U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

GEOLOGIC MAP OF THE CRAIG, DIXON ENTRANCE, AND PARTS OF THE KETCHIKAN AND PRINCE RUPERT QUADRANGLES, SOUTHEASTERN ALASKA

Compiled by

DAVID A. BREW

TO ACCOMPANY MISCELLANEOUS FIELD STUDIES MAP MF-2319

1996

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ACCOMPANYING ILLUSTRATIONS

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INTRODUCTION

BACKGROUND AND PURPOSE

This map and report covers the southwestern part of southeast Alaska (fig. 1). The geology of this area is critical to the understanding of the whole region because here are found the oldest isotopically dated rocks and the region's most complete, most fossiliferous, most varied, and relatively unmetamorphosed and undeformed Paleozoic stratigraphic section. The rocks in the eastern part of the area include features transitional to the tectonic, magmatic, and metamorphic character of the Coast Mountains geology of southeastern Alaska.

This compilation was stimulated (1) by the need for a coherent geologic map of the area for use in the study of the undiscovered mineral resources of the Tongass National Forest and adjacent lands (Brew and others, 1991a; Brew and Drinkwater, 1991; Brew and others, 1992a); (2) by the related requirements that (a) correlative units mapped by different recent workers be examined and summarized, and (b) newly available age information from fossil determinations and isotopic dating be integrated into the descriptions of the map units; and (3) by the need for a geologic base map for use in interpretation of the geochemical study of the Craig study area (Cathrall and others, 1993a, b; Cathrall, 1994). It brings together several regional geologic studies which differ somewhat in their treatment of the geology of the Craig, Dixon Entrance, and the western parts of the Ketchikan and Prince Rupert quadrangles. The compilation was made to reconcile these differences.

In regard to point 2b, above and to stratigraphic nomenclature in general: As part of this compilation process I have examined both the fossil and isotopic evidence used by the geologists who produced the maps listed in the following paragraph and the new fossil information that has been published in journals since some of those maps were produced. From this synthesis came age assignments for some formal geologic units that differ in part from previous assignments. The evidence for these changes is cited in every case. Inasmuch as the age of a unit is not a criterion in the definition of lithostratigraphic units (North American Commission on Stratigraphic Nomenclature, 1983, Article 22(e), p. 856), any such changes in age are not a formal stratigraphic problem. Nor is the extension of such an age assignment from the area where to rocks have been dated into areas where the same lithostratigraphic unit is present, but not dated. In some cases I have extended the use of formal names beyond where they have been previously applied, into areas where informal unit names have been used in the past. In all such cases I followed the published suggestions of recent mappers in the area. No rock units with previously applied formal names have been assigned to different units with different names. Informal names are applied to both metamorphic and plutonic lithodemic units to facilitate organization and presentation.

The compilation is based mainly on: (1) the 1:250,000-scale geologic map of the Petersburg area based on 1978 to 1983 mapping by Brew and others (1984); (2) the 1:250,000-scale geologic map of the Craig quadrangle based on 1950 to 1971(?) mapping by Eberlein and others (1983); (3) the 1:250,000-scale geologic map of the Ketchikan and Prince Rupert quadrangles based on 1970(?) to 1977 mapping by Berg and others (1988); (4) the several different reports and maps by G.E. Gehrels and J.B. Saleeby that are cited below; (5) the 1:200,000-scale geologic map of Annette Island by Karl (1992) and Horton and others (1992); and on unpublished mapping by J.F. Baichtal of the U.S. Forest Service. The areas covered by these different reports are shown on figure 2.

LOCATION AND PHYSIOGRAPHY

The map area covers the southwesternmost part of the Alexander Archipelago (fig. 1). It includes most of Prince of Wales Island, the third largest island (after Kodiak and Hawaii) of the United States, and an abundance of smaller islands of greatly differing size. Steep, forested mountains; deep, broad valleys; lakes and sreams; and many tidewater bays and coves dominate the landscape. Most of the lower parts of the area are covered by heavy forest and brush, with minor muskegs and meadows. It rains a lot.

Physiographically, the map area (fig. 1) consists of parts of the Coastal Trough and Pacific Border Ranges provinces of Wahrhaftig (1965). The Coastal Trough province is a series of lowlands that extend the length of the Pacific Mountain System, interrupted along its length by mountain groups. The Pacific Border Ranges province consists mainly of several mountain ranges bordering the Pacific Coast. Within the map area, the Coastal Trough province is represented by part of the Kupreanof Lowland and the Pacific Border Ranges province is represented by the Prince of Wales Mountains.

The Kupreanof Lowland consists of islands, channels, and adjacent areas. Most of it is rounded heavily glaciated terrain with a local relief of 300-500 feet (90-160 m) and a maximum relief of 1,000-1,500 feet (310-470 m) separated by complex waterways. Some blocklike mountains that rise above the general level have summits at 2,000-3,000 feet (620-930 m). The Lowland is characterized by many lakes.

The Prince of Wales Mountains consists of moderately rugged glaciated mountains with rounded summits 2,000- 3,500 feet (620-1,090 m) high. The high point of the map area is Pin Peak, 3,806 feet (1,185 m) high, about 10 miles (16 km) east of Klawock. The mountains are dissected by steep-walled U-shaped glacial valleys and by several fiords 600-1,000 feet (190-310 m) deep. Several passes less than 500 feet (160 m) high cross the range. Lakes are abundant and karst topography and locally extensive cave systems occur in localities underlain by carbonate rock. The east and northeast front of the range is steep and abrupt against Clarence Strait, but the north and northwest front against the Kupreanof Lowland is not as distinct (Wahrhaftig, 1965). The karst topography of this province has been the focus of intense cave exploration in recent years and one cave has been found to contain very significant bear remains (Heaton and Grady, 1992a,b, 1993; Heaton, 1995).

There are five larger communities and several smaller ones in the map area. The main ones are the ferry terminal community of Hollis, the logging village of Thorne Bay; the fishing town of Craig; the fishing village of Klawock, which is populated mostly by Tlingit Indians; and the fishing village of Hydaburg, which is populated mostly by Haida Indians. There are also numerous abandoned logging camps, mining and quarry camps, and Indian village sites. Logging, fishing, mineral exploration, and tourism are the major economic activities in the area. The Alaska Marine Highway System connects Hollis by ferry with Ketchikan to the east of the map area. An extensive network of U.S. Forest Service roads that are now part of the State of Alaska highway system cover the central part of Prince of Wales Island (U.S. Forest Service, 1987).

Most of the map area is part of the Tongass National Forest, but significant areas are Alaska Native Regional and Village Corporation, State of Alaska, and private lands, and scattered patented mining claims (U.S. Forest Service, 1987). Five Wilderness Areas within the Tongass Forest are administered by the U.S. Forest Service (1987) and one National Wildlife Refuge on Forrester Island is administered by the U.S. Fish and Wildlife Service (Brew and Drinkwater, 1991).

HISTORY OF GEOLOGIC AND RELATED STUDIES

Geologic investigations in the map area fall into several roughly defined periods. The first was during the latter part of the 1800's when Prince of Wales Island and adjacent areas received early attention in the form of prospecting and sporadic reconnaissance studies. The first systematic geologic mapping and mineral-deposit studies were those of Theodore Chapin in the early 1900's which are reported in Buddington and Chapin (1929), the Wright brothers' studies (Wright and Wright, 1908; Wright, 1915), and the extensive mapping of Buddington himself (Buddington and Chapin, 1929).

Mineral exploration, mining, and the quarrying of marble (Burchard, 1913, 1920) and limestone (for cement) continued in the 1800's and 1900's up to World War II, with some interruption during World War I (See references to local U.S.G.S studies in the compilations of Cobb). Immediately following World War II, U.S. Geological Survey parties visited and studied several metallic-mineral-deposit localities, some in detail (Robinson and Twenhofel, 1953; Kennedy, 1953; Warner and others, 1961).

Somewhat later U.S.G.S. studies (Rossman and others, 1956; Sainsbury, 1961; MacKevett, 1963) were concerned with geophysics, areal mapping, and mineral deposits. In the late 1950's through the 1970's E.H. Cobb (Cobb, 1972a, b, c, d; 1978a, b; Cobb and others, 1968; Cobb and Elliott, 1980) compiled mineral-deposit information from all available sources. Condon (1961) compiled a reconnaissance geologic map of the Craig quadrangle using both available previous mapping and aerial photographs. This same period saw the first intense work on the Alaskan-type mafic-ultramafic plutons in and close to the map area (Ruckmick and Noble, 1959; Taylor, 1967; Irvine, 1974)

The next roughly defined period of U.S.G.S. and other studies was in the late 1960's, but the effort really started with the 1950's work of Eberlein in the western Prince of Wales Island area; this series of studies emphasized regional geologic, geophysical, and geochemical mapping (Barnes and others, 1972a, b; 1975; Berg, 1972, 1973, 1978, 1980, 1982; Berg and others, 1976, 1978a, b, 1988; Clark and others, 1971; Clark and Greenwood, 1972; U.S. Geological Survey, 1977, 1979). During this same general period State of Alaska parties were doing detailed studies of selected mineral deposits (Herreid and others, 1978) and an extended series of paleontologic studies was started (Armstrong, 1970; and the numerous references of Churkin, Savage, and Soja) that continues to the present. The original work of Eberlein, together with that of several colleagues, was released in Eberlein and others (1983).

One result of these geologic studies was the inclusion of some new information in the regional-scale geologic map compilations of Beikman (1974, 1975). Other regional-scale results were the regional mineral-resource-oriented compilations of Berg and others (1981) and Berg (1984) and the aeromagnetic compilations of Decker (1979) and Decker and others (1981).

In the late 1970's and 1980's the U.S.G.S, through G.D. Eberlein and H.C. Berg, started supporting J.B. Saleeby of the California Institute of Technology in geologic and geochronologic studies of southern Prince of Wales Island. This led to the involvement and support of Saleeby's students G.E. Gehrels and C.M. Rubin; to further support by the National Science Foundation; and to the eventual publication of a series of important topical and regional studies by the California Institute of Technology group (Gehrels, 1980, 1991; Gehrels and others, 1983, 1987; Gehrels and Saleeby, 1986, 1987; Rubin and Saleeby, 1987, 1991, 1992; Saleeby, 1991, 1992). In addition, at least one thesis (Sullivan, 1991) of local significance has been produced.

In 1978, the U.S.G.S started a regional geologic mapping and mineral-resource assessment study in what was then the almost totally unmapped Petersburg project area, just north of the Craig quadrangle. This project required examining and extending as appropriate the stratigraphic units described by Ovenshine and Webster (1970), Eberlein and Churkin (1970a), Eberlein and others (1978), and Eberlein and others (1983) from the Craig map area. The major Petersburg project maps and reports to date are Brew and others (1984, 1989b), Gryback and others (1984), Barnes and others (1989), and Karl and Koch (1990).

Following the completion of the Petersburg project, the U.S.G.S. initiated a geochemical, geophysical, and mineral-resource assessment study in the Craig and Dixon Entrance quadrangles. To date the results of the aeromagnetic survey (U.S. Geological Survey, 1984), a mineral-resource study (Gehrels and others, 1983), and the geochemical studies have been reported (McDanal and others, 1991; Detra and others. 1992; Cathrall and others, 1993a, b; Cathrall, 1994); and mineral-resource-assessment information provided (D.J. Grybeck, written commun., 1990) for the regional mineral-resource study of Brew and others (1991a). During the U.S.G.S. study, the U.S. Bureau of Mines studied some of the alkalic igneous rocks (Warner and Barker, 1989; Barker and Mardock, 1988, 1990) and also started an ongoing study of the identified mineral resources of the Ketchikan Mining District, which includes the study area (Maas and others, 1991; Clautice and others, 1994). Several mineral-exploration companies have been active in the Prince of Wales Island part of the study area for the past several years and are continuing their efforts. The results of a cooperative U.S. Geological Survey-Bureau of Indian Affairs geological and geophysical study of the mineral resources of Annette Island during this same period are reported by Karl (1992) and Horton and others (1992). Drinkwater and Calzia (1994) described the geochemistry of the alkalic plutons in the area and Himmelberg and Loney (1995) described several of the ultramafic-mafic intrusions in the area. More recently, J.F. Baichtal of the U.S. Forest Service has done detailed geologic mapping in selected areas, mostly on Prince of Wales Island.

Other regional-scale studies concerned in part with the map area are the geothermal compilation of Motyka and Moorman (1987); the U.S. Geological Survey (1989) Mineral Resources Data System compilation of mineral-deposit information; and the mineral-deposit-locality compilations of Nokleberg and others (1987, 1994a, b).

Most of the information mentioned above was evaluated and used in the U.S.G.S. study of the undiscovered mineral resources of the Tongass National Forest and adjacent lands (Brew and others, 1991a; Brew and Drinkwater, 1991; Brew and others, 1992a) and much of it was used by the U.S. Bureau of Mines in their study of the identified resources (Coldwell, 1990). These studies were available to the U.S. Forest Service for their land planning process and mineral-resource considerations are contained in the various land-use classifications proposed for the Craig, Dixon Entrance and adjacent areas (U.S. Forest Service, 1990, 1991).

Finally, as the compiler of this map, I have had some, but not extensive, field experience in the area. It consists of a reconnaissance trip to eastern Prince of Wales Island in 1967, geologic mapping in the Dall Island and Craig areas in 1969, lengthy reconnaissance and familiarization trips to Dall Island and western Prince of Wales Island in 1978 and 1979, geologic mapping in the northernmost part of the Craig quadrangle in 1978 to 1981 as part of the Petersburg project (Brew and others, 1984, 1989b), and geologic mapping in the vicinity of Ketchikan and Gravina Islands (Brew and Karl, 1988a, b, c; Ford and Brew, 1988, 1994). As part of the study of the undiscovered mineral resources of the Tongass National Forest and adjacent lands (Brew and others, 1991a, 1992a; Brew and Drinkwater, 1991; Brew and others, 1992a), I examined almost all of the available geologic, geochemical, and geophysical information in some detail.

SOME FEATURES OF THIS REPORT

Three specific aspects of this report should be emphasized: one is the origin of the unit descriptions, and the second is the alphabetical index of map units at the end of the text, and the third is a *caveat* regarding the geology of the inland areas. These aspects are described briefly here, together with a note on the geologic-time divisions used in this report for the Silurian Period.

(1) As explained in the section of this report titled "Description of Map Units", those descriptions have been adapted directly from the citations given for each unit. In most cases the descriptions been been shortened and altered. In every case, however, the descriptions are those of the original workers.

(2) The "Brief Description of Map Units" section on the map sheet that includes the page numbers for the complete descriptions of the units and the alphabetically-arranged index (by map unit title) at the end of this text are intended to allow the reader to go back and forth between the text and the map with a minimum of page turning and searching.

(3) Finally, there were very few logging or other roads in the interior of any of the islands in the study area at the time that most of the geologic mapping was done. Contacts were located on the map using a high degree of intuition and photogeologic interpretation. Detailed follow-up mapping along the now-existent roads (U.S. Forest Service, 1987) would certainly result in many changes. Thus this map cannot be used to locate contacts between map units precisely in the previously inaccessible areas.

The geologic time series divisions of the Silurian used in this report are based on those proposed by Berry and Boucot (1970) for North America, and they are not the divisions in previous common use by the U.S. Geological Survey. However, some Geological Survey reports have already used the Berry and Boucot divisions (Hansen, 1991, p. 61). Those divisions are, from youngest to oldest, Pridoli, Ludlow, Wenlock, and Llandovery. In this report, rocks assigned to Pridoli and Ludlow are considered to be the Upper Silurian and those assigned to Wenlock and Llandovery to be the Lower Silurian. There is no Middle Silurian in this scheme.

ACKNOWLEDGMENTS

First of all, thanks are due to the geologists who did most of the mapping that I have compiled here: Hank Berg, Mike Churkin, Allan Clark, Don Eberlein, George Gehrels, Don Grybeck, Ed MacKevett, Tom Ovenshine, Pete Sainsbury, Jason Saleeby, and Charlie Rubin. Next, thanks are due to the many paleontologists who have determined the fossils and established the ages of most of the rock units, but especially to Claire Carter, Mike Churkin, Norm Savage, and Connie Soja; the last two have helped a great deal in providing data and checking my correlations for this report. Next, thanks are due to George Gehrels, Marv Lanphere, Jason Saleeby, and Don Turner for their dating of hitherto poorly bracketed granitic units and their country rocks. Next, I acknowledge the encouragement and gentle prodding of John Cathrall during the compilation, discussions with Sue Karl about the Descon Formation and related rocks, Don Grybeck for some corrections to the previous geologic compilation in the Trocadero Bay and Noyes Island areas, and Jim Baichtal of the Forest Service for sharing his unpublished mapping in the Tuxekan Passage area. Finally, thanks to the technical reviewers, Sue Karl and Don Grybeck; to the Geologic Names Unit reviewer, Ron Le Compte; and to the map editor, Carol Ostergren.

DESCRIPTIONS OF LITHOTECTONIC TERRANES

Southeastern Alaska and adjacent British Columbia is where the tectonostratigraphic/lithotectonic terrane concept was first conceived and developed (Monger and Ross, 1971; Jones and others, 1972, Berg and others, 1972, 1978; Monger and others, 1982; Brew and Ford, 1983, 1984; Monger and Berg, 1987) and both the tectonic evolution and the evolution of tectonic understanding of the region are therefore of special interest. Brew and others (1991a, b, 1992a) and Brew (in Nokleberg and others,1994c) have summarized a current interpretation of the lithotectonic terrane situation in southeastern Alaska. Some of that summary applies to this map area and selected parts are abstracted here.

Southeastern Alaska is comprised of several types of lithotectonic elements. The fundamental elements are accreted terranes, meaning terranes that originated elsewhere and were transported by plate-tectonic movements and joined to previously accreted terranes or to proto-North America in approximately their present locations. The boundaries between terranes are commonly obscured by later geologic events, but vestiges of some remain. After accretion, the terranes and their boundaries were covered in part by overlap assembages made up of sedimentary rocks derived from the underlying juxtaposed terranes. All of these elements were faulted and rearranged by later movements. Finally, post-accretion units of sedimentary and volcanic rocks were deposited after the last major movements.

Brew and others (1991a, b, 1992a) and Brew (unpub. data, 1996) summarized the lithotectonics of northern southeastern Alaska and adjacent parts of British Columbia, where all of the elements are present. The terranes and overlap assemblage rocks are shown on figure 3.. From west to east, the generally north-south-trending elements (including the boundaries) are the (1) Pacific plate, (2) Transitional fault contact with the Yakutat terrane, (3) Yakutat terrane, (4) Fairweather-Queen Charlotte Islands fault, (5) Chugach terrane, (6) Border Ranges fault, expressed as the western limit of the Tarr Inlet suture zone, (7) Wrangellia terrane, (8) obscured, probably stratigraphic, contact of Wrangellia terrane with Alexander terrane, (9) Alexander terrane, (10) Alexander terrane with stratigraphically overlying Wrangellia terrane, (11) stratigraphic contact of Wrangellia terrane with the Gravina overlap assemblage, (12) Gravina overlap assemblage, (13) fault contact of Gravina overlap assemblage with the Behm Canal structural zone, (14) Behm Canal structural zone, (15) fault contact of the Behm Canal structural zone with the Nisling terrane, (16) Nisling terrane, (17) Meade fault and (or) Tally Ho-Llewellyn fault contact of Nisling terrane with Stikine terrane, (18) Stikine terrane, (19) Laberge overlap assemblage on Stikine and Cache Creek terranes. (20) Nahlin fault contact of Stikine terrane with Cache Creek terrane, and (21) Cache Creek terrane. The Coast Range megalineament (Brew and Ford, 1978) is an important young north-south element that cuts above-listed elements 10, 11, 12, 13, and 14.

The westward elements (1 through 4, above)of this array are still active, but the other parts were assembled more or less as follows: Chugach terrane to Wrangellia terrane in mid- to Late Cretaceous time; Wrangellia terrane to Alexander terrane before Carboniferous time (presuming that they were ever apart); Alexander terrane to Yukon prong and Stikine terranes in Middle Jurassic to Late Cretaceous time; Yukon prong terrane to Stikine terrane probably before Triassic time (presuming that they were ever apart); and Stikine terrane to Cache Creek terrane in Triassic time.

The study area does not include all of these many lithotectonic elements, nor does it include all of the tectonic and magmatic elements that constitute the entire tectonic history of southeastern Alaska (fig. 3). Nevertheless, it does have some post-accretionary continental volcanic and sedimentary rocks, namely the isolated Tertiary and Quaternary volcanic fields and one very small sedimentary basin; one post-accretionary overlap assemblage, the Gravina belt rocks; and two closely related major accreted terranes, the Alexander terrane and the Alexander terrane together with the Wrangellia terrane and the boundaries between them.

The small post-accretionary isolated Tertiary and Quaternary volcanic fields and the very small coal-bearing continental sedimentary basin are dispersed over the map area and there is no evidence that they were formerly of much greater extent. The rock units involved are mapped largely as extrusive volcanic rocks (QTvo, QTvr, QTvb) and as the Kootznahoo Formation (Tk).

The post-accretionary overlap assemblage, consisting of the Gravina belt rocks (KJgg, Jgd, Jgs, Jgv) are exposed on Gravina and Revillagigedo Islands near Ketchikan and on the Cleveland Peninsula to the north. The assemblage consists of Middle Jurassic to Upper Cretaceous graywacke, argillite, and conglomerate; basaltic and andesitic breccia, tuff, flow, and volcaniclastic rocks. Sedimentary rocks are dominantly marine turbidites with minor shallow-water deposits. Coarse clastic rocks are locally derived from the stratigraphically underlying Alexander and Wrangellia terranes mainly to the west (Brew and Karl, 1988a, b, c) but may also have been derived from the Yukon prong and Stikine terranes to the east, outside the study area. The Gravina belt rocks have been interpreted by Gehrels and others (1990) to have been thrust under the Nisling terrane rocks to the east, but at least some of those faults are younger than the original juxtaposition of the Gravina belt and Nisling terrane rocks.

The two closely related major accreted terranes known as the Insular superterrane or as Superterrane II (Monger and others, 1982) make up the rest of the study area. This superterrane consists of two parts: (1) the Alexander terrane *sensu stricto*, here meaning the lower Paleozoic rocks of the terrane as originally defined by Berg and others (1978b), and (2) the Alexander terrane *sensu stricto* together with what are interpreted here to be stratigraphically overlying Wrangellia terrane rocks. Most, but not all, of the rock referred here to the Wrangellia terrane were included by Berg and others (1978b) in their Alexander terrane. Previous subdivisions of the Alexander terrane into the Annette, Craig, and Admiralty subterranes (Berg and others, 1978b; Monger and Berg, 1987) were based on local age and stratigraphic variations and do not indicate significant differences in stratigraphic, magmatic, or tectonic history.

The Insular superterrane is a composite terrane consisting of island-arc rocks between the Chugach terrane on the west and the Gravina overlap assemblage belt on the east; the Chugach terrane is not exposed at the latitude of the study area. As noted above, the superterrane includes rocks of Devonian and younger age that are here referred to the Wrangellia terrane that are in apparent stratigraphic contact with Alexander terrane *sensu stricto* rocks of Silurian and older age.

In the Wrangell Mountains, northwest of southeastern Alaska, the Wrangellia and Alexander terranes have been together since Pennsylvanian time (Gardner and others, 1988). To the south, on Vancouver Island, the Wrangellia terrane includes rocks as old as Devonian. These two facts, together with permissive evidence that the Wrangellia terrane rocks of its "type area" are facies equivalents of the rocks of the same age that are stratigraphically on the Alexander terrane *sensu stricto*, are the reasons for the interpretation used here. Although this interpretation is controversial, the sum of now-available evidence indicates that the two terranes have always been together. The Alexander terrane *sensu stricto* and Wrangellia terrane are described separately below.

The Alexander terrane *sensu stricto* as defined here is a subcontinental-size volcanic-island-arc terrane consisting of Late Proterozoic to lower Paleozoic volcaniclastic turbidites, siliceous shale, chert, limestone, and intermediate to mafic volcanic rocks, with locally developed polymictic conglomerate. Locally it includes pre-accretionary granitic plutons and batholiths. Deep-water sedimentary rocks predominate, but deep- to shallow-water volcanic rocks and shallow-water carbonate rocks represent periods of intense magmatic activity and general quiescence, respectively. As noted above, the Devonian through Lower Jurassic parts of the Alexander terrane as defined by Berg and others (1978b) are here considered to belong to the Wrangellia terrane part of the Alexander superterrane and are thus described below.

The Late Proterozoic and Lower Cambrian Wales Group in the study area consists of metamorphosed and unmetamorphosed volcanic, turbidite, and carbonate rocks intruded by small intermediate composition plutons. The overlying Ordovician through Silurian section consists of mixed volcaniclastic turbidites, carbonate rocks, and volcanic rocks intruded locally by intermediate to gabbroic and ultramafic plutons.

The Wrangellia terrane is an island-arc terrane that includes Devonian shallow-water clastic, carbonate, and sparse volcanic rocks that record local variations in the continued active volcanic-arc environment. These are succeeded upward by upper Paleozoic volcanic breccias, flows, and volcaniclastic rocks and carbonate rocks that are locally intruded by late Paleozoic granitic rocks. These are overlain by nonvolcanic Permian limestone, pelitic rocks, and chert. Regionally, these rocks are overlain by black cherty argillite and by many thousands of meters of Upper Triassic subaerial to pillowed massive tholeiitic basalt with locally abundant gabbro dikes, sills, and small plutons. These are, in turn, overlain by platformal and basinal Upper Triassic limestones that grade upward into basinal, spiculitic, argillaceous and calcareous rocks. Jurassic chert and sandstone overlie Triassic(?) rocks at one locality in northern southeastern Alaska. The terrane is overlain by the Gravina overlap assemblage and is intruded locally by extensive Late Jurassic and Early Cretaceous plutonic-arc rocks.

MINERAL RESOURCES

The most recent summary of known deposits, identified mineral resources, and undiscovered mineral resources of the Craig and Dixon Entrance quadrangles is given by Brew and others (1991a) and Brew and Drinkwater (1991). The known-deposit and identified-resource information in those reports was derived mainly from Cobb (1972a, b; 1978a, b), Cobb and others (1968), Elliott and others (1978), Berg (1984), and U.S. Geological Survey (1989); and the basic undiscovered mineral resource information was provided by D.J. Grybeck (written commun., 1989). The results of recent geochemical studies are reported by McDanal and others (1991) and by Cathrall and others (1993a, b) and by Cathrall (1994). Philpotts and others reported (1993) on some small molybdenite occurrences near Dora Bay. Previous to all of these reports, the State of Alaska Division of Geological and Geophysical Surveys was active in the area: Roehm (1946) described some high-calcium limestone deposits in the area; Herreid (1964) studied the Niblack Anchorage area; Herreid and Rose (1966) described the Hollis and Twelvemile Creek areas; Herreid (1967) described the Dolomi area; Bufvers (1967) provided a compendium of historical mining information; Eakins (1970) reported on a geochemical experiment in the Bokan Mountain area; Herreid (1971) did geochemical work in the Hetta Inlet area; Herreid and Trible (1973) did geochemical work in the Craig A-2 quadrangle; Herreid and others (1978) studied one area in detail, and Bundtzen (1978) briefly described the copper mining in part of the area. Horton and others (1992) evaluated the mineral resources of the Annette Island [Indian] Reserve, part of which is covered in this compilation, Karl (1992) compiled information on the known mineral deposits of Annette Island, and Godwin and Smith (1993) edited a volume containing several pertinent papers on the same topic. Most recently, Bundtzen (in Nokleberg and others, 1995) described a copper-moly porphyry system in southeasternmost Prince of Wales Island.

Briefly, the Craig and Dixon Entrance quadrangles were the sites of some of the earliest prospecting and mine development in southeastern Alaska. Mining and quarrying started in the late 1800's and has continued intermittently since then. Past production from the two quadrangles is estimated at about $100 million (Brew and others, 1991a). At this time (March 1995), there are no mines or quarries operating, but metallic mineral exploration activity is at a sustained moderate to high level.

All or parts of five metallogenic belts are present in the map area (Brew, 1993). One belt is defined by skarn and vein deposits associated with granitic plutons of mid-Cretaceous age in westernmost prince of Wales and adjacent islands. Another belt includes those parts of that same belt that contain evidence indicating porphyry molybdenum and (or) copper deposits. Two other belts adjoin these first belts at their southeast end and together cover all of southeasternmost Prince of Wales Island; one is defined by uranium-thorium- and rare-earth-element-bearing veins associated with Jurassic peralkalic intrusions and the other by rare-earth-element deposits associated with Ordovician and (or) Silurian alkalic intrusions. The fifth belt also is in southernmost Prince of Wales and adjacent islands; it is defined by volcanogenic massive-sulfide deposits in Paleozoic and older(?) rocks.

DESCRIPTION OF MAP UNITS

[NOTE: These descriptions have been adapted from the citations given for each unit. In some cases the previous material has been used almost *verbatim*; however in most cases it has been shortened and altered. In every case, however, the descriptions are those of the original workers and the sources are cited.]

UNITS EXPOSED SOUTHWEST OF CLARENCE STRAIT

Qs **Surficial deposits (Holocene and (or) Pleistocene)**--Alluvium, colluvium, tidal mudflat deposits, and some possible glaciofluvial deposits. Distribution of most large areas of surficial deposits was mapped in field, but deposits have not been studied in detail; many small areas are not shown. Within Craig quadrangle, major areas have been delineated by examination of aerial photographs. [Description adapted from Eberlein and others, 1983, p. 4, unit Qag]

Extrusive volcanic rocks (Quaternary? and Tertiary)--As mapped, divided into:

QTvb **Basaltic to rhyolitic breccia and tuff**--Poorly consolidated, iron-stained; weathers brown and reddish brown. Contains abundant plagioclase and minor biotite phenocrysts. Breccia consists of plagioclase porphyry fragments in crystal-lithic-lapilli tuff; breccia is associated with similar dikes that contain xenoliths of agglomerate derived from Descon Formation. Small, widely separated outcrops are probably from separate vents. Unit is exposed on northeastern Prince of Wales Island. [Description adapted from Eberlein and others, 1983, p. 16, unit QTv]

QTvr **Rhyolite and dacite**--Flows and small plugs with locally well developed columnar jointing (especially near Arena Cove). Quartz and sanidine phenocrysts present. Obsidian in rhyolite has black glass nodules in layered greenish black and yellow glass. Associated with unit QTvo. Outcrops on southern Suemez Island. [Description adapted from Eberlein and others, 1983, p. 25-26, unit QTrd]

QTvo **Olivine basalt and andesite**--Flows, breccia, lapilli tuff, and dikes. Layered units are flat-lying, fresh, and subaerial. Conspicuously columnar jointed porphyritic olivine basalt flows and dikes on southern Suemez Island. Flows are interbedded with massive basaltic breccia and lithic lapilli tuff. Buddington and Chapin (1929, p. 271) reported coal associated with basalt in small outcrops along streams draining into Port Refugio. Associated with unit QTvr on southern Suemez Island. At Tlevak Strait, between Dall and Prince of Wales Islands, consists of the Tlevak Basalt (Eberlein and Churkin, 1970b). Exposed on Suemez, northern Dall Island, and nearby islands. [Description adapted from Eberlein and others, 1983, p. 25, unit QTb; Brew, 1988, p. 6-7, 15, 16, 1994]

Tk **Kootznahoo Formation (Paleogene)**--Sandstone, conglomeratic sandstone, and conglomerate. Exposed at widely spaced localities on northern Prince of Wales Island: at Coal Bay (south of Kasaan Bay) unit consists of light-gray to light-yellow-brown wacke with large fragments of carbonized logs; to northeast at head of Little Coal Bay, unit consists of conglomerate and conglomeratic sandstone with cobbles and boulders of locally derived diorite and some black argillite interbedded with wacke and several-centimeter-thick seams of lignitic coal; in Lava Creek valley (west of Thorne Bay) unit consists of conglomerate with pebbles and cobbles of locally-derived argillite gneiss, trachyte, amydgdaloidal basalt, granite, schist, and chert in a wacke matrix (at this locality the unit is cut by pitchstone dikes). Unit is everywhere probably less than 30 m thick and was deposited as alluvial fans, piedmont gravels, and deltas in areas of steep relief. Name and age assignments are based on correlation of this unit with type Kootznahoo Formation on Admiralty Island (Lathram and others, 1965, p. R28) and its outliers on Kuiu, Kupreanof, Zarembo, and northern Prince of Wales Islands (Brew and others, 1984, p. 10). [Description adapted from Eberlein and others, 1983, p. 4-5, unit Ts; and Brew and others, 1984, p. 10, unit Tk]

Intrusive rocks of Chilkat-Prince of Wales plutonic province (Early Cretaceous)--Province named by Sonnevil (1981). K-Ar age determinations on hornblende from hornblende quartz monzodiorite with minor tonalite, granodiorite, quartz diorite, diorite, quartz monzonite, and monzodiorite unit (Kwqo) on northern Kosciusko and Prince of Wales Islands by M.A. Lanphere (written commun., 1981, 1982) give 98.7 and 100.0 Ma, respectively (Brew and others, 1984, p.10-11; Douglass and others, 1989). K-Ar age determinations on hornblende and biotite reported by Turner and others (1977) and Herreid and others (1978, p. 22) from same unit in Craig A-2 quadrangle give concordant ages averaging 102 Ma. Unit age is considered to be early Late Cretaceous. As mapped, numerous plutons on Prince of Wales Island and islands to the west are divided into:

Kwqo **Hornblende quartz monzodiorite with minor tonalite, granodiorite, quartz diorite, diorite, quartz monzonite, and monzodiorite**--Unit is massive to foliated, equigranular to locally porphyritic; medium-grained; color index (C.I.) 2 to 48, average (approx.) 15; locally hornblende porphyritic; contains local rounded fine-grained mafic inclusions; and includes common aplite, less common pegmatite, and several mafic dikes. Typical petrographic features are: seriate twinned and zoned plagioclase with minor alteration; K-feldspar interstitial to plagioclase and occasionally in poikilitic clots; hornblende anhedral to subhedral with some plagioclase inclusions and ubiquitous opaque inclusions; pyroxene and biotite locally present and subordinate to hornblende; pyroxene altering to hornblende and biotite to chlorite; accessories are apatite and sphene. Unit differs in general from the Late Cretaceous plutons of the Admiralty-Revillagigedo plutonic belt northeast of Clarence Strait by lack of epidote and garnet, lower color index, and by lack of local plagioclase porphyry phase. Exposed on Prince of Wales, Warren, and Coronation Islands. [Description adapted from Eberlein and others, 1983, p. 20, units Kd and MzPzg, p. 37-38, units Kgrd and Kd]

Kwgd **Hornblende granodiorite, hornblende diorite, and biotite-hornblende monzodiorite**--Unit is fine to medium grained, color index (C.I.) about 10-25; and includes some biotite-hornblende monzodiorite. In Kasaan Bay area includes some sodic granite (from Eberlein and others, 1983, p. 20, unit Kd); at Squaw Mountain on Dall Island: light-gray, medium- to fine-grained sphene-biotite-hornblende quartz diorite and granodiorite; at Stripe Mountain on Dall Island: homogeneous, massive to moderately foliated, medium- to coarse-grained, C.I. 5 to 20, sphene-biotite-hornblende granodiorite with U-Pb (zircon) apparent age of 114±2 Ma (Gehrels, 1990). Exposed on Prince of Wales and Dall Islands. [Description adapted from Eberlein and others, 1983, p. 24, unit MzPzd; Gehrels and Saleeby, 1986, p. 16-17, units Kgd and Kd; Gehrels and Saleeby, 1987, p. 134-135, diorite and granodiorite unit; Gehrels, 1990, 1991, unit Kg; Gehrels, 1992, p. 10-11, units Kgd and Kd]

Kwgb **Gabbro**--Unit exposed at several localities. At Thunder Mountain on northern Dall Island: deformed and altered stock- or sill-like hornblende(?) gabbro body consists of medium-grained, hypidiomorphic and subidiomorphic aggregates of calcic plagioclase and pale-green amphibole (Eberlein and others, 1983, p. 24-25, unit MzPzgb); on shore of Cordova Bay between Klakas and Kassa Inlets on southern Prince of Wales Island: a small body of altered, medium- to coarse-grained biotite-hornblende gabbro intrudes Shipwreck Point fault and rocks of Wales Group (from Gehrels and Saleeby, 1986, p. 17, unit Kgb; Gehrels, 1992, p. 11, unit Kgb); west of West Arm of Cholmondeley Sound and elsewhere: small plutons and plugs of gabbro and pyroxenite (from Eberlein and others, 1983, p. 38-39, unit Kgb)

Intrusive rocks of Bokan Mountain plutonic province (Middle Jurassic)--Province named in this report for Bokan Mountain on southeastern Prince of Wales Island. As mapped, divided into:

Jbgr **Peralkaline granite of Bokan Mountain**--Concentrically zoned pluton between Kendrick Inlet and South Arm of Moira Sound consisting of three main phases (Thompson and others, 1982; De Saint-Andre and others, 1983; Gehrels and Saleeby, 1987, p. 17-18; Gehrels, 1992, p. 11-12): an outer porphyritic aegirine-bearing albite granite, a porphyritic arfvedsonite-bearing albite granite inward, and an innermost fine-grained, but locally porphyritic, arfvedsonite- and aegirine-bearing albite granite. Veins in body have been mined for uranium, thorium, and rare-earth-elements. A variety of age determinations (discussed by Armstrong, 1985) indicate a minimum age of 151±6 Ma

Jbsy **Syenite of Dora Bay**--Nepheline- and eudialyte-bearing syenite with associated pegmatites (Eberlein and others, 1983, p. 39). Hornblende K-Ar age is 175.4±6.6 Ma (N.B. Shew, written commun., 1990)

Hyd(?) Group (Late Triassic?)--Consists of:

Ꞧhb **Oligomictic breccia**--Poorly sorted, angular pebble- to boulder-size clasts of plutonic rock derived from adjacent diorite, quartz diorite, gabbro, hornblendite, leucogabbro, trondhjemite, pyroxenite, and migmatite (SOdi) unit. Unit has little matrix; gabbroic and metadioritic clasts are most common; hornfels, mafic dike, mudstone, and fossiliferous limestone clasts also present and are interpreted to be derived from nearby siltstone, sandstone, polymictic conglomerate, and limestone of Clover Bay unit (Dkcb). Unit is interpreted to be a submarine talus deposit. Exposed near Clover Bay on eastern Prince of Wales Island. Originally considered to be Middle and Early(?) Devonian on basis of fossiliferous clasts, but here considered Late Triassic(?) on regional relations described by Gehrels and others (1987, p. 877). Tentative correlation with Hyd Formation is based on inferred relation of this unit to Hyd rocks on northeast side of Clarence Strait. [Description adapted from Eberlein and others, 1983, p. 29-30, unit Dbx]

PIPsy **Leucosyenite of Klawock and Sukkwan Island (Early Permian and Late Pennsylvanian)**--Biotite- and hornblende-bearing syenite with C.I. 15 near Klawock has K-Ar age on biotite of 276±8 Ma (Churkin and Eberlein, 1975, unit Pzsy). Sphene-apatite-amphibole-aegerine/augite-bearing biotite leucosyenite on Sukkwan Island has hornblende and biotite K-Ar ages of 283 and 293 Ma, respectively and is surrounded by extensive hornfels aureole (Eberlein and others, 1983, p. 39, unit Psy)

IPk **Klawak Formation (Middle and Early Pennsylvanian)**--Sandstone, siltstone, and minor limestone and chert-pebble conglomerate. Unit is about 150-300 m thick and contains small fusulinids (Douglass, 1971); abundant productid brachiopods, corals, bryozoans, conodonts (Savage and Bradley, 1985), and trace fossil *Spirophyton*. Unit named by Eberlein and Churkin (1970a, p. 54). Exposed near Klawock. [Description adapted from Eberlein and others, 1983, p. 8, unit IPk]

IPl **Ladrones Limestone (Middle and Early Pennsylvanian)**--Massive and sublithographic limestone and minor dolomite. Unit is about 300+ m thick and contains some light-gray cherty nodules. Contains öolites, endothyrid foraminifers, fusulinids, conodonts (Savage and Bradley, 1985), and shelly fossils, including trilobites (Hahn and Hahn, 1991, 1992). Unit named by Eberlein and Churkin (1970a, p. 59). Exposed in Trocadero Bay and Tlevak Strait areas. [Description adapted from Eberlein and others, 1983, p. 8, unit IPl]

Mp **Peratrovich Formation (Late and Early Mississippian)**--Limestone with dark-gray chert nodules and beds that grade downward to bedded chert. Unit is about 300+ m thick and contains abundant shelly fossils, especially rugose corals (Armstrong, 1970) and conodonts in upper part (Faulhuaber, 1977); and also trilobites (Hahn and Hahn, 1991) and microfossils (Mamet and others, 1993). Unit named by Eberlein and Churkin (1970a, p. 49); (from Eberlein and others, 1983, p. 8, unit Mp)

Dsj **St. Joseph Island Volcanics (Devonian?)**--Massive, locally amygdaloidal and pillowed, basalt flows; also basaltic breccia, tuff, agglomerate, and minor siltstone, mudstone, and sandstone; about 2,000-3,000 m thick; nonfossiliferous; cut by lamprophyre dike that has whole rock(?) K-Ar age of 328±10 Ma; unit named by Eberlein and Churkin (1970a, p. 27). [Description adapted from Eberlein and others, 1983, p. 16-17, unit Dsv]

Dpr **Port Refugio Formation (Late Devonian; Famennian)**--Massive to thick- and thin-bedded volcanic-detritus-rich graywacke, mudstone, siltstone, and minor polymictic conglomerate, black pyritic siltstone, calcareous siltstone, pillow basalt, tuff, fossiliferous limestone, and quartzofeldspathic arenite. Unit is several thousand meters thick; closely resembles Descon Formation and may not be separable where unfossiliferous. Northern exposures are on San Juan Bautista and Balandra Islands, southern ones include Shelikof Island, where aquagene tuff and breccia directly underlie Peratrovich Formation, and Soda Bay, where a complex section consists of amygdaloidal and scoriaceous pillow basalt, breccia, tuff, calcareous siltstone, dolomitic breccia, tuffaceous calcareous siltstone, and dark-gray to black silty limestone. Age is based on abundant brachiopods in certain limestone beds (Savage and others, 1978). Savage and Gehrels (1984) and Savage (1988) discuss general distribution of faunas. Unit named by Eberlein and Churkin (1970a, p. 43). [Description adapted from Eberlein and others, 1983, p. 8-9, 26-27, unit Dp.] Locally includes:

Dprv **Volcanic rocks**--Agglomerate, pillow basalt, and aquagene tuff. [Description adapted from Eberlein and others, 1983, p. 27, unit Dpv]

Dw **Wadleigh Limestone (Late to Early Devonian; Famennian to Emsian)**--Massive and thick- to medium-bedded limestone, minor argillaceous limestone and calcareous shale. Unit is about 300 m thick and is composed of abundant fragmented shelly fossils in a dark-gray lime-mudstone matrix. Locally rich in stromatoporoid *Amphipora* and corals (Oliver and others, 1975; Tchudinova and others, 1974; Savage, 1977a; Savage and Funai, 1980); massive stromatoporoids locally in reefs and reef breccias; brachiopods (Soja, 1988b, c), gastropods, ostracodes, pelecypods, and crinoids locally abundant; conodonts described by Savage (1977b, 1987, 1992) and Savage and Funai (1980). Savage and Gehrels (1984) and Savage (1988) discuss general distribution of faunas. Unit named by Eberlein and Churkin (1970a, p. 37). Age assignment based on information from Savage and Gehrels (1984) and Soja (1988b, c). Exposed on west side of Prince of Wales Island near Klawock. [Description adapted from Eberlein and others, 1983, p. 9, unit Dw]

Dc **Coronados Volcanics (Middle Devonian)**--Fragmental basalt interbedded with fossiliferous limestone and amygdaloidal pillow. Basalt fragments present in matrix of aquagene tuff and breccia. Unit is about 150 m thick; limestone consists mainly of fragments of tabulate corals, massive stromatoporoids, horn corals, gastropods, crinoid columnals, and brachiopods (Tchudinova and others, 1974). Savage (1988) discusses general distribution of faunas. Unit named by Eberlein and Churkin (1970a, p. 33). Exposed in vicinity of Coronados Islands. [Description adapted from Eberlein and others, 1983, p. 17, unit Dc]

Karheen Formation and associated rocks (Middle? and Early Devonian)--The Karheen Formation was named by Eberlein and Churkin (1970a, p. 22) and extended geographically by Gehrels and Saleeby (1986, 1987) and Gehrels (1992) to include age-equivalent rocks of different facies south of Karheen type area. "Dkk" symbols indicate Karheen Formation rocks; the "Dk" symbols indicate associated rocks. As mapped, divided into:

Dkr **Rhyolite of Kasaan Island (Middle? and Early Devonian)**--Rhyolite dikes and sills that cut limestone of Kasaan Island unit (Dkl). Thickness not known. [Description adapted from Eberlein and others, 1983, p. 17, unit Dkr]

Dkl **Limestone of Kasaan Island (Middle? and Early Devonian)**--Limestone and minor rhyolite tuff associated with rhyolite of Kasaan Island (Dkr). Unit is greater than 150 m thick and thick to thin bedded. Some thin layers of welded rhyolite tuff similar to rhyolite of Kasaan Island and fragments of rhyolite present in limestone breccia that consists mainly of fossil debris. Abundant fossils, including corals, stromatoporoids, crinoids, brachiopods (Soja, 1988a, b, c), conodonts (Savage, 1981a), and ostracodes (Berdan and Copeland, 1973). Soja (1988d) discusses depositional environment in detail and Savage (1988) discusses general distribution of faunas. [Description adapted from Eberlein and others, 1983, p. 12, unit Dkl]

Dkkt **Turbidite-facies rocks (Middle? and Early Devonian)**--Mudstone, siltstone, shale, sandstone, conglomerate, and minor limestone. Unit is greater than 2,000 m thick. Upper part of unit is dominantly interbedded andesitic flows, broken pillow breccia, and tuff; contact with younger units has not been seen and top is apparently not exposed. Basal part of unit in southern part of Craig quadrangle is conglomerate and sedimentary breccia that unconformably overlies (1) metamorphic rocks at Klakas Inlet (DSmk), (2) basaltic to andesitic volcanic rocks (SOdb) and volcaniclastic graywacke, siltstone, mudstone turbidites, and minor sedimentary breccia, limestone and polymictic conglomerate (SOdg) units of Descon Formation, (3) diorite, quartz diorite, gabbro, hornblendite, leucogabbro, ***migmatite unit (SOdi), and (4) greenstone, ***and minor marble (ЄZwg) unit of Wales Group. Lower contact relations are described in detail by Eberlein and others (1983, p. 27). In Dixon Entrance quadrangle, these basal strata are mapped separately as Karheen polymictic conglomerate, .***and volcanic rocks of conglomerate facies (Dkkc) of Karheen Formation. Interbedded black pyritic slate layers contain *Monograptus pacificus*, indicating a Pragian age (Churkin and others, 1970), and graptolites and shelly faunas from limestone beds in unit support that age. Unit is considered coeval with all other units mapped here as parts of Karheen Formation and associated rocks, with Wadleigh Limestone (Dw) and perhaps Coronados Volcanics (Dc). Unit age is considered to be Early and early Middle(?) Devonian. Savage and Gehrels (1984) discuss distribution of conodonts. Exposed on southern Prince of Wales Island between Kassa Inlet and Klakas Inlet. [Description adapted from Eberlein and others, 1983, p. 27-28, unit Ds; Gehrels and Saleeby, 1986, p. 3-7, units Dsh, Dms, Ds, Dls, Dbx; Gehrels and Saleeby, 1987, p. 124-125, p. 132: sandstone, siltstone, and limestone, and mudstone and shale units of the Karheen Formation; Gehrels, 1992, p. 2-4, units Dksh, Dkms, Dks, Dkl, Dkbx]

Dkkr **Redbed-facies rocks (Early Devonian)**--Sandstone, shale, conglomerate, and minor well-bedded platy limestone. Unit is about 1,800 m thick. Characterized in north by red beds, calcareous cement, festoon crossbedding, ripple marks and mud cracks (Eberlein and Churkin, 1970a; Ovenshine, 1975). Clasts are mostly mafic volcanic rocks and chert, with lesser amounts of sandstone, graywacke, quartz, siltstone, limestone, and felsic to mafic granitoid rocks present as pebbles and boulders; detrital K-spar and bronze-colored biotite distinguish sandstones from those in older formations. Overlies various units conformably and unconformably, and to east may interfinger with sedimentary rocks of the Staney Creek and Tuxekan Passage area unit, as described in detail by Eberlein and others (1983, p. 10). Locally contains abundant Early Devonian brachiopods (Kirk and Amsden, 1952; Savage, 1981b), and conodonts (Savage, 1977a, 1982), but relations to other fossiliferous units suggest that deposition of unit may have began in Late Silurian time. Exposed discontinuously from Kosciusko Island on north to southernmost Prince of Wales Island on south. [Description adapted from Eberlein and others, 1983, p. 9-11, unit Dk]

Dkbn **Breccia of northeastern Noyes Island (Early Devonian)**--Olistostromal blocks and breccia beds of limestone rich in shelly fossils and conodonts in matrix of graptolite- and plant-bearing shale (Churkin and others, 1969), together with graywacke, sandstone, and conglomerate. Unit is more than 400 m thick and unconformable on Descon Formation. Blocks and breccia beds contain reworked shallow-water faunas and a block of Lower Silurian shale; matrix contains *Monograptus yukonensis* and other Early Devonian graptolites. [Description adapted from Eberlein and others, 1983, p. 11-12, unit Dn]

Dksn **Sedimentary rocks of Port Nicholas area (Early Devonian)**--Sandstone overlain by massive limestone about 50 m thick, in turn overlain by graptolitic shale about 50 m thick (Churkin and others, 1970). Total thickness about 400+ m. Sandstone is calcareous, light gray, crossbedded, contains scattered chert pebbles, and is interbedded with mudstone; limestone is fossil fragmental, fetid, and contains abundant corals and stromatoporoids. Conodonts indicate an early to middle Pragian age (Savage and others, 1977). Shale contains abundant *Monograptus yukonensis and M. pacificus.* Unit is in part similar to *M. pacificus*-bearing shale of unit Dkkt described below. [Description adapted from Eberlein and others, 1983, p. 11, unit Dsn]

Dkp **Plagioclase-porphyritic dacite(?), andesite, and diorite(?) (Early Devonian)**--Small plugs and associated(?) flows, breccias, and dikes. Flow layers to several hundred meters thick are interbedded with units Dkkt and Dkkc (see below) and hypabyssal plugs cut same units. [Description adapted from Gehrels and Saleeby, 1986, p. 5-6, units Dpv, Dbv, p. 18, unit Dph; Gehrels and Saleeby, 1987, p. 124-125, 132-133: volcanic and hypabyssal rocks unit of Karheen Formation; Gehrels, 1992, p. 3, units Dkpv, Dkbv, p. 11-12, unit Dph]

Dkcg **Conglomerate-facies rocks (Early Devonian)**--Polymictic conglomerate, conglomeratic sandstone, sandstone, siltstone, and volcanic rocks. Reddish-brown cobble to boulder conglomerate and pebbly sandstone; thickness ranges from a few meters in north to greater than 1 km in south. To north, moderately well rounded clasts less than 40-cm in diameter of Ordovician volcanic and plutonic rocks are most common; to south, where unit is closely associated with plagioclase-porphyritic dacite(?), andesite, and diorite(?) (Dkp) unit, clasts are larger and more angular than to north and are mostly derived from that unit. Near mouth of Klakas Inlet, conglomerate grades laterally into coarse sedimentary breccia that both overlies and contains clasts of Ordovician volcanic and plutonic rocks. Exposed on southern Prince of Wales Island between Klakas Inlet and Point Nunez. [Description adapted from Gehrels and Saleeby, 1986, p. 3-7, units Dcg, Dbx; Gehrels and Saleeby, 1987, p. 132: conglomerate and breccia unit of Karheen Formation; Gehrels, 1992, p. 4, unit Dkcg]

Dkcb **Siltstone, sandstone, polymictic conglomerate, and limestone of Clover B (Early? Devonian)**--Calcareous well-bedded sandstone, siltstone with subordinate gray argillaceous limestone, banded mudstone with graded bedding. Locally cross-laminated (in sets a few centimeters to about 1 m thick) granule to pebble conglomerate. Thickness probably more than 75 m. Unit includes at least two subunits as thick as about 15 m of dark- to medium-gray, fetid argillaceous limestone with abundant fragmented shelly and coralline fossils; these fossils indicate a Devonian age, and ostracodes resembling *Beyrichia* suggest an Early Devonian age. Conglomerate clasts are mainly mafic volcanic rock, red and green chert, and minor granitic rock like that in diorite, quartz diorite, gabbro, hornblendite, leucogabbro, trondhjemite, pyroxenite, and migmatite (SOdi) unit. Exposed only at Clover Bay on eastern Prince of Wales Island. [Description adapted from Eberlein and others, 1983, p. 30-31, unit Dcb]

DSmk **Metamorphic rocks at Klakas Inlet (Early Devonian and Silurian)**--Semischist, greenstone, and leucodiorite. Age assigned is that of metamorphism of highly altered and brecciated rocks of dominantly intermediate composition derived from volcaniclastic graywacke, ***conglomerate (SOdg) and basaltic to andesitic volcanic rocks (SOdb) units of Descon Formation of Early Silurian to Early Ordovician age and foliated hornblende granodiorite***quartz-porphyritic granodiorite (Ogd) unit of the older part of the Cape Chacon plutonic province. Overlain by turbidite-facies rocks (Dkkt) of Karheen Formation. Exposed only at mouth of Klakas Inlet. [Description adapted from Gehrels and Saleeby, 1986, p. 12, unit DSk; and Gehrels, 1992, p. 7, unit DSk]

DSs **Sedimentary rocks of Staney Creek and Tuxekan Passage area (Early Devonian? and Late and Early Silurian)**--Limestone, sandstone, mudstone, and polymictic conglomerate. Unit is about 300 m thick and consists of interbedded light-gray, massive- to well-bedded, cyclically repeated limestone that resembles Heceta Limestone (Shl) and sandstone, conglomeratic sandstone, limy sandstone, and concretionary mudstone with locally well developed mudcracks and ripplemark like the redbed-facies rocks (Dkkr) in Karheen Formation and in clastic strata in Heceta Limestone (Shl). Basal limestone and shaly beds contain *Catenipora* and late Llandoverian graptolites that are younger than highest-occurring graptolites in volcaniclastic graywacke, limestone beds in upper part of sequence contain dasycladacean algae, corals, *Amphipora*, and *Conchidium*. Stratigraphic relations discussed by Eberlein and others (1983, p. 14) and field relations suggest that this unit, the Heceta Limestone, and the Bay of Pillars Formation are, in part, facies equivalents. Savage (1988) discusses general distribution of faunas. Exposed in northern part of quadrangle on Prince of Wales Island. [Description adapted from Eberlein and others, 1983, p. 13-14, unit DSs]

Sld **Leucodiorite at Kassa Inlet (Late Silurian)**--Medium- to-coarse-grained melanite(?)-sphene-arfvedsonite (with cores of aegerine-augite) leucodiorite with C.I. <15. Age is 418±5 Ma. Exposed only at Kassa Inlet, southern Prince of Wales Island. [Description adapted from Gehrels and Saleeby, 1986, p. 18, unit Sd; Gehrels and Saleeby, 1987, p. 131-132, leucodiorite unit; Gehrels, 1992, p.12, unit Sd]

Heceta Limestone (Late and Early Silurian)--Unit named by Eberlein and Churkin (1970a, p. 15). Age is late Early and Late Silurian. As mapped, divided into:

Shl **Limestone, minor limestone breccia, sandstone, mudstone, and polymictic conglomerate**--Unit is over 3,000 m thick on western Heceta Island, thins abruptly eastward due to facies change into sedimentary rocks of Staney Creek and Tuxekan Passage area (DSs) unit, and southward due probably to pre-Karheen erosion. Irregular masses in the Logjam Creek area east of the northern continuation of the Lake St. Nicolas fault are tentatively interpreted to be olistoliths. Limestone is massive, sublithographic, and lighter colored than other limestone units in map area; and is richly fossiliferous with corals, dasycladacean algae, brachiopods (Savage, 1989), stromatoporoids (including *Amphipora*), gastropods, pelecypods, bryozoans, trilobites, conodonts (Savage, 1985), trace fossils (Soja, 1991b), graptolites. Soja (1991a, 1990, 1993), and sphinctozoans (Rigby and others, 1994). Riding and Soja (1993) and Soja (1993b, 1994) discussed depositional environments in detail. Contact with underlying Descon Formation is generally conformable, but on west side of Heceta Island basal breccia consists of angular slabs of black graptolitic shale with monograptids of middle Early Silurian age. Exposed in northwestern Prince of Wales Island and on adjacent islands. [Description adapted from Eberlein and others, 1983, p. 12-13, unit Sh]

Shc **Polymictic conglomerate**--Thick lenses and pods of limestone breccia, polymictic conglomerate, and sandstone in central part of type locality of Heceta Limestone on Heceta Island. Limestone breccia and conglomerate consists of reworked intraformational lithologies; polymictic conglomerate contains clasts of plutonic, volcanic, and sedimentary rock, including chert; latter is significant because chert is uncommon in older units in area. [Description adapted from Eberlein and others, 1983, p. 13, unit Shc]

Bay of Pillars Formation (Late and Late? and Early Silurian)--Unit named by Muffler (1967, p. C6); extended geographically into Prince of Wales Island by Ovenshine and Brew (1972) and Brew and others (1984, p. 19). Unit on northeastern Prince of Wales Island (Spg, Spc) is distinguished from that on northern and northwestern Prince of Wales Island (Spsv) by its more volcaniclastic and less calcareous composition. As mapped, divided into:

Spsv **Sedimentary and volcanic rocks**--Graywacke, and mudstone turbidites, polymictic conglomerate, minor limestone, andesitic to basaltic volcanic flows, breccia, and tuff. Thickness probably exceeds a few thousand meters. Dominantly graywacke, mudstone, and calcareous mudstone turbidites, with subordinate conglomerate, limestone, and intermediate to mafic volcanic flows, breccia, and tuff. Sedimentary features in sandstone turbidites include massive, amalgamated beds, channelized beds, graded beds with Bouma sequences, and chaotically deformed slump deposits. Sandstones are extremely variable in composition: three dominant varieties in Petersburg quadrangle to north are calcareous graywacke, volcaniclastic graywacke, and quartzofeldspathic graywacke; proximal turbidite facies and crossbedding in conglomerates suggest shallow to moderate water depths. Karl and Giffen (1992) discuss sedimentology of this unit in Petersburg quadrangle to north. Graptolite collections made during Petersburg area study range in age from middle Llandoverian to early Ludlovian (Claire Carter, written commun., 1980); unit is of Early and Late Silurian age. Unit differs from Descon Formation because it has significantly less volcanic debris, both in subunits and as individual clastic grains; it also is mostly younger than Descon. Exposed along El Capitan Passage on northern and northwestern Prince of Wales Island. [Description adapted from Brew and others, 1984, p. 17-18]

Spg **Volcaniclastic graywacke and mudstone turbidites and minor limestone**--Greenish-gray, buff-weathering, volcaniclastic graywacke and argillite turbidite deposits in massive to amalgamated, graded, and rhythmic beds of Mutti and Ricchi-Lucchi A, B, C, and E facies, which suggest proximal depostional environment in moderate water depths. Thickness not known. Graptolites on some argillite bedding surfaces are all of Early Silurian age (Claire Carter, written commun., 1980); unit is considered to be of Early and Late(?) Silurian age. Exposed only in small area at northern edge of map on northeastern Prince of Wales Island. [Description adapted from Brew and others, 1984, p. 19]

Spc **Conglomerate, agglomerate, and volcanic breccia**--Mostly volcaniclastic polymictic conglomerate and volcanic breccia of intermediate to mafic composition with feldspar- and clinopyroxene porphyry common. Thickness not known. Exposed only in small outcrop area at north edge of map. [Description adapted from Brew and others, 1984, p. 19]

Shpc **Polymictic conglomerate between Heceta Limestone and Bay of Pillars Formation (Early? Silurian)**--Polymictic pebble and cobble conglomerate and other clastic rocks like those in polymictic conglomerate of Heceta Limestone (Spc), but present between unit Shl of Heceta Limestone and Bay of Pillars Formation (Spsv) on northern Prince of Wales Island. Thickness not known, but probably greater than several thousand meters locally. Exposed on Coronation Island and on Spanish Islands. [Description adapted from Brew and others, 1984, p. 17, unit Scp]

Intrusive and related rocks of younger part of Cape Chacon plutonic province (Early Silurian and Late Ordovician)--This province named in this report from locality of its southernmost exposures at Cape Chacon, Prince of Wales Island. As mapped, divided into:

SOmk **Metamorphic rocks at Kendrick Bay**--Heterogeneous schistose biotite-hornblende-quartz-plagioclase gneiss, schist, and amphibolite. Unit consists of (1) fine- to very fine grained layered and well-foliated (muscovite-sphene-pyrite-magnetite-ilmenite-monazite(?)-) K-feldspar-biotite-hornblende-plagioclase gneiss, probably derived from sedimentary and volcanic rocks; (2) very fine grained, well-foliated, dark- and medium-gray (K-feldspar-muscovite-) biotite-hornblende-plagioclase schist of amphibolite facies; and (3) dark-green and dark-greenish-brown, coarse-grained (augite-) plagioclase-hornblende amphibolite, probably derived from mafic rocks. [Description adapted from MacKevett, 1963, p. 17-18, units Dsc, Dgn, Dam; Gehrels and Saleeby, 1986, p. 12, unit SOk; Gehrels, 1992, p. 7-8, unit SOk]

SOdi **Diorite, quartz diorite, gabbro, hornblendite, leucogabbro, trondhjemite, pyroxenite, and migmatite**--Heterogeneous complex consisting of these rock types; cut by locally sheeted mafic and by felsic dike swarms. Host rock for skarn deposits on Kaasan Peninsula (Eberlein and Churkin, 1976). U-Pb (zircon) apparent age of rock from same unit on Duke Island is 429±20 Ma (Gehrels and others, 1987, p. 872). Exposed on eastern Prince of Wales Island from Cholmondeley Sound to upper Kaasan Bay. [Description adapted from Eberlein and others, 1983, p. 20-24, unit Pzic; Gehrels and others, 1987, p. 871-872, diorite unit]

SOsy **Quartz syenite and granite**--Medium-grained, leucocratic, grayish-red to reddish-gray, massive-appearing, poorly foliated to nonfoliated (garnet-aegerine/augite-hornblende-) biotite syenite. Unit may be genetically related to unit SOgr. U-Pb (zircon) apparent age is 438±5 Ma (Gehrels and Saleeby, 1987, p. 130). Exposed near Stone Rock Bay on southeastern Prince of Wales Island. [Description adapted from MacKevett, 1963, p. 32-33, unit Ksy; Gehrels and Saleeby, 1986, p. 19, unit SOsy; Gehrels and Saleeby, 1987, p. 130, quartz syenite unit; Gehrels, 1992, p. 12-13, unit SOsy]

SOgr **Granite**--Coarse- to medium-grained, locally well foliated and banded, porphyritic biotite granite. Unit may be genetically related to unit SOsy. U-Pb (zircon) apparent age is 438±5 Ma (Gehrels and Saleeby, 1987, p. 130). Exposed on Kendrick Islands and south of mouth of Kendrick Bay. [Description adapted from MacKevett, 1963, p. 30-31, part of unit Kgq; Gehrels and Saleeby, 1986, p. 20, unit SOgr; Gehrels and Saleeby, 1987, p. 130, granite unit; Gehrels, 1992, p. 13, unit SOgr]

SOqm **Unfoliated and foliated quartz monzonite and granite**--Homogeneous, massive-appearing, medium-grained, light-gray hornblende granodiorite, biotite-hornblende granodiorite, leucocratic granodiorite, biotite granodiorite, biotite quartz monzonite, leucocratic quartz monzonite, and hornblende quartz monzonite. Albitized in vicinity of peralkaline granite of Bokan Mountain (Jbgr). U-Pb (zircon) apparent age is 438±4 Ma (Gehrels and Saleeby, 1987, p. 130). [Description adapted from MacKevett, 1963, p. 24-30, unit Kqm; Gehrels and Saleeby, 1986, p. 20-21, unit SOqm; Gehrels and Saleeby, 1987, p. 130, quartz monzonite unit; Gehrels, 1992, p. 13-14, unit SOqm]

SOpx **Pyroxenite, hornblendite, and gabbro**--Composition of unit differs from locality to locality: (1) At Salt Chuck near Kasaan Bay: discordant, pipe-like stock of olivine-bearing pyroxenite and gabbro, diorite, and hornblendite; host rock for Cu, Au, Ag, and PGM (platinum-group-metal)-bearing magmatic sulfide deposits; minimum age is about 429±11 Ma, based on K-Ar dating of biotite (Gault, 1945; Gault and others, 1992; Loney and others, 1987; Loney and Himmelberg, 1992; Himmelberg and Loney, 1995). [Description adapted from Eberlein and others, 1983, p. 18-19, unit Kpg.] (2) Near Stone Rock Bay on southeastern Prince of Wales Island: elongate body of dark-gray, medium- to coarse-grained, locally porphyritic (magnetite-biotite-hornblende-) augite pyroxenite; some parts contain magnetite in potential economic amounts; intruded by unfoliated and foliated quartz monzonite and granite (SOqm) unit. [Description adapted from MacKevett, 1963, p. 17-18, unit Kpy; Gehrels and Saleeby, 1986, p. 19, unit SOpx; Gehrels, 1992, p. 13, unit SOpx.] (3) On southern Sukkwan Island: medium- to coarse-grained hornblende gabbro, hornblendepyroxenite, and hornblendite; minimum age is about 440 to 449 Ma, based on K-Ar dating of two hornblende concentrates (M.A. Lanphere, oral commun. to G.D. Eberlein, 1981; Himmelberg and Loney, 1995). [Description adapted from Eberlein and others, 1983, p. 39-40, unit Ogb; Gehrels, 1991, unit Ogb.] (4) On western Long and western Dall Islands: medium- to coarse-grained, locally porphyritic (biotite-hornblende-) augite pyroxenite and pyroxene gabbro; minimum age is about 400 Ma, based on K-Ar dating of hornblende concentrate (M.A. Lanphere, oral commun. to R.A. Loney, 1991; Himmelberg and Loney, 1995). [Description adapted from Gehrels, 1991, unit Opx]

SOhb **Hornblendite**--Altered hornblendite; probably similar to hornblende gabbro on Duke Island. Exposed on east shore of Prince of Wales Island north of Clover Bay. [Description adapted from Eberlein and others, 1983, p. 40; Gehrels and others, 1987, p. 872-873, hornblende gabbro unit]

SObl **Andesitic breccia of Luck Creek (Early Silurian and Late Ordovician)**--Angular fragments of porphyritc andesite in a matrix of hornblende-diopsidic augite crystal tuff of andesitic composition. Unit is as thick as several thousand meters. Massive and structureless in outcrop, but crude large-scale layering apparent from distance west and east of Thorne River. At Staney Cone and elsewhere 10-m-thick lenses of light-gray aphanitic limestone contain *Catenipora* sp. of Late Ordovician to Early Silurian age. K-Ar dating of hornblende from the breccia along Big Salt Lake and near Kogish Mountain gives a minimum age of about 440 Ma (M.A. Lanphere, oral commun. to G.D. Eberlein, 1981; Eberlein and others, 1983, p.18). May be in part extrusive equivalent of diorite, quartz diorite, gabbro, hornblendite, leucogabbro, trondhjemite, pyroxenite, and migmatite (SOdi) unit, and more proximal equivalent of the Descon Formation (SOdg). However, close association and lithologic similarity of this unit with Descon volcanic and other rocks make the two units difficult to distinguish. As presently mapped, exposed in large areas in central Prince of Wales Island. [Description adapted from Eberlein and others, 1983, p. 17-18]

Descon Formation (Early Silurian to Early Ordovician)--Unit named by Eberlein and Churkin (1970a, p. 5) and geographically extended by Herreid and others (1978, p. 10) into southern Prince of Wales Island. As mapped, divided into:

SOdg **Volcaniclastic graywacke, siltstone, mudstone turbidites, and minor sedimentary breccia, limestone, and polymictic conglomerate**--Mainly graywacke and mudstone with some interbedded massive basalt lava and pyroclastic flows that cannot be mapped separately at this scale. Unit is at least 3,000 m thick, and base is not exposed. Graywacke consists of dominantly basaltic detritus in a noncalcareous chlorite-rich matrix; graded bedding common; interbedded mudstone is rhythmically bedded and has graded bedding and penecontemporaneous slump features. Conglomerate and sedimentary breccia range from crudely layered augite-phenocryst-rich andesite breccia like that of andesitic breccia of Luck Creek (SObl) to polymictic types with clasts of chert, felsic volcanic rock, graywacke, and gabbro. Minor black graptolite-bearing chert and siliceous shale present. Orange-weathering quartzofeldspathic wacke present in vicinities of Heceta and Lulu Islands and near Salt Chuck Bay on western Prince of Wales Island. To south and west, unit is less indurated, less metamorphosed, and more calcareous. Abundant and well-preserved graptolites establish presence of virtually all of the Ordovician and Lower Silurian graptolite zones (Churkin and others, 1970; Carter and others, 1980; Eberlein and others, 1983, table 1, localities G1, 2, 4-6, 8-10, 12-23, 25-48). Locally penetratively deformed and metamorphosed to hornfels, slate, phyllite, semischist, schist, and greenschist. Close association and lithologic similarity of this unit with andesitic breccia of Luck Creek (SObl) make the two units difficult to distinguish. Exposed throughout Prince of Wales and adjacent islands north of about latitude 55° N. (Craig-Dixon Entrance quadrangle boundary). [Description adapted from MacKevett, 1963, p. 8-10, unit Dsl; Eberlein and others, 1983, p. 15-16, unit SOd, p. 31-33, unit SOs; Gehrels and Saleeby, 1986, p. 7-9, units SOa, SOms, SOgw, SOls; Gehrels and Saleeby, 1987, p. 127-128, argillite, and mudstone and siltstone units of Descon Formation; Gehrels, 1991, units SOda, SOdm; Gehrels, 1992, p. 4-6, units SOda, SOdms, SOdgw, SOdl]

SOdc **Volcaniclastic conglomerate**--Mapped by J.A. Baichtal (written comm., 1995) inland to the east of Tuxekan Passage and south of Karheen Passage. Mapped by Eberlein and others (1983) as parts of units DSs and SObl.

SOdr **Dacitic to rhyolitic volcanic rocks**--Silicic (dacite to rhyolite) breccia, tuff-breccia, tuff, and extrusive domes. Exposed in southeasternmost part of Prince of Wales Island, and in one locality at Augustine Bay on Dall Island. [Description adapted from Gehrels and Saleeby, 1986, p. 10-11, unit SOsv; Gehrels and Saleeby, 1987, p.127, rhyolitic volcanic rocks unit; Gehrels, 1991, unit SOdr; Gehrels, 1992, p. 6-7, unit SOdsv]

SOda **Andesitic to dacitic volcanic rocks**--Intermediate (andesite to dacite) flows and breccia. Exposed south of Moira Sound and near Klakas Inlet on southern Prince of Wales Island, and in Barrier Islands. [Description adapted from Gehrels and Saleeby, 1986, p. 10, part of unit SOiv; Gehrels and Saleeby, 1987, p.127, included these rocks in their rhyolitic volcanic rocks unit of Descon Formation; Gehrels, 1992, p. 6, part of unit SOdiv]

SOdb **Basaltic to andesitic volcanic rocks**--Augite-bearing basaltic to andesitic pillow flows, pillow breccia, agglomerate, breccia, and tuff-breccia; some massive lava flow deposits. Exposed in vicinity of El Capitan and Esquibel Islands and at Salt Lake Bay on northern Prince of Wales Island, on Sukkwan Island, and in central and southeasternmost parts of Prince of Wales Island. [Description adapted from MacKevett, 1963, p. 6-8, unit Dv; Eberlein and others, 1983, p. 15, 16, unit SOdv, p. 33-34, unit SOv; Gehrels and Saleeby, 1986, p. 10, units SObv and SOms, part of unit SOiv; Gehrels and Saleeby, 1987, p.127, basaltic to andesitic volcanic rocks unit of Descon Formation; Gehrels, 1991, unit SOdb; Gehrels, 1992, p. 5-6, units SOdbv and SOdms, part of unit SOdiv]

Intrusive and related rocks of older part of Cape Chacon plutonic province (Late and Middle Ordovician)--This province named in this report from locality of its southernmost exposures at Cape Chacon, Prince of Wales Island. As mapped, divided into:

Oqd **Hornblende quartz diorite, diorite, and quartz monzonite (Late Ordovician)**--Massive, fine- to medium-grained, C.I. about 20, biotite-hornblende quartz diorite and minor diorite. U-Pb (zircon) apparent age is 445±5 Ma (Gehrels and Saleeby, 1987, p. 130). K-Ar dating of hornblende there gave apparent age of 439±21 Ma (Lanphere and others, 1964, p. 705, recalculated by Gehrels and Saleeby, 1986). Exposed at and near Kendrick Bay. [Description adapted from MacKevett, 1963, p. 22-28, unit Kqm; Gehrels and Saleeby, 1986, p. 21-22, unit Oqd; Gehrels and Saleeby, 1987, p. 128-130, part of quartz diorite unit; Gehrels, 1992, p. 14-15, unit Oqd]

Odi **Foliated and layered hornblende diorite and quartz diorite, heterogeneous diorite and gabbro, and minor foliated granodiorite (Late and Middle? Ordovician)**--Massive and homogeneous bodies and heterogeneous masses of medium-grained, C.I. 30-50, foliated diorite and hornblende gabbro. U-Pb (zircon) apparent age is 446±5 Ma (Gehrels and Saleeby, 1987, p. 130). Exposed at and near Tah Bay. [Description adapted from Gehrels and Saleeby, 1986, p. 24-25, 22-23, units Od, Ofd, Ofgd; Gehrels and Saleeby, 1987, p.128-130, diorite unit and part of quartz diorite unit; Gehrels, 1992, p. 15-16, units Od, Ofd, Ofgd]

Ogd **Foliated hornblende granodiorite, chlorite leucogranodiorite, and quartz-porphyritic granodiorite (Middle Ordovician)**--Homogeneous, massive, medium- to coarse-grained, C.I. 5-20, hornblende granodiorite. U-Pb (zircon) apparent ages from this unit are 462±15 Ma, 468±15 Ma, and 472±5 Ma (Gehrels and Saleeby, 1987, p. 128). Exposed on southern and southeastern Prince of Wales Island. [Description adapted from Gehrels and Saleeby, 1986, p. 24-25, 23-24, units Oqgd and Ogd; Gehrels and Saleeby, 1987, p. 128-129, granodiorite unit; Gehrels, 1992, p. 16-17, unit Ogd]

Omr **Metamorphic rocks at Ruth Bay (Middle Ordovician)**--Foliated and layered metaplutonic and minor metavolcanic and metasedimentary rocks: about 60 percent foliated and slightly layered hornblende gabbro; about 35 percent well-foliated, C.I. less than15, hornblende-biotite granodiorite; and about 5 percent hornblende-bearing metavolcanic and metasedimentary rocks. U-Pb (zircon) apparent age of a granodiorite sill is 465±7 Ma (Gehrels and Saleeby, 1987, p. 130). Exposed between mouths of Kassa and Klakas Inlets. [Description adapted from Gehrels and Saleeby, 1986, p. 12-13, unit Or; Gehrels and Saleeby, 1987, p. 130-131, Ordovician metaplutonic rocks; Gehrels, 1992, p. 8-9, unit Or]

Ꞓmpw **Metamorphic rocks on eastern Prince of Wales Island (Late and Middle Cambrian)**--Foliated, slightly layered, metamorphosed diorite, microdiorite, quartz diorite, gabbro, microgabbro, and hornblendite. Correlates with unit on southern tip of Gravina Island, where a U-Pb (zircon) apparent age of a sample from Bronough Islands (off south tip of Gravina Island) is in range 540 to 510 Ma (Gehrels and others, 1987, p. 868-869). Exposed to west and east of entrance to Cholmondeley Sound on southeastern Prince of Wales Island. [Description adapted from Gehrels and others, 1987, p. 867, 869, Cambrian metaplutonic rocks unit]

Intrusive rocks of southern Dall Island plutonic province (Early Cambrian)--This province named in this report from its only exposures on southern Dall Island. As mapped, divided into:

Ꞓqd **Foliated, lineated, and gneissic biotite-hornblende quartz diorite, granodiorite, and minor diorite**--Massive, medium-grained, C.I. 20-40, hornblende-biotite quartz diorite and granodiorite with no fabric grades to strongly foliated and locally layered quartzofeldspathic schist. U-Pb (zircon) apparent age of a gneissic granodiorite that intrudes rocks of Wales Group at Cape Muzon is 555±4 Ma. [Description adapted from Gehrels, 1991, unit Ꞓq]

Ꞓdi **Foliated and layered biotite-hornblende diorite and quartz diorite**--Foliated, compositionally-layered and grain-size-layered biotite-hornblende diorite and lesser quartz diorite. [Description adapted from Gehrels, 1991, unit Ꞓd]

Ꞓgb **Hornblende gabbro, microgabbro, and quartz diorite**--Gabbro is foliated, lineated, and metamorphosed to chlorite and locally biotite schist; grades into heterogeneous quartz diorite, granodiorite, and gabbro containing as much as 50 percent screens and pendants of metavolcanic rocks. [Description adapted from Gehrels, 1991, units Ꞓgb and Ꞓqb]

Wales Group (Early Cambrian? and Late Proterozoic)--Unit named by Brooks (1902) as Wales Series and redefined by Buddington and Chapin (1929, p. 45-49) as Wales Group. As mapped, divided into:

ꞒZwgb **Metagabbro south of Kassa Inlet**--Heterogeneous deformed and metamorphosed hornblende-clinopyroxene gabbro. Intrusive into Wales Group, but included here as part of Wales Group because it has been metamorphosed together with surrounding rocks whereas other intrusive rocks in the area (those of Cape Chacon plutonic province) were not. [Description adapted from Gehrels and Saleeby, 1986, p. 25, unit pmOgb; Gehrels, 1992, p. 17-18, unit pOgb]

ꞒZwg **Greenstone, greenschist, black phyllite, quartz-sericite schist, metakeratophyre, and minor marble**--Folded and otherwise-deformed, light- to dark-green, greenschist- and local amphibolite-facies schist and gneiss derived from basaltic to andesitic volcanic rocks, volcaniclastic rocks, and some sedimentary rocks; also some schist is derived from meter-thick layered silicic volcanic rocks. Most common rock type is fine-grained (actinolite-)epidote-albite-chlorite schist. Highest grade rocks are garnet-biotite-hornblende-plagioclase gneiss near Kassa Inlet. Metamorphosed silicic volcanic rocks are quartz-porphyritic quartz-albite schist (that has been called metakeratophyre) that have locally preserved protolithic volcanic features. Unit thickness is at least several thousand meters. Age assignment used here is based on interpretation of intrusive relation described above for foliated, lineated, and gneissic biotite-hornblende quartz diorite, granodiorite, and minor diorite (Ꞓqd) unit into this unit on southern Dall Island; that relation establishes a pre-Early Cambrian age for at least some protoliths of Wales Group (Gehrels, 1991). D.J. Grybeck reported (oral commun., April 22, 1993) that G.E. Gehrels has obtained a U-Pb age of about 595 Ma on a zircon sample from this unit near Niblack Anchorage on southeastern Prince of Wales Island; this determination is interpreted here to indicate that unit is of Late Proterozoic and Early Cambrian(?) age. Exposed on southern Prince of Wales and southern Dall Islands. [Description adapted from Eberlein and others, 1983, p. 23-24, unit PzpꞒs, p. 34-37, unit PzpꞒw; Gehrels and Saleeby, 1986, p. 14-15, unit pmOw; Gehrels and Saleeby, 1987, p. 126-127, informally named Wales metamorphic suite; Gehrels, 1991, units pOwb, pOwd, pOwr, pOws, pOwp, pOwu; Gehrels, 1992, p. 9-10, unit pOw]

-Ꞓ-Zwm **Marble and minor calcsilicate rocks**--Medium- to fine-grained, medium- to light-gray and tan marble. Present both as centimeter- to meter-thick layers in greenstone, greenschist, black phyllite, quartz-sericite schist, metakeratophyre, and minor marble (-Ꞓ-Zwg) unit and as massive to very thick (200 m) masses in localities shown on map at head of Hetta Inlet on Prince of Wales Island and on Long and Dall Islands. Massive parts have 5-cm- to 2-m-thick compositional layering. At Hetta Inlet unit is host to skarn deposits associated with a pluton of hornblende quartz monzodiorite with minor tonalite, granodiorite, quartz diorite, diorite, quartz monzonite, and monzodiorite (Kwqo) unit. [Description adapted from Eberlein and others, 1983, p. 37; *Gehrels, 1991, unit pOwm*]

UNITS EXPOSED NORTHEAST OF CLARENCE STRAIT

Qs **Surficial deposits (Holocene and (or) Pleistocene)**--Alluvium, colluvium, tidal mudflat deposits, and some glaciofluvial deposits. Distribution of most large areas of surficial deposits was mapped in field, but deposits have not been studied in detail. Many small areas of surficial deposits are not shown

QTv **Extrusive volcanic rocks (Quaternary? and Tertiary)**--Basalt and andesite exposed on Eagle and Muffin Islands at juncture of Clarence Strait and Ernest Sound. [Description adapted from Eberlein and others, 1983, p. 5-6, unit Tba; Brew, 1988, p. 6-7, 15, 16, unit QTb, 1994]

Intrusive and related rocks of Kulu-Etolin volcanic-plutonic province (Miocene and (or) Oligocene)--Province named by Brew and others (1979) for area of its greatest exposure on Kuiu and Etolin Islands. Brew and Morrell (1983) and Brew (1988) provide general background information for these rocks. As mapped, divided into:

Tsh **Hornfelsed sedimentary rocks**--Composition of unit differs from locality to locality: (1) On southern Etolin, Brownson, and Deer Islands its protoliths are turbidites of Seymour Canal Formation of original Late Jurassic and Early Cretaceous age that are hornfelsed to albite-epidote hornfels facies metamorphic rocks and generally preserve both original structures and textures as well as metamorphic effects of Cretaceous metamorphic events. [Description adapted from Brew and others, 1984, p. 9, unit Tsh.] (2) On southwestern Revillagigedo Island metasedimentary rocks in vicinity of leucogabbro (Tlgb) unit are hornfelsed to spotted schist and hornfels. [Description adapted from Berg and others, 1988, p. 2, 17-18, hornfelsed unit MzPzms]

Tvh **Hornfelsed volcanic rocks**--Hornfelsed metavolcanic rocks in vicinity of leucogabbro (Tlgb) unit on southwestern Revillagigedo Island. [Description adapted from Berg and others, 1988, p. 2, 17-19, hornfelsed unit MzPzmv]

Tme **Migmatitic granitic rocks of southern Etolin Island**--Hornblende-biotite-pyroxene quartz monzodiorite, quartz monzonite, granodiorite, quartz diorite, and diorite paleosomes invaded by neosomes of these same compositions as well as of granite, alkali granite, and quartz syenite. Massive, extremely heterogeneous, and generally nonfoliated; hypidiomorphic to allotriomorphic; equigranular to seriate to porphyritic; generally fine- to medium-grained; C.I. 10 to 50 (paleosomes), 03 to 25 (neosomes). [Description adapted from Brew and others, 1984, p. 7, unit Tmme]

Tge **Granitic rocks of southern Etolin Island**--Hornblende-biotite granite, alkali granite, quartz syenite, and alkali quartz syenite. Massive, nonfoliated; allotriomorphic to hypidiomorphic; equigranular to seriate; medium- to coarse-grained; C.I. 01 to 07. Weathers to a distinctive pale orange to white; miarolitic cavities common, often rusty weathering; generally quite homogeneous at outcrop scale. [Description adapted from Brew and others, 1984, p. 7, unit Tmme]

Tlgb **Leucogabbro near Ketchikan**--Olivine-bearing (biotite-)two-pyroxene leucogabbro; forms crudely zoned stock at Deer Mountain and a small body on northeast shore of Gravina Island. [Description adapted from Koch and Elliott, 1984; Berg and others, 1988, p. 10, 15, unit Tgb]

Tk **Kootznahoo Formation (Paleogene)**--Conglomerate, sandstone, siltstone, shale, and minor lignite that are in general similar to rocks in Kootznahoo Formation southwest of Clarence Strait. Unit is everywhere probably less than 30 m thick and was deposited as alluvial fans, piedmont gravels, and deltas in areas of steep relief. Name and age assignments are based on correlation of these rocks with type Kootznahoo Formation on Admiralty Island and its outliers on Kuiu, Kupreanof, Zarembo, and northern Prince of Wales Islands. Exposed on northeastern Eagle Island, off south tip of Etolin Island, and south of Union Point, northeast headland of Union Bay. [Description adapted from Eberlein and others, 1983, p. 4-5, unit Ts; Brew and others, 1984, p. 10, unit Tk]

Intrusive and related rocks of Admiralty-Revillagigedo plutonic province (Late Cretaceous)--Province named by Brew and Morrell (1983) for northern and southern ends of province in southeastern Alaska. Table 1 gives age information; the first five-listed K-Ar ages in Ketchikan quadrangle are interpreted to be either cooling ages or to have been reset in by later magmatic events to northeast (Smith and others, 1979). Unit Ktif does not occur in this map area, but does crop out not far to the north (Brew and others, 1984, p. 21). Similarly dated rocks also present in lithically correlative units to northeast in the Bradfield Canal quadrangle (R.L. Elliott and R.D. Koch, oral commun., 1982). Rocks in these units in Petersburg quadrangle to north are described in detail by Burrell (1984a, b, c). As mapped, divided into:

Table 1. K-Ar and other age determinations of rocks from the Admiralty-Revillagigedo plutonic province. [Determinations from nearby in Petersburg quadrangle are by M. A. Lanphere (written communs., 1981, 1982, cited in Brew and others (1984)) and from this part of the Ketchikan quadrangle are those cited by Berg and others (1988). Map unit symbols are those on cited maps.]

Map unit	General location	K-Ar (Ma) Biotite	K-Ar (Ma) Hornblende	K-Ar (Ma) Muscovite	Pb-U (Ma) (Zircon)
		Petersburg quadrangle			
Ktif	Wrangell Is.	83.2	91.6	- - -	- - -
Ktif	Mitkof Is.	- - -	89.1	- - -	- - -
Ktef	Zarembo Is.	90.4	93.0	- - -	- - -
		Ketchikan quadrangle			
Ktef	Bell Is.	74.2	80.2	- - -	- - -
Ktef	Revillagigedo Is.	70.9	85.4	- - -	- - -
Ktef	Cleveland Peninsula	- - -	- - -	89, 91	- - -
Ktef	Cleveland Peninsula	70.4	79.5	- - -	- - -
Ktef	Cleveland Peninsula	74.2	85.9	- - -	- - -
Ktef	Black Is.	74.4	81.8	- - -	- - -
Ktoc	Revillagigedo Is.	96.5	94.5	- - -	- - -
Ktqd	Spire Is.	- - -	- - -	- - -	89.1

Krtn **Nonfoliated plagioclase-porphyritic (hornblende-)(epidote-)garnet-biotite tonalite, quartz diorite, and minor granodiorite**--Nonfoliated crowded-plagioclase-phenocryst rock; inequigranular to porphyritic; very fine to medium-grained; C.I. 14 to 29; medium gray fresh; weathers light gray. Generally forms small elongate bodies less than 3 km^2 in area. Minerals include reddish-brown garnet, clinozoisite (or rarely epidote) and local muscovite; biotite and quartz commonly interstitial to closely spaced plagioclase laths. Some of epidote is magmatic (Zen and Hammarstrom, 1984). Unit is similar to the porphyritic, foliated biotite tonalite, quartz diorite, and granodiorite (Krtp) unit mineralogically, but differs texturally by its finer grain size and lack of large phenocrysts. Exposed on Brownson Island, Cleveland Peninsula, and Revillagigedo Island. [Description adapted from Brew and others, 1984, p. 21-22, unit Ktoc; Berg and others, 1988, p. 16, part of unit Kpg]

Krtp **Porphyritic, foliated biotite tonalite, quartz diorite, and granodiorite**--Prominently porphyritic, foliated, medium- to coarse-grained, C.I. 11 to 35, local cataclastic texture. Minerals include zoned, complexly twinned plagioclase, quartz, interstitial K-feldspar, partly chloritized biotite, epidote, minor local hornblende; and garnet, sphene, apatite, and allanite as accessories; in this map area lacks K-feldspar and shows moderate to extreme alteration of plagioclase, biotite, and garnet. Locally cut by pegmatite and basalt dikes; local inclusions of country rock. Exposed on southern Etolin Island and on Cleveland Peninsula. [Description adapted from Brew and others, 1984, p. 22, unit Ktgp; Berg and others, 1988, p. 16, part of unit Kpg]

Krtf **Foliated to massive hornblende-biotite tonalite and granodiorite, quartz monzonite, and quartz diorite**--Foliated to massive equigranular, average grain size is medium, but is fine grained near some margins, C.I. 17 to 50, light to medium gray where fresh, weathers brownish to dark gray. Minerals include zoned, complexly twinned plagioclase with minor alteration to sericite, mafic minerals usually biotite greater than hornblende, subhedral epidote, and local garnet and pyroxene; some of epidote is magmatic (Zen and Hammarstrom, 1984); accessory minerals are sphene, apatite, opaque mineral, and allanite. Foliation varies both in direction and development; locally semischistose and cataclastic. Contains aplite dikes, pegmatite dikes and veins, and rounded very fine grained hornblende diorite inclusions near pluton margins. Exposed on Cleveland Peninsula, Bell Island, and elsewhere in northeastern corner of map area. [Description adapted from Brew and others, 1984, p. 36, unit Ktef; Berg and others, 1988, p. 16, unit Kq]

Krqd **Quartz diorite**--Strongly sheared and altered brownish-gray, medium-grained, quartz diorite. Minerals include albite, quartz, muscovite, chlorite, epidote-clinozoisite, calcite, apatite, sphene, and pyrite. Exposed only on Spire Island, to northeast of Annette Island. [Description adapted from Berg and others, 1988, p. 10, unit Kqd]

Krmg **Migmatite**--Mainly agmatite and irregular banded gneiss, in zones between foliated to massive hornblende-biotite tonalite and granodiorite, quartz monzonite, and quartz diorite (Krtf), porphyritic, foliated biotite tonalite, quartz diorite, and granodiorite (Krtp), and hornfelsed sedimentary rocks (Tsh) units. Exposed only on east side of Ernest Sound. [Description adapted from Brew and others, 1984, p. 37, unit Kmgf]

Intrusive rocks of Klukwan-Duke plutonic province (Early Cretaceous)--Province named by Brew and Morrell (1983) for northern and southern ends in southeastern Alaska. Himmelberg and Loney (1995) summarized petrology of rocks in this belt. A variety of K-Ar and other dates (Lanphere and Eberlein, 1966; Saleeby, 1991; Meen and others, 1991a, b) indicate that age of ultramafic rocks is about 110-125 Ma (late Early Cretaceous). As mapped, divided into:

Kku **Ultramafic rocks, mainly dunite, peridotite, clinopyroxenite, and hornblendite**--(Olivine-)(chromite-)peridotite, (chromite-)dunite, (magnetite-)clinopyroxenite, and (magnetite-)hornblendite. Composition apparently differs from locality to locality: (1) On Annette Island: occurs in concentrically zoned complex with dunite and pyroxenite core and hornblende gabbro margin; (2) On Percy, and Revillagigedo Islands: present, but no detailed studies available for those localities. (3) On Duke Island not far to east of map area unit: Present in concentrically zoned complex with dunite and peridotite core and clinopyroxenite and hornblendite margin. [General description adapted from Berg and others, 1988, p. 11, unit Kum; description for Annette Island from Karl, 1992, units Kdu, Kpx, and Khg; comprehensive description of Duke Island body in Irvine, 1974]

Kkdu **Dunite, pyroxenite, and peridotite at Union Bay**--(Magnetite-)hornblende pyroxenite, (magnetite-)pyroxenite, (magnetite-)olivine pyroxenite, peridotite, and dunite. Rock types present in concentrically zoned pipe and lopolith with dunite in central part and pyroxenite and hornblende pyroxenite at margin. [Description adapted from Eberlein and others, 1983, p. 7, unit Kum; comprehensive description in Ruckmick and Noble, 1959]

Kkgu **Gabbro and diorite at Union Bay**--Moderately foliated to massive, medium-grained, (magnetite-) biotite-)gabbro and hornblende. Forms partial margin and carapace of younger dunite, pyroxenite, and peridotite (Kkdu) unit. [Description adapted from Eberlein and others, 1983, p. 7, unit Kgb; comprehensive description in Ruckmick and Noble, 1959]

Sedimentary, volcanic, and related rocks of Gravina belt--Gravina belt named by Berg and others (1972) for Gravina Island, which is in this map area. Brew and Karl (1988a, b, c) summarized stratigraphic relations; Ford and Brew (1988) reviewed volcanic rock compositions. Composite units of Berg and others (1988) reinterpreted by D.A. Brew and A.B. Ford (unpublished data, 1988) to include separate Upper Jurassic and Lower Cretaceous and Middle and Upper Jurassic units. As mapped, divided into:

KJgg **Gravina Island Formation (Early Cretaceous and Late Jurassic)**--Sedimentary and minor volcanic rocks. Basal, locally derived, polymictic conglomerate and grit grade upward and laterally into slaty but otherwise unmetamorphosed, dark-gray, thin-bedded graywacke and minor limestone. Graywacke locally contains *Buchia* of Late Jurassic age. Unit named by Berg (1973, p. 27-28). Exposed on southwestern Gravina Island. [Description adapted from Berg and others, 1988, p. 11-12, part of unit KJgs]

Jgs **Sedimentary and minor volcanic rocks (Late and Middle Jurassic)**--Regionally metamorphosed and deformed greenschist-facies metaflysch and meta-andesitic tuff. Metaflysch consists of phyllitic graywacke, argillite, polymictic conglomerate, grit, and minor silty limestone. Unit locally contains poorly preserved pectinid clams and belemnoids of possible Middle or Late Jurassic age (Berg, 1973, p. 27-28). Unit named by Berg (1973, p. 28). Exposed on northeastern Gravina and northern Annette Islands. [Description adapted from Berg and others, 1988, p. 11-12, part of unit KJgs]

Jgv **Andesitic to basaltic volcanic and volcaniclastic rocks and minor sedimentary rocks (Late and Middle Jurassic)**--Locally massive, but generally foliated and schistose metabasaltic tuff and agglomerate and minor metaandesitic tuff and agglomerate; flows are rare; also contains minor grayish-green and black phyllite and phyllitic siltstone that intertongue with metavolcanic rocks. Exposed on northeastern Gravina and northern Annette Islands. [Description adapted from Berg and others, 1988, p. 11-12, part of unit KJgv]

Jgd **Altered diorite and quartz diorite (Late and Middle Jurassic)**--Massive to locally moderately foliated, hydrothermally altered, actinolite-epidote-chlorite-sericite-sphene-amphibole(?)-albite-quartz rock; present in elongate, zoned (from hypidiomorphic core to porphyritic margin) stock exposed on northern Annette Island. Relict minerals suggest that original composition was mostly pyroxene(?)-hornblende diorite. Field relations suggest that it grades into rocks of adjacent andesitic to basaltic volcanic and volcaniclastic rocks and minor sedimentary rocks (Jgv) unit. [Description adapted from Berg and others, 1988, p. 11, unit KJgd]

Hyd Group (Late Triassic)--Unit named by Loney (1964, p. 43) on Admiralty Island and extended by Gehrels and others (1987, p. 877) into the area. As mapped, divided into:

Ŧhc **Chapin Peak Formation**--Basaltic volcanic and minor sedimentary rocks. Mainly basaltic pillow flows, calcareous agglomerate and volcanic breccia, and aquagene tuff that intertongue with minor conglomerate, limestone, and calcareous detrital sedimentary rocks near base. Unit is 150- to 500-m thick. Limestone beds and limestone clasts in conglomerate contain a variety of well-preserved Late Triassic (late Norian) fossils (Berg, 1973, p. 24). Unit named by Berg (1973, p. 23-26). Exposed on western Gravina and northern Annette Islands. [Description adapted from Berg and others, 1988, p. 12, unit Ŧc]

TRhsv **Sedimentary and mafic volcanic rocks**--Unit consists of Nehenta Formation, a unit named by Berg (1973, p. 19-23) on Gravina Island, and correlative rocks on northwestern Annette Island. Unit is about 500-m thick. As described includes three members: (1) carbonaceous limestone and siltstone member that grades into limestone, limestone breccia, and calcareous conglomerate, grit, and sandstone; (2) coarse-grained, trondjhemite-clast-rich grit and conglomerate member; and (3) basaltic pillow flows, agglomerate, and aquagene tuff member. More metamorphosed and deformed on Annette Island than on Gravina. Age assignment is based on *Heterastridium* (late Norian) from upper part, and *Halobia* (of early and middle Norian age) from lower part of carbonaceous limestone and siltstone member, and on conodonts of latest Carnian and early Norian age from near base of unit on Annette Island (Savage and Gehrels, 1987). [Description adapted from Berg and others, 1988, p. 12-13, unit TRsv]

TRhl **Limestone and dolomite**--Massive to moderately thick bedded, dark-bluish-gray, very fine grained recrystallized limestone or marble. Unit is about 70 m thick. Age assignment is based on conodonts collected from unit to east of this map area (Berg, 1982, p. 5-7). Exposed on southern Gravina and northwestern Annette Islands. [Description adapted from Berg and others, 1988, p. 13, unit TRl]

TRhv **Felsic volcanic rocks**--Unit consists of Puppets Formation, a unit named by Berg (1973, p. 10-14) on Gravina Island, and correlative rocks on northwestern Annette Island. Unit is about 350 m thick. As described includes two main intertonguing members: (1) massive-appearing, thinly layered recrystallized rhyolite member, and (2) recrystallized rhyolitic to latitic tuff, and minor bedded tuffaceous limestone and calcareous tuff member. Second member occurs as discontinuous layers, generally near base of unit, that locally contain trondjhemite clasts. Age assignment based on stratigraphic relation to overlying fossiliferous unit and a U-Pb apparent age of 225±3 Ma on zircon from a sample on Gravina Island (Gehrels and others, 1987, p. 877). [Description adapted from Berg and others, 1988, p. 13, unit TRv]

Metamorphosed sedimentary, volcanic, and intrusive rocks (Mesozoic and (or) Paleozoic)--Relations of these unfossiliferous rocks to nearby unmetamorphosed paleontologically or otherwise-dated units are discussed by Berg and others (1988, p. 17-18). On this map, units are depicted more or less as shown by Berg and others (1988), however, Rubin and Saleeby (1991) presented a significantly different alternative interpretation. As mapped, divided into:

MzPzms **Metasedimentary rocks**--Metamorphosed pelitic and semipelitic flysch with minor interlayered basaltic and (or) andesitic volcanic or volcaniclastic rocks. Dominantly dark-gray phyllite and fine-grained semischist with minor green phyllite and semischist to southwest on Etolin and Revillagigedo Islands and Cleveland Peninsula, grades into schist and gneiss to north and east. Typical metamorphic minerals to southwest are quartz, feldspar, biotite, garnet, muscovite, hornblende or actinolite, calcite, and chlorite; typical metamorphic minerals to northeast are quartz, plagioclase, biotite, garnet, hornblende, and muscovite. Sillimanite and other minerals occur in an aureole adjacent to the large pluton (Krtf) in the northeastern part of the map area. Protoliths of this unit probably include Gravina belt rocks, other Mesozoic rocks, and nearby Paleozoic rocks. Lower grade metamorphism to the southwest is post-mid-Cretaceous and pre-95 Ma in age; that to northeast is about 95 Ma (Brew and others, 1989a, 1992b). [Description adapted from Berg and others, 1988, p. 18, unit MzPzms]

MzPzmv **Metavolcanic rocks**--Metamorphosed marine andesitic and basaltic lava flows, agglomerate, and tuff, together with minor pelitic and semipelitic flysch. Exposures to southwest are massive-appearing layers and lenses of coarse, blocky, dark-green breccia with conspicuous relict augite phenocrysts and light-green laminated and lineated semischist and phyllite. Common greenschist-facies metamorphic minerals there are albite, epidote, calcite, quartz, chlorite, actinolite, and sphene. Exposures to northeast are dark-green, greenish-gray, and gray phyllite, semischist, and schist, together with minor marble. Common greenschist-facies metamorphic minerals there are albite, epidote, quartz, chlorite, blue-green hornblende and actinolite, and sphene. Exposures farthest north in map area are dark-green and dark-gray amphibolitic and quartzofeldspathic schist and gneiss with minor marble and pelitic schist. Common amphibolite-facies metamorphic minerals there are hornblende, biotite, quartz, plagioclase, and sphene. Protoliths of this unit probably include Gravina belt rocks, other Mesozoic rocks, and nearby Paleozoic rocks. Lower grade metamorphism to southwest is post-mid-Cretaceous and pre-95 Ma in age; that to northeast is about 95 Ma (Brew and others, 1989a, 1992b). Exposed on Cleveland Peninsula and Onslow and Revillagigedo Islands. [Description adapted from Berg and others, 1988, p. 18-19, unit MzPzmv]

MzPzmc **Metapolymictic conglomerate**--Spheroidal to ellipsoidal clasts to 25 cm maximum dimension of fine- to coarse-grained leucocratic (trondjhemitic?) plutonic rocks, phyllite, quartzite, marble, pelitic schist, and semischist in matrix of fine-grained schist consisting of quartz, plagioclase, biotite, epidote-clinozoisite, garnet, calcite, muscovite, and pyrite. Generally in lenses less than 1-m thick. Exposed at Helm Bay, on Back Island, and at one locality north of Ketchikan on Revillagigedo Island. [Description adapted from Berg and others, 1988, p. 19-20, unit MzPzmc]

MzPzmi **Metaintrusive rocks**--Regionally metamorphosed, recrystallized, or altered diorite, quartz diorite, and gabbro. Ages of protoliths and of metamorphism(s) are uncertain. Exposed on Cleveland Peninsula and Revillagigedo Island. [Description adapted from Berg and others, 1988, p. 20, unit MzPzmi]

Pp **Pybus(?) Formation (Early Permian)**--Light-brown weathering, massive to laminated, light- dark-, and bluish-gray marble, together with minor phyllite, semischist, metapolymictic conglomerate or sedimentary breccia, and quartzite-or-felsic-volcanic-rock fragmental schist and semischist. Age assignment is based on conodonts and brachiopds of late Early Permian (Leonardian) age. Unit named Pybus Dolomite by Loney (1964, p. 36) and redefined as Pybus Formation by Muffler (1967, p. C25). Unit questionably extended geographically into this area of this report to include age- and lithologically-equivalent rocks. [Description adapted from Berg and others, 1988, p. 20-21, unit Pm]

Karheen Formation and associated rocks (Middle? and Early Devonian)--Karheen Formation was named by Eberlein and Churkin (1970a, p. 22) on Prince of Wales Island and was extended geographically by Gehrels and others (1987, p. 876-877) to age-equivalent rocks in vicinity of Hotspur Island. "Dkk" symbol indicates Karheen Formation rocks; "Dk" symbol indicates the associated rocks. As mapped, divided into:

Dka **Andesitic flows and breccia (Middle? Devonian)**--Slightly deformed and metamorphosed andesitic pillow flows, tuff, tuff breccia, massive flows, hypabyssal intrusive rocks, and minor clastic beds. Unit is at least 800 m thick. Exposed on Hotspur Island. [Description adapted from Berg and others, 1988, p. 13-14, part of unit Dsv; Gehrels and others, 1987, p. 875-877, upper part of Early Devonian Karheen Formation and associated volcanic rocks unit]

Dkkm **Mudstone-and-siltstone-facies rocks (Middle? and Early Devonian)**--Slightly deformed and metamorphosed interbedded gray mudstone and siltstone, crossbedded and channeled brownish-gray sandstone, gray tuffaceous mudstone, massive to thinly bedded limestone and marble, and olistostromal rocks consisting of meter-size olistoliths of intraformational limestone, siltstone, and sandstone in a matrix of chaotically deformed mudstone, siltstone, and sandstone. Unit is about 1,000 m thick. Megafossils (Berg, 1972) and conodonts (Savage and Gehrels, 1987) indicate an Early Devonian and early Middle(?) Devonian age. Exposed on Hotspur Island. [Description adapted from Berg and others, 1988, p. 13-14, part of unit Dsv; Gehrels and others, 1987, p.875-877, Karheen Formation]

Stj **Trondhjemite, diorite, and granite of Annette Island (Late Silurian)**--Medium- to coarse-grained, light-gray, generally leucocratic (chlorite-)(biotite-)(hornblende) trondhjemite, quartz diorite, diorite, granite, quartz monzonite, and granodiorite. Pb-U (zircon) ages of 409±30, 410±5, and 415±5 Ma are reported by Gehrels and others (1987, p. 873) from this unit in this general area. Exposed on Annette Island and on southern and western Gravina Islands. [Description adapted from Berg and others, 1988, p. 14, unit St; Gehrels and others, 1987, p. 873, trondhjemite to granite unit]

Intrusive rocks of younger part of Cape Chacon plutonic province (Early Silurian and Late Ordovician)--Consists of:

SOdi **Diorite, quartz diorite, gabbro, hornblendite, leucogabbro, trondhjemite, pyroxenite, and migmatite**--Locally heterogeneous, locally homogeneous; variably deformed and metamorphosed; locally foliated and layered. Biotite, hornblende, chlorite, quartz, plagioclase, and K-feldspar are dominant primary minerals; secondary minerals are epidote, white mica and calcite. Pb-U (zircon) ages of 429±20 and 426±15 Ma are reported by Gehrels and others (1987, p. 872) from this unit in this general area. Exposed on Annette and Gravina Islands. [Description adapted from Berg and others, 1988, p. 14-15, units SOu and SOui; Gehrels and others, 1987, p. 871-872, "Ordovician-Early Silurian" diorite unit]

Metamorphosed rocks on Cleveland Peninsula (Silurian and (or) Ordovician)--Contacts for units shown on map are based on Berg and others (1976) and on unpublished mapping and interpretation by D.A. Brew, A.B. Ford, and S.M. Karl (1987). Age assignment is based on zircon Pb-U age of cross-cutting dike (Rubin and Saleeby, 1987). As mapped, divided into:

SOms **Metasedimentary rocks**--Metamorphosed mudstone, siltstone, sandstone, grit, conglomerate, and minor limestone. Generally phyllite to southwest and schist to northeast; hornfelsed adjacent to plutons. May include some rocks that should be assigned to unit MzPzms. [Description adapted from Eberlein and others, 1983, p. 5-6, part of metasedimentary rocks (MzPzms) unit; Berg and others, 1988, p. 14, part of unit SOu; p. 18, and part of metasedimentary rocks (MzPzms) unit; Rubin and Saleeby, 1991, fig. 2, includes parts of their "Ordovician-Silurian tonalite, diorite, & gabbro" unit (which is like unit SOdi of this map) and of their "Ordovician-Silurian basaltic andesite, tuff, breccia, pillowed flows and hypabyssal rocks" unit]

SOmv **Metavolcanic rocks**--Metamorphosed andesitic and basaltic metatuff and agglomerate with minor pelitic rocks and limestone. Relict euhedral augite(?) phenocrysts and coarse- to fine-grained fragmental textures preserved locally. Now green phyllite to semischist with greenschist-facies minerals albite, epidote, chlorite, actinolite, quartz, muscovite, biotite, and calcite. [Description adapted from Eberlein and others, 1983, p. 5-6, part of andesitic and basaltic metatuff and agglomerate (MzPzvm) unit; Rubin and Saleeby, 1991, fig. 2, includes parts of their "Ordovician-Silurian tonalite, diorite, & gabbro" unit (which is like unit SOdi of this map) and of their "Ordovician-Silurian basaltic andesite, tuff, breccia, pillowed flows & hypabyssal rocks" unit]

SOmc **Metacarbonate rocks**--Metamorphosed limestone; now fine-grained gray marble; exposed near Caamano Point. [Description from Brew and others, unpublished mapping; Berg and others, 1988, p. 14, subunit "m" of unit MzPzu]

Descon Formation (Early Silurian to Early Ordovician)--Unit named by Eberlein and Churkin (1970a, p. 5) on Prince of Wales Island and geographically extended by Gehrels and others (1987, p. 869-871) across Clarence Strait to east. As mapped, divided into:

SOdr **Dacitic to rhyolitic volcanic rocks**--Moderately deformed and metamorphosed dacitic to rhyolitic tuff and tuff-breccia with well preserved pyroclastic fragments and tuffaceous lamination and layering; some interbedded basaltic to andesitic pillow flows and tuff-breccia. Generally similar to dacitic to rhyolitic volcanic rocks unit described southwest of Clarence Strait. Exposed on western Annette and southern Gravina Islands. [Description adapted from Berg and others, 1988, p. 14, part of unit SOu; Gehrels and others, 1987, p. 869-871, Dacitic to rhyolitic volcanic rocks of Descon Formation]

SOdb **Basaltic to andesitic volcanic rocks**--Basaltic to andesitic pillow flows, tuff, and tuff breccia with interbedded black argillite and mudstone; exposed on western and northern Annette Island. [Description adapted from Gehrels and others, 1987, p. 869-871, Basaltic to andesitic volcanic rocks of Descon Formation]

Ꞓmgl **Metamorphic rocks on southern Gravina Island (Late and Middle Cambrian)**--Foliated, slightly layered, metamorphosed diorite, microdiorite, quartz diorite, gabbro, microgabbro, and hornblendite. U-Pb (zircon) apparent age of a sample from Bronough Islands (off south tip of Gravina Island) is in range 540 to 510 Ma (Gehrels and others, 1987, p. 868-869). Correlates with unit to west and east of entrance to Cholmondeley Sound on southeastern Prince of Wales Island. Exposed on southern tip of Gravina Island. [Description adapted from Gehrels and others, 1987, p. 867, 869, Cambrian metaplutonic rocks unit]

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INDEX TO MAP UNITS, BY NAME

[An index to map units, by symbol, is part of the "Brief Description of Map Units" section on the map sheet]

Hornblende gabbro, microgabbro, and quartz diorite (INTRUSIVE ROCKS OF SOUTHERN DALL ISLAND PLUTONIC PROVINCE)	Ꞓgb	22
Hornblendite (INTRUSIVE AND RELATED ROCKS OF YOUNGER PART OF CAPE CHACON PLUTONIC PROVINCE)	SOhb	20
Hornblende granodiorite and diorite and biotite-hornblende monzodiorite (INTRUSIVE ROCKS OF CHILKAT-PRINCE OF WALES PLUTONIC PROVINCE)	Kwgd	12
Hornblende quartz diorite, diorite, and quartz monzonite (INTRUSIVE AND RELATED ROCKS OF OLDER PART OF CAPE CHACON PLUTONIC PROVINCE)	Oqd	21
Hornblende quartz monzodiorite with minor tonalite, granodiorite, quartz diorite, diorite, quartz monzonite, and monzodiorite (INTRUSIVE ROCKS OF CHILKAT-PRINCE OF WALES PLUTONIC PROVINCE)	Kwqo	12
Hornfelsed sedimentary rocks (INTRUSIVE AND RELATED ROCKS OF KUIU-ETOLIN VOLCANIC-PLUTONIC PROVINCE)	Tsh	23
Hornfelsed volcanic rocks (INTRUSIVE GRANITIC AND RELATED ROCKS OF KUIU-ETOLIN VOLCANIC-PLUTONIC PROVINCE)	Tvh	23
KLAWAK FORMATION	IPk	13
KOOTZNAHOO FORMATION	Tk	11, 24
LADRONES LIMESTONE	IPl	13
LEUCODIORITE AT KASSA INLET	Sld	17
Leucogabbro near Ketchikan (INTRUSIVE AND RELATED ROCKS OF KUIU-ETOLIN VOLCANIC-PLUTONIC PROVINCE)	Tlgb	23
LEUCOSYENITE OF KLAWOCK AND SUKKWAN	PIPsy	13
Limestone and dolomite (HYD GROUP)	TRhl	27
Limestone, minor limestone breccia, sandstone, mudstone, and polymictic conglomerate (HECETA LIMESTONE)	Shl	17
Limestone of Kasaan Island (KARHEEN FORMATION, ETC.)	Dkl	14
Marble and minor calcsilicate rocks in Wales Group (WALES GROUP)	ꞒZwm	23

Volcaniclastic graywacke, siltstone, and mudstone turbidites, minor sedimentary breccia, limestone, and polymictic conglomerate (DESCON FORMATION)	SOdg	20
WADLEIGH LIMESTONE	Dw	14

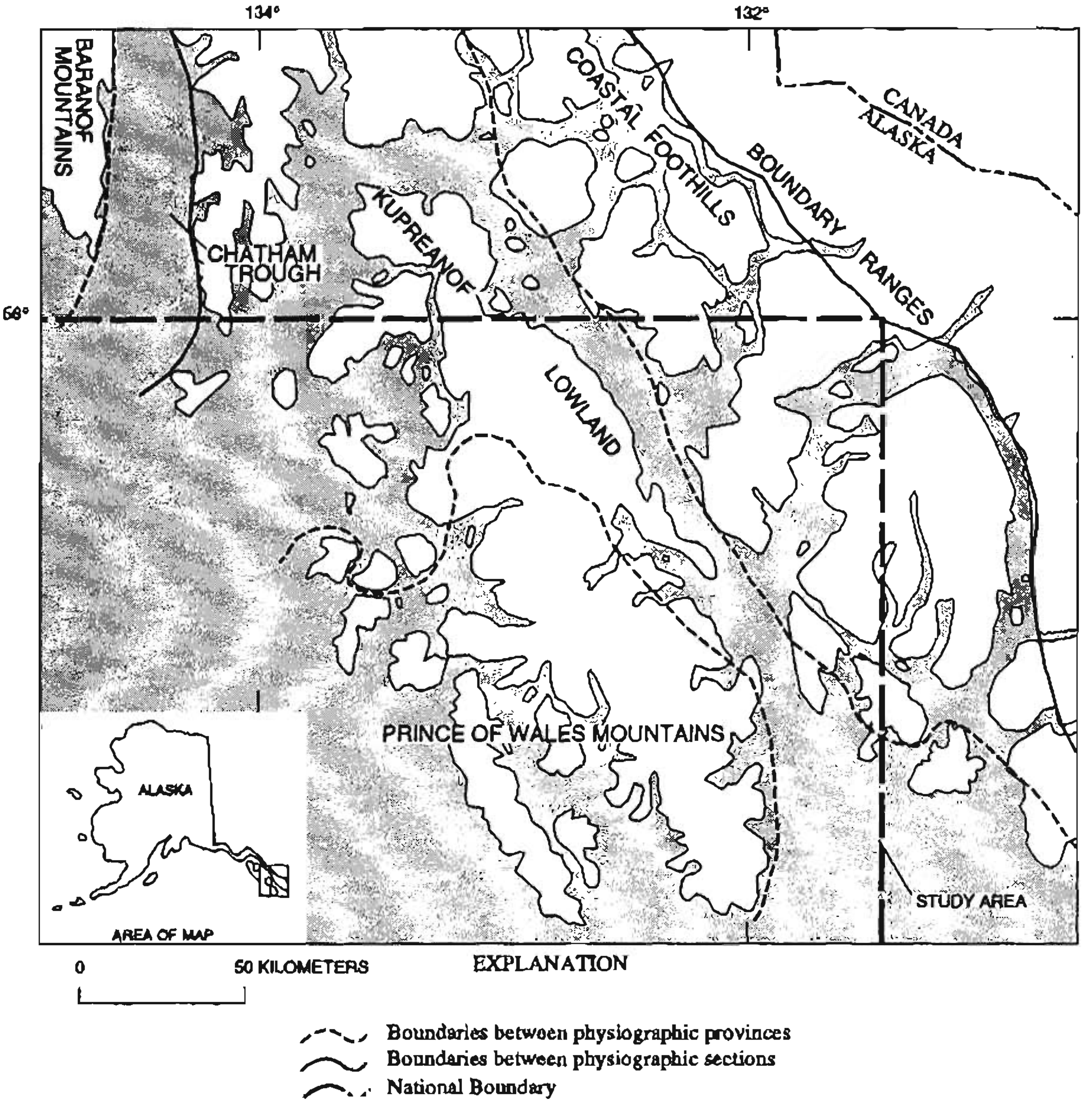
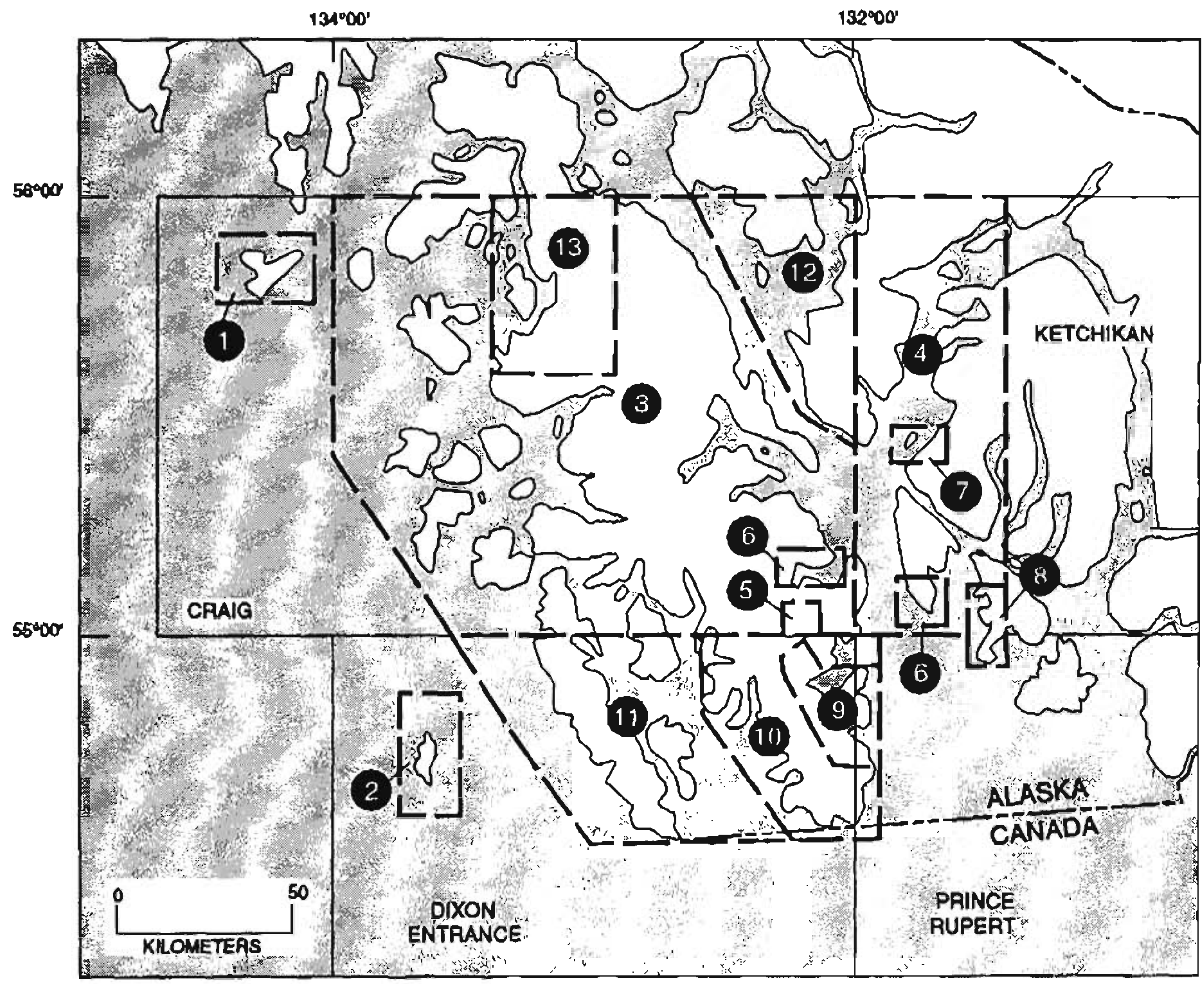


Figure 1. Index map showing location of study area and physiographic provinces and sections (from Wahrhaftig, 1965).



EXPLANATION

1. George Moerlein (written commun. to G.D. Eberlein, 1981)
2. Clark and others (1971)
3. Eberlein and others (1983)
4. Berg and others (1988)
5. Redman (1982)
6. Gehrels and others (1987)
7. Sullivan (1991)
8. Horton and others (1992) and Karl (1992)
9. MacKevett (1963)
10. Gehrels and Saleeby (1986) and Gehrels (1992)
11. Gehrels (1991)
12. Berg and others (1976)
13. J.F. Baichtal (written comm., 1995, selected units shown)

Figure 2. Sources of geologic information, 1983-1995.

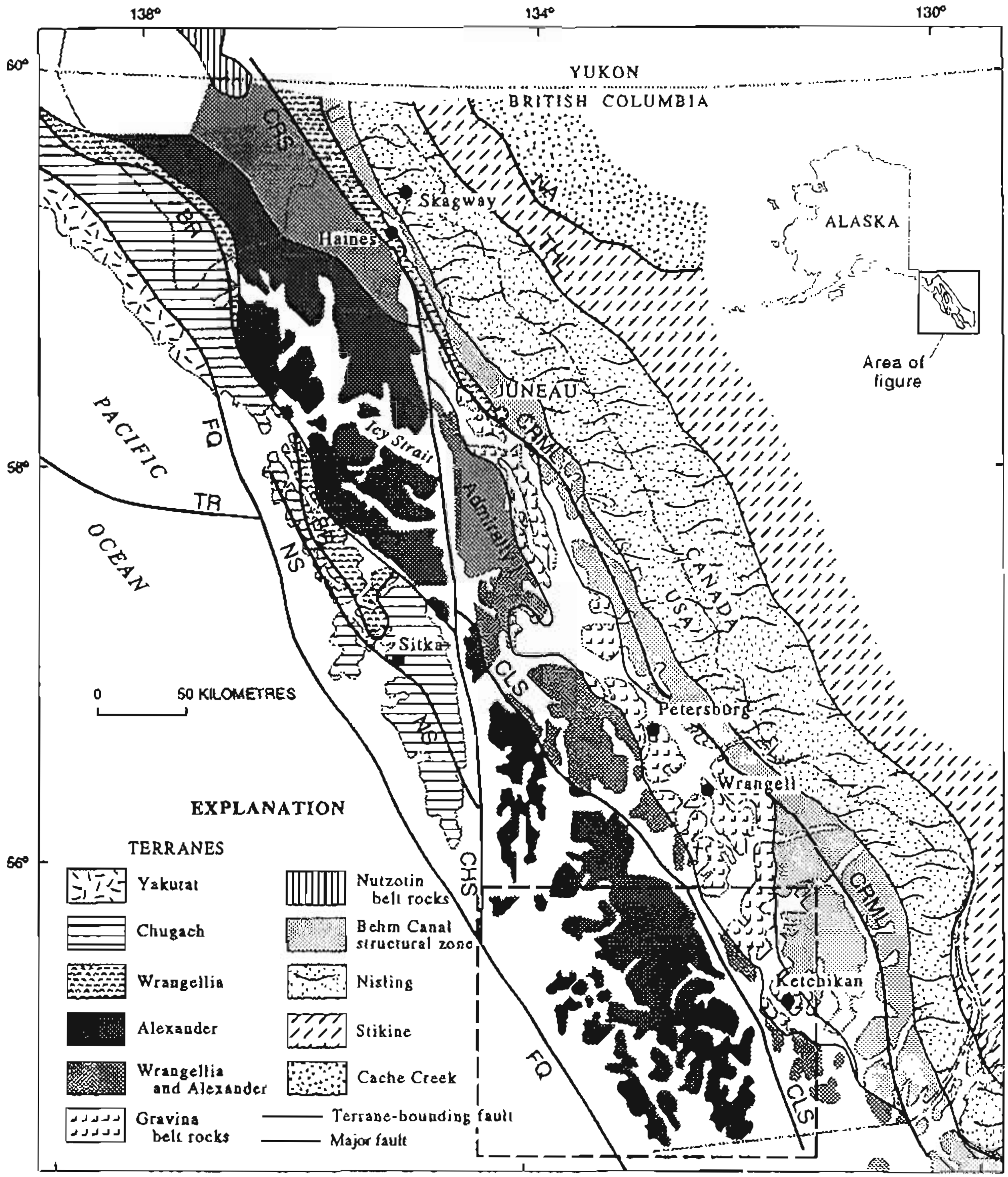


Figure 3. Lithotectonic terrane and major fault map of southeastern Alaska and adjacent regions. Dashed line is boundary of the Craig, Dixon Entrance, and parts of the Ketchikan and Prince Rupert quadrangles map area (after Brew and others, 1991a, b, 1992a). Major faults are labeled as follows: BR, Border Ranges; CHS, Chatham Strait; CLS, Clarence Strait; CRML, Coast Range megalineament; FQ, Fairweather-Queen Charlotte; NA, Nahlin; NS, Neva Strait; THL, Tally Ho-Llewellyn; and TR, Transitional.