Stratigraphy of the Keku Islets and Neighboring Parts of Kuiu and Kupreanof Islands Southeastern Alaska

By L. J. PATRICK MUFFLER

CONTRIBUTIONS TO GENERAL GEOLOGY

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Geologic map and preliminary stratigraphic interpretation of a well-exposed sequence of sedimentary and volcanic rocks ranging in age from Late Silurian to Tertiary

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STRATIGRAPHY OF THE KEKU ISLETS AND NEIGHBORING PARTS OF KUIU AND KUPREANOF ISLANDS, SOUTHEASTERN ALASKA

By L. J. PATRICK MUFFLER

ABSTRACT

Rocks ranging in age from Late Silurian to Tertiary are well displayed in shoreline exposures at the north end of Keku Strait between Kuiu and Kupreanof Islands. The section, one of the most nearly complete in southeastern Alaska, is at least 15,000 feet thick, and many units are exceedingly fossiliferous.

Upper Silurian rocks crop out extensively on Kuiu Island and include two new formations: the Bay of Pillars Formation, composed of calcareous lithic sandstone, argillite, and limestone, and the Kuiu Limestone, composed primarily of massive limestone that contains sporadic conglomerate and thin-bedded limestone. An unnamed unit of unfossiliferous red arkose is inferred to overlie the Kuiu Limestone and to underlie an unnamed unit of volcanic graywacke and argillite of Late Silurian age. Volcanic breccia, either of Silurian or of Devonian age, crops out in one large fault slice.

The Gambier Bay Formation, of Middle(?) Devonian age, is composed of greenstone, greenschist, phyllite, and marble. It crops out on Kupreanof Island but not on Kuiu Island or in the Keku Islets.

An unnamed brown fetid limestone of Late Devonian age is exposed at two localities in the Keku Islets, where it is stratigraphically overlain by an unnamed crinoidal limestone of probable Mississippian age. The Saginaw Bay Formation (new), of Mississippian and Pennsylvanian age, crops out on Kuiu Island and in the Keku Islets. The formation is divided into four informal members: a volcanic member, a black chert member, a chert and limestone member, and a silty limestone member.

Permian units comprise the Halleck Formation (new), the Cannery Formation, and the Pybus Formation (previously described as the Pybus Dolomite on Admiralty Island, 25 miles to the north). The Halleck, which consists of siltstone, sandstone, limestone, conglomerate, and basaltic volcanic rock, is of Early Permian age (probably Leonard) and appears to be restricted to Kuiu Island and the Keku Islets. The Halleck is coeval with the Cannery Formation, a sequence of volcanic graywacke, volcanic argillite, and chert that crops out on Kupreanof Island and on Admiralty Island but is not found in the Keku Islets or on Kuiu Island. Both formations are overlain by the Pybus Formation, a prominent cliff-forming unit of white limestone, dolomite, and chert.

The Pybus Formation is overlain unconformably by a sequence of felsic and mafic volcanic rocks, herein named the Keku Volcanics. The unit is restricted to Kuiu Island and is of Late Triassic age, probably early and late Karnian.

The Upper Triassic Hyd Group, previously described as the Hyd Formation on Admiralty Island, is herein elevated from formational rank and divided into four new formations—the Burnt Island Conglomerate, the Cornwallis Limestone, the Hamilton Island Limestone, and the Hound Island Volcanics. The Burnt Island Conglomerate is recognized only in the Keku Islets and on Kupreanof Island, where it rests unconformably on either the Cannery Formation or the Pybus Formation. Stratigraphically equivalent beds on Kuiu Island are included in the uppermost part of the Keku Volcanics and in the lowermost part of the Cornwallis Limestone. The Cornwallis Limestone is a medium- to thick-bedded brown-weathering medium-gray oolitic limestone that crops out on Kuiu Island. It is coeval with the Hamilton Island Limestone, a very thin bedded dark-gray to black fetid aphanitic limestone exposed in the Keku Islets and on Kupreanof Island. The Hound Island Volcanics consist of basaltic pillow breccia and pillow lava, andesitic volcanic breccia, aquagene tuff, and limestone. Breccia, flow, and aquagene-tuff structures are superbly displayed, and the tuffs locally contain fragments of glass that has not yet been devitrified. Forty-seven Upper Triassic (Karnian and Norian) fossil collections from the Keku Islets area make the Hyd Group an important stratigraphic and paleontologic standard for North America.

The Seymour Canal Formation, of Jurassic and Cretaceous age, crops out on Kupreanof Island at the northeast corner of the mapped area. An unnamed unit of lithic sandstone and mudstone of Early Cretaceous age is exposed locally along Keku Strait.

Plutonic rocks ranging in composition from gabbro to adamellite intrude the Bay of Pillars Formation of Kuiu Island; they are probably of Cretaceous age or younger.

Lower Tertiary continental sedimentary rocks and felsic volcanic rocks that crop out along Keku Strait were deposited in the northwest extremity of a major Tertiary depositional basin that lies between Kuiu and Kupreanof Islands. These rocks are cut by gabbro and microgabbro that was probably intruded during the middle part of the Tertiary.

The major deformation probably took place in Late Cretaceous time. Several generations of folds are present, and structure is particularly complex in the Bay of Pillars, Gambier Bay, and Cannery Formations, and in the Hamilton Island Limestone.

The disparity between the Paleozoic stratigraphic columns on opposite sides of Keku Strait and the marked lithologic dissimilarity of the coeval Cannery and Halleck Formations can be explained either by exceedingly abrupt facies variation or by major telescoping by thrusting prior to deposition of the Pybus Formation.

INTRODUCTION

PHYSICAL SETTING

The Keku Islets area is at the northwest entrance to Keku Strait, a tortuous passage separating Kuiu and Kupreanof Islands (fig. 1). This northwest entrance to Keku Strait is alined with the axis of the Keku synclinorium; to the southeast, the strait is in a basin of Tertiary continental sedimentary and volcanic rocks.

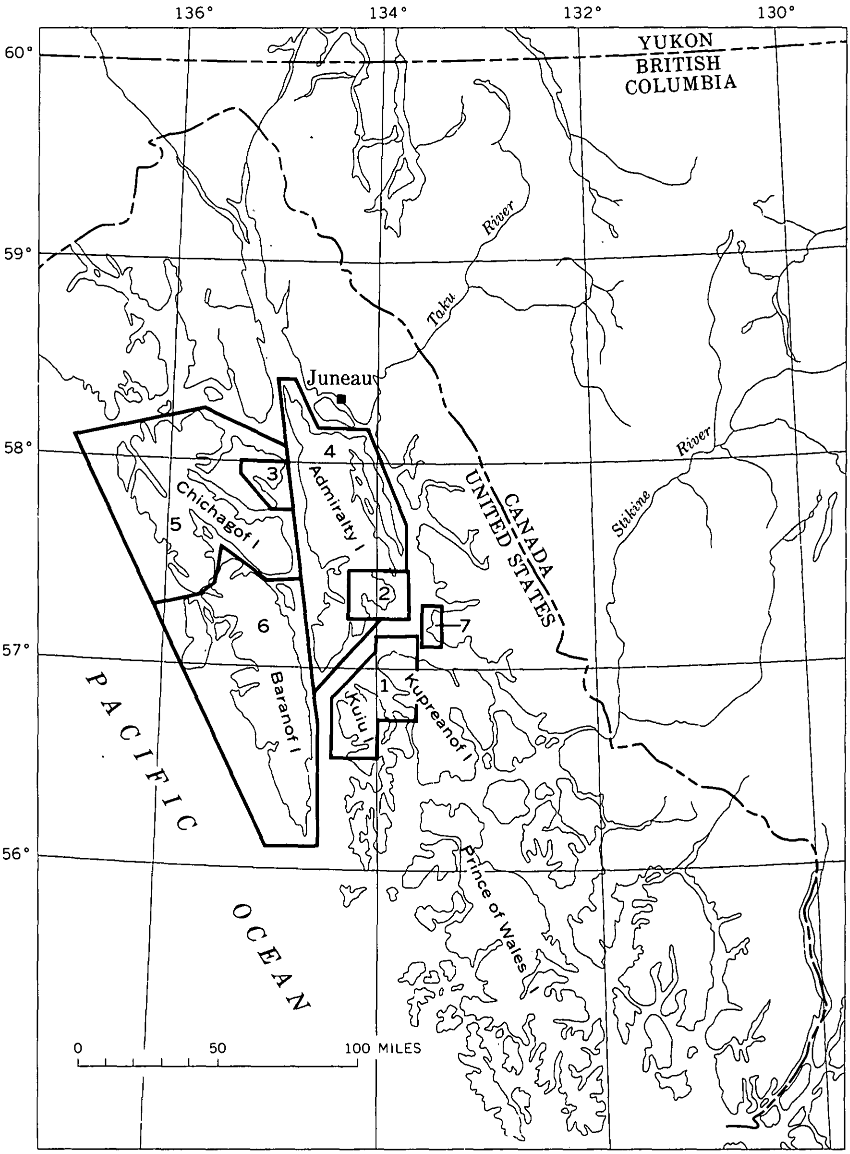

FIGURE 1.—Location of the Keku Islets area and of other recently studied nearby areas in southeastern Alaska. 1, Keku Strait area; 2, Pybus-Gambier area (Loney, 1964); 3, Freshwater Bay area (Loney, Condon, and Dutro, 1963); 4, Admiralty Island (Lathram and others, 1965); 5, Chichagof Island (Loney, Berg, Pomeroy, and Brew, 1963); 6, Baranof and Kruzof Islands (Loney and others, 1964); 7, Cape Fanshaw (Muffler, unpub. data, 1963).

Topographic forms correlate closely with underlying rock types and structural features. The pronounced northwest grain of the topography in the pre-Tertiary rocks is a reflection of the northwest-trending folds and faults and was accentuated by Pleistocene glaciation. The topography in areas underlain by Tertiary rocks is irregular and is controlled primarily by gently inclined Tertiary gabbro sills.

Two conspicuous low-lying flat topographic surfaces in the Keku Islets—one at high-tide level and one at an altitude of about 75–100 feet—were interpreted by Buddington (1927) as being formed by postglacial marine planation at low-tide level, followed by uplift.

Climate is moist and moderate, perhaps milder than that of most of southeastern Alaska owing to location of the area 30 miles east of the 5,000-foot rampart of Baranof Island. A dense forest of spruce and hemlock mantles the land area, except for the highest peaks. Outcrops are excellent in the tidal zone (mean tidal range, 11.4 ft; diurnal tidal range, 13.8 ft) and above timberline. Between these zones, outcrops are very sporadic except in creeks of steeper gradient. Even these creeks give little usable information, for they are choked with devilsclub and alder and are commonly blocked by beaver dams. Outcrops along the creeks are commonly covered with moss.

PREVIOUS WORK

The good outcrops, detailed stratigraphy, and abundant fossils of the Keku Islets area were recognized by some of the first geologists to explore southeastern Alaska. Wright and Wright (1908), during a study of the Ketchikan and Wrangell mining districts, described some stratigraphic features and listed a few fossil collections. W. A. Atwood studied the Tertiary sedimentary rocks in Port Camden and Hamilton Bay in 1907 and made several plant collections. Atwood's work was never published, but his field notes were made available to me.

A. F. Buddington studied the area in considerable detail in 1922 and 1923, and the relations that he deduced formed the basis for much of the stratigraphy discussed in Buddington and Chapin (1929), the classic reconnaissance study in southeastern Alaska. Barite and zinc prospects in the Keku Islets were discussed by Buddington (1925, p. 136–139). Buddington's data were much more complete, detailed, and accurate than is suggested by plate 1 of Buddington and Chapin (1929); it is most regrettable that his data could not have been published on a larger scale map of the Keku Islets area. Fortunately, Buddington's detailed field notes for 1922 and 1923 were made available to me.

After Buddington's pioneering work, the stratigraphy of the Keku Islets received no further attention, although G. O. Gates made a brief study of the witherite and barite deposits (Twenhofel and others, 1949, p. 40–44).

PURPOSE OF PRESENT STUDY

Well-exposed stratigraphic sections of unmetamorphosed rocks are very few in southeastern Alaska, particularly in the northern half of the panhandle. Loney, Condon, and Dutro (1963) studied the Freshwater Bay area on Chichagof Island, and Loney (1964) studied the stratigraphy in the Pybus-Gambier area of Admiralty Island. The Keku Islets area, which contains the most complete stratigraphic section in southeastern Alaska, had not been studied since 1923, and the only existent geologic map was the 1:500,000 map of Buddington and Chapin (1929, pl. 1). An integrated geologic and paleontologic study of the Keku Islets area would not only add to the existing knowledge of southeastern Alaska but would also facilitate correlation of the upper Paleozoic and Triassic strata of North America with the equivalent strata of Siberia.

Accordingly, this study was designed to produce a 1:63,360 geologic map of the Keku Islets area, to set up formal stratigraphic nomenclature for the units, and to gather well-located fossil collections to enable future regional and systematic paleontologic studies by other scientists. A mapping program was established whereby the paleontologists and the geologist worked together in the field in order to facilitate preliminary stratigraphic interpretations during the course of the mapping. This program resulted in extensive faunal control and in considerable refinement of the boundaries of stratigraphic units in the Triassic.

FIELDWORK AND ACKNOWLEDGMENTS

Mapping was done during June–August 1965. The base of operations was MV *S. R. Capps*, manned by R. D. Stacey, master, and John Muttart. Reconnaissance mapping of the high country on Kuiu Island was done from a helicopter in June by D. A. Brew and me. Detailed mapping was done along the shoreline from 14-foot skiffs equipped with outboard motors and was supplemented by a few stream traverses inland and traverses to the tops of the two high peaks on northern Kupreanof Island. The detailed mapping was done at a scale of approximately 1:15,800 on enlargements of compilation sheets of published topographic maps.

Inasmuch as most good outcrops are within the tidal zone, the reef and tidal-flat symbols on plate 1 are used as somewhat arbitrary seaward limits of the rock units.

I was capably assisted throughout the mapping by Steven Schamel, and, for 1 week at the end of the season, by Darryl M. Laye. D. A. Brew and N. J. Silberling participated in the mapping in June, when all the Triassic rocks were mapped and most of the Triassic fossil collections were made. C. W. Merriam and G. D. Eberlein spent 4 days in the area assisting in interpretation of lower and middle Paleozoic stratigraphy.

Triassic fossils were collected from 51 localities. The best localities were studied carefully by Silberling, and large diverse faunas were collected. The detailed paleontology will be reported on separately by Silberling; however, the preliminary results of his study are presented in table 1 of this paper.

Large collections of diverse Silurian faunas were made at four localities by C. W. Merriam and will be reported on separately by him.

The 35 collections of upper Paleozoic fossils have not yet been studied.

SILURIAN SYSTEM

BAY OF PILLARS FORMATION

A thick sequence of complexly folded calcareous sandstone and argillite that underlies most of the northwestern part of Kuiu Island is here named the Bay of Pillars Formation. The type locality is designated as the north shoreline of the Bay of Pillars (pl. 1). The Bay of Pillars Formation in the mapped area of this report corresponds to a graywacke and slate unit described by Buddington and Chapin (1929, p. 77–79) as underlying most of Kuiu Island.

The Bay of Pillars Formation is composed primarily of medium-grained medium-light-gray calcareous lithic sandstone. The sand grains are subangular to subrounded and consist of volcanic rock of intermediate composition, calcite, slate, plagioclase (ranging in composition from albite to andesine), and quartz. Matrix usually makes up less than 15 percent of the rock, and calcite cement is commonly subordinate to matrix. This sandstone comprises both the lithic arenite and the lithic wacke of Williams, Turner, and Gilbert (1955, p. 301–310), and corresponds to the subgraywacke of Pettijohn (1957, p. 290–291, 316–321). The lithic sandstone forms thin to very thick beds that alternate with thin beds of dark-gray calcareous argillite (fig. 2). Conspicuous primary sedimentary features such as graded beds, lode casts, and small-scale crossbedding suggest submarine deposition by turbidity currents.

FIGURE 2.—Interbedded calcareous sandstone and argillite in the Bay of Pillars Formation, Christmas Island, Security Bay. Tops of beds are to right. Note lode casts (just left of geologic pick) and cleavage in argillite (at left).

Locally the sandstone and interbedded argillite form sequences 20–50 feet thick that alternate with sequences of similar thickness made up of very thin to thin-bedded interbedded dark-gray calcareous argillite and light-gray impure limestone (both calcarenite and calcsiltite) (fig. 3). Interbedded argillite and limestone are particularly common along the shore near the mouth of Security Bay. Thin-bedded lithic sandstone occurs sporadically with the limestone and argillite.

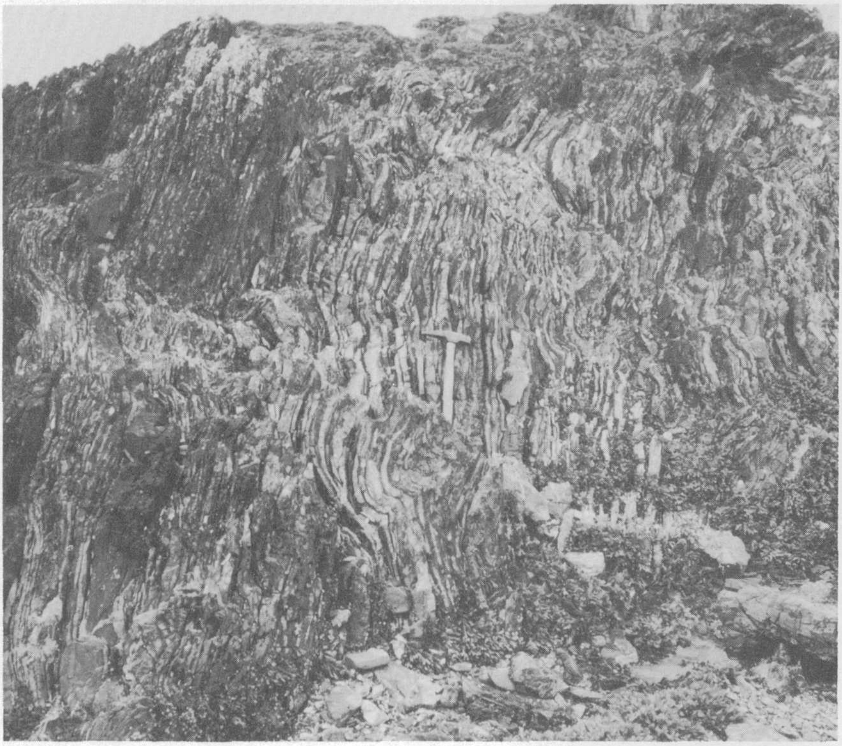

FIGURE 3.—Thin-bedded argillite (dark) and limestone (light) in the Bay of Pillars Formation, northwest end of Christmas Island, Security Bay. Dark area at lower right is rockweed.

Intraformational conglomerate, probably formed by penecontemporaneous slump of soft sediment on the sea floor, crops out locally, particularly near the head of Bay of Pillars. Several beds of polymict boulder conglomerate crop out just northeast of the narrows at the entrance to the salt lake at the head of Bay of Pillars. The most prominent conglomerate bed is approximately 300 feet thick and contains rounded clasts of granitic rocks (syenite, adamellite, granodiorite, and seyenodiorite) and subordinate clasts of greenstone. The matrix is medium-grained medium-gray volcanic graywacke.

On northwesternmost Kuiu Island the Bay of Pillars Formation is intruded by gabbro and adamellite plutons of Cretaceous(?) age, and contact aureoles of hornfels extend, in places, as much as 2 miles from the plutons. The available reconnaissance data suggest that three facies of contact metamorphism are represented, and that these facies are roughly concentric to the plutons. The metamorphosed calcareous sandstones are characterized by the following assemblages:

andesine–diopside–biotite–quartz–potash feldspar in the pyroxene hornfels facies; oligoclase–actinolite–quartz–biotite–potash feldspar in the hornblende hornfels facies; and epidote–calcite–quartz–actinolite–albite in the albite–epidote hornfels facies. Rocks of the albite–epidote hornfels facies crop out along the shore north of Washington Bay; they are readily distinguished from the unmetamorphosed equivalents by a glazed appearance and red and green colors, conchoidal fracture, and high resistance to breaking. Rocks of the hornblende hornfels and pyroxene hornfels facies crop out primarily along the ridges north of Washington Bay; the exact spatial relations between these two facies are uncertain.

The Bay of Pillars Formation is intensely and complexly deformed. The thick sandstone beds are relatively competent and form gentle, simple folds; fracture cleavage is poorly developed and widely spaced, and the beds yielded internally by irregular fracturing and shearing. The interbedded argillite, limestone, and thin-bedded sandstone, on the other hand, show several generations of complex folds and exhibit pervasive closely spaced fracture cleavage (fig. 4). Much of the folding in the thin-bedded limestone and argillite sequences appears to be disharmonic, occurring between relatively competent

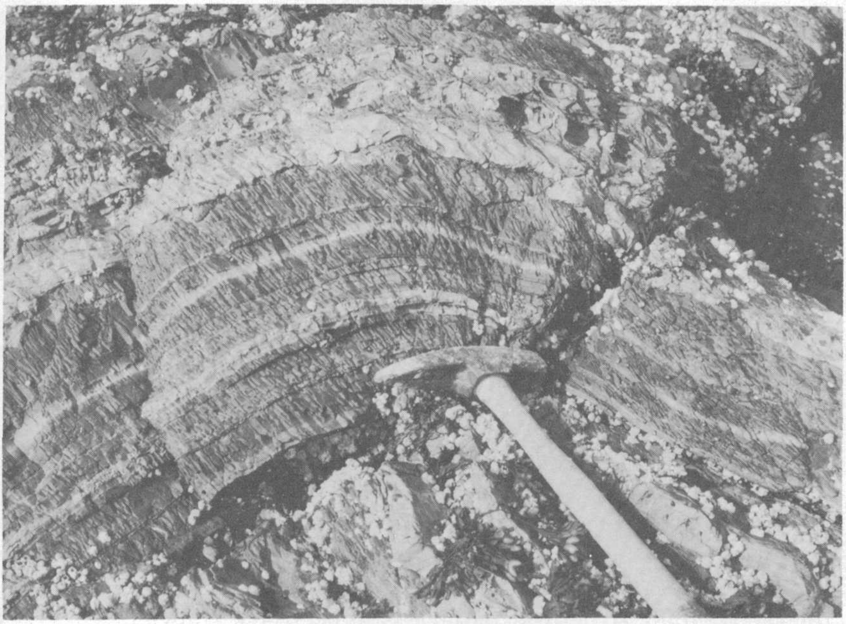

FIGURE 4.—Anticline in interbedded argillite (dark) and thin-bedded very fine grained calcareous lithic sandstone (light) in the Bay of Pillars Formation. Fracture cleavage dips to right. Meade Point, at entrance to Security Bay.

bounding sandstone beds. Major repetitions and mappable folds were not observed but were possibly overlooked because of the lack of marker beds. Observations of sedimentary structures in the predominantly vertical beds of the Bay of Pillars Formation indicate that sequences of beds with tops to the west are at most only a few hundred feet thick and alternate with the more prevalent eastward-dipping sequences. The axial regions of the inferred folds connecting these sequences were rarely observed. These inferred folds are interpreted as relatively minor disharmonic flexures on a steeply dipping homocline with the top to the east.

Owing to the complex deformation, the thickness of the Bay of Pillars Formation is unknown but is probably several thousand feet.

The Bay of Pillars Formation is at least in part of Late Silurian age. Graptolites collected by C. W. Merriam and me at three localities along the north shore of the Bay of Pillars were identified by W. B. N. Berry (written commun., 1964) as follows:

D203 SD. From very fine grained lithic sandstone on north shore of Bay of Pillars, Kuiu Island, 4.34 miles N. 45° E. of Bay of Pillars cannery, Port Alexander C–1 quadrangle. Lat 56°38.63′; long 134°09.61′.

Monograptus sp. (of the *M. dubius* group. Relatively thin and having a high thecal number).

Monograptus sp. (of the *M. vulgaris* type?)

Age: Silurian, in the span of late Llandovery into early Ludlow, possibly early Ludlow.

D204 SD. From lithic sandstone on north shore of Bay of Pillars, Kuiu Island, 2.09 miles N. 22° E. of Bay of Pillars cannery, Port Alexander C–1 quadrangle. Lat 56°37.65′; long 134°13.27′.

Monograptus sp. (appears to be like *Monograptus micropoma micropoma* (Jaekel)).

Age: Silurian, possibly early Ludlow.

D205 SD. From calcareous lithic sandstone on north shore of Bay of Pillars, Kuiu Island, 1.35 miles N. 11° W. of Bay of Pillars cannery, Port Alexander C–1 quadrangle. Lat 56°37.10′; long 134°14.87′.

Monograptus nilssoni (Barrande)

Monograptus sp. (of the *M. dubius* group)

Age: Silurian, early Ludlow, *Monograptus nilssoni* zone.

Buddington and Chapin (1929, p. 77–79) found no fossils in their graywacke and slate unit on Kuiu Island and considered the unit to lithologically resemble known Ordovician and Lower Silurian beds on Prince of Wales Island. The Late Silurian fossils found during the present work do not preclude the possibility that some Ordovician or Lower Silurian rocks are present in the Bay of Pillars Formation, for the complex structural pattern is imperfectly known; however, I consider this possibility unlikely.

The Bay of Pillars Formation may correlate with the sequence of graywacke, slate, chert, and thin-bedded limestone of Silurian(?) age that crops out at the southern tip of Admiralty Island (Lathram and others, 1965, p. R10).

KUIU LIMESTONE

The massive limestone that forms the prominent cliffs on the southwest shore of Saginaw Bay and that crops out on a few islets and reefs in the Keku Islets is here named the Kuiu Limestone. The type locality is designated as the shoreline of Kuiu Island, just west of the entrance to Saginaw Bay.

The characteristic and dominant rock type of the Kuiu Limestone is brownish-gray dense styolitic limestone. Bedding is extremely obscure. Fossil fragmental textures can be seen in some thin sections, but commonly these textures have been obliterated by recrystallization. Southwest of Saginaw Bay the limestone is cut by many veinlets of white calcite and locally is completely recrystallized to coarsely crystalline white calcite.

Limestone sedimentary breccia with a sparse matrix of red silty material occurs a few hundred feet north of the conglomerate lens half a mile west of the entrance to Saginaw Bay. In the Keku Islets the Kuiu Limestone is commonly a limestone breccia cemented by dolomite and pyrite and contains a few thin interbeds of red and brown siltstone.

Lenses of polymict conglomerate occur sporadically throughout the formation. Southwest of Saginaw Bay these conglomerates contain rounded clasts of gray and green chert, gray limestone, red feldspar porphyry, and red siltstone in a red sandy matrix. They are interbedded with massive hematite-stained limestone and with thin-bedded gray limestone (commonly fossiliferous). In the Keku Islets the conglomerate lenses contain subrounded clasts of white limestone, gray limestone, silicified coral masses, chert, red arkose, red pebble conglomerate, and a green volcanic rock. The matrix here is limestone. The abundant clasts of limestone and of silicified corals suggest that these conglomerates were derived largely from a nearby coral reef.

The Kuiu Limestone is probably about 2,500 feet thick on the southwest side of Saginaw Bay.

The Kuiu Limestone is considered to be of Late Silurian age. Fossil assemblages from four localities in the Kuiu Limestone were assigned as follows by C. W. Merriam (unpub. data, 1964):

63AMp420. From massive limestone on the south side of the islet 1.59 miles S. 34° W. of triangulation station Tack, Keku Islets.

Halysites sp.
Heliolites sp.
Favosites sp.
stromatoporoids
Age: Silurian.

63AMp428. From limestone-matrix conglomerate on the west tip of the islet 1.83 miles S. 20° E. of triangulation station Tack, Keku Islets.

Syringopora sp. (common)
Favosites sp. (abundant)
Heliolites sp.
Halysites (Halysites) sp. (common)
Cystiphyllum sp. (large form, common)
Phaulactis sp.
Zelophyllum sp.
Petrozium cf. *P. dewari* Smith (with well-developed axial structure)
stromatoporoids
Huroniella cf. *H. inflecta* Parks
Age: Silurian; as old as early Wenlock or as young as Ludlow.

63AMp430. From limestone at east end of the islet S. 7° E. of triangulation station Tack, Keku Islets.

?*Striatopora* sp.
Zelophyllum sp.
Entelophyllum sp.
Lissatrypa sp. (abundant)
Fardenia sp.
Obturamentella sp.
?*Coelospira* sp.
Age: Silurian. The small and very abundant brachiopod assigned to *Lissatrypa* suggests a rather late Silurian, perhaps late Wenlock or early Ludlow.

63AMp592. From limestone 2.78 miles S. 41° W. of triangulation Corn, Kuiu Island.

Chaetetes-like corals
?*Parachaetetes* sp. (alga?)
Microplasma n. sp. (abundant)
Entelophyllum-like rugose corals
Zelophyllum sp.
Conchidium alaskense Kirk and Amsden (very large heavy-shelled form; common)
Age: late Middle or Late Silurian.

The contacts of the Kuiu Limestone either are faults or are of equivocal nature; exact stratigraphic relations are uncertain. The distribution of the formations of the Silurian System (pl. 1) suggests that the Kuiu Limestone overlies the Bay of Pillars Formation and underlies the red arkose unit and the volcanic graywacke and argillite of Saginaw Bay. Fossils of Late Silurian age were found in all these mapped units except the red arkose.

RED ARKOSE

A medium- to thick-bedded unit composed mainly of medium-grained red arkose but including some red siltstone crops out for a distance of 1 mile along the southwest shore of Saginaw Bay. Texturally the arkose ranges from wacke to arenite and has variable percentages of hematite-rich silty matrix and calcite cement. Detrital grains comprise quartz, plagioclase (albite to oligoclase), and chert. Neither volcanic fragments nor potash feldspar were detected.

Dikes and irregular masses of altered red feldspar porphyry and altered dark-green feldspar porphyry occur extensively throughout the arkose unit; some masses are demonstrably intrusive, whereas others are possibly extrusive. Similar porphyries occur in no other mapped unit. The age of the porphyries is unknown; if any were proved to be extrusive, they would obviously be the same age as the arkose itself.

The red arkose unit is provisionally assigned to the Late Silurian, although no fossils have been found in the unit. It lies in apparent stratigraphic conformity between the Kuiu Limestone of Late Silurian age and the volcanic graywacke and argillite on the islets in Saginaw Bay, also of Late Silurian age (see below). However, the red arkose unit was observed to be in contact with the Kuiu Limestone only along faults and is separated by a quarter of a mile of water from the nearest outcrop of the Late Silurian volcanic graywacke and argillite. Accordingly, the red arkose unit may be older than Late Silurian and is possibly an allochthonous fault block.

VOLCANIC GRAYWACKE AND ARGILLITE

Volcanic graywacke and argillite of Late Silurian age crop out on a group of islets and reefs in the middle of Saginaw Bay and in the tidal flats at the head of the bay. The unit consists of medium- to thick-bedded dark-gray calcareous feldspathic volcanic graywacke and subordinate calcareous volcanic argillite. The graywacke grades locally into a pebble and cobble conglomerate that contains subrounded clasts of an altered red porphyritic rock (probably volcanic) and subordinate clasts of argillite. The graywacke displays many sedimentary structures that indicate deposition by turbidity currents; contorted beds and breccias, interpreted as being due to penecontemporaneous slump, are common. The graywacke differs from the lithic sandstone of the Bay of Pillars Formation in its greater percentage of dark chloritic matrix, greater percentage of volcanic detritus, less calcareous nature, and association with conglomerate composed predominantly of volcanic detritus.

Mollusks (*Orthoceras*, *Pterinea*, and *Hercynella?*) and *Tentaculites* collected by Buddington (No. 936; PC–2022) from graywacke on a reef in the middle of Saginaw Bay were reported by Edwin Kirk to be of probable Middle Devonian age (Buddington and Chapin, 1929, p. 102, 105–106); additional material was collected from the same

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locality (63AMp365) during the present study. The forms present in these collections, however, are considered by C. W. Merriam (oral commun., 1963) not to be diagnostic of the Devonian as distinguished from the Silurian. Further, beds at approximately the same stratigraphic horizon 300 feet northwest yielded graptolites (USGS colln. D202 SD) identified by W. B. N. Berry (written commun., 1964) as *Monograptus micropoma micropoma* of Silurian age, probably early Ludlow. Because of the much greater stratigraphic reliability of *Monograptus*, the unit of volcanic graywacke and argillite is here considered to be of Late Silurian age.

The volcanic graywacke and argillite unit is perhaps 2,000 feet thick. I infer that the volcanic graywacke and argillite unit stratigraphically overlies the red arkose unit on the southwest shore of Saginaw Bay. However, inasmuch as the units are separated by water, faulting cannot be precluded. I also infer that the volcanic graywacke and argillite unit stratigraphically overlies the Kuiu Limestone at the head of the bay, and that the red arkose unit is absent owing to nondeposition or to erosion prior to deposition of the volcanic graywacke and argillite unit. Again, however, the possibility of faulting along the contact cannot be evaluated, owing to the fact that the contact is obscured by tidal-flat mud.

It should here be emphasized that the stratigraphic relations in this part of the stratigraphic column are tenuous and to a large degree inferential.

SILURIAN OR DEVONIAN SYSTEM

VOLCANIC BRECCIA

Altered volcanic rocks of Silurian or Devonian age crop out along 2¾ miles of the southwest shore of Saginaw Bay near the bay entrance. These rocks consist predominantly of massive hematite-bearing dark-reddish-gray altered volcanic breccia. Altered gray and greenish-gray flow rock of intermediate composition and volcanic cobble conglomerate are subordinate rock types, and thick-bedded volcanic graywacke occurs very sporadically. Bedding is absent or very obscure. The breccias and conglomerates are interpreted as submarine slides off a site of volcanic eruption.

Petrographically, the breccias and flows are altered porphyritic andesite(?). Crystals of intensely altered plagioclase (probably originally andesine; now sodic plagioclase, sericite, chlorite, and calcite) and chlorite-calcite pseudomorphs (perhaps originally pyroxene) are set in a felted groundmass of plagioclase, chlorite, clay(?), and hematite.

These volcanic rocks are of uncertain age, inasmuch as they are unfossiliferous and the contacts with the Kuiu Limestone are not exposed. They are on strike with the Late Silurian graywacke and argillite exposed on the islets in Saginaw Bay (p. C13–C14), but no indications were observed of gradation between the two lithologically distinctive units that would suggest lateral equivalence. Accordingly, I have interpreted the volcanic breccia unit as a fault slice (pl. 1).

The volcanic breccia is probably of Silurian or Devonian age; it has no lithologic similarities to the well-dated volcanic rocks of late Paleozoic or Mesozoic age that are present in the Keku Islets area. Buddington and Chapin (1929, p. 101–102) considered this volcanic breccia unit to overlie the "upper Silurian beds consisting of interbedded fossiliferous limestone and conglomerate" (the Kuiu Limestone of this report) and to structurally underlie "probably middle Devonian" rocks on islets in Saginaw Bay (the Upper Silurian volcanic graywacke and argillite of this report). They assigned the volcanic breccia a probable Devonian age. However, a Silurian age is not precluded because:

1. The contact with the Kuiu Limestone may be a fault.
2. "Probable middle Devonian" rocks of Buddington and Chapin (1929, p. 102) are actually Late Silurian (p. C13–C14).
3. The structural relation to the volcanic graywacke and argillite unit is equivocal.

The volcanic breccia may correlate with the Silurian "volcanic rocks and conglomerate composed of lava pebbles" described by Buddington and Chapin (1929, p. 82) as occurring in narrow synclinal troughs on southern Kuiu Island.

DEVONIAN SYSTEM

GAMBIER BAY FORMATION

Metamorphic rocks that crop out along the north shore of Kupreanof Island near Pinta Point are assigned to the Gambier Bay Formation, named by Loney (1964) in the Pybus-Gambier area of Admiralty Island. This formation on Kupreanof Island is composed primarily of greenstone, greenschist, and pelitic and quartzofeldspathic phyllite. Marble and recrystalized dolomite form sporadic layers up to 50 feet thick throughout the formation, and east of Pinta Point a marble of uncertain thickness was mapped separately as a member (pl. 1). All these rocks are in the quartz-albite-muscovite-chlorite subfacies of the greenschist facies of regional metamorphism (Turner and Verhoogen, 1960, p. 534–537). Amphibolite that crops out in the high country around Turn Mountain probably represents more intensely metamorphosed greenstone of the Gambier Bay Formation and is of the almandine-amphibolite facies.

Greenstone is dominant west of Pinta Point. Relict textures indicate that both porphyritic basalt and basaltic tuffs are represented. The greenstone contains relict phenocrysts of clinopyroxene and plagioclase in an obscure chlorite-plagioclase groundmass. Clinopyroxene may form up to 40 percent of the rocks and in the metatuffs is shattered and granulated. Colorless tremolitic amphibole veins and rims the clinopyroxene. Plagioclase phenocrysts are replaced by chlorite and sericite. Potash feldspar occurs in veins, along with epidote and calcite. Epidote also occurs as disseminated crystals, and in one specimen it made up over 35 percent of the rock. Clear secondary albite occurs sporadically in veinlets and is disseminated throughout the greenstones east of Pinta Point. Calcite, sphene, and quartz are minor.

The greenstones commonly are massive and are cut by anastomosing bands of greenschist up to 2 inches thick spaced at ½- to 6-foot intervals. East of Pinta Point the greenstones are more schistose, and locally grade into intensely foliate greenschist.

The greenstone is mineralogically similar to the chlorite-epidote-calcite phyllite and schist of the Gambier Bay Formation in the Pybus-Gambier area (Loney, 1964, p. 17–18); the similarity of the abundant relict shattered pyroxene crystals is particularly noteworthy. Many rocks on Kupreanof Island, however, have undergone much less intense deformation and do not display pervasive metamorphic foliation. The metatuffs do display a rude foliation that I interpret as relict primary bedding. The lack of shattering of the plagioclase and the general absence of metamorphic foliation suggests that the pyroxene phenocrysts of the metatuffs were shattered at the time of deposition of the tuff, perhaps during cooling.

Dark-gray and medium-green pelitic and quartzo-feldspathic phyllite is common in the Gambier Bay Formation, particularly east of Pinta Point. These rocks are intensely foliated and commonly display on a small scale one or two generations of tectonite structures. Foliation is due primarily to alinement and concentration of sericite and chlorite flakes in thin laminae separated by bands as much as 5 mm thick of granular quartz, albite, and calcite. Epidote is a minor constituent; graphitic(?) material occurs in the more calcareous phyllites; and pyrite may be present. No amphibole was detected in phyllite.

A mappable unit composed primarily of marble crops out along the north shore of Kupreanof Island east of Pinta Point. The marble is medium bedded and of medium crystallinity, is locally siliceous or dolomitic, and contains obscure stylolites marked by carbonaceous material. Individual calcite crystals display conspicuous deformation lamellae, and in the more schistose varieties, show a strong shape orientation.

The marble is intensely folded (fig. 5) and at many places displays strong fracture cleavage that passes into schistosity. Several generations of tectonite structures are apparent.

Masses of greenstone and greenschist up to 25 feet across and bounded by shear surfaces are included in the marble. Thin-section study suggests that these masses are probably metamorphosed porphyritic intrusive rocks of basaltic composition.

Very poorly preserved corals (or stromatoporoids) and mollusks occur locally in the marble. The corals (or stromatoporoids) were tentatively identified by C. W. Merriam (oral commun., 1963) as *Amphipora* or *Cladopora*, thus indicating a Middle Devonian or possibly Late Silurian age. This marble probably correlates with the marble unit of the Gambier Bay Formation in the Pybus-Gambier area, assigned a Middle(?) Devonian age by Loney (1964, p. 14, 19).

FIGURE 5.—Anticline in thick-bedded marble in the Gambier Bay Formation 0.6 mile east of Pinta Point, Kupreanof Island. Overturned and sheared limb of fold (at left) is thrust over greenstone.

Amphibolite cut by dikes of hornblende gabbro, hornblende, tonalite, and hornblende-bearing alaskite crops out near Turn Mountain. The dominant rock is a fine-grained (avg grain size, 0.3 mm) dark-green amphibolite containing dark-green hornblende, calcic labradorite, diopside, and pyrite. This assemblage suggests the almandine-amphibolite facies of regional metamorphism.

This amphibolite is interpreted to represent a higher grade equivalent of the greenstone just described. High-grade equivalents of the phyllite and the marble were not seen, probably owing to poor outcrops. The transition between greenstone and amphibolite takes place in the densely wooded slopes between sea level and an altitude of 2,000 feet, where almost no outcrops are present. The contact delimiting the amphibolite on plate 1 was inferred from aerial photographs.

Relations of the Gambier Bay Formation to other stratigraphic units are uncertain. The contact with the Cannery Formation (Lower Permian) west of Pinta Point appears to be a fault. The contact to the east with the Seymour Canal Formation (Upper Jurassic and Lower Cretaceous) is obscured along the shore by alluvium and may be either a fault or an unconformity. The Gambier Bay Formation does not crop out southwest of Keku Strait.

LIMESTONE

Limestone of Late Devonian age crops out locally along the northeast shore of the Cornwallis Peninsula and on one of the adjacent islets. The dominant rock type is thin-bedded dark-gray fetid limestone that weathers brownish gray. Locally the limestone is cherty and contains sporadic wispy laminae of gray calcareous siltstone that weathers dark brown.

About 50 feet of Upper Devonian limestone is exposed on the southwest side of an islet just northeast of the Cornwallis Peninsula (pl. 1, No. 91). Silicified corals from these beds were identified by C. W. Merriam (written commun., 1964) as follows:

Locality 63AMp414:

Trapezophyllum n. sp.

Breviphyllum cf. *B. lindstromi* (Frech)

These two rugose coral genera are of Devonian age. *Breviphyllum* is commonly Middle Devonian, whereas *Trapezophyllum* is reported to be in rocks of Early, Middle, and Late Devonian age. I am inclined to think that *Trapezophyllum* is polyphyletic and that those represented are related to *Pachyphyllum*, a Late Devonian genus.

The Upper Devonian limestone on this islet is stratigraphically overlain immediately to the south by thick-bedded crinoidal limestone of Carboniferous age (p. C19). The stratigraphic sequence on this islet apparently spans the Devonian-Carboniferous systemic boundary and is therefore worthy of more detailed study.

Brachiopods were collected from thin-bedded dark-brown-weathering fetid limestone on the northeast shore of Kuiu Island about 100 feet west of the conspicuous sea arch (pl. 1, No. 90). These brachiopods were identified by C. W. Merriam (written commun., 1964) as follows:

Locality 63AMp226:
- *Cyrtospirifer* cf. *C. whitneyi* (Hall)
- *Athyris* cf. *A. angelicoides* Merriam
- *Nudirostra* cf. *N. seversoni* McLaren
- ?*Pugnoides* n. sp. (smooth form)
- *Productella* cf. *P. coloradensis* Kindle

This assemblage is of Late Devonian age, approximately equivalent to the upper Devils Gate Limestone in the Great Basin or to the Chemung Formation of New York State. The coral fauna containing *Trapezophyllum* from the nearby small island could be of about the same age as this brachiopod assemblage, especially if one is to regard the *Trapezophyllum* in question as a derivative of the Late Devonian *Pachyphyllum* with which it shares several significant morphologic features.

To the south of this locality the Upper Devonian limestone is in fault contact with massive crinoidal limestone of Carboniferous age.

CARBONIFEROUS SYSTEMS

CRINOIDAL LIMESTONE

Medium-bedded to massive fossil fragmental limestone crops out in a belt that extends from the Cornwallis Peninsula northwest through the islets just northeast of the peninsula. This limestone is white and medium gray, weathers white, and exhibits conspicuous crinoid columnals. Some beds contain abundant poorly preserved small fusulinids. The formation is at least several hundred feet thick. Brachiopods and corals from several localities (63AMp410, 590, and 607) were tentatively considered by J. T. Dutro, Jr. (oral commun., 1963) to be of Mississippian or Pennsylvanian age.

On one islet (pl. 1, No. 91) this crinoidal limestone stratigraphically overlies Upper Devonian limestone (p. C18). This relation suggests that the crinoidal limestone is of Mississippian rather than of Pennsylvanian age, but precise assignment can be made only after a more thorough study of the fossil collections.

The upper contact of this crinoidal limestone is not exposed, for the outcrop belt is bounded by faults. I infer that the limestone underlies the Saginaw Bay Formation but that it is absent under Saginaw Bay itself owing to nondeposition or to the inferred faulting along the contact between the Saginaw Bay Formation and the volcanic graywacke and argillite of Late Silurian age.

SAGINAW BAY FORMATION

A heterogeneous sequence of sedimentary and volcanic rocks that crops out in the north part of Kuiu Island and in the Keku Islets is here named the Saginaw Bay Formation. The type locality is designated as the long islet near the head of Saginaw Bay (pl. 1, Nos. 64, 65, 66, 69) and the adjacent shore of the bay to the south. The formation is divided, from oldest to youngest, into four informal members: a volcanic member, a black chert member, a chert and limestone member, and a silty limestone member. The excellent outcrops on the southeast side of the cove 3.4 miles southeast of triangulation station Corn (at the tip of the Cornwallis Peninsula) are designated as a supplementary section (pl. 1, Nos. 72, 73, 74).

The volcanic member of the Saginaw Bay Formation is a heterogeneous unit characterized by massive light-greenish-gray medium-grained to coarse-grained aquagene tuff and subordinate broken- and isolated-pillow breccia.[1] The tuff and the matrix of the breccia consist of shards of devitrified glass in a matrix of sparry calcite. Analcite and a birefringent zeolite occur in amygdules in the shards. In Saginaw Bay the member crops out only on a few islets and reefs but is inferred to underlie much of the bay. The thickness of the member is not definitely known, and the base is not exposed. The apparent southward thinning of the member is possibly due to faulting at the head of Saginaw Bay.

The volcanic member is exposed on one islet in the Keku Islets (pl. 1, Nos. 78, 79, 80). The section on this islet comprises, from bottom to top: (a) thin-bedded limestone, tuffaceous sandstone, aquagene tuff, and minor pillow flows; (b) massive broken- and isolated-pillow breccia of basaltic composition; (c) very thin bedded limestone containing approximately 30 percent beds and nodules of chert; (d) analcite-bearing aquagene tuff; (e) maroon-gray limestone rich in tuffaceous detritus; (f) altered basaltic flow breccia with intercalated red calcareous sandstone; and (g) massive white limestone that weathers tan. This section is approximately 550 feet thick. Fossils (63AMp448a) from unit "c" were considered by J. T. Dutro, Jr. (oral commun., 1963) to be of probable Mississippian age. The analcite-bearing aquagene tuffs of units "a" and "d" are lithologically similar and can probably be correlated with the tuffs of the volcanic member of the Saginaw Bay Formation in Saginaw Bay.

[1] See p. C36 for definitions of these terms.

Thick-bedded white limestone and intercalated mafic pillow breccias overlie thin-bedded cherty limestone along the northeast shore of Kuiu Island west of Hound Island. Pending study of fossil collections 63AMp238 and 63AMp239 by others, this sequence is assigned to the volcanic member of the Saginaw Bay Formation and is correlated lithologically with units "f" and "g" of the section in the Keku Islets.

The black chert member of the Saginaw Bay Formation consists of thin-bedded black chert and minor thin-bedded dense dark-gray limestone. The member crops out only near the head of Saginaw Bay and along a small creek west of Kadak Bay. Outcrops are poor, and the rocks locally exhibit complex folds. Thickness of the black chert member is unknown. The member is apparently underlain by the volcanic member of the Saginaw Bay Formation and is overlain by the chert and limestone member. Contact relations are very uncertain, however, owing to poor outcrops in the tidal flats of the head of Saginaw Bay.

The chert and limestone member consists of thin- to medium-bedded light-brown-weathering calcareous chert and subordinate thin-bedded brown-weathering, medium-gray cherty fossil fragmental limestone that is locally dolomitic. Tan biostromal limestones that weather light gray occur sporadically along the west side of the long islet near the head of Saginaw Bay. The chert and limestone member is at least 400 feet thick; it does not crop out in the Keku Islets.

The silty limestone member consists of thin- to medium-bedded brown-weathering, medium-gray fossil fragmental and clastic limestone containing variable amounts of terrigenous cherty debris. Light-gray-weathering bioherms are present locally throughout the member, and a conglomerate containing chert and limestone cobbles occurs near the base. Worm borings are conspicuous on bedding surfaces. The silty limestone member is about 300 feet thick and is apparently overlain conformably by the Halleck Formation.

Fossils are extremely abundant throughout the chert and limestone member and the silty limestone member. Dutro and Douglass (1961) described an early Middle Pennsylvanian fauna from the north tip of the islet near the head of Saginaw Bay in rocks that are here assigned to the silty limestone member. A new fossil collection (63AMp343) from the chert and limestone member on the west side of this islet was tentatively considered to be of Mississippian or Pennsylvanian age (J. T. Dutro, Jr., oral commun., 1963). Inasmuch as the paleontologic reports on a number of large collections from the Saginaw Bay Formation had not been received at the time of this report (1966), the Saginaw Bay Formation is here tentatively assigned a Mississippian and Pennsylvanian age.

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PERMIAN SYSTEM

HALLECK FORMATION

A heterogeneous sequence of siltstone, sandstone, limestone, conglomerate, and basaltic volcanic rock that crops out on the northeast shore of Saginaw Bay and on several of the Keku Islets is here named the Halleck Formation. The type locality is designated as the tidal flats of Halleck Harbor; excellent exposures on the tidal flats on the east side of Saginaw Bay south of the abandoned cannery are designated as a reference section. The Halleck Formation corresponds to the "lower division of the Permian" of Buddington and Chapin (1929, p. 118–127).[2]

The dominant rock type of the Halleck Formation in Saginaw Bay is dark-gray very calcareous siltstone that grades into silty limestone. This rock type is particularly well exposed in the tidal flats southeast of the abandoned cannery, where it is complexly folded and exhibits an intense pervasive fracture cleavage. Subordinate thin beds of tan-weathering fossil fragmental limestone are intercalated in the siltstone. In the upper 40 feet of the formation, the siltstone grades into a very fossiliferous medium-bedded crossbedded medium-gray-weathering calcareous sandstone. Both siltstone and sandstone contain much detrital chert and volcanic rock.

Pillow flows, pillow breccias, and epiclastic volcanic breccias of olivine-rich basalt occur near the middle of the unit southeast of Halleck Harbor. These volcanic rocks are complexly intercalated with fossiliferous sedimentary rock a quarter of a mile southeast of the entrance to Halleck Harbor and on the islet 3½ miles southeast of the entrance to Halleck Harbor, opposite the abandoned cannery.

The Halleck Formation is covered on the northeast coast of Kuiu Island but crops out again in the northern Keku Islets. Here the formation is made up mainly of thick-bedded pebble and cobble conglomerate. Subordinate rock types include dark-gray calcareous siltstone and thin- to medium-bedded medium-gray fine- to coarse-grained crossbedded sandstone rich in chert and shale fragments. Limestone and volcanic rocks are absent. The conglomerate is densely packed; clasts are rounded and consist of dominant chert, subordinate volcanic rock rich in potash feldspar, and minor limestone.

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[2] Buddington and Chapin (1929, p. 119–120) included beds "exposed along the northeast coast of the Cornwallis Peninsula from the point about 10 miles southeast of Point Cornwallis" in their "lower division of the Permian." The present study showed that these beds are Carboniferous and Triassic. The "rhyolite of unknown age" and the "series of volcanic rocks and conglomerate" exposed "about 4 miles southeast of Point Cornwallis" (Buddington and Chapin, 1929, p. 120) are Triassic rocks of the Keku Volcanics. Likewise, the "small islet and reefs about 4 miles southeast of Point Cornwallis, opposite a conspicuous sea arch" (Buddington and Chapin, 1929, p. 120) are Triassic (clastic rocks at the top of the Keku Volcanics).

The Halleck Formation is approximately 700 feet thick on the northeast shore of Saginaw Bay. The volcanic rocks (separated in Plate 1 as a member) may be as much as 400 feet thick but thin to the southeast and are absent along the shore southeast of the abandoned cannery.

In Saginaw Bay the Halleck Formation conformably overlies the Carboniferous Saginaw Bay Formation and is conformably overlain by the Pybus Formation (Permian). In the Keku Islets the Halleck Formation is conformably overlain by the Pybus Formation, but the relation of the Halleck to the Saginaw Bay Formation is obscured by water and by inferred faulting.

The Halleck Formation is of Early Permian age, probably Leonard (J. T. Dutro, Jr., oral commun., 1963). This age designation is based on Dutro's study of fossils collected by Buddington and by C. W. Wright (Buddington and Chapin, 1929, p. 122–126) and on the recognition by Dunbar (1946) of *Parafusulina* in a specimen of limestone thought to be from the Halleck Formation in Halleck Harbor. The 10 collections made by me in 1963 have not yet (September 1966) been studied.

CANNERY FORMATION

The Cannery Formation, named by Loney (1964) on southeastern Admiralty Island, crops out extensively on northwestern Kupreanof Island. It is of Early Permian age (probably Leonard) and appears to have been deposited at about the same time as the Halleck Formation. The possible relationship of the two formations is discussed on p. C24–C25.

Thin-bedded gray tuffaceous volcanic argillite and fine-grained gray tuffaceous volcanic graywacke are dominant. Both rock types characteristically weather blue green or reddish brown, commonly have a glazed appearance, and are intensely fractured. Clastic grains in these rocks consist of oligoclase, volcanic fragments, quartz, sporadic bioclastic calcite, and sparse biotite. Altered glass shards and pumice fragments were observed in some thin sections of both graywacke and argillite; the tuffaceous nature of these rocks was emphasized by Buddington and Chapin (1929, p. 106–107). Some angular and fresh grains of plagioclase may also be pyroclastic. The argillite and the matrix of the graywacke consist primarily of chlorite, kaolinite, quartz, and plagioclase. Secondary veinlets of clear albite are common.

Chert, pillow flows, and limestone occur locally in the Cannery Formation. Chert is much less abundant in the Keku Strait area than in the type area of the Cannery on Admiralty Island (Loney, 1964). However, dark-gray very thin bedded intensely contorted chert is a common rock type along the shore of Keku Strait southeast of Point White. Altered pillow flows and greenstone crop out both southeast of Point White and northeast of Cape Bendel. Gray clastic limestone that weathers to a rough brown surface is a characteristic (though sparse) rock type, occurring as lenses 2–5 feet long and ½–1 foot thick. A few beds of crinoidal and bryozoan hash crop out along Hamilton Bay, and thin- to medium-bedded siliceous fossil fragmental limestone containing abundant brachiopods and bryozoans is exposed in a roadcut on the new Forest Service road north of Little Hamilton Island.

The Cannery Formation was intensely deformed by both folding and faulting. The seemingly irregular folding could not be unraveled, even by the use of structural-analysis techniques such as those applied by Loney (1965) in the Pybus-Gambier area. Consequently, the internal stratigraphy and the thickness of the Cannery are unknown. The formation is probably at least 2,000 feet thick, and possibly as much as 4,000–5,000 feet.

Brachiopods collected from a siliceous bioclastic limestone of the Cannery in a roadcut along the new Forest Service road north of Hamilton Bay (63AMp296; fig. 2, No. 57), were considered by J. T. Dutro, Jr. (oral commun., 1963) to be of Early Permian age, probably Leonard. Buddington and Chapin (1929, p. 106–107) considered this sequence to be of Middle(?) and Late Devonian age, basing this assignment primarily on fossils collected from Hamilton Bay "about 6½ miles southeast of Kake" identified by Edwin Kirk as "*Fenestella*? sp. and crinoid columnals, of either Late Devonian or Mississippian age, with the chances rather favoring the former." This assignment is probably in error,[3] as it is incompatible with both the Permian brachiopods previously discussed and the Permian fossils found by Loney (1964) in the Cannery Formation on Admiralty Island.

The northeastern part of the Cannery Formation on Kupreanof Island is intensely deformed, and the contact with the Middle(?) Devonian Gambier Bay Formation is a fault. Along Hamilton Bay and on the prominent mountain (alt 2,099 ft) on northwestern Kupreanof Island, the Cannery Formation is overlain by the Pybus Formation; the contact on northwestern Kupreanof Island may be an unconformity (p. C26). On the islets opposite Kake, the Cannery Formation is overlain by the Burnt Island Conglomerate of Late Triassic age.

The Cannery Formation is probably the lateral equivalent of the Halleck Formation. Both the Cannery and the Halleck contain fos-

[3] Reports on bryozoans collected near this locality by me had not been received at the time of this report (1966).

sils of Early Permian (Leonard(?)) age (J. T. Dutro, Jr., oral commun., 1963) and are everywhere overlain by the Pybus Formation. The Cannery and the Halleck Formations are separated across Keku Strait by only 4½ miles of water, and beds of transitional lithology do not crop out, although they may be hidden under the waters of the strait. There are no strike-slip faults of large displacement in Keku Strait, nor is there any direct evidence of a major thrust fault that could have brought such strikingly dissimilar facies so close together. Facies relations in the Triassic rocks preclude a major post-Triassic thrust, and the continuity of the Pybus across the area indicates that a post-Permian thrust is unlikely. Major thrusting in the Permian just after deposition of the Halleck is possible and is supported somewhat by the apparent discordance of bedding between the Cannery and the Pybus. Alternatively, this discordance may be due merely to the differing responses of the two formations to tectonic stresses. Also, the Halleck-Pybus contact is apparently conformable. Some support for a possible facies transition is provided by the reconnaissance map of the area south of Young Bay on northern Admiralty Island (Lathram and others, 1965), where the Cannery Formation appears to contain slightly metamorphosed equivalents of the Halleck Formation.

PYBUS FORMATION

The unit of white limestone, dolomite, and chert that forms conspicuous cliffs on Kuiu, Kupreanof, and Admiralty Islands is here designated the Pybus Formation. The unit was named the Pybus Dolomite on southeastern Admiralty Island by Loney (1964). Because the unit is dominantly limestone in the Keku Strait area and everywhere contains abundant chert, the name is here changed to Pybus Formation. The Pybus Formation corresponds to the "upper division of the Permian" of Buddington and Chapin (1929, p. 121, 127–129).

The Pybus Formation on Kuiu Island and in the Keku Islets is predominantly medium-bedded to massive coarsely crystalline white to very light gray dolomitic limestone, with subordinate light-gray chert that occurs as thin beds, nodules, fragments, and crosscutting masses. Both limestone and chert weather white, and the unit forms prominent white cliffs (Buddington and Chapin, 1929, pl. 20*A*). Silicified spiriferid and productid brachiopods are abundant and characteristic. Light-gray thin-bedded chert that weathers gray green dominates the lower 50–100 feet of the formation on the north side of Halleck Harbor and in the Keku Islets. Coarsely crystalline light-gray limestone and fetid saccharoidal medium-gray dolomite are interbedded with white limestone near the top of the formation in the Keku Islets.

On Kupreanof Island the Pybus Formation consists of white calcareous dolomite and subordinate white-weathering, light-gray chert.

Along Saginaw Bay on Kuiu Island, the Pybus Formation is approximately 500 feet thick; in the Keku Islets it may be slightly thicker. The Pybus Formation is also about 500 feet thick northeast of Hamilton Bay on Kupreanof Island, but it is only about 200 feet thick where it crops out on the prominent peak (alt 2,090 ft) of northwesternmost Kupreanof Island, where it may have been thinned tectonically.

The Pybus Formation is of Permian age. Studies made by others of the eight fossil collections which I assembled in 1963 had not been completed at the time of this report (1966). However, Buddington and Chapin (1929, p. 127–129) listed 10 fossil collections from Halleck Harbor and the Keku Islets, all of which G. H. Girty assigned to the Permian and correlated with the fauna of the Artinsk Sandstone of Russia (Buddington and Chapin, 1929, p. 121).

The Pybus Formation conformably overlies the Halleck Formation on Kuiu Island and in the Keku Islets. On Kupreanof Island the Pybus appears to unconformably overlie the Cannery Formation, although precise relations of the formations are obscured by faulting and by poor outcrops. The angular unconformity shown on plate 1, section *D–D′*, may actually be a surface of tectonic slip between units of markedly different competencies.

The Pybus Formation is disconformably overlain on Kuiu Island by the Keku Volcanics of Late Triassic age, and in the Keku Islets and east of Keku Strait by the Burnt Island Conglomerate, also of Late Triassic age. Angular discordance at the unconformity above the Pybus is minor. Pre-Late Triassic erosion of the Pybus is indicated by the abundant white limestone and chert detritus in the basal beds of the Burnt Island Conglomerate and in the conglomerate at the base of the Keku Volcanics.

TRIASSIC SYSTEM

KEKU VOLCANICS

The sequence of felsic and mafic volcanic rock and intercalated clastic rock that crops out on the Cornwallis Peninsula and on a few of the adjacent Keku Islets is here named the Keku Volcanics. The type locality is designated as the shoreline 3–3.5 miles east of Cornwallis Point. The unit is lenticular; its maximum thickness is probably over 1,000 feet, yet it thins abruptly to the north and east and is absent in the northeastern Keku Islets. The Keku Volcanics correspond to the "rhyolite of unknown age" and to the "series of volcanic rocks and conglomerate" of Buddington and Chapin (1929, p. 120). (See footnote, p. C22.)

The unit is dominantly altered felsic flow rock and flow breccia. These felsites are aphanitic and contain obscure feldspar microphenocrysts. The flows show conspicuous convolute flow banding, and fragments in the breccias are also banded. Color is highly variable, ranging from the usual light gray or violet gray to brick red, yellow brown, and even emerald green. Petrographic and X-ray diffraction studies show an extreme variation in the ratio of potash feldspar to albite, probably owing to deuteric alteration. The general aspect of these volcanic rocks is similar to that of the Permian and Triassic Koipato Group of western Nevada (described by Knopf, 1924) and to that of the Permian(?) volcanic rocks of the Frenchie Creek quadrangle in north-central Nevada (Muffler 1964, p. 14–20).

Subordinate rock types in the Keku Volcanics include mafic flow rock and flow breccia, volcanic wacke, and volcanic conglomerate. Detrital fragments of the intercalated clastic rocks are predominantly felsite. Chert pebbles occur sporadically, and limestone cobbles occur locally near the base of the unit. A minor amount of oolitic limestone is present near the top of the unit.

The Keku Volcanics are unique among the rocks of the Keku Islets area in that they weather to form extensive beaches. Also, outcrops inland from the shore are more abundant and larger than those of any other unit except the Pybus Formation. Small streams on the northeast side of the Cornwallis Peninsula have eroded amphitheatres of bare felsite; some of these amphitheatres are several hundred feet wide and 50–200 feet deep.

The islet and reefs 4.3 miles east-southeast of Point Cornwallis (pl. 1, No. 52) are predominantly gray medium-grained sandstone, polymict pebble conglomerate, felsic flow rock, and dense gray limestone. Green aquagene tuff and volcanic sandstone are minor. Corals and brachiopods of uncertain position within the upper Triassic were collected from the limestone (table 1, loc. M2135). This sequence of sedimentary and volcanic rocks appears to overlie the felsic and mafic flows along the northeast shore of the Cornwallis Peninsula and is placed at the top of the Keku Volcanics. A fault separates this Upper Triassic sequence from the Saginaw Bay Formation of Carboniferous age on the islets to the east.

The age of the Keku Volcanics is Late Triassic—probably mostly early Karnian—although the uppermost beds extend into the late Karnian. Of the three fossil collections from the Keku Volcanics, two—from localities M1917 and M2135 (table 1)—are of uncertain position within the Late Triassic. The third collection, from locality M1918 (table 1; fig. 2, No. 32), came from thick-bedded gray oolitic limestone intercalated in the uppermost part of the Keku Volcanics and is of early or early late Karnian age. Three miles east-southeast of Cornwallis Point (pl. 1, near No. 31), clastic rocks of the Keku Volcanics grade upward into the Cornwallis Limestone, here of late Karnian age. Fossils were found only in the sedimentary rocks intercalated in the upper part of the Keku Volcanics; therefore, the lower part of the formation is possibly older than early Karnian.

The Keku Volcanics are interpreted to overlie the Pybus Formation unconformably. The contact is not exposed, but scattered poor outcrops on the forest-covered southwest slope of the Cornwallis Peninsula suggest that there may be an extensive chert- and limestone-clast conglomerate at the base of the formation. The Keku Volcanics are conformably overlain by the Cornwallis Limestone (p. C34).

TABLE 1.—*Age assignments of Upper Triassic fossil collections from the Keku Volcanics*

[N. J. Silberling, written commun., 1963]

Age of fauna	*Characteristic fossils*	*USGS Mesozoic locality numbers*
Early or early late Karnian.	*Styrites* cf. *S. tropitiformis* Mojsisovics, *Thisbites* cf. *T. agricolae* Mojsisovics, and *Pinacoceras* cf. *P. rex* Mojsisovics.	[1] M1918
Uncertain age within the Late Triassic.	Scleractinian corals and (or) the spiriferid brachiopod *Spondylospira;* arcestid or clydonitacid ammonites.	[1] M1917 M2135

[1] Fossils listed are only part of a large diversified marine invertebrate fauna.

HYD GROUP

The name Hyd Formation was proposed by Loney (1964) for the Upper Triassic limestone, argillite, and spilitic volcanic rock in the Pybus-Gambier area of Admiralty Island. Rocks of similar lithology and of identical age crop out extensively in the Keku Islets area and can be divided into four formations. Accordingly, the Hyd Formation of Loney (1964) is here designated as the Hyd Group in the Keku Islets area, where it comprises the Burnt Island Conglomerate, Cornwallis Limestone, Hamilton Island Limestone, and Hound Island Volcanics. These new formations can be broadly correlated with the basal breccia, limestone, argillite, and volcanic members, respectively, of the Hyd Formation of the Pybus-Gambier area.

Numerous fossil collections, primarily of the delicate flat clam *Halobia*, were made from the Hyd Group and were studied by N. J. Silberling. These collections were assigned by Silberling to five generalized stratigraphically successive (but possibly overlapping) faunal units that represent most of the Karnian and Norian Stages of the Upper Triassic. Five collections of uncertain position within the Late Triassic make up a sixth faunal unit. These units and the collections (identified by USGS Mesozoic locality numbers) are listed in table 2, and the localities are shown on plate 1 and in figures 6 and 7. The detailed paleontology of these collections will be reported on by Silberling in a separate report.

Application of this extensive paleontologic data reveals a pattern of facies variation in the Hyd Group and the Keku Volcanics. This pattern is shown diagrammatically in figure 8.

BURNT ISLAND CONGLOMERATE

The conspicuous basal marine conglomerate of the Hyd Group in the Keku Islets area is here named the Burnt Island Conglomerate. The type locality is designated as the reefs between Burnt Island and Grave Island, west of Kake. Supplementary sections are designated on the north shore of Hamilton Bay 2,000 feet northwest of Little Hamilton Island (fig. 6, near fossil loc. M1892; pl. 1 near No. 13), and on the northeast shore of the islet 0.6 mile west-southwest of triangulation station Isle in the northern Keku Islets.

The Burnt Island Conglomerate is correlated lithologically and stratigraphically with the basal breccia member of the Hyd Formation in the Pybus-Gambier area of Admiralty Island (Loney, 1964, p. 43–44). Like the basal breccia member in the Pybus-Gambier area, the Burnt Island Conglomerate can be subdivided according to the nature of the detritus. Where the Burnt Island Conglomerate overlies the Pybus Formation, the detritus is primarily chert and limestone from the Pybus Formation. Where the Burnt Island Conglomerate overlies the Cannery Formation, the detritus is primarily blue-green argillite, graywacke, and chert of the Cannery Formation. These variants can be lithologically correlated with the white chert and the red and green chert phases, respectively, of the basal breccia member of the Hyd Formation in the Pybus-Gambier area.

The Burnt Island Conglomerate at the type locality is a rudely bedded poorly sorted pebble conglomerate consisting almost entirely of clasts of blue-green and black argillite, graywacke, and chert derived from the underlying Cannery Formation. Pebbles and boulders of light-gray limestone of uncertain derivation are sporadic; clasts derived from the Pybus Formation are scarce. The matrix of the conglomerate is gray calcite. Thickness is at least 100 feet at the type locality, but the member thins to a few tens of feet at the northwest tip of Hamilton Island and is absent on much of the northeast shore of Hamilton Island.

TABLE 2.—*Age assignments of Upper Triassic fossil collections from the Hyd Group*

[N. J. Silberling, written commun., 1963]

Age of fauna	*Characteristic fossils*	*USGS Mesozoic locality numbers*	
Late Norian	*Monotis subcircularis* Gabb and *Heterastridium* sp.	*Hound Island Volcanics*	
		M1898	[2] M1912
Early or middle Norian.	*Halobia* cf. *H. halorica* Mojsisovics, *H.* cf. *H. plicosa* Mojsisovics, or *H.* cf. *H. fallax* Mojsisovics; *Monotis scutiformis* cf. *M. s. pinensis* Westermann.	*Hound Island Volcanics*	
		M1886	M1901
		M1890	M1902
		M1891	M1921
		M1894	M1923
		M1895	M1935
		M1896	M1936
		M1897	M2113
		M1899	[1] M1887
		M1900	[1] M1927
Latest Karnian or earliest Norian.	*Halobia dalliana* Smith, *H. septentrionalis* Smith, *H.* cf. *H. brooksi* Smith, or *H.* cf. *H. cordillerana* Smith; *Mojsisovicsites* sp., and (or) *Halobia* cf. *H. alaskensis* Smith.	*Hound Island Volcanics*	
		[2] M1919	
		Hamilton Island Limestone	
		M1882	M1933
		M1883	M1934
		M1884	[1] M1888
		M1885	[1] M1903
		M1904	[1] M1928
		M1920	
		Cornwallis Limestone	
		[2] M1910	M1930
		[2] M1911	
Late Karnian	*Tropites* sp., *Discotropites* sp., and (or) *Halobia ornatissima* Smith.	*Hound Island Volcanics*	
		[2] M1913	
		Hamilton Island Limestone	
		M1893	M1931
		M1922	M1932
		M1924	
Early Karnian	*Coroceras* cf. *C. suessi* (Mojsisovics), and *Halobia* cf. *H. rugosa* Gümbel.	*Burnt Island Conglomerate*	
		M1889 (allochthonous cobbles)	
		[2] M1892	
Localities of uncertain age in the Late Triassic.	Scleractinian corals and (or) the Spiriferid brachiopod *Spondylospira*; arcestid or clydonitacid ammonites.	*Hamilton Island Limestone*	
		M1937	M2126
		Cornwallis Limestone	
		[2] M1906	
		M2125 (cobbles in creek)	
		M2136	

[1] Presence of characteristic fossils not positive.
[2] Fossils listed are only part of a large diversified marine invertebrate fauna.

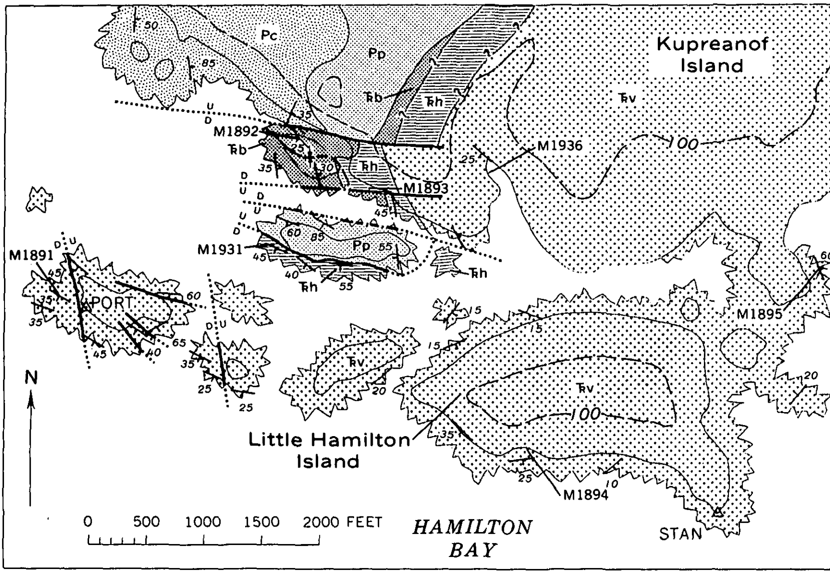

FIGURE 6.—Geology of area near Little Hamilton Island, north side of Hamilton Bay. Pc, Cannery Formation; Pp, Pybus Formation; Ŧb, Burnt Island Conglomerate; Ŧh, Hamilton Island Limestone; Ŧv, Hound Island Volcanics. Numbers (such as M1891) are USGS Mesozoic locality numbers.

Similar conglomerate occurs on the reefs west of Mosquito Island and on Kupreanof Island 1.2 miles south-southeast of Cape Bendel. At the Kupreanof Island locality, both clasts and matrix were subjected to irregular red staining after the deposition and consolidation of the rock.

At the supplementary section on the north side of Hamilton Bay, the Burnt Island Conglomerate overlies the Pybus Formation and is about 150 feet thick. The basal beds consist of poorly sorted conglomerate rich in cobbles of chert and limestone derived from the Pybus Formation, in pebbles of blue-green detritus derived from the Cannery Formation, and in cobbles of medium-gray limestone that contains Late Triassic fossils. Interbedded with conglomerate is medium to very thick bedded light-brown-weathering, medium-gray calcarenite and fossil fragmental limestone containing abundant sand- and silt-size terrigenous debris. Higher in the unit, limestone increases in abundance and conglomerate decreases in abundance. Interbeds of dark-gray fetid silty and sandy limestone similar to that of the overlying Hamilton Island Limestone occur in the upper 70

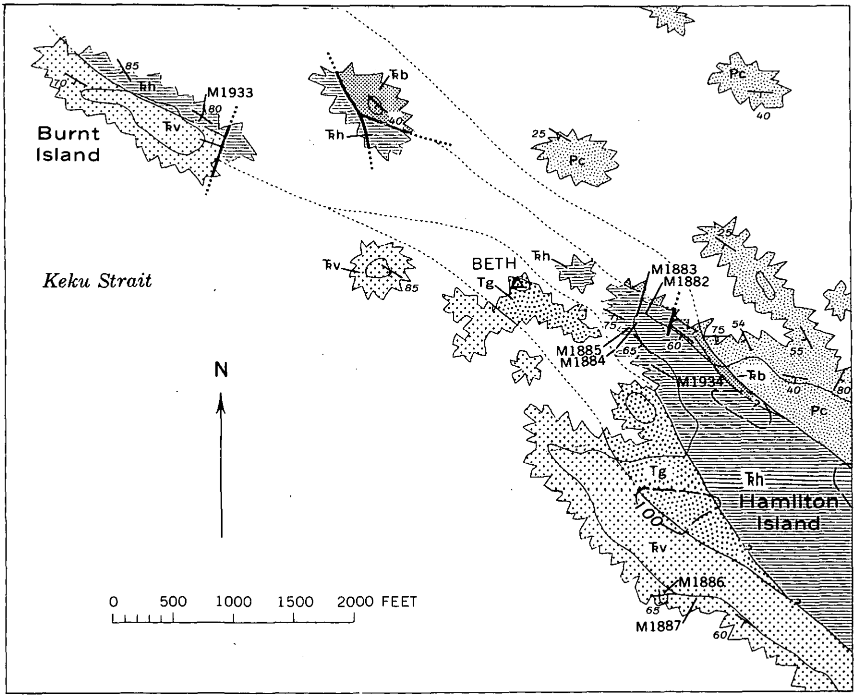

FIGURE 7.—Geology of the northwest tip of Hamilton Island. Pc, Cannery Formation; ℞b, Burnt Island Conglomerate; ℞h, Hamilton Island Limestone; ℞v, Hound Island Volcanics; Tg, Tertiary gabbro.

feet of the section; the upper contact of the Burnt Island Conglomerate is put at the top of the highest light-brown-weathering limestone.

In the Keku Islets, the Burnt Island Conglomerate is less than 50 feet thick and consists of equal parts of calcarenite and conglomerate. Pebbles of the conglomerate are chert and limestone derived primarily from the Pybus Formation.

Farther west on the Cornwallis Peninsula, the conglomerate was not mapped. Its stratigraphic position is represented by the uppermost clastic beds of the Keku Volcanics and by the beds of pebbly calcarenite at the base of the Cornwallis Limestone.

Fossils of early Karnian age were collected from a 5-foot-thick bed of tan-weathering, medium-gray fossil fragmental and clastic limestone near the base of the supplemental section on the north side of Hamilton Bay (table 2, loc. M1892; fig. 6). An early late Karnian age is not precluded for the upper part of the formation, particularly near Cape Bendel.

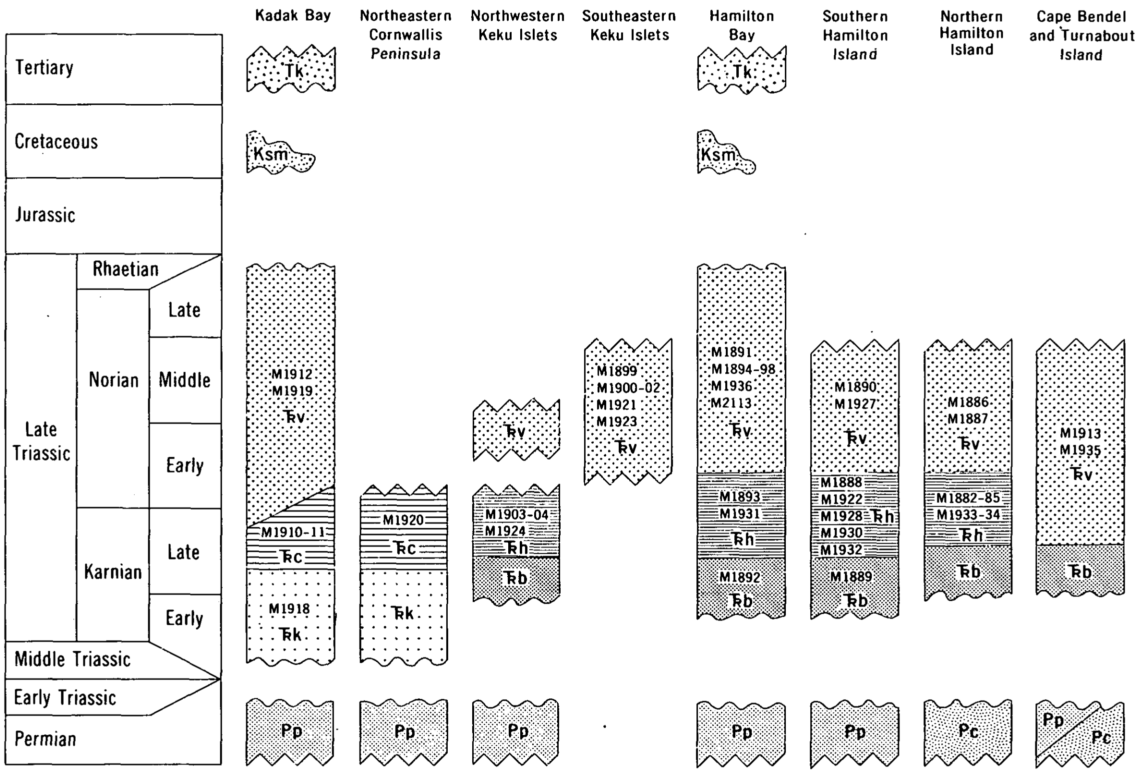

FIGURE 8.—Stratigraphic relations of Upper Triassic rocks of the Hyd Group and the Keku Volcanics. Pc, Cannery Formation; Pp, Pybus Formation; Ꞧk, Keku Volcanics; Ꞧb, Burnt Island Conglomerate; Ꞧc, Cornwallis Limestone; Ꞧh, Hamilton Island Limestone; Ꞧv, Hound Island Volcanics; Ksm, Lower Cretaceous lithic sandstone and mudstone; Tk, Kootznahoo Formation. Fossil collections in a given formation are listed in arbitrary order.

CORNWALLIS LIMESTONE

A medium-bedded to very thick bedded medium-gray oolitic limestone that overlies the Keku Volcanics is here named the Cornwallis Limestone. The type locality is designated as the northwest shore of Kuiu Island 0.75–2 miles east-southeast of Point Cornwallis. The Cornwallis Limestone is at least 200 feet thick on the northern part of the Cornwallis Peninsula, and is possibly thicker to the southeast.

The Cornwallis Limestone is characteristically oolitic. It weathers medium brown, has a conspicuously knobby appearance, and contains thin wispy interbeds of resistant dark-brown-weathering aphanitic limestone. Beds of calcarenite, locally pebbly, occur near the base of the limestone on the northern part of the Cornwallis Peninsula. Fossils suggest a shallow-water marine environment (N. J. Silberling, oral commun., 1963).

On most of the Cornwallis Peninsula, the Cornwallis Limestone overlies the Keku Volcanics conformably. Oolitic limestone similar to that of the Cornwallis is interbedded with clastic and volcanic rocks of the uppermost Keku Volcanics, and the contact between the Keku Volcanics and the Cornwallis Limestone is placed at the top of the highest volcanic rock or conglomerate composed primarily of volcanic detritus. At the northwest tip of the Cornwallis Peninsula, the Cornwallis Limestone is inferred to disconformably overlie the Pybus Formation. The contact is not exposed owing to minor faulting and to absence of outcrops inland, but the lowest beds of the Cornwallis Limestone are calcarenite that contains pebbles and sporadic cobbles of chert and limestone derived from the Pybus Formation.

The age of the Cornwallis Limestone is Late Triassic, ranging from late Karnian to earliest Norian (table 2; fig. 8). The formation is coeval with the Hamilton Island Limestone and is interpreted to be the shallow-water facies equivalent of the deep-water Hamilton Island Limestone.

HAMILTON ISLAND LIMESTONE

Very thin bedded dark-gray aphanitic limestone that crops out on Hamilton Island, on the north side of Hamilton Bay, and in the northeastern Keku Islets is here named the Hamilton Island Limestone. The type locality is designated as the northwest tip of Hamilton Island, 800 feet east-southeast of triangulation station Beth (figs. 2, 9).

The Hamilton Island Limestone is probably several hundred feet thick. Where exposed, it is so intensely and complexly folded that thickness estimates are unreliable.

The dominant rock type is very thin bedded dark-gray to black fetid aphanitic limestone that is locally dolomitic. Black argillaceous laminae and thin to medium beds of dark-green calcarenite are subordinate. Conspicuous color and textural banding in many outcrops is due to variation in calcite grain size and to variation in abundance of cryptocrystalline opaque material (carbonaceous?). Fossils are very abundant. The dominance of the flat clam *Halobia* suggests a deep-water marine environment (N. J. Silberling, oral commun., 1963).

The Hamilton Island Limestone is of Late Triassic age—predominantly late Karnian. The youngest beds may be of Norian age (table 2; fig. 8). Fossils from the formation fall into two groups, considered by N. J. Silberling (table 2) to be of late Karnian age and of latest Karnian or earliest Norian age. The Hamilton Island Limestone appears to have been deposited in deep water at the same time as the Cornwallis Limestone was deposited to the west in a nearshore shallow-water environment, and at the same time as the Hound Island Volcanics were first extruded near Cape Bendel (fig. 8).

The Hamilton Island Limestone rests with apparent conformity on the Burnt Island Conglomerate. On the northeast side of the central part of Hamilton Island and on the northeast side of Hamilton Bay, it appears to rest disconformably on the Pybus Formation, but exposures are not adequate to preclude the possibility of a thin intervening unit of Burnt Island Conglomerate. The Hamilton Island Limestone is overlain conformably by the Hound Island Volcanics. Uppermost beds of the Hamilton Island Limestone are interbedded with the lower part of the Hound Island Volcanics on Hamilton Island.

The Hamilton Island Limestone is similar to the thin-bedded argillite member of the Hyd Formation in the Pybus-Gambier area of Admiralty Island. This argillite member (Loney, 1964) contains more argillite, chert, and graywacke and less limestone than the Hamilton Island Limestone, yet the general appearance of the outcrops and the bedding characteristics are very similar (personal observation, 1963). Fossils from the argillite member of Admiralty Island, however, are of middle or late Norian age (N. J. Silberling, in Loney, 1964), whereas the fossils from the Hamilton Island Formation are restricted to the late Karnian and earliest Norian.

HOUND ISLAND VOLCANICS

Basaltic pillow breccia and pillow lava, andesitic volcanic breccia, and aquagene tuff that crop out over much of the Keku Strait area make up a unit here named the Hound Island Volcanics. Some thin-bedded limestone is also present in the unit. The type locality is designated as the shores of Hound Island, where about 2,000 feet of strata is exposed; a detailed map (scale, 1:15,800) of Hound Island is given in Brew and Muffler (1965, fig. 2). Thickness of the unit ranges from several hundred feet on Kuiu Island to more than 2,000 feet on northwest Kupreanof Island near Cape Bendel.

The rock nomenclature used in this report is that used by Carlisle (1963), who studied a similar Triassic volcanic sequence on Quadra Island, British Columbia. Pillow lava refers to closely packed accumulations of unbroken pillows with less than 10 percent matrix. Accumulations with greater than 10 percent matrix are designated as pillow breccias. Pillow breccias comprise two types—isolated-pillow breccia and broken-pillow breccia. Isolated-pillow breccia consists of irregularly shaped but unbroken pillows separated from each other by a cogenetic tuffaceous matrix that makes up more than 10 percent of the rock. Broken-pillow breccia consists of disaggregated fragments of pillows set in a tuffaceous matrix that makes up more than 10 percent of the rock. The term "aquagene tuff" was proposed by Carlisle (1963, p. 61) for a tuff "which has been produced by globulation or granulation through quenching, or both, or by a similar process entirely beneath water * * *." Carlisle contends that the shards in the volcanics of Quadra Island resulted from autocomminution upon quenching, and that the actual shattering occurred only after the volcanic liquid had chilled almost to the temperature of the water.

The estimated percentages of the various rock types in the Hound Island Volcanics are given in table 3.

TABLE 3.—*Estimated percentages of various rock types in the Hound Island Volcanics*

Rock type	*Southwest of Keku Strait*	*Northeast of Keku Strait*
Basaltic massive lava	10	25
Basaltic pillow lava	10	10
Basaltic broken-pillow breccia	30	40
Basaltic isolated-pillow breccia	14	12
Andesitic volcanic breccia	17	1
Aquagene tuff	15	5
Limestone and sandstone	2	2
Polymict tuffaceous conglomerate	2	5
	100	100

Massive flows of basaltic lava are most conspicuous on the southwest side of Hamilton Island and on Turnabout Island and nearby reefs. Individual flows range in thickness from 2 feet to more than 50 feet and commonly display polygonal jointing and vesicular tops. The massive basalts are fine grained, as contrasted to the microcrystalline texture of the pillow lavas and breccias, and contain labradorite and titanaugite in a chlorite-plagioclase mesostasis.

The pillow lavas of the Hound Island Volcanics are all of basaltic composition. They are composed of microphenocrysts of labradorite and titanaugite set in devitrified groundmass consisting of cryptocrystalline chlorite, clay, opaque material, and sporadic microcrystalline epidote. The interstices between pillows are commonly filled with comminuted volcanic material, but in many outcrops the interstices are filled with light-gray limestone (fig. 9) that is locally fossiliferous. Pillow flows are best displayed on the west side of Hound Island (fig. 10) and on the north shore of Hamilton Bay, about a third of a mile west of triangulation station Lee.

A typical isolated-pillow breccia (fig. 11) is an unsorted unstratified deposit of irregular very dark green basaltic pillows 6 inches to 2 feet in diameter in a matrix of gray-green aquagene tuff or of limestone. The fragments are petrographically similar to pillows of the pillow lava but are slightly finer grained. The aquagene tuff matrix is an unsorted aggregate of angular sand- to pebble-size fragments of devitrified basaltic glass. The material interstitial to these fragments is either comminuted chloritic volcanic detritus or white sparry calcite. Most of the calcite is probably a diagenetic cement, but sporadic relict bioclastic textures suggest that some may represent original bioclastic material that has partly recrystallized to form sparry calcite.

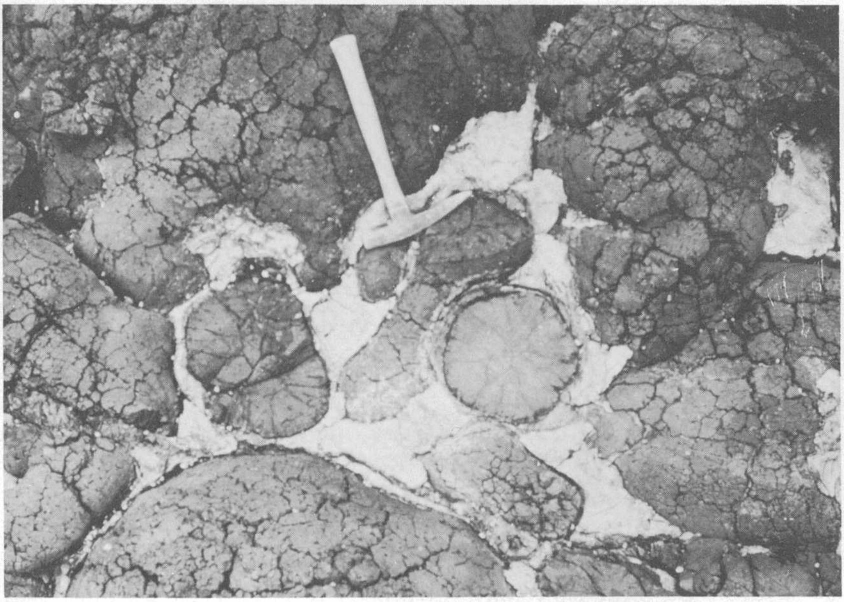

FIGURE 9.—Basaltic pillow flow in the Hound Island Volcanics on the west side of Hound Island. Interstices between pillows are filled with limestone.

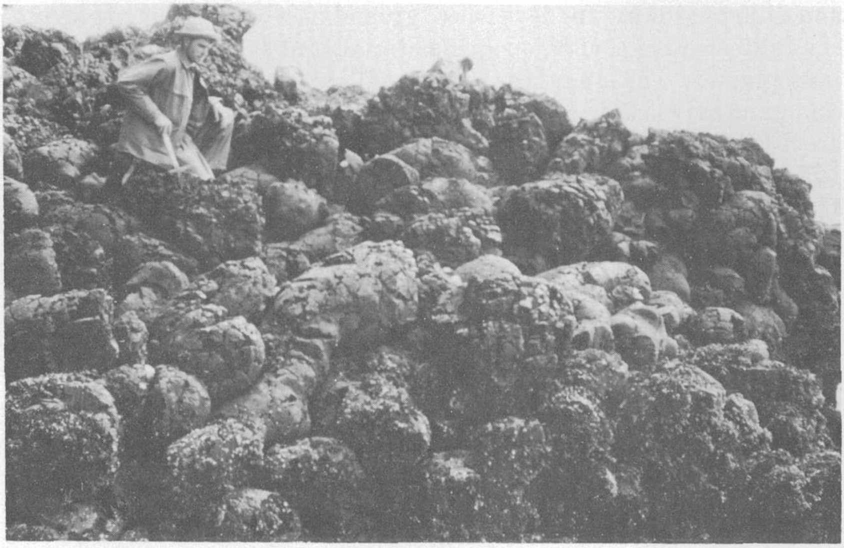

FIGURE 10.—Basaltic pillow lava in the Hound Island Volcanics on west side of Hound Island.

Isolated-pillow breccias grade with increasing disruption of fragments and increasing percentage of matrix into broken-pillow breccias (figs. 12–14). Many fragments in these breccias are readily identifiable as broken pillows by features such as radial joints and concentric bands of vesicules, and parts of the original chilled pillow margins. Most fragments in a given outcrop of broken-pillow breccia, however, do not show such diagnostic textural features, but the consistent association of these equivocal fragments with recognizable broken pillows suggests that they represent, at least in part, the interior, texturally less diagnostic parts of disrupted pillows.

Andesitic and dacitic(?) volcanic breccias are common in the Hound Island Volcanics in the Keku Islets and along the shore of Kuiu Island north of Kadak Bay. The fragments of these breccias are altered light-gray fine-grained to microcrystalline andesite or dacite, made up primarily of plagioclase crystals that range in composition from oligoclase to andesine and are alined in a trachytic texture. The mesostasis consists of chlorite, dolomite, calcite, clay, epidote, and sporadic quartz. Fragments in these breccias can seldom be recognized as parts of pillows; they may have been produced by disruption of blocks of a non-pillow flow rather than by disruption of pillows. The matrix of these breccias is aquagene tuff, composed of volcanic material cogenetic to the fragments, and commonly contains much sparry calcite and sporadic dolomite.

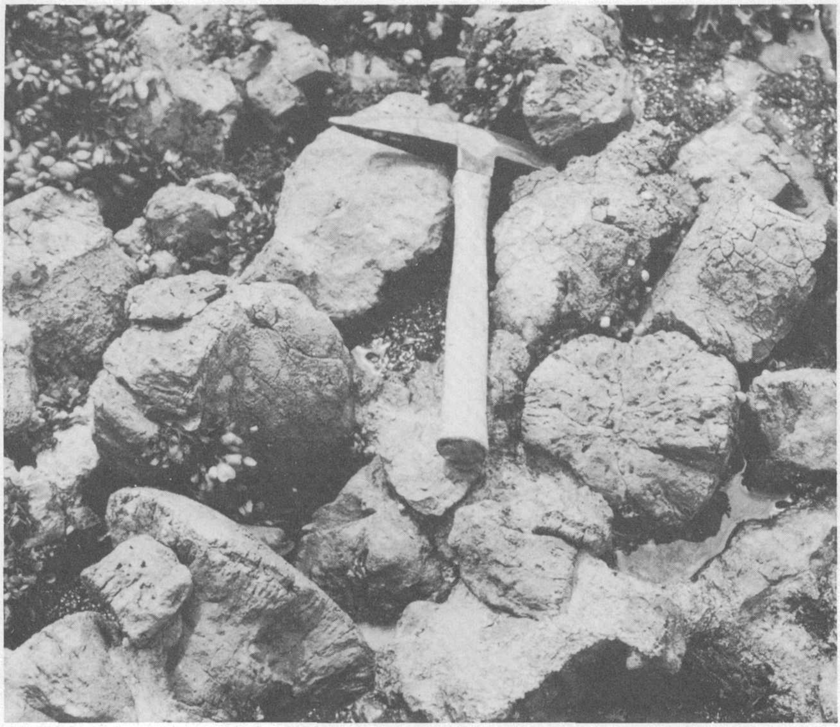

FIGURE 11.—Basaltic isolated-pillow breccia in the Hound Island Volcanics on west side of Hound Island. Note radial structure in the pillow to right of hammer handle. Interstices between pillows are limestone.

The aquagene tuff is commonly stratified in medium to thick beds and sporadically displays graded bedding and crossbedding. The tuff grades with increasing cobble- and boulder-size volcanic fragments into pillow breccia or andesitic breccia and is texturally identical with the matrices of these breccias. Typically the aquagene tuff consists of sand- to granule-size angular fragments of basaltic glass in varying stages of devitrification and alteration. In some samples none of the glass is devitrified (Brew and Muffler, 1965). In other samples the glass is devitrified to a poorly crystalline montmorillinoid clay mineral of uncertain specific composition. The material interstitial to the glass fragments is commonly sparry calcite (Brew and Muffler, 1965, figs. 4–7), particularly in the tuffs southwest of Keku Strait. Other tuffs contain a matrix of comminuted chloritic volcanic detritus, and a few tuffs are intensely altered to aggregates of datolite, analcite, calcite, epidote, and quartz.

FIGURE 12.—Basaltic broken-pillow breccia in the Hound Island Volcanics on the southwest side of Hamilton Island. Note radial and concentric structures in disrupted pillow to right of hammer.

Pillow breccias grade laterally and vertically with decreasing content of matrix into pillow flows, and with decreasing number and size of fragments into aquagene tuff. The systematic cyclical succession of pillow lava, isolated-pillow breccia, broken-pillow breccia and laminated tuff, and massive lava described by Carlisle (1963, p. 51) does not occur in the Hound Island Volcanics.

Spectacular polymict tuffaceous boulder conglomerate occurs near the base of the Hound Island Volcanics on the islets and reefs northwest of Hamilton Island and on the islets on the north shore of Hamilton Bay. This conglomerate is a poorly sorted, rudely stratified massive deposit as much as 130 feet thick. Clasts are angular, are as much as 4 feet in diameter, and comprise aquagene tuff, dark-green vesicular basalt, black limestone and argillite, light-greenish-gray calcareous siltstone, and light-gray andesitic(?) lava; these rock types were all derived from Triassic units. Light-gray cherty limestone from the Pybus Formation, green crinoidal sandy limestone from the Cannery Formation, and pumice also occur as clasts.

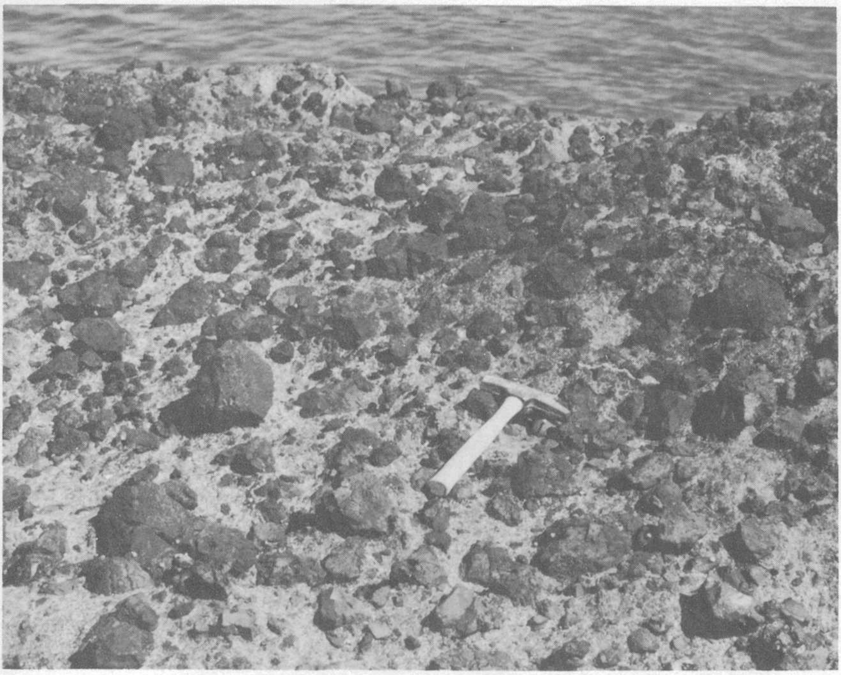

FIGURE 13.—Basaltic broken-pillow breccia in the Hound Island Volcanics a quarter of a mile west-northwest of triangulation station Luck, and approximately 2 miles north of the mouth of Kadak Bay, Kuiu Island.

Pumice fragments are particularly conspicuous on the islets on the north shore of Hamilton Bay. The matrix is a chlorite-rich unsorted aggregate of comminuted volcanic detritus. On the north side of Hamilton Bay, the conglomerate grades upward through bedded conglomeratic tuff into medium-grained aquagene tuff, and on Burnt Island are several beds about 20 feet thick that grade upward from boulder conglomerate to lithic sandstone.

This conglomerate appears to be a local deposit, perhaps the result of submarine landslides or mudflows. The presence of exotic fragments of the Pybus and Cannery Formations suggests that these formations were exposed nearby. Brown-weathering calcareous medium- to thick-bedded tuffaceous sandstone and a minor amount of conglomerate occur at the base of the Hound Island Volcanics on the west side of Hamilton Island and probably represent the lateral equivalent of the polymict tuffaceous boulder conglomerate.

Thin beds of dark-gray aphanitic limestone and calcareous siltstone, commonly containing abundant *Halobia* and (or) *Monotis* fragments, are locally interbedded with aquagene tuff and tuffaceous sandstone. Siliceous dark-gray limestone also occurs as stringers and

FIGURE 14.—Aquagene tuff matrix of basaltic broken-pillow breccia in the Hound Island Volcanics, on west side of cove 1¼ miles southwest of triangulation station Luck, and approximately 1 mile north of the head of Kadak Bay, Kuiu Island.

beds enclosed by pillow breccia. Some of these masses are as much as 20 feet thick and 150 feet long. Many such masses are probably lenses of limestone deposited on the sea floor during a temporary cessation of volcanic activity. Others appear to be inclusions in pillow breccia. One such inclusion, on the west side of Hamilton Island, is 15 feet thick and 120 feet long in outcrop. This inclusion is intruded along bedding planes by chilled lava and is bounded above and below by chilled lava that passes into pillow breccia away from the inclusion (fig. 15). These features suggest that the pillow breccia was injected into sediments on the Late Triassic sea floor as well as extruded onto the sea floor.

Tan-weathering, medium-gray fossil fragmental limestone is locally interbedded with the Hound Island Volcanics on Kuiu Island north of Kadak Bay.

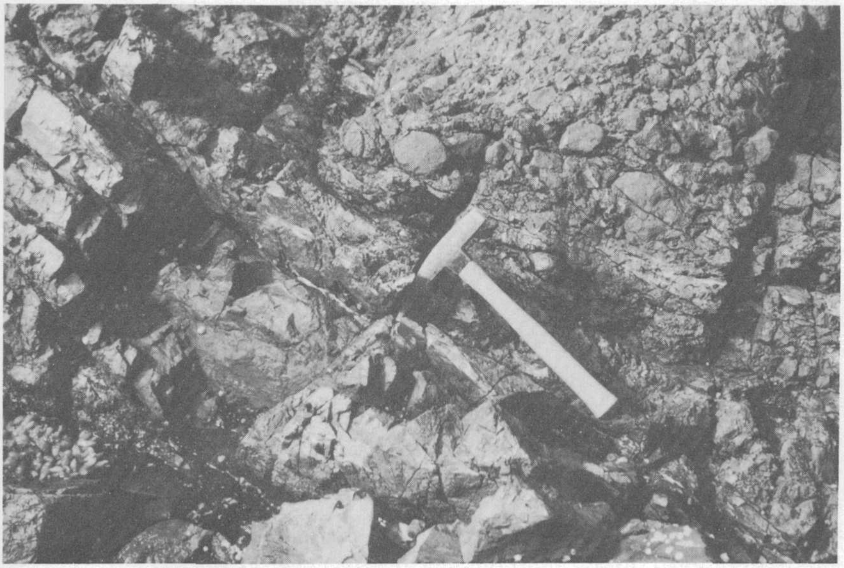

FIGURE 15.—Contact between pillow breccia and a limestone inclusion in the Hound Island Volcanics at triangulation station Ham, on the southwest side of Hamilton Island. Siliceous limestone (lower left) dips to right and away from viewer. Point of hammer head is on the contact with chilled basalt, which passes upward and to the right into broken-pillow breccia.

The Hound Island Volcanics is of Late Triassic age. Of the 21 fossil collections taken from the Hound Island Volcanics, 17 are of early or middle Norian age (table 2). Fossils collected from the intricately folded dark-gray limestone interbedded with volcanic rocks near the middle of the formation on Kupreanof Island east of Cape Bendel (table 2, loc. M1913; pl. 1, No. 30) are of late Karnian age, and fossils from the lowest beds of the Hound Island Volcanics on Kuiu Island a third of a mile south of triangulation station Low are of latest Karnian or earliest Norian age (table 2, loc. M1919; pl. 1, No. 33). Extrusion of volcanic material thus had begun at least by the late Karnian in the Cape Bendel area and had spread throughout much of the Keku Straits area by the early Norian. Late Norian fossils were collected from the Hound Island Volcanics on the north shore of Hamilton Bay (table 2, loc. M1898; pl. 1, No. 19) and in the cove 2 miles north of the west end of Kadak Bay on Kuiu Island (table 2, loc. M1912; pl. 1, No. 29).

Stratigraphic relations between the Hound Island Volcanics and the other formations of the Hyd Group are shown in figure 8.

JURASSIC AND CRETACEOUS SYSTEMS

SEYMOUR CANAL FORMATION

The Seymour Canal Formation is part of the belt of Jurassic and Cretaceous graywacke, argillite, and conglomerate that extends along the west side of the Coast Range batholith throughout the length of southeastern Alaska. These rocks were described by Buddington and Chapin (1929, p. 156–173, 253–260) and were named the Seymour Canal Formation by Loney (1964) in the Pybus-Gambier area of Admiralty Island. The Seymour Canal Formation, assigned a Late Jurassic and Early Cretaceous age by Loney (1964), is part of the Stephens Passage Group (Lathram and others, 1965), which also includes the Douglas Island Volcanics and the Brothers Volcanics.

The Seymour Canal Formation in the Pybus-Gambier area consists largely of dark-gray slaty argillite and thin-bedded volcanic graywacke and locally contains thick lenticular bodies of conglomerate and massive graywacke (Loney, 1964). The graywacke contains only a small amount of quartz, and potash feldspar is very sparse.

Rocks that almost certainly are part of the Seymour Canal Formation crop out along the north shore of Kupreanof Island for about 30 miles (Buddington and Chapin, 1929, p. 161 and pl. 1). The area of the present report (pl. 1) extends only to the west end of this belt, where interbedded medium-gray fine-grained slightly calcareous graywacke and dark-gray argillite outcrop adjacent to the Gambier Bay Formation. The contact is not exposed along the shore and may be a fault. No fossils have been found in these rocks; however, the rocks are correlated by lithologic similarity with the Seymour Canal Formation of Admiralty Island and with graywacke and argillite at Cape Fanshaw, about 25 miles to the northeast.

CRETACEOUS SYSTEM

LITHIC SANDSTONE AND MUDSTONE

Lithic sandstone and mudstone of Early Cretaceous age crop out along Keku Strait both northeast and southwest of Hound Island (pl. 1; Buddington and Chapin, 1929, p. 256–257). These rocks consist of thin-bedded fine-grained to very fine grained light-gray calcareous feldspathic lithic wacke and arenite and dark-gray to black mudstone. The sandstone does not have the dark chloritic matrix that characterizes graywacke. These rocks differ from the Seymour canal Formation in the lesser percentage of matrix, the paucity of volcanic detritus, the presence of abundant quartz, and the presence of about 10 percent potassic feldspar. Perhaps these differences are due to derivation of detritus primarily from the nearby Triassic and

Paleozoic sedimentary and volcanic rocks, rather than from volcanic and metamorphic rocks, as in the Pybus-Gambier area.

These Lower Cretaceous rocks disconformably overlie the Hound Island Formation and were intruded by Tertiary gabbro and converted to hornfels. The contact with the Tertiary Kootznahoo Formation was obscured by this intrusion.

Perhaps as much as 1,000 feet of stratigraphic section is present near Point Hamilton, but only a few hundred feet of section is represented on Kuiu Island north of Kadak Bay.

Fossils from two localities near Point Hamilton were identified by D. L. Jones (written commun., 1964) as follows:

M2114.—From hornfelsic mudstone on the southwest shore of Hamilton Bay 0.81 mile S. 40° E. of triangulation station Ton, Kupreanof Island.

Buchia cf. *B. Subokensis?*

M2112.—From brown calcareous sandstone on southwest side of the small islet just off Point Hamilton 0.54 mile N. 87° W. of triangulation station Ton, Hamilton Bay, Kupreanof Island.

Buchia sp., similar to M2114.

According to Jones, these fossils are fragmentary and deformed but seem to have closest affinities to lowest Cretaceous, Berriasian species.

CRETACEOUS(?) SYSTEM

HORNBLENDITE

Coarse-grained biotitic hornblendite partly altered to chlorite and sphene and containing much secondary calcite crops out on a tiny reef 2.24 miles N. 52° W. of triangulation station Low, in the southwestern Keku Islets. The reef is exposed only at low tide. Relations are unknown, but analogy with other southeastern Alaska ultramafic masses dated by potassium-argon geochronology (Lanphere and Eberlein, 1966) suggests emplacement during the middle part of the Cretaceous Period.

GRANITIC ROCKS

Two major granitic plutons and numerous smaller irregular masses and dikes intrude the Upper Silurian Bay of Pillars Formation on northwestern Kuiu Island. Metamorphic effects are outlined on p. C8–C9. The plutons are posttectonic and thus are either middle Cretaceous or younger.

The pluton southeast of Washington Bay is composite. Gabbro forms a roughly elliptical outer ring ¼–1½ miles wide. Foliation, where detected in gabbro, dips toward the center of the pluton. Where the ring is widest, at the northwestern part of the pluton, the rocks are predominantly fine- to medium-grained layered hypersthene-augite-olivine gabbro. The plagioclase is bytownite. Biotite is a minor interstitial and secondary constituent that is conspicuous on weathered surfaces. The eastern and southern parts of the outer ring are composed of amphibole-bearing augite gabbro that contains minor biotite. Here the plagioclase is labradorite. The amphibole is light brownish green in thin section and is only slightly pleochroic; it replaces clinopyroxene. Olivine and hypersthene were not detected. The amphibole and biotite may have formed during later intrusion of the adamellite core of the pluton at lower temperatures and higher water pressures.

The core of this composite pluton is fine- to medium-grained hornblende–biotite adamellite and granodiorite. The plagioclase is oligoclase. The hornblende is euhedral and is pleochroic from dark green to light tan. Adamellite also occurs as a small mass enveloped in gabbro near the northwest margin of the pluton.

The pluton west of Security Bay is dominantly fine- to medium-grained quartz-bearing hornblende diorite. Biotite-hornblende adamellite crops out at the south margin, and hornblende granodiorite near the northeast margin. Medium-grained hornblende gabbro forms the southeast projection of the pluton.

The hornfels along the ridge between these two major plutons are intruded by numerous irregularly shaped plutonic bodies, most of which are too small to show at the map scale. Quartz-bearing hornblende-pyroxene diorite is dominant; biotitic hornblende-pyroxene gabbro and hornblende adamellite are subordinate. The field relations seen in this reconnaissance were not adequate to preclude the possibility that some of the fine-grained diorites and gabbros are metamorphic amphibolites. Igneous breccias consisting of fragments of dark-green hornblende gabbro or amphibolite in a dioritic host are common. Dikes of microdiorite and hornblende dellenite are also present.

Dikes and irregular masses intrude hornfelsic graywacke and slate for approximately 2 miles north and south of Washington Bay. These intrusive rocks are dark gray and were designated in the field as diabase or basalt; petrographic examination showed them to be dominantly hornblende microdiorite; a few are biotite-hornblende microtonalite. Sporadic dikes of porphyritic hornblende dellenite also occur.

Fine- to medium-grained biotite-hornblende granodiorite crops out over at least 7 square miles about 3 miles south of the head of Port Camden. This pluton was studied in the field only briefly. On its west margin it appears to intrude basalt and greenstone of uncertain age and stratigraphic relations. This basalt and greenstone are possibly part of the Tertiary basaltic and andesitic lava (Tba) shown by Buddington and Chapin (1929, pl. 1) at the head of Port Camden. If so, this granodiorite pluton and possibly the other granitic plutons on Kuiu Island are of Tertiary age and may be related to the demonstrably Tertiary gabbro, basalt, and dellenite of Keku Strait (p. C48–C50).

TERTIARY SYSTEM

KOOTZNAHOO FORMATION

Nonmarine sandstone, conglomerate, and subordinate shale that extend in a belt across Keku Strait from Kadak Bay to the head of Hamilton Bay make up the northern part of a lower Tertiary basin that lies between Kupreanof and Kuiu Islands (Buddington and Chapin, 1929, p. 260–263). These rocks are here correlated with the Kootznahoo Formation (Paleocene through Miocene) of southern Admiralty Island.

The present investigation of the Keku Strait area did not involve detailed study of the Kootznahoo Formation, and I have little information to add to the description of the Kootznahoo by Buddington and Chapin (1929). The dominant rock type is a medium-grained to very coarse grained lithic feldspathic quartz arenite. Conglomerate containing clasts of granitic rock, slate, schist, and chert is common. Along the shores of Port Camden, just south of the mapped area, and stratigraphically above the altered dellenite flows (described in the next section) are pebble and cobble conglomerates composed primarily or entirely of felsic volcanic debris. Subordinate shale is locally carbonaceous and contains abundant plants. Petrified wood is common. The Kootznahoo Formation rests unconformably on the Hound Island Volcanics and on the Cannery Formation, but its contact with the Seymour Canal Formation is obscured by a gabbro intrusion. The Kootznahoo is overlain to the south by felsitic flows and volcanic conglomerate and is intruded by gabbro. The thickness is probably more than 1,500 feet.

The Kootznahoo Formation in the Keku Strait area is probably of Paleocene age, although the upper beds may be younger. Several plant collections from Hamilton Bay and Port Camden were assigned by F. H. Knowlton to the Eocene (Buddington and Chapin, 1929, p. 268). However, Jack A. Wolfe (in Lathram and others, 1965, p. 31) has recently considered the flora from Hamilton Bay to be Paleocene and has correlated it with the flora from the Kootznahoo Formation in Little Pybus Bay, Admiralty Island. No new collections were made during the present study in the Keku Strait area.

Wolfe (in Lathram and others, 1965, p. 30–31) has also discriminated three distinct, younger floral assemblages in the Kootznahoo Formation of the Kootznahoo Inlet area on the west side of Admiralty Island. The oldest assemblage is Eocene, the second is Oligocene, and the youngest is late Oligocene or early Miocene. Oligocene or Miocene plants possibly occur in stratigraphically higher parts of the Kootznahoo Formation on Kuiu and Kupreanof Islands, south of the Keku Strait area.

ALTERED DELLENITE FLOWS

Gently dipping felsic flow rock, predominantly dellenite in composition, crops out in a belt that was mapped from Port Camden on Kuiu Island to the shore of Kupreanof Island east of Entrance Island. The extent of this belt to the northeast or to the southwest in unknown. Dellenite flow rock also crops out on the south side of the peninsula at Salt Point, Kupreanof Island.

Much of this unit underwent deuteric alteration and partial recrystallization soon after extrusion. The least altered rocks—on Entrance Island—are medium gray, display flaggy parting parallel to an obscure flow foliation, and contain microphenocrysts of clinopyroxene in a groundmass of plagioclase (zoned from cores of labradorite to thin rims of albite), quartz, potash feldspar, wispy green biotite, an opaque mineral, and a myrmekitic intergrowth of plagioclase and quartz. The myrmekite mantles plagioclase crystals, and the albitic phase of the myrmekite is in crystallographic continuity with the rims of the plagioclase crystals. The more intensely altered rocks are very light gray or white, display closely spaced irregular fractures, and consist of plagioclase (altered to albite and sericite and rimmed by potash feldspar), potash feldspar, and quartz. The altered rocks show marked variation in the proportion of potash feldspar and plagioclase and are very similar to the lighter colored varieties of the Keku Volcanics (p. C27) and altered Permian volcanic rocks of central and western Nevada (Knopf, 1924; Muffler, 1964).

Pebble conglomerate composed exclusively of angular fragments of altered dellenite is locally intercalated with altered dellenite flows along the east shore of Port Camden, Kuiu Island. Some fragments consist primarily of potash feldspar, whereas others have a high content of plagioclase. All the fragments have sharp edges. These observations suggest that the alteration of the dellenitic volcanic rock took place before erosion of the flows and before deposition of the conglomerate beds, and that alteration was a deuteric phenomenon.

Stratigraphic relations of the dellenite flow unit are poorly displayed in the mapped area, for the unit is in contact only with intrusive Tertiary gabbro. Presumably the dellenite flow unit is intercalated with the Kootznahoo Formation, as suggested by the general conformity of attitude with the nearly flat lying Kootznahoo

Formation and by the conglomerates containing only clasts of altered felsite that are common in the Kootznahoo Formation in Port Camden (p. C47).

This dellenite unit probably corresponds both to the north end of the dacite porphyry mass and to the rhyolite breccia, tuff, and conglomerate unit described by Buddington and Chapin (1929, p. 263–264, p. 273–274).

GABBRO AND MICROGABBRO

Medium-grained gabbro of Tertiary age (Eocene or younger) cuts the Tertiary Kootznahoo Formation and the Jurassic and Cretaceous Seymour Canal Formation on Kuiu and Kupreanof Islands in the southeast corner of the mapped area. This gabbro forms gently dipping sills as much as 1,500 feet thick. In addition, microgabbro dikes occur sporadically throughout the outcrop area of the Kootznahoo and Seymour Canal Formations.

The gabbro least affected by deuteric alteration contains olivine, fresh subpoikilitic clinopyroxene, and labradorite. The more altered specimens are devoid of olivine, contain as much as 10 percent secondary potash feldspar, and carry deuteric chloritic minerals as interstitial mats and as veins in plagioclase. In one specimen the plagioclase is rimmed and veined by secondary albite. Buddington and Chapin (1929, p. 274–275) described a gabbro containing analcite, thomsonite, and pectolite from a locality that I infer to be at Salt Point, Kupreanof Island.

Several sills of altered gabbro intrude the Hound Island Volcanics on Hamilton Island and on the islets immediately to the southeast. These sills are probably of Tertiary age, but the possibility that they are Late Triassic age and genetically related to the Hound Island Volcanics cannot be excluded either by field relations or by petrography.

Swarms of microgabbro dikes and sills of probable Tertiary age intrude various pre-Tertiary formations. These intrusive bodies are 3–25 feet thick and display chilled margins bordered by hornfels.

One swarm of dikes and sills intrudes rocks of the Seymour Canal Formation and the Hound Island Volcanics on the east shore of Kuiu Island from Kadak Bay to the string of islets 4 miles to the north. The sill that forms these islets is at least 200 feet thick. Both dikes and sills display conspicuous columnar jointing perpendicular to the cooling surfaces.

A second swarm of microgabbro dikes intrudes the Silurian Kuiu Limestone on the southwest islets of the Keku group, where the dikes appear to be associated with barite and witherite mineralization (Twenhofel and others, 1949, p. 43–44; Buddington, 1925, p. 136–137).

The Halleck Formation was particularly susceptible to intrusion by microgabbro. Conglomerate, siltstone, and sandstone on the large islet in the northwestern part of the Keku group (5.5 miles S. 80° E. of Point Cornwallis) are cut by many dikes, some of which are associated with sphalerite mineralization (Buddington, 1925, p. 138–139). Many microgabbro dikes intrude the Halleck Formation at the head of Saginaw Bay, where they postdate both the Jurassic (or Cretaceous) folding of the sedimentary rocks and the formation of fracture cleavage. Sphalerite was not seen in this area.

Microgabbro dikes occur sporadically in a few other formations, particularly in the Kuiu Limestone and the Bay of Pillars Formation west of Saginaw Bay and in the Cannery Formation on Kupreanof Island northeast of Hamilton Bay.

The gabbro and microgabbro of the Keku Strait area probably were intruded during a single episode, and they almost certainly are genetically related to basalts that overlie the Kootznahoo Formation on Kuiu and Kupreanof Islands to the south (Buddington and Chapin, 1929, p. 266) and to the basalts of the Admiralty Island Volcanics to the north. The Admiralty Island Volcanics are considered by Lathram, Pomeroy, Berg, and Loney (1965, p. 33) to be of Eocene and Oligocene age. However, the relationship between these volcanics and the Miocene beds of the Kootznahoo Formation at Kootznahoo Inlet (Lathram and others, 1965, p. 30–31) is unknown; the outcrop areas of the two formations are not contiguous.

STRUCTURE

The structure of the Keku Islets area is imperfectly understood, even after completion of detailed mapping. Buddington and Chapin (1929) correctly pointed out the existence of three major northwest-trending structural features, here termed the Keku synclinorium, the Kake anticline, and the Cape Bendel syncline. The present mapping indicates, further, that there are at least two generations of folds and some major high-angle faults. The rocks show a puzzling alternation of gently dipping areas and complexly deformed areas. For example, the belt of Permian rocks trending northwest through the center of the Keku Islets is only gently warped, yet the Permian and Triassic rocks in the northern islets are intensely deformed. The Triassic rocks on Hound Island are essentially homoclinal, whereas those on Hamilton Island are intensely folded and faulted.

This alternation is partly due to differing response to tectonic stresses by different rock types. The Pybus Formation acted as a rigid unit and either was deformed into broad folds (as on the Cornwallis Peninsula) or was intensely fractured and brecciated (as in the west-northwest-trending fault zone in the Keku Islets). The Hamilton Island Limestone, however, was commonly deformed into appressed intricate folds, as were the Bay of Pillars and Cannery Formations. Irregularity of the deformational pattern may also be partly due to localization of tectonic stresses along belts or zones.

There appears to be no evidence of major tectonic transport along any of the faults shown on plate 1. Areal distribution of formations precludes any appreciable amount of strike-slip movement; movement along the faults appears to have been primarily vertical, with no consistent sense of slip. However, the marked dissimilarity in both lithology and tectonic style between the coeval Cannery and Halleck Formations suggests that a major thrust may have brought these dissimilar facies into proximity. Such a thrusting would have necessarily taken place just after deposition of the Halleck and Cannery Formations of Early Permian age, for the Late Permian Pybus Formation and the Late Triassic Hyd Group crop out continuously across the Keku Islets area and therefore could not have been affected by any major thrusting. (See also p. C25). This thrusting would also account for the dissimilarity of the pre-Permian sections of Kupreanof and Kuiu Islands.

Temporal relations of tectonic features are uncertain. The major deformation that affected the Keku Islets area was definitely post-Late Triassic, and probably occurred during the Late Cretaceous. Although the Early Cretaceous sedimentary rocks in the southern part of the Keku Islets area are only gently deformed, the Jurassic and Cretaceous rocks of the Seymour Canal Formation at the northeast corner of the area, as well as on Admiralty Island (Loney, 1965) and on the mainland at Cape Fanshaw (Muffler, unpub. data, 1963), are intensely deformed and show several generations of structural features. Deformation may also have taken place prior to deposition of the Permian Pybus Formation, as suggested by the apparent unconformity between the Pybus Formation and the Cannery Formation and by the possibility of tectonic juxtaposition of the Cannery and Halleck Formations before deposition of the Pybus Formation.

Structural analysis similar to that applied by Loney (1965) in the Pybus-Gambier area of Admiralty Island was attempted unsuccessfully on the Bay of Pillars Formation, the Hamilton Island Limestone, and the Cannery Formation. Further attempts should be made, however, for the Bay of Pillars Formation, in particular, appears to be very promising for structural analysis.

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