Reconnaissance Geology of Admiralty Island Alaska

By E. H. LATHRAM, J. S. POMEROY, H. C. BERG, *and* R. A. LONEY

CONTRIBUTIONS TO GENERAL GEOLOGY

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A reconnaissance study of a geologically complex area in southeast Alaska

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RECONNAISSANCE GEOLOGY OF ADMIRALTY ISLAND, ALASKA

By E. H. Lathram, J. S. Pomeroy, H. C. Berg, and R. A. Loney

ABSTRACT

Admiralty Island, one of the major islands of the Alexander Archipelago, lies adjacent to the Alaskan mainland south of Juneau. Silurian(?) to Quaternary sedimentary, metamorphic and igneous rocks crop out in the largely uninhabited, moderately rugged area.

The layered rocks of Admiralty Island comprise six depositional sequences, five of marine (eugeosynclinal) and one of nonmarine origin, each separated by unconformities. Graywacke, slate, and limestone of Silurian(?) age are the oldest sequence. Schist and marble, representing metamorphosed graywacke, siltstone, limestone, and volcanic rocks, form the Retreat Group and the Gambier Bay Formation. These rocks, together with the apparently coeval unmetamorphosed black argillite and chert of the Hood Bay Formation, make up the next younger sequence (Devonian and Devonian(?)), which is of unknown thickness. The Cannery Formation, consisting of more than 2,000 feet of graywacke, agrillite, chert, and conglomerate, and the overlying Pybus Dolomite, as much as 1,000 feet thick, form the next younger sequence (Permian). The Hyd Formation (Triassic), composed of thin-bedded impure limestone, black chert, and black slate interfingering with and overlain by basalt and andesite pillow flows, forms the fourth sequence. The fifth sequence, the Stephens Passage Group (Jurassic and Cretaceous) is more than 5,000 feet thick; it comprises the Seymour Canal Formation, composed of slate, graywacke, and conglomerate, the Douglas Island Volcanics, which includes augite-bearing andesitic and basaltic flow breccia, and the Brothers Volcanics flow breccia. The formations of the fifth sequence are equivalent in age and intertongue along Seymour Canal and Stephens Passage. The youngest sequence is nonmarine, late Paleocene through Miocene in age, and includes the Kootznahoo Formation, composed of about 5,000 feet of conglomerate, sandstone, siltstone, shale, and coal, and the overlying Admiralty Island Volcanics, which consists of basaltic andesite flows more than 10,000 feet thick.

A major orogeny, post-earliest Early Cretaceous to pre-Paleocene in age, probably culminated in middle-Cretaceous time and formed the major structural features of the Island. These are the Admiralty anticlinorium, which forms the central and western part of the island and is a part of the Prince of Wales geanticline, and the adjoining Juneau synclinorium to the east. Folding of at least two stages resulted in superposition of the folds. Most of the folds are overturned—those in the anticlinorium largely to the northeast and those in the

synclinorium to the southwest. Earlier deformation may be the reason for differences in folding and metamorphic grade observed in the older depositional sequences, but lack of critical exposures has prevented recognition of earlier orogeny. The emplacement of felsic to ultramafic plutonic rocks may have been largely posttectonic, although one pluton, that at Point Retreat, is clearly pre- or syntectonic. Large bodies of contact-metamorphic rocks and migmatite border some of the plutonic masses. Low-grade regional metamorphism accompanied the orogeny and affected most of the island, particularly the central and western parts. Faulting along northwest trends, with both vertical and horizontal movement, accompanied and followed the folding. The Tertiary sedimentary rocks were deposited in two unconnected intermontane basins. Although there is no evidence of post-Miocene folding or plutonism, post-Miocene faulting, largely with vertical movement, occurred along north and northeast trends.

The area was glaciated to an elevation of about 3,000 feet during Pleistocene time. No glaciers remain at present. Fossiliferous marine beaches at elevations of 475 feet attest to a higher sea level or a lower elevation of the land surface during Pleistocene time.

Metamorphic rocks west of Hasselborg Lake and around Slide Lake contain local concentrations of sulfide and oxide minerals. Aside from intermittent exploration at the Funter Bay nickel-copper deposit, there is currently (1963) little mining activity on the island, although some of the now inactive mines have produced modest amounts of gold and silver.

INTRODUCTION

GEOGRAPHY

Admiralty Island, one of the major islands of the Alexander Archipelago of southeastern Alaska, lies between lat. 57° N. and 58°25′ N. and long. 133°50′ W. and 135° W. (fig. 1). It trends in a northerly direction, is approximately 96 miles in length, and ranges in width from less than a mile to 30 miles. The northern shore, along Stephens Passage, is 10 miles south of Juneau, the State capital. The island is bounded by Stephens Passage, Frederick Sound, Chatham Strait, and Lynn Canal, all inland waterways. Admiralty Island is shown on parts of three 1:250,000-scale U.S. Geological Survey reconnaissance topographic maps—the Sitka, Juneau, and Sumdum quadrangles.

The population is small, and the few settlements are located on the west coast. The only permanent village is Angoon with a population of about 300. Seasonal settlements are located adjacent to the canneries at Hood Bay and Hawk Inlet. As a rule the canneries are closed during the winter. The villages of Funter, Killisnoo, Neltushkin, and Tyee have been abandoned.

Admiralty Island is accessible only by airplane or boat. Alaska Coastal-Ellis Airline flights from Juneau or Sitka make daily stops at Hood Bay, Angoon, and Hawk Inlet during the summer. Charter service is needed for other areas. Most of the inlets and bays provide good anchorages for boats; however, utmost care is needed when entering or leaving Kootznahoo Inlet. Strong tidal currents make entry feasible only at slack water.

The interior of Admiralty Island is accessible by a network of good to fair trails which connect many lakes. Also, a trail across Mansfield Peninsula connects Funter Bay with the mouth of Bear Creek, and a road about 3 miles long joins Angoon with the point opposite Killisnoo. Shelters are at some of the large lakes in the central part of the island, and a lodge is at the west end of Thayer Lake. The shelters at Camp Shaheen on the eastern shore of Hasselborg Lake are maintained by the Forest Service.

Moderately rugged relief is characteristic of most of Admiralty Island. Elevations are generally less than 4,000 feet, although areas of greater elevation occur in the ridge system a few miles northwest of Hasselborg Lake, and also in the Eagle Peak area south of Point Young. Randolph Peak on Glass Peninsula also exceeds 4,000 feet. The highest point on Admiralty Island is an unnamed peak slightly more than 4,800 feet high which is roughly 5 airline miles west-northwest of the northern end of Hasselborg Lake. Summits and slopes below 3,000 to 3,300 feet are rounded and smooth; those above are extremely jagged and precipitous. In the southern part of the island the lower elevations consist of plateaus having gentle slopes. Relatively low areas are northern Mansfield Peninsula, the northern half of Glass Peninsula, and a northeast-trending belt that includes Kootznahoo Inlet and Mole Harbor.

Physiographic features are commonly oriented in a northwestward direction throughout southeastern Alaska and reflect the dominant strike of the foliation or bedding in the rocks. This orientation is conspicuous on northern Admiralty Island, in the Seymour Canal area, and in parts of Pybus and Gambier Bays. Many of the physiographic feautres of southern and central Admiralty Island, however, trend northeastward. The belt that includes Kootznahoo Inlet and Mole Harbor, the valley between Hood and Gambier Bays, and the southeastern coastline are all examples.

Admiralty Island has the mild winters, cool summers, and plentiful precipitation characteristic of most of southeastern Alaska. June is usually the driest month. Precipitation increases progressively each month thereafter and reaches a peak in October. Snowfall is relatively light at or near sea level. Weather records are available only for the southwestern and extreme northern parts of the island. For the 29 years prior to 1923 the Weather Bureau records indicate that the annual precipitation in the Killisnoo-Angoon area averaged about 53 inches (Buddington and Chapin, 1929, p. 15). Evidently no record was kept at Point Retreat during that period. A series of recent climatic maps (Weather Bureau, 1959) for the period 1931 to 1955 indicate that the annual rainfall for Angoon and Point Retreat is 80 inches. The isolines reveal that heavier precipitation, as much as 100 inches, is characteristic of most of the island.

According to the climatic maps, the mean minimum and maximum temperatures (Admiralty Island) for January are 24° and 32°–34° F. Mean minimum and maximum temperatures for July are 48°–50° and 60°–64° F.

Generally, optimum conditions for fieldwork exist from the middle of May to the first of July. During this interval the number of clear to cloudy days exceeds the number of rainy days; however, there is snow cover on the higher elevations. A heavy early-spring snowfall will obscure outcrops at elevations as low as 2,000 feet until June. By midsummer the snow is gone from most of the ridges, but frequent low clouds, fog, and rain hamper field work.

In the summer of 1959, more rain fell in the month of July than in the month of August, a departure from the usual rainfall pattern. The following table indicates the weather conditions observed by the field party for the period May 22 to August 27, 1959.

Period	Weather condition			
	Clear	Partly cloudy	Cloudy	Rainy
May 22-31	4	2.0	2	2.0
June 1-30	6	8.5	5	10.5
July 1-31	4	1.0	7	19.0
Aug. 1-27	4	4.5	6	12.5

Vegetation is luxuriant up to the timberline, which is generally at about 2,500 feet. In the low-lying areas, thick undergrowth in the form of devilsclub, alder, and various types of berry bushes make travel slow. Hemlock and spruce are the most abundant coniferous trees and form dense stands. Vegetation above the timberline is sparse and consists of lichens and heather. The entire island is part of Tongass National Forest.

PREVIOUS INVESTIGATIONS

The earliest geologic investigation of Admiralty Island (fig. 1) was made in 1895 by Dall (1896, p. 776–783) in the Kootznahoo Inlet area. Prior to this time both the U.S. Navy Department and private prospectors had looked for coal in the Kootznahoo Inlet area and near Murder Cove.

Wright (1906, pl. 33) made the first geologic reconnaissance map of Admiralty Island. This map was based primarily on shoreline studies

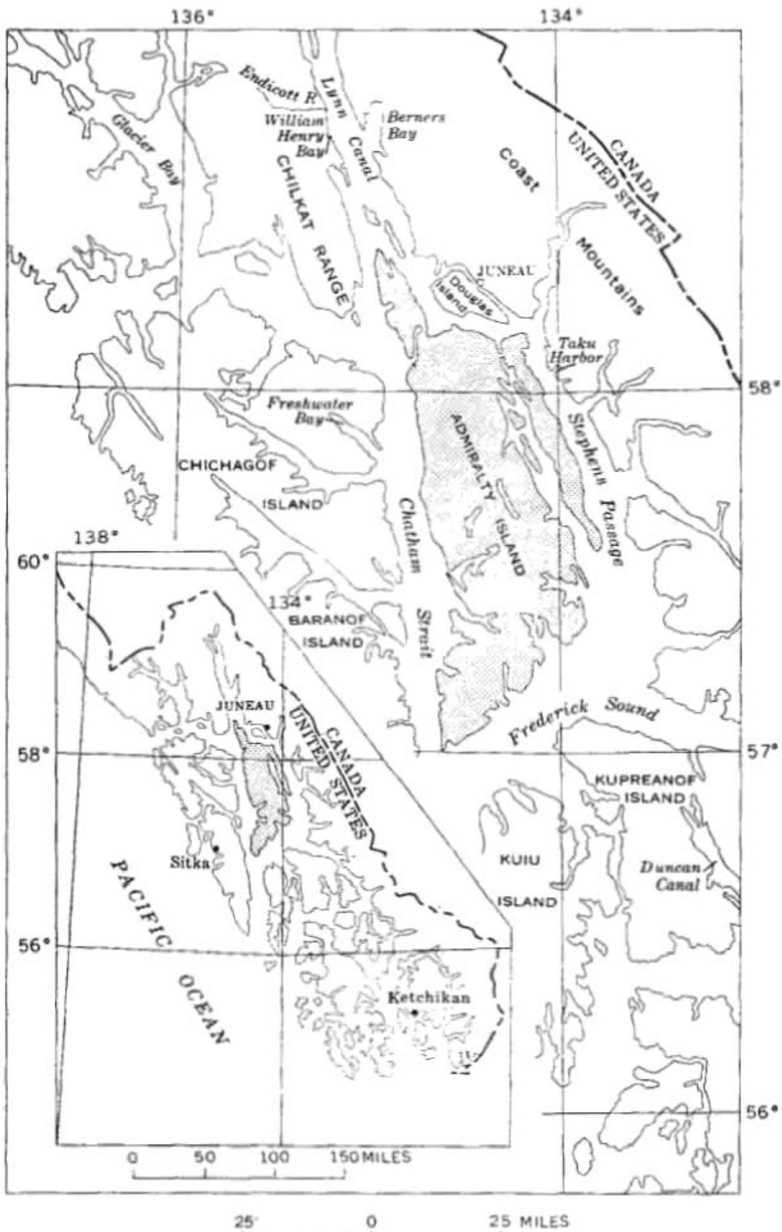

FIGURE 1.—Index map showing location of Admiralty Island, Alaska.

made in 1904 and on visits to some of the prospects existing at that time. Kirk (1918, unpublished data) made further observations as part of a reconnaissance study of Admiralty and Chichagof Islands, but his report was never completed. Kindle (1907) and Martin (1926) collected fossils from Pybus Bay and nearby areas.

A great deal of prospecting took place around 1900, and various prospects and small areas have been examined by geologists since that time. The northern part of Admiralty Island, particularly the area around Funter Bay and Hawk Inlet, has received the most attention. Nickel-copper-gold deposits were examined and described by Wright (1906, p. 147–150), Eakin (1918, p. 84–92), Mertie (1921, p. 113–118), Buddington (1926, p. 42–50), and Reed (1942). Burchard (1920, p. 48–56), surveying the marble resources of southeastern Alaska, examined the marble outcrops along the western and southwestern shorelines. An asbestos prospect east of Funter Bay was examined in 1928 and 1944 (Twenhofel, Reed, and Gates, 1949, p. 34–37). In 1949 reconnaissance radioactivity studies were conducted in the Funter Bay area (West and Benson, 1955, p. 51–52).

A. F. Buddington and Theodore Chapin (1929), in their reconnaissance study of the geology of southeastern Alaska, modified Wright's early map of the island and correlated the geology of the island with that of the rest of southeastern Alaska. Observations on the geology of the southern end of Hasselborg Lake were made by R. E. Fellows in 1947 (unpublished data). C. L. Sainsbury made numerous observations in Funter Bay and nearby areas (1953, unpublished data). Most recently, Fred Barker (1957) mapped the geology of the Juneau (B–3) quadrangle, which includes the northermost part of Mansfield Peninsula.

PRESENT INVESTIGATIONS

Systematic geologic mapping of southeastern Alaska at a scale of 1:250,000 was begun in 1956, as a part of the long-range minerals program of the Geological Survey. The purpose of this mapping is the preparation of regional geologic reports, such as the present report, which may be used to guide the search for mineral resources.

The field data upon which this report is based were derived chiefly from exposures along beaches and streams, and in the high country above timberline. Field observations elsewhere, were very sparse. Small boats were used in mapping the beaches, and a helicopter was used in mapping the interior of the island. Mapping in the field was done on U.S. Geological Survey topographic quadrangle maps at 1:63,360 scale. Geologists worked individually for the most part, and communicated by means of walkie-talkie radios. Base camp was maintained on the Geological Survey motor vessel *Stephen R. Capps*, an 88-foot self-propelled barge with a heliport on the bow. R. D. Stacey, Master, and John Muttart, cook-seaman, operated the vessel.

The reconnaissance mapping of Admiralty Island was done under the general supervision of E. H. Lathram. During the period of his absence from the field in 1959, fieldwork was directed by R. A. Loney. The mapping was accomplished largely during June and July of 1957 and the summer of 1959. In 1957 the field party consisted of Lathram, Loney, W. H. Condon, H. C. Berg, and Maurice Grolier. A preliminary interpretation of the geology north of lat. 58° was subsequently published (Lathram and others, 1958, 1959). Lathram, accompanied by Condon, made a preliminary survey of the southern and central parts of the island in late 1958. In 1959 the field party consisted of Lathram, Loney, Berg, J. S. Pomeroy, and D. W. Hinckley. Douglas Barnes assisted the geologists during the summer of 1959.

R. A. Loney studied the stratigraphy and structure of the Pybus-Gambier area in detail in 1958 and 1959. This work (Loney, 1964) greatly facilitated the reconnaissance mapping.

In the course of the mapping, scattered small areas were studied in detail in order to define mappable units, whose contacts were then extended laterally by reconnaissance methods, including spot checks and aerial photograph interpretation. Because of structural complexity and metamorphism, as well as vegetation and unconsolidated cover, placement of contacts on the geologic map (pl. 1) at some places was quite arbitrary; the units mapped may include small areas of other map units either unrecognized or too small to represent at the scale of this map.

Thin sections were studied to classify most of the rocks; unless otherwise noted, rock terminology throughout the report follows that used by Williams, Turner, and Gilbert (1954).

TECTONIC ASPECTS OF THE GEOLOGY

Admiralty Island lies wholly within a mobile belt that borders the Pacific Ocean and has been the site of marine geosynclinal deposition and intermittent deformation throughout most of the Paleozoic and Mesozoic Eras. The deposits belong to the typical eugeosynclinal suite of Pettijohn (1957, p. 640) and other writers; that is, these deposits are predominantly siltstone, graywacke, bedded chert, limestone, and abundant volcanic rocks.

The consolidated rocks range in age from Silurian(?) to Miocene (table 1). Six depositional sequences are recognized, which reflect five episodes of marine eugeosynclinal sedimentation and one episode of terrestrial deposition. Graywacke, slate, and limestone of Silurian(?) age form the oldest sequence. The second sequence consists of metamorphic rocks, mapped as the Retreat Group and Gambier Bay Formation, of Devonian age. Black argillite and chert of the Hood Bay Formation, probably of comparable age and deposited in a reducing environment, may represent coeval deposition in a different part of the geosyncline and a facies of the second sequence. This second sequence forms the major part of the island. The third sequence, of Permian age, crops out on the eastern and southern slopes and shores of the island, and records deposition in a rapidly sinking trough during Early Permian time (Cannery Formation), followed by less active subsidence and shallower seas (Pybus Dolomite). Volcanism was minor. The Upper Triassic Hyd Formation forms the fourth sequence, whose wide distribution of thin-bedded black shale, chert, and impure limestone indicates deposition in a broad, slowly subsiding seaway in which reducing conditions were widespread. Extensive volcanism closed Triassic deposition. The fifth sequence is Late Jurassic and Early Cretaceous in age; it once more records deposition in a rapidly subsiding eugeosyncline. This sequence, the Stephens Passage Group, consists of slate, graywacke, and conglomerate (Seymour Canal Formation), and augite-bearing andesite and basalt flow breccia (Douglas Island Volcanics and Brothers Volcanics). The last sequence, which is Tertiary in age, is entirely nonmarine. Paleocene through Miocene deposition occurred in disconnected intermontane basins, largely as alluvial fans, piedmont and swamp deposits (Kootznahoo Formation), and as extensive fissure eruptions of lava (Admiralty Island Volcanics). The flows apparently overrode the boundaries of some of the basins, but were not extruded in others.

These sequences are separated by unconformities, only one of which is unquestionably angular. The period of uplift and erosion which separated Jurassic and Cretaceous from Tertiary deposition was attended by at least two stages of folding, one superimposed on the other, accompanied and followed by the emplacement of plutonic rocks, by regional metamorphism, and by major faulting resulting in faults striking northwestward. This orogeny probably reached its maximum in middle Cretaceous time. Faulting again occurred after the deposition of the Tertiary volcanic flows, this time resulting in faults striking northeastward and north.

The island was intensely glaciated during Pleistocene time, but elevations above 3,000 feet were mostly ice free. No glaciers exist at present. Ancient marine terrace deposits, some of which contain Pleistocene fossils, have been found at elevations of as much as 475 feet. These deposits indicate a higher sea level or lower elevation of the land surface, in Pleistocene time than now.

TABLE 1.—*Summary of stratigraphic units on Admiralty Island*

System	Series	Unit	Character	Thickness (in feet)
Quaternary	Recent	Alluvium, colluvium, beach, terrace, and glacial deposits	Gravel, sand, and silt	0-50
	Pleistocene			
		Unconformity		
Tertiary	Paleocene through Miocene	Admiralty Island Volcanics	Basaltic andesite flows	10,000±
		Kootznahoo Formation	Sandstone, siltstone, conglomerate, and coal	5,000+
		Angular unconformity		
Cretaceous	Lower	Stephens Passage Group: Douglas Island Volcanics (includes Brothers Volcanics)	Augite-bearing flow breccia	3,000+
Jurassic	Upper	Stephens Passage Group: Seymour Canal Formation	Graywacke, slate, and conglomerate	5,000+
		Unconformity		
Triassic	Upper	Hyd Formation	Andesite flows, some with pillows	0-2,000+
			Thin-bedded impure limestone, chert, black slate, stylolitic limestone, and conglomerate	200-600
		Unconformity; ? Barlow Cove Formation ?	Schist, slate, and phyllite	?
Permian		Pybus Dolomite	Dolomite with blue chert	0-1,000
	Lower	Cannery Formation	Graywacke, argillite, chert, and conglomerate	2,000+
		Unconformity		
Devonian and Devonian(?)		Hood Bay Formation (Devonian?) ? Gambier Bay Formation (Middle? Devonian) ? Retreat Group (Middle? Devonian)	Schist and marble	?
			Argillite and chert (Hood Bay Formation)	?
		Unconformity(?)		
Silurian(?)		Sedimentary rocks	Graywacke, slate, and limestone	?

STRATIGRAPHY

SILURIAN(?) ROCKS

Rocks of probable Silurian age crop out only on the peninsula and islands east of Murder Cove (pl. 1). At this locality, schistose gray graywacke, dark-gray slate, chert, and minor graywacke conglomerate underlie dark-gray thin-bedded limestone. The sequence is folded and the thickness is unknown. The Silurian(?) rocks are overlain by almost flat-lying Tertiary rocks to the north, but the contact is covered. Triassic rocks of the Hyd Formation bound the Silurian(?) rocks on the east, but the contact is covered and may be a fault. A fossil collection, 59ABg40 (USGS Silurian-Devonian loc. 6384-SD), made on Carroll Island (pl. 2) contains *Tryplasma*, indicative of Early Devonian or more probably Silurian age (W. A. Oliver, Jr., U.S. Geological Survey, written commun., 1959). Silurian rocks of comparable lithology are reported in other parts of southeastern Alaska (Buddington and Chapin, 1929), but detailed correlation is not possible.

DEVONIAN AND DEVONIAN(?) ROCKS

RETREAT GROUP AND GAMBIER BAY FORMATION

Distribution and lithology.—From Pybus Bay northwestward to Point Retreat (pl. 1), schist and marble form the backbone and the western side of the island. The belt of outcrop is not continuous, but is interrupted by the batholith at Thayer Lake (pl. 1), which divides the belt into a northern and a southern segment. In the northern segment, the rocks are continuous with those of the Retreat Group, named and mapped by Barker (1957) on Mansfield Peninsula, and are assigned to that group. In the southern segment, the rocks are continuous with those of the Gambier Bay Formation, mapped by Loney (1964) in the Gambier Bay area (pl. 1), and are assigned to that formation. The lithology, state of metamorphism, structure, and stratigraphic position of the two units are the same, and they are considered to be correlative and probably equivalent. Consequently, although the two units are mapped separately, they are discussed together.

The most typical and most accessible exposures of the rocks of the Retreat Group are along the shores of Hawk Inlet and the western shore of the island from Point Retreat to near Marble Bluffs (pl. 1). The rocks of the Gambier Bay Formation are best seen along the south shore of Gambier Bay.

Schist and lesser phyllite predominate in the two units; the most common varieties of schist are chlorite-albite-epidote schist, calc-silicate schist, sericite-chlorite-albite schist, graphitic quartz-muscovite schist, sericite schist, amphibole schist, and garnet-muscovite-quartz-feldspar schist. Graphitic schist is commonly pyritiferous, and pyrite crystals an inch in maximum dimension may be found. Thick lenses of thin- to thick-bedded, dark-gray and light-gray to buff, fine- to medium-grained marble are common. Some outcrops of marble show thin dark-gray laminations; others are mottled and contain irregular dolomitic areas. Thick, prominent exposures consisting mostly of marble and subordinate interbedded schist form the highland areas south and north of Hood Bay and north of Gambier Bay, the wide belts at Marble Cove, and along the beach from Kootznahoo Inlet to Parker Point. These units are shown separately on the geologic map (pl. 1). Generally, the marble in the highland areas north of Hood and Gambier Bays is massive, whereas that in the wide belts along the west coast of the island is schistose. Smaller exposures of marble occur along the north (Barker, 1957) and south shores of Funter Bay, on nearby islands, on the bluff 1½ miles southwest of the cannery at Hawk Inlet, on the coast 1 mile south of Cube Point, on the headland between the northwest and west arms of Gambier Bay, and on Muse Island in Gambier Bay. Graphitic and pyritic black slate is common locally on Mansfield Peninsula (Barker, 1957). Thin beds of fine-grained greenish to white quartzite are common; these beds may be metamorphosed chert. An outcrop of serpentinized dolomite 6.5 miles N. 63° E. of Point Marsden probably represents the alteration of limestone by an ultramafic intrusive body.

Thickness and stratigraphic relations.—The thickness of the Retreat Group and the Gambier Bay Formation is unknown. The base of neither sequence has been recognized, and the rocks have been folded several times, sheared, and recrystallized. As a result, the conspicuous compositional layering in the rocks is rarely the orginal bedding. The most conspicuous surface is a foliation that is oblique to the original bedding. The bedding is visible only as bands on the foliation. Marble beds are strongly folded and discontinuous. The thickness of this sequence is at least several thousand feet, and may be many thousands of feet. Some of the marble units are as much as 1,000 feet thick; one north of Gambier Bay may be as much as 4,000 feet thick, but repetition by folding may be responsible for this great thickness.

Several maps of parts of Mansfield Peninsula which show the distribution of various lithologic types in the Retreat Group (Reed, 1942, fig. 1; Lathram and others, 1958, 1959) have been published. Inasmuch as the compositional layering commonly is not the original bedding, the distribution of these lithologic units is probably not directly related to their stratigraphy. Accordingly, no subdivision of the schist in this area is made in this report.

The stratigraphic position of the thick marble unit that is mapped separately in the Gambier Bay Formation is obscure. In general, exposures of the unit cap ridges formed of schist; locally, however, schist appears to overlie the marble, and the marble commonly contains schist interbeds. Hence, it is not known whether this unit overlies the schist sequence that forms the Retreat Group and the Gambier Bay Formation or whether the unit lies within the upper part of the schist sequence.

The Cannery Formation, of Permian age, rests directly on the Gambier Bay Formation in the hills west of Gambier Bay and overlies the Retreat Group near the headwaters of Wheeler, Pack, and Green Creeks. On Mansfield Peninsula, the Retreat Group is overlain by the Barlow Cove Formation of Permian and Triassic(?) age, (considered by Barker, 1957, to be Jurassic? to Early Cretaceous?). Barker placed the contact between the Retreat Group and the Barlow Cove Formation at a prominent northwest-striking fault which bisects Barlow Cove at its head. After reexamining this locality, the authors feel that the rocks immediately west of the fault at the head of the cove are more comparable lithologically to those of the Barlow Cove Formation east of the fault than to those which make up the bulk of the Retreat Group. Accordingly, in this report, the contact is placed along the west shore of the cove. The nature of the contact is uncertain, and to the south this contact is covered. Near the head of Wheeler Creek, an outcrop of Upper Triassic limestone and chert is completely surrounded by schist of the Retreat Group, but the contact is concealed. Tertiary rocks overlie the Gambier Bay Formation with angular unconformity on the southwest side of Kanalku Bay.

The Gambier Bay Formation was not seen in contact with the Hood Bay Formation. The areas where the contact is drawn on the map are covered.

A major unconformity separates the Retreat Group and Gambier Bay Formation from all younger rocks. Lower Permian rocks are the oldest that overlie these two units. Upper Devonian and Mississippian strata that total approximately 11,000 feet in thickness on northeastern Chichagof Island (Loney and others, 1963), as well as Pennsylvanian rocks, are missing on Admiralty Island.

Age and correlation.—On the basis of fossils of Devonian (probably Middle Devonian) age found in marble beds on and near the south shore of Gambier Bay, Loney (1964) assigned an age of Middle(?) Devonian to the Gambier Bay Formation. Additional collections made north of the bay substantiate this age assignment (pl. 2). As Loney pointed out, however, rocks older than Devonian may be included in the sequence. Edwin Kirk (unpublished data) found corals he referred to as the genera *Favosites* and *Cladopora* in the prominent marble bluff north of Village Point, a locality that was not covered again in the present study. He believed that, although the fossils could be of either Middle or Late Devonian age, the lithology of the marble and associated sedimentary rocks indicated a Middle Devonian age assignment.

No fossils have been found in the Retreat Group. Barker (1957) assigned the group an age of Late Triassic(?) to Early Cretaceous(?) because of its stratigraphic position below unfossiliferous rocks that he correlated with known Cretaceous rocks of Pybus Bay. Because of comparable lithology, structure, state of metamorphism, and stratigraphic position, the Retreat Group is now correlated with the Gambier Bay Formation and is also here considered Middle(?) Devonian.

In age and lithologic type, the rocks of the Retreat Group and the Gambier Bay Formation are similar to Silurian(?) to Middle(?) Devonian clastic sequences on northeastern Chichagof Island (Lathram and others, 1959; Loney and others, 1963) and in the central and southern part of the Chilkat Range (Lathram and others, 1959). In the Glacier Bay area, Rossman (1963) has mapped the Tidal Formation, which has a similar lithology, and which he considers to be of Late Silurian age. The marble sequences are similar to the Kennel Creek Limestone of Middle Devonian age in the Freshwater Bay area (Loney and others, 1963) and Middle Devonian limestones elsewhere in northeastern Chichagof Island, and the Chilkat Range (Lathram and others, 1959).

South of Admiralty Island, Devonian rocks of comparable lithology are widespread (Buddington and Chapin, 1929), but it is not possible to correlate with assurance any particular stratigraphic section with that of Admiralty Island.

HOOD BAY FORMATION

Between the northwest arm of Pybus Bay and the head of the North Arm of Hood Bay, rocks of probable Devonian age consist of a monotonous succession of black argillite, thin-bedded black chert, and minor thin interbeds of black, impure limestone. This section was named the Hood Bay Formation by Loney (1964). The thickness of the formation is unknown. Between Hood and Whitewater Bays a group of similar-appearing rocks is exposed on the beach under the Tertiary flows. These rocks are also assigned to the Hood Bay Formation.

The formation is overlain with angular unconformity by volcanic flows of Tertiary age. Its relationship to other mapped units is less clear. It is in contact with the Cannery Formation of Permian age in

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the Pybus Bay area, but the contact is covered in some places and in others is a fault. The contact between the Hood Bay Formation and the Gambier Bay Formation is also covered everywhere. The two formations are of quite different lithology, the Hood Bay Formation being relatively unmetamorphosed, whereas the Gambier Bay Formation has undergone low-grade metamorphism. The area of cover along their contact is too broad to determine whether the change in metamorphic grade is gradual or abrupt. Lathram and others (1960) correlated the rocks of the Hood Bay Formation with those of known Permian or Triassic age in the Pybus area. However, Loney (1964), on the basis of fossil evidence, showed that these rocks are probably Devonian and suggested that they are correlative with those of the Gambier Bay Formation and that the two formations may intertongue. Thick sections of rocks similar in lithology and age to those of the Hood Bay Formation are known in the Chilkat Range north of William Henry Bay (Lathram and others, 1959).

PERMIAN ROCKS

CANNERY FORMATION

Distribution and lithology.—The Cannery Formation, named by Loney (1964) in the Pybus and Gambier Bays area, is exposed in discontinuous large outcrops throughout a wide belt that extends along the eastern flank of the island from Herring Bay to Young Bay. The formation is least metamorphosed and deformed in its type locality along the shores of Cannery Cove, in Pybus Bay. Another outcrop of slightly metamorphosed and deformed beds, but one which is less accessible, lies atop the ridge southwest and west of Eagle Peak in the northern part of the island.

The dominant lithologies of the Cannery Formation are argillite, graywacke, chert, and phyllite. The argillite is dark gray to black. The graywacke is commonly light to dark gray or greenish gray, lithic, calcareous, and fine to medium grained; it is foliated in the northern part of the island. The amount of argillite increases and the grain size of the graywacke decreases from the northern part of the island southward. Dark-gray to green chert, which occurs in beds as much as 4 inches thick, is common in the area from Pybus Bay to Windfall Harbor, but is less common to rare northward. The chert is recrystallized, and evidence of its origin is thus obscured, but some samples show ghosts of radiolarian tests in thin section. The phyllite is gray, siliceous, finely crenulated, and commonly contains thin ribbons of gray chert. Phyllite is most common at the top of the formation north of the latitude of Windfall Harbor.

Minor constituents of the formation are conglomerate, limestone, marble, and volcanic rocks. Pebble to cobble conglomerate with a graywacke matrix occurs south of Eagle Peak and in the Pybus Bay area. Clasts are composed of dark-gray slate, dark-gray chert, volcanic rock, and limestone near Eagle Peak, and of dark-gray chert and volcanic rock in the Pybus Bay area. Thin discontinuous beds of chocolate-brown-weathering gray limestone are interbedded with the graywacke, phyllite, and conglomerate. When weathered, these beds form distinctive outcrops but the strata are too discontinuous to serve as stratigraphic markers.

Several large masses of marble crop out along westward-trending ridges at about lat. 58°05′ N. For the most part these masses are structureless lenses of white, coarsely crystalline marble. Although their stratigraphic position cannot be accurately determined, the lenses occur near the contact between the Cannery Formation and the overlying Triassic schists. These marble masses are anomalous, but have been included in this formation because they lack the characteristics of the Pybus Dolomite, particularly the characteristic light bluish-gray chert.

Volcanic rocks are rare in the Cannery Formation. Southwest of Eagle Peak a bed consisting of greenstone (ranging in thickness from 75 to 100 ft) caps a thick section of phyllite. South of Gambier Bay a section of light-gray altered pillow lava, possibly several hundred feet thick, crops out. Altered and sheared light-gray aphanitic volcanic breccia occurs locally in the Pybus Bay area.

Several disconnected outcrops comprising rocks of a distinctive lithologic unit cap ridges of Retreat Group schist north of lower Ward Creek and near the headwaters of Ward, Wheeler, and Pack Creeks (pl. 1). Phyllite, marble, chert, and greenschist predominate. The top of the unit is largely dark-gray to black contorted phyllite. Interbedded below this are laminated crinkled fine-grained silvery-gray phyllite, fine-grained light-gray quartz-feldspar schist, thin-bedded gray medium-grained crystalline marble, and massive chocolate-brown-weathering gray marble. The marble contains intercalated fine-grained cross-crinkled, partly graphitic phyllite or sericite schist, light-gray sheared chert, dark-gray chert lenses, and pyritic greenschist. The phyllite commonly contains thin ribbons of light-gray chert. The thickness of this unit is unknown, but probably does not exceed several hundred feet. The dominant feature of the unit is a foliation, which strikes east in the western exposures, gradually changing through northeast to northwest in the northeastern exposures, and which generally dips moderately to the south, southeast, and east. This foliation is parallel to compositional layering in many outcrops but intersects it at various angles in others. The relation of the foliation to large fold structures is not completely understood. No fossils were found in this unit. The rocks are in contact only with the Retreat Group, which they overlie. Many of the rock types, particularly the phyllite, the ribbon chert, and the brown-weathering marble, strongly resemble rocks of the Cannery Formation that is exposed in the northern part of the island. Accordingly, these rocks are considered to be of Early (?) Permian age, although they may be older.

Thickness and stratigraphic relations.—The thickness of the Cannery Formation is unknown, owing to structural complexity, but it may be as much as several thousand feet.

The formation unconformably overlies Devonian schists. (The contact with these older rocks was discussed on page R12). The Cannery Formation is in fault contact with the Hood Bay Formation in the Pybus Bay area.

In the Pybus-Gambier area, the Pybus Dolomite commonly overlies the Cannery Formation, but locally here, and generally throughout the island, the Pybus Dolomite is missing and Upper Triassic rocks rest unconformably on the Cannery Formation. The contact between the Pybus Dolomite and Cannery Formation is poorly exposed, and its nature is uncertain. The unconformity between Permian and Triassic rocks may be angular, but if so, the degree of angularity is slight.

Tertiary rocks rest on the Cannery Formation with angular unconformity southwest of Pybus Bay.

Age.—Fossils have been found in the Cannery Formation southwest of Eagles Peak, on Pack Creek, at Windfall Harbor, and in the area between Pybus and Gambier Bays (pl. 2). Collection 57AL117a from northern Admiralty Island contains the brachiopod *Muirwoodia* sp. (G. A. Cooper, U.S. National Museum, written commun., 1957) which indicates an Early Permian age for this sequence. An assemblage (59 ALy329, USGS 19401–PC) Composed almost exclusively of echinoderm and bryozoan debris from Windfall Harbor was examined by Helen Duncan of the U.S. Geological Survey (written commun., 1960). She states that the occurrence of *Streblascopora*, *Rhombatrypella*, and *Polypora*, in addition to a deformed brachiopod identified by J. T. Dutro, Jr., of the U.S. Geological Survey, as *Spiriferella?* indicate Permian age. On the basis of fossils from the type area, at Pybus and Gambier Bays, Loney (1964) assigned the formation an age of Permian. On the basis of the collection from northern Admiralty Island, the present authors assign it an age of Early Permian.

PYBUS DOLOMITE

The Pybus Dolomite of Permian age (Loney, 1964) is known only in the area between Gambier Bay and Herring Bay, where the dolomite forms ridges and distinctive white bluffs. The formation is structurally complicated, and the complete section is not known. The characteristic lithology is light brownish-gray to white medium-bedded fossiliferous fine- to medium-grained dolomite which contains irregular layers and scattered angular fragments of bluish-white chert. The chert content increases upward, and near the top of the formation constitutes as much as 90 percent of the rock. The formation has a probable maximum thickness of 1,000 feet, although it is commonly thinner or is missing from large areas.

The Pybus Dolomite is overlain unconformably by Upper Triassic rocks, and fragments of Pybus Dolomite are commonly found in the basal Triassic breccia. The contact with the Cannery Formation is not exposed.

UNDIFFERENTIATED PERMIAN AND TRIASSIC ROCKS

Undifferentiated Permian and Triassic rocks include the Barlow Cove Formation, named by Barker (1957), related rocks on Mansfield Peninsula, and a sequence north of Gambier Bay.

On Mansfield Peninsula, albite-epidote-chlorite schist, schistose graywacke, slate, conglomerate, phyllite, and minor augite-bearing schistose volcanic flow breccia and andesite flows form a belt of outcrop east of the Retreat Group from the Barlow Islands to the head of Young Bay. The northern half of the belt is the Barlow Cove Formation considered by Barker (1957) to be Jurassic(?) to Early Cretaceous(?). The southern half of this belt is also assigned to the Barlow Cove Formation by Barker and includes one and possibly several discontinuous beds of coarse-grained marble which contain lenses of quartz conglomerate and breccia. The contact between this unit and the Retreat Group is mostly covered; consequently, the location and nature of this contact are in question (see p. R12). The rocks at the southeastern end of the formation are also covered.

The Barlow Cove Formation and related rocks strike directly into Permian and Triassic rocks to the south. To the east they are in contact with strata of Jurassic and Cretaceous age, but the contact is covered except at Symonds Point. Barker (1957) reports that there, "The laminated graywacke and slate of the Symonds formation conformably overlie the uppermost Barlow Cove greenschist with a sharply defined contact." This contact was reexamined, and the authors agree with Barker. The marble bed exposed at the southwest head of Young Bay contains a few poorly preserved and distorted fossils (pl. 2). Crinoid columnals, corals, gastropods, and a few indeterminate objects that may be pelecypods were collected. Concerning the corals, Helen Duncan reports (written commun., 1958), "The corals are hexacorals related to the genus *Palaestraea* as interpreted by

Squires (American Museum Novitates, No. 1797, 1956). Forms similar to this have been described by Smith from the Upper Triassic of southeastern Alaska (USGS Prof. Paper 141, 1927)." Norman Sohl and E. L. Yochelson of the U.S. Geological Survey examined the gastropods and state (written commun., 1958), "The specimens are incomplete and poorly preserved. No definite age assignment other than post-Cambrian can be given. High spired genera with numerous revolving lirae, similar to two of the three specimens submitted, appear to be relatively more common in the Jurassic and Cretaceous than in the Permian and Triassic." On the basis of this evidence, Lathram and others (1960) assigned an age of Permian and Triassic(?) to the Barlow Cove Formation.

North of Gambier Bay, a large area is underlain by a thick series of dense fine-grained grayish-green andesitic flows and tuffs, minor black chert layers, and micaceous schist. Near Yellow Bear Mountain, aphanitic red and green flows crop out. Some of these flows contain feldspar phenocrysts. Pillow structure is rare. These rocks overlie the Gambier Bay Formation, apparently unconformably. They resemble known Triassic volcanic rocks to the east, but they may also include rocks of Permian age. Accordingly they are assigned an age of Permian and Triassic.

TRIASSIC ROCKS

HYD FORMATION

Distribution and lithology.—The Hyd Formation (Loney, 1964) occurs extensively along the eastern slopes and shores of the island, and generally is exposed east of the area of Permian outcrop (pl. 1). It is comprised of a sedimentary section and a volcanic section. Parts of the sedimentary section are absent north of Gambier Bay, and the volcanic section is largely absent south of the bay.

The most complete section of sedimentary rocks of the Hyd Formation occurs in the Pybus and Gambier Bays area, where the section consists of a basal conglomerate or breccia, a middle limestone, and an upper limestone, slate, and chert unit. The conglomerate or breccia is very distinctive, being composed of angular to subrounded fragments of bluish-white chert, red and green bedded chert, and limestone imbedded in a limestone matrix. The middle limestone is gray to brown weathering, brownish gray, fine to medium grained, and fossiliferous, and it has stylolitic bedding surfaces. The upper unit is thin bedded and consists of varying proportions of alternating dark-gray calcareous argillite or slate, black chert, and gray-weathering black limestone. Minor spilitic flows, commonly including pillow lavas, occur throughout the Hyd Formation in this area.

Outside the area of Pybus and Gambier Bays the sedimentary section is commonly incomplete. The conglomerate is known with certainty only on the peninsula between Chapin and Herring Bays, where it lies directly on the Pybus Dolomite. The middle limestone occurs on the point between Chapin and Herring Bays. The upper unit is widely exposed. It is exposed on the tidal flat north of Carroll Island, and it forms a band which occupies most of the western shore of the northwest-trending bay near the mouth of Gambier Bay and extends north-northwest to the first small lake; it also forms the head of Mole Harbor and is exposed along the beach south of Staunch Point and in Windfall Harbor. The upper unit has not been recognized north of Windfall Harbor; however, a discontinuous bed several hundred feet thick, composed mostly of black slate directly underlies the Triassic volcanic rocks in many places between the approximate latitude of 58°05′ and Young Bay. The slate is apparently conformable with the volcanic rocks, is of approximately the same thickness as the upper unit of the Hyd Formation, and may represent a temporal equivalent of the Hyd.

A thick section of volcanic rocks forms the major part of the Hyd Formation north of Gambier Bay and thickens rapidly northward. Volcanic rocks form the easternmost high ridge from Gambier Bay to Windfall Harbor, the east shore of the head of Windfall Harbor, and the west shore of Seymour Canal from within Windfall Harbor northward toward Swan Cove, and cap the ridges at the headwaters of Greens Creek.

Massive or thick-bedded jasper-bearing red and green amygdaloidal altered basic flows are characteristic. They are commonly schistose, porphyritic, and scoriaceous; many exhibit pillow structure. Columnar jointing was observed on the peak south of Eagle Peak. Breccia is rare. Layers of fine-grained greenschist that probably were originally tuff beds are common in the northern part of the island, but diminish in thickness and number southward, and are rare south of Windfall Harbor.

Altered green andesite flows form most of the ridge between Swan Cove and King Salmon Bay. They are fine to medium grained and contain phenocrysts of hornblende and augite as much as one-eighth inch long. They structurally overlie Jurassic and Cretaceous slate and graywacke and may form the overturned limb of a large fold. They are identical lithologically to some Triassic volcanic rocks in the Eagle Peak area and in Gambier Bay and are of a type that has not been seen in the Jurassic and Cretaceous volcanic section. They are provisionally considered to be a part of the volcanic section of the Hyd Formation.

Thickness and stratigraphic relations.—In the Pybus and Gambier Bays area, the conglomerate has a maximum thickness of 300–400 feet, but is not present everywhere. On the point between Herring and Chapin Bays, the conglomerate is at least 75 feet thick. The middle limestone is probably several hundred feet thick in Pybus Bay, but elsewhere is thinner. The upper unit is very persistent and maintains about the same lithology and thickness along strike for more than 50 miles along the southern and eastern coastline of the island. This unit is generally two to three hundred feet thick. The thickness of the volcanic section varies, but it is as much as several thousand feet in the northern part of the island and in the area north of Gambier Bay.

The stratigraphic position of the volcanic rocks relative to the sedimentary section is not known with certainty. In the northern part of the island, and in many places south of Windfall Harbor, a thick volcanic section overlies a thin sedimentary band. Locally, thin sedimentary sections occur within the lower part of the volcanic section. From this evidence, the authors conclude that most of the volcanic section is younger than the sedimentary section, although some of the volcanic rocks may be equivalent to the younger part of the sedimentary section.

An unconformity apparently occurs everywhere at the base of the Hyd Formation. The relations of these rocks with those of Permian age were discussed above. Near the head of Wheeler Creek, an outcrop of Upper Triassic limestone and chert lies directly on Devonian schists. Although the contact is covered, it is believed to be an unconformity rather than a fault. The absence of diagnostic Early and Middle Triassic fossils in any of the Triassic rocks examined lends further support to the existence of an unconformity and gives some indication of the possible length of the hiatus.

The upper contact, between the Upper Triassic section and the Jurassic and Cretaceous slate and graywacke is almost everywhere concealed. Where it is exposed, the formations are seen to be structurally conformable. The oldest fossils found in the slate and graywacke are Late Jurassic (Portlandian) in age. This age suggests a break in deposition and that the contact is a disconformity. On the north shore of Herring Bay, gently dipping strata containing fossils of Valanginian (Early Cretaceous) age overlie steeply dipping beds containing fossils of Karnian (Late Triassic) age. Beds of Norian (Late Triassic) and Jurassic age are missing. The beds are apparently angularly discordant; however, the contact is covered, and, in view of the structural complexity of the area, may be a fault. The contact between Triassic and Jurassic rocks in the Pybus and Gambier Bays area is a disconformity, and beds of Portlandian age overlie Upper Triassic strata with structural concordance. Three miles south of Staunch Point, sheared graywacke-limestone pebble conglomerate and argillite, considered to be a part of the Jurassic and Cretaceous section, appear to overlie unconformably a sequence of brecciated graywacke, black limestone, chert, and volcanic rocks assigned to the Triassic. A major fault separates the Triassic rocks of Windfall Harbor from the slate and graywacke of Swan Island. The contact between the Triassic and the Jurassic and Cretaceous rocks on Mansfield Peninsula has been discussed previously.

Age and correlation.—Limestone beds in the Hyd Formation are commonly fossiliferous, containing ammonites and pelecypods. Collections from near Carroll Island to Young Bay were studied (pl. 2) by N. J. Silberling of the U.S. Geological Survey (written commun., 1959), who reported that these collections contain definitive forms of Late Triassic age only and represent that portion of Late Triassic time equivalent to the Karnian and Norian Stages of the European time scale. Fossils have not been found in the conglomerate member. The middle limestone member apparently is characterized by a fauna of Karnian age. Collections from this limestone contain *Tropites*, *Juvavites* (*Anatomites*) cf. *J.* (*A.*) *externiplicatus* Mojsisovics, and *Halobia*, cf. *H. ornatissima* Smith. The upper sedimentary member contains fossils of Norian age including *Monotis subcircularis* Gabb and *Heterastridium* sp.

The distribution and correlation of the Triassic rocks of southeastern Alaska have been discussed by Martin (1926) and by Buddington and Chapin (1929). It is difficult to correlate the Triassic rocks of Admiralty Island with Triassic sections to the south which the authors have not examined. To the north, in the Juneau area, the Gastineau Volcanic Group comprises the only known Triassic section. The volcanic rocks of the Hyd Formation are lithologically similar to the volcanic rocks of the Gastineau Volcanic Group, and both are characterized by pillow lavas. The lithology of the sedimentary section in the Gastineau Volcanic Group from which fossils were obtained (Martin, 1926, p. 95) is very similar to that of the upper part of the sedimentary section of the Hyd Formation south of Windfall Harbor. The fossil locality in the Gastineau Volcanic Group was resampled in 1957, and the Late Triassic age was reaffirmed (N. J. Silberling, written commun., 1959). The Gastineau Volcanic Group, however, seems to contain a greater amount of tuffaceous and shaly beds than does the Hyd Formation in the northern part of Admiralty Island. No thick limestone comparable to the middle limestone of the sedimentary section of the Hyd Formation has been described in the Gastineau Volcanic Group.

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JURASSIC AND CRETACEOUS ROCKS

STEPHENS PASSAGE GROUP

The name Stephens Passage Group is given here to the sequence of slate, graywacke, conglomerate, and augite-bearing volcanic flow breccia, Late Jurassic and Early Cretaceous in age, which forms a well-defined northwest-trending belt of rocks exposed along the eastern slopes and shores of Admiralty Island, and bordered on the east by the Gastineau Channel fault and southern Stephens Passage. It extends from Shelter Island in the northwest to Pybus Bay in the southeast (fig. 2). The belt is known to continue farther both northwest and

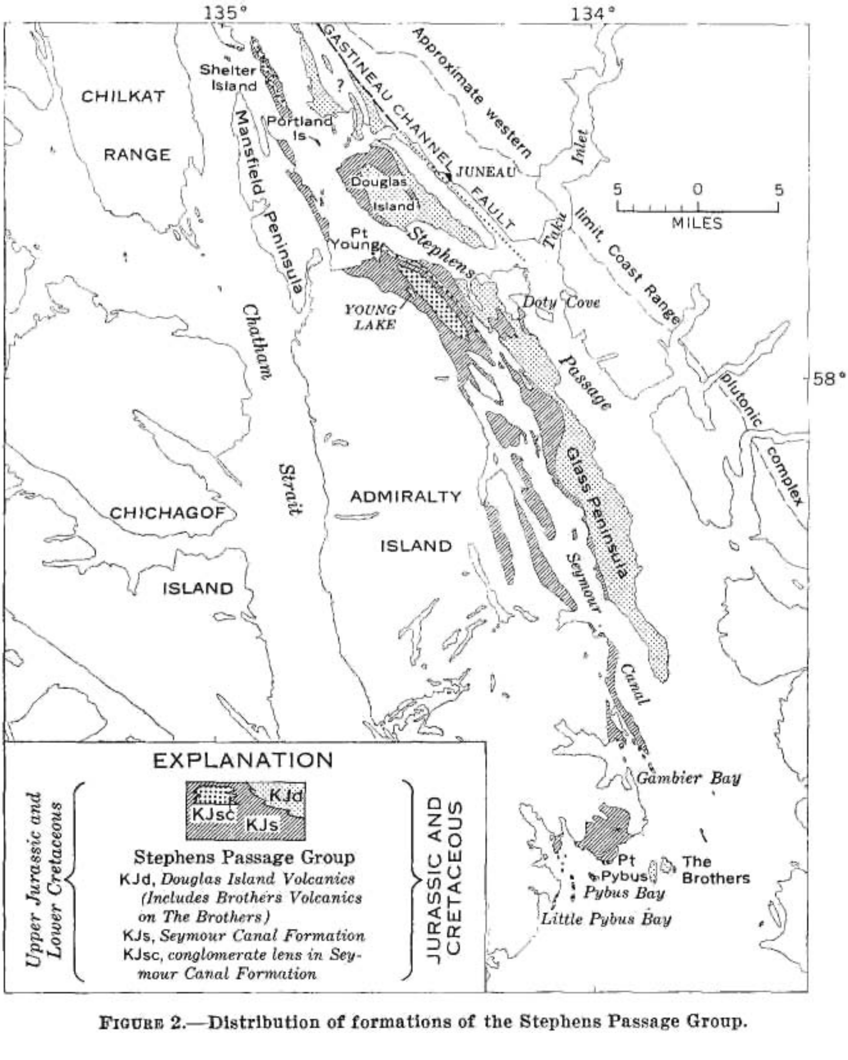

FIGURE 2.—Distribution of formations of the Stephens Passage Group.

southeast (Buddington and Chapin, 1929), but the stratigraphy in these areas has not yet been studied in detail. The name of the group is taken from its type locality, Stephens Passage, the waterway between Admiralty and Douglas Islands along which the formations that the group comprises are best exposed. The formations are the Seymour Canal Formation, the Douglas Island Volcanics (redefined), and the Brothers Volcanics. The thickness of the group is unknown, but may exceed 10,000 feet.

The Seymour Canal Formation is composed mainly of slate and graywacke. It includes all the exposed rocks of the group in the western part of the outcrop belt and is the lowest formation of the group in the eastern part.

Within the Seymour Canal Formation, well above its base, large lenses of graywacke conglomerate composed of rounded clasts occur. These lenses grade into the slate and graywacke both vertically and laterally. The largest lenses are shown on figure 2.

The Douglas Island Volcanics consists principally of augite-bearing volcanic flow breccia and some tuff, graywacke, and slate. This formation forms the major part of the Stephens Passage Group in the eastern part of the outcrop belt. The Brothers Volcanics are a lithologically similar but geographically discrete body of rocks which may be a lens in the Seymour Canal Formation or may be equivalent to the Douglas Island Volcanics and a southern continuation of the Douglas Island Volcanics outcrop belt. The latter interpretation is shown in figure 2.

The formations of the Stephens Passage Group seem to be interrelated parts of a single depositional sequence (inset, fig. 2). The nature of the formational contacts on Glass Peninsula and Douglas Island show conclusively that the Douglas Island Volcanics conformably and gradationally overlie the lower part of the Seymour Canal Formation. Lenses and layers of volcanic breccia identical to the main rock type of the Douglas Island Volcanics occur throughout exposures of the Seymour Canal Formation to the west. Slate and graywacke are interbedded with the volcanic breccia both at the top and bottom of the Douglas Island Volcanics and occur as large irregular bodies within the breccia. These data suggest that the Douglas Island Volcanics occupy a stratigraphic interval equivalent to at least a part of the Seymour Canal Formation and that the two formations intertongue along the central zone of the outcrop belt.

The Stephens Passage Group is Late Jurassic and Early Cretaceous in age. Fossils have been found only in the lower part of the Seymour Canal Formation. They are Kimmeridgian to Portlandian (Late Jurassic) and Berriasian (Early Cretaceous) in age and were collected from beds not separated by an apparent disconformity. Since the fossils were not collected from the basal beds, the possibility that Middle and Lower Jurassic beds exist cannot be ruled out. The Seymour Canal Formation is overlain with angular unconformity by beds of Paleocene age at Little Pybus Bay (Loney, 1964); thus the group is no younger than Late Cretaceous. On Douglas Island, the Douglas Island Volcanics are overlain conformably by the Treadwell Slate, considered Jurassic(?) to Early Cretaceous(?) by Barker (1957). Future mapping may show the Treadwell Slate to be a part of the Stephens Passage Group, but at present the relation of this formation to the Seymour Canal Formation cannot be clearly defined, and the Treadwell Slate is excluded from the group. On Mansfield Peninsula the Seymour Canal Formation conformably overlies the Barlow Cove Formation of Permian and Triassic(?) age (Barker, 1957; Lathram and others, 1960), and farther south on Admiralty Island the Seymour Canal Formation disconformably overlies the Hyd Formation of Late Triassic age (Lathram and others, 1960; Loney, 1964).

SEYMOUR CANAL FORMATION

Distribution and lithology.—Slate, graywacke, and conglomerate form a broad area around Pybus Bay and extend as a belt that trends roughly N. 30° W. from Gambier Bay along Seymour Canal to Young Bay and Stephens Passage (pl. 1). South of Pybus Bay, these rocks crop out only on the northeast shore of Herring Bay. In the Pybus and Gambier Bays area, Loney (1964), named these the Seymour Canal Formation, a name which is applied to the entire belt in this report. On Mansfield Peninsula, Barker (1957) named and mapped the Symonds Formation, which, by analogy with the rocks at Pybus Bay, he believed to be Early Cretaceous(?) in age. The current mapping has shown that the exposures of the Symonds Formation at Symonds Point on Admiralty Island are a northward continuation of the lower part of the Seymour Canal Formation. The Symonds Formation is therefore stratigraphically below the Douglas Island Volcanics (p. R23), rather than above, as Barker believed. Further, rocks of the Symonds Formation are unfossiliferous and are generally exposed in widely separated and discontinuous outcrops. Consequently, these rocks are mapped as the Seymour Canal Formation, and the name Symonds Formation is here abandoned.

Slate and slaty argillite are the dominant rock types. The slate is dark gray to grayish black and contains sparse calcareous beds. The slaty argillite is dark gray and commonly contains beds of lighter gray siltstone that show graded bedding and slump structures. Slaty cleavage is poorly developed and widely spaced in the fine-grained rocks south of Gambier Bay but is progressively better developed and more closely spaced to the north. The slate in the Young Bay area is very fissile.

The graywacke is medium to dark gray, fine to coarse grained, lithic, and commonly calcareous. Graded bedding is common. Slate particles predominate in the coarser grained graywacke. South of Gambier Bay, the graywacke shows little or no internal deformation, but eastward and northward in the belt of outcrop it becomes progressively more foliated and in the Young Bay area is schistose.

Conglomerate forms thin discontinuous lenses interbedded with the slate and graywacke at many places throughout the section. Thick units of conglomerate crop out at Point Pybus, on the islands in the mouth of Pybus Bay, and on the ridge between Young Lake and Oliver Inlet. These thick units are shown separately on the geologic map (pl. 1). A conglomerate belt several hundred feet thick within the slate and graywacke that extends nearly continuously from Point Young southeastward to the head of Seymour Canal is also shown on the geologic map. The conglomerate is thickly bedded to massive, and its clasts range from pebbles to cobbles. Sorting as to size is poor. The clasts are well rounded and imbedded in a graywacke matrix. The most common clasts are argillite, banded graywacke, light- to medium-gray limestone, marble, felsite, quartz, chert, granite, and quartz diorite. Dark-gray to black argillite fragments form the dominant clasts in the Young Lake area and are abundant but subordinate to limestone and marble clasts in the Pybus Bay area. Pebble counts made at several places indicate that the composition is extremely variable. The conglomerate at Point Pybus intertongues laterally with slate and graywacke both at the northern end of the outcrop and to the south on the San Juan Islands. The conglomerate east of Young Lake is exposed as a high, resistant ridge above a lowland composed of less resistant slate and graywacke. The beds of this conglomerate are believed to have intertongued laterally with slate and graywacke also, but these less-resistant lateral equivalents have been removed by erosion.

The conglomerate on Shelter Island was mapped as part of the Shelter Formation by Barker (1957), who suggested that this conglomerate "may grade by a facies change into the Symonds formation on Douglas Island * * *." The lithology and relation of the conglomerate in the Shelter Formation to the slate and graywacke sequence are similar to those of the conglomerate lenses in the Seymour Canal Formation to the south. This similarity suggests that the Shelter Formation is a similar lens and future mapping may prove it to be a member of the Seymour Canal Formation.

Thin layers, lenses, and concretionary nodules of limestone occur locally, as at Herring Bay. Lenses and layers of volcanic flow breccia that contain conspicuous phenocrysts of augite are interbedded with the slate and graywacke on Horse Island (Barker, 1957), on the small island southwest of Point Young, on the shore between Point Young and Oliver Inlet, on Bug Island in Seymour Canal, and at several places along the west shore of Glass Peninsula.

Black pyritic slate crops out on the shore of Glass Peninsula opposite Grand Island. Pyrite cubes are unusually large, and crystals an inch long are common.

Thickness and stratigraphic relations.—The thickness of the Seymour Canal Formation is unknown because intense folding and lack of marker beds preclude accurate measurement. In the Pybus Bay area, Loney (1964) has estimated a minimum thickness of 4,000 feet and believes the formation may be as much as 8,000 feet thick. The conglomerate lens east of Young Lake is approximately 3,500 feet thick.

The Seymour Canal Formation disconformably overlies Triassic rocks (p. R20). Along most of Glass Peninsula, the Seymour Canal Formation is overlain by the Douglas Island Volcanics in normal stratigraphic sequence, and the contact is conformable and gradational. Near the head of Seymour Canal and east of Swan Island, large areas underlain by rocks of the Seymour Canal Formation lie on the projection of the strike of beds of the Douglas Island Volcanics. This change in rock type is probably the result of lateral intertonguing of the two formations, but the contacts are covered and could not be studied. At Little Pybus Bay, the Seymour Canal Formation is overlain with angular unconformity by Tertiary rocks.

Age and correlation.—Fossils in the slate and graywacke of the Seymour Canal Formation have been collected in the Pybus and Gambier Bays area (Loney, 1964) and also at Herring Bay (pl. 2). Those in the former area are characterized by the pelecypod *Buchia* and range in age from Late Jurassic (middle Kimmeridgian) to Early Cretaceous (Berriasian) (Loney, 1964). At Herring Bay, *Buchia cf B. crassicollis* (Keyserling) was collected. This fossil was identified and assigned an age of early Early Cretaceous (middle to late Valanginian) by N. J. Silberling, assisted by D. L. Jones of the U.S. Geological Survey (written commun., 1959). This evidence supports the assignment of the Seymour Canal Formation to Late Jurassic and Early Cretaceous age by Loney. One poorly preserved bryozoan fragment was found as a pebble in the conglomerate east of Young Lake. This find serves only to indicate that the conglomerate was deposited in post-Permian time (Jean Berdan, U.S. Geological Survey, written commun., 1957). Several Early Cretaceous (Berriasian) collections are associated with the conglomerate at Point Pybus and give a better indication of its age. Fossils of Lake Jurassic and Early Cretaceous age are found near each other. Loney states, in reference to these occurrences, that the Lower Cretaceous beds are generally east of the Upper Jurassic beds, but there is no evidence of a stratigraphic break between them.

An outcrop belt of slate, graywacke, and conglomerate similar to the rocks of the Seymour Canal Formation continues from Pybus Bay northwestward through Stephens Passage to Berners Bay. In the Berners Bay and Eagle River areas, Knopf (1911, 1912) included these rocks in his Berners Formation, a name now abandoned.

The belt of slate, graywacke, and conglomerate also continues southeastward from Admiralty Island (Buddington and Chapin, 1929), but detailed correlation in this area is not yet possible.

DOUGLAS ISLAND VOLCANICS

A thick sequence composed mostly of augite-bearing volcanic flow breccia forms a belt that underlies most of Glass Peninsula. This belt, projected northwestward along strike across Stephens Passage, coincides with a belt of lithologically identical rocks that form the main ridges of Douglas Island and which were named the Douglas Island Volcanic Group by Martin (1926). The rocks form a coherent mappable unit not susceptible to subdivision over broad areas, which is here reduced to formation status. Accordingly, the volcanic rocks exposed on Glass Peninsula are mapped as the Douglas Island Volcanics.

Distinctive porphyritic volcanic flow breccia is the dominant rock type. Clasts are composed of the same material as the matrix and seem to consist of solidified fragments of a flow incorporated by later movement of the flow. The phenocrysts are as much as a half inch in diameter and are generally augite, although hornblende is common; feldspar phenocrysts are rare. The augite phenocrysts are set in a dense grayish-green to green altered basaltic or andesitic groundmass. The breccia is generally massive, and bedding planes are poorly developed. It is the most common rock type in the highland areas of Glass Peninsula but is less widespread along the eastern shore of Seymour Canal. On the eastern coast of the peninsula the breccia is schistose. Massive and schistose nonporphyritic flows are also present, but uncommon. A few thin tuff beds also occur. The flows and tuff beds are limited to the lower part of the section and are interbedded with slaty argillite. Slate is commonly interbedded with the breccia in the highland areas.

The Douglas Island Volcanics conformably overlies rocks which are a part of the Seymour Canal Formation, and the contact between the two units is gradational. Sedimentary structures of the siltstone and graywacke beds underlying the volcanic rocks show that the section is upright. On Glass Peninsula, beds of the Douglas Island Volcanics probably intertongue laterally with beds of the Seymour Canal Formation (p. R26). The thickness of the Douglas Island is variable, but it is at least 3,000 feet. The Douglas Island was considered to be late Jurassic(?) by Martin (1926, p. 255–256) and Jurassic(?) to Early Cretaceous(?) by Barker (1957). On the basis of the stratigraphic relation of the Douglas Island Volcanics to the Seymour Canal Formation, the present authors assign the former a Late Jurassic and Early Cretaceous age.

Volcanic rocks crop out along the mainland northwest of Douglas Island and extend northwestward almost to Berners Bay. They are identical lithologically to the Douglas Island Volcanics and have been correlated with this formation by many previous workers (Spencer, 1906; Knopf, 1911, 1912; Eakin, 1918, and unpublished data, 1922; Martin, 1926; Buddington and Chapin, 1929; Barker, 1957). Similar rocks have been reported to the south (Buddington and Chapin, 1929) associated with the belt of Jurassic and Cretaceous graywacke and slate that trends southeast through Kupreanof Island and east of Clarence Strait.

BROTHERS VOLCANICS

Volcanic rocks similar to those of the Douglas Island Volcanics compose the isolated Brothers Island and were named the Brothers Volcanics by Loney (1964). These rocks are geographically discrete and may prove to be either a lens in the Seymour Canal Formation or equivalent to the Douglas Island Volcanics as a southern continuation of its outcrop belt. The Brothers Volcanics is mapped with the Douglas Island Volcanics in this report.

TERTIARY ROCKS

KOOTZNAHOO FORMATION

Distribution and lithology.—The Kootznahoo Formation (new name) is here named for Kootznahoo Inlet, along which typical exposures may be seen (pl. 1). The formation is composed of nonmarine clastic rocks. It mainly occupies the lowland bounded by Favorite Bay, Kanalku Bay, Davis Creek, and Mitchell Bay on the west, southeast, and east and the low foothills northwest of Kootznahoo Inlet and Mitchell Bay. Favorite Bay and Davis Creek appear to lie along the traces of faults. The strike of the beds, which is generally north in the southwestern part of the area, changes gradually to northeast in the central and north-central parts and to northwest in the eastern part. The prevailing dip is about 45° in a southeasterly or easterly direction.

Similar rocks form a belt which underlies most of Little Pybus Bay and continues north nearly to Cannery Cove (pl. 1). Loney (1964) has suggested they are roughly correlative with rocks herein called the Kootznahoo Formation, and they are mapped with the Kootznahoo Formation in this report. The regional dip of this belt is approximately 15° to the west.

The dominant rock types in the Kootznahoo Formation are pebble to cobble conglomerate, fine-grained to conglomeratic arkosic sandstone, lithic sandstone, calcareous siltstone, carbonaceous shale, lignite, and subbituminous coal. Conglomerate with lithic sandstone matrix constitutes most of the exposures northwest of Kootznahoo Inlet and Mitchell Bay. Minor conglomeratic sandstone, siltstone, and shale are interbedded with the conglomerate. Along the north shores of Kootznahoo Inlet and Mitchell Bay, the conglomerate is moderately to well cemented and is poorly to moderately sorted. Pebbles are commonly black, gray and white chert, and light-gray quartz. Argillite, phyllite, slate, and dark-gray schist fragments are also common. Graywacke pebbles are less common. Plutonic rocks similar to types found in the batholith at Thayer Lake occur as clasts in the conglomerate on the northeast shore of Mitchell Bay and along Freshwater Lake. On the northwest side of the prominent hill 4 miles north of Angoon the conglomerate contains poorly sorted clasts of black chert, argillite, and gray quartz as much as 4 inches long. At the top of the hill, black argillite clasts predominate.

Southwest of Kootznahoo Inlet and Mitchell Bay, sandstone, siltstone, and shale make up most of the formation. The arkosic sandstone is friable, and beds commonly show crossbedding. The carbonaceous shale commonly contains abundant plant fossils, particularly at Sullivan Point and Diamond Island. Coal beds and lenses that are as thin as 1 inch and rarely as thick as 4 feet are locally intercalated with the fine-grained sediments. Conglomerate crops out along the east shore of Favorite Bay, but eastward it grades rapidly into sandstone and siltstone. Pebbles of black phyllite and argillite are the dominant constituents of the conglomerate at the mouth of the bay; the phyllite and argillite decrease in amount southward, and at the head of the bay are equalled in amount by gray and white chert and quartz. Scattered but conspicuous conglomerate beds of small lateral extent are found near Davis Creek between Kanalku and Mitchell Bays.

At Little Pybus Bay the formation comprises coarse-grained lithic sandstone and conglomerate. Phyllite fragments are especially abundant in the sandstone. The conglomerate contains rounded pebbles and cobbles of diorite, basalt, graywacke, phyllite, and quartz, and the matrix resembles the lithic sandstone interbeds.

Thickness and stratigraphic relations.—The thickness of the Kootznahoo Formation is only approximately known. Faults whose strike parallels that of the bedding have been found and are believed to be abundant. The faults are believed to be normal ones on which the northwest side has moved down; thus the beds are duplicated. The formation is believed to be wedge shaped, the thickest area occurring southeast of Kootznahoo Inlet. This thickness is probably about 5,000 feet. The section at Little Pybus Bay is approximately 2,000 feet thick (Loney, 1964), but the formation thins northward and disappears south of Cannery Cove.

The Kootznahoo Formation lies with angular unconformity on the Gambier Bay Formation at the southern end of Kanalku Bay and on the Seymour Canal Formation at Little Pybus Bay. In Kootznahoo Inlet, the Kootznahoo Formation unconformably overlies plutonic rocks. In the type area, the upper surface is erosional, and no younger bedded rocks occur. In the Little Pybus Bay area, the formation is overlain conformably by the Admiralty Island Volcanics.

The conglomerate and finer sediments of the Kootznahoo Formation are believed to represent temporally equivalent facies within a wedge-shaped body of terrestrial sediments. Conglomerate was deposited near the source and graded laterally into finer sediments away from it. Coal beds are associated with the finer sediments.

Age and correlation.—Fossil flora have been collected at several localities in the type area. Edwin Kirk (unpublished data) in 1918 collected material which was identified by F. H. Knowlton. Knowlton's report has never been published; he assigned the sequence to the Eocene and stated that the flora was similar to that found in the Kenai Formation of south-central Alaska.

Fossil flora from the Kootznahoo Inlet area were collected again by J. A. Wolfe of the U.S. Geological Survey in 1961 (pl. 2), and his report is as follows (written commun., 1963):

> Most of the fossil plants collected from the Kootznahoo Formation are poorly preserved, and thus many specific and generic determinations are of questionable value. Nevertheless, the lowest floras are strikingly different from those from the highest part of the section collected, and a third type of flora occurs between these other two floras.
>
> The lowest flora collected (loc. 9822) contains "*Ulmus*" *pseudodbrauni*, *Ocotea* sp., Dilleniaceae, and *Dryophyllum* sp.; these forms are found in floras that are in the upper half of the Eocene or lowermost Oligocene. Notably lacking from the flora at 9822 are Betulaceae, Aceraceae, and Salicaceae.
>
> The middle type of assemblage in the Kootznahoo Formation (localities 9825, 9826, 9827, 9829) is dominated by *Carya magnifica*, *Juglans orientalis*, *Alnus alaskana*, *Cercidiphyllum* aff. *C. crenatum*, *Vitis atwoodi*, *Populus* sp., and "*Ficus*" *alaskana*. It is difficult to determine the age of this assemblage because most of the species are endemic to the Kootznahoo, or, if known from other Alaskan floras, occur in floras whose age is also somewhat in doubt. Several of

the species listed above were originally said to have come from Cook Inlet (Newberry, 1883) and would therefore be from the Kenai Formation. It is almost certain, however, that the specimens were mislabeled and actually came from Kootznahoo Inlet. *C. magnifica* and *J. orientalis* are restricted to Oligocene rocks elsewhere in Alaska and the Northwest, and it is probable that the middle Kootznahoo assemblage is Oligocene, although not in the earliest part of that epoch. There are some differences between the various floras of the middle type of assemblage, but the collections are too small and poorly preserved to consider the age significance, if any, of these differences.

The highest Kootznahoo assemblage (localities 9824, 9826, 9828) contains *Fagus antipofi*, *Quercus furuhjelmi*, *Comptonia naumani*, and *Populus lindgreni*. This type of flora is typical of other rocks of early Miocene age in Alaska.

Thus the floras from the [type area of the] Kootznahoo Formation indicate that [there] this unit contains rocks ranging in age from probably late Eocene through early Miocene.

Fossils were also collected by Wolfe from the beds at Little Pybus Bay. Concerning these Wolfe states (written commun., 1963):

The flora from loc. 9831 contains: *Glyptostrobus* cf. *G. nordenskioldi*, *Metasequoia occidentalis*, *Dioon praespinulosum*, *Laurus hamiltonensis*, *Malpoenna magnifica*, *Sassafras alaskanum*, and *Dillenites microdentatus*. All of these species occur in the Tertiary flora on Hamilton Bay, Kupreanof Island. The age of the Hamilton Bay flora is based on the occurrence of several species characteristic of the Paleocene in North America: *Onoclea hesperia*, *Carya antiquora*, "*Quercus sullyi*," and *Planera microphylla*. The lack of these species in the present collection from loc. 9831 is probably a function of the small collection. The high degree of conspecificity between the Hamilton Bay and Little Pybus Bay floras indicates a similar age, that is, Paleocene.

On the basis of the fossil evidence, the Kootznahoo Formation as mapped in this report is considered to be Paleocene through Miocene in age. To the north, sedimentary rocks which may be correlative have been found underlying the volcanic rocks of Pleasant Island (Lathram and others, 1959).

ADMIRALTY ISLAND VOLCANICS

Distribution and lithology.—The Admiralty Island Volcanics (Loney, 1964) occupies an area of roughly 350 square miles on the southern end of Admiralty Island. These volcanic rocks extend northward to the North Arm of Hood Bay on the west coast and virtually to Pybus Bay on the southeast coast. They form a broad elongate basin whose axis trends roughly northeast. Older rocks are exposed only on the perimeter, in unconnected areas at Chaik, Whitewater, Hood and Herring Bays, and in the area east of Murder Cove. In general, the strata incline toward the center of the basin at angles of 25° or less.

The formation consists of basalt or andesite flows that are commonly dark gray and less commonly light gray, grayish green or red. A representative suite of 31 samples was collected for thin-section study. The results show that no significant compositional or textural change occurs either stratigraphically through the sequence or laterally across the outcrop area. The flows are commonly sparsely porphyritic and often contain phenocrysts of labradorite-bytownite and augite set in a finely crystalline groundmass. Phenocrysts of olivine are uncommon, and hypersthene was noted in one thin section. Some flows are scoriaceous; others contain amygdules of calcite and chalcedony. Tuff and breccia beds are commonly interlayered with flows in the lower part of the sequence. Felsic rocks are rare. Near Cannery Cove and on the west side of Chapin Bay, felsic tuff and breccia beds occur. An altered felsic flow is exposed in the highland area 3 miles west of Herring Bay.

Locally the flows are altered and sheared along major linears believed to be faults of considerable displacement. Along a fault zone on the west side of Surprise Harbor, the flows are intensely sheared and are mottled red and green. Along the Eliza fault complex folding can be seen on the east side of Eliza Harbor about 1½ miles north of Liesnoi Island.

In several places sedimentary sandstone and conglomerate are interbedded with flows and tuff beds at the base of the Admiralty Island Volcanics. Although some of these sedimentary rocks are lithologically similar to and may be correlative with the Kootznahoo Formation, they are all too small in outcrop area to map separately and are therefore included with the volcanic formation. A typical exposure is a basalt pebble conglomerate at Whitewater Bay, 1 miles southeast of Lone Tree Islet. The largest exposure of these rocks forms the east side of the peninsula separating Surprise Harbor from Murder Cove and extends through the head of the cove for an unknown distance northward. On the peninsula a homoclinal sequence of basaltic flows, arkosic sandstone, conglomerate, and breccia is exposed. Coal beds occur 2 miles north of the head of Murder Cove (Wright, 1906, p. 152–153).

Thickness and stratigraphic relations.—Volcanic rocks 9,500 feet thick have been measured in a continuous section west of Donkey Bay (Loney, 1964). This section, on the eastern edge of the basin, is incomplete because the top is eroded. Westward, toward the center of the basin, younger flows occur. Although the area is faulted, the younger flows are probably as much as 2,000 feet thick. The total exposed thickness, therefore, is about 10,000 feet, but because the top of the formation is everywhere an erosion surface, the original thickness is unknown.

The Admiralty Island Volcanics lie conformably on rocks assigned to the Kootznahoo Formation in Little Pybus Bay. Elsewhere, the formation lies with angular unconformity on pre-Tertiary rocks. This contact is exposed near Herring, Chapin, Chaik, Whitewater, and Hood Bays.

Age and correlation.—Fossils have been found within the sedimentary rocks interbedded with the volcanic rocks at Murder Cove. Of these fossils, J. A. Wolfe (written commun., 1961) states:

WP–6114. Coords. on Sitka (A–2) quad., 1:63,360: long 134°34′00″ W., lat 57°1′20″ N. (3.74, 1.48). Murder Cove.

Fossils identified:

Conifers:

Metasequoia glyptostroboides Hu and Cheng Dicot:

Alnus alaskana Newb.

Acer sp.

Age: The collection from Murder Cove is small, and the leaves are not well preserved. The presence of *Alnus alaskana* indicates a correlation with the middle Kootznahoo assemblage, and hence an Oligocene age is probable.

Inasmuch as the formation conformably overlies Paleocene rocks at Little Pybus Bay and contains rocks of Oligocene age near its base, it is considered to be Eocene and Oligocene in age. Buddington and Chapin (1929) correlated this formation with the volcanic rocks of Kuiu, Kupreanof, and Zarembo Islands which they considered to be of Eocene(?) age. To the north of Murder Cove, volcanic flows of comparable age and lithology crop out on Pleasant Island and on The Sisters in Icy Strait (Lathram and others, 1959).

QUATERNARY SEDIMENTARY DEPOSITS

Unconsolidated sedimentary deposits consist mainly of alluvium, glacial material, and talus. High-level terraces of fossiliferous marine gravel, sand, and clay occur in places, but these deposits are too small to be shown at the scale of the map.

UNDIFFERENTIATED METAMORPHIC ROCKS

Some of the rocks have been so metamorphosed that criteria for distinguishing stratigraphic units have been obscured or destroyed. These units have been combined into a group of undifferentiated metamorphic rocks on the map (pl. 1). Parts of the group are contiguous to the less metamorphosed formations that range in age from Devonian to Cretaceous. The most widespread rock types are hornblende-albite-epidote hornfels, micaceous schist, metamorphosed chert, coarse-grained marble, slate, and phyllite.

The largest area underlain by these rocks is a belt about 25 miles long extending from Mount Distik and Yellow Bear Mountain northwest to Ward Creek. This area is partly bounded on the west by the batholith at Thayer Lake and on the east by the plutons between Hasselborg Lake and Pleasant Bay.

Less extensive metamorphic rocks are associated with two intrusive bodies north of the west end of the Gambier fault. The nature of the western part of these rocks is little known; the terrain is low and covered, and outcrops are scarce. Small masses of hornfels occur south and west of Point Arden and are associated with the intrusive body at Doty Cove.

MIGMATITE, GNEISS, AND FELDSPATHIC SCHIST

Three large areas of mixed rocks, closely associated with exposures of plutonic rock, have been mapped separately (pl. 1). They consist of migmatite, of gneiss, and of several types of schist that contain large porphyroblasts of feldspar.

At the east end of Lake Florence, an area that contains poor exposures is underlain by hornblende-biotite-quartz-plagioclase gneiss and hornblende-diorite gneiss. In the high mountains northwest of Hasselborg Lake, gabbroic, dioritic, and granitic plutonic rocks are mixed with hornfels, schist, and amphibolite.

The largest mass of migmatite and gneiss lies west of the head of Seymour Canal, but its eastern exposures are poor. A small granite body, whose boundaries are gradational with the surrounding gneiss, crops out near the center of the area. The gneiss differs in mineralogy depending on metamorphic grade and original composition, but in general these rocks are characterized by thin layers of quartzofeldspathic rock alternating with mica and chlorite schists and amphibolite. Porphyroblasts of plagioclase, as much as several millimeters in diameter, are common in all the rock types. These porphyoblasts as well as the quartzofeldspathic layers decrease in size and number away from the center of the migmatite area. There appears to be a corresponding decrease in metamorphic grade, but the meager petrographic data do not permit determination of the metamorphic zones or facies represented. The quartz-albite-epidote association, indicative of the greenschist or albite-epidote hornfels facies (Fyfe and others, 1958) appears to be widespread, whereas the calcium-bearing plagioclase-hornblende association, indicative of the almandine amphibolite or hornblende hornfels facies, appears to be more restricted areally. The following are representative rock types: quartz-andesine-hornblende-biotite amphibolite, andesine-garnet-pyroxene gneiss, quartz-andesine-diopside-microcline-calcite gneiss, quartz-albite-chlorite-epidote schist, and quartz-albite-chlorite-biotite-epidote schist. Chloritization and sericitization are widespread in the higher grade rocks. Granite pegmatite dikes are common in the feldspathic schists along the northeastern boundary of the area.

PLUTONIC ROCKS

Plutonic rocks are exposed over about 10 percent of Admiralty Island. They range from felsic to ultramafic types, but most are of intermediate composition. Because contacts with the intruded rocks are generally covered, discussions of relationships are largely inferential.

FELSIC PLUTONIC ROCKS

Allanite-biotite granite, biotite-quartz monzonite, and quartz-albite-microcline pegmatite form a small plutonic body surrounded by migmatite a few miles west of King Salmon Bay. Nearby rocks as young as Jurassic and Cretaceous have been metamorphosed.

INTERMEDIATE PLUTONIC ROCKS

A batholith that underlies almost 150 square miles is centered around Thayer Lake to the north of Kootznahoo Inlet and extends inland about 16 miles from the west coast of the island. Analysis of a few thin sections shows that the dominant rock constituents are hornblende-biotite quartz diorite, hornblende-biotite granodiorite, and biotite granodiorite. Small bodies of hornblende gabbro are scattered throughout the batholith, and pink granite underlies a small area at and north of Thayer Lake Lodge. The contact between the batholith and adjacent rocks is generally covered but is apparently crosscutting. Near the contact the effects of contact metamorphism have, in many places, been superimposed on those of regional metamorphism. On the west coast of the island, low-grade schist, marble, and chert of the Retreat Group have been altered to amphibolite, biotite-hornblende-garnet schist, garnet-epidote-calcite rock, and sugary-textured quartzite. North and east of the batholith, the rocks have been metamorphosed to gneiss and hornfels. The southern border of the batholith is mostly covered. Rocks of the batholith are poorly to well foliated, but the trend of the foliation relative to that of the invaded rocks was not studied in detail. Strata ranging in age from Devonian to Early Cretaceous have been metamorphosed. Rocks of the Kootznahoo Formation near the batholith are unaltered, and the conglomerate beds at Mitchell Bay contain a sparse amount of pebbles lithologically similar to plutonic rocks of the batholith. Hence, the batholith probably was intruded after Early Cretaceous time and prior to Paleocene time.

Other small plutons that are lithologically similar to the batholith at Thayer Lake crop out at, and to the northwest of, Hasselborg Lake, at Mitchell Bay, between Mitchell and Gambrier Bays, north of Hood Bay, and on the west coast of the island near Fishery Point. These plutons are probably satellites of the batholith.

Barker (1957) has discussed the pluton that forms the western part of Mansfield Peninsula from False Point Retreat to a poorly defined cove 4 miles south of Funter Bay. The pluton consists mainly of albite-oligoclase-biotite quartz diorite. It is lineated, well foliated, and sheared. The trend of the foliation is parallel to that of the country rock. Barker indicates that the pluton was intruded after the formation of the schistosity in the Retreat Group and that, after solidification, the intrusive rock was deformed and metamorphosed in a later stage of the orogeny.

The plutonic rocks exposed on Grand Island and around Doty Cove and Oliver Inlet are probably parts of a single stock. The rocks are dominantly hornblende-biotite-quartz diorite. The contact with the country rock is generally concealed, but is apparently crosscutting. There are several small areas of hornfels adjacent to the contact on the northeastern coast of Glass Peninsula; however, contact metamorphic effects are not widespread. Some phases of the pluton are directionless and some are poorly to moderately foliated. Jurassic and Cretaceous volcanic rocks, slate, and graywacke have been intruded and metamorphosed by the pluton.

The three small bodies of possible plutonic rock immediately north of Beaver Lake could not be examined in the field owing to vegetative cover. These bodies were mapped by photointerpretation, and their composition is unknown.

MAFIC AND ULTRAMAFIC PLUTONIC ROCKS

Mafic and ultramafic plutonic rocks crop out at and near Mole Harbor, near Point Marsden, and in the mountains southeast of Hawk Inlet. The largest body is near Pleasant Bay and Mole Harbor. It is predominantly hornblendite and foliated, saussuritized augite-hornblende gabbro and, less commonly, augite-uralite diorite and augite-hornblende diorite. Parts of the body are gneissose. At the mouth of Mole Harbor, sheared siliceous graywacke and slate of Jurassic and Cretaceous age are cut by dikes of hornblendite and gabbro that probably emanated from the gabbroic body to the west. The pluton west of the head of Mole Harbor is hornblendite.

A sill-like body of ultramafic rock at least 500 feet thick crops out on the coast about 2 miles south of Point Marsden. The body is mostly serpentinite composed of antigorite, carbonate minerals, and talc. Two bodies of serpentinized periodotite or pyroxenite occur in the mountains about 4 miles southeast of Hawk Inlet. One is crudely layered and probably more than 200 feet thick; the other is too poorly exposed to determine its structure or size. These bodies intrude schists of the Retreat Group.

Small masses of hornblende-plagioclase rock too small to show on the map are scattered throughout the area south and west of Mitchell Bay.

STRUCTURAL GEOLOGY

The structure of Admiralty Island is too complex to permit more than general conclusions to be reached at the scale of mapping employed. Several broad structural features can be recognized.

ADMIRALTY ANTICLINORIUM

The name "Admiralty anticlinorium" is here given to the complex positive structural element that trends roughly northwest from the Pybus-Gambier Bays area to west of Hawk Inlet. The trend is deduced from the distribution of younger formations along the flanks of the Devonian schist and marble core. The structure is cut off on the west by the Chatham Strait fault (p. R40) which trends nearly north. Formations of Permian and Mesozoic age form the northeastern flank. The trend of the anticlinorium, if projected to the southeast, would coincide with the trend of the Duncan anticlinorium (Buddington and Chapin, 1929, p. 299), which can be traced through northern Kupreanof Island, along Duncan Canal, and through Zarembo Island.

Within the anticlinorium most known major folds are folds in the foliation. The foliation is believed to be parallel to the axial planes of earlier folds in the bedding about which little is known. The folds in the foliation have no simple relation to the stratigraphic sequence, and field evidence indicates that the bedding in schists has been generally disrupted and transposed into discontinuous layers subparallel to the foliation. These folds are mapped as antiforms, or synforms (Bailey and others, 1939), to distinguish them from anticlines or synclines—folds in which the attitude of the bedding can be determined.

The axial planes of the major folds generally strike northwest and dip steeply, although near Gambier Bay the axial planes dip moderately northeast. Another local variation in orientation occurs west of Young Lake on the eastern flank of the anticlinorium. A large anticline, overturned to the northeast, is reflected in the areal distribution of the Permian and Triassic formations. The limbs are complicated by minor folds, and the attitude of the bedding is therefore not everywhere consistent with the major structure. The trace of the axial plane of the large anticline trends more to the west than do the axial traces of other folds in the anticlinorium, but its axis is parallel to the axes of other folds. The anticline plunges about 15° to the southeast. The dip of the axial plane of this fold is variable and difficult to determine, but is probably about 50°–60° SW. Near the crest of the anticlinorium in the headwaters of Ward, Wheeler, and Pack Creeks, questionable Permian beds (p. R15) may be the remnants of one or both limbs of a large isoclinal recumbent fold, overturned to the northeast.

JUNEAU SYNCLINORIUM

The Juneau synclinorium (Buddington and Chapin, 1929, p. 298) adjoins the Admiralty anticlinorium on the northeast. Permian and Triassic strata overlie the northeastern flank of the Admiralty anticlinorium on Admiralty Island. Permian rocks recur along the coast of the mainland at Taku Harbor. These rocks were examined by the authors in 1957, and fossils were collected which are of Permian age (J. T. Dutro, Jr., oral commun., 1957). Late Triassic rocks crop out on the mainland east of Gastineau Channel (Martin, 1926). Jurassic and Cretaceous strata underlie Seymour Canal and Glass Peninsula between these two belts of older rock. The Jurassic and Cretaceous strata in the synclinorium are complexely folded, but on Glass Peninsula the contact between the Seymour Canal Formation and the stratigraphically overlying Douglas Island Volcanics dips regionally to the northeast. Hence, probably only the western flank of the synclinorium is exposed on Admiralty Island. Structures in the Juneau synclinorium are more strongly oriented in a northwest direction than those in the Admiralty anticlinorium, and the folds are predominantly overturned to the southwest.

TERTIARY BASINS

Rocks of Tertiary age are exposed in two large basins. In the Kootznahoo Inlet area, rocks of the Kootznahoo Formation represent deposits of coalescing streams entering an intermontane basin. Coarse material was deposited in alluvial fans near the source, on the flanks of the mountains; sand and silt were deposited further out in the basin, and coal formed in the low swampy areas on the level floor. These strata dip southeast an average of 45°. On southern Admiralty Island, flows of the Admiralty Island Volcanics dip inward and form a broad basin which has a general axial trend of northeast. There is no evidence that the basins were connected, although they may have been. No volcanic rocks occur in the Kootznahoo Inlet area. Basaltic feeder dikes are abundant south of the Gambier fault, and rare to absent north of it. These facts imply that the Tertiary volcanism was limited to the area south of Hood Bay and never reached Kootznahoo Inlet.

There is no evidence that the Tertiary rocks have been folded. Only one small fold was observed, on Lighter Creek, and this fold was along the trace of a probable major fault. The dip of the strata in the

Kootznahoo Inlet area is probably the result of the tilting of the beds to the southeast through vertical movement on northeast-trending faults. The inward dip of the flows is probably due to subsidence of the central area under the weight of the thickest section, augmented by later movement along normal faults.

Buddington and Chapin (1929, p. 303–304) pointed out that the Jurassic rocks on the southern end of Admiralty Island have been folded about two axes, one trending northwest and the other trending northeast, and that the Tertiary volcanics dip northwestward in this area. From this they deduced the "Frederick Sound axis of cross-folding" trending northeast and an episode of Tertiary folding that resulted from a force oriented at right angles to the force that caused the folding of the Mesozoic formations. Inasmuch as the westward trend of the folds in the Jurassic rocks in the Pybus Bay area resulted from an episode of folding that occurred prior to the deposition of the Paleocene sediments (Loney, 1964) and no evidence of folding in Paleocene rocks was found, the post-Eocene episode of cross-folding is not substantiated by the present mapping.

FAULTS

On Admiralty Island, as well as in many other areas of southeastern Alaska, faults are an important factor in the orientation of many prominent topographic and hydrographic features. Examples of such areas are Chatham Strait, Hasselborg Lake, Thayer Lake, and Eliza Harbor. The major faults of the island generally trend northwest, northeast, or north. In general, the faults are marked by depressions that are not deflected by hills and valleys and whose traces can be followed for long distances; hence, these faults dip nearly vertically. The traces are visible on aerial photographs, and their significance was correctly interpreted and discussed by Twenhofel and Sainsbury (1958). No evidence of low-angle thrust faulting was found anywhere on the island. The direction and amount of the movement along the faults are difficult to determine owing to scarcity of distinctive marker beds.

Northwest-trending faults are most conspicuous in areas not covered by Tertiary strata. Some faults show apparent displacements in both vertical and horizontal directions. South of Gambier Bay these faults are high-angle reverse faults, with the northeast side upthrown. Between Gambier Bay and Windfall Harbor both high-angle reverse and normal faults are found. Along the fault in the North Arm of Pybus Bay the Pybus Dolomite has been offset 0.2 mile in a right lateral sense. The fault exposed on the small island west of Swan Island also shows right-lateral separation.

Northeast-trending faults occur throughout the island, but they are most prominent in the area underlain by the Admiralty Island

Volcanics, in a wide belt extending from Favorite Bay to Mole Harbor, and on Glass Peninsula. North-trending faults are not common, except in the area of outcrop of the Admiralty Island Volcanics, and are included with the northeast-trending faults. The trend of the faults ranges from due north to N. 60°E. but is predominantly about N.45°–50°E. Normal faults are dominant in the Tertiary rocks. In the Kootznahoo Inlet area, the northwest sides of these faults are apparently downthrown; elsewhere they are apparently upthrown. The Gambier fault (Loney, 1964) is a normal fault on which the northwest side is apparently upthrown. Along the southeastern shore of Gambier Bay, Permian and Triassic rocks are displaced right laterally along a northeast-trending fault. Similar displacement is suggested along a northeast-trending fault on Shelter Island (Barker, 1957), a few miles northeast of Barlow Cove. Right-lateral separation occurred on north-trending faults north of the head of King Salmon Bay. Left-lateral displacement apparently took place along the fault northeast of Funter Bay.

Chatham Strait, which bounds Admiralty Island on the west, has been considered by many authors to be the trace of a major fault (see St. Amand, 1957, p. 1356–1357; Twenhofel and Sainsbury, 1958, p. 1434–1435; Lathram, 1964). The strait separates metamorphosed and structurally complex Middle(?) Devonian rocks on Admiralty Island from unmetamorphosed and structurally less complex Upper Devonian and Mississippian rocks on northeastern Chichagof Island. Insufficient evidence is available from the mapping on Admiralty Island to determine either the age of the faulting or the amount and direction of fault movement.

AGE OF FOLDING, FAULTING, AND PLUTONISM

Meager evidence suggests that the Devonian rocks were folded prior to the deposition of the Permian and younger strata. Rocks of the Retreat Group and Gambier Bay Formation are generally more highly deformed than those of the younger formations. Foliation is more conspicuous in the older rocks, and thin-section studies show that shearing has affected even the smallest grains. Loney (1964), in discussing several episodes of folding that affected the Permian and younger rocks, suggests that the earliest post-Permian folds were superimposed on a previously folded terrane. At least two periods of Mesozoic folding are recognizable, one in which Early Cretaceous and older rocks were tightly folded and a second in which these folds were themselves deformed. Paleocene rocks apparently have not been folded.

Faults of two ages are recognized. North- and northeast-striking faults cut rocks as young as Eocene to Miocene. The northwest-striking faults cut all rocks except Tertiary; hence, these faults are older and are probably associated with the major folding. Two short but fairly prominent northwest-trending traces appear on the aerial photographs of the Kootznaho Inlet area and are shown on plate 1 and figure 2 as questionable faults. These are the only northwest-trending traces found in Tertiary rocks and may be surface reflections of buried older faults.

All the plutonic rocks seem to be related to one general period of plutonic activity. Only one of the plutons mapped, that on the west coast of Mansfield Peninsula, clearly has been subjected to the same deformation as the country rock. However, the form and contacts of this pluton have been controlled by the schistosity of the Retreat Group (Barker, 1957); hence, the pluton is pretectonic to syntectonic and is probably the oldest plutonic body exposed. Scattered observations indicate that parts of the other bodies lack noticeable foliation and appear to cut across the grain of the country rock; these plutons may be in part posttectonic. Some of the plutons, those at Doty Cove and Mole Harbor, intrude Lower Cretaceous strata. The contact metamorphic aureole of others, those west of King Salmon Bay and northwest of Mole Harbor, affects Lower Cretaceous rocks. Although granitic pebbles are scarce in conglomerate of the Kootznahoo Formation in the type area, some that are lithologically similar to phases of the batholith at Thayer Lake do occur. Further, conglomerate of the Kootznahoo Formation at Little Pybus Bay contains numerous granitic and gneissic pebbles, some of which are similar to, or identical with, plutonic rocks and migmatites exposed west and north of Gambier Bay. Most of the plutons are cut by faults of both the northwest and the northeast and north sets.

The regional metamorphism of the pre-Tertiary rocks seems to have occurred during the Mesozoic period of tectonic activity. Schist fragments are rare in conglomerate beds of Triassic and older rocks, and there is no evidence of the superimposition of two stages of regional metamorphism. Contact metamorphism related to the plutons seems to be superimposed on a preexisting regional metamorphism; hence, at least part of the plutonism is a later event.

The rapid sinking in Late Jurassic time of the linear trough in which the Jurassic and Cretaceous sediments were deposited may have been the beginning of the Mesozoic orogeny. The major deformation and plutonism, however, occurred after early Early Cretaceous time. Payne (1955) has suggested that the area was strongly deformed both in late Neocomian (middle Early Cretaceous) time and in post-Paleocene but pre-Eocene time. The existence of two stages of folding in the Lower Cretaceous rocks of Admiralty Island fits well with this interpretation. The petrography and field relations of the plutonic rocks suggest that these rocks are phases of one general period of intrusion. No evidence of Tertiary plutonic intrusion was found, and the plutons are probably satellitic bodies of the Coast Range plutonic complex, as Wright (1906, p. 146) believed. Recently, absolute ages based on lead-alpha (Larsen and others, 1958; Matzko and others, 1958) and on potassium-argon methods (Beveridge and Folinsbee, 1956; Evernden and others, 1958; Baadsgaard and others, 1959) indicate that the Coast Range plutonic complex was largely emplaced in Cretaceous, probably middle Cretaceous, time. The authors conclude that the deformation and plutonism probably occurred in middle Cretaceous time.

GLACIATION AND CHANGES IN SEA LEVEL

No true glaciers are present on Admiralty Island, although a permanent snowfield that shows some glacial characteristics lies a few miles northwest of Hasselborg Lake. This snowfield covers a total area of about 1 square mile.

During Pleistocene time most of Admiralty Island was covered by an ice sheet emanating from north and northeast of the island. Glacial grooves 3 feet wide and 1 foot deep on the ridge south of Young Bay trend S. 15° W. The altitude of the ice sheet appears to have been between 3,000 and 3,300 feet on most of the island. The smooth contours of the ridge north of Hood Bay, of Yellow Bear Mountain, of Botany Peak, and of other areas 3,000 feet in elevation or less, in contrast to nearby precipitous and serrated ridges a few hundred feet higher, attest to the approximate elevation of the ice sheet.

Cirques are widely distributed throughout the higher glaciated country and generally lie below the level of the immense ice sheet that once covered the area. Many of these cirques contain lakes that feed waterfalls.

Valleys are both U- and V-shaped. The troughs of both Fishery and Ward Creeks and the flat floors east of Lakes Florence and Kathleen appear to have been sculptured by tongues of ice reaching out toward Chatham Strait. East of the north-south island divide some of the valleys have been only slightly modified by the movement of glaciers.

A postglacial change of sea level in southeastern Alaska has been discussed by Twenhofel (1952a). Evidence of the former lower land or higher sea level is found on Admiralty Island. South of Young Bay, Recent marine fossils were found at an elevation of about 150 feet. In the Pybus-Gambier Bay area, Recent foraminifera have been found in marine clays at an elevation of 475 feet. Most of the U-shaped valleys in the western part of the island north of Parker Point become V-shaped near their mouths. Reed and Coats (1941, p. 11) noted this characteristic to be true of many stream valleys on northwestern Chichagof Island. These changes along the west coast commonly occur at about 300 feet elevation. The coast on the east side of Mansfield Peninsula is suggestive of marine planation that formed a gently sloping platform that now rises westward to 400–500 feet. Less clear indications of former higher shorelines were found on both sides of Seymour Canal. The data indicate a former lower land or higher sea level of at least 475 feet on the eastern side of the island and of at least 300 feet on the western side.

ECONOMIC GEOLOGY

The most active mineral exploitation on Admiralty Island took place between 1885 and 1940, when gold was the chief metal sought. Most of the deposits, whose descriptions have been previously published (Wright, 1906; Eakin, 1918; Mertie, 1921; and Buddington, 1926), consisted of gold-bearing minerals in quartz veins that cut schistose rocks. A nickel-copper deposit near Funter Bay consists of sulfide minerals in a pluglike mafic intrusive body. The ore minerals, chiefly pentlandite and chalcopyrite, form veinlets that locally coalesce to make up masses of nearly solid sulfide ore. Exploration activity is currently underway at this deposit.

In recent years the island has been prospected sporadically, and several groups have made reconnaissance mineral surveys using helicopter and airplane support. Little trenching, test pitting, or other physical exploration has been undertaken, however, and few claims have been staked.

In the course of the present investigation, mineralized grab samples from many parts of Admiralty Island were analyzed, principally by X-ray methods. The results of these studies are shown on table 2. In connection with these studies, the mineral resources of two areas on the island have been summarized by Berg (1960) as follows:

> About 100 square miles of the central part of Admiralty Island is underlain by intrusive, contact-metamorphic, and migmatitic rocks. The area comprises most of the high mountains west and northwest of Hasselborg Lake, and includes the southern end of the lake. It contains numerous outcrops of orange, dark-red, and dark-brown gossan, whose areas range from less than 100 to several thousand square feet. Field and laboratory (chemical, X-ray) studies indicate local concentrations of oxide and sulfide minerals, chiefly rutile, pyrite, pyrrhotite, and chalcopyrite, which contain traces to significant amounts of copper, zinc, titanium, and niobium.
>
> Yttrium, zirconium, niobium, thorium(?), and the rare earth elements lanthanum, cerium, phraseodymium, and neodymium were detected by X-ray spectroscopic analysis of heavy minerals from pegmatite veins on Admiralty Island 5 miles west-southwest of the head of Seymour Canal. The pegmatite veins are associated with granite, migmatite, and contact-metamorphic rocks, which underlie an area of 50 square miles.

TABLE 2.—*Results of X-ray spectroscopic examination of sulfide oxide, and rare earth mineral-bearing samples collected in 1957, 1959*

[M, major constituent; T, major trace constituent; t, minor trace constituent; ?, presence of element is questionable. Iron is major constituent in all samples. X-ray analyses by H. C. Berg. Specimens represent grab samples and, except when otherwise noted under "Remarks," data are for unconcentrated material]

Sample (pl. 2)	Ti	Cr	Mn	Co	Ni	Cu	Zn	As	Se	Rb	Sr	Y	Zr	Nb	Mo	Sb	Ba	La	Ce	Pr	Nd	Au	Pb	Th	Remarks
1							t	t									?						t		Dark-brown cellular "limonite" gossan.
2	t		t				t				t														Disseminated pyrite in granulite-gneiss.
3			t								t														Pyrrhotite, pyrite in calcite veinlets in schist.
4			t			t																	t		Disseminated pyrite, chalcopyrite, galena in siderite-cemented quartz breccia.
5	t					t																			Pyrite crystals in schist. Pyrite locally contains chalcopyrite.
6		t	t		T		t																t		Disseminated sulfide and oxide minerals in altered (serpentinized) ultramafic sill.
7	t		t				t	t															t		Pyrite in spongy quartz associated with serpentinite.
8						t	t	?																	Disseminated magnetite, pyrite, chalcopyrite in brown-weathering schist.
9			t								t														Magnetite crystals in gneissic calc-silicate marble.
10						M					T			?			T								Chalcopyrite, minor pyrite veinlets in chert.
11			t			M	?																		Pyrite, chalcopyrite veinlets in calcite-cemented greenstone breccia.
12			t								t														Copper-colored graphite(?) on shear surfaces of amygdaloidal volcanic rocks.
13			t					?			t														Sparse pyrite veinlets in chert.
14	t		t								T														Disseminated pyrite, pyrrhotite in siliceous greenstone or hornblendite.
15			t			T					t														Disseminated pyrrhotite, pyrite, minor chalcopyrite in rust-weathering siliceous hornfels.
16	t		t				t						?												Pyrite crystals in bleached actinolitic greenstone.
17								t																	Pyrite crystals as much as 1 inch long in black slate, phyllite.
18	?		t				?				t					?	t								Small pyrite crystals in brecciated chert.
19			t	?		?					t		t				t								Quartz, pyrite, minor chalcopyrite(?) veins as much as 1 inch thick in fractured diabasic igneous rock.
20	t		t	?			t	?			t						t								Pyrite and calcite veinlets, disseminated pyrite in chert pebbles from sheared conglomerate.
21						M	t	t									t						?		Pyrite, chalcopyrite in bands as much as 3 inches thick, interlayered with chert or cherty hornfels. Sulfide-rich layers locally contain quartz or chert.
22			t								t	?	t				t								Disseminated pyrite in plutonic igneous rock.
23	t		t				t				t						t								Pyrrhotite, pyrite veinlets in sheared mafic volcanic rock.
24	?		t				t																?		Veinlets, disseminated crystals of pyrite in sheared serpentinous greenstone.
25			M				t					t	T									?			Heavy mineral concentrate (bromoform) of garnet-bearing pegmatite.

26	T		t				t	?		?	t	t	T	T				t	t					?	Heavy mineral concentrate (bromoform) of rare earth-bearing pegmatite.
27	T		t				t	t				t	T	t				t	T	t	t			?	Do.
28	t		t			t	t				t														Veinlets and disseminated grains of pyrite, chalcopyrite in orange- and brown-weathering sheared and brecciated hornfels.
29	t		t	?			t				t		?												Disseminated pyrite, pyrrhotite in biotite-rich hornfels.
30	t		t			t	t				t		t												Veinlets and disseminated grains of pyrite, minor chalcopyrite in schistose serpentinous greenstone.
31			t				t				t				?										Pyrite, pyrrhotite, calcite, quartz veinlets in brecciated, slightly schistose argillite.
32	t		t				t				t				?										Magnetite, pyrrhotite in schistose greenstone.
33			t		?						T														Pyrrhotite, pyrite, magnetite in porphyritic igneous rock.
34	?		t				t				T				?										Disseminated pyrite, pyrrhotite in foliated plutonic rock.
35			t			M																			Chalcopyrite, malachite in quartz- and calcite-cemented silicified limestone breccia.
36			t				t				t		t												Sparse sulfide (pyrite?) in mafic dike.
37	t		t			t	t		?		t														Sparse chalcopyrite, pyrite in schistose greenstone.
38							t	t					t												Rust-weathering "limonite" gossan in black chert and argillite.
39			t			t	t				t														Pyrite, minor chalcopyrite in calcite and quartz veinlets in mica schist.
40			t			t					?														Pyrite- and chalcopyrite-rich pods in amphibolite near contact with plutonic igneous rock.
41	?		t				?				t														Pyrrhotite veinlets in greenstone.
42						t		t																	Pyrite crystal in greenschist inclusion in large quartz lens in schist.
43			t			M	t	?															?		Pyrite, chalcopyrite, quartz veins in rust-weathering quartz-mica schist. Minor secondary copper salts.
44			t			t					t														Pyrite, chalcopyrite, minor pyrrhotite(?) veinlets in light-brown weathering marble and calcareous greenschist.
45	t		t				t						t												Disseminated pyrite cubes in dark-brown-weathering quartz-feldspar-mica schist.
46				?		M	t																		Pyrite, chalcopyrite, malachite in laminated quartzite, marble, schist.
47								t					t												Disseminated pyrite in quartzite and mica schist.
48				t			t	t									t								Pyrite crystals, veinlets in brown-weathering quartzite or chert, phyllite, schist.
49	M		t											T											Crystals of niobian rutile as much as 4 inches long in breccia, migmatite, and gneiss.
50		t	t				t	t			t														Bright-green mica (mariposite?), serpentine veinlets in foliated marble. Marble contains white mica, sparse pyrite.
51		T	t		t		t																		Bright-green mica (mariposite?) interlayered with serpentine, calcite. Associated with ophicalcite.
52	t		t								t	?													Disseminated pyrite in feldspar-mica-hornblende schist.
53	t		t			t	t				t														Sparse chalcopyrite, pyrite in schistose greenstone.
54	t		t				t				t														Disseminated magnetite in mafic igneous rock.
55			t				t				t														Disseminated pyrite, minor magnetite, pyrrhotite(?) in greenstone.

The lignitic coal beds in the Kootznahoo Inlet and Murder Cove areas are thin and discontinuous and are of no commercial value at present (1963).

The economic potential of limestone and marble beds in the Pybus and Gambier Bay area, and along the west coast of Admiralty Island, has been evaluated by Burchard (1920, p. 49–56); to date (1963), no effort has been made to exploit these deposits.

Little is known of the structural factors that controlled the deposition of metalliferous minerals on Admiralty Island. Twenhofel and Sainsbury (1958, p. 1442) postulate that the distribution of mineral deposits, particularly the gold-bearing lodes, in the Juneau district is related to the position of regional faults. The results of the present investigation neither confirm nor deny this theory. At a prospect on the west side of Seymour Canal about 3 miles northwest of Windfall Harbor, sulfide minerals seem to be concentrated near the intersection of northwest and northeast-trending shear zones, and, in a few places on the island, gossan occur along probable faults. In many places, however, gossan zones and sulfide-bearing rocks are not associated with discernible regional faults.

The mineral potential of Admiralty Island has not yet been fully tested. Thick soil, glacial deposits, and dense vegetation cover much of the area; hence the application of geochemical and geophysical exploration techniques will probably be necessary to evaluate completely its economic possibilities.

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