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PRELIMARY GEOLOGIC MAP OF NORTHEAST CHICHAGOF ISLAND, ALASKA

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Introduction

The geology of northeastern Chichagof Island was initially mapped in part by Lathram and others (1959), and in part by Loney and others (1963), whose work was incorporated in a more comprehensive professional paper by Loney and others (1975). This report revises and updates previous mapping and stratigraphy on northeastern Chichagof Island, utilizing new fossil data and new geologic mapping. The purpose of the new work is to provide a foundation for mineral assessment studies of the Tongass National Forest by the U.S. Geological Survey, and a foundation for ecological studies of northeastern Chichagof Island conducted in a cooperative effort led by the U.S. Forest Service, with the Alaska Department of Fish and game, and the U.S. Geological Survey.

Geologic Framework

In the middle Mesozoic, southeastern Alaska was involved in oblique subduction of the Pacific plate beneath North America; in the early Cenozoic, this segment of the plate boundary evolved to a dominantly transform boundary. On Chichagof Island, at the western margin of southeastern Alaska, this tectonic history is represented by a complicated pattern of thrust faults, oblique slip faults, and strike-slip faults. The major faults have been used to carve southeastern Alaska into geologic entities called tectonostratigraphic terranes (fig. 1) (Berg and others, 1972, 1978.) These terranes are defined as unique stratigraphic sequences of similar age that are juxtaposed by faults.

The rocks on Chichagof Island have been assigned to three different terranes: the Alexander terrane, Wrangellia, and the Chugach terrane (figs. 1, 2). These terranes extend from southeastern Alaska to central Alaska along the south and west, or oceanward, side of the Denali fault system, a fundamental structure in Alaska . Oceanward of the Denali fault system are mainly accreted oceanic and island arc terranes; to the north and east of the fault are mainly displaced fragments of North America. Paleomagnetic, structural and stratigraphic data indicate the Alexander, Wrangellia and Chugach terranes have moved northward relative to their original sites of deposition and northward relative to North America (Berg and others, 1978, Hillhouse and Gromme, 1984; Monger and Berg, 1987; Gardner and others, 1988).

The study area on northeastern Chichagof Island lies entirely within the Alexander terrane. The Alexander terrane consists of Precambrian to Middle Jurassic sedimentary, volcanic, and plutonic rocks interpreted to represent intermittent volcanic arc activity on a fragment of crust that is thicker than ocean crust but thinner than typical continental crust (Dehler and Clowes, 1992). The Alexander terrane is inferred, based on bimodal basalt-rhyolite volcanism, shallow marine shelf deposits, and Rb-Sr isotopic analyses (Armstrong, 1985), in the Cambrian and older Wales Group on Prince of Wales Island, to have continental origins (Eberlein and others, 1983; Gehrels and Saleeby, 1987a; 1987b; Karl, 1993). Paleomagnetic data indicate it was translated northward and it ultimately was accreted to North America in the mid-Cretaceous (Plafker and others, 1989). On northeastern Chichagof Island, the oldest exposed rocks of known age are Silurian (fig. 3). In the study area, a faulted but relatively undisturbed section of Silurian to Mississippian rocks is exposed; younger stratigraphic rock units are absent. The Paleozoic rocks are intruded by Paleozoic and Mesozoic plutons and overlain by Quaternary alluvial and glacial deposits.

Paleozoic Stratigraphy

The Paleozoic rocks in the map area include metasedimentary rocks, metavolcanic rocks, and marble of the Pzh and Pzm units, Silurian volcaniclastic rocks with minor limestone, Silurian to Devonian reefal limestone, gradational facies of Devonian carbonate, volcanic, and volcaniclastic rocks, and fossiliferous Mississippian limestone, shale, and cherty limestone. The protoliths of the Pzh and Pzm are inferred to include Silurian and Devonian sedimentary and volcanic rocks. The units on Chichagof Island consist of less volcanic and more clastic rocks in the Silurian, and more volcanic and less clastic rocks in the Devonian, than elsewhere in the Alexander terrane.

Silurian rocks

The Silurian Point Augusta Formation represents the oldest rocks of known age exposed on eastern Chichagof Island. Paleozoic schist and gneiss along the northeast shore of Tenakee Inlet may include protoliths stratigraphically equivalent to, or older than, the Point Augusta Formation. The Point Augusta Formation consists of conglomerate, massive to medium bedded calcareous graywacke turbidites with associated debris flow deposits, and interbedded limestone (Karl and Giffen, 1992). The turbidites represent mid- to inner fan facies in the classification of Mutti and Ricchi-Lucci (1972), which is interpreted to represent a depositional environment proximal to its volcanic arc source. Eberlein and others (1983) envisioned the depositional environment for Silurian rocks of the Alexander terrane as a marine volcanic arc characterized by volcanic centers with fringing limestone reefs. There are no Silurian volcanic strata exposed on Chichagof Island, but there are abundant volcanic clasts in the Point Augusta Formation, and in Silurian and Devonian Kennel Creek conglomerates that overlie the Point Augusta Formation. There is a limestone facies within the Point Augusta Formation in addition to the thick-bedded to massive Silurian and Devonian Kennel Creek Limestone, which represents reef facies deposition adjacent to, and overlying, the Point Augusta Formation. No fossils have been identified from the limestones of the Point Augusta Formation, but graptolites are reported from turbidites in this unit on the Chilkat Peninsula. In the map area, the Point Augusta Formation is intruded by Silurian and younger syenitic plutons (Ford and others, 1990), that are probably related to the sources of the syenitic clasts in the Silurian and Devonian conglomerates.

Devonian rocks

Overlying the Silurian clastic rocks are Devonian polymictic conglomerates and thick sections of bedded Devonian limestone and dolostone. On northeastern Chichagof Island this succession is represented by the locally fossiliferous, reefal Kennel Creek limestone and conglomerate, by argillite, fossiliferous limestone, volcanic wacke, and minor conglomerate of the Cedar Cove Formation, and by the extensive volcanic flow and volcaniclastic deposits and minor limestone of the Freshwater Bay Formation. Sedimentary structures and rapid facies changes in all of these units indicate a shallow marine depositional environment.

Mississippian rocks

Unconformably overlying the Devonian rocks on Chichagof Island is the fossiliferous limestone of the Mississippian Iyoukeen Formation. This dark gray, thin-bedded, fine-grained limestone contains interbedded chert. The middle part of this unit contains increasing amounts of shale, indicating a change toward a deeper water depositional environment in the Late Mississippian. The upper part of the unit is characterized by medium bedded fossiliferous gray limestone with chert nodules. Gypsum is commonly found at the top of the unit. The upper contact of the Iyoukeen Formation appears to be an erosional surface. No Permian, Mesozoic, or Tertiary strata are known from eastern Chichagof Island.

Paleozoic and Mesozoic plutons

There are three main periods of intrusive activity represented by granitic rocks in the map area. One is Paleozoic, and two are Mesozoic. The oldest intrusive rocks consist of hornblende syenite, and are exposed on an island south of the village of Tenakee. A sample from this island yielded a K-Ar radiometric age of 417 Ma (recalculated with modern constants from a reported age of 406 Ma in Lanphere and others, 1965). A biotite syenite intrudes sandstone and shale of the Point Augusta Formation, Kennel Creek Limestone, and porphyritic andesite of the Freshwater Bay Formation. This syenite looks similar to the Silurian syenite, and may represent part of the same alkalic intrusive episode.

The Late Jurassic Kennel Creek pluton consists of adamellite, granodiorite, and alaskite with associated diorite, forming a horseshoe-shaped body intruding Silurian and Devonian conglomerate, turbidites, and limestone that occupy the Kennel Creek drainage. It yielded a K-Ar radiometric age of 147 Ma (recalculated with modern constants from a 144 Ma age reported by Loney and others, 1967).

Cretaceous granodiorite, adamellite, quartz diorite and diorite intrude the Paleozoic rocks throughout the map area. Granodiorite exposed in the Tenakee school yard yielded a $^{40}Ar/^{39}Ar$ radiometric age of 108.5 Ma, which correlates with a K-Ar age of 110 Ma for quartz diorite nearby to the south on Catherine Island (Loney and others, 1975). The Cretaceous plutons contain more mafic minerals, including magnetite, than the Kennel Creek pluton, and on this basis most of the undated bodies in the map area have been lithologically correlated with the Catherine Island pluton (Loney and others, 1975.)

Quaternary deposits

Quaternary deposits consist of undifferentiated alluvium, including fluvial deposits, landslide slump deposits, beach and terrace deposits, and glacial deposits. The Quaternary geology of northeastern Chichagof Island has not been studied in detail, but conforms to the regional interpretation of Mann and Hamilton (1995). The Last Glacial Maximum (LGM) occurred between 24,000 and 14,000 years before present (BP) in a time transgressive fashion from southwestern Alaska to southeastern Alaska and British Columbia (Mann and Hamilton, 1995). Maximum ice cover in southeastern Alaska was attained about 20,000 years BP. During the LGM, glaciers covered most of the continental shelf, which would include Chichagof Island, and no tree species survived (Mann and Hamilton, 1995.) So much water was tied up by ice on the earth's surface that global sea level dropped by about 120 meters. Both deep sea records and Alaskan glacial records indicate full glacial conditions lasted until about 15,000 years BP (Mann and Hamilton, 1995), after which a climatic warming caused the ice to rapidly recede, causing a worldwide rise in sea level. A small distance north of Chichagof Island on the Chilkat Peninsula there are 3 raised marine terraces which represent maximum flooding of sea level at about 10,000 years BP (Mann and Hamilton,1995). Sea level rose as much as 230 meters along the isostatically depressed coast of southeastern Alaska (Miller, 1975). Isostatic rebound was complete, and modern sea level was achieved by about 9000 years BP. During the glacial retreat, by approximately 12,500 years BP, lodgepole pine and alder reached the northern archipelago; but a climatic reversal restored the area to herb-tundra vegetation between 10,000 and 9,800 years BP (Engstrom and others, 1990). Sometime after this, Sitka spruce arrived, followed by western hemlock, and then mountain hemlock. By 5,000 years BP, red cedar extended into southeastern Alaska, and by 4,000 years BP all modern species had arrived (Peteet, 1986; Heusser, 1985; Cwynar,1990). There were subsequent minor glacial advances around 2,700, 850, and 250 years BP, with intervening glacial retreats.

Structural geology

The rocks on northeastern Chichagof Island are generally characterized by broad open folds plunging shallowly southeastward, and overturned folds south of Freshwater Bay indicated by inverted bedding. The Mesozoic plutons intrude structures in the rocks and tend to be located in the axes of the major folds, suggesting that intrusion was during or after deformation.

Northwest and north-northwest trending faults of the Tenakee fault system, defined by Loney and others, (1975), postdate the folding and intrusive events. These faults in the map area are mostly right lateral with up to a few km of displacement. Some of the major faults have associated uplift of the southwest side relative to the northeast side, indicated by increasing metamorphic grade and deeper levels of pluton exposure toward the southwest across the northeastern Chichagof region (Loney and others, 1975). These right lateral, northwest-trending faults are inferred to be related to the major right lateral Fairweather and Chatham fault systems that bound the west and east sides, respectively, of Chichagof Island. The Fairweather and Chatham Strait faults were active during the Tertiary (Loney and others, 1975; Hudson and others, 1982; Plafker and others, 1989).

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Lithostratigraphic Units

Qu Unconsolidated sedimentary deposits (Quaternary): alluvium, colluvium, and glacial deposits. In the map area, glacial deposits are overlain by colluvium or by a thin organic soil. The glacial deposits are typically 1 to 4 meters thick, and consist of buff to gray sandy till with rounded and striated matrix-supported pebbles to boulders, or of blue-gray indurated clay with rounded and striated pebbles to boulders. Glacial till has been observed up to 1100 feet elevation and is interpreted to represent morainal deposits. The blue-gray diamicton has been found to contain marine organisms (Tom Hamilton, personal communication, June, 1995) and has been identified in the map area up to 800 feet elevation. The blue-gray diamicton is interpreted to represent glaciomarine deposits. Only locally derived clasts were observed within the glacial deposits. Boulders "exotic" to Chichagof Island have only been recognized on beaches of major waterways such as Chatham Strait and Frederick Sound. The glacial deposits are locally overlain by 1 to 2 centimeters of peat, but generally overlain by colluvium up to 5 meters thick. The colluvium is buff to brown or reddish brown and consists of clayey to sandy silt with matrix-supported, unsorted angular clasts. At lower elevations the colluvium contains reworked glacial material. In some places the colluvium contains thin, millimeter- to centimeter-scale lenses of dark peat. No ash layers were observed in the colluvial deposits in this map area, although they are commonly observed in colluvial deposits on northern Baranof Island. The valley walls are steep and colluvial deposits are thin to absent at higher elevations, forming wedge-shaped deposits that may be several meters thick below 1000 feet elevation. They are sandy and poorly consolidated and slide easily. Poorly developed, highly organic soil, typically one half to one meter thick, overlies the colluvial deposits, and in some places directly overlies glacial deposits. Streams cut v-notches into the wedge-shaped colluvial and glacial deposits along the valley walls. Alluvial deposits on the broad, poorly drained, u-shaped glacial valley floors consist of reworked glacial and colluvial material. These alluvial deposits are underlain by glacial deposits.

Qls Unconsolidated landslide deposits (Quaternary): Landslide deposits, consisting of unsorted, matrix and clast supported debris flows, including rock slides and mudslides. There is a prominent rock slide on the ridge south of Kennel Creek.

Mi Iyoukeen Formation (Mississippian): Thick sequence of gray fossiliferous limestone and shale. The unit was named by Loney and others (1963) and is exposed in a syncline whose axis lies along a trend from Elephant Mountain to Gypsum Creek. The unit's basal contact is unconformable on the Freshwater Bay Formation. The lower member of the Iyoukeen Formation has an average thickness of 130 meters and is composed of dark gray, thin-bedded, fine-grained limestone with thin dark gray chert interbeds and lenses. The limestone contains corals, brachiopods, gastropods, and conodonts. The middle member has an average thickness of 200 meters, and consists of dark gray, calcareous to noncalcareous, sparsely fossiliferous shale that grades northwestward into dark gray, yellow weathering shaley limestone. The upper limestone member, estimated to be as much as 1000 meters thick, is characterized by dark gray, medium-bedded, fossiliferous limestone with dark gray, nodular chert lenses. Gypsum is commonly found at the top of the upper limestone member. The upper contact is an erosional surface cut in the upper limestone member. The upward-diminishing proportion of shale and thickening limestone beds suggest the depositional environment was getting shallower with time. Fossil species present indicate warm, shallow water and a high energy environment (Anita Harris, U.S. Geological Survey, written communication, January, 1995). There are no overlying rock units in the map area.

Age and correlation: Corals, brachiopods and gastropods, suggest an Early Mississippian age for the lower (map fossil locality numbers 10, 14, 16) and middle members (locality 19) of the Iyoukeen Formation and a Late Mississippian age for the upper member (map fossil localities 7, 12, 13, 18, 20, 26-28). The oldest fossils identified are from locality 10, and include conodonts of Kinderhookian, or early Early Mississippian age, and the youngest fossils recorded from this unit are conodonts of late Chesterian, or Latest Mississippian age, from locality 28 (see table 1). The Iyoukeen Formation correlates with part of the Saginaw Bay Formation of Kuiu Island (Muffler, 1967) and with Mississippian limestones of the Peratrovich Formation along the west side of Prince of Wales Island (Eberlein and Churkin, 1970; Loney and others, 1975).

Df Freshwater Bay Formation (Devonian): Green and red andesite and basalt flows, breccia, and tuff, pyroclastic rhyolite deposits, minor amounts of interbedded conglomeratic volcanic graywacke, grayish-black argillite, and dark-gray limestone. The unit was named by Loney and others (1963). In the immediate vicinity of Freshwater Bay, the unit consists of a discontinuous lower dark gray greenstone member with a maximum thickness of 1000 meters, a middle light-colored, pyroclastic rhyolite member up to 500 m thick in some places, and an upper variegated dark gray, green, and purple andesite member as much as 1000 m thick. At the head of Freshwater Bay, the greenstone member consists of massive mafic flows commonly altered to a mineral assemblage of sericite, albite, epidote, chlorite, calcite, and iron oxides. A relict porphyritic texture is represented by sericitized and albitized plagioclase phenocrysts and rare mafic, mainly amphibole, phenocrysts. Chemistry of unaltered samples of basalt indicates compositions transitional between tholeiitic and alkaline within-plate basalts, enriched in incompatible, large high-valency cations like Nb, Ta, and Zr (Karl, unpublished data). The rhyolite member consists of mainly pyroclastic deposits that contain fragments of rhyolite, microcrystalline quartz, monocrystalline quartz, albite-oligoclase, k-feldspar, and baked argillite. The unit also includes silicic agglomerate with a devitrified glassy matrix, andesitic tuff breccia, and volcanic wacke. The rhyolite member is ubiquitously intruded by mafic dikes. The andesite member includes basal lenses of coarse, poorly sorted, matrix supported conglomerate and volcanic breccia that are interpreted to represent debris flows. This upper member also includes andesite flows, tuff, breccia conglomerate, graywacke, argillite, and limestone. The andesitic flows are commonly plagioclase porphyritic with sparse mafic phenocrysts, typically altered to chloritized euhedral clinopyroxene and sericitized zoned plagioclase. Some flow rocks have relict amygdules filled with calcite and chlorite. Northeast of Freshwater Bay, the formation consists of massive, dark gray porphyritic andesite flows with minor amounts of flow breccia. Graywacke, argillite, and limestone occur locally. The graywacke contains coarse angular grains of volcanic rock fragments, feldspar microlites, chloritic chert, and siltstone. Graywacke is medium- to thick-bedded, limestone is thin- to medium-bedded. Toward Wukuklook Creek, the upper member contains a relatively high proportion of conglomerate, in contrast to a higher proportion of limestone toward Hoonah. The Freshwater Bay Formation unconformably overlies the Cedar Cove Formation, Kennel Creek Limestone, and Point Augusta Formation, and unconformably underlies the Mississippian Iyoukeen Formation. The total thickness of the unit is estimated to be as much as 2000 meters. Rapid facies changes within the Freshwater Bay Formation indicate shallow water deposition; welded tuffs indicate local subaerial deposition.

Age and correlation: Fossil assemblages collected from sandstone interbeds at Port Frederick contain brachiopods (including Cyrtospirifer), mollusks, and corals, (map fossil locality 1), yielding a Late Devonian (late Frasnian) age for the upper member of the Freshwater Bay Formation (Loney and others, 1963; 1975). Another locality from near the top of the upper member, map locality 15, yielded Famennian (late Late Devonian) conodonts (table 1) (collection of David A. Brew, U.S. Geological Survey, age provided by written communication from Anita Harris, U.S. Geological Survey.) The rocks are similar to basalt and andesite flows, agglomerates, and tuff of Devonian age in the north central Chilkat Range (Lathram and others, 1959; Loney and others, 1975).

Dc Cedar Cove Formation (Devonian): Unit consists of a lower member of mixed argillite, tuff, limestone, and graywacke, and an upper dominantly limestone member. The unit was named by Loney and others (1963) for exposures along the southwest shore of Freshwater Bay. The type section extends from the southwest shore of Cedar Cove to a point 3 miles to the west. The base of the unit is not exposed on the shores of Freshwater Bay, but is considered to be gradational to the underlying Kennel Creek Limestone, and is placed at the lowest occurrence of interbedded limestone and graywacke by Loney and others (1963). The top of the Kennel Creek Limestone unit consists of millimeter laminated limestone and tuffaceous limestone. The base of the Cedar Cove Formation includes tuffaceous to arkosic lime mudstone and wacke. The matrix of the mudstone and wacke is dominantly calcareous, and contains angular clasts of quartz, plagioclase and potassium feldspar, angular biogenic debris, subrounded clasts of calcite, volcanic rock fragments, pyrite, and grains and patches of secondary chlorite and epidote. Some graywackes have a matrix of secondary chlorite, epidote, albite, quartz, and opaque iron minerals. The lower member of the Cedar Cove Formation includes thin bedded limestone, thin to medium interbedded tuffaceous limestone and tuff, and pebbly graywacke in mass flows, amalgamated beds, turbidite beds, and cross beds, and minor conglomerate. There are both clast- and matrix-supported conglomerates. The conglomerates contain pebbles and cobbles of granite, alaskite, syenite, graywacke, quartz, chert, and limestone in a graywacke matrix. The upper member includes medium to thick bedded gray limestone, fetid fossiliferous limestone, interbedded bioclastic limestone and black organic calcareous mudstone, and limestone turbidite beds that grade from fossiliferous calcarenite to black, organic calcilutite. The limestones of both the lower and upper members yield argillite grains, iron oxides and sulfides, dolomite rhombs, and phosphatic druses or phosphatized bryozoan fragments (Anita Harris, U.S. Geological Survey, written communication, Jan. 12, 1995). The top of the unit is depositionally overlain by mafic agglomerate and flows of the Freshwater Bay Formation. The upper contact, though not exposed, appears to be an erosional unconformity, for in some places strata from the upper member of the formation are missing (Loney and others, 1963). The maximum thickness of the unit is estimated to be about 1000 meters.

Age and correlation: The Cedar Cove Formation contains conodonts that range from Ordovician to Devonian in age (map fossil localities 4, 39, 41) and from Silurian to Devonian in age (map fossil localities 3, 29, 30, 43). There are also some Devonian conodont assemblages (map fossil localities 31, 32, 35, 36, 37), and all the megafossil collections range in age from Early Devonian to early Late Devonian (map fossil localities 2, 35, 38, 40). All of the megafossil collections are from the upper member of the unit. Late Early Devonian (Emsian) conodonts from the lower member of the Cedar Cove Formation at map locality 32 indicate a probable maximum age of Devonian for the unit, but do not preclude a Silurian age for the very base of the unit. A variety of rugose corals, tabulate corals and stromatoporoids recovered from the upper member of the Cedar Cove Formation (map fossil localities 2, 38) provide the youngest ages for the unit. A re-evaluation of a trilobite collection (map fossil locality 40) by Alan Ormiston provides a late Early to early Middle Devonian age (Robert Blodgett, U.S. Geological Survey, written communication, July 7, 1989.) The unit is considered to be gradational to the Kennel Creek Limestone, which has yielded Silurian to Devonian fossil ages, suggesting that the contact between the two units may be a facies transition. Parts of the Cedar Cove Formation are thought to be correlative with the Black Cap Limestone, and possibly the Rendu Formation of the Glacier Bay region (Rossman, 1963; Loney and others, 1975).

Dch Cedar Cove Formation, horfelsed (Devonian): Recrystallized sedimentary and volcanic rocks. Weathers rusty and contains pervasive finely disseminated pyrite.

Age and correlation: Protoliths and stratigraphic position are consistent with Cedar Cove Formation. Intruded by dikes of gray quartz diorite. Adjacent to syenite, but no contacts exposed.

DSk Kennel Creek Limestone, undivided (Devonian and Silurian): Gray, thin- to very thick-bedded limestone with a few beds of dolostone and limestone breccia, minor shale and siltstone, and rare polymictic conglomerate. The unit was named by Loney and others (1963), for limestone that is best exposed near the mouth of Kennel Creek along the shore of Freshwater Bay. The lower part of the unit, 300 to 500 meters thick, is characterized by medium-grained, thick-bedded to massive limestone, with local interlayers of thin-bedded calcareous shale, siltstone and conglomerate. The upper part of the formation consists of thin-bedded limestone with very thin siliceous tuffaceous partings. The formation ranges from 700 to 1600 meters in thickness and forms prominent ridges.

In some parts of the unit, calcite is replaced by dolomite. Because dolostone dissolves more easily than limestone, caves are most likely to form in these areas. Caves in this unit are also structurally controlled. Heavy mineral residues from this unit contain dolomite and pyrite. The contact with the overlying Cedar Cove Formation is gradational; the nature of the contact with the underlying Point Augusta Formation has not been determined, but is inferred to be a lateral and vertical facies relationship.

Age and correlation: The Kennel Creek Limestone is considered to be Devonian and Silurian in age based on abundant amphipora, Pycinodesma, and conodonts recovered from the type section of the Kennel Creek Limestone (map fossil locality 33). Corals from map localities 6, 42, and 44, that were previously assigned Devonian ages, are now considered to range into the Silurian in age (Anita Harris, U.S. Geological Survey, written notes based on oral communication with W.A. Oliver, U.S. Geological Survey, August 21, 1995). An isolated limestone exposure at map locality 9 yielded early Devonian conodonts, (sample collection submitted as possibly Kennel Creek limestone by David A. Brew, U.S. Geological Survey), but the map unit designation of this locality is not certain. Thick-bedded to massive limestone units that closely resemble the Kennel Creek both in lithology and in stratigraphic position include the Willoughby Limestone of Glacier Bay (Rossman, 1963), the Heceta Limestone on Prince of Wales Island (Eberlein and Churkin, 1970; Loney and others, 1975), and Limestone in the William Henry Bay area on the east side of the Chilkat Range. The Silurian Kuiu Limestone of northern Kuiu Island (Muffler, 1967) may also be correlative.

DSkc Conglomerate member of Kennel Creek Limestone (Devonian and Silurian): Gray to buff polymictic conglomerate containing angular and rounded fragments of syenite, leucocratic granite, mafic volcanic rock, chert, graywacke, and limestone. The composition of the clasts and the graywacke matrix of this conglomerate suggest that it may represent a proximal facies to the contemporaneous and locally adjacent Point Augusta Formation.

Age and correlation: Limestone boulders near the top of the conglomerate unit southwest of East Point contain Coelocaulus (map fossil locality 46), and are inferred to be derived from the Kennel Creek Limestone.

Sa Point Augusta Formation (Silurian?): Interbedded gray graywacke, calcareous wacke and dark gray argillite. Unit includes massive conglomeratic debris flows, massive amalgamated sandstone beds, and turbidites consisting of graded beds with full Bouma sequences, and ungraded rhythmic beds with sharp contacts (Karl and Giffen, 1992). Thin-bedded, light gray, medium-grained limestone occurs as isolated beds intercalated with argillite and graywacke throughout. The graywacke is arkosic to lithic and contains medium to fine, poorly- to well-sorted, angular to subrounded grains of plagioclase, quartz, volcanic rock, mudstone, siltstone, limestone, shelly debris, algae, chert, k-feldspar, perthite, detrital biotite, epidote, chlorite, and glauconite(?) in a calcareous and chloritic matrix. Massive conglomeratic graywacke contains matrix-supported cobbles of limestone to 10 cm in some places. Local sedimentary structures include web structures in massive graywacke, and graded bedding, crossbedding, convolute bedding and load casts in bedded turbidites. The argillite interbeds are dark gray, thin, locally calcareous and have sedimentary slump structures. Upper and lower contacts have not been recognized for the Point Augusta Formation, but the unit is estimated to be at least 1500 meters thick. The turbidites are interpreted to represent an inner fan, very proximal facies association (Karl and Giffen, 1992). Near the head of Tenakee Inlet, the sandstones are very thin bedded, sericitic, and calcareous, with locally abundant pyrite. In general the unit is more calcareous and contains a smaller proportion of volcanic clasts toward the southwest, or stratigraphically lower in the section, and the graywackes have a higher proportion of granitic and volcanic clasts to the northeast, or stratigraphically higher in the section. Unit was named by Loney and others (1975) for a widespread graywacke and argillite unit best exposed along Icy Strait near Point Augusta.

Age and correlation: No fossils have been recovered from the Point Augusta Formation in the map area, but it has been correlated with graywackes containing Silurian graptolites in the Chilkat Mountains to the north of Chichagof Island (Loney and others, 1975) and graywacke turbidites of the Bay of Pillars Formation on Kuiu Island, which lies to the south and on the other side of the Chatham Strait fault.

Sal Limestone member of the Point Augusta Formation (Silurian?): dark gray, thin- to thick-bedded, medium-grained limestone. Limestone sections are as much as 100 m thick and are commonly intricately folded. No fossils have been reported from this unit in the map area.

Sah Hornfelsed Point Augusta Formation (Silurian?): Maroon and maroon and green altered pyritic biotite hornfels with rhythmically bedded fine-grained clastic protolith. More calcareous protoliths weather orange. Contains garnet in some places. Locally contains abundant finely disseminated pyrite.

Pzh Hornfels, schist, and gneiss (Paleozoic): Interlayered light gray and light green fine-grained schist, gneiss, and hornfels. Compositional layering is cm to meter scale. This unit also includes foliated, layered, medium- to dark-gray, medium- to coarse-grained schist and gneiss, marble, skarn, and foliated, dark gray to black amphibolite. Schist contains biotite, muscovite, and/or chlorite. Metamorphic mineral assemblages also include quartz, plagioclase, hornblende, pyroxene, actinolite, sphene, apatite, magnetite, and ilmenite, and have been assigned to the hornblende hornfels metamorphic facies (Loney and others, 1975). Skarn contains calcite, diopside, garnet, and other calc-silicate minerals. Marble units range to tens of meters in thickness. Unit locally contains white, banded metachert layers and white, garnet-bearing quartzite. In places the unit is migmatitic, with a dioritic to granodioritic invader.

Age and correlation: These rocks, apparently metamorphosed during the emplacement of the Chichagof plutonic complex, lie along strike with the Point Augusta Formation clastic rocks, and were probably derived from the calcareous middle Paleozoic rocks of northeastern Chichagof Island and from the slate, graywacke and limestone of the Point Augusta Formation. The protoliths of these rocks are locally more variable than the Point Augusta turbidites in the area, and may include protoliths older than the Point Augusta Formation. Some of the metamorphic rocks are also derived from the Kennel Creek, Cedar Cove, Freshwater Bay, and Iyoukeen formations.

Pzm Marble (Paleozoic): Dark gray to white, massive, fine- to medium-grained, and gray-weathering marble in layers ranging from less than 1 cm to several meters in thickness. Chert nodules and contorted ribbon chert are abundant at some localities.

Age and correlation: Protolith is probably Paleozoic limestone associated with Sa or DSk on northeastern Chichagof Island.

Intrusive rock units

Kgr Granite (Cretaceous): Light gray, CI 5-10, biotite granite. Minor hornblende. Accessory zircon and magnetite. Plagioclase is subhedral, mafic minerals are interstitial. Medium- to fine-grained.

Age and correlation: A new $^{40}Ar/^{39}Ar$ radiometric age of 108.5 $\pm$ 1.0 Ma (plateau age for biotite) (written communication from Paul Layer, Geochronology Lab, Geophysical Institute, Fairbanks, Alaska, November 5, 1996) for this pluton is reported here. This pluton correlates with the suite of Cretaceous plutons on eastern Chichagof Island which includes the body extending from Seal Bay to Catherine Island, south of Tenakee Inlet, that has yielded K-Ar ages for hornblende separates of 117.2 $\pm$ 6 Ma ,112 Ma, and 110 Ma (recalculated with modern decay constants from

Loney and others, 1967). This suite is part of the Nutzotin-Chichagof belt of Hudson (1979;1983).

Kd Diorite (Cretaceous): Gray, CI 25-35, hornblende diorite and biotite-hornblende quartz diorite. Unit includes uralitized biotite-augite diorite and uralitized biotite-hypersthene diorite (Loney and others, 1975). Fine- to medium-grained. Accessory sphene and apatite. Secondary minerals include epidote, white mica, and opaques (mostly magnetite). Unit is very magnetic, and can be observed in plots of a NURE aeromagnetic survey (LK and B Resources, Inc., 1979).

<u>Age and correlation</u>: No isotopic ages have been obtained for this unit in the map area. It is considered to be Cretaceous because it is similar in composition and magnetic character to dioritic phases of Kad. Part of Nutzotin-Chichagof belt of Hudson (1979; 1983).

Kgd Granodiorite (Cretaceous): Light to medium gray, CI 10-30, medium-grained, equigranular, biotite-hornblende granodiorite, hornblende-biotite granodiorite, with zones of hornblende diorite, biotite-hornblende tonalite, and biotite granite. Accessory minerals include magnetite, sphene, epidote, apatite, sericite, and zircon. The unit is locally fractured and sheared, and commonly contains rounded mafic inclusions.

<u>Age and correlation</u>: This unit has been assigned a Cretaceous age because of similarities in compositon and magnetic character with Kd and Kad. Part of Nutzotin-Chichagof belt of Hudson (1979; 1983.)

Kgdm Migmatitic granodiorite (Cretaceous): Light gray biotite hornblende granodiorite (Kgd) invader with mafic agmatite, plastically deformed schist, gneiss, and marble inclusions, and with felsic segregation and restite fabrics. Border phase to Kgd.

Kad Adamellite (Cretaceous): Medium-gray, medium-grained hornblende-biotite adamellite with subordinate diopside- and hornblende-bearing monzonite and diorite, CI 10-30. Hypidiomorphic texture; subhedral to euhedral mafic minerals. The diorite contains up to 5 percent uralitized augite, and accessory sphene, apatite, and magnetite. Secondary chlorite; sericitized feldspar. Northeast of Freshwater Bay.

<u>Age and correlation</u>: A K-Ar age of 105 ± 5 Ma (recalculated with modern decay constants from Loney and others, 1967), indicates a Cretaceous age for this unit. These Cretaceous plutons are associated with the Nutzotin-Chichagof belt of the Cretaceous intrusive rocks (Hudson 1979; 1983,) but are interpreted to represent intrusions into a structurally higher part of the crust than are the intrusions to the southwest of the Tenakee fault (Loney and others, 1975).

Jd Diorite (Jurassic): Biotite-hornblende diorite, biotite hornblende meladiorite, and hornblende syenodiorite. CI 30-50, with accessory magnetite; mafic minerals are subhedral, hypidiomorphic. Plagioclase altered to calcite and sericite; common secondary epidote and iron sulfides. Kennel Creek area, southwest of Freshwater Bay.

<u>Age and correlation</u>: The Jurassic age assignment for the diorite and the associated adamellite (Jad) is based on a hornblende K-Ar age determination of 147 ± 7 Ma (recalculated with modern decay constants from Loney and others, 1967). Part of Tonsina-Chichagof belt of Hudson (1979; 1983.)

Jad Adamellite (Jurassic): Hornblende adamellite, biotite alaskite, and hornblende monzonite; CI 2-10, with accessory magnetite, sphene, and zircon. Fine- to medium-grained; mafic minerals subhedral; hypidiomorphic. Cores of plagioclase grains altered to sericite. Horseshoe-shaped body on ridges above Kennel Creek, southwest of Freshwater Bay.

Age and correlation: The Jurassic age assignment for the adamellite and the associated diorite (Jd) is based on a hornblende K-Ar age determination of 147 ± 7 Ma (recalculated from Loney and others, 1967). There are plutons of similar age on west Chichagof Island (Karl and others, 1988). These Late Jurassic (to Early Cretaceous) plutons are part of the Tonsina-Chichagof belt of Hudson (1983.)

Pzsy Syenite (Paleozoic): Pink biotite syenite and hornblende syenite with subordinate biotite monzonite and hornblende-bearing biotite monzonite. Fine- to medium-grained, hypidiomorphic. Mafic minerals are rich in inclusions of chlorite, albite, and epidote. Pluton is locally rich in disseminated sulfides, mainly pyrite. Locally miarolitic.

Age and correlation: The syenite is similar in aspect and composition to the alkalic plutonic complex on southeastern Chichagof Island, near Sitkoh Bay (Ford and others, 1990.) Clasts of syenite similar to the rocks of the alkalic complex occur in the Silurian Point Augusta Formation (Sa), in the Silurian and Devonian Kennel Creek Limestone (DSk and DSkc), and in the Devonian Cedar Cove Formation (Dc). There is a Silurian K-Ar age for the syenite body that forms an island south of Tenakee, but the body south of Pavlof Bay may be younger than Silurian because it apparently intrudes (contact not observed) the Freshwater Bay Formation (Df).

Ssy Syenite (Silurian): Pink hornblende syenite. Medium-grained. CI 10. Minor biotite. Accessory zircon and magnetite.

Age and correlation: The dated syenite is an isolated island in Tenakee Inlet, south of the village of Tenakee. Hornblende from this body yielded a K-Ar age of 417 ± 16 Ma (recalculated with modern decay constants from Lanphere and others, 1964; 1965).

References cited

Armstrong, R.L. 1985, Rb-Sr dating of the Bokan Mountain granite complex and its country rocks; Canadian Journal of Earth Sciences, v. 22, p. 1233-1236.

Berg, H.C., Jones, D.L., and Richter, D.H., 1972, Gravina-Nutzotin belt--tectonic significance of an upper Mesozoic sedimentary and volcanic sequence in southern and southeastern Alaska, in Geological Survey Research, 1972, Chapter D: U.S. Geological Survey Professional Paper 800D, p. D1-D24.

Berg, H.C., Jones, D.L., and Coney, P.J., 1978, Map showing pre-Cenozoic tectonostratigraphic terranes of southeastern Alaska and adjacent areas: U.S. Geological Survey Open-File Report 78-1085, scale 1:1,000,000, 2 sheets.

Cwynar, L.C., 1990, A late Quaternary vegettion history from Lily Lake, Chilkat Peninsula, southeast Alaska: Canadian Journal of Botany, v. 68, p. 1106-1112.

Dehler, S.A., and Clowes, R.M., 1992, Integrated geophysical modeling of terranes and other structural features along the Canadian margin: Canadian Journal of Earth Sciences, v. 29, p. 1492-1508.

Eberlein, G.D., and Churkin, Michael, Jr., 1970, Paleozoic stratigraphy in the northwest coastal area of Prince of Wales Island, southeastern Alaska: U.S. Geological Survey Bulletin 1284, 67 p.

Eberlein, G.D., Churkin, Michael, Jr., Carter, Claire, Berg, H.C., and Ovenshine, A.T., 1983, Geology of the Craig quadrangle, Alaska: U.S. Geological Survey Open-File Report 83-91, 28 p., scale 1:250,000.

Engstrom, D.R., Hansen, B.C.S., and Wright, H.E., 1990, A possible Younger Dryas record in southeastern Alaska: Science, v. 250, p. 1383-1385.

Ford, A.B., Brew, D. A., and Loney, R.A., 1990, The Sitkoh Bay alkalic plutonic suite: Silurian or older alkalic magmatism on eastern Chichagof Island, southeastern Alaska; U.S. Geological survey Open-file Report 90-297, 41p.

Gardner, M.C., Bergman, S.C., Cushing, G.W., MacKevett, E.M., Jr., Plafker, F., Campbell, R.B., Dodds, C.J., McClelland, W.C., and Mueller, P.A., 1988, Pennsylvania pluton stitching of Wrangellia and the Alexander terrane, Wrangell Mountains, Alaska: Geology, v. 16, p. 967-971.

Gehrels, G.E., and Saleeby, J.B., 1987a, Geology of southern Prince of Wales Island, southeastern Alaska: Geological Society of America Bulletin, v. 98, p. 123-137.

Gehrels, G.E., and Saleeby, J.B., 1987b, Geologic framework, tectonic evolution, and displacement history of the Alexander terrane: Tectonics, v. 6, no. 2, p. 151-173.

Heusser, C.J., 1960, Late-Pleistocene environments of North Pacific North America, an elaboration of late-glacial and post glacial climatic, physiographic, and biotic changes: American Geographic Society, Special Publication 35, 308 p.

Heusser, C.J., 1985, Quaternary pollen records from the Pacific-Northwest Coast: Aleutians to the Oregon-California border: *in* Bryant, V.M., and Holloway, R.G., eds., Pollen Records of Late Quaternary North American Sediments p.141-165; Dallas, Texas: American Assoc. of Stratigraphic Palynologists Foundation, p. 353-387.

Hillhouse, J.W., and Gromme, C.S., 1984, Northward displacement and accretion of Wrangellia: New paleomagnetic evidence from Alaska: Journal of Geophysical Research, v. 89, p. 4461-4467.

Hudson, 1979, Mesozoic plutonic belts of southern Alaska: Geology, v. 7, no. 5, p. 230-234.

Hudson, 1983, Calc-alkaline plutonism along the Pacific rim of southern Alaska, *in* Roddick, J.A., ed., Circum-Pacific plutonic terranes: Geological Society of America Memoir 159, p. 159-169.

Hudson, Travis, Plafker, George, and Dixon, Kirk, 1982, Horizontal offset history of the Chatham Strait fault, *in* Coonrad, W.L., ed., The United States Geological Survey in Alaska: Accomplishments during 1980: U.S. Geological Survey Circular 844, p. 128-132.

Karl, S.M., 1993, The geology of Annette Island, *in* Godwin. L.H., and Smith, B.D., eds., Economic Mineral Resources of the Annette Islands Reserve, Alaska: Bureau of Indian Affairs Division of Energy and Mineral Resources, Northwest Mining Association Symposium, p. 21-25.

Karl, S.M., and Giffen, C.F., 1992, Sedimentology of the Bay of Pillars and Point Augusta Formations, Alexander Archipelago, Alaska, in Bradley, D.C., and Dusel-Bacon, Cynthia, eds., Geologic Studies in Alaska by the U.S. Geological Survey, 1991, U.S. Geological Survey Bulletin 2041, p. 171-185.

Karl, S.M., Johnson, B.R., and Lanphere, M.A., 1988, New K-Ar Ages for plutons on western Chichagof Island and on Yakobi Island, in Galloway, J.P., and Hamilton, T.D., eds., Geologic Studies if Alaska by the U.S. Geological Survey during 1987, U.S. Geological Survey Circular 1016, p. 164-168.

Lanphere, M.A., Brew, D.A., Eberlein, G.D., Loney, R.A., and MacKevett, E.M., Jr., 1964, Ar^{40}-K^{40} ages of Paleozoic intrusive rocks in southeastern Alaska [abs.]: American Geophysical Union Transactions, v. 45, no. 1, p. 116-117.

Lanphere, M.A., Loney, R.A., and Brew, D.A., 1965, Potassium-argon ages of some plutonic rocks, Tenakee area, Chichagof Island, southeastern Alaska, in Geological Survey research 1965: U.S. Geological Survey Professional Paper 525-B, p. B108-B111.

Lathram, E.H., Loney, R.A., Condon, W.H., and Berg, H.C., 1959, Progress map of the geology of the Juneau quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geological Investigations Map I-303, scale 1:250,000.

LK and B Resources, Inc., 1979, NURE aerial gamma-ray and magnetic reconnaissance survey, Southeastern area-Alaska: U.S. Department of Energy, Grand Junction Office Report GJBX-048(79), 15 vols.

Loney, R.A., Condon, W.H., and Dutro, J.T., Jr., 1963, Geology of the Freshwater Bay area, Chichagof Island, Alaska: U.S. Geological Survey Bulletin 1108-C, p. C1-C51.

Loney, R.A., Brew, D.A., and Lanphere, M.A., 1967, Post Paleozoic radiometric ages and their relevance to fault movements, northern southeastern Alaska: Geological Society of America Bulletin, v. 78, no. 4, p. 511-526.

Loney, R.A., Brew, D.A., Muffler, L.J.P., and Pomeroy, J.S., 1975, Reconnaissance geology of Chichagof, Baranof, and Kruzof Islands, southeastern Alaska: U.S. Geological Survey Professional Paper 792, 105 p.

Mann, D.H., and Hamilton, T.D., 1995, Late Pleistocene and Holocene Paleoenvironments of the North Pacific Coast, Quaternary Science Review, v. 14, p. 449-471.

Miller, R.D., 1975, Surficial geologic map of the Juneau urban area and vicinity, Alaska: U.S. Geological Survey Miscellaneous Investigations Map I-885, scale 1:48,000.

Monger, J.W.H., and Berg, H.C., 1987, Lithotectonic terrane map of western Acanda and southeastern Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1874-B, scale 1:250,000.

Muffler, L.J.P., 1967, Stratigraphy of the Keku Islets and neighboring parts of Kuiu and Kupreanof Islands, southeastern Alaska: U.S. Geological Survey Bulletin 1241-C, p. C1-C52.

Mutti, E., and Ricchi-Lucci, F., 1972, Letorbidite dell 'Appennino setentrionale-Introduzione all' analisi de facies: Societa Geologica Italiana Memoir, v. 11, p. 161-199.

Peteet, D.M., 1986, Vegetational history of the Malaspina Glacier district: Quaternary Research, v. 25, p. 100-120.

Plafker, George, Nokleberg, W.J., and Lull, J.S., 1989, Bedrock geology and tectonic evolution of the Wrangellia, Peninsula, and Chugach terranes along the trans-Alaskan crustal transect in the Chugach Mountains and southern Copper River basin, Alaska: Journal of Geophysical Research, v. 94, no. B4, p. 4255-4295.

Rossman, D.L., 1963, Geology of the eastern part of the Mount Fairweather quadrangle, Glacier Bay, Alaska: U.S. Geological Survey Bulletin 1121-K, 57p.

Figure Captions

Fig. 1. Map showing distribution of terranes in southern and southeastern Alaska (after Berg and others, 1978, Monger and Berg, 1987).

Fig. 2. Map showing distribution of terranes in the Sitka quadrangle (after Berg and others, 1978).

Fig. 3. Lithologic chart comparing lithostratigraphic sequences for components of the Alexander and Wrangellia terranes. Tectonic interpretation and columns from Central Prince of Wales-Kuin, and Annette-Gravina-Duke-Southern Prince of Wales Islands are from Gehrels and Saleeby (1987b).

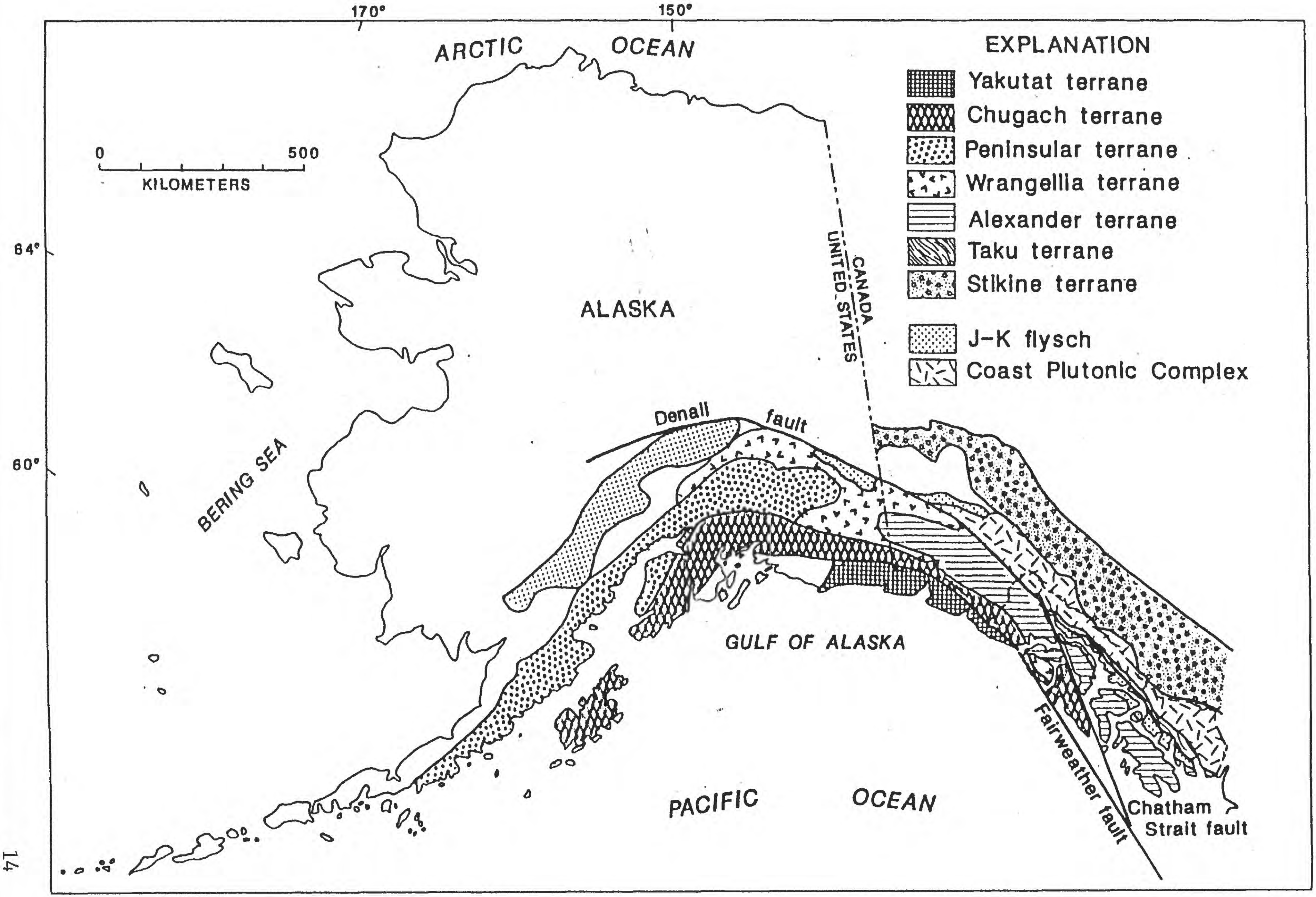

170°
150°
ARCTIC
OCEAN
0
500
KILOMETERS
64°
60°
ALASKA
BERING SEA
CANADA
UNITED STATES
EXPLANATION
Yakutat terrane
Chugach terrane
Peninsular terrane
Wrangellia terrane
Alexander terrane
Taku terrane
Stikine terrane
J–K flysch
Coast Plutonic Complex
Denali
fault
GULF OF ALASKA
PACIFIC
OCEAN
Fairweather fault
Chatham
Strait fault

Figure 1

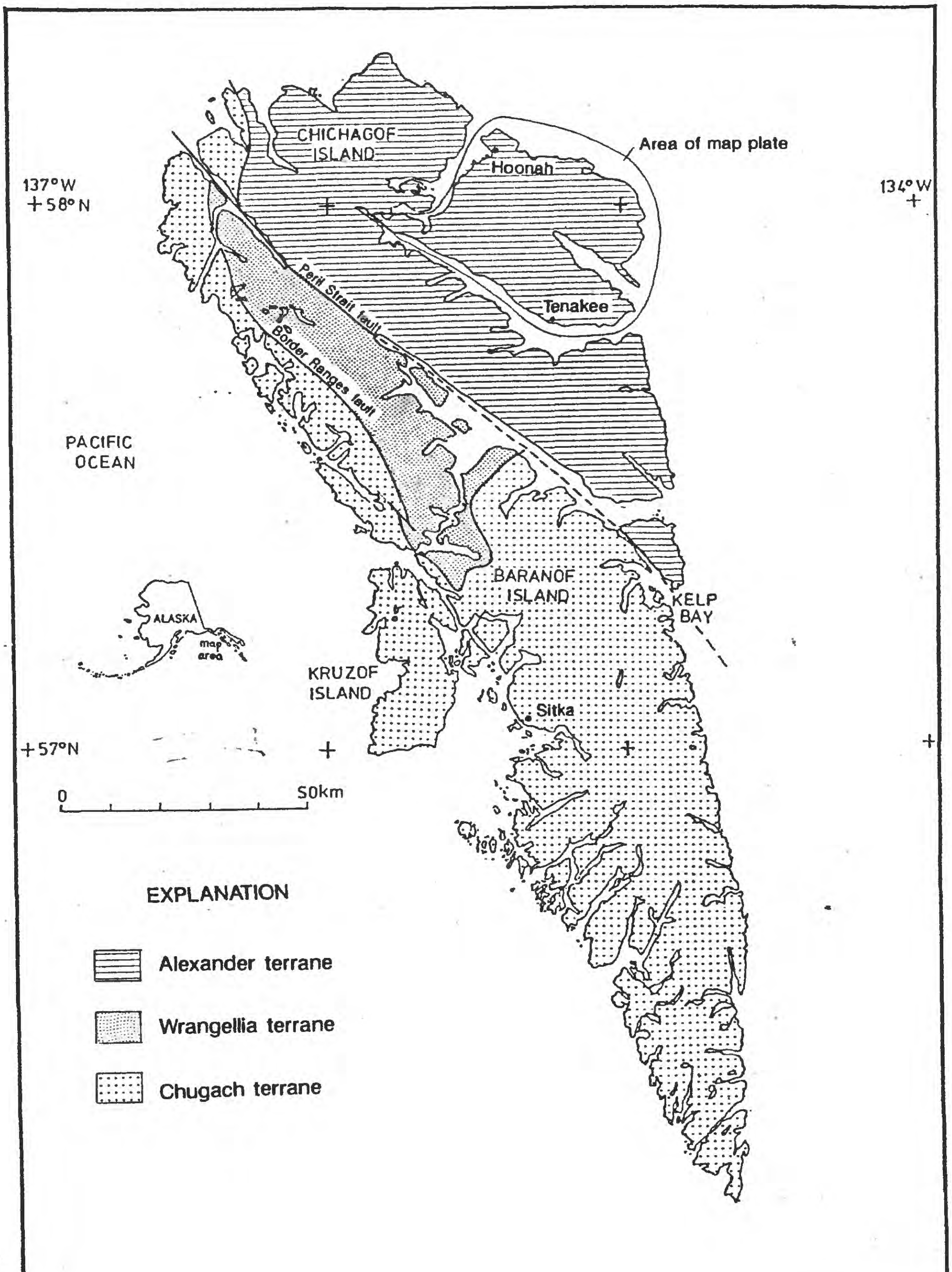
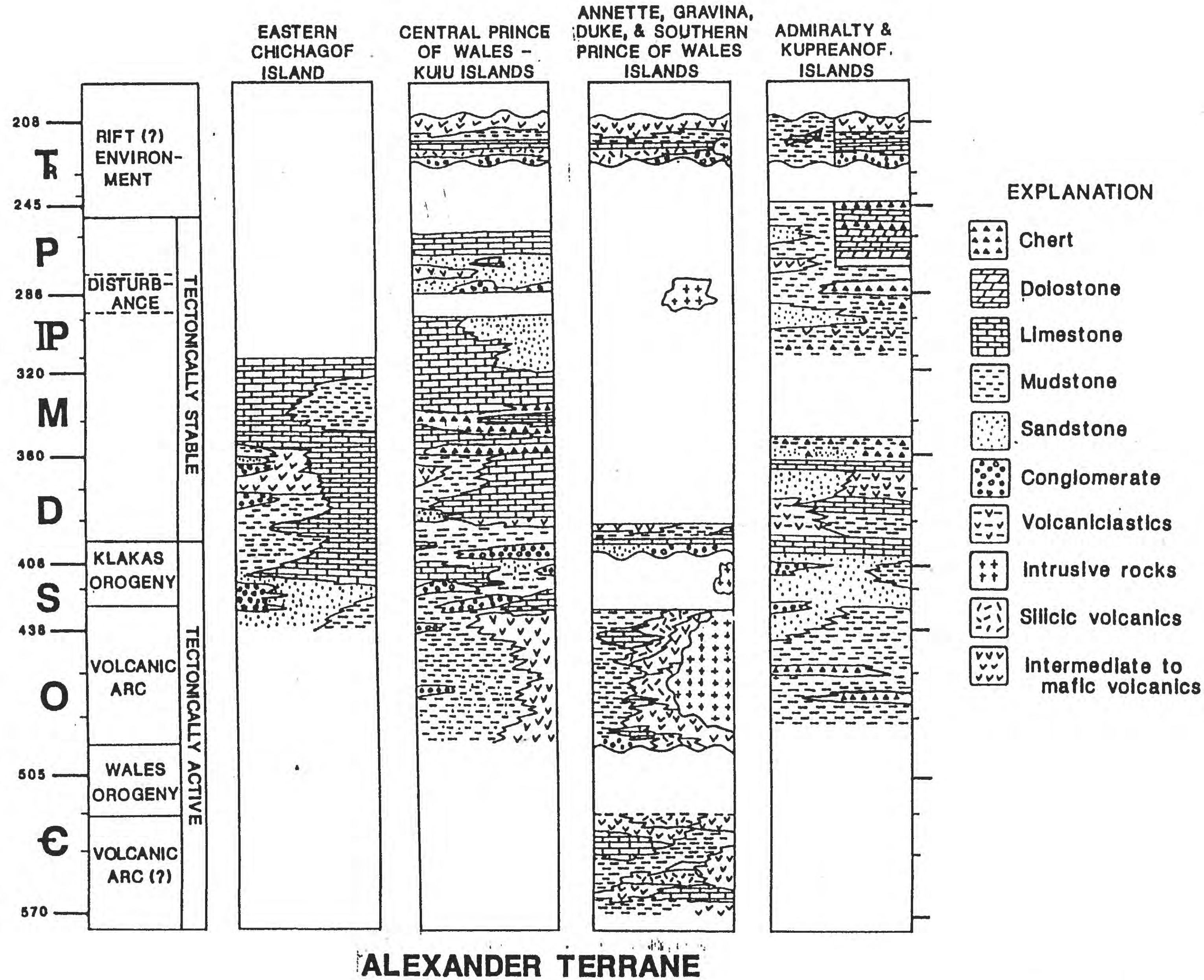

CHICHAGOF ISLAND
Area of map plate
Hoonah
137°W
58°N
134°W
Tenakee
Peril Strait fault
Border Ranges fault
PACIFIC OCEAN
BARANOF ISLAND
KELP BAY
ALASKA
map area
KRUZOF ISLAND
Sitka
57°N
0
50km
EXPLANATION
Alexander terrane
Wrangellia terrane
Chugach terrane

Figure 2


EASTERN CHICHAGOF ISLAND
CENTRAL PRINCE OF WALES - KUIU ISLANDS
ANNETTE, GRAVINA, DUKE, & SOUTHERN PRINCE OF WALES ISLANDS
ADMIRALTY & KUPREANOF. ISLANDS
208
245
286
320
360
408
438
505
570
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P
IP
M
D
S
O
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RIFT (?) ENVIRON- MENT
TECTONICALLY STABLE
DISTURB- ANCE
TECTONICALLY ACTIVE
KLAKAS OROGENY
VOLCANIC ARC
WALES OROGENY
VOLCANIC ARC (?)
EXPLANATION
Chert
Dolostone
Limestone
Mudstone
Sandstone
Conglomerate
Volcaniclastics
Intrusive rocks
Silicic volcanics
Intermediate to mafic volcanics
ALEXANDER TERRANE

Figure 3

Table 1. Fossil localities on northeastern Chichagof Island

map no.	field no.	USGS collection no.	formation	age	fossils
1	56ADu77		Freshwater Bay Formation	Late Devonian (late Frasnian)	*Crytospirifer* sp.
2	57AGe232		Cedar Cove Formation	early Late Devonian (Frasnian)	brachiopods and corals
3	85WNO39A		Cedar Cove Formation	middle Late Silurian-very earliest Devonian (late Ludlovian-early Lochkovian)	conodonts, including *Panderodus*, sp. *Ozarkodina remscheidensis eosteinhornensis* (Walliser)
4	85DB029A 85DB029B		Cedar Cove Formation	Middle Ordovician-Middle Devonian	*Panderodus*, sp. *Favosites*, sp., thamnoporoid corals
5	85EL003A		Kennel Creek Limestone	Silurian-Middle Devonian	*Belodella*, sp. indet., *Panderodus*, sp.
6	56ADu70		Kennel Creek Limestone	Devonian	corals
7	85WNO19A	30022-PC	Iyoukeen Formation	Mississippian (middle Meramecian)	ichthyoliths, gastropod steinkern conodonts, including *Hindeodus* cf. *H. spiculus* (Youngquist and Miller), *Kladognathus tenuis* (Branson and Mehl), *Taphrognathus varians* (Branson and Mehl) tr. to *Cavusgnathus*, sp.
8	57ALy152f		Iyoukeen Formation	Mississippian	brachiopods bryozoans
9	91DB043A	12211-SD	Kennel Creek	Early Devonian	*Icriodus?* sp. indet., *Panderodus* sp.

			Limestone?		*Pelekysgnathus* sp. indet.
10	85WNO18A	30012-PC	Iyoukeen Formation	Mississippian (late Kinderhookian)	conodonts, including *Polygnathus* cf. *P. purus* (Voges), *Siphonodella isosticha* (Cooper)
11	57AGe93F	5575-SD	Iyoukeen Formation	Mississippian	Orthid brachiopods, productid, aff. *Plicatifera*, spiriferids, including *Eomartinopsis*(?), gastropod, trilobite pygidium, echinoderms
12	57ACo407	18387-PC	Iyoukeen Formation	Late Mississippian	lithostrotionoid corals, undet.
13	57ALy168 57ALy168a	18385-PC 18386-PC	Iyoukeen Formation (upper)	Late Mississippian	lithostrotionoid corals, undet. variety of large horn corals, undet. *Gigantoproductus* sp.
14	57ALy165 57ALy165a	18383-PC 18384-PC	Iyoukeen Formation (lower)	Early Mississippian	syringoporoid, indet. spiriferoid and chonetid brachiopods, indet. gastropods, including *Straparollus* (*Euomphalus*) sp.
15	85DB040A	11544-SD	Freshwater Bay Formation (upper member)	late Late Devonian (Famennian)	conodonts, including *Apatognathus varians*, *Ozarkodina* n. sp., *Pelekysgnathus* sp. indet., juvenile *Polygnathus* cf. P. *semicostatus*
16	57ACo420	18388-PC	Iyoukeen Formation	Early Mississippian	syringoporoid coral, indet. euomphalid gastropod, indet.
17	57ACo349		Iyoukeen Formation	Mississippian	brachiopod fragments, bryozoan or coralline forms, crinoid stems
18	57ALy140	18379-PC	Iyoukeen Formation	Late(?) Mississippian	coral fragments, indet.
19	57ALy137 57ALy139	18376-PC 18377-PC	Iyoukeen Formation (middle)	Early Mississippian	*Syringopora*, sp spiriferoid and chonetid brachiopods gastropods, including *Straparollus* (*Euomphalus*) sp.

					solitary rugose corals, undet. productoid brachiopods, undet. Leptaena cf. L. analoga (Phillips)
20	57ALy135 57ALy135a 57ALy136 57ALy135	18372-PC 18373-PC 18374-PC 18375-PC	Iyoukeen Formation (upper)	Late Mississippian	lithostrotionoid coral, undet. variety of large horn corals, undet. large gigantoproductid brachiopods, including Striatifera sp.
21	57ACo381		Iyoukeen Formation	Mississippian	crinoid stems and poorly preseved corals
22	56ACo89		Kennel Creek Limestone	Silurian-Devonian	
23	56ACo95		Kennel Creek Limestone	Silurian-Devonian	Pycinodesma sp.
24	46AFL38 46AFL39		Iyoukeen Formation	Mississippian	
25	85SK005A		Iyoukeen Formation	Late Devonian to Permian	conodonts, undet.
26	85EL002A	30019-PC	Iyoukeen Formation (upper member)	Late Mississippian	conodonts, including Cavusgnathus?, sp. indet. ichthyoliths
27	46AFL70 46AFL71 46AFL72	16753-PC 16754-PC 16755-PC	Iyoukeen Formation	Late(?) Mississippian	corals, fragmentary (include syringoporoid and caninoid types) Lithostrotionoid coral (perhaps Thysanophyllum) Linoproductus? sp.
28	85DB025A	30018-PC	Iyoukeen Formation (upper member)	Latest Mississippian	conodonts, including Adetognathus sp. indet., ichthyoliths ostracodes gastropod steinkerns

29	94SK436A		Cedar Cove Formation	Silurian-Permian	conodont fragments
30	94SK366A	12388-SD	Cedar Cove Formation	Late Silurian-Devonian	conodonts, including <u>Pelekysgnathus?</u> sp. indt.
31	94SK368A	12388-SD	Cedar Cove Formation	Devonian	conodonts, including <u>Icriodus</u>, sp. indet., <u>Pelekysgnathus</u> sp. indet.
32	9-19-79F 56Co40 56Co41	10143-SD	Cedar Cove Formation	latest Early Devonian (latest Emsian)	<u>Polygnathus serotinus</u> (Telford)
33	56ALy47f 56ALy48f 56ADu50 56ADu49 56ADu48 56ADu47	5482-SD 5481-SD 5475-SD 5491-SD 5444-SD 5480-SD	Kennel Creek Limestone	Middle-early Late Devonian to Silurian	<u>Amphipora</u>, sp. <u>Pycinodesma</u>, sp.
	85EL001A 9-19-79E	11545-SD	Kennel Creek Limestone	Silurian, Middle Devonian	conodonts, including <u>Oulodus</u>? sp. indt., <u>Panderodus</u> sp., (shallow marine)
	85EL001A	11180-SD		Silurian - lower Middle Devonian	gastropods, indet. - (shallow marine), <u>Amphipora</u>, sp.
34	94SK338A		Kennel Creek Limestone	Middle Ordovician-Middle Devonian	conodonts, <u>Panderodus</u>, sp.
35	94SK291A	12361-SD	Cedar Cove Formation	Emsian (late Early Devonian)	conodonts, including <u>Belodella devonica</u> (Stauffer), <u>Ozarkodina prolata</u> (Mawson), <u>Panderodus</u>, sp., <u>Pelekysgnathus</u> n. sp., <u>Polygnathus gronbergi</u> (Klapper and Johnson)
	94SK291B			Emsian	brachiopods
36	85DB022A	11299-SD	Cedar Cove Formation	Early Devonian	conodonts, including <u>Panderinella exigua philipi</u>, <u>Cladopora</u>, sp., <u>Favosites</u>, sp.
37	85SD002A	11555-SD	Cedar Cove Formation	Early Devonian (Emsian)	conodonts, including <u>Belodella</u> sp., <u>Panderodus</u>, sp. <u>Panderinella exigna philipi</u>, <u>P.e. exigua</u>, <u>Pelekysgnathus</u> cf.

					P. serratus, *Pedavis*, sp. indet.
38	56ADu1 56ADu2 56ADu10	5489-SD 5446-SD 5483-SD	Cedar Cove Formation (upper)	Middle-early Late Devonian	abundant rugose corals, undet. stromatoporoids, indet. favositid, thamnoporoid, and cladoporoid corals, indet.
39	94SK295A		Cedar Cove Formation	Middle Ordovician-Middle Devonian	conodonts; *Panderodus*, sp.
40	61Ly38	D206-SD	Cedar Cove Formation	late Early/ early Middle Devonian (Emsian/Eifelian)	*Dechenella* sp.
41	85DB021A		Cedar Cove Formation	Middle Orodovician-Middle Devonian	conodonts, including *Panderodus*, sp
42	57ALy167		Kennel Creek Limestone	Middle(?) Devonian	*Amphipora*? sp. *Thamnopora*? sp.
43	85SK002B		Cedar Cove Formation	Silurian-Middle Devonian	conodonts, including *Panderodus* sp.
44	57ALy179f		Kennel Creek Limestone	Middle(?) Devonian	stromatoporoids, indet. thamnoporoids, indet.
45	85DB018A	11543-SD	Kennel Creek Limestone	Late Silurian to early late Early Devonian (Ludlovian to early Emsian)	conodonts, including *Ozarkodina excavata*, *Panderodus* sp., *Pedavis*, sp. indet.
46	56ADu13f	5452-SD	Kennel Creek Limestone	mid-Paleozoic	*Coelocaulus* sp.