GEOLOGIC MAP OF WESTERN CHICHAGOF AND YAKOBI ISLANDS, SOUTHEASTERN ALASKA

By

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INTRODUCTION

Western Chichagof and Yakobi Islands are in the Alexander Archipelago of southeastern Alaska. The study area, which is within the Tongass National Forest, was under consideration for wilderness designation at the time of this study. Public Law 96-487 (December 2, 1980) created a wilderness area which includes almost all of the area of this study. The study area is bounded on the northeast by a linear topographic low which includes Hoonah Sound and Lisianski Inlet, and which nearly separates eastern Chichagof Island from western Chichagof Island. The area is bounded on the southeast by Peril Strait, on the northwest by Cross Sound, and on the southwest by the Pacific Ocean. The area is approximately 95 kilometers long by 32 kilometers wide at the widest point.

The sedimentary and metamorphic rocks of western Chichagof and Yakobi Islands can be divided into four roughly linear belts with their long dimensions alined northwest-southeast, and with each belt younger in a progression from northeast to southwest. The oldest rocks in the study area form a discontinuous belt along Hoonah Sound and Lisianski Inlet consisting of Mesozoic and Paleozoic(?) medium- to high-grade metasedimentary, metavolcanic, and sheared intrusive rocks. The next belt of rocks to the southwest is composed of Triassic(?) greenstone and massive marble which have been correlated with rocks of the Wrangellia terrane to the north (Jones and others, 1977). Both of these northeastern belts are extensively disrupted by Jurassic and Cretaceous foliated diorite, quartz diorite, and tonalite.

The two northeastern belts are separated from two belts of younger rocks to the southwest by a major fault which has been correlated with the Border Ranges fault of the Chugach Mountains (Plafker and others, 1976, 1977; Decker and Johnson, 1981). The fault is believed to represent a mid-Cretaceous to early Tertiary accretionary event (MacKevett and Plafker, 1974; Plafker and others, 1976; Decker and Johnson, 1981) which juxtaposed Cretaceous rocks to the west against the Triassic(?) and older terrane to the east.

The Kelp Bay Group (as redefined here) comprises the third belt in the study area. It consists of a tectonic assemblage of a variety of upper Mesozoic metasedimentary and metavolcanic rocks including greenschist, phyllite, greenstone, metatuff, graywacke, argillite, marble, and chert. These units typically occur as highly deformed, generally irregular, fault-bounded blocks.

Southwest of the redefined Kelp Bay Group, the fourth belt consists of Cretaceous sandstone, siltstone, and mudstone turbidite and massive graywacke and conglomerate, which constitute the Sitka Graywacke. Subsequent to the amalgamation of these four belts of rocks, the entire study area has been intruded by Tertiary(?) plutons composed dominantly of nonfoliated tonalite, granodiorite, and granite.

PREVIOUS WORK

The earliest interest in the geology of Yakobi and western Chichagof Islands resulted from the discovery of gold-bearing quartz veins near Klag Bay in 1905. C. W. Wright examined the shoreline of Chichagof Island and reported the gold discovery in 1906. He spent the next season visiting claims which he briefly described in 1907 (Wright and Wright, 1906, p. 45-46; Wright, 1907, p. 59-61). In 1910 Knopf (1912) studied the geology of the mining districts. Overbeck (1919) examined the west coast of Chichagof Island in more detail than previous workers and made several fossil collections. Nickel-copper-cobalt deposits were discovered at Mirror Harbor on the west coast of Chichagof Island in 1911 and at Bohemia Basin on Yakobi Island in 1920. The Yakobi Island deposits were described by Buddington (1925). A major summary of southeastern Alaska geology was published by Buddington and Chapin (1929), which includes summaries of the known mineral deposits.

During the field seasons of 1938 and 1939, Reed and Coats (1941) produced the first detailed map of western Chichagof Island including a 1:62,500-scale map of the Chichagof mining district as well as detailed maps and cross sections of the important prospects. Miscellaneous mineral deposits were investigated by Twenhofel and others (1949). Reed and Dorr (1942) mapped the nickel deposits of Bohemia Basin, and Pecora (1942) studied the nickel deposits at Mirror Harbor. In 1942 and 1943, Kennedy and Walton (1946) continued the investigations of the nickel deposits on Yakobi and Chichagof Islands.

The next detailed map of the study area, produced by Rossman (1959), covered northwestern Chichagof Island and Yakobi Island at a scale of 1:63,360. Loney and others (1963) published a compilation of previous work along with their own mapping on a map which covered the entire area of this study at a scale of 1:250,000. This was later superseded by a major recompilation and additional mapping, which resulted in Loney and others' (1975) map of Chichagof and Baranof Islands at a scale of 1:250,000. Our report relies heavily on the preceding work of Loney and others (1975).

Recent work has resulted in a detailed map of a part of western Chichagof Island by Decker (1980a; 1980b) at a scale of 1:63,360, as well as several short reports concerning the geology of the study area (Decker and others, 1979, 1980; Decker and Johnson, 1981; Zuffa and others, 1980).

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STRATIGRAPHY

Paleozoic(?) rocks

Hornfels, schist, and gneiss.—Metamorphic rocks of this unit east of the Peril Strait fault are dominantly granoblastic, layered, light-gray to light-green, fine-grained hornfels. This unit also includes foliated, layered, medium- to dark-gray, medium- to coarse-grained schist and gneiss, and foliated, dark-gray to black amphibolite. It locally contains white, banded metachert layers and white, garnet-bearing quartzite. Metamorphic grade varies with proximity to intrusive bodies. These rocks are considered by Loney and others (1975) to have been derived from the middle Paleozoic rocks of northeastern Chichagof Island (fig. 1).

Marble.—Blocks and layers of marble east of the Peril Strait fault are generally massive, dark gray to white, fine to medium grained, and gray weathering in layers ranging from less than 1 cm to several meters in thickness. Chert nodules and contorted ribbon chert are abundant at some localities. These rocks are considered by Loney and others (1975) to have been derived from the calcareous middle Paleozoic rocks of northeastern Chichagof Island.

Paleozoic and (or) Mesozoic rocks

Siliceous metasedimentary and metavolcanic rocks.—A heterogeneous unit of metasedimentary and metavolcanic rock of slightly higher metamorphic grade than the overlying Goon Dip Greenstone was recognized by Reed and Coats (1941), by Rossman (1959), and was named the chert, limestone, sandstone, and greenstone unit by Loney and others (1975, p. 15). The metasedimentary rocks are typically thin-bedded, fine-grained to aphanitic, dominantly siliceous rocks, including grayish-green, white-weathering ribbon chert; light-green, tuffaceous, quartzose sandstone; white to buff, rusty-weathering, thinly laminated, felsic metatuff; light-gray, thin-bedded, fine-grained, unfossiliferous limestone; and dark-gray, slatey argillite; all of which are intercalated with well-foliated greenstone and greenschist. Mafic metavolcanic rocks compose approximately 40 percent of the sequence. Complex faulting precludes precise estimations of thickness, but the unit as a whole is probably more than 600 m thick. Near its contact with the Goon Dip Greenstone to the west, this unit is generally intruded by abundant mafic dikes and small microdiorite bodies. To the east it is intruded by tonalite of Cretaceous or Jurassic age and faulted against amphibolite and gneiss.

No ages have been determined for the rocks in this unit. Rossman (1959) considered it to unconformably underlie the Goon Dip Greenstone and favored a pre-Mesozoic age. Loney and others (1975) assigned it an early Mesozoic or Paleozoic age on the basis of the same stratigraphic relationship. Lacking further evidence, we concur with Loney and others (1975). Because the Goon Dip Greenstone has been correlated with the Nikolai Greenstone (Jones and others, 1977), which overlies the Skolai Group of southern Alaska, the rocks of this unit may be equivalent to the Skolai rocks. However, there is very little lithologic correspondence between these two units. The Skolai Group consists of a basal unit of mafic flows and tuffs, a middle unit of dark-colored cherts, black shale, sandstone, and carbonaceous bioclastic limestone, and a thick, upper unit of massive, bioclastic, Permian limestone (Smith and MacKevett, 1970). Thus, this unit is lithologically distinct from the Skolai Group, but apparently occupies a similar stratigraphic position.

Amphibolite, gneiss, schist, and marble.—High-grade metamorphic rocks composed chiefly of amphibolite, gneiss, and schist, locally intercalated with thin units of marble and calc-silicate granofels, are faulted against metasedimentary and metavolcanic rocks to the west, and grade into dioritic rocks to the east. The amphibolite unit was first mapped by Rossman (1959), and extended to include Rossman's marble sequence by Loney and others (1975). The most common lithology in this unit is a quartz-andesine-biotite-hornblende schist, typically containing almandine garnet; with alternating plagioclase-hornblende and quartzofeldspathic layers several centimeters thick. Common accessory minerals include apatite, epidote, pyrite, and sphene. Relatively pure, white marble and calc-silicate granofels occur locally as thin units several meters in thickness, particularly along Peril Strait between Poison Cove and Deep Bay. The calc-silicates are characterized by calcite, plagioclase, diopside, clinozoisite, quartz, grossularite, pyrite, and sphene. Loney and others (1975) considered the metamorphic facies of this unit to be transitional between the hornblende-hornfels and amphibolite facies. It becomes increasingly migmatitic near its contact with large diorite bodies along the eastern edge of the map area. The protolith of this unit, on the basis of bulk composition, was probably mafic volcanic rock and marine sediments.

There are no direct age determinations for this unit. The associated dioritic bodies, which at least locally intrude the gneiss, are considered by Loney and others (1975) to be of probable Cretaceous age on the basis of lithologic correlations with radiometrically dated plutonic rocks to the north and south of the mapped area. We consider these plutonic rocks to be Cretaceous or Jurassic on the basis of similar correlations. Lacking any other age information, we concur with the Mesozoic or Paleozoic age assignment for this unit by Loney and others (1975).

Mesozoic and Paleozoic(?) undivided.—A complex assortment of highly tectonized igneous, metamorphic, and sedimentary rocks are located along the Peril Strait fault zone at the eastern margin of the study area. Protoliths are difficult to recognize, and rocks of different compositions and textures are juxtaposed along faults and shear zones. Textures range from massive to foliated, undisturbed to brecciated or mylonitic. Recognizable lithologies include (in decreasing order of abundance) interlayered mafic metavolcanic and siliceous to calcareous metasedimentary rock, granodiorite, amphibolite, greenstone, amphibole gneiss, greenschist, marble, metagraywacke turbidite, Inoceramus-bearing calcareous argillite, and serpentinized gabbro. These rocks may or may not have originally been related to one another. They are commonly found on the islands in Hoonah Sound, or as blocks tens of meters in dimension along the shores of Hoonah Sound and Peril Strait.

Inoceramus prisms and belemnites have been found in calcareous argillite on Emmons Island, yielding late Valanginian-early Hauterivian age (Plafker and others, 1976, p. 15; locality a on map). This rock is overlain by greenstone pillow breccia, which lies against migmatite and sheared diorite. These rocks are of uncertain affinity, but were considered to be part of the Sitka Graywacke by Loney and others (1963, 1975). However, the rocks on Emmons Island are far removed from any other rocks in the Sitka Graywacke, and are distinctly different lithologically.

There are no other age determinations pieces for this unit, but the wide variety of lithologies and structural complexity suggest to us that some of the faulted blocks may be similar to Paleozoic rocks on eastern Chichagof Island. We therefore assign this unit a Mesozoic and Paleozoic(?) age.

Triassic(?) rocks

Goon Dip Greenstone.—The name Goon Dip Greenstone was proposed by Loney and others (1963) for a sequence of dominantly massive greenstone with minor greenschist and marble. This unit is equivalent to the "greenstone schist" and "greenstone" units of Reed and Coats (1941) and the "greenstone" unit of Rossman (1959). The greenstone is dark grayish green, dense, fine grained, commonly amygdaloidal, and occasionally porphyritic or holocrystalline. The greenstone consists of flows, sills, and flow breccias with thicknesses of 1 to 5 m. Locally, red oxidized flow tops and pipe amygdules suggest a subaerial origin for at least some of the flows. Relict labradorite laths and augite crystals support an original basaltic composition, although most of the greenstone has been recrystallized to epidote, actinolite, chlorite, albite, prehnite, calcite, pyrite, and sphene. Foliated greenstone is composed dominantly of epidote, chlorite, and albite. Relict amygdules are filled with quartz and epidote, accompanied by chlorite or prehnite. The greenstone also commonly contains sparsely distributed copper-bearing sulfides.

No fossils have been reported from the Goon Dip Greenstone. Loney and others (1975) considered this unit to be Triassic(?) on the basis of its conformity with the overlying Triassic(?) Whitestripe Marble. Plafker and others (1976) and Jones and others (1977) correlated the Goon Dip Greenstone with the Nikolai Greenstone of the Wrangell Mountains in southern Alaska based on similar lithology and stratigraphic position relative to the overlying Whitestripe Marble which they correlated with the Upper Triassic Chitistone Limestone also of the Wrangell Mountains. The Goon Dip Greenstone is considered to be a part of Wrangellia by Jones and others (1977).

Whitestripe Marble.—The name Whitestripe Marble was proposed by Loney and others (1963) for a long, narrow belt of unfossiliferous, massive- to thick-bedded, white- to light-gray, fine-grained marble, which is well exposed on Whitestripe Mountain, the type locality. The marble is composed of nearly pure calcite, but locally contains accessory chlorite, sericite, graphite, quartz, albite, and pyrite. The calcite is a product of inhomogeneous and irregular neomorphic recrystallization similar to the crystallization characteristics of the Chitistone Limestone as described by Armstrong and Mackevett (1977). The marble is locally stylolitic, and Reed and Coats (1941) also reported local occurrences of cream-colored dolomite. The unit varies from less than 30 m to a maximum of about 500 m in thickness, with an average thickness of about 100 m.

Loney and others (1963, 1975) assigned a Triassic(?) age to the Whitestripe Marble on the basis of a coralline fossil of possible Triassic age found in a boulder in the Goon Dip River (Reed and Coats, 1941). No recognizable fossils have been found in place within the marble. The marble appears to lie conformably above the Goon Dip Greenstone, although locally the contact is a steep fault. The marble is intruded by numerous mafic dikes and sills; the largest of which are shown on the map as Cretaceous(?) diorite. One diorite body follows the western contact of the Whitestripe Marble for many kilometers. The western contact is interpreted to be the location of the Border Ranges fault (Plafker and others, 1976; Decker and Johnson, 1981). Plafker and others (1976) and Jones and others (1977) correlate the Whitestripe Marble with the Chitistone Limestone in the Wrangell Mountains. The marble is considered to be a part of Wrangellia along with the Goon Dip Greenstone by Jones and others (1977).

Kelp Bay Group

The Kelp Bay Group is a complicated, heterogeneous assemblage of various fault-bounded metavolcanic and metasedimentary rocks exposed on northern Baranof, western Chichagof, and Yakobi Islands. The unit was first named the Kelp Bay Group by Berg and Hinckley in 1963, who did not divide it into named formations (fig. 1). It was extended to other areas and divided into four formations by Loney and others (1963) and subsequently redefined by Loney and others (1975) to include a new unit at the base. Decker (1980b) proposed a further redefinition of the Kelp Bay Group, and a modification of this suggested redefinition is adopted here.

As a result of its complexity, the Kelp Bay Group has been a continuing subject of controversy. The name Kelp Bay Group was proposed by Berg and Hinckley (1963) for rocks typically exposed at Kelp Bay on northern Baranof Island. These rocks consisted of "fissile quartzose greenschist and phyllite; graywacke, slate, and sheared conglomerate; calcareous and quartzose slate that contains scattered lenses of metachert and volcanic rock; and granular appearing, moderately platey siliceous greenschist that commonly contains layers and lenses of jasper or is interbedded with slate or argillite" (Berg and Hinckley, 1963, p. 10). Loney and others (1963) extended the Kelp Bay Group to include similar rocks on Chichagof Island. Further mapping led Loney and others (1975) to expand the Kelp Bay Group on Chichagof Island to include the unit they mapped as Kelp Bay Group in 1963 (which was renamed the Khaz Formation), plus the Waterfall Greenstone, the Pinnacle Peak Phyllite, the Whitestripe Marble, and the Goon Dip Greenstone.

Later workers have recognized a major structural break which divides the Kelp Bay Group into two distinct sequences of rock on Chichagof Island. Plafker and others (1976, 1977) traced this major structural break, the Border Ranges fault, from the Chugach Mountains, through the St. Elias Mountains, Chichagof Island, and Baranof Island to Chatham Strait. The location of the Border Ranges fault on western Chichagof Island, where it separates the Whitestripe Marble and Goon Dip Greenstone from the rest of the Kelp Bay Group, has been confirmed by recent mapping (Decker, 1980a; Decker and Johnson, 1981; this study). The Border Ranges fault was interpreted by Plafker and others (1976) to represent a late Mesozoic or early Tertiary plate boundary juxtaposing outboard upper Mesozoic deep marine rocks against inboard upper Paleozoic and lower Mesozoic rocks. As noted earlier, Jones and others (1977) correlated the Whitestripe Marble and Goon Dip Greenstone with the Triassic Chitistone Limestone and Nikolai Greenstone in the Wrangell Mountains on the basis of similar lithology and structural position and included the Whitestripe Marble and Goon Dip Greenstone in the terrane named "Wrangellia." Plafker and others (1977) included the remainder of the Kelp Bay Group in an upper Mesozoic accretionary terrane, which they traced around the Gulf of Alaska margin immediately outboard of the Border Ranges fault system. Radiolarian age determinations within this accretionary terrane are consistently Late Jurassic to Early Cretaceous (Plafker and others, 1976, 1977; Karl and others, 1979; George Plafker, oral commun., 1979; D. L. Jones, oral commun., 1980). This accretionary terrane had first been referred to as the Chugach terrane (Berg and others, 1972, 1978).

The Wrangellia part of the Kelp Bay Group of Loney and others (1975) (Whitestripe Marble and Goon Dip Greenstone) and the accretionary or Chugach part (the Pinnacle Peak Phyllite, the Waterfall Greenstone, the Khaz Formation, and some unnamed rocks) have undergone significantly different geologic histories as suggested by the following evidence:

1. They have distinctly different ages. The Wrangellia component of the Kelp Bay Group is Triassic(?) in age, and the Chugach component is Cretaceous in age.

2. They are compositionally distinct. The Wrangellia component consists of thick sequences of greenstone and marble. The Chugach component is a mixture of blocks of massive, pillowed, and brecciated greenstone, metatuff, argillite, graywacke, chert, limestone, greenschist, and melange.

3. They are structurally distinct. The Wrangellia component consists of long, narrow, lithologically continuous rock units. The Chugach component consists of a collage of kilometer-scale, fault-bounded blocks of lithologically heterogeneous and structurally complex rocks.

4. They are metamorphically and texturally different. The Wrangellia component consists of massive, nonfoliated rocks of low metamorphic grade. The Chugach component includes well-foliated rocks ranging up to greenschist facies metamorphism, with local occurrences of sodic amphibole.

5. They are separated by a major fault. The considerable differences in metamorphic grade, textural characteristics, and structural complexity suggest significant relative displacement between the Wrangellia and Chugach rocks.

6. No rocks similar to the Goon Dip Greenstone or Whitestripe Marble have been recognized at the type locality of the Kelp Bay Group at Kelp Bay on Baranof Island.

Because the rocks on either side of the Border Ranges fault on Chichagof Island are of different original ages, have had different subsequent geologic histories, and because the type locality of the Kelp Bay Group does not include the Whitestripe Marble and Goon Dip Greenstone, the Kelp Bay Group is here revised to exclude the Goon Dip Greenstone and Whitestripe Marble, and to include the Pinnacle Peak Phyllite, the Waterfall Greenstone, the Khaz Formation, the Freeburn assemblage (new informal name, see below), and related rocks recognized to be elements of the melange facies of the Chugach terrane on Chichagof, Baranof, Kruzof, and Yakobi Islands. As such, the Kelp Bay Group is restricted to rocks representing the melange facies of the Chugach terrane in this area. The Goon Dip Greenstone and Whitestripe Marble are retained as independent formations. These two units represent Wrangellia on Chichagof Island.

Current age information for the units within the Kelp Bay Group comes entirely from fault-bounded blocks. As described in more detail below, fossils of Early Cretaceous age occur in the Waterfall Greenstone, and fossils of Triassic or Jurassic age, Late Jurassic age, and Early Cretaceous age occur in blocks in the Khaz Formation. Ages of metamorphic minerals in blocks in the Freeburn assemblage are mid-Cretaceous. No age information is available for the matrix of the Khaz, and there is no matrix for the blocks in the Freeburn assemblage. However, radiolarian cherts intercalated with greenstone in depositional relationships date volcanism in the Waterfall Greenstone as Early Cretaceous. Aquagene tuff, finely interlaminated with argillite in the matrix of the Khaz Formation and also occurring locally in the Waterfall Greenstone, suggest a contemporaneous relationship between volcanism and the deposition of the melange matrix. The matrix of the melange must be the same age or younger than the youngest block within it, which is Early Cretaceous in age. Metamorphic minerals provide a minimum age for the Kelp Bay Group. Therefore, we assign a Cretaceous and Cretaceous(?) age to the Kelp Bay Group.

Khaz Formation.—The Khaz Formation (Loney and others, 1975) is a melange that includes chaotically deformed rocks composed of blocks of greenstone, greenschist, tuff, graywacke, argillite, chert, limestone, and phyllite in a foliated argillaceous and tuffaceous matrix.

The Khaz Formation is characterized by a blocks and matrix fabric without consistent internal stratigraphy. The deformational styles of the blocks and of the matrix are the result of a continuum of soft, prelithification deformation, to brittle, post-lithification deformation. Relationships are now sufficiently obscured by overprinting and differing competencies of the lithologies involved, that initial deformational phases are impossible to isolate except on a small, local scale. The components of the melange include blocks of differing composition, texture, and metamorphic grade, and several types of matrix, which were first recognized by Decker (1980a, 1980b). Matrix types include in order of decreasing abundance: (1) dominantly streaky, green and dark-gray, tuffaceous or arenaceous argillite; (2) dominantly medium- to coarse-grained, internally chaotic graywacke; and (3) dominantly massive to foliated metatuff, tuff breccia, and pillow breccia intercalated with minor amounts of dark-gray, argillaceous metasedimentary rock. The different types of matrix are commonly intimately intermixed, but locally one type may dominate.

Blocks within the matrix of the Khaz Formation closely resemble rocks in other units of the Kelp Bay Group. The Khaz is distinguished from the rest of the Kelp Bay Group by the presence of a matrix and the distinctly chaotic style of deformation. Based on lithologic affinities and structural relationships, we consider the Khaz to be an integral part of the accretionary complex represented by the Kelp Bay Group.

The Khaz forms a belt which separates the rest of the Kelp Bay Group, which is a collage of fault-bounded blocks (the Freeburn assemblage), from the Sitka Graywacke, which is a "broken formation" (Decker and others, 1979) of disrupted graywacke turbidites. Poorly controlled fossil ages and petrologic similarities between the sandstone in the Sitka Graywacke and the Khaz Formation (Decker, 1980b) suggest that these two units may be depositionally related to one another. However, the differing degrees of compositional and tectonic complexity between these two units indicates that they may have sustained different deformational histories since deposition.

No fossils have been reported from the matrix of the Khaz Formation. Fossils found in blocks within the melange include a possibly Triassic or Jurassic scleractinian coral (Loney and others, 1975) and several species of Buchia: Buchia piochii(?) of Tithonian age (Loney and others, 1975), Buchia c.f. B. fischeriana of Tithonian Age (Decker, 1980b), Buchia subokensis of Berriasian Age (Loney and others, 1975), and Buchia okensis of Berriasian Age (Decker, 1980b). The Buchia localities are along the southwest shore of Slocum Arm (localities b and c on map). The youngest fossils found in blocks within the melange provide a maximum Berriasian Age of formation of the melange. Lacking other age information, we therefore assign the Khaz a Cretaceous age.

The Khaz Formation correlates with other components of the melange facies of the upper Mesozoic accretionary terrane of Plafker and others (1977), including parts of the Uyak Complex on Kodiak Island (Connelly, 1978) and the McHugh Complex of the Chugach Mountains (Karl and others, 1979).

Freeburn assemblage.—The informal name Freeburn assemblage is here proposed for a collage[1/] composed of kilometer-scale, fault-bounded, lozenge-shaped blocks of metasedimentary and metavolcanic rocks which form a continuous belt on Chichagof and Yakobi Islands immediately west of the Border Ranges fault. The western margin of the assemblage is its contact with the Khaz Formation. Portions of this unit have previously been mapped as unnamed schist units (Reed and Coats, 1941; Rossman, 1959; Loney and others, 1975), and as Waterfall Greenstone (Loney and others, 1963, 1975), and Pinnacle Peak Phyllite (Loney and others, 1963, 1975). The names Waterfall Greenstone and Pinnacle Peak Phyllite are retained for previously designated formations within the Freeburn assemblage.

The Freeburn assemblage includes rocks which appear to be compositionally, texturally, and structurally related. Although metamorphic grade tends to increase from west to east, similar sedimentary and volcanic protoliths can be recognized throughout the unit. Locally, lower textural-grade blocks are structurally inserted between higher grade blocks. The structural grain of the complex is dominantly northwest-southeast, with mappable lithologic and textural subunits conforming in shape to this pattern. The overall configuration of the subunits is that of a collage (Decker, 1980b), which is an assemblage of related, fault-bounded, elongate blocks which have moved relative to one another such that sharp breaks in lithologic ratios, metamorphic grade, and fabric orientation occur at the block boundaries. Although the ratios of various lithologies are highly variable from block to block, the same lithologies occur in nearly all blocks. The dominant lithologies include tuffaceous argillite, tuff, massive greenstone, and graywacke turbidite. Other common lithologies include chert, limestone, phyllite and schist. Various types of melange, such as those described as being within the Khaz Formation also occur locally within blocks in the collage.

Metamorphic grade varies from block to block within the collage but is generally consistent within an individual block. Lowest grade blocks include prehnite-pumpellyite facies argillite, metatuff, greenstone, and graywacke in which sedimentary features are typically preserved. Higher grade blocks include foliated to phyllitic gray metasedimentary rocks and green metavolcanic rocks which contain local, discontinuous segregation layers typically

[1/] A package of rocks consisting of blocks juxtaposed by faults and lacking a matrix (Decker, 1980b).

composed of quartz or quartz and sericite. Highest grade blocks include greenschist facies metasedimentary and metavolcanic rocks which are commonly foliated, crenulated, and contain millimeter-scale segregation layering.

Mineral assemblages are a function of protolith and metamorphic grade. The highest grade metavolcanic rocks are characterized by epidote, clinozoisite, tremolite, actinolite, chlorite, albite, quartz, and rarely sodic amphibole (crossite?), biotite, or fuchsite. Highest grade metasedimentary rocks are characterized by quartz, albite, chlorite, muscovite, and graphite, commonly accompanied by pyrite or pale-pink garnet. Lowest grade metavolcanic rocks are characterized by calcic plagioclase, augite, chlorite, and magnetite, typically in various stages of replacement by epidote, chlorite, albite, calcite, and prehnite. Lowest grade metasedimentary rocks are characterized by grains of plagioclase, quartz, volcanic rock fragments, and chert, in a matrix composed of chlorite, clay minerals, calcite, epidote, prehnite, and white mica.

The Freeburn assemblage is proposed as a new informal rock unit for the following reasons: (1) the unit consists of a mix of compositionally diverse rocks which are mappable at a large scale as a consequence of the unit's pervasive disruption; (2) the unit may be characterized by this pervasive and distinctive compositional and structural complexity; (3) all of the component lithologies in this unit, which are compositionally and depositionally related, recur in various combinations throughout its extent, though individual lithologies are not mappable at a reconnaissance scale; and (4) the various lithologies are incorporated together into a collage belt, which is structurally distinct from the melange unit to the west and the massive greenstone and marble units to the east.

The Freeburn assemblage, which includes two formations as well as several informal rock units, constitutes an informal subgroup within the Kelp Bay Group. This unit does not bear any discernible stratigraphic relationship to the other rock units it is associated with in the study area.

The name, Freeburn assemblage, is chosen for typical exposures of this unit on Freeburn Mountain, on western Chichagof Island. The unit is particularly well exposed from its contact with the Whitestripe Marble on the east side of Freeburn Mountain, to Rust Lake, and from Rust Lake along Rust Creek to, and including, the east end of Sister Lake.

The age of the Freeburn assemblage can be bracketed with uncertainty by paleontologic and metamorphic-mineral isotopic-age determinations. The only fossils known from this unit are Lower Cretaceous Radiolaria from the Waterfall Greenstone (see below), which provide a maximum age for the formation of the Freeburn assemblage. Potassium-argon dating of actinolite and sericite concentrations from interlayered phyllitic metasedimentary and metavolcanic rocks near Pinta Bay yielded ages of 91-106 m.y. (Decker and others, 1980). If these minerals are syntectonic or post tectonic (Decker, 1980b), the dates represent a minimum age for the Freeburn assemblage. If, however, the metamorphism represented by these minerals was pre tectonic, then the minimum age of the unit is unknown. In recognition of this uncertainty, we assign the Freeburn assemblage a Cretaceous and Cretaceous(?) age.

The Freeburn assemblage, as a structurally disrupted component of the Kelp Bay Group, is correlated with other elements of the melange facies of the Chugach terrane.

Waterfall Greenstone.—The name Waterfall Greenstone was proposed by Loney and others (1963) for rocks which crop out on the ridge immediately east and north of Waterfall Lake, the type locality. The unit was reported to be dominantly greenstone with lesser amounts of graywacke, greenschist, radiolarian chert, and marble (Loney and others, 1963, 1975).

The greenstone is chiefly light green to gray green, red weathering, massive to banded, locally foliated, and locally tuffaceous. Local relict textures are indicative of massive flows, flow breccia, pillow breccia, and tuff. Protoliths of the greenstone are subalkaline and tholeiitic basalts, based on major, minor, and trace-element analyses reported by Decker (1980b). These analyses plot consistently in the ocean-floor basalt fields of the basalt discrimination diagrams of Pearce and Cann (1973), Pearce and others (1975), and Garcia (1978) as shown by Decker (1980b). Greenstone typically contains intercalated lenses of white-weathering, red, green and gray radiolarian chert; orange-weathering, green, volcaniclastic graywacke; minor gray to tan limestone; and dark-gray tuffaceous argillite. Chert occurs as tightly folded blocks of ribbon chert with chloritic or graphitic partings, and as streaky lenses and pods within the greenstone. Graywacke is locally interlayered with greenstone. Limestone and argillite generally occur as meter-scale lenses.

The Waterfall Greenstone is generally recrystallized to epidote, chlorite, albite, calcite, and prehnite with occasional relict plagioclase and augite phenocrysts. The clasts in fine- to medium-grained graywacke include plagioclase, quartz, volcanic rock fragments, and chert in a recrystallized matrix composed of chlorite, epidote, prehnite, and clay minerals. Since the Waterfall Greenstone is fault bounded and lithologically and texturally similar to other components of the Freeburn assemblage, we consider it to be an integral part of the assemblage.

Loney and others (1963, 1975) assigned a Triassic(?) age to the Waterfall Greenstone on the basis of its association with the Whitestripe Marble, which they considered to be Triassic(?). Radiolarian collections from lenses of chert in greenstone have yielded diagnostic Radiolaria of Early Cretaceous age (Charles Blome, oral commun., 1980; locality d on map) including Parvicingula boesi (Parona), of middle Tithonian to late Valanginian age (Pessagno, 1977); Thanarla sp. c.f. T. conica (Aliev), of Early Cretaceous age (Pessagno, 1977); and Archiodictyomitra apiarium (Rust), of Berriasian to late Valanginian age (Pessagno, 1977). The Waterfall Greenstone is, therefore, here assigned an Early Cretaceous age.

Chert in the Waterfall Greenstone is coeval with chert collected from greenstone in the McHugh Complex (Karl and others, 1979), which is also considered to be a component of the melange facies of the Cretaceous accretionary terrane of Plafker and others (1977).

Pinnacle Peak Phyllite.—The name Pinnacle Peak Phyllite was proposed by Loney and others (1963) for a thinly laminated, siliceous phyllite unit which is well exposed on Pinnacle Peak. Loney and others (1975) correlate the Pinnacle Peak Phyllite with the basal part of the "schist" unit of Reed and Coats (1941) and Rossman (1959). This unit includes a significant amount of chloritic and graphitic schist, as well as graywacke semischist, phyllite, and nonfoliated metagraywacke turbidite. Similar rocks occur throughout the Freeburn assemblage as individual collage units and also in the Khaz Formation as discrete blocks in an argillaceous matrix. The Pinnacle Peak Phyllite itself consists of numerous blocks of consistently higher metamorphic grade than the remainder of the Freeburn assemblage, forming a long narrow band immediately west of the Border Ranges fault. This unit includes the highest metamorphic grade rocks in the Kelp Bay Group. The Pinnacle Peak Phyllite is fault-bounded and lithologically and texturally similar to other components of the Freeburn assemblage; we therefore consider it to be an integral part of the assemblage.

Graphitic and chloritic schist in the Pinnacle Peak Phyllite are often intimately associated and typically alternate on about a meter scale. Occasionally, original sedimentary textures, as well as relict melange textures can be recognized through the metamorphic fabric. Locally, relatively competent blocks of metasandstone, metachert, and greenstone can be identified within the schist.

Siliceous graphitic schist is more common than chloritic schist, and is characterized by quartz, sericite, and albite in layers up to a centimeter thick but averaging less than 2 mm thick, with partings rich in muscovite, chlorite, and graphite. Garnet, pyrite, and calcite are common accessory minerals. Green chloritic schist is characterized by epidote, clinozoisite, chlorite, actinolite, tremolite, albite, and quartz. Calcite and, rarely, muscovite may be present.

Phyllite is generally dark gray, siliceous, and foliated with a well developed phyllitic sheen on foliation surfaces. Metamorphic minerals are extremely fine grained, and discontinuous siliceous segregation layering occurs locally. The phyllite is composed principally of quartz and feldspar with graphitic coatings; where segregation layers occur, they consist of quartz and albite. Grains of chlorite, actinolite, muscovite, epidote, and pyrite occur locally in the phyllite. Metagraywacke turbidite consists of quartz, sedimentary and volcanic rock fragments, albite, epidote, chlorite, tremolite, garnet, calcite, biotite, magnetite, and local veining and replacement by prehnite. Quartz segregation layers as much as a few millimeters thick have developed parallel to sedimentary layering in metasandstone layers. Locally, these segregation layers follow sedimentary convolute layering within the turbidite beds. Schists and phyllites are commonly highly crenulated and lineated.

No fossils have been reported from the Pinnacle Peak Phyllite. Loney and others (1963, 1975) assigned a Triassic(?) age to the unit because they believed it conformably overlay the Triassic(?) Whitestripe Marble. However, the Border Ranges fault is now known to separate these two units. The Pinnacle Peak Phyllite is lithologically, texturally, and structurally similar to the rest of the Kelp Bay Group as revised in this report. Since there is no evidence that the Pinnacle Peak Phyllite is of different age than the rest of the Kelp Bay Group, we assign it a Cretaceous(?) age.

Sitka Graywacke

The Sitka Graywacke was named for exposures near Sitka on the west coast of Baranof Island (Berg and Hinckley, 1963, p. 12). The original name proposed was the Sitka Group; however, since the unit was never subdivided, the Sitka was reduced in stratigraphic rank and renamed Sitka Graywacke (Loney and others, 1963, p. 5). The unit forms a discontinuous belt of interstratified metagraywacke and argillite along the west coast of Yakobi, Chichagof, and Baranof Islands and includes large portions of Krestof, Partofshikof, Kruzof, and many other smaller islands.

Berg and Hinckley (1963) noted that the principal rock type in this unit on northern Baranof Island is thin- to medium-bedded graywacke and argillite, and that massive graywacke, conglomerate, and breccia are widespread, but less abundant. Decker and others (1979) analyzed the Sitka Graywacke in terms of Mutti and Ricci-Lucchi (1972) turbidite facies concepts on Chichagof and northern Baranof Islands, and interpreted it to consist of dominantly middle-fan facies association turbidites with local slope facies and inner-fan facies association turbidites.

On western Chichagof and Yakobi Islands, the Sitka Graywacke is a "broken formation" which consists dominantly of sandstone and siltstone turbidite intercalated with shaley mudstone and rarely conglomerate or basalt. Turbidite facies (Mutti and Ricci-Lucchi, 1972) represented are typically C, D, and E, with A, B, F, and G occurring locally. Zuffa and others (1980) have interpreted these rocks as a trench-fill deposit of dominantly volcanic derivation. The thickness of the Sitka Graywacke is unknown due to pervasive chaotic disruption accompanied by an indeterminant amount of repetition of section by internal faulting. Stratigraphic facings, where determinable, are dominantly toward the northeast, with the layering overturned and dipping steeply to the southwest.

The Sitka Graywacke on Chichagof Island is regionally metamorphosed to prehnite-pumpellyite facies with prehnite typically occurring in veinlets or clots. In the vicinity of Tertiary(?) plutons, the Sitka Graywacke has been thermally metamorphosed to at least hornblende hornfels facies. Metamorphic minerals include biotite, garnet, and andalusite. On western Yakobi Island, banded quartzo-feldspathic gneiss and migmatite occur at the contacts with Tertiary(?) tonalite and gabbronorite plutons.

The age of the Sitka Graywacke was thought to be Late Jurassic to Early Cretaceous (Berg and Hinckley, 1963; Loney and others, 1963; Loney and others, 1975), as determined from fossils reported to have come from graywacke on Kruzof Island (Reed and Coats, 1941), and collected on Chichagof Island by Overbeck (1919) and by Loney and others (1975). The Kruzof Island(?) collection included Terebellina palachei and Aucella crassicollis, indicating an Early Cretaceous age (Reed and Coats, 1941, p. 50). Several species of Buchia, with ages ranging from Late

Jurassic to Early Cretaceous were collected from rocks in Slocum Arm on Chichagof Island by Overbeck (1919, p. 108), Loney and others (1975, p. 25), and Decker (1980b). In addition, Inoceramus prisms of Cretaceous or Jurassic age (Loney and others, 1975, p. 5) were found in argillite on Emmons Island. Material from the same locality was reported to be late Valanginian-early Hauterivian by Plafker and others (1976). Recent mapping has placed the fossiliferous rocks in Slocum Arm within the Kelp Bay Group (Decker, 1980a; this report) and the fossiliferous rocks on Emmons Island within an informal Paleozoic(?) and Mesozoic undivided unit of highly tectonized rocks (this report). Therefore, the only fossils presently believed to be from the Sitka Graywacke are those of Early Cretaceous age reported to have come from Kruzof Island. The only other age control on the Sitka Graywacke is the intrusion of Eocene granodiorite (Loney and others, 1975) on Baranof Island. We therefore assign a Cretaceous age to the Sitka Graywacke.

The Sitka Graywacke is considered to be correlative with rocks of the Valdez Group by Plafker and Campbell (1979) and Brew and Morrell (1979) based on continuity of exposure from Baranof and Chichagof Islands to the Chugach Mountains.

Quaternary rocks

Unconsolidated sediments of Quaternary age occur in lowlands throughout the study area. Included in this unit are alluvium, colluvium, and glacial till and outwash. Contacts of this unit are based on aerial photograph interpretation with limited field checking.

Intrusive igneous rocks

The plutonic rocks of western Chichagof and Yakobi Islands occur in two, northwest-trending, overlapping belts: one of Mesozoic age, and one of Cenozoic age. The portion of the study area east of the Border Ranges fault is dominated by a belt of upper Mesozoic, foliated diorite, quartz diorite, and tonalite. The foliation is generally alined northwest-southeast. Individual plutons were assigned either Cretaceous or Jurassic ages by Loney and others (1975) on the basis of similarity to isotopically dated Cretaceous and Jurassic plutons on northeastern Chichagof and Baranof Islands. Because lithological similarities are not sufficient to confidently predict whether a particular pluton is Cretaceous or Jurassic in age, we have assigned "Cretaceous or Jurassic" ages to the entire group with the exception of two Jurassic plutons which have been dated isotopically.

Generally to the west of, but partially overlapping, the belt of upper Mesozoic plutons is a more scattered belt of Tertiary(?) plutons. These intrusives are dominantly equidimensional stocks composed of nonfoliated tonalite and quartz diorite, containing lesser amounts of granite, granodiorite, diorite, and gabbronorite. The Tertiary(?) age was assigned by Loney and others (1975) on the basis of similarity to other isotopically dated plutonic rocks which crosscut Cretaceous plutons on Baranof Island. Local field relations indicate some of these plutons intrude the Cretaceous Sitka Graywacke.

Plutonic rock names used throughout these descriptions are based on the classification scheme of Streckeisen (1973).

Jurassic plutons

Tonalite.—A light- to medium-gray (C. I. color index approx. 20), coarse-grained, locally porphyritic, foliated, biotite + hornblende tonalite which is generally hypidiomorphic, seriate, well foliated, and crops out at the southern end of the study area on Peril Strait. Biotite is commonly more abundant than hornblende. This unit contains elongate, fine-grained, mafic inclusions and occasional quartz veins, particularly near the border zones. A sample of the tonalite (locality 1 on map) has been dated at 152±4 m.y. on biotite and 151±5 m.y. on hornblende by the potassium-argon method (Loney, Brew, and Lanphere, 1967).

Quartz diorite.—This unit consists of a poorly exposed, medium-gray (C. I. 30-35), medium- to coarse-grained, hornblende + biotite quartz diorite which crops out south of Ushk Bay. It contains 1-2 percent magnetite, and hornblende is always more abundant than biotite. The quartz diorite is principally hypidiomorphic, equigranular to seriate, and weakly foliated. Elongate to nebulitic mafic inclusions are common near contacts. A hornblende separate of a sample of quartz diorite (locality 2 on map) has been dated at 164±5 m.y. by the potassium-argon method (Loney, Brew, and Lanphere, 1967).

Cretaceous or Jurassic plutons

Granodiorite.—A very poorly exposed, light- to medium-gray (C. I. 10-20), medium-grained, hornblende + biotite granodiorite, which contains zones of biotite granite, crops out south of Patterson Bay. Hornblende and biotite are generally approximately equal. This rock is generally hypidiomorphic, equigranular, and weakly foliated with local zones of fracturing and shearing. It commonly contains scattered rounded, fine-grained, mafic inclusions.

Tonalite.—White- to medium-gray (C. I. 2-35), medium- to coarse-grained, biotite + hornblende tonalite and biotite ± muscovite ± garnet tonalite which contain a wide range of quartz to plagioclase ratios (approx. 1:4 to 1:1), and crop out along the Peril Strait fault and south of Patterson Bay. Plagioclase-rich samples tend to contain hornblende and have a higher color index; quartz-rich samples tend to be hornblende-free and leucocratic. This rock is principally allotriomorphic, equigranular, and generally weakly foliated away from major faults. In the vicinity of Peril Strait fault, it is generally seriate with common shear foliation and locally extensive cataclasis. The tonalite contains local zones of fine-grained, rounded, mafic inclusions, and occasional, pink pegmatitic dikes.

Quartz diorite and tonalite.—This unit is dominantly medium- to dark-gray (C. I. 20-55), medium-grained, foliated, hornblende + biotite quartz diorite and biotite + hornblende tonalite, which crop out in several bands from Lisianski Strait to Patterson Bay. It commonly contains as much as 2 percent magnetite. Hornblende tends to be most abundant in quartz diorites; biotite most abundant in tonalites. The rock is variably hypidiomorphic to allotriomorphic, equigranular to seriate, and weakly to strongly foliated. Gneissic banding and nebulitic to agmatitic migmatites are common. The gneissic features, elongate mafic inclusions, and color index, all increase near the amphibolite, gneiss, schist, and marble map unit. Quartz veins and pods and aplite dikes are found locally. Large areas with abundant inclusions and septa of metamorphic rocks are shown by a stipple pattern on the map.

Quartz diorite.—A medium- to dark-gray-green (C. I. 25-50), medium- to coarse-grained, foliated, hornblende ± biotite quartz diorite, in which hornblende is always more abundant than biotite, crops out along the west side of Lisianski Inlet and Hoonah Sound. One to 2 percent magnetite is common in these rocks, some samples contain as much as 5 percent. Pyroxene-cored hornblende crystals are common locally. The rock is principally hypidiomorphic, equigranular, and poorly to well foliated; however, in the vicinity of major faults it becomes allotrimorphic, seriate, and cataclastic. On Yakobi Island, this unit is typically extensively sheared, altered, and light to dark green. Angular to rounded, elongate, fine-grained, mafic inclusions are common, and minor nebulitic to banded gneiss zones are found locally, as are occasional quartz veins and pods, aplite veins, and leucocratic granitic veins.

Biotite-bearing diorite.—A poorly exposed, medium-gray (C. I. approx. 40), medium-grained, hornblende + biotite diorite crops out northwest of Patterson Bay. In this unit, hornblende is more abundant than biotite, although biotite is present in all samples. The rocks are generally hypidiomorphic, equigranular to seriate, and very weakly foliated. This unit locally contains numerous, small, rounded mafic inclusions.

Diorite.—This unit is dominantly a medium- to dark-gray-green (C. I. 35-50), medium- to coarse-grained, foliated, hornblende diorite with minor clinopyroxene gabbro. It crops out in various bodies in the northeastern portion of the study area and contains as much as 3 percent magnetite. The rocks are principally allotriomorphic and seriate, although they are locally hypidiomorphic and equigranular. The diorite is typically extensively altered so that only relicts of the primary minerals are identifiable. The unit is pervasively sheared, locally to cataclasite, and generally well foliated. Local zones of banded to nebulitic gneiss and rounded, elongate, mafic inclusions are common. Aplite dikes and leucocratic granitic veins are found locally. Areas with abundant inclusions and septa of metamorphic rock are shown by a stipple pattern on the map.

Gabbro.—This unit is composed of medium- to dark-gray (C. I. 30-40), medium- to coarse-grained, gneissic, pyroxene + hornblende gabbro and leucogabbro with local foliated hornblende ± biotite diorite. Gabbro crops out east of the Peril Strait fault and commonly contains 2-4 percent magnetite. These rocks are principally hypidiomorphic, equigranular, with weak- to well-developed foliation. Banded to migmatitic gneiss is common.

Quartz gabbro and gabbro.—Medium- to dark-gray (C. I. 25-35), medium-grained, pyroxene + hornblende ± biotite quartz gabbro and gabbro crops out west of Ushk Bay. These rocks contain as much as 2 percent magnetite and are principally hypidiomorphic, equigranular, and weakly foliated. Locally banded, granitic veins are common.

Cretaceous(?) plutons

Diorite.—An extensively altered and sheared, green to gray-green (C. I. 15-25), medium-grained, hornblende ± biotite diorite with minor quartz diorite forms extensive sills and dikes within the Whitestripe Marble and along the contacts of the Whitestripe Marble and Goon Dip Greenstone with the Kelp Bay Group. Mafic minerals are generally altered to chlorite + epidote ± clinozoisite, which gives the rocks a green color. These rocks are generally foliated with locally extensive shearing and cataclasis. The diorite was assigned a Cretaceous age by Loney and others (1975) on the basis of similarity to other Cretaceous plutons. Since there are no units which crosscut the diorite, a minimum age is not established.

Similar sheared dioritic rock intrudes marble and greenstone and also occurs as large blocks in the melange facies of the Yakutat Group, which is thought to be correlative with the Kelp Bay Group (Plafker and others, 1976, 1977). The dioritic rocks of the Yakutat Group have yielded Early to Middle Jurassic radiometric ages (George Plafker, oral commun., 1980), including an age of 160±3.5 m.y. for a tectonically emplaced biotite hornblende tonalite body at Marble Point in Russell Fiord (Hudson, Plafker, and Lanphere, 1977). The diorite which intrudes the Whitestripe Marble and Goon Dip Greenstone along the Border Ranges fault may correlate with these similar dioritic rocks to the north. If so, better age control for the unit on Chichagof Island may require a revision of the presently assigned Cretaceous age. We therefore assign this unit a Cretaceous(?) age.

Tertiary(?) plutons

Granite.—A very light gray to white (C. I. approx. 3), medium-grained biotite + muscovite granite crops out among the small islands along the west coast of Chichagof Island. It is principally hypidiomorphic and equigranular, but locally seriate. This unit is very weakly foliated and commonly cut by numerous leucocratic veins.

Granodiorite.—A light-gray to white (C. I. less than 10), medium-grained, biotite ± hornblende ± muscovite ± garnet granodiorite crops out in scattered plutons from Lake Elfendahl to Deep Bay. Biotite is generally much more abundant than hornblende. In some localities this unit grades to granite and tonalite. It is principally hypidiomorphic and seriate to equigranular. The granodiorite is mostly nonfoliated but contains small zones of weak to moderate foliation. Mafic xenoliths are numerous locally, particularly near contacts with the Goon Dip Greenstone. Large areas with abundant inclusions and septa of metamorphic rock are shown by a stipple pattern on the map.

Tonalite.—A dominantly light- to medium-gray (C. I. 5-40), medium-grained, biotite ± hornblende ± muscovite tonalite, having biotite generally more abundant than hornblende, crops out over a large part of Yakobi Island. This unit includes small zones of medium- to dark-gray, medium-grained, hornblende ± biotite ± pyroxene quartz diorite with hornblende dominant. Mafic portions commonly contain pyroxene-cored hornblende. These rocks are dominantly hypidiomorphic (the quartz diorite is locally allotriomorphic) and dominantly equigranular but occasionally seriate. Textures are locally cataclastic, but generally nonfoliated. The rock becomes foliated and banded, to migmatitic near its contacts. This unit contains numerous inclusions near its contact with the Sitka Graywacke and the Freeburn assemblage. Large areas containing abundant inclusions and septa of metamorphic rock are shown by a stipple pattern on the map.

Diorite.—This unit consists of a medium-gray (C. I. 35-50), fine- to medium-grained, hornblende diorite, which is probably a border phase of the Tertiary(?) tonalite on Yakobi Island. It contains occasional pyroxene-cored hornblende crystals and is generally hypidiomorphic, equigranular, and nonfoliated, although it is locally weakly foliated and contains scattered mafic inclusions.

Gabbronorite and norite.—This unit is composed dominantly of medium- to dark-gray (C. I. 40-75), locally brown-gray, medium- to coarse-grained, orthopyroxene + plagioclase + clinopyroxene gabbronorite and norite containing minor amounts of plagioclase-bearing orthopyroxenite. This unit crops out on Yakobi Island and near Mirror Harbor on Chichagof Island. Olivine is present in some norite, and postcumulous, brown hornblende is ubiquitous. All rock types are gradational, with no intrusive relationships noted. The unit locally contains abundant sulfides and forms the host rock for the Bohemia Basin and Mirror Harbor nickel-sulfide ore bodies. It is generally hypidiomorphic equigranular with cumulate textures locally well developed. These rocks are currently being studied in detail by R. A. Loney and G. R. Himmelberg (Loney, oral commun., 1980).

STRUCTURE

The general structural evolution of western Chichagof Island has been broken into five phases by Loney and others (1975): (1) initial deposition of sediments and volcanic material, resulting in compositionally layered rocks; (2) strong compression in a northeast-southwest direction, producing subisoclinal folds having northwest-striking, nearly horizontal to moderately plunging fold axes and steeply dipping axial-plane foliations; (3) deformation of earlier folds by open folding about axes plunging steeply southwest; (4) northwest-trending strike-slip and dip-slip faulting accompanied by shearing and rotation along preexisting bedding and foliation surfaces; and (5) uplifting and tilting with tensional jointing and pulling apart along pre-existing faults and shear planes. The structural history of Yakobi Island has been almost entirely obscured by Tertiary(?) plutonism. Where the country rocks are exposed, they appear to conform to the generally northwest trending, steeply dipping structural grain characteristic of western Chichagof Island.

The above general structural evolution is oversimplified in that it does not take into account the large-scale tectonic transport that has occurred, nor does it relate specific deformational events to the effects of that transport. This large-scale tectonic transport can be described in terms of three terranes: the Paleozoic to lower Mesozoic Alexander terrane, the Triassic(?) Wrangellia terrane, and the Cretaceous Chugach terrane. The Wrangellia tectonostratigraphic terrane, represented by the Goon Dip Greenstone and Whitestripe Marble, was probably amalgamated to the Alexander terrane to the east by middle Mesozoic time; the Kelp Bay Group and Sitka Graywacke of the Chugach terrane were in turn joined to the amalgamated Wrangellia and Alexander terranes between middle Cretaceous and early Tertiary time (Coney and others, 1980; Berg and others, 1978).

All of these terranes may have originated in different places with respect to each other, and probably all originated at significantly lower latitudes than their present position (Coney and others, 1980). The structural features within any one of these three major terranes may have formed prior to, or during, their accretion. Field relations suggest that these terranes achieved their present positions relative to each other prior to late Tertiary uplift and strike-slip faulting. Several implications of these large-scale tectonic transports are discussed below under "Geologic History."

The average strike of the rocks on western Chichagof Island is approximately N. 50, W., and rocks dip steeply southwest. Compositional layering, foliation planes, and fault surfaces are generally subparallel. Contacts between lithologic units are dominantly faults. The resultant map pattern is characterized by long northwest-southeast trending belts of lenticular rock units.

No detailed structural analysis was performed for this report. Loney and others (1975) treated all of western Chichagof Island as a single domain in their structural analysis. Inasmuch as most of the critical fold data analyzed by Loney and others (1975) are from the Chugach terrane, their general inferences about folding are restricted to that terrane. Faulting affects all of the terranes, but is least obvious within the Wrangellia terrane. Detailed work would probably distinguish the less deformed lower Mesozoic and older rocks from the more intensely deformed upper Mesozoic rocks. Decker (1980a) attempted to show this, but his results were inconclusive. Loney and others (1975) suggested that the older Mesozoic and Paleozoic rocks behaved as a buttress against which the younger rocks were deformed, which would imply that the deformation in the Chugach terrane occurred during or after accretion. This relationship may be largely obscured by Cenozoic faulting and by complex Mesozoic and Cenozoic plutonism.

Folds

Loney and others (1975) recognized two main folding events on western Chichagof Island. The earlier event produced subisoclinal folds, with well-developed axial-plane foliation, accompanied by lineations, mineral elongations, crenulations, striations, and mullions subparallel to fold axes. The mullions were interpreted to represent the intersections of bedding and foliation surfaces. The axes of these earlier folds trend northwest-southeast;

plunges are gentle to moderate in either direction. Fold axes diverge from this orientation where they have been folded around steep, southwest-plunging fold axes during a later folding event (Loney and others, 1975).

The oldest Mesozoic and Paleozoic rocks in the easternmost part of the study area are too disrupted and discontinuous, due to plutonism and faulting, to generalize about the deformational style of folding. Deformational style is also poorly displayed in the massive Goon Dip Greenstone and Whitestripe Marble. Within the Kelp Bay Group, two dominant deformational patterns emerge. The more competent sandstones are tightly folded and generally overturned to the northeast. The less competent fine-grained sedimentary and volcanic rocks are plastically deformed and very chaotic and streaky in appearance, with a well-developed foliation.

Faults

Reed and Coats (1941) found that most of the faults on western Chichagof Island trend northwest and dip steeply southwest and are roughly parallel to compositional layering and foliation. These faults are generally both strike-slip and dip-slip faults, which offset lithologic units and the earlier fold structures. Two of the three major faults in the study area, the Slocum Arm fault and the Peril Strait fault, show right-lateral offset (Loney and others, 1975; Plafker and others, 1976). The third major fault, the Border Ranges fault, may initially have been a thrust fault (MacKevett and Plafker, 1974; Plafker and others, 1976) along which right-lateral translation may subsequently have occurred, as suggested by the long, straight, steep fault zone, and adjacent foliations and outcrop patterns. The Border Ranges fault is mapped along the western margin of the Whitestripe Marble, which generally trends north to northwest. Dip of the fault is variable within the study area. It is 50, SW south of Freeburn Mountain, vertical at Freeburn and Whitestripe Mountains, 30, SW at the Goon Dip River, 70, SW north of Goon Dip Mountain, and 80, NE at the head of Goulding Harbor (Reed and Coats, 1941; this report). Outcrop patterns west of the Border Ranges fault, such as the deep embayment of graywacke into the phyllite and schist east of Klag Bay, are not reflected in the long straight pattern of the Whitestripe Marble.

Metamorphic and structural evidence suggests that the rocks on the western side of most northwest-striking faults are uplifted relative to the rocks on the east side of the faults (Reed and Coats, 1941; Loney and others, 1975; this report), except in the case of Peril Strait fault, the northeast side of which is up. Faults are characterized by graphite coatings, polishing, striations, gouge, and quartz fillings. Crushing and offsets on fault-filling quartz veins are evidence of repeated movement along some faults (Reed and Coats, 1941). Because many faults are subparallel to compositional layering and foliation planes, these surfaces are locally characterized by abundant shearing and cataclasis.

Joints

The dominant joint sets are typically normal to the regional foliation on western Chichagof Island, suggesting that they represent a response to tensional stress (Reed and Coats, 1941). Uplift and tilting have exposed Mesozoic and Tertiary(?) plutons which intrude the older Mesozoic and Paleozoic terrane. Sources of tensional stress may be a combination of lateral translation along faults and uplift related to plutonism.

GEOLOGIC HISTORY

The geologic history of western Chichagof and Yakobi Islands is obscured by complex structure and plutonism. In general, Paleozoic and lower Mesozoic sedimentary and volcanic rocks accumulated somewhere to the south of their present position with respect to North America, and were rafted into place along a major right-lateral fault system (Jones and others, 1977; Coney and others, 1980). These older rocks are foliated and broken by later faulting but escaped the intense folding, shearing, and chaotic disruption which characterizes the upper Mesozoic rocks. Metamorphic and structural evidence suggests juxtaposition of the upper Mesozoic sedimentary and volcanic rocks against the lower Mesozoic and older rocks commenced sometime in the middle Cretaceous (Decker and others, 1980; Decker, 1980b; this report). Displacement along several major, current fault systems continues to complicate the relative positions of these two packages of rocks. Middle to upper Mesozoic and Tertiary(?) plutons intrude the older rocks, and Tertiary(?) plutons intrude the younger rocks, with attendant thermal overprinting of previous deformation as well as interruption of stratigraphic and contact relationships.

Paleozoic events

Metamorphic rocks, which occur as small inclusions within the Chichagof plutonic complex east of the Peril Strait fault, consist of hornfels, granofels, marble, schist, and amphibolite. Loney and others (1975) thought the protoliths of these rocks were probably marine sedimentary and volcanic rocks of Silurian, Devonian, and possibly Mississippian age. The Paleozoic rocks on Chichagof Island are thought to represent the Alexander terrane of Berg and others (1972; 1978) and Jones and others (1972), which they consider to be allochthonous with respect to the North American craton.

Paleozoic rocks west of the Peril Straight fault also consist of marine metasedimentary and metavolcanic rocks, including limestone, sandstone, argillite, felsic to mafic metatuffs and flows, marble, phyllite, schist, and amphibolite. The presence of pelitic rocks and the compositional variation of the metavolcanic rocks suggests that this package of rocks may have accumulated in either an active continental margin- or island-arc-related setting. These rocks west of the Peril Strait fault on Chichagof Island are considered to represent the basement of another allochthonous terrane known as Wrangellia (Jones and others, 1977; Berg and others, 1978).

Mesozoic events

The earliest known Mesozoic rocks on western

Chichagof Island consist of a thick sequence of massive, mafic volcanic flows, which comprise the Goon Dip Greenstone. These flows are overlain by the massive, unfossiliferous Whitestripe Marble. Red-oxidized flow tops and pipe amygdules in the greenstone suggest that at least some of the mafic flows were subaerial. The unfossiliferous nature of the Whitestripe Marble is remarkable. The unit may represent a pelagic deposit. These two units have been correlated with the Nikolai Greenstone and Chitistone Limestone of the Wrangell Mountains (Plafker and others, 1976; 1977; Jones and others, 1977), which are of similar lithology and relative stratigraphic position. The Goon Dip Greenstone and Whitestripe Marble have therefore been included in the Wrangellia terrane of Jones and others (1977). Wrangellia is thought to represent an upper Paleozoic to lower Mesozoic arc complex composed of mafic submarine and subaerial flows overlain by shallow marine limestone and clastic rocks (Jones and others, 1977). Paleomagnetic data suggest that Wrangellia originated at low Triassic paleolatitudes with respect to Triassic North America (Hillhouse and others, 1977).

Stratigraphic relationships and paleomagnetic data for rocks to the north and south of Chichagof Island indicate that Wrangellia amalgamated with the Alexander terrane prior to its accretion to North America in post-Early Cretaceous time (Coney and others, 1980). On Chichagof Island, Jurassic and younger plutons intrude the Paleozoic and Mesozoic rocks of Wrangellia, suggesting the allochthonous terranes had amalgamated by Late Jurassic time. However, the Peril Strait fault has separated Wrangellia on western Chichagof Island from the Alexander terrane on eastern Chichagof Island since late Mesozoic time (Berg and others, 1978), obscuring many previous relationships between the terranes.

Upper Jurassic and Cretaceous strata of the Gravina-Nutzotin belt, thought to represent a volcanic arc which overlapped the amalgamated Wrangellia and Alexander terranes (Berg and others, 1972, 1978; Coney and others, 1980), are missing on Chichagof Island. However, the Jurassic and Cretaceous tonalites, quartz diorites, and diorites, which intrude the Triassic and older rocks on western Chichagof Island, may be related to such an arc.

Upper Mesozoic rocks on western Chichagof Island occur west of the rocks which compose Wrangellia and are separated from Wrangellia by a major structure, the Border Ranges fault (Plafker and others, 1976, 1977; Decker and Johnson, 1981). The rocks west of the Border Ranges fault have been described as an accretionary flysch and melange terrane by Plafker and others (1976, 1977) in recognition of their disrupted nature. These rocks on Chichagof Island compose part of the upper Mesozoic Chugach terrane of Berg and others (1972, 1978).

The rocks of the Chugach terrane immediately west of the Border Ranges fault on Chichagof Island have been described as a collage of kilometer-scale, fault-bounded blocks composed of different proportions of metasedimentary and metavolcanic rocks of variable metamorphic and textural grade (Decker, 1980a). The protoliths of these rocks consist of fine-grained sedimentary and volcanic rocks including, in decreasing order of abundance, mudstone, tuff, sandstone, basalt, limestone, and chert. The abundant mudstone and associated coarse clastic deposits suggests that most of these rocks were deposited in a slope-facies environment near a continental margin. It is not presently possible to trace the clastic rocks to a source terrane across the Border Ranges fault using currently available information. Thick accumulations of mafic volcanic rock associated with predominantly slope-facies mudstone suggests proximity to an arc, a rift, or a "leaky" transform; or extrusion along zones of tension at the flexure of a subducting oceanic slab (Tysdal and others, 1978; Decker, 1980b). The rocks are now too disrupted to recognize original relationships between protoliths, in order to determine which, if any, of the above models best explain these rocks.

Accretionary processes are poorly understood, and it is difficult to unravel the mechanism by which these rocks of differing lithology and metamorphic grade were juxtaposed. Except for rocks adjacent to plutons, the highest temperature mineral assemblages are found nearest the Border Ranges fault. Possible high-pressure blueschist facies minerals have only been discovered as discrete occurrences in greenschist facies rocks several kilometers to the west of the fault, and rocks of low-temperature and low-pressure mineralogy and texture are typically sandwiched between the higher temperature and higher pressure units. Possible factors contributing to the observed relationships include: (1) nonuniform equilibration of isotherms within the accretionary zone; (2) differential relative rates and depths of subduction or obduction between packages of rocks; (3) variable relative proportions of translational versus compressional components in the accretionary tectonic regime; and (4) nonuniform distribution of isotherms due to local volcanism.

West of the collage, a belt of melange (the Khaz Formation) characterized by blocks of a variety of lithologies in a sheared matrix of argillite, tuffaceous argillite or sandstone, separates the rocks of the collage (the Freeburn assemblage) from the outboard flysch (the Sitka Graywacke). The Khaz contains blocks of schist and phyllite, but the matrix has never achieved greater than prehnite-pumpellyite-facies metamorphic grade. The melange may have formed by cannibalization of rocks inboard of it by processes such as slumping, folding, thrusting, or translational wrenching. The melange matrix bears evidence of both soft-sediment and mechanical deformation, suggesting that deformation was continuous through and beyond successive stages of lithification. The matrix of the melange is compositionally gradational to the flysch, which is composed of proximal, thin- to thick-bedded turbidites (Decker and others, 1979; Decker, 1980b) and is also metamorphosed to prehnite-pumpellyite facies. Locally, mafic volcanic rocks are intercalated with the turbidites, but in general the Khaz appears to represent an environment transitional from earlier low sedimentation rates accompanied by abundant mafic volcanism to later high sedimentation rates in which clastic material apparently overwhelmed volcanism or succeeded it. The components of the flysch have been interpreted to have been derived from a volcano-plutonic source terrane (Decker and others, 1979; Zuffa and others, 1980), and paleocurrent information suggests this terrane was to the east. However, no terrane of a reasonable age is available to the east. Regional considerations, including translation along several major fault systems, suggest the source terrane was somewhere south of the present position of these rocks.

The rocks west of the Border Ranges fault are considered to represent the upper Mesozoic Chugach terrane of Berg and others (1972, 1978). The collage belt and the melange belt together comprise the melange facies of the Chugach terrane on Chichagof Island. The flysch facies of the Chugach terrane is represented by the Sitka Graywacke on Chichagof Island. Radiolarian ages from cherts in the collage belt on Chichagof Island are Early Cretaceous (Waterfall Greenstone). Ages of blocks in the melange belt on Chichagof Island range from Triassic(?) (Goon Dip Greenstone and Whitestripe Marble) to Cretaceous (Khaz Formation). Ages of fossils found in the flysch facies of the Chugach terrane are also Cretaceous (Sitka Graywacke). Metamorphic mineral ages from the collage belt are mid-Cretaceous (Freeburn assemblage). Apparently, all of the rocks west of the Border Ranges fault on Chichagof Island accumulated nearly simultaneously, which would explain the compositional similarities between them. The mid-Cretaceous metamorphic age may represent the time of accretion of these rocks to Wrangellia (Decker and Johnson, 1981; Decker, 1980b), or to some other terrane along the western margin of North America. Since middle Cretaceous time, translation has continued to move these rocks of the Chugach terrane northward with respect to North America and possibly with respect to the rocks of Wrangellia as well (D. L. Jones, oral commun., 1980). Thus the Border Ranges fault may represent the locus of accretion of the Chugach terrane, initially by a combination of compressional and translational tectonic processes and later by dominantly translational tectonic processes.

Intensely sheared diorite of probable Cretaceous age (Cretaceous? diorite) apparently intrudes the Border Ranges fault as long thin sills. Nowhere does this diorite intrude rocks west of the fault. The shearing of the diorite suggests movement along the fault since the emplacement of the diorite. However, the amount of movement along the fault since the intrusion of the diorite is unknown, so the diorite sills may be pretectonic, syntectonic, or late tectonic.

Tertiary events

The only rocks of known Tertiary age on western Chichagof and Yakobi Islands are intrusive rocks. Rocks of mafic to felsic composition intrude all of the older rock units and major structures such as the Border Ranges fault.

Felsic intrusive rocks of Eocene age intrude the Sitka Graywacke and have been interpreted to be anatectic plutons (Hudson, Plafker, and Lanphere, 1977; Hudson, Plafker, and Peterman, 1977, 1979; Hudson, Plafker, and Turner, 1977) generated in response to heating of deeper parts of the accretionary prism after it was tectonically thickened and deformed against the continental margin. This heating was possibly related to equilibration of isotherms within the upper crust following cessation of compressional accretion and underthrusting of cold sediments (Hudson and others, 1979). The Eocene plutons are unfoliated and thus place an upper limit on the duration of the compressional tectonic regime in the vicinity of western Chichagof Island (Loney and others, 1975).

Intermediate and mafic plutons of probable Tertiary age (Loney and others, 1975) on Yakobi and Chichagof Islands are compositionally unique with respect to the belt of Tertiary plutons around the Gulf of Alaska margin (Hudson, Plafker, and Lanphere, 1977). The plutons on Yakobi and Chichagof Islands apparently intrude the Border Ranges fault at Lake Elfendahl and Bohemia Basin and thus their age places an upper limit on movement along the Border Ranges fault in those areas. This evidence suggests that the Chugach terrane had achieved its present position with respect to Wrangellia on Chichagof and Yakobi Islands by the time the Elfendahl and Bohemia Basin plutons were intruded. The unusual composition of these Tertiary(?) plutons may be related to their unique setting, in that they straddle a major structure characterized by large components of compressional and translational movement, in contrast to the more passively generated anatectic felsic Eocene plutons, which typically, but not exclusively, intrude the flysch prism.

Metamorphic mineral assemblages in hornfelsed rocks adjacent to the Tertiary(?) plutons suggest shallow to intermediate levels of intrusion (Loney and others, 1975; Hudson, Plafker, and Lanphere 1977; Hudson and others, 1979), and their exposure indicates significant uplift of this geographic area since Tertiary time.

Correlations across the Peril Strait fault suggest a maximum of 11 km (Plafker and others, 1976) or possibly 30 km (Loney and others, 1975) of net right-lateral strike-slip displacement since Late Cretaceous time. Intense cataclastic deformation of the rocks along Hoonah Sound is attributed primarily to movement along this fault system.

Quaternary events

Uplift and displacement along numerous faults described above has continued since Tertiary time. During the late Pleistocene, most of the map area was buried under ice (Loney and others, 1975), resulting in locally intense mechanical erosion and deposition of glacial deposits in topographically low-lying areas.

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