MAP I-684

DEPARTMENT OF THE INTERIOR
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GEOLOGIC MAP OF ANNETTE ISLAND, ALASKA

By
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MISCELLANEOUS GEOLOGIC INVESTIGATIONS
MAP I-684

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BERG—ANNETTE ISLAND, ALAS. 1:63 360 MAP I-684

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GEOLOGIC SUMMARY AND DESCRIPTION OF MAP UNITS

INTRODUCTION

Only the bedrock units are shown on the accompanying map, but between high tide and timberline, unmapped unconsolidated surficial deposits, muskeg, and thick vegetation cover all but the south-central part of Annette Island. The unconsolidated deposits range in thickness from a few inches to many feet and consist of river and beach alluvium, marine terrace deposits, and glacial debris. The surficial deposits of Metlakatla Peninsula have been studied by Eckel (written commun., 1940), and by Marcher (1969), who measured maximum thicknesses of 15 and 33 feet.

Annette Island consists of two geologically distinct bedrock terranes—mainland Annette Island and Metlakatla Peninsula, a large southwestern appendage of the island. The terranes differ markedly in lithology and in style and grade of metamorphism, and are described separately in this report.

In general, the rock nomenclature and classification used in this report follows that of Williams, Turner, and Gilbert (1954); in part, however, the metamorphic rocks are classified according to Turner and Verhoogen (1960), and Turner (1968). Unless otherwise noted, mineral assemblages throughout the report are given in estimated order of decreasing abundance. Plagioclase compositions accompanied by numerical An values were determined either by whole-rock X-ray diffraction or by measuring the refractive index of crushed fragments in high-dispersion oils; plagioclase compositions unaccompanied by numerical An values were determined by examination of thin sections on a flat-stage petrographic microscope.

All the rocks in the Annette Island area have undergone one or more episodes of metamorphism during which they recrystallized and were more or less foliated, depending on the metamorphic susceptibility of the original rock. In the lithologic descriptions that follow, however, nonmetamorphic rock names such as limestone, graywacke, diorite, etc., are occasionally used to avoid undue repetition of such cumbersome qualifying terms as "recrystallized", "altered", "meta-", etc.

GEOLOGY

Mainland Annette Island

Mainland Annette Island consists of a core of Silurian trondhjemite (Annette pluton) and a fringe of predominantly greenschist-facies regionally metamorphosed bedded rocks that range in age from Silurian or older to Jurassic. The bedded rocks include recrystallized, predominantly calcalkaline, basaltic, andesitic, and rhyolitic volcanic and volcaniclastic units, graywacke-slate assemblages, and subordinate, but stratigraphically significant, limestone and conglomerate. In addition to the Annette pluton there are two other plutons within the mainland terrane. One, on a small island just off the northeast coast, is foliated quartz diorite of Cretaceous age. The other, on northern Annette Island, is an elongate body of altered diorite inferred to be Jurassic or Cretaceous in age.

Cretaceous quartz metadiorite

Brownish-gray medium-grained recrystallized quartz diorite containing albite (An_{5-6}), 15-20 percent quartz, and accessory muscovite, sphene, apatite, and pyrite. In addition to the albite, other alteration minerals, which locally form up to 20 percent of the rock, include chlorite, derived from biotite; clinozoisite-epidote, a coproduct of the albitization of the originally more calcic plagioclase; and calcite and sericite, probably also formed at the expense of the primary plagioclase. Rock textures range from granitoid to gneissic. Some of the planar structure may be due to flow foliation near the margin of the pluton during emplacement, but most is probably due to subsequent regional metamorphism. Other evidence of postmagmatic deformation includes strained quartz and microscopically kinked micaceous minerals, especially the chlorite.

The muscovite has yielded a potassium-argon age of 87 ± 3 m.y.

The pluton is interpreted as a small stock or plug. On the islet southeast of Spire Island, it intrudes Jurassic graywacke and slate, which, near the contact, is metamorphosed to andalusite-bearing schist and hornfels.

Jurassic or Cretaceous metadiorite

This texturally diverse pluton consists of greenish-gray, fine- to medium-grained diorite and minor quartz diorite. It is moderately foliated and strongly hydrothermally altered, but relict granitoid, porphyritic, and ophitic textures generally are preserved. The granitoid and porphyritic varieties predominate and probably occur in about equal amounts; field relations indicate that they probably are transitional and that the porphyritic parts of the pluton generally are more abundant near its margin.

The granitoid phase typically contains about equal amounts of strongly altered plagioclase and ferromagnesian minerals, up to about 10 percent interstitial quartz, and accessory sphene, apatite, and pyrite. It is cut by a few seams of quartz and calcite. The plagioclase is converted almost entirely to very fine grained clinozoisite, sericite, and albite, and the ferromagnesians largely to actinolite, chlorite, and epidote. The porphyritic variety most commonly consists of randomly oriented to crudely alined individual crystals or clumps of crystals of altered plagioclase up to about a quarter of an inch

long, plus subordinate actinolite, chlorite, and epidote derived from hornblende and possibly pyroxene. The interstices among the plagioclase crystals are occupied by clinozoisite-epidote, chlorite, sericite, pyrite, and in some specimens, up to about 10 percent quartz.

The pluton intrudes Jurassic bedded rocks, but except for some local baking of the beds along the southwest shoreline of Annette Bay, the contact generally is not marked by an intense thermal aureole. The outcrop pattern and structural relations indicate that the pluton is a northeastward-dipping (or plunging) body, possibly with an elongate plug-like or crudely tabular shape.

The porphyritic parts of the pluton, which probably signify relatively rapid chilling at its margin, are texturally, compositionally, and chemically similar to parts of the adjoining intermediate metavolcanic country rocks. These similarities, plus their close spatial relation and lack of significant thermal effects at their contact, suggest that the pluton and the metavolcanic rocks may be cogenetic, the pluton being a hypabyssal variant of the intermediate volcanic rocks.

If, as suggested, the pluton and the volcanic rocks are cogenetic, then the pluton is Jurassic; if they are not, then the pluton probably is post-Jurassic and may correlate with the Cretaceous quartz diorite on Spire Island.

Jurassic intermediate metavolcanic rocks and metasedimentary rocks

Jv, intermediate metavolcanic rocks. Light-greenish- and brownish-gray recrystallized andesitic to basaltic volcanic and volcaniclastic rocks and subordinate metasedimentary rocks. Some of the metavolcanics are massive or only crudely foliated, but most are phyllitic and contain the regional greenschist-facies metamorphic mineral assemblage albite, chlorite, actinolite, epidote-clinozoisite, sericite, quartz, calcite, apatite, sphene, and pyrite. North of Crab Bay, the member is mixed with dioritic intrusive rocks and partly converted to epidote-almandine-actinolite hornfels.

Despite recrystallization, relict porphyritic, fragmental, amygdaloidal, and aphanitic textures are common. The prevailing rock type is foliated agglomerate consisting of porphyritic clasts in a porphyritic to aphanitic base. Relict phenocrysts consist of altered (clinozoisite, albite, sericite) plagioclase crystals up to half an inch long and less abundant altered (actinolite, epidote, chlorite) ferromagnesian crystals of comparable size. Most of the ferromagnesian minerals apparently are hornblende or its alteration products; relict clinopyroxene phenocrysts have been recognized only in a small part of the member. Varieties containing only plagioclase phenocrysts are common, but most of the member contains at least some ferromagnesian phenocrysts; locally they are strikingly abundant and the plagioclase is absent. Quartz is rarely visible in hand specimens, but under the microscope can be detected in some specimens in amounts up to about 10 percent.

The metasedimentary rocks, which intertongue gradationally with the metavolcanic rocks, vary in amount from place to place, but by definition make up less than half of the metavolcanic member. Where the metasedimentary rocks predominate, they are mapped separately.

Jsgc, metasedimentary rocks. The most abundant rock types in this member are lineated dark-gray slate and silvery green and gray phyllite; less abundant, but locally prominent, are slaty to phyllitic graywacke, calcareous siltstone and other fine-grained detrital rocks, and conglomerate. The conglomerate consists of moderately to strongly deformed, angular to subrounded clasts up to 4 feet long in a matrix of dark-gray phyllite and phyllitic grit. The clasts include porphyritic and aphanitic intermediate igneous rocks derived from the metavolcanic member of this unit, dark-gray phyllitic limestone and fine-grained sedimentary rocks, minor felsic igneous rocks, and rare mafic igneous rocks.

In general, the metasedimentary member contains the same metamorphic mineral assemblage as the metavolcanics. Near the contact with the Cretaceous quartz diorite on the islet southeast of Spire Island, however, the beds are metamorphosed to andalusite-bearing hornfels and schist. Fossils have not been found in either member of this unit on Annette Island, but a Middle or Upper Jurassic age is indicated by the following relations: 1) it transitionally overlies beds (Jsg) containing belemnitelike organic(?) structures that might be Jurassic in age; and 2) it is on strike with, and lithologically identical to, fossiliferous Middle or Upper Jurrassic beds nearby on Gravina Island.

The thickness of the unit is difficult to determine owing to complex structure and lack of persistent marker beds. It probably varies in original thickness from place to place, but its maximum thickness on Annette Island might be about 2,500 feet. On the Queen Charlotte Islands in British Columbia, the Yakoun Formation, a unit of similar age and lithology, is estimated to be 3,000-6,000 feet thick (Southerland-Brown, 1968).

Jurassic slate and phyllitic graywacke

Thinly interbedded dark-gray and dark-green lineated slate and phyllite, phyllitic calcareous siltstone and graywacke, and subordinate phyllitic conglomerate, limestone, and intermediate volcanic and volcaniclastic rocks containing relict feldspar and ferromagnesian phenocrysts. In general, the unit is regionally metamorphosed and contains the greenschist-facies mineral assemblage albite, chlorite, actinolite, epidote-clinozoisite, sericite, quartz, calcite, and pyrite; on the shoreline of Hassler Harbor due west of Pow Island, a black carbonaceous member also contains abundant sand-size euhedra of spessartite(?) garnet. The unit grades upward into Jurassic intermediate metavolcanic rocks (Jv) by increase in green phyllite, porphyry, and agglomerate.

Although the unit apparently is structurally conformable with the underlying bedded rocks, its areal distribution shows that it is in contact with several rock types of widely different ages. The lower contact thus may be a fault or an unconformity, but is too poorly exposed to characterize with certainty.

The unit is assigned a Middle or Upper Jurassic age, based in part on the occurrence of very sparse belemnitelike structures in calcareous concretions in

phyllitic conglomerate near the base of the unit north of Pillow Point, and in part on lithologic correlation with fossiliferous Middle or Upper Jurassic beds nearby on Gravina Island. The unit probably is at least several hundred feet thick, but its widely fluctuating outcrop width on Annette Island is probably due as much to structural complexity as to variations in original thickness.

Triassic breccia, conglomerate, and intermediate to basic metavolcanic rocks

Ṯrbx, breccia and conglomerate. This predominantly metasedimentary member consists of phyllitic breccia and conglomerate containing flattened, sheared clasts, up to several feet long, of green-weathering intermediate metavolcanic rocks and dark-gray limestone, slate, siltstone, and graywacke. The matrix is lineated dark-gray calcareous phyllite and phyllitic grit. The member is regionally metamorphosed and contains the greenschist-facies mineral assemblage albite, sericite, epidote-clinozoisite, actinolite, chlorite, calcite, and quartz. In Kwain and Crab Bays, the basal part of the breccia contains slabs and discontinuous layers of fossiliferous Upper Triassic limestone that establish the age of the member in that area. In Kwain Bay the member apparently conformably overlies Upper Triassic limestone (Ṯrls); south of Kwain Bay, however, it unconformably overlies felsic metavolcanic rocks older than the Triassic limestone.

Ṯrv, intermediate to basic metavolcanic rocks. Near Pillow Point this member consists of altered andesitic pillow flows and broken-pillow breccia that grade laterally into massive carbonate-cemented andesite-clast breccia. The flows are characterized by deformed pillows up to 2 feet in diameter and a matrix of calcitic limestone and altered volcanic material. The pillows are very fine grained, dark greenish gray, and consist of a relict intersertal-felty aggregate of secondary minerals, plus pinhead-size calcite amygdules. On Sylburn Peninsula, the member comprises altered andesitic to basaltic marine tuff and breccia. It is dark olive green, thin to medium bedded, and consists of deformed angular clasts up to a foot long of aphanitic metavolcanic rock in a sandy, platy to fissile matrix rich in calcite and chlorite. Some of the clasts are amygdaloidal and closely resemble the pillow breccia at Pillow Point. Weathered surfaces of this member have a conspicuous pock-marked or "Swiss-cheese" appearance.

At Pillow Point, the member unconformably(?) overlies Triassic limestone (Ṯrls), and underlies, apparently with little structural discordance, Middle or Upper Jurassic bedded rocks (Jsg). On Sylburn Peninsula, it is in contact with fossiliferous Triassic limestone and felsic metavolcanic rocks, but the stratigraphic relations are obscured by structural complexity.

The two members of this unit do not occur together on Annette Island and have been correlated on the basis of lithologic similarities and roughly equivalent stratigraphic position relative to other units. Despite the apparent conformity of the breccia member with the underlying limestone in Kwain Bay, the fact that the unit elsewhere overlies different Triassic formations suggests that, at least locally, there is an unconformity at its base. The maximum thickness of the unit is probably about 500 feet.

Triassic(?)[1] and Triassic metasedimentary and felsic metavolcanic rocks

This unit comprises four members whose principal rock types, in order of generally increasing age, are: 1) recrystallized carbonaceous limestone and siltstone (Ṯrls); 2) recrystallized massive gray limestone (Ṯrl); 3) felsic metavolcanic rocks (Ṯrf); 4) recrystallized conglomerate and breccia (Ṯrc). Their stratigraphic relations range from what seems to be simple superposition in the Crab Bay-Kwain Bay area, to complex intertonguing, apparently further complicated by faulting and multiple folding, on Sylburn Peninsula. The age of the carbonaceous limestone and siltstone member is well established by the occurrence of Upper Triassic fossils. The other members do not carry identifiable fossils, but are grouped with the carbonaceous member and provisionally assigned a Triassic age on the following grounds: 1) they apparently are structurally and depositionally concordant with the carbonaceous member west of Kwain and Crab Bays; 2) the metavolcanic and fragmental rocks seem to intertongue with the carbonaceous member on Sylburn Peninsula; 3) at least three of the four members are associated in a distinctive lithologic assemblage wherever they occur; and 4) there is a marked unconformity at the base of the unit.

Ṯrls, recrystallized carbonaceous limestone and siltstone. Dark-brown to sooty-gray, thinly interbedded, carbonaceous limestone, calcareous siltstone and mudstone, subordinate thin- to medium-bedded light-gray very fine grained limestone, and minor pebbly limestone and carbonate-cemented granule to cobble conglomerate. The member characteristically is intricately folded, complexly lineated, and phyllitic and contains the greenschist-facies regional metamorphic mineral assemblage sericite, quartz, albite, chlorite, calcite, and clinozoisite. The darker-hued parts contain abundant graphite and locally are strikingly rich in well-crystallized pyrite. Locally well-preserved Upper Triassic fossils indicate that the upper half of member is upper Norian and the lower half is lower and middle Norian. The estimated maximum thickness of the member is 300 feet.

Ṯrl, recrystallized massive gray limestone. Dark-bluish-gray, very finely crystalline limestone distinguished by such weathering features as solution pits and valleys, caverns, and underground drainage. Most of the limestone is massive and calcitic, but locally it is moderately to thickly bedded and, in a few places, dolomitic. In places, it contains fairly abundant bits of white-weathering material that probably are of organic origin, but identifiable fossils have not been found. A small amount of limestone that provisionally is correlated with this member crops out on the east shore of Port Chester, where it is in fault(?) contact with the Annette pluton. The maximum thickness of the member is about 200 feet.

[1] Field studies in 1970 on nearby Gravina Island indicate that most of these units are of Middle and Late(?) Paleozoic age

Trf, felsic metavolcanic rocks. Foliated recrystallized rhyolitic to dacitic volcanic and volcaniclastic rocks that probably originated mainly as subaerial ash flows and tuff and subordinately as marine tuff and tuffaceous sediments. A small part of the member probably was extruded as domes and short lava flows. In the Kwain Bay-Crab Bay area, the metavolcanics consist chiefly of light-gray, light-green, and light-brown phyllite and platy, nonfissile schist containing the greenschist-facies regional metamorphic mineral assemblage quartz, muscovite, K-feldspar, albite, calcite, and dolomite. Despite the recrystallization, relict features such as flow lamination and spherulitic, vitroclastic, fragmental, and porphyroaphanitic textures locally are well preserved. On Sylburn Peninsula and southeast of Pillow Point the member consists of massive to thinly laminated, diversely colored aphanite, locally with prominent spherulitic texture, and subordinate phyllite and phyllitic aphanite. At Driest Point, massive light-gray aphanitic metarhyolite is overlain by about 50 feet of recrystallized marine rhyolite tuff and rhyolitic ash- and lapilli-rich dolomite. The estimated maximum thickness of the member is about 600 feet.

Trc, recrystallized conglomerate and breccia. Massive to phyllitic fragmental rocks that have two principal occurrences: 1) as lenses and discontinuous beds at the base of the four-member Triassic(?) and Triassic unit; and 2) as lenses and wedges that intertongue with the metavolcanic and carbonaceous members and possibly with the massive gray limestone. The origin of the fragmental rocks is complex. Some clearly are sedimentary and some are pyroclastic, but in many cases a distinction between them has not been made, partly because of the transitional nature of the deposits, and partly because of subsequent deformation and recrystallization. For the same reasons, it was not always possible to distinguish this sedimentary member from tectonic breccia, especially on western Annette Island, and small zones of fault breccia may have been mapped as fragmental bedded rocks.

In the Kwain Bay-Crab Bay area, the member forms the base of the Triassic(?) and Triassic unit and consists of elongate lenses up to 50 feet thick of quartz-sericite-albite phyllite and schist containing prominent relict clasts of trondhjemite, quartz diorite, and sparse greenstone. This rock, which depositionally overlies the Annette pluton and older rocks and grades upward into rhyolitic metatuff, is interpreted as a recrystallized subaerial ash-flow that accumulated abundant surficial debris as the flow advanced over exposed, predominantly granitic terrane.

Elsewhere on Annette Island, no systematic distinction could be made between the diverse parts of the member. From place to place, it includes massive to phyllitic, chaotic to well-bedded, brown- , green- , and red-weathering breccia, grit, and conglomerate containing clasts up to 2 feet long of leucocratic granitic rocks, fragmental quartz and plagioclase, and minor metarhyolite, limestone, and foliated fine-grained detrital rocks. In the massive and well-bedded varieties, the matrix is brown-weathering dolomite containing minor sericite and hematite and thin seams of K-feldspar; in the phyllitic varieties the matrix is mainly sericite, microgranular quartz and albite, hematite, and calcite. The estimated maximum thickness of the member is 500 feet.

Undivided Triassic(?) rocks[2]

Scattered outcrops of rocks lithologically identical to parts of the Triassic(?) and Triassic unit occur on the heavily timbered ridges northeast of Round Mountain and east of middle Todd Lake, but the sparsity and poor quality of exposures, coupled with complex structure, preclude mapping individual members. While all four members of the unit may occur in the areas of undivided rocks, only two have been recognized: the recrystallized massive gray limestone, whose occurrences are marked by the letter "l", and the recrystallized conglomerate and breccia, whose outcrops are indicated by the letter "c". Other rock types in the areas of undivided Triassic(?) rocks include slate and phyllitic fine-grained rocks too lacking in distinctive character to assign to any member of the Triassic(?) and Triassic unit.

Middle or upper Paleozoic(?) phyllite and schist

Predominantly metamorphosed bedded rocks consisting of phyllite and schist containing the regional greenschist-facies mineral assemblage quartz, plagioclase (albite and sodic oligoclase), potassium feldspar, muscovite, calcite, dolomite, and subordinate chlorite, magnetite, and hematite. Relict textures indicate that unit has been derived from: 1) sedimentary rocks ranging from feldspathic to arkosic siltstone and sandstone to cobble conglomerate containing abundant clasts of leucotrondhjemite; 2) silty to sandy, probably tuffaceous, dolomite; 3) felsic tuff(?); and 4) felsic to intermediate intrusive(?) rocks.

On Hotspur Island and southern Annette Island, phyllite and schist assigned to this unit contain relict detritus derived from the Annette pluton and appear to overlie fossiliferous Lower and Middle Devonian beds; south of Kwain Bay, recrystallized red- and green-weathering tuffaceous dolomite also assigned to the unit is unconformably(?) overlain by Triassic(?) metarhyolite. On this basis, the unit is provisionally assigned an age of middle or late Paleozoic(?). Because of metamorphism, complex structure, and lithic similarities to some Devonian, Silurian, and Triassic(?) units, however, it may include significant amounts of those units that could not be distinguished in the field.

Devonian phyllite and recrystallized limestone and dolomite

On Annette Island, this unit comprises interbedded pyritic phyllite, phyllitic silty limestone and calcareous siltstone, feldspathic to arkosic sandstone, grit, and conglomerate, dolomitic limestone and arenite, and phyllitic calcarenite and limestone breccia. Locally the phyllite and limestone carry poorly preserved Middle Devonian fossils. On Harris Island and northern Hotspur Island, the unit consists of thin- and medium-bedded slate and phyllite, phyllitic calcareous siltstone and feldspathic sandstone, limestone-clast conglomerate and lime-

[2]Field studies in 1970 on nearby Gravina Island indicate that most of these units are of Middle and Late(?) Paleozoic age

stone, and concretionary dolomite. Fossils are locally abundant and better preserved than on Annette Island; most range in age from Early to Middle Devonian, but some may be as old as latest Silurian. The base of the unit is not exposed; its thickness is unknown but it probably is at least several hundred feet thick.

In general, members of this unit weather somber shades of olive, greenish, reddish, and neutral gray, but several are distinguished by relatively vivid weathering colors. The phyllite has gray, brown, black, green, and maroon phases; the dolomitic limestone and arenite weather red; and the concretionary dolomite weathers maroon.

Although generally foliated to some extent, the members of this unit vary widely in degree of recrystallization and penetrative deformation, which ranges from relatively intense on Annette Island to relatively slight on Harris Island and northern Hotspur Island. All, however, are regionally metamorphosed and contain the greenschist-facies mineral assemblage quartz, sericite, chlorite, epidote-clinozoisite, calcite, dolomite, leucoxene, very fine grained carbonaceous material, and pyrite.

Annette pluton

The name Annette pluton is given to the composite trondhjemitic stock that makes up about two-thirds of Annette Island. The pluton is crudely and incompletely zoned and grades from a core of leucotrondhjemite (Salt) and minor leucocratic granite, quartz monzonite, and granodiorite (Salg), to bordering masses of trondhjemite (Sat) and leucocratic quartz diorite and minor diorite (Salq).

The rock types have gradational boundaries and are distinguished either by percentage of mafic minerals or by potassium feldspar content. The leucotrondhjemite is a strikingly leucocratic granitoid rock rich in sodic plagioclase and quartz, but virtually free of mafic minerals and potassium feldspar. The trondhjemite and leucocratic quartz diorite contain up to about 15 percent hornblende and biotite, or their alteration products, and a little potassium feldspar. The leucocratic granite, quartz monzonite, and granodiorite are identical to the leucotrondhjemite except that they carry significant amounts of potassium feldspar.

A minimum age of 416±12 m.y. (Silurian) has been determined for hornblende in the leucocratic quartz diorite.

Most of the pluton is hydrothermally altered, especially the trondhjemitic phases, which have undergone locally intense sericitization and albitization. The pluton also is moderately to strongly deformed and in many places has a border zone up to several hundred feet wide of schist, gneiss, and breccia. The deformation diminishes toward the center of the pluton, but all parts show at least mild cataclasis.

The effect of the pluton on the rocks it intrudes is relatively slight; in most places the greenstone country rocks near the contact are marked by a baked zone only a few inches wide.

Silurian or older greenstone

gu, undivided greenschist-facies metamorphic rocks, including greenstone and greenschist, subordinate dark-gray phyllite and phyllitic limestone, dolomite, graywacke and siltstone, and minor quartzite and marble. The assemblage was derived mainly from calcalkaline intermediate to basic volcanic and volcaniclastic rocks that either intertongued with or were interbedded with marine sedimentary rocks. On southeastern Annette Island, the unit also includes light-gray phyllite and schist derived from felsic to intermediate igneous rocks probably at least partly of volcanic origin; because of metamorphism and complex structure, however, they are difficult to distinguish from leucocratic apophyses of the Annette pluton.

The unit is regionally metamorphosed and, depending on original rock type, generally contains variable amounts of the greenschist-facies mineral assemblage chlorite, epidote-clinozoisite, albite, actinolite, sericite, quartz, calcite, dolomite, hematite, pyrite, and potassium feldspar. Locally, however, especially near contacts with intermediate and basic intrusive rocks in the Tamgas Lake-Davison Mountain area, it also contains hornblende and plagioclase ($An_{>20}$), indicating a maximum metamorphic grade in the amphibolite facies.

The unit is intruded by the Annette pluton, determined to be Silurian by K/Ar dating, and thus is assigned an age of Silurian or older. The thickness of the unit is unknown, but its large outcrop area suggests that it is at least several hundred and perhaps several thousand feet thick.

gi, foliated dioritic intrusive(?) rock. Dark-green, medium-grained, granitoid to schistose rock composed of albite and sodic oligoclase, subordinate chlorite, quartz, epidote-clinozoisite, and sericite, and minor apatite, sphene, leucoxene, calcite, pyrite, hematite, and magnetite. Cataclastic textures are ubiquitous and range from incipient mortaring of mineral grains to mylonitic.

The unit generally forms veinlike and irregular masses mixed with metamorphosed bedded rocks (gu). The contacts with these enclosing rocks range from sharp to diffuse, and thermal effects are absent. In part, the unit forms at least some of the dots labelled "*i*" on the map; in the Dubuque Mountain-Sink Lake area, however, it also forms an elongate body that may be a deformed stocklike pluton.

The unit probably was derived from intermediate igneous rocks ranging in composition from quartz diorite to diorite. The sharp contacts signify an intrusive origin, but the transitional contacts and lack of thermal effects suggest that at least part was metamorphically derived from the enclosing metamorphosed bedded rocks.

In the Dubuque Mountain and Sink Lake areas the unit is intruded by the Annette pluton, and thus is assigned an age of Silurian or older.

Metlakatla Peninsula

Metlakatla Peninsula is underlain mainly by greenschist- to amphibolite-facies metamorphic rocks derived from an unknown thickness of interbedded sodic and calcalkaline volcanic, volcaniclastic, and pelitic rocks inferred to be Silurian(?) or older in age. The bedded rocks are intruded by foliated leucocratic quartz diorite that may be coeval with the Silurian Annette pluton, and by younger,

possibly middle or late Paleozoic, foliated quartz diorite-diorite. At Yellow Hill, the metamorphosed bedded and intrusive rocks are in contact with an ultramafic body that probably was tectonically emplaced in Cretaceous time.

Cretaceous(?) ultramafic rocks

Kdn, partly serpentinized dunite. This medium-grained, dark-brownish- and greenish-black, massive-appearing rock characteristically weathers light yellowish gray and consists of forsteritic olivine, 10–60 percent serpentine, and a few percent chromite. The olivine forms an aggregate of anhedral, roughly equigranular grains. Under the microscope, the serpentine is seen to form a trellislike network among the olivine grains, and at outcrop scale its occurrences range from abundant closely spaced thin seams to ellipsoidal masses many feet thick. Preliminary (whole-rock) X-ray analyses of the dunite indicate that the serpentine consists mainly of lizardite and probably clinochrysotile. The chromite occurs in disseminated grains and in thin, discontinuous veinlets; in general, it makes up 3 percent or less of the dunite, but locally it may amount to as much as 10 percent.

Despite its massive aspect, the dunite is deformed at all scales. Structures range from microscopic deformation lamellae and kink bands, through mesoscopic cleavage and small folds, to large complex shear zones, especially at the margins of the ultramafic.

Kpx, clinopyroxenite. Texturally similar to the dunite, this relatively minor unit consists of diopsidic clinopyroxene, up to about 10 percent serpentine, and a little chromite. It forms dikes, deformed layers, and streaks in the dunite, and masses of uncertain but probably layered structure, apparently near the margins of the ultramafic. Taylor and Noble (1960, p. 179) mapped a thin zone of hornblende pyroxenite along the western border of the ultramafic, but it could not be found in the present investigation and thus does not appear on the map.

The dunite-pyroxenite body is in contact with several varieties of metamorphic country rocks but in none of them could thermal metamorphism associated with the emplacement of the ultramafic be detected. Although Taylor (1967, p. 97–121) classified the body as a zoned ultramafic complex, it appears instead to be an alpine-type ultramafic, emplaced by faulting as a relatively cool, solid mass.

The age of the ultramafic body at Yellow Hill is inferred to be probably Cretaceous on the basis of correlation with potassium-argon-dated ultramafic rocks elsewhere in southeastern Alaska (Lanphere and Eberlein, 1966, p. 94). Its presumed age, however, probably reflects the effect of heating during fault emplacement, and its maximum age may be much greater.

South Metlakatla pluton

The name South Metlakatla pluton is given to the stocklike quartz diorite-diorite pluton that crops out at the south end of Metlakatla Peninsula. The pluton, which locally contains large inclusions of metamorphosed bedded rocks, consists of medium- and dark-greenish-gray medium-grained recrystallized quartz diorite and diorite. The relative abundance of each rock type has not been determined, but the diorite seems to increase in abundance southward, toward Point Davison, suggesting that the pluton may be crudely zoned.

The granitoid texture of the original rock is locally preserved, but the pluton generally consists of a granoblastic to strongly foliated aggregate of dark-green and dark-bluish-green (Z) hornblende, plagioclase (An_{33-37}), brown (Z) biotite, quartz, and epidote. The metamorphic mineralogy and fabric indicate amphibolite-facies metamorphism, possibly coincident with the emplacement of the pluton. Subsequent deformation and accompanying retrogressive metamorphism have produced zones of greenschist-facies chlorite-sericite-albite-quartz, epidote/clinozoisite phyllite and schist, and still later cataclasis, evidently without significant recrystallization, has produced granulation and microbrecciation. In addition, the pluton is cut by planar to irregular veins of epidote-clinozoisite, albite, quartz, calcite, and, locally, prehnite that postdate all but the late cataclastic structures.

Throughout the pluton, but especially near the margins, the intrusive rock is more or less abundantly mixed with amphibolite-facies metamorphosed bedded rocks, forming diffusely bounded bodies of migmatite. Because of this, the distinction between plutonic and country rocks is largely indefinite, and on the accompanying map the contact is drawn wherever the volume of plutonic rocks was deemed greater than the volume of metamorphosed bedded rocks.

The age of the South Metlakatla pluton is inferred to be middle or late Paleozoic(?) on the basis of provisional correlation with quartz diorite nearby on northern Duke Island whose age, determined by potassium-argon dating, may be Carboniferous (M. A. Lanphere, oral commun., 1969).

Central Metlakatla pluton

The name Central Metlakatla pluton is given to the foliated recrystallized leucocratic quartz diorite stock that underlies the central part of Metlakatla Peninsula. In part, the foliation may be due to flow near the margins of the pluton during emplacement; most, however, is due to subsequent metamorphism, and some to still later relatively local cataclastic deformation.

Most of the pluton is light to medium gray and medium grained, and consists of plagioclase, quartz, brown (Z) biotite, pale-green (Z) actinolite, bluish-green (Z) hornblende, epidote-clinozoisite, chlorite, sericite, and calcite. In hand specimens, the quartz has a distinct bluish cast. A small part of the pluton is dark-greenish-gray, medium- to coarse-grained diorite that differs from the quartz diorite in containing more hornblende and biotite and less than 10 percent quartz. Optical and X-ray analyses of the plagioclase show that it consists mainly of albite and oligoclase-andesine (An_{15-31}).

The mineral paragenesis suggests a complex metamorphic history similar to that of the adjoining metamorphosed bedded rocks, all of which are assigned to a metamorphic subunit transitional between greenschist and amphibolite facies (mag). Features suggesting polymetamorphism include:

1) rosettes and individual crystals of actinolite, bluish-green hornblende, and, less commonly, biotite randomly superimposed on an earlier foliation; 2) replacement of "early" biotite by chlorite that in turn appears to be partly replaced by a second generation of biotite; and 3) the occurrence of replacement veins and masses of epidote-clinozoisite, albite, quartz, and calcite that postdate all but the local cataclasis.

The available evidence bearing on the metamorphic history of the Central Metlakatla pluton is incomplete and not always unambiguous, but it seems to favor three events. Two, apparently of regional extent, are suggested by the early foliation and late replacement veins; the third, an intervening thermal event probably associated with the emplacement of the South Metlakatla pluton, is assumed to have produced the randomly oriented ferromagnesian crystals, the second-generation biotite, and most of the plagioclase more calcic than An_{20}

Locally the quartz diorite contains abundant inclusions of metamorphosed bedded rocks or forms migmatitic aggregates with the country rocks, but in general few significant thermal effects are visible at the plutonic-metamorphic contacts. In areas of mixed rocks, the pluton is mapped where the volume of intrusive rock is greater than the volume of metamorphosed bedded rocks.

The age of the Central Metlakatla pluton is inferred to be Silurian(?) because: 1) it apparently is older than the middle or late Paleozoic(?) South Metlakatla pluton; and 2) it is similar to the trondhjemite and leucocratic quartz diorite phases of the Annette pluton, with which it may be coeval.

Silurian or older metamorphosed bedded rocks

This unit, which consists of recrystallized sodic volcanic and subordinate(?) calcalkaline volcanic and pelitic rocks, underlies slightly more than half of Metlakatla Peninsula and, except for Hemlock Island, is inferred to make up all of the islands in Port Chester. The rocks have been converted to hornfels, phyllite, schist, and gneiss, but even in the most intensely metamorphosed parts of the unit, the metavolcanic members are distinguished by relict porphyritic (feldspar and subordinate ferromagnesian phenocrysts), amygdaloidal, and fragmental textures. On Metlakatla Peninsula, the term hornfels applies to a complexly metamorphosed volcanic rock that appears nonfoliated at hand-specimen and outcrop scales, but which generally shows at least weak foliation in thin section. The hornfels is interbedded with the phyllite and schist.

The unit is divided into three subunits, based on metamorphic grade, that trend west-northwestward across the peninsula in belts crudely concentric to the South Metlakatla pluton. From south to north, in order of generally decreasing metamorphic grade and increasing distance from that pluton, they are distinguished by amphibolite-facies minerals (ma), minerals transitional between amphibolite and greenschist facies (mag), and greenschist-facies minerals (mg). Two occurrences of the amphibolite-facies subunit near the head of Tamgas Harbor interrupt the south-to-north progressive decrease in metamorphism. These apparently isolated occurrences of relatively high grade rocks may be due to undetected, possibly shallow apophyses of the South Metlakatla pluton, but both occurrences are in complex shear zones and probably are in fault contact with the enclosing lower grade rocks.

The unit is assigned an age of Silurian(?) or older because it is intruded by the Central Metlakatla pluton, which may be coeval with the Silurian Annette pluton.

ma, amphibolite-facies subunit. This subunit consists of schist, hornfels, and gneiss containing plagioclase (An_{16-33}; An_{10}?), bluish-green to dark-green (Z) hornblende, brown (Z) biotite, epidote-clinozoisite, chlorite, colorless to pale-green (Z) actinolite, sericite, and calcite; almandine garnet, staurolite(?), and potassium feldspar occur locally in small amounts. It commonly is mixed with foliated quartz diorite and diorite that increase in abundance toward the contact with the South Metlakatla pluton. In areas of complexly mixed rocks, the metamorphosed bedded rocks are mapped wherever their volume is greater than the volume of plutonic rocks.

The mineral paragenesis suggests a complex metamorphic history. The assemblage plagioclase ($An_{>20}$)-hornblende-biotite-garnet-staurolite(?) indicates that the highest grade attained was in the amphibolite facies. In the schist and gneiss, the minerals are alined parallel to the foliation, but in the hornfels, the ferromagnesian minerals appear to be randomly superimposed on an earlier, generally weakly expressed, foliation.

Some of the plagioclase ($An_{<20}$), actinolite, chlorite, epidote-clinozoisite, and sericite may be due to incomplete amphibolite-facies recrystallization of forerunner greenschist-facies metamorphic rocks, but in general these minerals replace the amphibolite-facies minerals and thus mark an episode of greenschist-facies retrogressive metamorphism. The late greenschist-facies minerals also occur in hydrothermal veins and in shear zones.

The subunit also is cut by albite-quartz-prehnite veinlets that postdate the retrogressive metamorphism, but whose relation to the shear zones and the other hydrothermal veins was not determined.

mag, transitional subunit. This subunit consists of hornfels, subordinate phyllite and schist, and minor gneiss that contain the metamorphic mineral assemblage plagioclase (An_{6-33}), quartz, weakly to moderately pleochroic pale-green to bluish-green (Z) amphibole, brown (Z) biotite, epidote-clinozoisite, chlorite, sericite, calcite, and potassium feldspar. The assemblage is interpreted as signifying a metamorphic grade transitional between amphibolite and greenschist facies. With increase in moderately pleochroic amphibole and in plagioclase $> An_{20}$, the subunit grades into the amphibolite-facies subunit; with decrease in plagioclase $> An_{20}$, biotite, and moderately pleochroic amphibole it grades into the greenschist-facies subunit. The contact between the transitional and greenschist-facies subunits is drawn where the biotite content of the transitional subunit diminishes nearly to zero.

As in the amphibolite-facies subunit, the mineral paragenesis in the transitional subunit suggests more than one episode of metamorphism, but because the metamorphic events affecting the

transitional subunit apparently were less intense, polymetamorphic textures are correspondingly less well developed. Evidence for more than one event include: 1) in some of the phyllite and hornfels, randomly oriented sprays and individual crystals of moderately pleochroic amphibole and biotite overprint an earlier foliation defined mainly by chlorite and sericite; and 2) the amphibole, biotite, and plagioclase > An_{20} locally are replaced by epidote-clinozoisite, chlorite, quartz, albite, and calcite, which also occur in shear zones and in late hydrothermal veins.

In many places, the outcrops of the transitional subunit are interspersed with those of foliated plutonic rocks, and near the contact of the Central Metlakatla pluton the subunit is migmatitic. In most instances, it was not possible to separate the two rock types on the map, and in areas of complexly mixed rocks, the metamorphosed bedded rocks are shown wherever they are more abundant than the plutonic rocks.

The transitional subunit weathers distinctive shades of chocolate brown and greenish gray and characteristically is streaked and mottled bright pistachio green due to late epidote-rich hydrothermal alteration.

mg, greenschist-facies subunit. On Metlakatla Peninsula, this subunit consists of thinly to moderately thickly interbedded greenschist, greenstone, and dark-gray phyllite, fine-grained schist, and hornfels; on the islands in Port Chester, it also includes dark-gray slate and phyllitic graywacke, siltstone, and limestone. Relict textures locally are well preserved and range from graded bedding in some of the pelitic rocks to porphyritic (plagioclase and ferromagnesian phenocrysts), amygdaloidal, and fragmental in the greenstone, greenschist, and hornfels.

The mineral assemblage, interpreted as signifying greenschist-facies metamorphic grade, comprises plagioclase, chlorite, quartz, epidote-clinozoisite, sericite, calcite, colorless to pale-green (Z) amphibole, and traces of brown (Z) biotite. Most of the plagioclase is albite and sodic oligoclase, much of which probably formed by simple recrystallization of albite- and oligoclase-bearing sodic volcanic parent rocks. In originally calcalkaline members of the subunit, however, albite partly to completely replaces plagioclase as calcic as An_{35}.

It was not possible to identify metamorphic textures or minerals in this subunit related to the emplacement of the South Metlakatla pluton. It is conceivable, however, that the traces of biotite, which occur only in the parts of the subunit on Metlakatla Peninsula, and some of the associated amphibole may be due to weak thermal metamorphism at the outermost fringes of the aureole concentric to that pluton.

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