these axes would correspond to the few southeast-plunging B_1 fold axes in the plot. The rough parallelism of B_1 small-scale fold axes and the π-axis in the domain demonstrates that the large-scale folds and most of the small folds and lineations belong to the same (F_1) generation.

SOUTHERN AND EASTERN BARANOF ISLAND

Southeast of domain I, the same general geometry and orientation of folds persist to the south tip of Baranof Island in spite of the fact that many of the data come from metamorphic rock in and around plutons. Only locally, at Redoubt Lake and Hoggatt Bay, does the foliation near intrusive contacts swing abruptly from the regional orientation to subparallelism with the intrusive contacts.

The metamorphic terrane in southern Baranof Island is divided into two domains (pl. 3): domain II in which folds plunge mainly to the northwest, and domain III in which folds plunge mainly to the southeast. The southeast-plunging domain contains a number of northwest plunging fold axes that are concentrated largely in four narrow eastward trending subdomains too small to show with separate plots. The plots of domains II and III show that plutonism has not disturbed the general northwest regional orientation of folds, as shown by domain I (pl. 3); instead the orientation is even more pronounced. The patterns of planar and linear elements in the plots of domains II and III show a greater preferred orientation than those in domain I.

The greater preferred orientation is in part due to a pronounced S_3 foliation that maintains a remarkably uniform orientation throughout the metamorphic terrane. The S_3 foliation cuts the B_1 folds and S_2 foliation and appears to be subparallel to axial planes of B_2 folds that deform S_1 bedding and S_2 foliation. In contrast to the commonly cataclastic nature of the S_2 foliation, the S_3 foliation is defined mainly by the planar preferred orientation of micaceous minerals and by strain-slip cleavage (Leith, 1905, p. 120; Harker, 1939, p. 157–159). There are thus two generations of folds and foliation in the metamorphic terrane; however, the geometry of the planar and linear structures of both generations have almost the same style and share almost the same axis of folding. In other words, when plotted, the planar structures of both generations tend to intersect in the same **ß-axis**, and the linear structures of both tend to parallel the same **ß-axis**. The two generations of structures represent either two distinct phases of the same episode of compression or two distinct episodes of compression with similar orientations. Because of their close similarity of orientation, the two generations could not be separated at the present scale of mapping; they are therefore considered two phases of a single deformation.

The eastern **Baranof** Island metamorphic terrane has also been divided into two domains, IV & V, (pl. 3): in domain IV the folds plunge southeast and in domain V the folds plunge northwest. As in southern **Baranof** Island, the regional northwest structural grain is maintained in spite of the fact that a large proportion of the structural data came from metamorphic inclusions in granitic rock. The well-developed girdles of poles to S_2 foliation show a relatively simple geometry that is not related to the shape of the Kasnyku Lake plutonic body but is related to the regional structural orientation. The girdle, however, contrasts with the poorly developed partial girdles seen in the areas thus far described and shows a nearly uniform distribution of poles from horizontal to vertical. This geometry suggests a major fold hinge that may be the southeast extension of the major **antiform** of domain VI. (See section below on "Northern **Baranof** Island.")

S_3 foliation, subparallel to the axial planes of **B_2** folds in both bedding (**S_1**) and **S_2** foliation, is mainly developed in the southeast-plunging domain, domain IV, (pl. 3) near Red Bluff Bay. In addition to small-scale folds and crenulations (both **B_1** and **B_2**), there are abundant **L_2** lineations parallel to the intersections of the **S_3** foliation with **S_1** and **S_2** foliation. The **L_2** linear structures thus produced consist largely of striations, mineral elongations, and mullions. When the poles to **S_1, S_2,** and **S_3** are plotted together, they form a distinct girdle whose **π-axis** plunges gently to the southeast (fig. 21). However, as shown in figure 21, only the poles of **S_1** and **S_2** foliation (determined in the field) make up the lower dip part of the girdle, which represents the hinges of folds, and the poles of S_3 foliation are restricted to the subvertical parts of the girdle. This relation demonstrates that the **S_3** foliation is subparallel to the axial planes of major folds in the **S_1** and S2 and is not itself folded. All linear structures in the area, whether **B_1** or B2, form a gentle southeast-plunging cluster that is subparallel to π, the major axis of folding (fig. 21). Thus two episodes of folding, **F_1** and F2, occurred about approximately the same axis, each with the development of an axial plane foliation—a situation nearly identical to that in the southern **Baranof** metamorphic terrane.

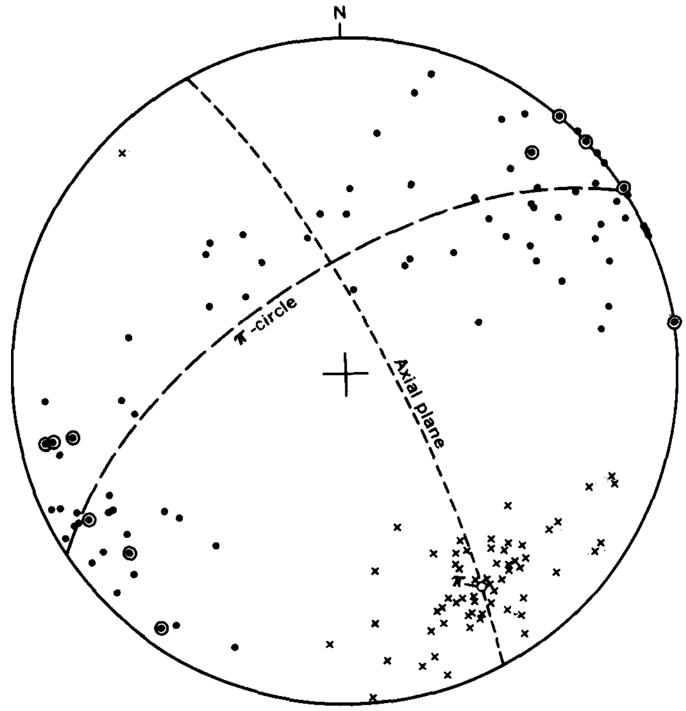


FIGURE 21.—Relation of S_3 foliation to bedding (S_1) and S_2 foliation in Red Bluff Bay area, Baranof Island (domain IV, pl. 3); ● = pole of S_1 or S_2; ◉ = pole of S_3; x = B_1 or B_2 fold axis or lineation.

The evidence from domain IV, therefore, strongly suggests that both domains IV and V are the crumpled hinge of a major **B_2** fold. The complete girdles represent openly folded **S_1** and **S_2** and, in addition, subvertical **S_3**. The fact that this probable fold hinge appears to be the southeastern extension of the major **B_2** ***antiform*** in northern **Baranof** Island suggests that it too is an ***antiform***.

The **F_1** folding in the southwestern province occurred after the deposition of the Sitka Graywacke in Late Jurassic and Early Cretaceous time and before the Tertiary plutonism on **Baranof** Island. The general parallelism of the axial planes of the **B_1** folds with the major folds in the northeastern province suggests that both generations of folds formed in response to the same general episode of compression. As mentioned previously, the folding in the northeastern province can be determined no more closely than post-middle Mesozoic. This age certainly does not rule out the possibility that the folding in both provinces occurred in Early Cretaceous time soon after or during the later stages of the deposition of the Sitka Graywacke.

In southern and eastern **Baranof** Island, the earlier **F_1** folding is related to regional low grade cataclastic deformation, whereas the later **F_2** folding took place in a higher grade metamorphic environment related to **plu**tons of Tertiary age. Elsewhere in the southwestern province, the **F_1** folding and cataclasis have been **re-**

crystallized by thermal metamorphism near plutonic bodies, possibly also of Tertiary age.

It is evident that the metamorphic conditions related to the plutonism in southern and eastern Baranof Island started some time during the F_2 folding. Further, the metamorphism appears to have continued after the F_2 folding stopped, as indicated in the inner zones of certain contact aureoles where metamorphic crystallization has tended to obscure the F_2 structures. The Tertiary plutons appear to be postkinematic, because they are distinctly crosscutting and not highly foliated. It is possible, therefore, that the metamorphism that occurred during the F_2 folding preceded the actual intrusion of the plutons to their present level which was largely attained after the folding.

Structural Effects Of Tertiary Plutonic Intrusion

The foregoing evidence shows that the intrusion of the Tertiary plutons on Baranof and Kruzof Island had little effect on the regional northwest trend of folds in the surrounding country rock, in roof pendants, and in inclusions. The country rock, therefore, was not significantly disoriented during stoping and sinking into the magma.

Similar examples of passive intrusion of granitic magma have been described in the literature. Kistler and Bateman (1966) give an example of the preservation of preexisting regional structural orientation in roof pendants in the Sierra Nevada of California; Pitcher (1970, p. 124–127) gives a similar example based on inclusions of country rock in the Coastal Batholith of Peru; and Pitcher (1953) and Knill and Knill (1961) give other similar examples from Donegal, Ireland.

Pitcher (1970) suggests that these circumstances can best be explained by stoping in which the thermally spalled-off blocks of the roof and walls sink passively with little rotation into the magma in which there was little or no circulation. This stoping would take place, according to Pitcher, over a considerable period during the early existence of the plutons at their final level in the crust. The mechanism seems to be characteristic of plutons emplaced in low and middle energy environments (epizone and mesozone) where mobilization and assimilation of country rock is negligible.

The Tertiary plutons of Baranof Island fall into this category, and this explanation seems appropriate for them. It is probable that the folding largely preceded the emplacement of the plutons at the "final" level at which the passive stoping took place. On Baranof Island, there were probably still later and possibly upward movements of relatively cold plutons or parts of plutons along marginal faults; these movements produced local bending of beds near contacts.

AREAS DOMINATED BY NORTH- TO NORTHEAST-TRENDING FOLDS

The general northwest-trend of folds in the southwestern province is interrupted by major north- to northeast-trending later folds in three areas: (1) northwestern Chichagof Island; (2) southwestern Chichagof Island; and (3) northern Baranof Island. Of these, only the latter two were mapped during the present work and will be described in detail here.

Northern Baranof Island

In northern Baranof Island, the marker units of the Kelp Bay Group bend from northwest to east in the Rodman Bay area. Bedding (S_1), earlier axial plane foliation (S_2), and earlier folds (B_1) are all involved in this bending; the result is a complex fold, roughly an antiform, in which stratigraphic relations are very complicated. In general, the axial plane of this fold strikes northwestward and dips steeply northeast; the antiform is largely responsible for the broad outcrop of the Kelp Bay Group that extends across northern Baranof Island.

In order to show the nature of this bending, the major hinge in the Rodman Bay area is described in detail. Domain VI (pl. 3) indicates that the bedding (S_1) and S_2 foliation in the hinge as a whole have been folded about a steep northward-plunging axis (B_2). Accordingly, the B_1 folds have also been bent about the steeply plunging B_2 axis. Three domains located nearly along strike in the major hinge have been established (fig. 22).

In domain VIa (fig. 22), most of the small-scale folds and lineations plunge either to the northwest or the southeast, the orientation characteristic of the B_1 folds in most of the southeastern province. The steeply plunging axes near the center of the diagram are probably B_2 folds, but the π-axis of the diagram, which represents the large-scale fold structure, is more nearly parallel to the axes of the B_1 folds. Hence the large fold represented here is a B_1 fold, which was identified in the field as the hinge of a syncline.

Domain VIb is located near the middle of the major hinge, where the bedding (S_1) and the S_2 foliation have a dominantly northeastern strike and a moderate to steep northward dip (fig. 22). No single large fold was observed here, but the rocks are isoclinally folded on a small scale. In places two generations of folds and lineations were seen, one overprinted on the other. The axes of the B_1 folds and lineations fall in the group that plunges gently northeast in figure 22, whereas the axes of the B_2 linear structures fall in the group that plunges moderately to steeply to the north.

In domain VIb, (fig. 22) the large-scale structures shown by the geometry of bedding (S_1) and S_2 foliation show no well defined π-girdle, therefore the domain is probably inhomogeneous. The geometry seems to result from the interference of B_1 and B_2 folds. Sparse data prevent further subdivision into more homogeneous domains.

The evidence from the small-scale structures, however, clearly demonstrates the bending of B_1 axes from a gentle northwest plunge in domain **VIa** to a gentle northeast plunge in domain **VIb.** The large change in trend with only a small change in plunge is a function of the steep B_2 axes about which the B_1 axes were bent. Thus, the orientation of the B_1 fold axes in general follows the bend in the strike of bedding and S_2 foliation, which are subparallel to the B_1 axial planes.

The scatter of B_1 linear structures in the diagram of domain VIb (fig. 22) is probably caused in general by two factors: (1) the angle through which the bedding (S_1) and hence the B_1 fold axes at a given locality were rotated during the F_2 folding and (2) the local orientation of the B_2 fold axis in bedding. In (2), the orientation of the B_2 fold axis at a given locality is dependent on the orientation of the bedding relative to compression at the onset of the F_2 folding. Thus differently oriented B_2 fold axes would form in bedding in differently oriented limbs of earlier (B_1) folds (see Weiss, 1959; also fig. 24). Factor (2) would also explain the scatter of small-scale B_2 fold axes in the diagram (fig. 22). The fact that some of the B_2 linear structures shown were formed in S2, the axial plane foliation which probably had a different orientation than the bedding (S_1) in the hinges of the B_1 folds, adds to their scatter.

Domain VIc (fig. 22) shows a still greater degree of rotation of S_1, S_2 foliation, and B_1 fold axes about steep northward plunging B_2 fold axes. The **π-axis** of the well-developed girdle of poles to S_1 and S_2 lies in a cluster of B_2 small-scale fold axes and lineations that plunge steeply to the north. The B_1 small-scale linear structures are scattered in an arc about the northern part of the diagram and they generally show a gentle plunge. The greater scattering of B_1 fold axes in domain **VIc** compared to domain **VIb** appears to be directly related to the greater degree of rotation by the folding of S_1 and S_2 in domain **VIc.**

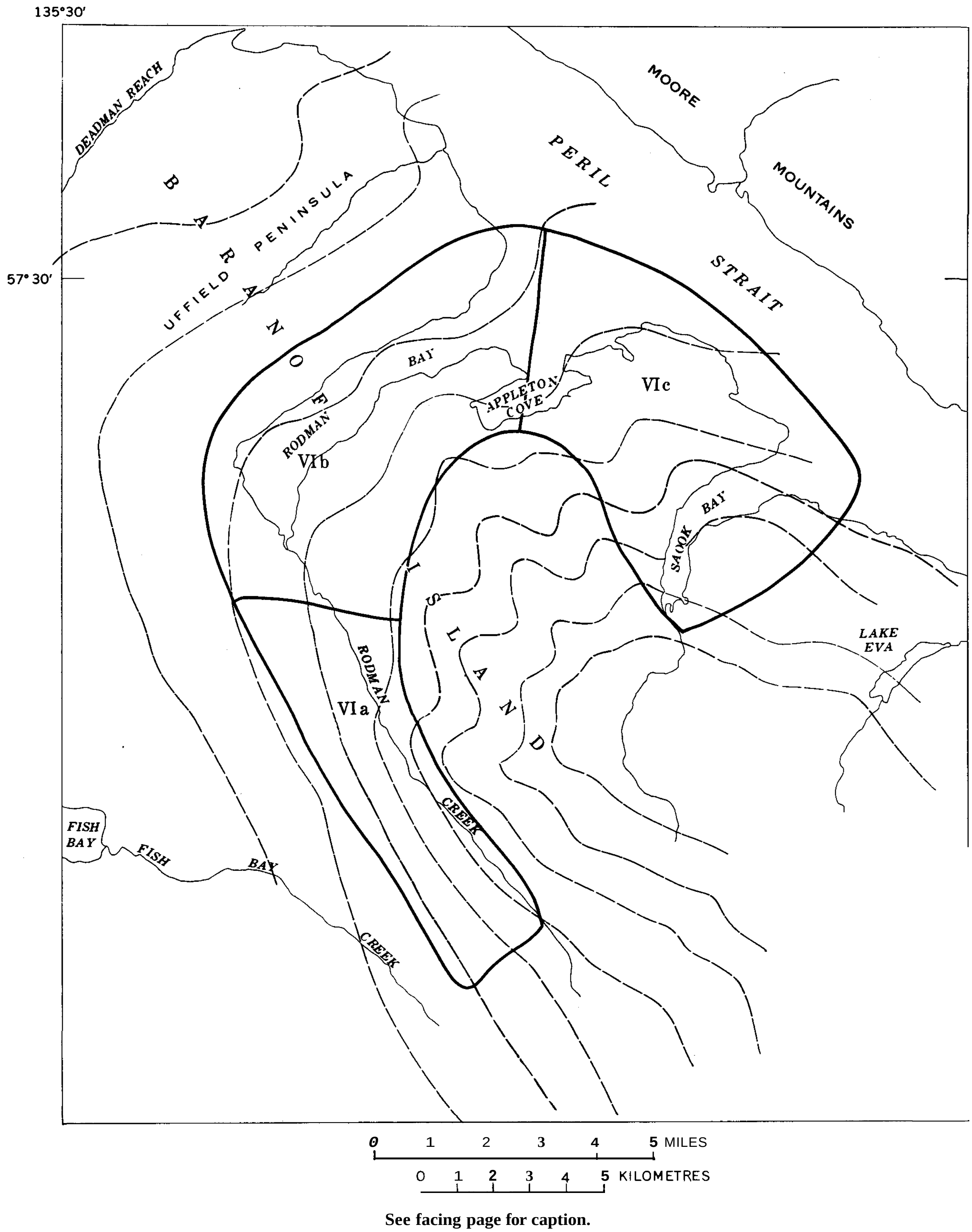
The distribution of B_1 linear structures in domain **VIc** can be explained by assuming that the F2 folding was accomplished by flexural slip of subparallel bedding (S_1) and S_2 foliation. Generally in flexural slip folding, the earlier fold axes are rotated through paths that are small circles, concentric about the later axis of folding (Sander, 1948, p. 171–172; see also Weiss, 1959, p. 98–100). As mentioned previously, the orientation of the B_2 fold axes would vary throughout the domain, depending on the initial orientation of the surface being folded. However, for purposes of discussion, it will be assumed that the statistically defined π-axis is, in effect, the single axis of F_2 folding. Figure 23 shows various small circle paths concentric about the later axis folding, B_2 ($B_2=\pi$), in domain **VIc.** Which small circle path a given linear structure travels is determined by the angle between it and the later fold axis at the onset of folding. The solid arcs are the paths traveled by B_1 linear structures when S_1 or S_2 at S' is rotated about B_2 to S . In the diagram, nearly all B_1 linear structures of domain **VIc** lie in the two segments defined by the solid arcs. B_1 fold axes and lineations may have varied initially in orientation because of yet earlier folds or warps in the bedding (S_1).

Southwestern Chichagof Island

In the Slocum Arm area in southwestern Chichagof Island, the effect of later folding is less evident from the map pattern than in the other two areas. For more than 20 miles northwest from this area, map units form a nearly straight northwest-trending pattern that reflects a uniform structure. However, field evidence indicates tight folding with much overturning toward the northeast. The uniform map pattern in a highly folded terrane suggests one generation of folds with uniformly subhorizontal northwest-trending fold axes. Most of this area of uniform structure was mapped prior to the present work (Reed and Coats, 1941), therefore detailed structural data are not available.

Southeast of Ford Arm the northwest-striking units bend southward and are truncated by the Slocum Arm fault. West of Slocum Arm, on Khaz Peninsula, the Kelp Bay Group crops out in a complexly faulted and folded structure which is not clearly understood. The Khaz Peninsula is a jumble of faulted folds; the faulting occurred chiefly on northwest-striking faults parallel to Slocum Arm. Further complexity arises from the presence of two generations of folds on all scales. The earlier folds (B_1) are similar to B_1 folds elsewhere in the southwestern structural province and are subisoclinal with a well-developed axial plane foliation (S_2). These structures have been deformed by later (B_2) folds whose axes plunge steeply to the southwest. The southward bend of the units toward Slocum Arm, their truncation by the Slocum Arm fault, and their reappearance on Khaz Peninsula suggest that domain VII consists of the much-faulted fragments of a large-scale B_2 fold.

The overall geometry of the Slocum Arm area (domain VII, pl. 3) shows a well-defined partial girdle whose **π-axis** plunges steeply southwest roughly parallel to the small-scale B_2 fold axes. Domain VII, however, is not structurally homogeneous, and the scatter of poles suggests several faint incipient girdles with gently plunging π - axes. These incipient girdles probably represent the deformed B_1 folds, but it is impossible to locate them accurately because of the interference of data in the diagram. Structural data are not abundant enough to permit further subdivision of the area into



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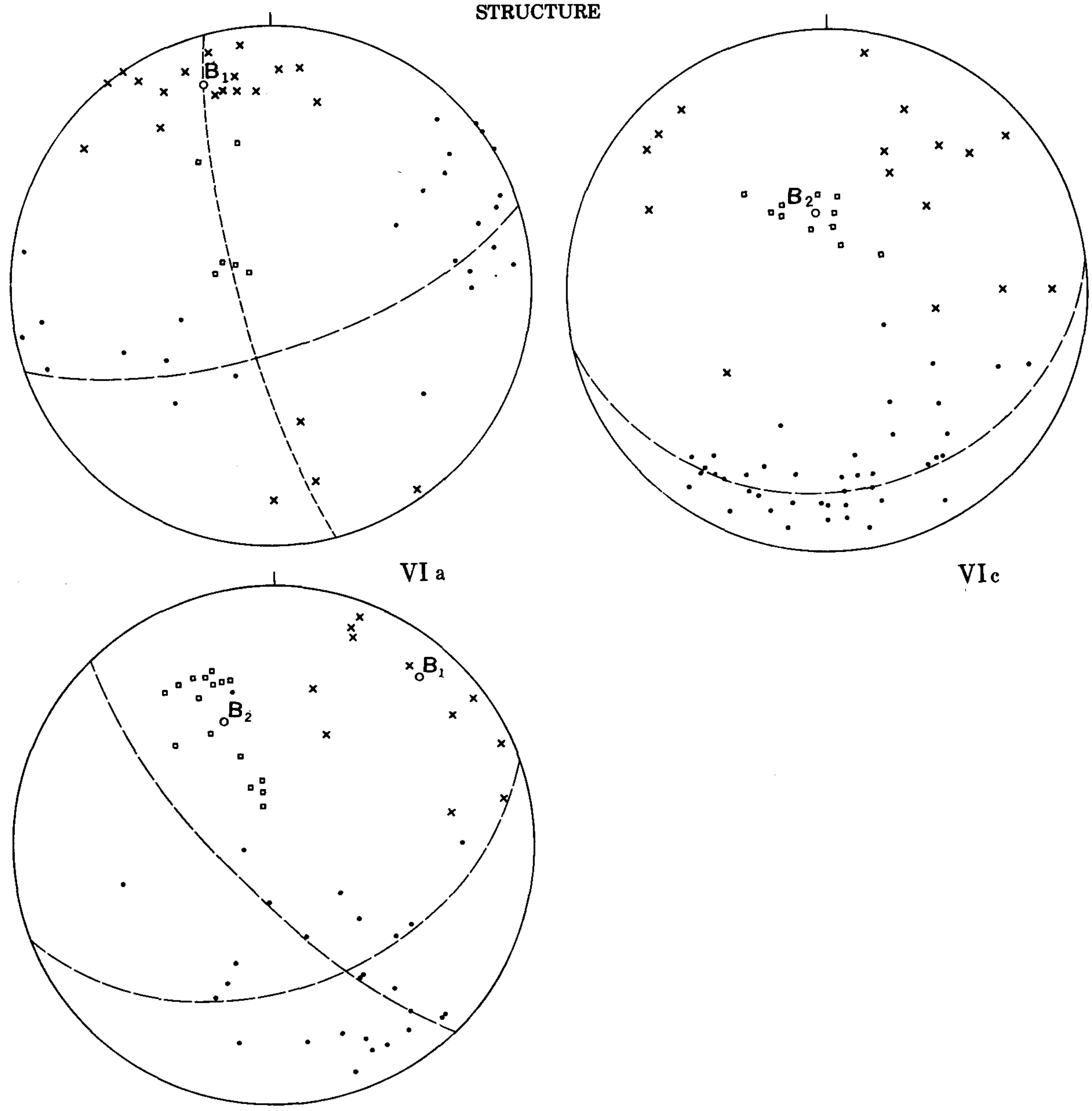


FIGURE 22.--Geometry of bedding, foliation, fold axes, and lineation in major fold hinge, northern Baranof Island (B_1 = π = earlier fold axis; B_2 = π = later fold axis; long-dashed lines = foliation form lines. See plate 3 for explanation of other symbols. Domain VIa: 26 poles, 26 axes. Domain VIb: 27 poles, 28 axes. Domain VIc: 46 poles, 27 axes.

more homogeneous domains. The plunges of the B_1 fold axes and lineations are gentle to moderate, but their trends vary widely. This geometry suggests the rotation of the B_1 fold axes about the steep B_2 fold axes during flexural slip folding in a manner similar to that suggested for domain VIc (fig. 22) in northern Baranof Island (fig. 23).

Small-scale evidence verifies such a rotation of B_1 fold axes. Figure 24 shows a specimen of thinly laminated phyllite from the Pinnacle Peak Phyllite near the head of Slocum Arm. In this specimen, isoclinal B_1 folds have been clearly defcrmed by B_2 open folds and lineations. As oriented in the field, the B_2 fold axes in this specimen plunge steeply to the southwest and fall in the cluster of B_2 fold axes in the plot of domain VII (pl. 3). The trends of the gently plunging B_1 fold axes in the specimen were markedly changed by this rotation, whereas their plunges were little affected, a relationship corresponding closely to that shown in the plot on a large scale.

The consistent steep southwestward plunge of the B_2 folds is probably a function of the predominantly steep southwestward dip of limbs of the B_1 folds and S_2 axial plane foliation at the onset of the F_2 folding. This is the present predominant attitude of fold limbs and axial

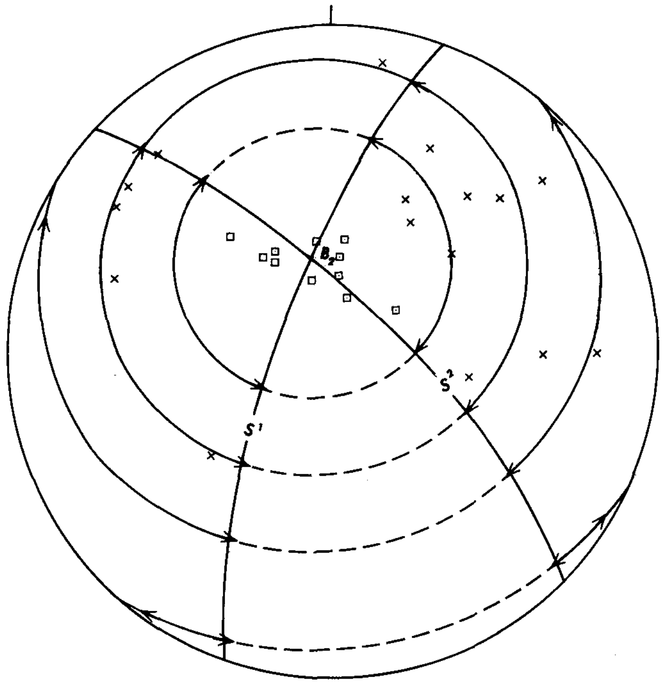


FIGURE 23.—Relation of B_1 fold axes to small circles concentric about the later axis of folding (B_2) in Appleton Cove-Saook Bay area (domain VIc, fig. 22); orientations of bedding (S_1) and S_2 foliation in domain lie in solid arc between S' and S'' (see text); x = B_1 fold axis, ◦ = B_2 fold axis.

planes along the coast of Baranof Island northwest of Slocum Arm.

The broad bending of the strike from northwest to north in northwestern Chichagof Island (Rossman, 1959) is possibly a large-scale manifestation of the later (B_2) folding. However, the map pattern (pl. 1) shows considerable complexity other than simple bending; notable are the abundant plutonic bodies and the repetition and discontinuity of units across the Peril Strait fault. Structural analysis is not possible because of the inadequacy of data; we did not remap this part of Chichagof Island.

DISCUSSION OF SUPERPOSED FOLDING

The northwest-trending fold belt in the southwestern province was probably the result of several pulses of northeast-southwest compression. In most of the province, this compression seems to have produced one and in places two generations of northwestward-trending folds, and in many domains the two generations are nearly homoaxial. However, in the vicinity of major bends in the fold belt, the earlier and later folds diverge markedly. It is tempting to ascribe these bends to large-scale drag due to right-lateral movement on major faults, such as the Slocum Arm and Peril Strait faults. But it seems unlikely that fault drag could have affected such wide belts of rock. More likely both the bending of the fold belts and the faulting are related to the reaction of deforming rock to large-scale basement inhomogeneities.

It is suggested that the southwestern Chichagof and northern Baranof were the sites of large-scale departures from the regional northwest strike of the axial planes and limbs of the earlier folds (B_1) at the onset of the later (F_2) folding. It is possible that these departures were produced by the B_1 folds being pressed and crowded into a large-scale but rather abrupt northeastward embayment in the edge of the geosyncline during the later stages of the F_1 folding. This crowding could have produced large-scale bending of the folds so that large parts of them could have trended at high angles to the regional northwestward trend. Similar large-scale later folding, possibly related to basement inhomogeneities, has been described on southern Admiralty Island (Loney, 1965).

The country rocks bordering this inferred embayment acted as a buttress; these rocks probably consisted of Paleozoic sedimentary and volcanic rocks and Paleozoic and Mesozoic plutonic rocks. Further northeast-southwest compression, either continuous with the earlier compression or as a separate pulse, caused the favorably oriented limbs and axial planes of B_1 folds in the embayment to be folded about new axial orientations (B_2).

In contrast, in southern and eastern Baranof Island, the B_1 and B_2 folding is nearly homoaxial. It seems likely that in order to be folded by compression about the same axial orientation, the earlier axial plane foliation (S_2) must have been rotated around the same axis from its initial orientation about normal to the compression at the end of the earlier F_1 folding to an orientation more nearly parallel to the compression. This relation strongly suggests that the rotation and the F_2 folding were genetically related to the F_1 folding as part of a continuous folding process.

Although the F_2 folding episodes in northern and southern Baranof Island are possibly related to the same general period of northeast-southwest compression, there is no evidence that they were contemporaneous. Indeed, the reasons for the development of B_2 folds in the two areas seem unrelated; in the north, there seems to have been a buttressing against an inferred major embayment in the depositional trough, and in the south, a rotation of structural surfaces, or of the principal stress axes, that is probably closely related to the folding mechanism itself.

FAULTS

Subsequent to the folding described above, Baranof and Chichagof Islands were subjected to intense faulting that probably continues to the present. A major north-trending fault separates Baranof and Chichagof Islands from Admiralty and Kuiu Islands to the east.

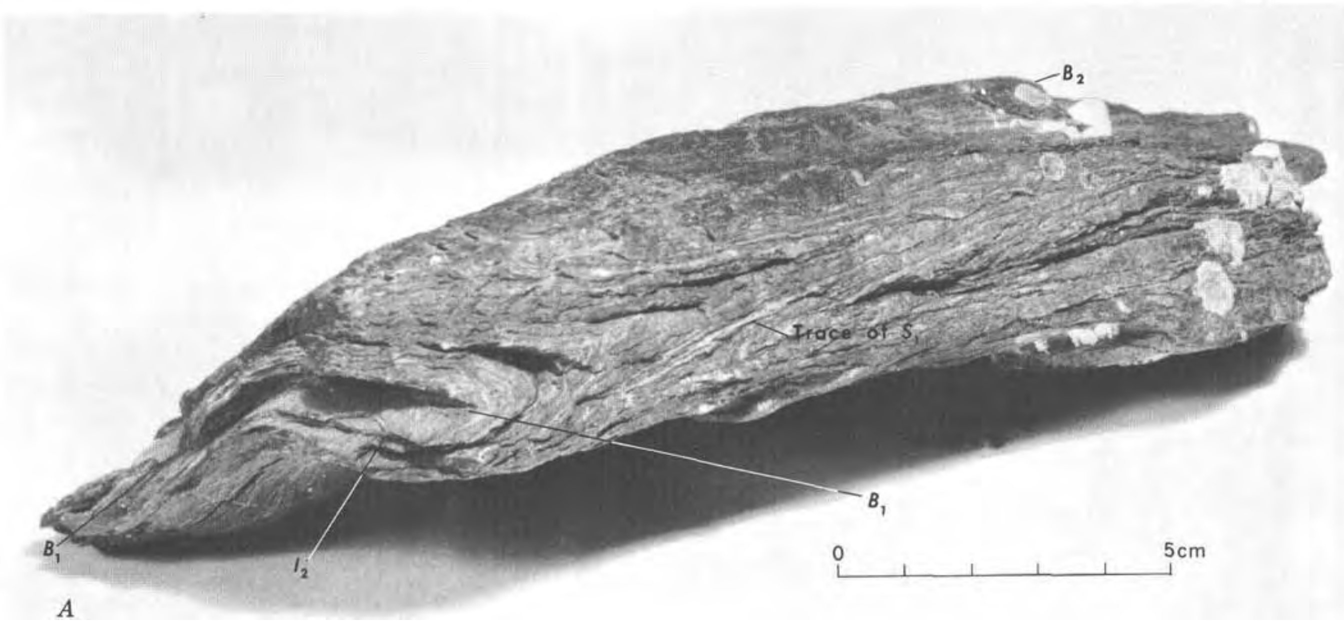
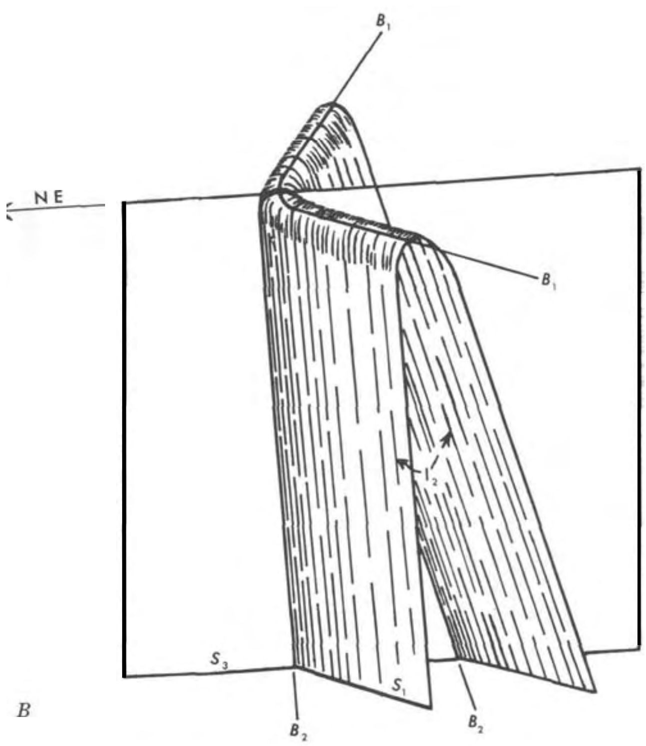


FIGURE 24.—Hand specimen of phyllite, Pinnacle Peak Phyllite, Slocum Arm, Chichagof Island. A, Showing superposition of open later folds (B_2) and lineation (l_2) on earlier isoclinal folds (b_1) in bedding (S_1).



***B*, Diagram showing orientation of specimen in field; axial plane of B, fold (S_3) is subvertical and strikes northeast (to the left); note divergent B, axes formed in opposite limbs of B_1 fold.**

Prominent throughgoing northwest-trending faults are conspicuous throughout Chichagof Island and in central Baranof Island. Northeast-and east-trending faults are numerous in northern and northeastern Chichagof Island and in central Baranof Island. Fault movement has been both dip slip and strike slip; several large faults probably have strike-slip displacements of tens of kilometers. Several of the major northwest-trending faults are of major geologic significance because they bound terranes of strikingly contrasting stratigraphic, structural, and intrusive character. Other northwest-trending faults were important in localizing deposition of gold and silver. Both major and minor faults have played an important role in channeling glaciers and thus in controlling the topography of Baranof and Chichagof Islands. Fault traces are commonly marked by deep fiords and valleys, and the major inlets and sounds that separate the islands in this part of southeastern Alaska are in large part fault controlled.

CHATHAM STRAIT FAULT

The Chatham Strait fault (pl. 2) separates Baranof and Chichagof Islands on the west from Admiralty and Kuiu Islands on the east. It extends north along Lynn Canal into Canada, where it somehow connects with the Shakwak fault zone (Bostock, 1952). The Chatham Strait fault may be a southeast continuation of the Denali fault system of central Alaska (St. Amand, 1957; Gabrielse and Wheeler, 1961). The Chatham Strait fault in southeastern Alaska is about 265 miles (426 km) long. Throughout most of its length, the fault is covered by waters of Chatham Strait and Lynn Canal, which range from 2 to 15 miles wide. Studies made in the Chilkat Peninsula along Lynn Canal where the fault goes on land indicate that it is a fairly wide zone of high-angle faults (D. A. Brew and Donald Grybeck, unpub. data, 1970).

The displacement on the Chatham Strait fault is known to be dominantly right lateral, with a significant vertical component (west side up). Gabrielse and Wheeler (1961) hypothesized 150 miles (241 km) of right-lateral separation. Lathram (1964) considered several lines of evidence and inferred about 120 miles (193 km) of right-lateral separation. Brew, Loney, and Muffler (1966), as a byproduct of a paleogeographic analysis, noted about 100 miles (161 km) of right lateral offset of older Paleozoic rocks and about 50 miles (80 km) of right-lateral separation of several younger stratigraphic units. A. T. Ovenshine (oral commun., 1968) has noted 120 miles (193 km) of right-lateral separation in lower and middle Paleozoic bedded rocks.

The vertical component of the Chatham Strait fault was considered by Loney, Brew, and Lanphere (1967), who concluded that the west side of the fault has moved relatively upward an estimated 10–15 km since Eocene time. This displacement amounts to about 2.2–3.3 cm per 100 years of vertical movement. The evidence suggests that the Admiralty Island block has been stable and near sea level throughout Tertiary and Holocene time and that all the upward movement has been in the Baranof Island block.

There is no conclusive evidence for the age of the strike-slip component of movement. The youngest rocks that Lathram (1964) considered to be offset by the fault are the volcanic rocks of middle Tertiary age. Brew (1968) has argued that the Tertiary volcanic rocks were deposited in relatively local basins and should not be used as evidence of major fault offset. The youngest strata known to occur on both sides of the fault are extensive graywacke, shale, and volcanic rocks of Late Jurassic and Early Cretaceous age (Brew and others, 1966). These rocks, however, have furnished few clues regarding the amount of separation and the maximum age of right-lateral horizontal movement on the Chatham Strait fault. If the horizontal movement started 45 m.y. ago, the same time as the vertical movement, and if the strike-slip component is considered to be 120 miles (193 km), then the rate of right-lateral displacement has been 43 cm per 100 years.

The Chatham Strait fault may still be active (Callahan, 1970, p. D9–D10). Heck (1958, p. 72–78) records nine earthquakes of intensity between 5 and 6 (Modified Mercalli Scale) in the area between Juneau and the International Boundary north of Haines and Skagway during the period 1899–1952. Callahan and Wayland (1965) state that epicenters were along the Chatham Strait lineament, but recent recalculations of epicenters of major earthquakes in the northeastern Pacific area (Tobin and Sykes, 1968) do not show any along the trace of the Chatham Strait–Lynn Canal fault. The Denali fault, however, which is inferred to connect with the Chatham Strait fault, is seismically active. Recently Boucher and Fitch (1969) showed that the Denali fault extension, near its junction at Haines with the Chatham Strait fault, is as active in terms of microearthquake activity as the San Andreas fault of California. Thus, despite the lack of major earthquake activity, the Chatham Strait fault may be subject to microearthquake activity. More recent analysis is in Ovenshine and Brew (1972).

TENAKEE FAULT SYSTEM

The Tenakee fault system is here defined as the complex of northwest- and north-northwest-trending faults on that part of Chichagof Island that lies northeast of Peril Strait, Hoonah Sound, and Lisianski Inlet. Included in the Tenakee fault system are the Freshwater Bay fault, the Indian River fault, and the Sitkoh Bay fault (pl. 2), along with a large number of relatively minor faults (see, for example, plate 1 of Loney, Condon, and Dutro, 1963). In general, individual faults are inferred to have right-lateral displacements of perhaps several kilometers and vertical displacements of up to a kilometer; the southwest sides of major faults are usually elevated. Upward movement on the southwest side along the faults of the Tenakee fault system was responsible for or related to the post-Early Cretaceous (possibly post-middle Tertiary) uplift of the Chichagof plutonic complex. The Tenakee fault system appears to extend northwestward across Icy Strait and to join with fault systems on the west side of the main arm of Glacier Bay and along the east side of Taylor Bay. The uplifted block of the Chichagof plutonic complex also extends northwestward across Icy Strait as the Fairweather Range fault block, which is presently the highest standing block in southeastern Alaska (MacKevett and others, 1971).

Prominent among the faults of the Tenakee fault system is a group of faults that extends from the mouth of Tenakee Inlet 40 miles northwest to Flynn Cove on northernmost Chichagof Island. Individual faults in the Freshwater Bay area include the Peninsula, North Shore, Cedar Cove, South Shore, and Kennel Creek faults (Loney, Condon, and Dutro, 1963). Some 2.5 miles of right-lateral separation are shown by the map pattern along these faults, and, with the exception of the North Shore fault, each fault has its southwest side upthrown relative to the northeast. The Cedar Cove fault continues south from Freshwater Bay to Hill Point on Tenakee Inlet, where it cuts granitic rocks of probable Cretaceous age. The Peninsula fault, on the other hand, appears to be truncated at its northwestern end by a Cretaceous adamellite plug. The Freshwater Bay fault (pl. 2), although not named on plate 1 of Loney, Condon, and Dutro (1963), seems to be the major fault of the group in the area northwest of Freshwater Bay.

The North Fork fault (Loney, Condon, and Dutro, 1963) continues north-northwest from the Freshwater Bay area to Port Frederick, where it joins the Freshwater Bay fault. The block southwest of the North Fork fault is uplifted, and the fault appears to have about a mile of right-lateral separation.

The Indian River fault is a vertical fault that strikes northwest for about 60 miles from Florence Bay at the southeast tip of Chichagof Island to Flynn Cove on northernmost Chichagof Island. The southwest side is upthrown relative to the northeast everywhere along the fault except to the northwest of Port Frederick, where the northeast side is up (Lathram and others, 1959). Maximum vertical displacement of about a kilometer occurs in the central part of the fault. In this central part, the fault separates rocks of greater contact metamorphic grade on the southwest from rocks of lesser grade on the northeast.

The Sitkoh Bay fault is a vertical zone, as much as 2 miles wide locally, that strikes northwest for 70 miles from Sitkoh Bay on southeastern Chichagof Island to Mud Bay on northernmost Chichagof Island. The fault is concealed beneath Tenakee Inlet for much of its length, but outcrops at Sitkoh Bay and near Mud Bay show that the fault cuts Cretaceous granitic rock. The Sitkoh Bay fault forms the northeast boundary of the Chichagof plutonic complex. The dominance of Cretaceous igneous rocks in the complex (see section on "Chichagof Plutonic Complex") and the character of the metamorphism that affected the complex (see section on "Metamorphic Facies") suggest that the fault block southwest of the Sitkoh Bay fault represents a deeper crustal level than the other fault blocks on Baranof and Chichagof Island and that the southwest side of the Sitkoh Bay fault has been uplifted relative to the northeast side. Given this sense of vertical movement, the distribution of rock units near Sitkoh Bay indicates that some 10 miles (16 km) of right-lateral slip has occurred along the Sitkoh Bay fault.

The Peril Strait fault strikes about N. 50° W. for 92 miles along Peril Strait, Hoonah Sound, and Lisianski Inlet (pl. 2). Where exposed on Catherine Island and between Hoonah Sound and Lisianski Inlet, the fault is a vertical zone approximately a mile wide. Vertical movement of about a kilometer has uplifted the northeast side relative to the southwest. Right-lateral separation of about 19 miles is shown by offset vertical formation contacts on northwest Chichagof Island (Rossman, 19592 The apparent right-lateral separation of 36 miles suggested by the outcrop distribution of the Cretaceous plutons appears to be excessive, owing to the effect of vertical slip on a nonvertical intrusive contact cut by the fault. The Peril Strait fault truncates a large complex fold structure in northern Baranof Island (see section on "Northern Baranof Island"), but the continuation of the fold structure on the opposite side of the fault has not been identified; it may well have been elevated and eroded away.

Movement on the Peril Strait fault in part appears to predate the Tertiary intrusive episode. A leucocratic trondhjemite body inferred to be Tertiary in age because of its composition and its lack of internal structure (excepting cataclasis) has apparently been emplaced along the fault (No. 77, pl. 2). Cataclastic features within this pluton indicate continued movement along the Peril Strait fault subsequent to the emplacement of the pluton.

FAIRWEATHER FAULT SYSTEM

The Fairweather fault system is the complex of vertical northwest striking faults that cuts across Chichagof Island along and southwest of Lisianski Inlet, Hoonah Sound, and Peril Strait and that continues southeast across Baranof Island. As shown on plate 2, the Fairweather fault system is the southeast continuation of the Fairweather fault, the conspicuous single fault that extends 160 miles northwest from Cross Sound to Yakutat (Miller, 1951; Plafker, 1967). The Fairweather fault is seismically active; movement during the 1958 earthquake consisted of upward displacement of 3.5 feet on the west side and left-lateral horizontal slip of 21.5 feet (Tocher and Miller, 1959; Miller, 1960).

Within the area of plate 2, we have mapped two zones of the Fairweather fault system: the Peril Strait fault (called the Fairweather–Peril Strait fault by Brew and others, 1966), and the Sitka fault zone, a complex zone of faults extending from Yakobi Island southeast to the eastern coast of Baranof Island. In addition, we infer that a segment of the Fairweather fault zone lies just offshore at the edge of the continental slope.

The Sitka fault zone is made up of three major segments: the Patterson Bay fault, the Neva Strait fault, and a zone of faulting 10–12 miles wide in western Chichagof Island. The Patterson Bay fault is connected to the Neva Strait fault by a complex of en echelon west-northwest-trending faults southeast of Sitka; the Glacier Lake fault may also be related to this transition zone. The Neva Strait fault is a single narrow trace' bounded on both sides by wide zones of cataclasis. To the northeast, the zone of cataclasis extends as far as the Glacier Lake fault. North of Partoshikof Island, the Neva Strait fault fans out into the Slocum Arm fault, the Hirst and Chichagof faults, and the Islas Bay fault;

movement along this part of the Sitka fault zone is also taken up by the Goulding Lakes fault, by the Stag Bay fault, and by a number of smaller, unnamed faults.

Evidence for displacement along the Sitka fault zone comes primarily from the part of the Patterson Bay fault south of Gut Bay. In this area, rocks on the west side of the fault are uplifted, probably at least 4 km relative to the east side, and amphibolite facies rocks are juxtaposed with low greenschist facies rocks east of the fault. The rocks on the east side of the fault are displaced right laterally about 5 miles. Movement occurred after the intrusion of the Crawfish Inlet pluton about 45 m.y. ago but prior to the intrusion of the Gut Bay pluton about 25 m.y. ago (Loney and others, 1967). This movement amounts to 2 cm per 100 years of vertical slip and 4 cm per 100 years of horizontal slip. There is no evidence of movement after intrusion of the Gut Bay pluton.

The Windy Passage fault may be an offshoot of the offshore segment of the Fairweather fault system. The southwest side of this fault has moved down, probably less than a kilometer; no strike-slip movement is apparent. The fault cuts granitic rocks of the Crawfish Inlet pluton, which has been dated at about 45 m.y. (Loney and others, 1967). Hot springs at Goddard (Waring, 1917) could be localized by upflow of hot water along this fault. The Windy Passage fault projects northwestward directly beneath the caldera of the Mount Edgecumbe volcanic field, and the fault may have served as the conduit along which the magma was transferred to the surface. A recent earthquake is described briefly in Page (1973).

NORTHEAST- AND EAST-STRIKING FAULTS

Numerous northeast- and east-striking faults occur on northern and northeastern Chichagof Island. Almost all the data pertaining to the age, movement, and geologic relations of these faults come from the Freshwater Bay area, where Loney, Condon, and Dutro (1963, p. C50) interpreted the northeast- and east-striking faults to be older than the northwest-striking faults (here termed the Tenakee fault system). The northeast- and east-striking faults displace Mississippian rocks but do not displace the Gypsum Creek pluton (No. 49, pl. 2) of Cretaceous age (table 2). Movement of the northeast- and east-striking faults appears to have been primarily dip-slip, but apparent left-lateral displacement of about 1 mile on the Iyouktug fault was noted by Loney, Condon, and Dutro (1963, p. C46).

The three northeast-striking faults mapped on central Baranof Island are all marked by prominent lineaments. About 1 mile of apparent left-lateral separation on the Medvejie Lake fault since the Eocene is indicated by the offsets of the Vodopad pluton and the Kasnyku Lake pluton (Nos. 85 and 84, pl. 2). The east end of this fault is close to the hot springs at Baranof Post Office. All three of these northeast-striking faults are truncated by conspicuous northwest-trending faults of the Sitka fault zone, an indication of more recent activity of the Sitka fault zone.

One northeast-trending fault was mapped on southern Baranof Island at Big Branch Bay. The southeast side of the fault has been apparently downdropped relative to the northwest. The apparent right-lateral separation indicated by the offset of the margin of the Redfish Bay pluton (No. 95, pl. 2) could have been produced by vertical movement on the Big Branch Bay fault.

THRUST FAULTS

Two relatively small zones of thrust faulting were noted in the Baranof-Chichagof map area. East of Freshwater Bay on Chichagof Island, the Kennel Creek Limestone is thrust over the Cedar Cove Formation along the Wukuklook thrust fault. The fault dips 30° northeast, and at least 7,500 feet of strata have been cut out by southwestward movement on the thrust fault (Loney, Condon, and Dutro, 1963, p. C48). The thrusting appears to postdate both the emplacement of the Cretaceous Gypsum Creek pluton (No. 49, pl. 2) and the formation of the northeast- and east-striking fault system.

The second thrust fault is on the south side of Tenakee Inlet and underlies the prominent limestone peak that is the highest point on Chichagof Island. The thrust fault is a zone at least several hundred feet thick dipping about 20° to the northeast. From minor fold structures, the upper plate is inferred to have moved southwestward, and a fairly large syncline just to the north of the limestone peak is overturned to the southwest. The fault postdates the Silurian and (or) Devonian Kennel Creek Limestone, but its age is otherwise unknown. The magnitude of movement is also not known but is probably less than a kilometer.

SUMMARY

The north-striking Chatham Strait fault and the northwest-striking Fairweather fault system are the most important fault structures in the Chichagof-Baranof area. These high-angle structures are Tertiary to Holocene in age and have a dominant right-lateral slip component of at least tens of miles. Vertical movement on these faults has uplifted the Chichagof-Baranof area relative to the terrain to the east and relative to the Pacific Ocean basin to the west.

The northwest-striking Tenakee fault system is somewhat less important. Vertical movement on the Sitkoh Bay fault has uplifted the Chichagof plutonic complex of central Chichagof Island relative to northeastern Chichagof Island, a terrain underlain primarily by Paleozoic sedimentary rocks and by only a few scattered plutons.

Northeast- and east-striking high-angle faults occur on northeastern Chichagof Island and Baranof Island, and two thrust faults occur on Chichagof Island. These faults all appear to be older than the northwest- and north-trending faults and have not had a strong effect on the present-day, overall geologic situation.

CONTACT METAMORPHISM AROUND TERTIARY PLUTONS

The metamorphic rocks described in t'his section were derived from rocks of the Sitka Graywacke and of the Kelp Bay Group. This section is mainly concerned with the contact aureoles of the Tertiary plutons but also includes discussions of the low-grade regional metamorphism upon which the contact aureoles were superimposed. In general, the mineral assemblages related to this regional "background" metamorphism are indicative of the prehnite-pumpellyite-metagraywacke facies (Turner, 1968), but in many places they are indistinguishable from those of the lower greenschist facies. These lower grade rocks are characterized by widespread chlorite which, in the vicinity of the plutons, is replaced by biotite. The first appearance of biotite, determined mainly in hand specimen, is the basis for the locations of the outer margins of the aureoles shown on the map (pl. 1).

The aureoles are generally zoned inward from low to high temperature. The pressure of metamorphism of the low-temperature outer part appears to have been low, while the pressure of the high-temperature inner zones appears to have been transitional between low and medium (that is, transitional between hornblende hornfels facies and the amphibolite facies; Turner, 1968). The distribution of the mineral assemblages indicative of this zonation is rather complex, varying from pluton to pluton and, around the Crawfish Inlet pluton, varying from one side of the pluton to the other.

The contact metamorphic rocks are divided into two groups: (1) those derived from the Sitka Graywacke, which occur mainly in and around the Crawfish Inlet pluton in southwestern Baranof Island and around the pluton on Kruzof Island, and (2) those derived from the Kelp Bay Group, which occur mainly in and around the Kasnyku Lake and Gut Bay plutons in eastern Baranof Island. These plutons are similar in composition and appear to represent similar depths of intrusion. Thus, differences in metamorphic mineral assemblages between these contact metamorphic areas probably are related to differences in the composition of the Kelp Bay Group and of the Sitka Graywacke. The metamorphic rocks in southern Baranof Island, which were developed from the Sitka Graywacke, display the most complex metamorphic zonation and are the best exposed. For these reasons, they are described in the most detail.

METAMORPHIC ROCKS DERIVED FROM THE SITKA GRAYWACKE

The Sitka Graywacke and its metamorphosed equivalents crop out in a narrow belt extending from Yakobi Island south-southeast along the west coast of Chichagof, Kruzof, and Baranof Islands to Cape Ommaney, a distance of 140 miles. Northwest of Kruzof Island, the Sitka Graywacke has been regionally metamorphosed to the prehnite-pumpellyite-metagraywacke facies or the greenschist facies. On Kruzof Island and on Baranof Island, this background metamorphism has been overprinted by low- to high-temperature low- to medium-pressure metamorphism associated with Tertiary granitoid intrusions. Observed mineral assemblages indicate the albite-epidote-hornfels, hornblende-hornfels, amphibolite, and perhaps pyroxene-hornfels facies.

The metamorphic rocks discussed here are derived mainly from semipelitic and pelitic sediments: very thick-bedded lithic and arkosic wacke, interbedded thin- to medium-bedded wacke and shale, and rhythmically thin-bedded wacke and shale turbidite. A few metavolcanic rocks and metacherts occur in the southeastern part of Baranof Island.

The study of the metamorphosed Sitka Graywacke is facilitated by the grossly similar composition and textures of the formation throughout its 140-mile long outcrop belt and by generally fine exposures at sea level and on ridge crests. In addition, the granitoid bodies are transverse to the dominant north-northwest-trending older structures, making it possible to investigate metamorphic changes along the strike of compositional layers (bedding or relict bedding). However, the restricted composition of the rocks in the Sitka Graywacke makes the assignment of metamorphic facies somewhat uncertain, because an assignment can seldom be checked by mineral assemblages in interbedded rocks of different compositions. Furthermore, the lack of detailed information on compositions of rocks and minerals makes it impossible to evaluate what effect slight compositional changes may have had on mineral assemblages.

The following sections are organized first by geographic area and then by pertinent metamorphic features. The first area, the hornfels area on Kruzof Island, is affected by low- to high-temperature low-pressure metamorphism. The second area, the hornfels aureole on the north side of the Crawfish Inlet pluton, represents a narrow aureole of low- to high(?)-temperature, low-pressure metamorphism. The third and fourth areas, the south side of the Crawfish Inlet pluton and the Redfish Bay area, respectively, are complex terranes in which low-temperature–low-pressure to high-temperature–medium-pressure metamorphism has

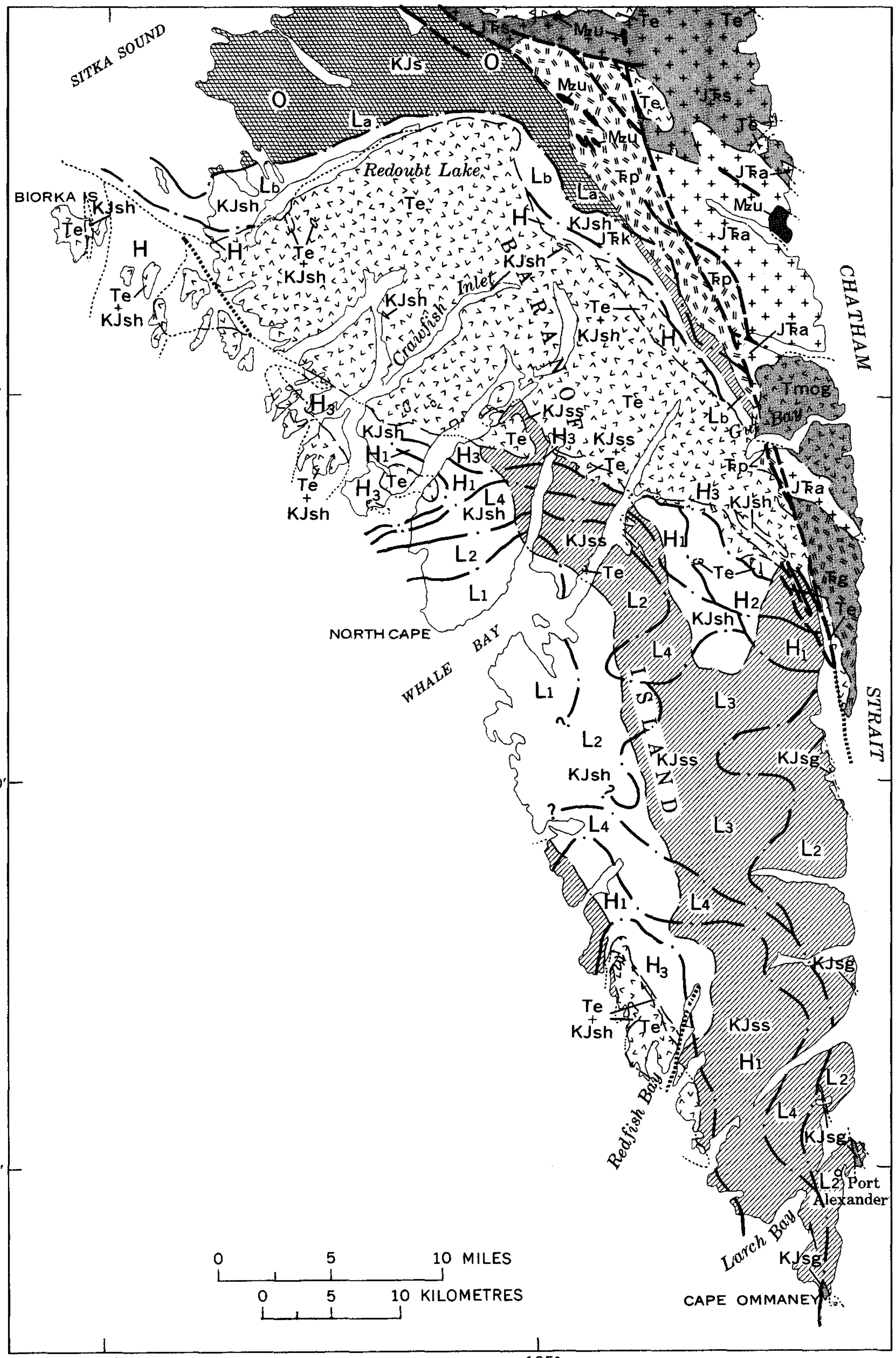


FIGURE 25.— Map of southern **Baranof** Island, showing major geologic units (taken from pl. 1), and metamorphic mineral zones related to the Crawfish Inlet and **Redfish** Bay plutons. Boundaries of the plutons differ from boundaries shown on plate 1 because marginal areas of abundant inclusions are included in the aureoles in this figure but are included instead in the plutons on plate 1.

EXPLANATION

TERTIARY

Tmog
Intrusive granitoid rocks of Miocene and Oligocene age at Gut Bay

Te
Intrusive granitoid rocks of Eocene age

MESOZOIC

Mzu
Ultramafic rocks

JURASSIC AND CRETACEOUS

KJsh KJss KJs KJsg
Sitka Graywacke and related rocks
KJs, *graywacke and argillite, minor conglomerate*
KJsh, *hornfels in contact aureoles*
KJss, *lineated, schistose, and semischistose graywacke and slate*
KJsg, *greenstone*

TRIASSIC AND (OR) JURASSIC

JRk
Khaz Formation

Kelp Bay Group

TRIASSIC(?)

Rp Rg
Phyllite, quartzite, greenschist, and graywacke semischist
Rp, *phyllite; some quartzite, greenschist, graywacke semischist, and metachert*
Rg, *greenschist and greenstone; some phyllite, graywacke semischist, and metachert*

JRa JRs
Schist, gneiss, amphibolite, and greenschist
JRa, *amphibolite and greenschist*
JRs, *biotite schist and gneiss; some amphibolite, quartzite, phyllite, and hornfels*

Fault
Dashed where approximately located; dotted where concealed by water

Formational contact
Dotted where concealed by water

Metamorphic mineral zone contact

Zone symbols explained in section on "Contact Metamorphism around Tertiary Plutons" and on the succeeding five figures. Outer contact of zone L_a not shown

taken place. The last three areas, with their pertinent metamorphic features, are shown in figure 25.

KRUZOF ISLAND

The Sitka Graywacke of Kruzof Island has been intruded by biotite granodiorite of Eocene age and has been subjected to low-pressure, low- to high-temperature metamorphism. The broad aureole is probably due to buried continuations of the exposed granodiorite mass, which, together with the irregular outcrop pattern of the mass, suggest that the body is only about half unroofed.

The available petrographic control in this area is sparser than in the aureoles of southern Baranof Island, therefore the data do not allow as detailed a subdivision of the aureole. Most of the following discussion is based on specimens collected on a single ridge that transects the aureole at a right angle just north of Gilmer Bay and on specimens collected along the west shore between Sea Lion Cove and Point Amelia (pl. 1). Most of the scattered data concerning the preintrusive background mineral assemblages in the Sitka Graywacke come from rocks collected on islands in Sitka Sound. These slightly metamorphosed rocks in the vicinity of Kruzof Island consist mainly of lithic graywacke with relatively minor amounts of shale or argillite, polymictic conglomerate, and very minor amounts of volcanic rocks (see section on "Sitka Graywacke").

The thermal effects of the Eocene granodiorite body of Kruzof Island are reflected in metamorphic mineral zones around the pluton (fig. 26). Outside the aureole, the rocks contain calcite, sphene, epidote, chlorite, albite, and muscovite that indicate either prehnite-pumpellyite metagraywacke or low greenschist facies metamorphism (Turner, 1968). This assemblage is re-

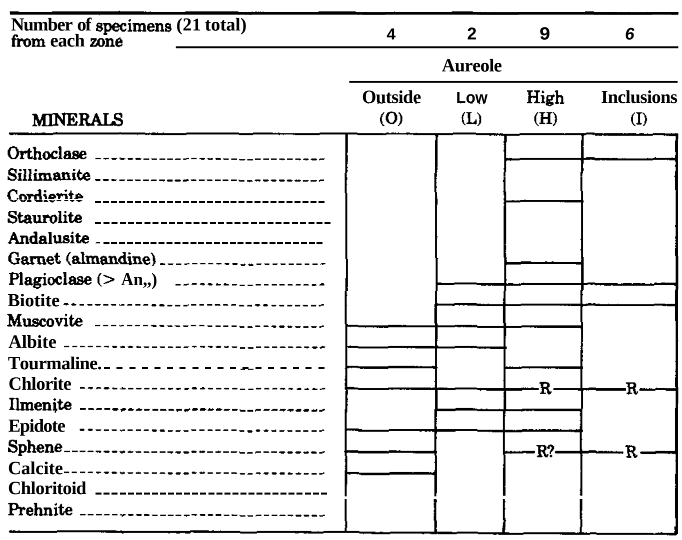


FIGURE 26.—Metamorphic mineral zones, Kruzof Island area. Quartz is present in all zones. R indicates that mineral is retrograde.

placed progressively toward the pluton by an epidote-chlorite-albite-muscovite-biotite-plagioclase zone that is recognized by the presence of biotite, which is visible in hand specimen. The original bedding is sometimes preserved in this low-grade aureole, but evidence of transposition of bedding and development of foliation approximately parallel to the bedding is present. It is not clear whether these structural changes are due to local deformation associated with the intrusion, to accentuation of the preexisting layering by neocrystallized minerals, or to preintrusive deformation. This mineral zone (fig. 26) represents either the greenschist facies or the albite-epidote hornfels facies. The local presence of plagioclase of greater than An_{10} suggests that the zone includes some hornblende hornfels facies rocks.

The thoroughly neocrystallized rocks of the "high aureole" (fig. 26) closest to the pluton constitute a zone that is defined in the field by readily visible garnet or cordierite in the biotite hornfels. Generally, garnet occurs farther from the pluton than does cordierite. The data are not complete enough to map the boundary between the low and high zones of the aureole. Relict textures and structures in the outer part of the zone are progressively destroyed toward the pluton.

The metamorphic minerals in the high part of the aureole indicate hornblende hornfels facies metamorphism according to Turner (1968).

The granodiorite body of Kruzof Island contains several zones of inclusions. The most studied zone is around Slaughter Island in Shelikof Bay, and another zone in the cupola exposed on Krestof Island has also been studied. The pelitic and semipelitic rocks in the inclusions contain quartz, orthoclase, plagioclase, biotite, and lesser amounts of dark green hornblende and retrograde chlorite and sphene (fig. 26). Calcareous rocks in the inclusions have been metamorphosed to sphene-calcite-plagioclase-quartz-diopside hornfels. Basic rocks have been metamorphosed to quartz-biotite-hornblende hornfels, orthoclase-biotite-plagioclase-hornblende-quartz hornfels, hypersthene?-orthoclase-hornblende-biotite-plagioclase-quz hornfels, and orthoclase-quartz-biotite-hornblende-plagioclase hornfels. The biotite has the following pleochroism typical of biotite in all the metamorphosed rocks of the Sitka Graywacke: X = strong pale brown, Z = dark reddish brown. The hornblende pleochroism is typically X = very pale green, Y = pale green, Z = medium brownish green. The metamorphic minerals in the inclusions suggest hornblende hornfels facies metamorphism with possible local incipient transitions to the pyroxene hornfels facies (Turner, 1968).

The metamorphic mineral zones of the Kruzof aureole are almost entirely compatible with a metamorphic facies series of the contact type (see curve A–A' fig. 31, for inferred Pressure–temperature gradient). The inferred pressure-temperature gradient has been drawn out of the hornfels fields because almandine garnet occurs in rocks of the "high aureole" metamorphic zone (Hietanen, 1967, p. 191).

SOUTHERN BARANOF ISLAND

The metamorphic rocks of southern and west-central Baranof Island cover at least 450 square miles (fig. 25). This terrane displays distinct, mappable zones of progressive metamorphism that are related in part to the distribution of Eocene plutons. Zones that show no relation to exposed granitic rocks are inferred to be related to nearby subjacent plutons.

The mineral assemblages in the aureole north of the Crawfish Inlet pluton suggest a lower pressure metamorphic facies than do the assemblages in the aureole to the south. The aureole north of the pluton is narrow and is interpreted to have been produced by low-to high-temperature low-pressure metamorphism; the metamorphic facies range from albite-epidote-hornfels to perhaps pyroxene hornfels facies. The aureole south of the Crawfish Inlet pluton, on the other hand, is broad and complex; the metamorphic facies range from albite-epidote-hornfels and (or) greenschist to amphibolite facies. This progressive low- to high-temperature medium-pressure metamorphism was accompanied by kinematic effects that intensified the preexisting foliation, produced new foliation, and developed new folds and lineations about axes subparallel to those of the earlier folds. The area in which these effects are most apparent has been mapped as "lineated and schistose Sitka Graywacke" on plate 1. The contacts of this lineated terrane with the adjacent nonlineated hornfels are abruptly gradational except in the area between Mount Emma and Necker Bay, where sporadic lineations occur over a broad area.

The areal distribution of the lineated and schistose terrane does not appear to be related to the exposed plutons, and lineated rocks do not occur adjacent to igneous masses except locally near the Redfish Bay pluton and at Whale Bay. The lineated terrane, however, does occupy in general the area between the Crawfish Inlet and Redfish Bay plutons. The configuration of the metamorphic isograds shows a close relationship to the Redfish Bay pluton and a somewhat less convincing relationship to the Crawfish Inlet pluton (fig. 25); these relationships suggest that the two igneous masses are connected at depth. Most of the lineated terrane is directly above and to the southeast of the inferred subsurface connection, and thus it is possible that the lineated terrane was produced during the emplacement of this inferred large igneous body. This suggestion is supported by the abruptness of transition between lineated and nonlineated terrane, and the greater width of the metamorphic zones south of the Crawfish Inlet pluton than north of the Crawfish Inlet pluton. If this interpretation is correct, the lineated terrane forms the southeastward dipping roof of a large concealed pluton and is analogous to the southward dipping deeply eroded roof of the Kasnyku Lake pluton (see section on "Contact Metamorphic Rocks Derived from the Kelp Bay Group").

Although the Sitka Graywacke that is outside of the aureole shown in figure 25 shows no megascopic metamorphic effects, microscopic study provides evidence of a background preintrusive low-grade metamorphism. Typical metamorphic mineral assemblages in these metagraywackes are:

quartz-albite-chlorite-muscovite-epidote (-prehnite-sphene)
quartz-albite-chlorite-muscovite-epidote(-calcite-sphene)
quartz-albite(?)-prehnite-calcite-epidote-muscovite-sphene(?).[3]

Tourmaline occurs locally. The prehnite occurs in veins and in irregular masses and is most widespread due south of Sitka Sound (fig. 25). The presence of prehnite in what otherwise would be a typical lower greenschist assemblage suggests that the background metamorphism is transitional between the prehnite-pumpellyite-metagraywacke facies and the greenschist facies (Turner, 1968, p. 268).

NORTH OF CRAWFISH INLET PLUTON

A well-defined metamorphic aureole borders the north side of the Crawfish Inlet pluton from Gut Bay on the east to the Necker Islands on the west (fig. 25). This aureole consists of an outer zone (La), an intermediate zone (Lb), and an inner zone (H) (figs. 27 and 28). The outer boundary of zone L is not shown, owing to paucity of data, but available information suggests that it parallels the inner boundary and that zone La is no more than 1¼ miles across. Zone La displays the faintest, most distant effects of the metamorphism associated with the Crawfish Inlet pluton; this faint metamorphism is overprinted on the background metamorphism.

The boundary between zone La and zone Lb is placed where megascopic biotite becomes visible. The boundary between zone Lb and zone H is fairly well defined on the northeast side of the pluton by porphyroblasts of cordierite, garnet, or andalusite. At the northwest corner of the pluton, there are few index minerals, and the boundary between zones Lb and H is drawn more subjectively on the basis of abundance of biotite in the hornfels. Zone H is discriminated only on the northeast side of the pluton and at the northwest corner, where it includes a large area of abundant inclusions in granitoid rocks of the Necker Islands.

The contact of the Crawfish Inlet pluton with adjacent hornfels is steep and fairly well exposed along the northeast side of the pluton. On the northwest side, the contact appears to be steep but is concealed beneath

[3]The "muscovite" here and in following sections is generally very fine grained; its polytype characteristics were not studied by X-ray diffraction. The chlorite generally shows abnormal blue birefringence and thus according to Albee (1962) is a high F/FM type. The term "albite" refers to plagioclase of composition more sodic than An10. The term "plagioclase" is used for compositions more calcic than An10.

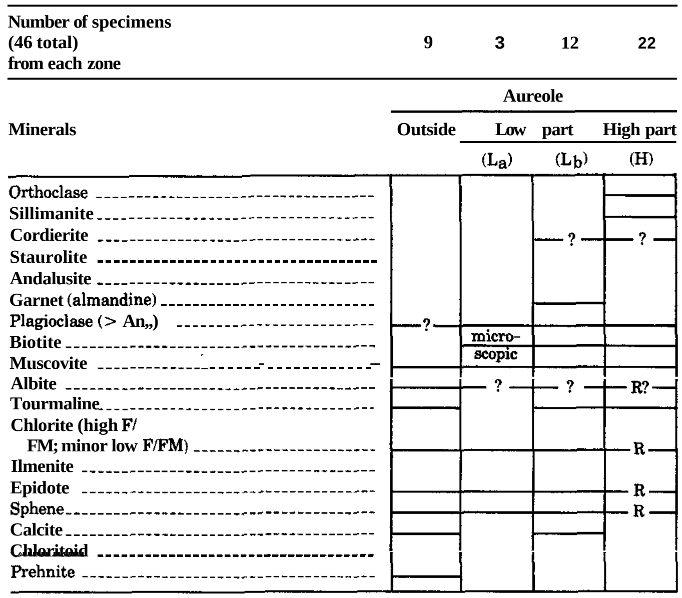


FIGURE 27.—Metamorphic mineral zones, northwest side of Crawfish Inlet pluton, Baranof Island, southeastern Alaska. Quartz is present in all zones. R indicates that mineral is retrograde. Query indicates questionable identification.

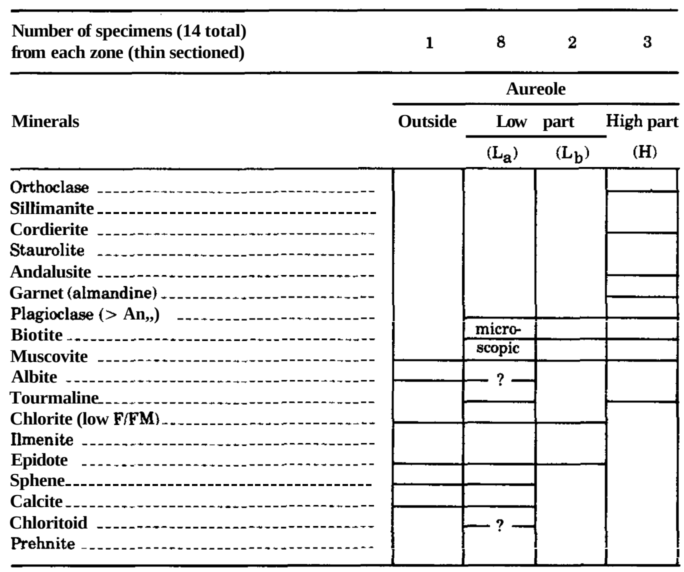


FIGURE 28.—Metamorphic mineral zones, northeast side of Crawfish Inlet pluton, Baranof Island, southeastern Alaska. Quartz is present in all zones. Query indicates questionable identification.

surficial deposits and Redoubt Lake. In the Necker Islands, inclusion contacts are generally steep; the abundance of inclusions suggests proximity to the pluton roof, and the inclusions may be in part roof pendants.

The eastern boundary of the aureole is shown in fig. 25 as terminating against the Patterson Bay fault 3 miles north of Gut Bay. Metamorphic rocks are also present on the east side of the fault, but the sparse data and the apparent complexity of metamorphism there do not permit delineation of the zone boundaries.

Zone La is characterized by the presence of microscopic biotite, the absence of prehnite, and the general absence of calcite. Chloritoid(?) may be present locally, and albite, although probably still present, appears to be yielding to oligoclase-andesine. Typical mineral assemblages are:

quartz-biotite-albite(?)-epidote-sphene
plagioclase-quartz-biotite-calcite-epidote-muscovite
plagioclase-quartz-chlorite-biotite-muscovite-epidote(-sphene-calcite-tourmaline).

The absence of prehnite and the presence of biotite suggest either higher greenschist facies or higher albite-epidote hornfels facies (Turner, 1968).

The metagraywackes in zone La are texturally similar to those outside the aureole but tend to display a cataclastic schistosity.

The metamorphic minerals in zone Lb northwest of the Crawfish Inlet pluton are summarized in figure 27. Typical mineral assemblages in metagraywackes are:

plagioclase-quartz-biotite-epidote(-muscovite-chlorite-sphene)
plagioclase-quartz-biotite-calcite-sphene-chlorite-tourmaline
biotite-quartz-plagioclase-almandine-albite(?)-sphene-epidote
biotite-quartz-plagioclase-albite(?)-muscovite
plagioclase-quartz-biotite-cordierite(?)-muscovite.

One greenstone specimen contained the assemblage:

plagioclase-actinolite-calcite-epidote.

In contrast to zone La, biotite occurs as grains large enough to be seen with a hand lens.

The metamorphic minerals in zone Lb northeast of the Crawfish Inlet pluton are summarized in figure 28. Mineral assemblages noted are:

plagioclase-quartz-muscovite-biotite-chlorite-epidote
quartz-plagioclase-biotite-muscovite-chlorite.

As in the aureole northwest of the pluton, plagioclase (>An_{10}) is associated with the pair muscovite-chlorite, but albite is absent.

The mineral assemblages in zone Lb seem to indicate metamorphism transitional between the albite-epidote hornfels (or greenschist) facies and the hornblende hornfels facies. Minerals suggestive of the hornblende hornfels facies (plagioclase, almandine, and cordierite) commonly occur with low-grade indicators such as albite and the mineral pairs, chlorite-muscovite and calcite-actinolite (Turner, 1968, p. 193–225).

The general aspects of the metagraywackes, metashales, and the rare metavolcanic lenses in zone Lb are the same as in zone La and outside the aureole. Even though the increasing degree of metamorphism is obvious in thin section, the sedimentary textures are well preserved and relatively unchanged to within a few hundred feet of the contact with the Crawfish Inlet pluton.

Zone H, northeast of the Crawfish Inlet pluton, is known from only a few specimens. Megascopically visible metamorphic minerals that define the zone are andalusite, garnet, and cordierite (fig. 28). Mineral assemblages noted are:

plagioclase-quartz-biotite-andalusite
plagioclase-quartz-biotite-orthoclase-tourmaline-garnet
quartz-plagioclase-biotite-cordierite-muscovite-garnet.

This part of zone H northeast of the pluton has undergone hornblende hornfels facies metamorphism (Turner, 1968).

Zone H northwest of the Crawfish Inlet pluton is relatively small except where it encompasses the extensive area of inclusions in the Necker Islands. Metamorphic minerals in the graywackes are shown in fig. 27. Typical mineral assemblages in the metagraywackes are:

quartz-plagioclase-biotite(-orthoclase-muscovite-tourmaline)
quartz-plagioclase-biotite-cordierite(?)-hornblende
quartz-plagioclase-orthoclase-sillimanite.

Calcareous nodules that occur as minor features in some of the very thick-bedded graywackes become very prominent, resistant knobs when metamorphosed. Mineral assemblages noted in zone H in these nodules are:

plagioclase-quartz-hornblende-(sphene-clinopyroxene)
diopside-hornblende-magnetite
plagioclase-diopside-quartz-sphene.

The metamorphic mineral assemblages found in zone H, northwest of the Crawfish Inlet pluton, particularly the association orthoclase-sillimanite and the scarcity of muscovite, suggest that these rocks have undergone metamorphism transitional between the hornblende hornfels facies and the pyroxene hornfels facies (Turner, 1968, p. 320).

The high-grade mineral assemblages of zone H have been extensively retrograded in the Necker Islands.

Chlorite and sphene developed from biotite, epidote and albite(?) from plagioclase, and muscovite from cordierite. In areas of intense cataclasis, retrograde metamorphism has also occurred; tremolite or actinolite has developed from diopside and hornblende, and epidote from plagioclase.

The metamorphic zones in the aureole northwest of Whale Bay are more or less parallel to the pluton boundary, in a manner similar to the aureole on the north side of the pluton. However, the unusual width of the zones and the similarity of their mineralogy to that in the rocks of the complicated aureole southeast of Whale Bay suggest that these rocks should be considered together.

All the mapped igneous-metamorphic rock contacts on the south and southwest side of the Crawfish Inlet pluton are steep, but several small cupolas indicate the probable presence of a larger granitic body at depth.

SOUTH OF CRAWFISH INLET PLUTON

The observed sedimentary features south of the Crawfish Inlet pluton are generally very similar to the Sitka Graywacke described previously north of the Crawfish Inlet pluton (see section on "North of Crawfish Inlet Pluton"). The following minor differences were noted: (1) calcareous nodules are rare in the metagraywackes to the south; (2) there is a significantly higher proportion of metashale (now mostly phyllite) to the south; (3) metacherts are more abundant in the Sitka Graywacke near Patterson Bay than anywhere to the north and west; (4) there are important mappable greenschist bodies within the Sitka Graywacke along the island coast south of Patterson Bay; and (5) all the metagraywackes and metashales south of the Crawfish Inlet pluton contain biotite that is visible with the hand lens; the amount of biotite present varies with the metamorphic zone, the outer parts of the lowest grade zone contain the least.

The aureole south of the Crawfish Inlet pluton is subdivided into metamorphic mineral zones that are numbered sequentially from outside the pluton to the inside, as follows (pl. 1 and figs. 25, 29): the outer or lower grade zones, L1 to L4, and the inner or higher grade zones, H1 to H3. The boundary between the lower grade (or L zones) and the higher grade (or H zones) parts of the aureole has been drawn at the first occurrence of andalusite or almandine or both. The subdivision within the lower and higher parts of the aureole are based mostly on petrographic criteria and are discussed below. This notation is extended into the Redfish Bay area to the south, but there the criteria for the boundary between the lower and higher grade zones (L4–H1 boundary) are largely petrographic.

As shown in figure 25, the metamorphic mineral zones and the structurally defined "lineated, schistose,

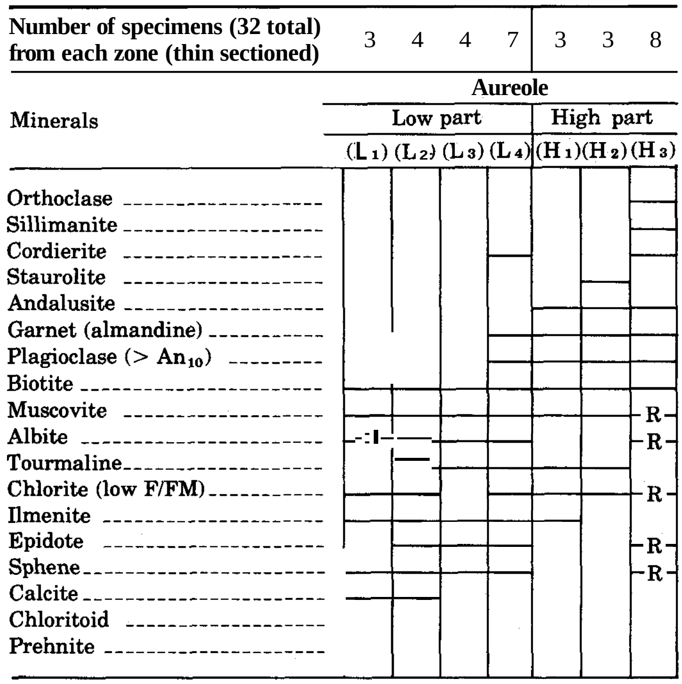


FIGURE 29.—Metamorphic mineral zones, south side of Crawfish Inlet pluton, Baranof Island, southeastern Alaska. Quartz is present in all zones. R indicates that mineral is retrograde. Query indicates questionable identification.

and semischistose graywacke and slate" unit do not have a simple relation to each other. The lineated and schistose unit, however, generally coincides with the broad areas of zones L2 through H1, except for a few relatively small areas where it includes higher and lower grade zones. These observations indicate that the lineated and schistose unit is generally associated with neither the innermost parts of the aureole nor with the outermost but instead coincides with those metamorphic zones that developed within a restricted temperature and pressure range some distance from the heat source. The implication is that the structurally defined lineated and schistose unit is genetically related to the contact metamorphism of the granitic bodies and that the distribution of the unit therefore indicates restricted proximity to concealed granitic bodies. However, as indicated by the structural study presented earlier in this paper (see section on "Structural effects of Tertiary Plutonic Intrusion"), the structural features were caused by the same episodes of regional deformation that affected the rest of the Sitka Graywacke on Baranof Island and not by forceful intrusion. The greater degree of synkinetic metamorphism of the lineated and schistose unit was produced by local hotspots due to the proximity of subjacent plutons during the deformation.

The L1 zone is found in the general area of the mouth of Whale Bay (fig. 25). These rocks were shown outside the aureole on the preliminary map of Loney, Pomeroy, Brew, and Muffler (1964). The well-folded metagraywackes and metashales show little obvious signs of metamorphism, although biotite is visible with the hand lens. Metamorphic minerals in this zone are summarized in figure 29. Mineral assemblages observed include:

quartz-biotite-albite(?)-calcite-chlorite-sphene
quartz-muscovite-chlorite-albite(?)-ilmenite
quartz-albite(?)-muscovite-biotite-ilmenite.

These mineral assemblages are compatible with either the albite-epidote-hornfels or greenschist facies metamorphism of Turner (1968).

Zone L_2 parallels the L_1 zone on the north and east; it broadens to the east and is also present on the east side of the island in the vicinity of Deer Lake (fig. 25). The metamorphic minerals in the metagraywackes and metashales are those of zone L_1, with the addition of epidote and tourmaline. The L_1–L_2 boundary is therefore the epidote isograd. Metamorphic mineral assemblages in the L_2 zone are:

biotite-quartz-albite-epidote-muscovite-sphene-calcite
quartz-albite-muscovite-sphene-chlorite-epidote-ilmenite-tourmaline.

The mineral assemblages are compatible with either the albite-epidote hornfels or greenschist facies metamorphism (Turner, 1968).

The L_3 zone covers a broad area near Rezanof Lake in the center of the island (fig. 25). Spatially, it appears to be an extension of the L_4 zone rather than of the L_2 zone that it closely resembles mineralogically. The metamorphic minerals in the zone are exactly like those in L_2, except for the absence of chlorite and of calcite (fig. 29). This absence is somewhat enigmatic, because chlorite is present in the "higher" L_4 zone. The pattern of chlorite distribution on the rest of the island argues against a compositional control. The other minerals present do not strongly suggest that the absence of chlorite may be due to slightly higher temperatures caused by the presence of a relatively close concealed thermal source, yet such an explanation would account for the unique occurrence of this zone. The common metamorphic mineral assemblage in the zone is:

quartz-biotite-albite-muscovite-epidote-tourmaline-ilmenite.

Actinolite is present in a few specimens together with biotite. The mineral assemblages are probably transitional between the albite-epidote-hornfels or greenschist facies and the hornblende hornfels facies; this conclusion is based on the presence of albite and epidote and the absence of chlorite (Turner, 1968).

Zone L_4 is more or less parallel to the south and southwest contact of the Crawfish Inlet pluton, which extends across the island from the Guibert Islets on the west almost to Patterson Bay on the east (fig. 25). The metamorphic minerals noted in this zone are shown in figure 29. The diagnostic minerals are plagioclase, garnet (almandine), and cordierite. The cordierite and garnet are rarely visible in hand specimen. Typical mineral assemblages in the L_4 zone are:

quartz-biotite-plagioclase-chlorite-tourmaline
albite-quartz-biotite-chlorite-ilmenite-epidote-almandine-tourmaline
albite-quartz-biotite-muscovite-chlorite-ilmenite-epidote-cordierite-tourmaline-plagioclase(?)-sphene.

These assemblages suggest a transition from albite-epidote hornfels or greenschist facies to hornblende hornfels facies metamorphism. Turner (1968) considers the presence of cordierite as an indication of the low-pressure hornfels facies. The highly sieved cordierite is locally retrograded to muscovite in some specimens but consistently stained a deep red with the method of Laniz, Stevens, and Norman (1964).

As mentioned earlier, the lower grade boundary of the H_1 zone is marked by the appearance in hand specimen of andalusite or almandine or both. Zone H_1 parallels the southern and southwestern boundary of the pluton from the mouth of Necker Bay on the west almost continuously to Patterson Bay on the east (fig. 25).

The metamorphic minerals of the H_1 zone are summarized in figure 29. Typical mineral assemblages are:

plagioclase-quartz-biotite-andalusite-muscovite
quartz-plagioclase-biotite-almandine(-muscovite-tourmaline-chlorite-ilmenite).

In some specimens, biotite has retrograded to chlorite with a high FIFM ratio. The low F/FM chlorite observed in one specimen was interpreted to be prograde and was partially replaced by biotite. The presence of andalusite suggests the hornblende hornfels facies (Turner, 1968).

The H_2 zone is characterized by the first appearance of staurolite in the metagraywackes and occupies a relatively small area extending southeast from near Mount Yanovski to Patterson Bay (fig. 25). The metamorphic minerals in the zone are shown in figure 29. Typical mineral assemblages are:

biotite-quartz-plagioclase-muscovite-almandine-tourmaline
biotite-quartz-plagioclase-staurolite-andalusite-muscovite-tourmaline.

Retrograde calcite, sphene, magnetite, and chlorite are present in some specimens. The assemblage garnet-hornblende-quartz occurs in rare metavolcanic rocks. Both high FIFM and low F/FM chlorite occur as retrograde in different specimens. The presence of andalusite in the assemblages indicates the hornblende hornfels facies according to Turner (1968, p. 223), but the presence of staurolite is out of harmony with the earlier definition of this facies (Fyfe and others, 1958).

The H_3 zone extends from the mouth of West Crawfish

Inlet on the northwest, where it joins the high grade part of the aureole in the Necker Islands described previously, to the southeast almost continuously along the pluton boundary to Patterson Bay. The zone includes the mile-wide belt of mixed granitic and country rock adjacent to the pluton proper and also some large hornfels inclusions within the pluton (fig. 25).

The metamorphic minerals that occur in this zone are summarized in figure 29. These minerals are locally retrograded, and muscovite, albite, epidote, sphene, and both high F/FM and low F/FM ratio chlorite (in different specimens) occur in some rocks. The H3 boundary is approximately the orthoclase and sillimanite isograds. Typical mineral assemblages found northwest of Whale Bay, where this zone is mineralogically similar to the "high" zone described in the Necker Islands, are:

quartz-biotite-plagioclase-cordierite
quartz-plagioclase-biotite-orthoclase
biotite-quartz-plagioclase-andalusite-cordierite
biotite-quartz-plagioclase-orthoclase-sillimanite (-enstatite).

These assemblages contrast with those southeast of the Great Arm of Whale Bay mainly in their lack of garnet; typical assemblages to the southeast are:

quartz-plagioclase-biotite-andalusite-cordierite
plagioclase-biotite-quartz-cordierite-almandine-sillimanite.

One basic granofels collected contains the assemblage:

hornblende-plagioclase-quartz-biotite-muscovite-chlorite.

The presence of cordierite and andalusite in these assemblages indicates the hornblende hornfels facies with possible local transition to the granulite facies (Turner, 1968).

REDFISH BAY AREA

The general picture of metamorphism present for the south side of the Crawfish Inlet pluton also applies to the Redfish Bay area. The description of the former situation is arbitrarily cut off at latitide 56°30′, but the metamorphic units continue uninterruptedly across the boundary southward toward the Redfish Bay pluton. The Redfish Bay pluton is relatively small and is associated with an almost equally large area of mixed igneous rock and country rock.

Other than the occurrence of several mappable greenstone and greenschist lenses within the metagraywacke and metashale on the east side of the island, there are no apparent differences in the original compositional, textural, or structural features of the Sitka Graywacke in the Redfish Bay area compared with the other parts of Baranof Island. All rocks in the Redfish Bay area appear to be within the contact aureole.

The metagraywackes, metashales, and metavolcanic rocks of the Redfish Bay area are subdivided into

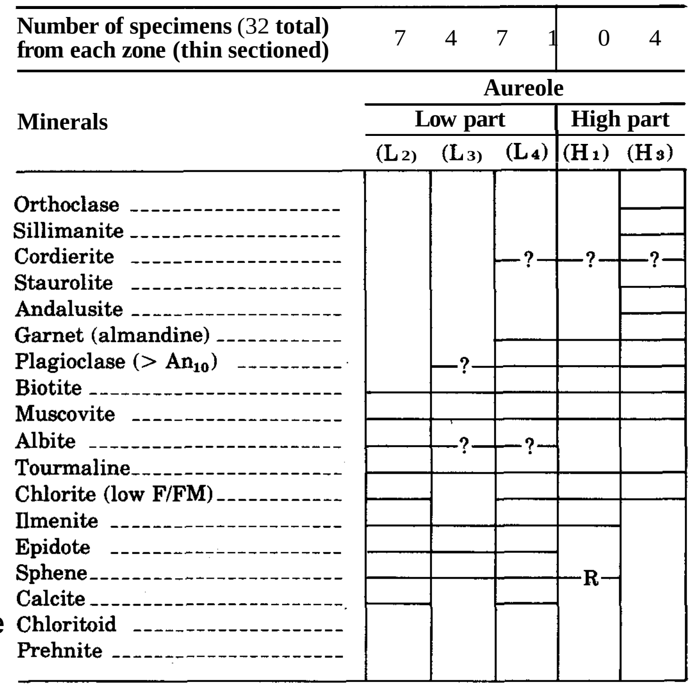


FIGURE 30.—Metamorphic mineral zones, Redfish Bay area, Baranof Island, southeastern Alaska. Quartz is present in all zones. R indicates that mineral is retrograde. Query indicates questionable identification.

metamorphic mineral zones L2, L3, L4, H1, and H3 (fig. 30), which correspond fairly closely to the zones described previously, except that zone H3 near Redfish Bay includes rocks that would have been mapped separately as zone H2 on the south side of the Crawfish Inlet pluton (fig. 25). Zone H1 is noticeably broad east of the Redfish Bay pluton and is also apparently broad northwest of the pluton. In both places, the zone is coincident with the lineated and schistose unit in the Sitka Graywacke and, as implied earlier, the combination of a high-grade aureole zone and lineated and schistose Sitka probably indicates proximity to a concealed part of the pluton.

The boundary between the L4 and H1 zones of the aureole has been determined petrographically in the Redfish Bay area, because the guide minerals andalusite and garnet were not consistently evident in hand specimen, as they were in the aureole south of the Crawfish Inlet pluton. If neither mineral was seen in thin section, other associated criteria were used, namely the complete substitution of more calcic plagioclase for albite and the absence of epidote in the H1 zone.

Metamorphic zone L1 appears to be absent in the Redfish Bay area. The lowest zone recognized is the L2 zone. The rocks of this zone are continuous with the L2 zone rocks described to the north in the aureole south of the Crawfish Inlet pluton.

The metamorphic minerals in the metagraywackes and metashales of the L2 zone on both sides of the island are summarized in figure 30. In some rocks, axial planes of small folds are accentuated by parallel biotite flakes and tabular ilmenite crystals that cut across the biotite and muscovite that define the compositional layering. The most typical mineral assemblage is:

quartz-albite-biotite-muscovite-epidote-chlorite (-ilmenite-calcite-tourmaline-sphene).

Mineral assemblages in the metavolcanic rocks are:

quartz-calcite-chlorite-muscovite-albite-biotite
actinolite-quartz-albite-sphene-epidote-biotite.

These mineral assemblages suggest greenschist or albite-epidote-hornfels facies metamorphism of Turner (1968).

The L3 metamorphic mineral zone in the Redfish Bay area is the direct continuation of the L3 zone south of the Crawfish Inlet pluton. The zone is flanked by L2 zone rocks to the east and west and butts directly into L4 zone rocks to the south (fig. 25). The metamorphic minerals in zone L3 are shown in figure 30. As in the aureole south of the Crawfish Inlet pluton, the diagnostic features are the absence of chlorite and calcite. The typical mineral assemblage of zone L3 is:

albite-biotite-quartz-epidote-muscovite(-tourmaline-ilmenite-sphene).

As suggested earlier, these assemblages indicate a facies transitional between greenschist or albite-epidote-hornfels and hornblende hornfels facies metamorphism (Turner, 1968).

Apparently the L4 zone completely encircles the Redfish Bay pluton on the north and east and pinches out toward the south tip of the island (fig. 25). The pinchout may represent lack of data rather than the actual situation. The metamorphic minerals in the L4 zone are summarized in figure 30. Typical mineral assemblages are:

quartz-plagioclase-biotite-chlorite-epidote-tourmaline
albite or plagioclase-quartz-biotite-muscovite-cordierite(?)-epidote-tourmaline(-chlorite-sphene-calcite)
albite or plagioclase-quartz-biotite-epidote-chlorite-almandine-tourmaline(-muscovite-sphene-ilmenite).

The presence of cordierite suggests the hornblende hornfels facies (Turner, 1968).

The H1 zone lies along the north and east sides of the Redfish Bay pluton (fig. 25). The criteria for the placement of the H1–L4 boundary have been discussed already. The metamorphic minerals in the H1 zone are summarized in figure 30. Typical mineral assemblages are:

quartz-biotite-muscovite-plagioclase-cordierite (retrograded to muscovite)-tourmaline(-chlorite-limenite)
quartz-plagioclase-biotite-chlorite-almandine-tourmaline(-muscovite-sphene)
quartz-plagioclase-biotite(-muscovite-high F/FM ratio chlorite-tourmaline-ilmenite).

These mineral assemblages suggest the hornblende hornfels facies (Turner, 1968).

Chemical analyses of two metagraywackes from this zone at Larch Bay are given in table 1. Garnets from these same metagraywackes are mainly almandine, as are probably all garnets that occur in metagraywackes and metashales on Baranof Island.

The H3 metamorphic mineral zone quite narrowly borders the Redfish Bay pluton on the north and east (fig. 25) and includes the associated areas of mixed igneous and country rock. The metamorphic minerals in the zone are summarized in figure 30. These minerals suggest equivalence to the combined H2 and H3 zones of the Crawfish Inlet pluton area. Typical mineral assemblages in metagraywackes and metashales of the H3 zone of the Redfish Bay area are:

biotite-muscovite-quartz-plagioclase-orthoclase
quartz-plagioclase-biotite-chlorite-muscovite-cordierite(?)-tourmaline-almandine
quartz-plagioclase-biotite-muscovite-almandine
quartz-plagioclase-biotite-sillimanite-almandine-andalusite(going to muscovite)-tourmaline
quartz-plagioclase-biotite-muscovite-almandine-staurolite-chlorite-tourmaline.

One metavolcanic rock from the zone has the assemblage:

plagioclase-hornblende-biotite-quartz-high F/FM chlorite.

These mineral assemblages are compatible with hornblende hornfels facies metamorphism (Turner, 1968, p. 223).

AGE OF CONTACT METAMORPHISM

The evidence presented above indicates that the metamorphic zonation in the Sitka Graywacke of southern Baranof Island is the product of contact metamorphism related to the Eocene plutonic rocks. Potassium-argon ages for these rocks range from 42.0 to 46.9 m.y. (see section on "Eocene Plutons on Baranof and Kruzof Islands"; Loney and others, 1967). Two of the three potassium-argon age determinations from metamorphic rocks in the southern Baranof Island contact aureoles fall in this range (table 14) and thus support the geometric evidence provided by the metamorphic zonation. The third age (No. 28, table 14) falls between the age range of the Eocene plutons and the Oligocene and Miocene age determined for the Gut Bay pluton (24–31 m.y.; see section on "Oligocene or Miocene Pluton at Gut Bay, Baranof Island"). This metamorphic age of 34.7 m.y. cannot be explained on the basis of the present data. There is no evidence of

TABLE 14.—*Potassium-argon age determinations, Sitka Graywacke, southern Baranof Island*

[Specimen numbers and ages are from Loney, Brew, and Lanphere (1967), tables 1 and 2]

Specimen No.	Rock type	Area	Metamorphic zone	Material analyzed	Age (m.y.)
25	biotite hornfels	small Arm of Whale Bay	L_2	biotite	45.7 ± 1.4
26	biotite semischist	south side of Whale Bay	L_1	whole rock	45.2 ± 0.7
28	muscovite-biotite almandine schist.	south side of Larch Bay	H_1	whole rock	34.7 ± 1.2

post-Eocene plutonism on Baranof Island south of the Gut Bay pluton, and the metamorphic zonation on southern Baranof Island is clearly related geometrically to the Eocene plutonism.

DISCUSSION

In the foregoing description of the contact aureoles developed in the Sitka Graywacke, reference has been made to the metamorphic facies of Turner (1968). According to his system, the lower grade aureoles belong either to the albite-epidote-hornfels facies or to the greenschist facies; the mineral assemblages do not permit distinguishing between the two. The higher grade aureoles belong to the hornblende hornfels facies, which are distinguished from the amphibolite facies by the presence of andalusite and cordierite. Almandine is common in the assemblages both north and south of Crawfish Inlet pluton and also in aureoles of Kruzof Island and Redfish Bay plutons. Staurolite, however, is restricted to the aureoles south of the Crawfish Inlet pluton, including the Redfish Bay area. According to Fyfe, Turner, and Verhoogen (1958), almandine and staurolite are characteristic of the higher pressure almandine amphibolite facies. The assemblage found south of the Crawfish Inlet pluton would then indicate metamorphism transitional between hornblende hornfels and almandine arnphibolite facies. Turner (1968, p. 233), however, cites recent work showing that almandine and staurolite are more common in contact aureoles than was formerly thought and concludes that their presence is probably more a function of rock composition (high FeO/MgO) then of high pressure.

Thus, the restriction of staurolite to the aureoles south of the Crawfish Inlet pluton may be due to differences in rock composition, but we do not have sufficient chemical data to test this conclusion. Other authors, however, namely Hietanen (1967) and Miyashiro (1961), consider these minerals to be pressure sensitive and would place the rocks in which they occur in a higher pressure facies series than those in which they are absent.

According to Miyashiro's (1961) classification, the andalusite, cordierite, and potassium-feldspar-bearing assemblages north of the Crawfish Inlet pluton belong to the low-pressure andalusite-sillimanite facies series, and staurolite plus the other minerals in assemblages south of the pluton belong to the low-pressure intermediate facies series.

In order to discuss clearly the relation of the mineral assemblages in Hietanen's (1967) facies system, it is necessary to refer to a modification of her pressure-temperature diagram (fig. 31). Curves A–A′ and *B–B′* in figure 31 represent the pressure-temperature gradient in the aureoles on Kruzof Island and north Crawfish Inlet respectively. Although not closely controlled, these curves indicate little or no pressure gradient and are close to Hietanen's contact metamorphism curve. However, the presence of almandine requires that these curves stay mostly below the hornfels boundary. Their low temperature end, by this construction, lies near the boundary between the knotted hornfels and greenschist facies.

The distribution of cordierite in the aureole south of Crawfish Inlet pluton suggests, according to Hietanen's classification, a much steeper pressure gradient toward the pluton (fig. 31, curve *C–C′*). Zones L_1 to L_3 are located in the shaded area in figure 31, because of the presence of biotite and chlorite, and the absence of almandine and andalusite. On the basis of the appearance of cordierite and almandine, disregarding for a moment the distribution of cordierite in the higher grade zones and considering only staurolite and the aluminosilicates, we see that the whole family of pressure-temperature curves, having a wide range in slope, can connect the shaded area and the field of the sillimanite-orthoclase-cordierite association (represented by the H_3 zone), each passing through the staurolite field (represented by zone Hz). However, if we consider the observation that cordierite is absent in the H_1 and Hz zones and reappears in the H_3 zone, we are constrained to draw a curve through the upward convex part of the cordierite field resulting in an unusually steep pressure gradient (fig. 31, curve *C–C′*).

If we use Hietanen's (1967) classification and interpretation, then the higher grade part of the aureole south of the Crawfish Inlet pluton had a considerably higher pressure during contact metamorphism than the lower grade part. Furthermore, the higher grade part of the southern aureole had a considerably higher pressure during metamorphism that the higher grade part

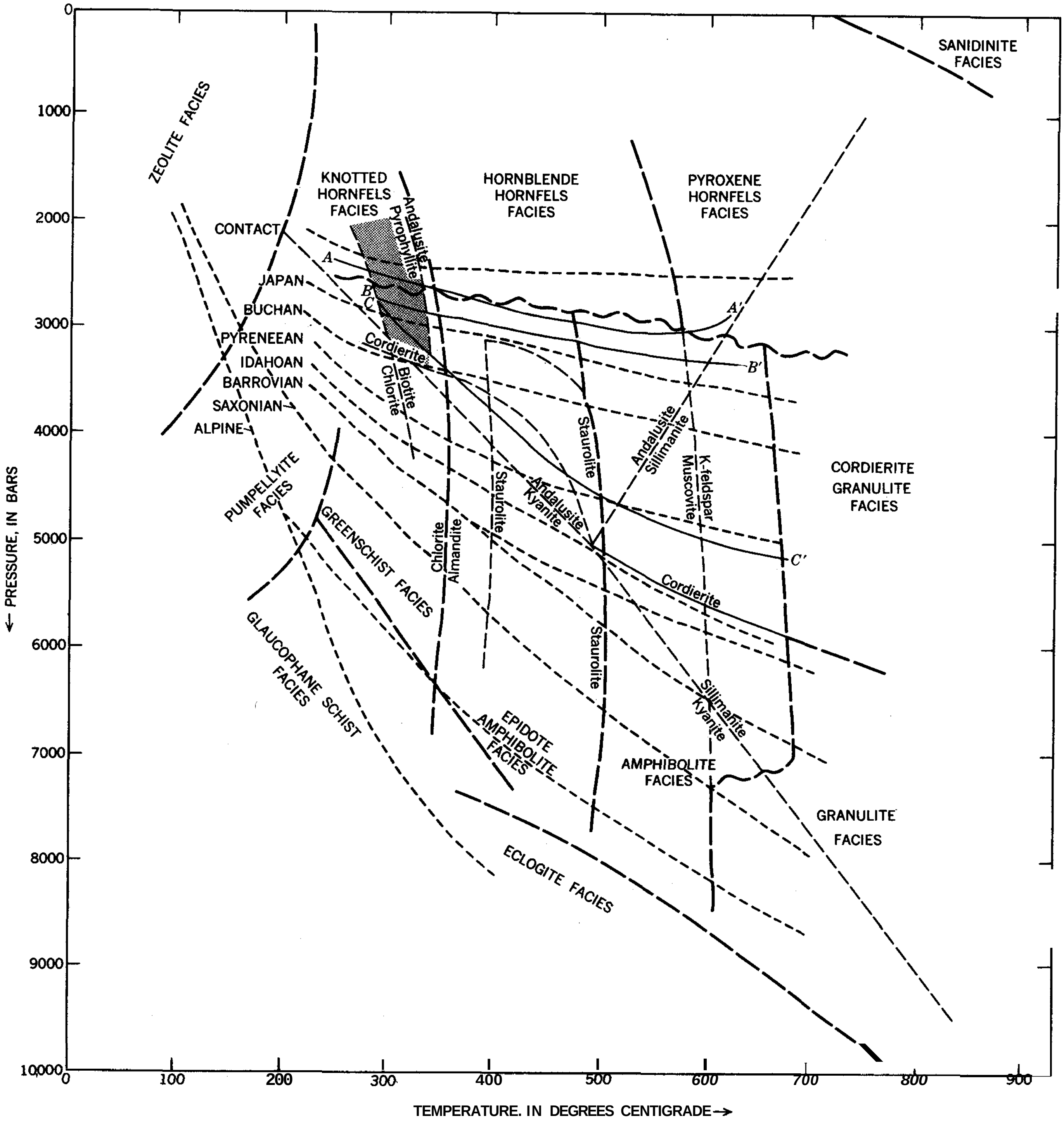


FIGURE 31.—**Possible stability fields of metamorphic facies, subfacies, pressure-temperature gradients of various metamorphic facies series, and stability boundaries of various metamorphic minerals as compiled by Hietanen (1967); see text.**

on the north side of the same pluton. These relations imply a pressure distribution during contact metamorphism in which the roof of the pluton, represented by the southern broad aureole, developed considerably higher pressures in the higher grade zones than did the sides of the pluton, which are represented by the narrow northern aureole.

We cannot adequately explain this anomalous pressure distribution on a purely physical basis. However, as indicated previously in regard to almandine and staurolite, factors other than pressure may control the distribution of some index minerals (Turner, 1968). The experimental work of Richardson (1968) suggests that the distribution of staurolite and cordierite could be affected by variations in any one of the following factors: the partial pressure of water, the composition (especially Mg/(Mg+Fe), MnO, and CaO), the fugacity of oxygen, and the distribution of muscovite. The greater development of coarse-grained schists and gneisses in the roofs of the plutons, both the Crawfish Inlet and the Kasnyku Lake plutons, suggests higher water pressure there. However, our data do not permit us to evaluate these factors; until such evaluation becomes possible, the steep pressure-temperature curve C in figure 31 should be viewed with reservation.

CONTACT METAMORPHIC ROCKS DERIVED FROM THE KELP BAY GROUP

The contact metamorphic rocks derived from the rocks of the Kelp Bay Group on Baranof Island occur in a clearly defined aureole around the Kasnyku Lake pluton and in less clearly defined aureoles along the coast to the south that are probably related mainly to the pluton at Gut Bay (pl. 1). The metamorphic rocks are divided into two map units: biotite-bearing schist and gneiss that has been mainly derived from the phyllite, graywacke semischist, and chert units of the Kelp Bay Group, and amphibolite and grenschist that has been derived mainly from the greenschist and greenstone unit of the Kelp Bay Group.

AUREOLE OF KASNYKU LAKE PLUTON

The contact metamorphic aureole around the Kasnyku Lake pluton consists chiefly of biotite-bearing schist, gneiss, and hornfels derived from the phyllite, graywacke, and chert of the Kelp Bay Group. Subordinate amounts of amphibolite are intertongued with the pelitic rocks. The amphibolite increases in abundance southward and immediately north of Red Bluff Bay becomes predominant. Locally, especially in the inner parts of the aureole, all of the rock types may grade into migmatite. The aureole is chiefly derived from the pelitic and semipelitic rocks of the Kelp Bay Group, and it is in these rocks that metamorphic zonation is best seen.

The grain size and metamorphic grade generally increase toward the pluton and reach a maximum in the inclusions and portions of the roof in the central part of the pluton. The aureole is relatively narrow (less than 0.8 km) north of the Medvejie Lake fault (pls. 1 and 2); the rocks in this part are relatively fine grained phyllite, schist, and locally hornfels. Inclusions of metamorphic rocks in the northwestern part of the pluton are also relatively fine grained, even where they contain staurolite and sillimanite. South of the fault the aureole is broad (about 6 km) and grades inward (northeastward) into an equally broad zone of mixed coarse schist, gneiss, migmatite, and small masses of plutonic rock.

The present scale of mapping does not permit the subdivision of the narrow northern aureole into zones, but a distinct zonation is apparent in the broad southern aureole (fig. 32). The narrow northern aureole is probably a reflection of the steep contact of the side of the pluton in this area, whereas the broad southern aureole and the adjacent broad mixed zone indicate a gentle to horizontal contact. The pluton probably underlies much of the high-grade terrane in the south at a shallow depth; this high grade terrane may properly be considered part of the roof of the pluton.

OUTER AUREOLE

The outer aureole is composed largely of fine-grained rocks, transitional between phyllite and schist, that are distinguished from the regional lower grade metamorphism of the Kelp Bay Group by the presence of metamorphic biotite.

The rocks commonly contain an incipient later foliation that cuts the earlier cataclastic foliation at high angles. The later foliation appears to be parallel to the axial planes of later folds (B_2) in the earlier foliation (S_2) (see section on folds of Southern and Eastern Baranof Island). The outer contact of the aureole shown on the map (pl. 1) is generally located by the presence of biotite that is seen in hand specimen; thin sections show that the actual biotite isograd is located slightly outward of the mapped contact. The biotite in pelitic and semipelitic rocks is associated with quartz, albite, chlorite, and muscovite (fig. 32). In mafic igneous rock derivatives the common mineral assemblages are:

quartz-albite-hornblende

actinolite-clinozoisite-chlorite-calcite.

Much of the hornblende in these rocks is a blue-green variety that cannot be distinguished optically from blue-green actinolite. Thus the possibility exists that the amphibole is actinolite in the lowest grade part of the aureole (Turner, 1968, p. 270).

INNER AUREOLE

Mineralogically the inner aureole is distinguished from the outer one by the presence of plagioclase that is more calcic than albite (fig, 32). Almandine seems to be absent from the lower grade part of the inner aureole. Common mineral assemblages are:

quartz-oligoclase-biotite ,

quartz-oligoclase-hornblendewotite.

The rocks of the lower part generally retain the relict cataclastic foliation seen in the outer aureole.

Inward toward the pluton, the grain size increases, and at a distance of about 2.4 km inward from the boundary of the inner aureole, almandine garnet be-

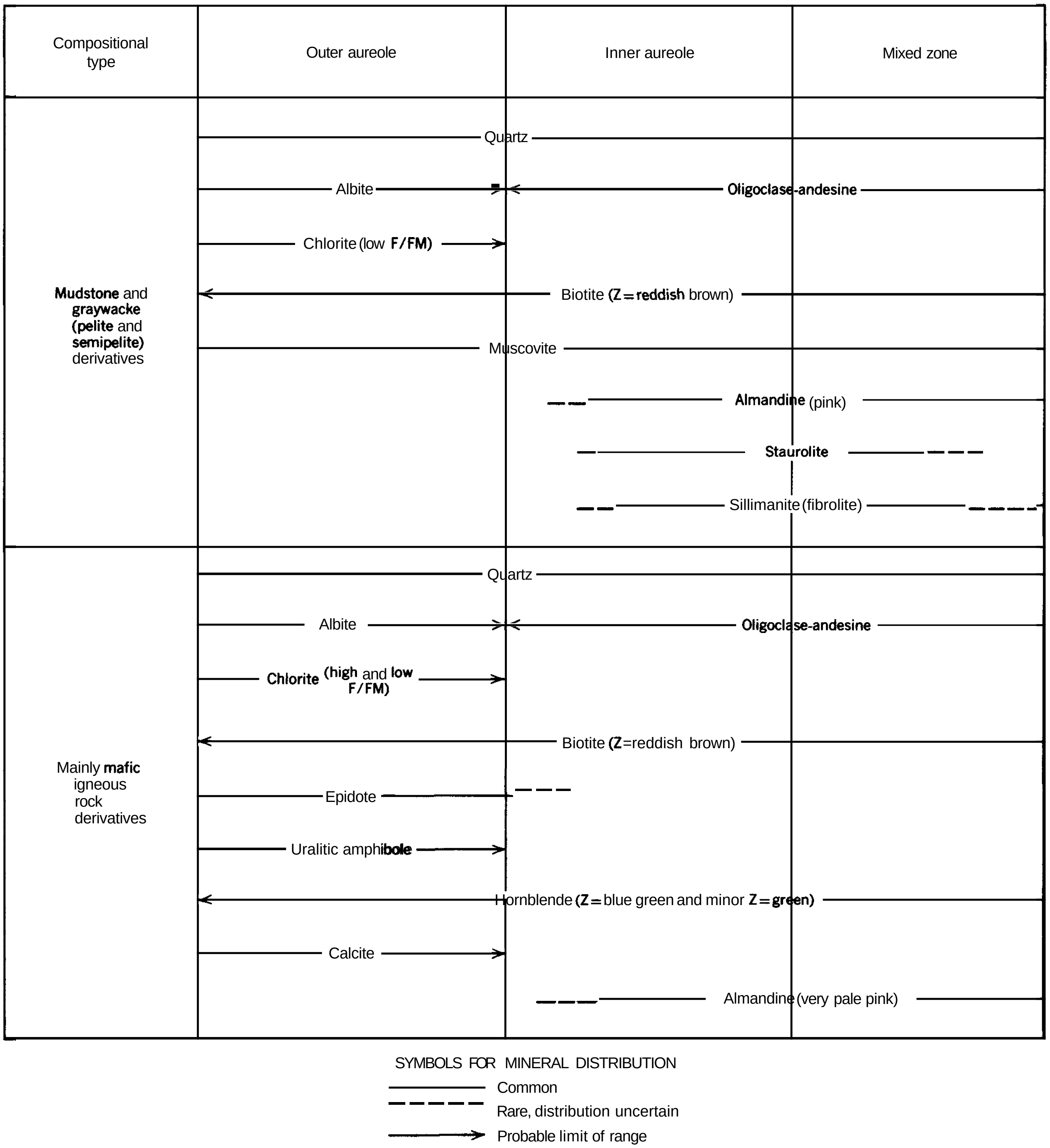


FIGURE 32.—Metamorphic mineral zones in the aureole of Kasnyku Lake pluton, derived from the Kelp Bay Group, Baranof Island, Alaska.

comes widely distributed in both pelitic schists and amphibolites. Common mineral assemblages are:

quartz-andesine-biotite-almandine
quartz-andesine-almandine-biotite-hornblende.

As the grain size increases, the relict cataclastic foliation becomes indistinct and is replaced by a single schistosity that characterizes most of the higher grade rocks of the schist and gneiss unit. This schistosity is probably equivalent to the later incipient foliation (S_3) seen cutting the earlier cataclastic foliation (S_2) at high angles in the lower grade parts of the aureole. (See section on "Southern and Eastern **Baranof** Island".)

About 0.5 km farther inward from the first appearance of almandine, staurolite and sillimanite (fibrolite) appear in the pelitic schists. The two minerals are not seen to replace one another, but they form independent mineral phases. Staurolite generally occurs as large (as much as 20 mm long) **euhedral** crystals, which commonly show the typical cruciform penetration twins. The biotite folia bend around the staurolite crystals, which generally have "strain shadows" composed of coarse mosaics of quartz and plagioclase. The staurolite crystals tend to lie in the foliation without noticeable linear preferred orientation.

The fibrolite sillimanite occurs as mats of randomly oriented needles; the thicker mats are distinctly brown in plane light. The sillimanite needles commonly grow on biotite crystals, but only rarely does it seem to replace the biotite. Most sillimanite-biotite relations are compatible with Chinner's (1961) conclusion that biotite acts as a nucleating agent for sillimanite.

The common mineral assemblages in the higher grade portion of the inner aureole are:

quartz-andesine **(An_{30-40})-biotite-almandine-** staurolite-sillimanite

quartz-andesine **(An_{30-35})-biotite-hornblende- al-mandine**

quartz-oligoclase **(An_{22-27})-hornblende.**

MIXED ZONE

The mixed zone includes tracts of schist, amphibolite, gneiss, and **migmatite** that are mixed with small bodies of plutonic rocks. The metamorphic rocks of the mixed zone are generally coarser grained and more quartzofeldspathic than those of the aureole, otherwise their mineralogy is similar to that of the higher grade part of the aureole (fig. 32). Staurolite and sillimanite are much less common in the mixed zone, and it is possible that sillimanite occurs alone in the rocks in the central part of the pluton. However, both minerals are so sparse that such a zone could not be defined at the present scale of mapping.

The common rocks of the mixed zone are intensely foliated and show a marked planar preferred orientation of biotite and hornblende. Dominant mineral assemblages are:

quartz-oligoclase **(An_{20-28})-biotite-muscovite-al-mandine**

quartz-oligoclase-biotite-almandine

quartz-andesine **(An_{40-48})-hornblende-almandine.**

However, hornfels and granofels, with equigranular granoblastic textures that show no trace of dynamic metamorphism, occur in blocks along with sillimanite- and staurolite-bearing schists in large inclusions in the northwestern part of the pluton. The hornfels contains abundant almandine in addition to quartz, oligoclase (**An_{20-25}**), and biotite. It is obvious that the hornfels has been subjected to high-grade metamorphism but somehow escaped the penetrative deformation that produced the schists.

DISCUSSION

In the outer aureole of the Kasnyku Lake pluton, the pelitic mineral assemblage quartz-albite-chlorite-biotite-muscovite coupled with the absence of almandine is indicative of the low-pressure albite-epidote-hornfels facies (Turner, 1968, p. 190). In the inner aureole, however, the widespread association in pelitic rocks of staurolite, almandine, and sillimanite appears to indicate a high-temperature metamorphism at pressures intermediate between the hornblende hornfels facies and the amphibolite facies (Turner, 1968). Such an intermediate facies has been called the Buchan-type by Read (1952) and the low-pressure intermediate type by Miyashiro (1961).

The pressure-temperature gradient can be further examined by means of the diagrams of **Hietanen** (1967, figs. 1 and 2). The absence of andalusite, kyanite, and cordierite, however, makes it difficult to construct a gradient curve, like the ones for aureoles in the Sitka Graywacke (fig. 31). The outer aureole, with the assemblage quartz-albite-chlorite-biotite-muscovite, is undoubtedly in the higher grade part of the **Hietanen** greenschist facies, but which side of the kyanite-andalusite boundary it is on is not certain. However, it seems likely, in view of the widespread occurrence of andalusite in the aureole of the Crawfish Inlet pluton in the Sitka Graywacke, that the pressure-temperature conditions were above the boundary. The inner aureole pressure-temperature conditions would lie in the narrow triangle in which staurolite and sillimanite coexist, in the uppermost part of the epidote-amphibolite facies. As is shown later in the section on the "Depth of Intrusion", there is no agreement on the location of the aluminum silicate triple point, and a slight change in its location would enlarge the area in which staurolite and sillimanite coexist. In fact, the common association of these two minerals in aureoles suggests a larger stability field than shown on Hietanen's (1967) diagrams. In any case, assuming that the metamorphism of the Kasnyku Lake aureole lay in the andalusite field, then a pressure-temperature gradient curve is obtained that is even steeper than curve *C–C′* for the south side of the Crawfish Inlet pluton (fig. *31*).

METAMORPHIC ROCKS SOUTH OF RED BLUFF BAY

South of Red Bluff Bay the metamorphic rocks consist largely of amphibolite and greenschist that are interlayered with subordinate amounts of **phyllite** and biotite schist. These rocks are the generally higher metamorphic grade equivalents of the unnamed greenschist and greenstone unit and the dominantly volcanic facies of the **Khaz** Formation, both of the Kelp Bay Group. The amphibolite and greenschist intertongues with the schist and gneiss unit. East of Patterson Bay, the slightly metamorphosed prehnite-bearing augite andesite and basalt flows, along with some gabbros, are probably closest to the type of volcanic rocks from which these metamorphics were derived. These metavolcanic rocks belong to the prehnite-pumpellyite-metagraywacke facies.

The pattern of metamorphism in the chief area of outcrop, south of Red Bluff Bay, is not entirely clear, but in general the amphibolite and greenschist unit increases in metamorphic grade both northward and southward of Red Bluff Bay. In the immediate vicinity of the bay, amphibolite with the assemblage:

quartz-albite-epidote-actinolite

is interbedded with greenschist with the assemblage:

quartz-albite-epidote-chlorite

and with phyllite with the assemblage:

quartz-albite-chlorite-biotite.

These mineral assemblages are indicative of the higher grade part of the greenschist or albite-epidote hornfels facies. The rocks show clearly the remnants of an early cataclastic foliation and generally two generations of hornblende growth. The earlier generation is represented by larger, rounded, and commonly broken, bluish-green (Z) hornblende crystals (possibly actinolite in part); the later generation consists of smaller euhedral needles of similar color that grow on and around the earlier fragments. Two episodes of metamorphism are indicated, separated by cataclastic deformation. At Red Bluff Bay, the later hornblende crystals define a marked lineation, but elsewhere no preferred orientation is apparent. Relict crystals of plagioclase (An_{55}–An_{85}) and augite are fairly common.

The rocks of the unit become coarser grained and higher grade toward the Gut Bay pluton and to a lesser extent toward the Kasnyku Lake pluton. The higher grade zones are medium to coarse grained and consist chiefly of amphibolite with the assemblages:

quartz-oligoclase or andesine-hornblende

quartz-andesine-epidote-hornblende.

Interlayered with these rocks (see fig. 32) are lesser amounts of amphibolite with the assemblage:

almandine-biotite-quartz-oligoclase-hornblende

and schist with the assemblage:

quartz-andesine-hornblende-biotite.

The presence of almandine garnet suggests the amphibolite facies rather than the hornblende hornfels facies; however, the garnet appears to be confined to biotite-bearing amphibolites. The original cataclastic textures are not generally visible in the higher grade rocks, and in places the amphibolite is interlayered with coarse-grained hornblende gabbro.

DEPTH OF INTRUSION

Physical conditions (including pressure-temperature) of contact metamorphism that are related to the Tertiary plutons of Baranof and Kruzof Islands have been mentioned briefly in the foregoing text where mineral assemblages have suggested them. This section presents a more detailed discussion of the pressure-temperature conditions of the main type of metamorphism in the aureoles in the light of recent work, both experimental and field. The main purpose of this discussion is to attempt to determine the approximate minimum depth of intrusion of the Tertiary plutons in order to attain some idea of the amount of uplift necessary to bring them to their present level at the surface. This depth was discussed by Loney, Brew, and Lanphere (1967), but recent experimental work on the stability of the aluminum silicates and of staurolite makes it desirable to bring this discussion up to date.

The pelitic rocks of the Kelp Bay Group in the inner aureole of the Kasnyku Lake pluton contain staurolite and sillimanite (fig. 32), whereas the pelitic rocks of the Sitka Graywacke in the inner aureoles of the Crawfish Inlet, Redfish Bay, and Kruzof Island plutons contain staurolite, sillimanite, andalusite, and cordierite (figs. 27, 28, 29, and 30). The absence of cordierite in metamorphic rocks derived from the Kelp Bay Group may be due to differing rock composition and not to differences in confining pressure. On the other hand, the apparent absence of both andalusite and kyanite in the aureole of the Kasnyku Lake pluton is not readily explained by differing rock composition, for andalusite or kyanite should be present at lower temperature in rocks that display sillimanite at higher temperature (fig. 33). However, in our reconnaissance mapping, the sampling density may not have been sufficient to pick up Al_2SiO_5 phases present in only small amounts. We note, however, that andalusite rather than kyanite is present in the aureoles around the Crawfish Inlet, Redfish Bay, and Kruzof Island plutons, and thus by analogy, we assume that undetected andalusite is present around the Kasnyku Lake pluton and that the aureole of the Kasnyku Lake pluton passed through the andalusite field rather than the kyanite field.

Metamorphic terranes that contain andalusite-sillimanite-staurolite in the pelitic rocks have been considered to be intermediate between the higher pressure kyanite-sillimanite-staurolite type and the lower pressure andalusite-sillimanite type (Harker, 1939, Read, 1952; Miyashiro, 1961; Hietanen, 1967). This concept is based on the idea that staurolite is a higher pressure mineral, the stability field of which ranges from that of the kyanite-sillimanite type down into the higher pressure part of the stability field of andalusite-sillimanite types.

The intermediate metamorphic type was not included in the facies classification of Turner and Verhoogen (1960, p. 508–560). The absence of kyanite and epidote minerals fits their hornblende hornfels facies, but the presence of staurolite and almandine is indicative of their higher pressure almandine amphibolite facies (staurolite-almandine subfacies). However, recently Turner (1968, p. 190–262) reviewed the facies of low pressure with respect to recent published accounts of metamorphic terranes and pointed out that Compton (1960) described staurolite associated with andalusite and cordierite in the contact aureole in the Santa Rosa Range, Nev. Compton estimated the cover at time of metamorphism to be between 3–8 km thick, equivalent to a pressure of about 1–2.5 kb. This estimate agrees with Turner's estimate for the pressure of metamorphism at Santa Rosa and also for the aureole at Ardara, Donegal, where a similar assemblage occurs. His estimates are based largely on a correlation of natural mineral assemblages with a series of critical experimental reactions. The chief pressure control of these data appears to be the intersection of the positively sloping univariant equilibrium curves of various reactions with the negatively sloping andalusite-sillimanite boundary curve. The andalusite-sillimanite curve used is that of Fyfe (1967); the curve is based on the Al_2SiO_5 triple point experiments of Weill (1966) and Newton (1966). A similar staurolite-andalusite-sillimanite mineral assemblage occurs in regionally metamorphosed rocks in the central Pyrenees; there Zwart (1962) estimates, from stratigraphic and tectonic evidence, that the thickness of cover at the culmination of metamorphism was not greater than 5 km, corresponding to 1–2 kb pressure. In view of this evidence, Turner considers that the presence of staurolite in these metamorphic assemblages does not indicate the high pressures, as formerly thought, but instead can indicate pressures as little as 1–2 kb.

Other experimental evidence, including the most recent Al_2SiO_5 triple point determinations (Althaus, 1967; Pugin and Khitarov, 1968; Richardson and others, 1969) give much higher pressures than those Turner presents (fig. 33). Loney, Brew, and Lanphere (1967) estimated the minimum pressure of metamorphism in the Baranof Island plutons to be in the range of 3 to 5 kb, which is equivalent to a depth of 12–19 km, assuming a density of 2.7 for the overburden and disregarding possible tectonic overpressures. This estimate was based on the stability field of mullite + quartz that terminated the low-pressure–high-temperature end of the sillimanite-andalusite boundary of the Al_2SiO_5 phase diagram of Khitarov, Pugin, Chao. and Slutskv (1963) and thus provided a basis for obtaining a minimum pressure for the sillimanite-andalusite reaction. Since then, experimental investigation of the Al_2SiO_5 triple point has continued, and a considerable range in the pressure-temperature location of the triple point has resulted, but no further experimental data have been published concerning the mullite + quartz field. Holm and Kleppa (1966), however, concluded, on the basis of new thermochemical measurements in the system Al_2O_3–SiO_3, that mullite is not stable with quartz below about 1,100°C at atmospheric pressure, and at higher pressures, the low temperature limits are even higher. This conclusion agrees with the known restriction of natural mullite to the metamorphism of aluminous rock in contact with basaltic magma (Moore and Best, 1969). Because of these considerations, it seems inappropriate to make further pressure-temperature estimations on this basis at this time.

Richardson's (1968) determination of the stability field of Fe-staurolite, when used in conjunction with Al_2SiO_5 stability fields, affords another means of estimating the pressure-temperature ranges in the contact aureoles (fig. 21). More recently Hoschekc (1969) obtained a similar staurolite stability field by using starting materials that are closer to the compositions of minerals in pelitic rocks (for example, more magnesian staurolite).

It can be seen from figure 33 that many of the experimentally determined Al_2SiO_5 triple points are at temperatures well below the staurolite field; therefore a discussion of the relation of their stability fields to the staurolite field is meaningless. The common association of the aluminum silicates and staurolite suggests that the triple point lies in or near the staurolite field. For this reason. only the Al_2SiO_5 stability fields related to triple points in or near the staurolite field are shown in figure 33 (points 1,2,3,5). The occurrence of both andalusite and sillimanite in the Crawfish Inlet aureole and of sillimanite alone in the Kasnyku aureole suggests that the pressure-temperature conditions near the andalusite-sillimanite boundary obtained. Of the stability fields shown, that of Pugin and Khitarov (1968; fig. 33, No. 5) gives the lowest pressure at the intersections of the low pressure end of the andalusite-sillimanite boundary and the boundary of the staurolite field, that is, 2.7 kb, equivalent to a hydrostatic depth of approximately 11 km. On this basis, the highest pressure of 4.0 kb (approximately 16 km depth) is given by the stability fields of triple point No. 1 (Richardson and others, 1969), however, it is possible that this boundary curve would intersect the granitic melting curve at an even higher pressure before intersecting the staurolite boundary.

By comparison, Hietanen (1967) gives 4.8 kb and

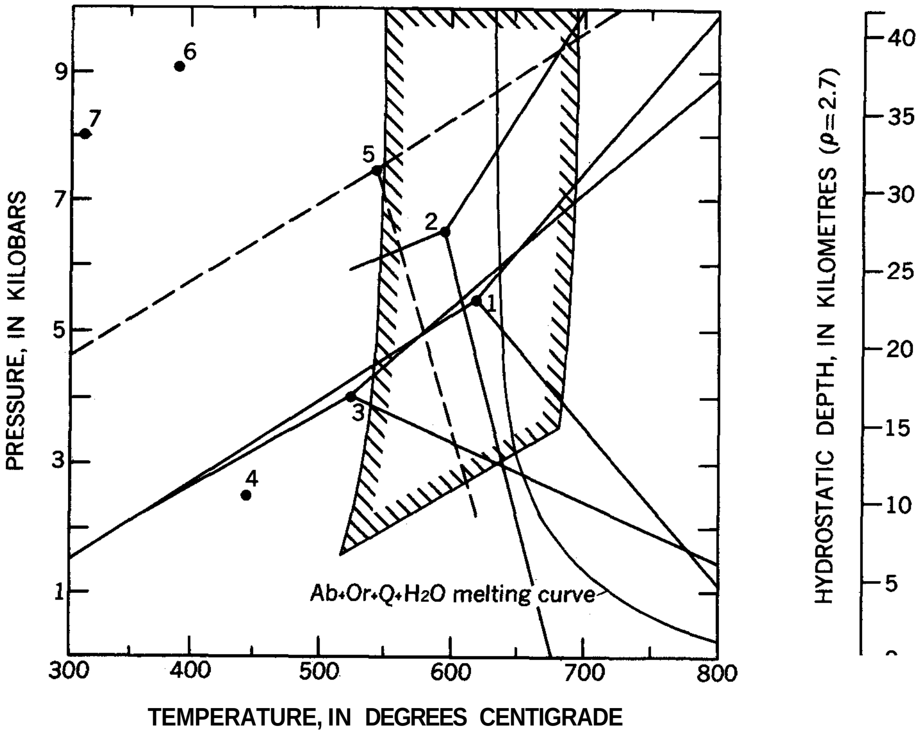


FIGURE 33.—Stability relations of kyanite-andalusite-sillimanite, and Fe-staurolite (Shaded field, Richardson, 1968); minimum melting curve of granitic composition + H_2O from Luth, Johns, and Tuttle (1964); for triple points 1. Richardson, Gilbert, and Bell (1969), 2. Althaus (1967), 3. Newton (1966), the stability fields of the aluminum silicates are shown by the intersections of the stability field boundaries (kyanite to upper left, sillimanite to right, andalusite below); other Al_2SiO_5 triple points shown as dots are: 4. Weill (1966), 5. Pugin and Khitarov (1968), 6. Khitarov, Pugin, Chao, and Slutsky (1963), 7. Bell (1963); pressure is fluid pressure for triple points 1 and 2, Fe-staurolite field, and granitic melting curve.

500°C for the lowest pressure point on the andalusite-sillimanite boundary in the staurolite field (fig. 31). Hietanen's data are derived indirectly from mineral assemblages of different metamorphic terranes tied to pressure and temperature by experimental data at key points.

The above discussion illustrates the wide range of pressure-temperature conditions that have been derived by various workers for the type of metamorphism that is represented in the contact aureoles of Tertiary plutons on Baranof Island. In general, the experimental evidence indicates a deeper minimum depth of metamorphism (about 11 km) for the association andalusite-sillimanite-staurolite than does the available field evidence (about 3 km, Compton, 1960).

Both types of evidence involve factors that are at present impossible to evaluate and that make the literal use of the derived pressure-temperature conditions hazardous. The facts that the experimental depths of metamorphism are hydrostatic and that the minimum depth (11 km) is much greater than the minimum derived from field evidence (3 km) suggest that the assumption that the overburden is without strength and acts like heavy liquid may be considerably in error (Birch, 1955, p. 115–116). Clark (1961) suggested that a tectonic overpressure of 1 kb could obtain during geologically short periods of active deformation (see Loney and others, 1967). Recent experimental work by Brace, Ernst, and Kallberg (1970) indicates that the strength of a mixed section of graywacke and shale is not great enough to produce a tectonic overpressure greater than 1 kb, and this strength would be much less in the likely event that the rocks were less indurated at the time of metamorphism and deformation than they are now. Such overpressure would reduce the depth necessary to obtain a given total pressure (1 kb = 3–4 km hydrostatic depth) and would bring the experimental results closer to those estimated from geologic evidence, but apparently it cannot bring them together. In any case, it seems safe to say that the plutons were intruded at a depth of at least a few kilometers.

MINERAL DEPOSITS

Baranof and Chichagof Islands, together with the nearby smaller islands, compose the Chichagof district

(Berg and Cobb, 1967, p. 141–146). Previously this area was called the Sitka mining district (Knopf, 1912). Gold, silver, and gypsum have been produced from the Chichagof district. In addition, there are occurrences of nickel, chromium, copper, molbydenum, tungsten, iron, potash feldspar, palygorskite, and andalusite.

As defined here and shown on plate 4, the district includes the Inian Islands and Lemesurier Island off the coast of Chichagof Island; these islands are not covered by the geologic map (pl. 1) or descriptions given in this report but are discussed by Rossman (1959; 1963b).

GOLD-SILVER DEPOSITS

The gold and silver deposits of the Chichagof district are almost exclusively lode deposits. They occur in two main areas: (1) Silver Bay (just southeast of Sitka), and (2) a belt trending north-northwest through westernmost Chichagof Island (pl. 4).[4] Although there has been extensive prospecting and some development in the Silver Bay area since 1871 (Knopf, 1912), there is little, if any, recorded production. The belt of deposits in westernmost Chichagof Island, however, has produced nearly a million ounces of gold, as well as some silver. Production was primarily from the Hirst-Chichagof mine and the Chichagof mine, although small amounts of gold were recovered from other mines, primarily the Apex, El Nido, Alaska Chichagof, and Cobol mines (Berg and Cobb, 1967, p. 141–146). There is no recorded production from any mines in the district since about 1945.

The gold-silver deposits of the Chichagof district occur as quartz veins in fault zones that cut low-grade metamorphic rocks and granitoid intrusive rocks. With the exception of the prospect in a Tertiary(?) pluton at the head of Lisianski Inlet, country rocks are of Mesozoic age. Gold occurs with pyrite, arsenopyrite, chalcopyrite, and rare galena and sphalerite. In the Chichagof area, the quartz veins contain less than 3 percent metallic minerals (Reed and Coats, 1941, p. 80).

Plate 4 shows that the gold-silver deposits all fall within the belt of Tertiary granitoid intrusions that trends northwest along the west side of Baranof and Chichagof Islands. This spatial relation suggests that the gold- and silver-bearing solutions were either derived from these Tertiary magmas or that the magmas were the source of the heat required to mobilize the quartz, gold, silver, and sulfides from the country rock. In either case, the gold-silver deposits appear to be genetically related to the Tertiary intrusive belt and would not be expected to occur away from that belt.

[4]The Rodman Bay mine on northern Baranof Island is not in the Silver Bay area or in the northwestern Chichagof Island area. The extent and grade of the ore at the Rodman Bay mine, if indeed there was any ore at all, are unknown. At one time, however, there were extensive workings, milling structures, and access facilities (Wright and Wright, 1905, p. 58; Wright, 1907, p. 60; Knopf, 1912, p. 8).

The gold-silver deposits, however, are not uniformly distributed along the Tertiary intrusive belt; instead they are restricted to the Silver Bay area and to northwestern Chichagof Island. Both of these areas lie along the Sitka fault zone. Though faults clearly played an important role in localizing ore deposition (Reed and Coats, 1941, p. 7); major segments of the Sitka fault zone appear to be completely barren of ore. What localized the ore deposition in some parts of the fault zone but not in others? We tentatively suggest that, during the period of ore solution transport (Tertiary?), the Silver Bay and northwestern Chichagof areas were subjected to more intense fracturing than were other segments of the Sitka fault zone. Both the Silver Bay deposits and the deposits on northwestern Chichagof Island lie in areas where the Sitka fault zone is not a single northwest-trending strand, instead the zone is a complex of faults oriented in various directions. In these areas, movement along the Sitka fault zone apparently shifted from one northwest-trending segment (for example, the Neva Strait fault) to another subparallel segment (for example, the Patterson Bay fault or the Lisianski Inlet fault) via an irregular network of faults. Such areas may well have been relatively prone to pervasive fracturing and thus would have been appropriate for ore deposition.

NICKEL COPPER DEPOSITS

The Tertiary(?) norite plutons along the west coast of Chichagof Island and on Yakobi Island locally contain concentrations of nickel- and copper-bearing sulfides, primarily pyrrhotite, pentlandite, and chalcopyrite. These deposits are magmatic, most probably immiscible segregations from the norite magma (Kennedy and Walton, 1946a). The deposits were investigated during World War II but proved too small and too low grade to mine.

The largest bodies of norite and the largest concentrations of sulfides are on Yakobi Island (Kennedy and Walton, 1946a; Reed and Dorr, 1942). The major deposits are on the east side of the island at Bohemia Basin; but some deposits of uncertain size are on the west side of the island. In addition, several deposits also occur in norite near Mirror Harbor on the west coast of Chichagof Island (Pecora, 1942). Buddington (1925) and Reed and Gates (1942) have described occurrences of pyrrhotite, chalcopyrite, and pentlandite in a small body of altered gabbro at Snipe Bay on the west coast of southern Baranof Island.

CHROMIUM DEPOSITS

The major chromium deposits of the Chichagof district occur as lenses and irregular masses of chromite in the Red Bluff Bay peridotite. According to Guild and Balsley (1942), this chromite is too rich in iron to be of metallurgical grade. They conclude that a few hundred tons of chromite could readily be mined but that the potential reserves are inadequate to make the deposit commercial.

Chromite also occurs in small quantities in a number of small serpentinite bodies near the center of Baranof Island (the Hill prospects in Kennedy and Walton, 1946b). These serpentinites lie in a belt that extends from a point about 4 miles west-southwest of Red Bluff Bay northwest to a point 2 miles north of Sitka. The chromite deposits are small and low grade, are inaccessible, and are clearly of no commercial significance.

MISCELLANEOUS METALLIC PROSPECTS

Overbeck (1919) described a few copper prospects (chalcopyrite and pyrrhotite) along the coast of westernmost Chichagof Island. Smith (1942) described molybdenite from the Magoun Islands (8 miles northwest of Sitka), from the mouth of Tenakee Inlet, and from two localities on Lemesurier Island. Tungsten (in scheelite) has been reported from the Apex and El Nido Mines on Chichagof Island (Twenhofel and others, 1949, p. 20–23. A small magnetite deposit at Stag Bay, Chichagof Island, was reported by Twenhofel, Reed, and Gates (1949, p. 23–24). Loney, Berg, Pomeroy, and Brew (1963) give X-ray spectrographic data on a number of metal-bearing samples collected from Chichagof and northern Baranof Islands.

GYPSUM

Gypsum is the only nonmetallic material that has been produced from the Chichagof district. Approximately 500,000 tons of gypsum was mined from the Pacific Coast Gypsum Company property at Iyoukeen Cove on eastern Chichagof Island from 1902 to 1923 (Flint and Cobb, 1953). The Gypsum-Camel property in the same area was also developed but was not productive. The gypsum occurs in the Iyoukeen Formation of Mississippian age, but it is uncertain whether the deposit is sedimentary or hydrothermal.

POTASSIUM FELDSPAR

A moderate-sized pegmatite dike cuts granodiorite of the Redfish Bay pluton (No. 97, pl. 2) on southern Baranof Island. The dike has a core of fractured quartz, an intermediate zone of muscovite, and a 4–10 foot thick marginal zone of microcline. Sainsbury (1957) reported no significant quantities of rare-earth minerals but suggested that the deposit could be mined for ceramic-grade potassium feldspar.

MISCELLANEOUS NONMETALLIC DEPOSITS

Palygorskite, a clay mineral with a chainlike crystal structure rather than a sheet crystal structure (Caillere and Henin, 1961), occurs in two deposits on Lemesurier Island that are probably of no economic significance (Rossman, 1963b, p. K51–K52). Andalusite deposits have been noted (C. T. Bressler, 1946, unpub. data) along the coast north of Mirror Harbor on western Chichagof Island and may be part of a contact aureole around the Mirror Harbor pluton.

GEOLOGIC HISTORY

The reconstruction of the geologic history of Chichagof and Baranof Islands is severely hampered by the scarcity of fossils in many parts of the section. This scarcity is due partly to the environments under which certain formations were deposited and partly to the low-grade metamorphism and intense deformation that affected the Mesozoic rocks. Furthermore, because of the complex structure, the original depositional loci of the various rock units are uncertain.

PALEOZOIC EVENTS

The earliest recognized event was the intrusion of Silurian or older plutonic rocks in southeastern Chichagof Island. The terrane into which these rocks were intruded has not been recognized and must be largely buried under younger rocks. At least part of this older terrane may be correlative with the eugeosynclinal, graptolite-bearing slate, graywacke, and volcanic rocks of Ordovician age on Prince of Wales Island (Eberlein and Churkin, 1970).

After the intrusion, uplift, perhaps accompanied by folding, brought the syenitic rocks to the surface where they were eroded into a topography of at least moderate relief. By Late Silurian time, subsidence caused the sea to cover the eastern Chichagof area, except for the northwest-trending syenitic ridge that appears to have extended from near Sitkoh Bay to beyond Tenakee Inlet. This ridge locally shed coarse detritus into the eugeosynclinal turbidite sediments that were being deposited in the encroaching sea. Thin-bedded slate, graywacke, and local limestone, and conglomerate of the Point Augusta Formation were the result of the deposition.

The turbidite sedimentation in eastern and northern Chichagof Island was followed, either in the Late Silurian or in the Early Devonian, or both, by the development of thick lenticular limestone reefs that make up the Kennel Creek Limestone; in places, conglomerate was deposited with the limestone. A period of mixed carbonate and turbidite deposition followed in Middle and Late Devonian, during which the thinly interbedded limestone and graywacke of the Cedar Cove Formation was deposited. Syenite and granite cobbles in conglomerate of the Cedar Cove Formation indicate that the old syenitic ridge to the southwest was probably still shedding detritus although the cobbles could have been reworked from the Point Augusta Formation or from the Kennel Creek Limestone.

The dominantly carbonate sedimentation was followed by an episode of volcanism in Late Devonian time, during which a thick pile of submarine andesitic and basaltic flows and breccias were erupted. Associated lesser amounts of rhyolitic lavas included subaerial rhyolitic ash flow tuffs. Locally marine limestone, argillite, and volcanic sandstone were deposited between flows. Together all these rocks form the Freshwater Bay Formation.

The volcanism was followed in Early Mississippian time by another period of dominantly carbonate deposition, during which several thousand feet of shallow-water limestone, chert, and shale of the Iyoukeen Formation were deposited. General uplift ended this depositional phase during the Late Mississippian, but before the end, restricted circulation and evaporation led to the local deposition of gypsum.

MESOZOIC EVENTS

After the Mississippian sedimentation, the area seems to have been generally emergent until the Permian or, more probably, the Triassic, when a long period of intermittent eugeosynclinal sedimentation and volcanism began. This period probably extended into the Cretaceous and was marked by increased plutonism and tectonism. The sedimentary record, which is known only from rocks on western Chichagof Island and on Baranof Island, contains great uncertainities, due in part to the general absence of fossils.

The period began with the deposition of chert, black shale, sandstone, siltstone, and limestone that are now exposed in western Chichagof Island. Relatively minor amounts of mafic lava were erupted during this sedimentation. These rocks are dated only indirectly by stratigraphic relations and are believed to be late Paleozoic or early Mesozoic.

Following a possible hiatus, the Kelp Bay Group was probably deposited during the Triassic and perhaps deposition continued into the Jurassic. The earliest phase was the eruption of several thousand feet of mafic flows and tuffs that constitute the Goon Dip Greenstone. The volcanic eruption was followed by a period of somewhat quiet sedimentation during which the relatively thin Whitestripe Marble was first deposited, followed by the probably deep water deposition of the thinly interlaminated chert and shale sequence that now forms the Pinnacle Peak Phyllite. Mafic and intermediate volcanism, associated with the deposition of lesser amounts of graywacke, radiolarian chert, and marble was the next major event, giving rise to the Waterfall Greenstone.

Increased tectonism is evident in the closing phase of Kelp Bay sedimentation, after the earlier deposits described above were at least partly lithified. These deposits were subjected to extensive brecciation, the products of which accumulated as the chaotic melange that constitutes much of the Khaz Formation. Whether this brecciation and accumulation was caused chiefly by gravitational sliding or by compressive deformation and faulting, or both, is uncertain. It is also uncertain whether or not normal marine sedimentation continued in other places in the interval during which the Khaz Formation was formed. Nonetheless the tectonic development of the Khaz Formation appears to be the first phase of a period of general uplift and plutonism that extended from Early Jurassic to Late Jurassic.

Early in this period of uplift and before much of the plutonism, the Paleozoic rocks of northeastern Chichagof Island were probably folded about northwest-trending axes. Later, sometime during an interval that includes the early Early and Middle Jurassic, tonalitic to adamellitic plutons of small-to-moderate size were emplaced in both Chichagof and Baranof Islands. The metamorphic complex of Peril Strait may have been formed at this time, but it seems more likely that narrow contact aureoles are characteristic of plutons of this age.

By Late Jurassic time, marine sedimentation resumed in at least the western parts of Chichagof and Baranof Islands and continued into Early Cretaceous time. The resultant thick section of thick-bedded graywacke and lesser amounts of interbedded shale, conglomerate, and mafic volcanic rock constitute the Sitka Graywacke. The source of these sediments was probably to the west, off the coast , and the northwest-trending depositional trough in which they were accumulated may have been connected in places with a generally parallel trough that trends through eastern Admiralty Island and that was the locus of thinly bedded, fine-grained turbidite deposits (Seymour Canal Formation). These deposits are probably distal facies equivalents of the Sitka Graywacke.

Later in the Early Cretaceous, the Sitka Graywacke sedimentation was brought to an end by a period of general uplift that has continued to the present day. During the early part of this period, probably extending into the early Tertiary, intermittent northeast-southwest compression produced northwest-trending folds in most places, but in northern Baranof Island, there were large-scale departures from this orientation, possibly caused by a major eastward embayment in the Mesozoic depositional trough. In northern Baranof Island, further northeast-southwest compression produced complex superposed folds. The major northwest-striking faults, such as the Peril Strait fault, probably originated during this early period of deformation.

During the early phases of this uplift, Chichagof and Kruzof Islands were subjected to extensive plutonism.

The plutons were probably intruded at depths of a few kilometers, where they metamorphosed the country rock and produced mineral assemblages that are characteristic of the hornblende hornfels facies. Synkinematic metamorphism is spotty, and most of the metamorphic rocks are hornfels. This Cretaceous plutonism was the most extensive to affect the area. Except for a few small outlying plutons, most of this plutonism was concentrated in a broad belt that extends from Catherine Island on the southeast to Icy Strait on the northwest. Important movement on the Peril Strait fault postdated these plutons.

TERTIARY EVENTS

The period of uplift and intermittent compression continued into the Tertiary, but the compression appears to end during the early stages of the middle and late Eocene plutonism. By this time, the Kelp Bay Group and the Sitka Graywacke had been regionally metamorphosed and ranged in grade from the prehnite-pumpellyite metagraywacke facies to the greenschist facies. In southern Baranof Island, the country rocks above the intruding plutons were intensely folded to lineated schists by northeast-southwest compression at elevated temperatures. By the time the plutons were emplaced, the episode of compression had waned, and the intrusions appear to have taken place passively and to have caused no important modificationof the earlier regional structural trends. In general, the plutons, which ranged from tonalitic to granodioritic, produced narrow contact aureoles in the low-grade regionally metamorphosed country rock. The contact metamorphism attained a grade intermediate between the hornblende hornfels facies and the amphibolite facies. The plutons probably solidified at a depth of at least 3 or 4 km. In western Chichagof and Baranof Islands, these plutons probably produced gold-silver deposits in major fault zones, either by supplying magmatic solutions or by supplying heat that mobilized the vein minerals in the country rock.

After the Eocene plutonism, dominantly right lateral movement continued on the Patterson Bay fault and probably also on the other major northwest-striking faults. The movement on the Patterson Bay fault had ceased before the intrusion of the granodiorite pluton at Gut Bay in Oligocene time, but by then the east end of the Crawfish Inlet pluton had been separated 3.5 miles right laterally.

After the Oligocene and Miocene plutonism, uplift continued and eventually brought the plutonic rocks to their present position at the surface. During the uplift, Chichagof and Baranof Islands probably moved upward at least a few kilometers more or less as a block. Most of this movement appears to have taken place on the Chatham Strait fault, which bounds the block on the east. This movement was the vertical component of a fault movement that had a much greater right-lateral horizontal component, probably about 120 miles.

Similarly, during this period Baranof Island and southwestern Chichagof Island moved down relative to the rest of Chichagof Island along the northwest-striking Peril Strait fault, the main movement of which was right lateral.

QUATERNARY EVENTS

The period of general emergence continued into the Quaternary. During the late Pleistocene, all but a few of the highest peaks of the area were buried under ice. In late Pleistocene and continuing into Holocene time, volcanic eruptions on southern Kruzof Island took place from a northeast-trending line of vents. The resulting Mount Edgecumbe volcanic field consists of high-alumina, calc-alkaline flows and pyroclastics, ranging in composition from early olivine-augite basalt to late quartz latite. A prominent ash layer, found as far northeast as Juneau, was erupted from the Mount Edgecumbe field about 9,000 years ago. The volcano appears to have had no activity during the past 200 years of historical records.

Recorded seismic activity has been concentrated along the Fairweather fault to the northwest of the map area. Other faults in the map area appear to be relatively inactive, indicating that the pattern of deformation has changed since late Tertiary time.

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