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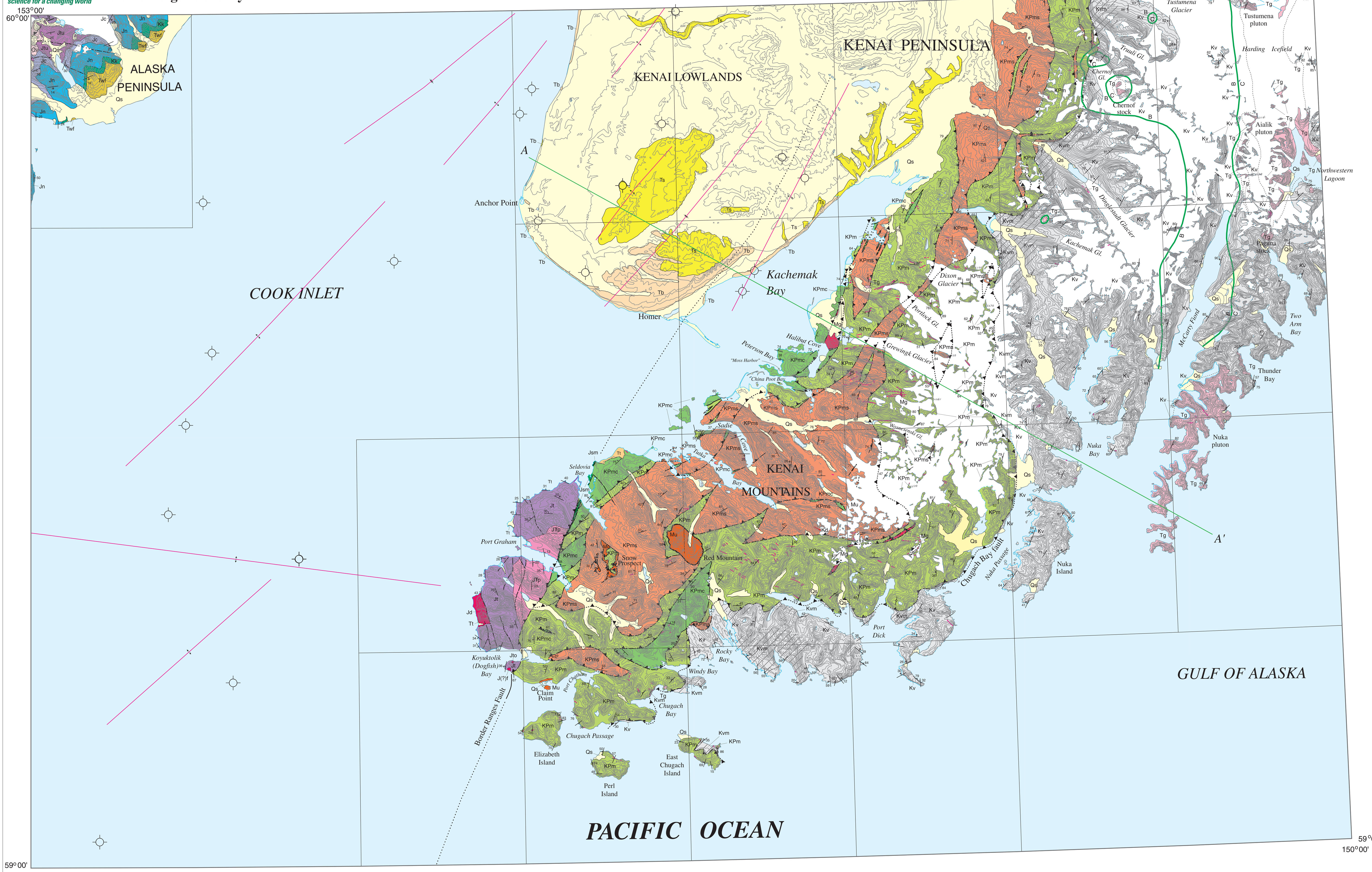
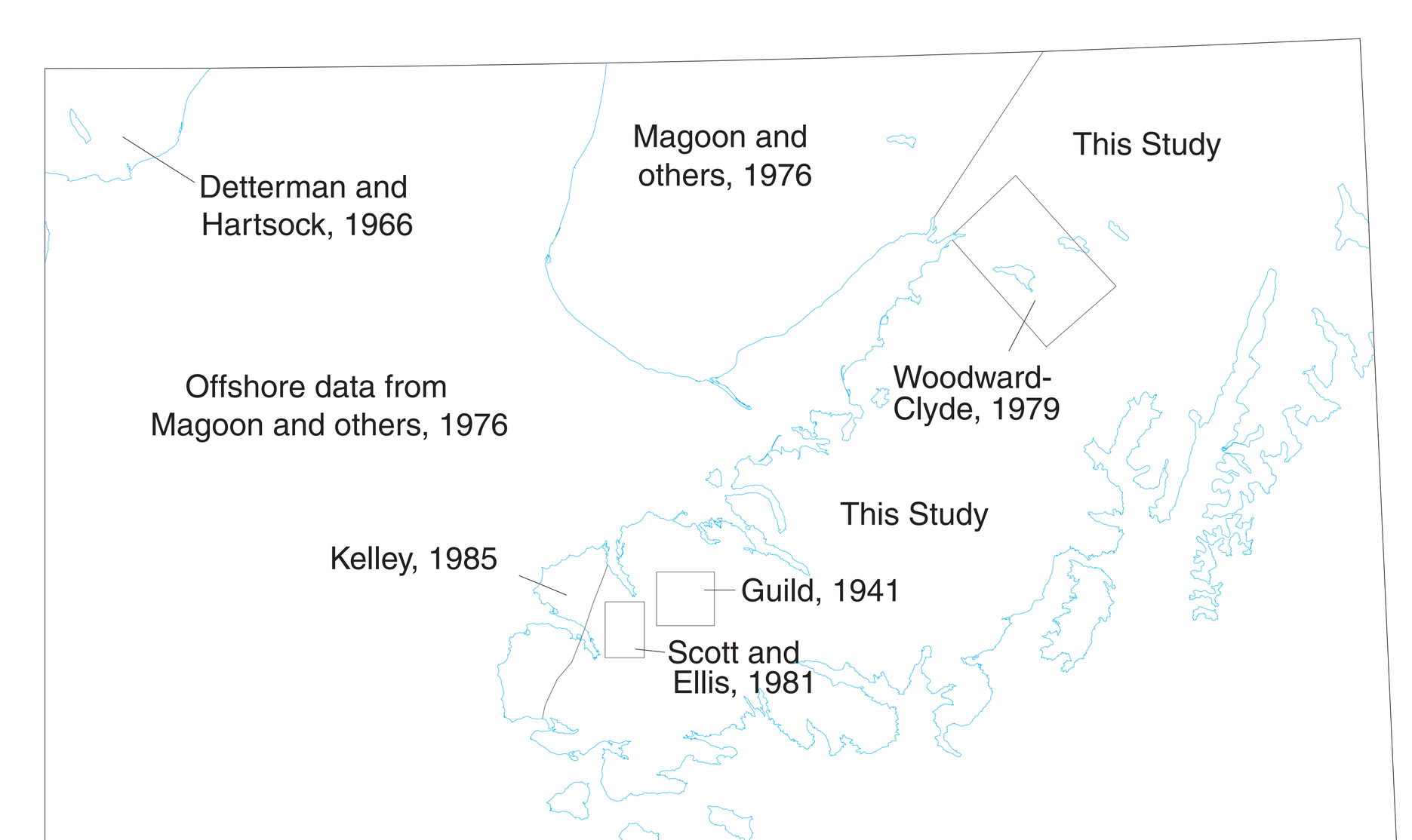
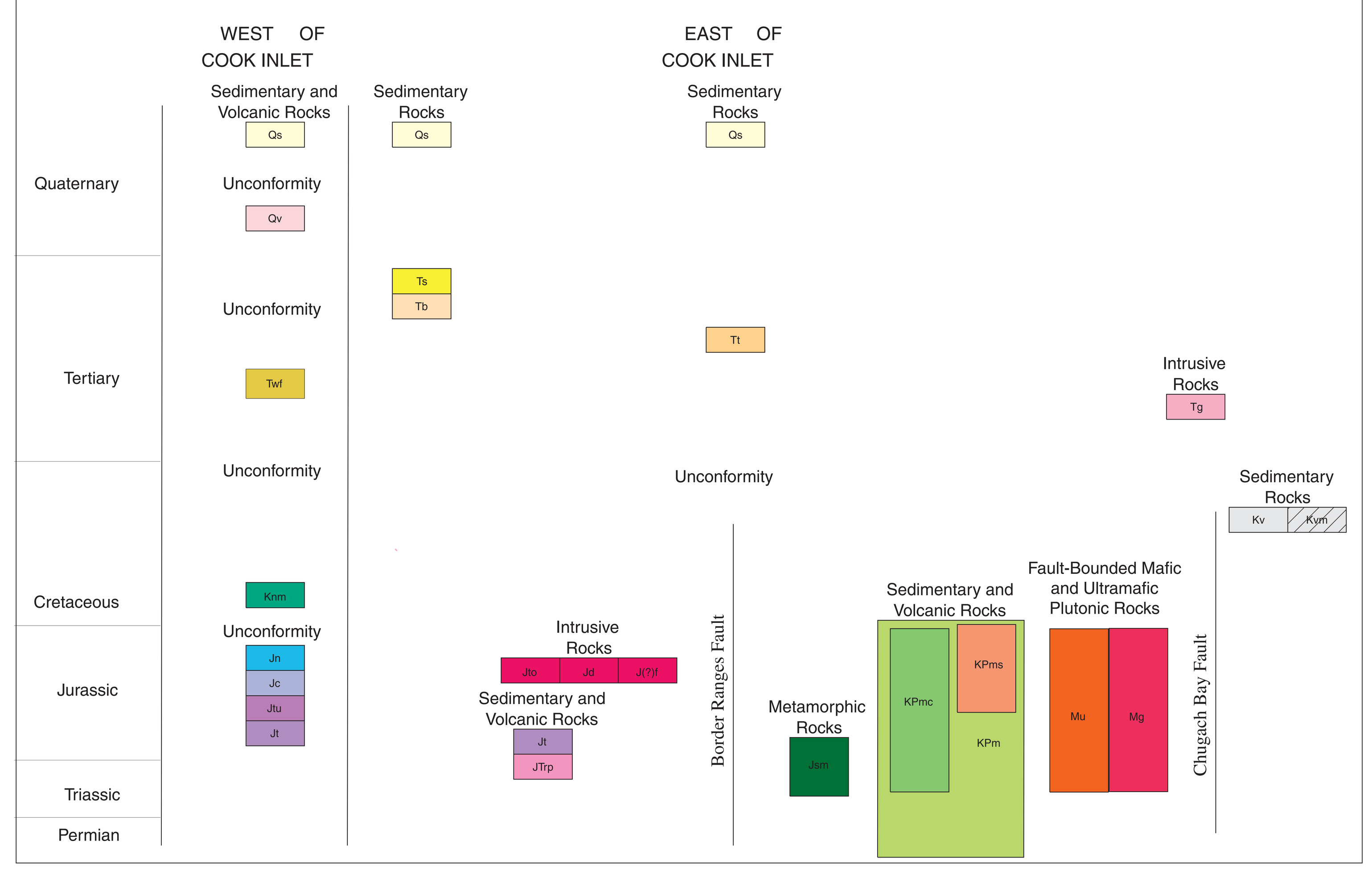


MAP LOCATION



SOURCES OF GEOLOGIC INFORMATION

CORRELATION OF MAP UNITS



5 0 5 10 15 20 25 30 KILOMETERS
5 0 5 10 15 20 STATUTE MILES

Scale 1:250,000

DESCRIPTION OF MAP UNITS

[ ] **Icefields and glaciers** — Many of the larger glaciers have retreated since publication of the USGS 1:63,360-scale topographic maps in the early 1950's. Ice margins were redrawn from 1978-1984 aerial photographs

[Qs] **Surficial deposits (Quaternary)** — Unconsolidated fluvial floodplain, colluvial, glacial, alluvial fan, landslide and swamp deposits

STRATIFIED ROCKS OF THE PENINSULAR TERRANE AND COOK INLET BASIN

[Qv] **Iliamna lava flows (Quaternary)** — Andesitic lava, breccia and pyroclastic rocks from Iliamna Volcano; west of Cook Inlet only

[Ts] **Sterling Formation (Miocene to Pliocene)** — Interbedded, weakly lithified sandstone, siltstone, mudstone, carbonaceous shale, lignite coal and minor volcanic ash. Sandstone fines upward from coarse- to very fine-grained, and occurs in trough-cross-bedded sequences with basal erosional contacts (Flores and others, 1997). Siltstone is typically ripple-laminated, rooted, or burrowed. Heavy minerals from Sterling Formation sandstones include abundant hornblende and hypersthene, believed to have been derived from the Peninsular terrane to the west; near the Kenai Mountains, however, epidote in the heavy-mineral fraction records the continued existence of an easterly source (Kirschner and Lyon, 1973)(see below). The contact between the Beluga and Sterling Formations mapped at the surface is not particularly striking, but is projected to the surface from wells closer to the axis of Cook Inlet Basin, where it does correspond to a major lithologic and provenance change. The Sterling Formation is up to 3050 meters thick in the subsurface (Hartman and others, 1972); only the lowest 700 meters of section are exposed at the surface. Both the Sterling and Beluga Formations (see below) dip no more than a few degrees where exposed in the Seldovia quadrangle; in the subsurface northeast of the Seldovia quadrangle, however, subvertical dips along the limbs of active growth folds are known (Hauessler and others, in press)

[Tb] **Beluga Formation (Miocene)** — Interbedded, weakly lithified sandstone, siltstone, mudstone, carbonaceous shale, coal and minor volcanic ash. Sandstone is medium-to very fine-grained, gray and buff, and typically occurs in fining-upward, trough-cross-bedded sequences with basal erosional contacts marked by lag deposits (Flores and others, 1997). Siltstone is typically ripple-laminated, rooted, or burrowed. Coal beds vary from lignite to subbituminous B in apparent rank (most is subbituminous C) and range in thickness up to about 2 meters (Barnes and Cobb, 1959). Heavy minerals from sandstones include abundant epidote, believed to have been derived from the Chugach terrane to the east (Kirschner and Lyon, 1973). The Beluga Formation is up to 1525 meters thick in the subsurface (Hartman and others, 1972)

[Tt] **Tyonek Formation (Oligocene to Miocene)** — Conglomerate plus subordinate sandstone, siltstone and coal. Crops out only in restricted areas along the southeastern shore of Kachemak Bay, where it fills paleovalleys at the margin of Cook Inlet Basin. Conglomerate clasts are of McHugh Complex,Valdez Group and Tertiary igneous rocks, derived from the Chugach terrane

[Twf] **West Foreland Formation (Eocene)** — Poorly sorted, polymictic conglomerate, graywacke, and siltstone with interbedded tuff and local subaerial basalt flows (Kirschner and Lyon, 1973); minor coal. Derived from Peninsular terrane to the west. Thickness in Seldovia D8 quadrangle is about 335 m (Detterman and Hartsock, 1966). West of Cook Inlet only

[Kk] **Kaguyak Formation (Upper Cretaceous, Maastrichtian)** — Nonmarine sandstone, conglomerate, siltstone, and minor coal are known from a single, 83-meter-thick section near the northern edge of Seldovia D8 quadrangle (Magoon and others, 1980). The sandstone is fine- to medium-grained, massive and cross-bedded, and typically soft and friable. The conglomerate contains clasts to 30 cm of volcanic and plutonic rocks, in a sandy matrix. The coal has yielded Maastrichtian sporomorphs. The map distribution of this unit is extrapolated from the position of the one known section, which lies between the Naknek Formation, below, and the West Foreland Formation, above; both contacts are angular unconformities. Equivalent rocks in the subsurface of Cook Inlet are 744 meters thick (Magoon, 1986)

[Jn] **Naknek Formation (Upper Jurassic, Oxfordian to Kimmeridgian)** — As mapped and described by Detterman and Hartsock (1966) in Seldovia D8 quadrangle, includes three members, each of marine origin. The Lower Sandstone Member consists of fine- to coarse-grained, thin-bedded to massive arkosic sandstone and graywacke. The overlying Snug Harbor Siltstone Member consists of massive to thin-bedded, dark-gray to black siltstone. Lastly, the Pomeroy Arkose Member consists of massive, medium- to coarse-grained arkose. Total thickness in Seldovia quadrangle, estimated from Detterman and Hartsock's (1966) cross section, is approximately 2000 meters. Fossil age is based on ammonites and pelecypods. West of Cook Inlet only

[Jc] **Chinitna Formation (Upper Jurassic, Callovian)** — As mapped and described by Detterman and Hartsock (1966) in Seldovia D8 quadrangle, includes two members, both of marine origin. The Tonnie Siltstone Member consists of massive to thin-bedded, brownish-gray arenaceous siltstone; small limestone concretions occur in parallel bands and minor sandstone occurs at the base.The overlying Paveloff Siltstone Member consists of gray-weathering, massive to thin- bedded siltstone; large concretions and lenticular beds of limestone are present; massive sandstone occurs at the base. Total thickness in Seldovia quadrangle, estimated from figures in Detterman and Hartsock (1966), is approximately 650-685 meters. Abundant ammonites indicate a Callovian age. West of Cook Inlet only

[Jtu] **Tuxedni Group (Middle to Upper Jurassic, Bajocian to Callovian)** — As mapped and described by Detterman and Hartsock (1966) in Seldovia D8 quadrangle, includes six formations, which are listed below from base to top. The Red Glacier Formation consists of massive to thin-bedded red-brown siltstone, massive gray sandstone, tan arkose, and minor black shale. It rests with angular unconformity on the Talkeetna Formation. The overlying Gaikema Sandstone consists of massive graywacke sandstone and cobble conglomerate, and minor siltstone and shale. The Fritz Creek Siltstone, next in the succession, consists of massive to thin-bedded gray siltstone that bears abundant small limestone concretions. The overlying Cynthia Falls Formation consists of massive graywacke sandstone and conglomerate.The Twist Creek Formation, next in the succession, consists of massive to thin-bedded gray siltstone with many small limestone concretions and thin ash beds. The Bowser Formation, at the top of the Tuxedni Group, consists of massive sandstone and conglomerate containing thin interbeds of sandstone and shale. All six formations are of marine origin; ammonites and pelecypods indicate an age range from Bajocian to Callovian. Total thickness in Seldovia quadrangle, estimated from Detterman and Hartsock (1966), is approximately 2400 meters. West of Cook Inlet only

[Jt] **Talkeetna Formation (Lower Jurassic; Hettangian toToarcian)** — West side of Cook Inlet: as mapped and described by Detterman and Hartsock (1966), consists of massive volcanic breccia, agglomerate, tuff, andesitic lava flows and volcaniclastic sedimentary rocks. Thickness is estimated at 2500-2750 meters. East side of Cook Inlet: corresponds to the informally named Pogibshi Formation of Kelley (1980, 1984), which consists of at least 5270 meters of andesite and dacite tuff, volcaniclastic conglomerate, sandstone, and mudstone, and minor coal and limestone. On both sides of Cook Inlet, ammonites in the Talkeetna Formation indicate that at least some deposition was under marine conditions. Coal, however, indicates nonmarine deposition for some strata east of Cook Inlet

[JTrp] **Port Graham Formation (Upper Triassic and Lower Jurassic)** — As mapped and described by Kelley (1980, 1984), characterized by dark-gray, carbonaceous limestone and silty limestone; also includes tuff, tuffaceous sedimentary rocks, and chert. Estimated minimum thickness is 1500 meters. Bivalves indicate a Late Triassic (Norian) age for most of the unit; the upper 240 meters is assigned to the Lower Jurassic based on fossils reported by Martin and others (1915). East of Cook Inlet only

INTRUSIVE ROCKS OF THE PENINSULAR TERRANE

[Jd] **Diorite of Point Bede (Jurassic)** — Fine- to medium-grained, nonfoliated quartz diorite consisting chiefly of plagioclase, quartz, chloritized biotite, and chloritized hornblende (Kelley, 1980). The Point Bede pluton is undated but is assumed to be roughly coeval with a quartz diorite pluton along strike in the Barren Islands, just south of Seldovia quadrangle, which yielded a K/Ar hornblende age of 187±1.3 Ma (Cowan and Boss, 1978)

[Jto] **Tonalite of Dogfish Bay (Jurassic)** — Medium-grained, nonfoliated tonalite consisting of plagioclase, quartz, and chloritized biotite; known only from shoreline exposures of Koyuktolik (Dogfish) Bay. Undated but mostly likely Jurassic, which is the age of isotopically dated intrusive rocks of the Peninsular terrane south of the Seldovia quadrangle. Moreover, chloritic alteration is very similar to that in the Point Bede diorite

[J(?)f] **Felsite (Jurassic?)** — Fine-grained, aphanitic, light gray felsite; known only from the unnamed peninsula south of Koyuktolik (Dogfish) Bay. Undated but mostly likely Jurassic in age, coeval with dated intrusive rocks of the Peninsular terrane south of the Seldovia quadrangle; alternatively, the felsite could be early Tertiary

STRATIFIED AND METAMORPHIC ROCKS OF THE CHUGACH TERRANE

[Jsm] **Seldovia metamorphic complex (Early Jurassic metamorphic age)** — Marble, quartzite, garnet-mica schist, and glaucophane-bearing amphibolite. These rocks represent metamorphosed limestone, chert, argillite, and greenstone, respectively. White-mica separates from two schist samples have yielded $^{40}Ar/^{39}Ar$ plateau ages of 191.1±0.3 and 191.7±0.3 Ma; hornblende from the second sample yielded a plateau age of 191.9±0.6 Ma (A.Till, written communication, 1995). Occupies a series of narrow fault slices along the Border Ranges fault zone

McHugh Complex (main protoliths are Triassic, Jurassic and Early Cretaceous; rare exotic(?) blocks are Permian; accreted during Jurassic and Cretaceous)

[KPm] **McHugh Complex, undivided** — A complexly deformed tectonic assemblage of argillite, tuff, graywacke, basalt, chert, mesoscale (outcrop-scale) melange, conglomerate, gabbro, and limestone. These rock types are distributed in fault-bounded tracts that have experienced variable, but generally severe, internal deformation. Some of the rocks occur as "matrix" of relatively less competent material between adjacent, more competent "blocks", which range in size from millimeters to several kilometers across. The matrix is typically argillite, with variable amounts of chert, graywacke and tuff. Despite structural disruption, locally preserved stratigraphic relations and fossil ages permit reconstruction of an original ocean-plate stratigraphy, which from base to top consists of ultramafic rocks, gabbro, Triassic to mid-Cretaceous basalt and chert (see below), argillite and graywacke; this succession — or parts of it — is repeated by innumerable faults, mostly subduction-zone thrusts. Mappable areas where one or two rock types predominate have been subdivided, as described below. Exotic limestone blocks, none large enough to map at 1:250,000 scale, occur throughout the McHugh Complex. Permian conodonts (A. Harris, written commun., 1994) and fusilinids (Stevens and others, 1997) of Tethyan affinity have been found in some blocks. (Radiolarian and conodont data from the McHugh Complex will be presented elsewhere.) Regionally metamorphosed to prehnite-pumpellyite facies

[KPms] **McHugh Complex, graywacke and conglomerate** — Occurs in fault-bounded slices that range up to several kilometers in structural thickness; similar rocks also occur throughout the undivided McHugh Complex in fault slices that are too small to be mapped at 1:250,000. Deformation has obliterated primary sedimentary features in most outcrops. The conglomerate and massive graywacke occur in thick, amalgamated bodies of turbiditic origin. Less abundant thin- and medium-bedded turbidites have been recognized. Graywacke is matrix-supported and poorly sorted; clast population consists of predominant chert and volcanic rock fragments, and subordinate quartz and feldspar. At one location, graywacke conformably overlies ribbon chert that yielded Pliensbachian (Early Jurassic) radiolarians (C. Blome, written communication, 1994). Regionally, the graywacke is believed to range in age from Pliensbachian through Early Cretaceous

[KPmc] **McHugh Complex, basalt and chert** — Pillow and massive basalt, depositionally overlain by complexly folded and faulted radiolarian chert. Three belts of basalt and chert are large enough to be mapped separately at 1:250,000 scale; similar belts occur throughout the undivided McHugh Complex in fault slices that are too small to be mapped at 1:250,000. The basalt includes pillow basalt, pillow breccia, and massive basalt; it is typically altered and metamorphosed to prehnite-pumpellyite facies. The chert includes gray, green, red, and black radiolarian-bearing chert, interbedded at centimeter scale with argillite. Radiolarians from bedded chert in the Seldovia quadrangle range in age from Middle Triassic (Ladinian) to Early Cretaceous (Albian) (C. Blome, written communication, 1994). The chert shows intense outcrop-scale folding at most exposures; its original stratigraphic thickness is unknown

Valdez Group (Upper Cretaceous; Campanian? to Maastrichtian)

[Kv] **Valdez Group** — Turbiditic sandstone, siltstone, and slate, plus subordinate conglomerate. Common facies include thin-bedded silt- to fine sandstone turbidites in graded couplets a few cm thick; medium-bedded turbidites in partial or complete Bouma sequences up to about 1 m thick; and thick-bedded coarse- to medium-grained sandstone in amalgamated beds many meters thick. Some very thick sandstone bodies contain cobble-size clasts of quartzite, intermediate and felsic volcanic rocks, and rare sandstone, limestone, and granitic rocks. Graywacke is moderately well-sorted; clast population consists of predominant quartz and feldspar, common volcanic rock fragments, and, in contrast to graywacke of the McHugh Complex, only rare chert. Metamorphosed to greenschist facies, except near large plutons, which are surrounded by concentric contact aureoles at biotite and cordierite grades. Stratigraphic thickness cannot be accurately measured owing to tight- to isoclinal folding and imbrication, but an apparently homoclinal section across Nuka Island, which has no known structural complications, has an estimated thickness of 6.5 km. The Valdez Group is Maastrichtian and possibly Campanian in age based on widely distributed, but rare, occurrences of the bivalve *Inoceramus* (Tysdal and Plafker, 1978); one collection from the Seldovia quadrangle has this same age range.

[Kvm] **Melange of Iceworm Peak (informal)** — Tectonic melange consisting of blocks of graywacke in a phacoidally cleaved matrix of slate; protolith of both blocks and matrix is the Valdez Group. Mainly crops out in a belt immediately below (east of) the Chugach Bay thrust fault, as described by Kusky and others (1997). Smaller areas of melange within the rest of the Valdez Group have not been mapped separately

INTRUSIVE ROCKS OF THE CHUGACH TERRANE

[Tg] **Granodiorite (Eocene)** — Medium- and coarse-grained biotite granodiorite. Occurs in three large plutons (Nuka, Aialik, and Tustumena), and numerous smaller stocks. A point count of a stained slab from the Aialik pluton showed 39% plagioclase, 31% quartz, 16% potassium feldspar, and 13%biotite. The Nuka pluton yielded a U-Pb monazite age of 56.0 ± 0.5 Ma (R. Parrish, written communication, 1998) and a $^{40}Ar/^{39}Ar$ biotite isochron age of 54.2±0.08 Ma (W. Clendenin, written communication, 1989). The Tustumena pluton yielded a $^{40}Ar/^{39}Ar$ biotite plateau age of 53.2±1.1 Ma (D. Lux, written communication, 1994). The Chernof stock yielded a $^{40}Ar/^{39}Ar$ biotite plateau age of 54.0±1.1 Ma (D. Lux, written communication, 1994). The Paguna stock, presumably a satellite of the Aialik pluton, yielded a $^{40}Ar/^{39}Ar$ plateau age of 53.4±1.5 (D. Lux, oral communication, 1994). A granodiorite sill at Thunder Bay yielded a $^{40}Ar/^{39}Ar$ biotite plateau age of 53.7±0.1 Ma (Haeussler and others, 1995). Granodiorite of the Nuka and Aialik plutons locally displays a weak tectonic foliation; the other bodies are unfoliated

[Td] **Intermediate, felsic, and mafic dikes (early Tertiary)** — Dikes of dacite, rhyolite, andesite, and rare basalt that intrude rocks of theValdez Group and McHugh Complex. One intermediate dike yielded a $^{40}Ar/^{39}Ar$ age isochron age of 57.0±0.22 Ma (W. Clendenin, written communication, 1989)

[Kd] **Intermediate dike (Early Cretaceous)** — One basaltic andesite dike containing hornblende phenocrysts is differentiated from the Eocene dikes, unit Td, on the basis of its isotopic age. It has yielded an Early Cretaceous $^{40}Ar/^{39}Ar$ hornblende plateau age of 115±2 Ma (D. Lux, written communication, 1994). Dike intrudes McHugh Complex; some other dikes mapped as part of the early Tertiary dike swarm may, instead, belong to this Early Cretaceous set

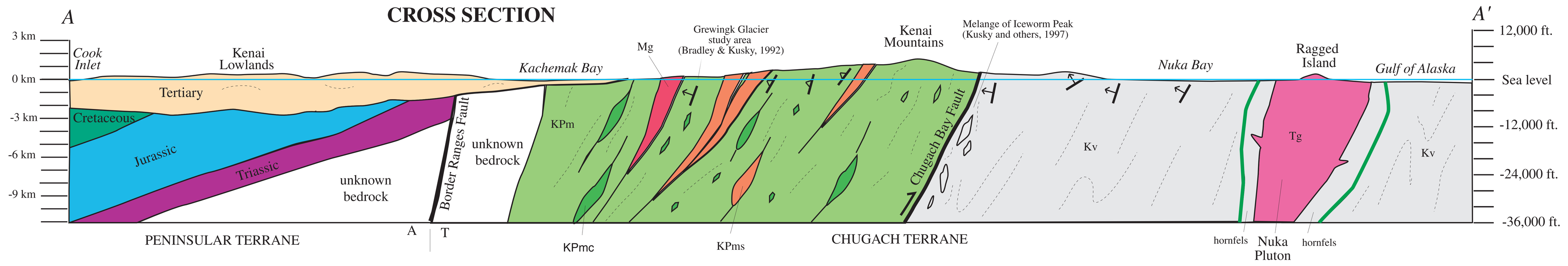
[Mg] **Gabbro (Mesozoic)** — Dark green medium- to coarse-grained gabbro and minor leucogabbro and plagiogranite. Occurs in four mappable, fault- bounded bodies within the McHugh Complex, and in numerous others that are too small to map. Associated with McHugh Complex pillow basalt in several places including Grewingk Glacier (Bradley and Kusky, 1992), suggesting a genetic relationship. If so, its age may range from Triassic to mid-Cretaceous

[Mu] **Ultramafic plutonic rocks (Mesozoic)** — Predominantly layered, variably serpentinized dunite; rare to locally abundant layers of chromitite and pyroxenite; and fault slices of garnet pyroxenite and serpentinite. The ultramafic rocks occur in at least seven known bodies within the McHugh Complex, all of them known or interpreted to be fault-bounded. The Red Mountain body was previously interpreted as a klippe (Magoon and others, 1976), but our mapping has shown it to be bounded on all sides by subvertical, late-stage faults; a thrust-fault may, however, bound the body at depth. Ultramafic rocks at the Snow Prospect are bounded below and above by such low-angle thrust-faults (Scott and Ellis, 1981). The ultramafic rocks are associated with gabbro at Halibut Cove and at a small fault sliver about 9 km east of the head of Tutka Bay. If, as suspected, the ultramafic rocks and gabbros are comagmatic, then the ultramafic rocks also range in age from Triassic to mid-Cretaceous. Included by Burns (1985) in her Border Ranges ultramafic and mafic complex

MAP SYMBOLS

- Contact — Dashed where approximately located, dotted where concealed
- Fault — Dashed where approximately located, dotted where concealed
- Thrust fault — Dashed where approximately located, dotted where concealed; teeth on upper plate
- A,T In cross section, indicates sense of relative fault motion away (A) and toward (T) observer
- Anticline
- Syncline
- Cordierite-in (C) and biotite-in (B) isograds in metagraywacke and metapelite; letter on index mineral side
- Exploration well
- 45 Strike and dip of beds, tops unknown
- 45 Strike and dip of beds, upright
- 85 Strike and dip of overturned beds
- 85 Strike and dip of cleavage or foliation

CROSS SECTION



GEOLOGY OF THE SELDOVIA QUADRANGLE

PHYSIOGRAPHY AND NEOTECTONICS

The quadrangle can be broadly subdivided into five physiographic provinces. (1) TheAlaska Peninsula, in the extreme northwest corner of the quadrangle, is part of a heavily glaciated, active volcanic arc built on the eroded remnants of a Mesozoic arc. The summit of Iliamna Volcano lies just 6 km northwest of the northwestern corner of Seldovia quadrangle; a shoulder of the mountain, and some Recent lava flows, lie within the quadrangle. (2) Cook Inlet, and (3) the Kenai Lowlands, are the offshore and onshore parts of the Cook Inlet forearc sedimentary basin, which has subsided intermittently from Jurassic to present, and which contains significant oil, gas, and coal resources. (4) The Kenai Mountains, part of the Chugach Mountains, are principally underlain by an accretionary prism that has been uplifted along an outer-arc high. The Kenai Mountains here reach a maximum height of 6612' at Truuli Peak; they host two icefields and many smaller glaciers. The southeastern coast of the Kenai Peninsula is marked by fiords and drowned cirques that form spectacular "biscuit-board" topography. Offshore to the southeast lies (5) the continental shelf, a region of fairly rugged submarine topography. Water depths on the shelf are generally less than 200 m except in a few glacially scoured depressions fairly close to shore, and in the extreme southeastern corner of the map. About 200 km southeast of that point lies the axis of the Aleutian Trench, where water depths exceed 4 km.

The Seldovia Quadrangle lies within the arc-trench gap of an active subduction zone that dips beneath south-central Alaska and the Aleutians.The subduction zone is the boundary between the North American plate and the Pacific plate, which are converging at a rate of about 6 cm per year; the Pacific seafloor has descended hundreds of kilometers into the earth's mantle beneath the Alaskan Peninsula. Subduction is ultimately responsible for the the main features of the bedrock geology of the Seldovia quadrangle, the many earthquakes, the frequent explosive eruptions of the Cook Inlet volcanoes, and some very pronounced long-term uplift and subsidence of the Kenai Mountains. The top of the subducted plate is located about 100 km below Mt. Iliamna in the northwestcorner of the quadrangle, but less than 50 km below the continental shelf in the southeast corner of the quadrangle. The March 27, 1964 earthquake (Mw = 9.2) resulted in net tectonic subsidence throughout most of the Seldovia Quadrangle, with maximum subsidence >6 meters along a NE-trending axis through McCarthy Fiord (Plafker, 1969). Curiously, the pattern of vertical motions related to the 1964 earthquake did not reinforce the present-day physiography. Both the Kenai Lowlands and the Kenai-Chugach Mountains underwent net subsidence, while much of the continental shelf was uplifted.

BEDROCK GEOLOGY

The Alaska Peninsula, Cook Inlet Basin, and southwesternmost Kenai Mountains are underlain by rocks assigned to Peninsular terrane (see summary in Nokleberg and others, 1994). The Mesozoic succession of the Alaska Peninsula includes Upper Triassic, Lower-, Middle-, and Upper Jurassic, and Upper Cretaceous strata; much of the section is made up of volcaniclastic and volcanic rocks that formed along a magmatic arc. The Jurassic section, which dips moderately southeast, away from the plutonic core of the Alaska Peninsula, is one of the thickest and most complete in the world. Cook Inlet Basin contains a nonmarineTertiary section that is nearly 8 km thick in the deepest part of the basin (Calderwood and Fackler 1972). The Tertiary rocks exposed at the surface are only weakly consolidated in places; nonetheless, strata definitely as young as Pliocene - and probably as young as Quaternary - have been involved in regional folding (Haeussler and others, in press).

The Kenai Mountains are underlain by accreted ocean-floor rocks assigned to the Chugach terrane (Plafker and others, 1994), which is divided into three main units: the Seldovia Metamorphic Complex, McHugh Complex, and Valdez Group. Farthest northwest is a narrow, fault-bounded package called the Seldovia Metamorphic Complex. It consists of amphibolite, schist, quartzite, marble, and dolostone - the metamorphic equivalents of volcanic, clastic sedimentary, and carbonate rocks. The origins of these protoliths remains to be investigated. Metamorphism occurred in Early Jurassic at conditions of high pressure and low temperature that are characteristic of the deep parts of subduction zones; this subduction zone may have been the same one that produced the coeval arc-related rocks of the Peninsular terrane. The Seldovia Metamorphic Complex is separated from rocks on either side by strands of the Border Ranges fault system, which is thought to have originated as a subduction-related thrust but which has since experienced strike-slip and possibly normal displacements. The next belt to the east is the McHugh Complex, which consists of intensely deformed sedimentary and volcanic rocks scraped off the deep-sea floor at the subduction zone. The main rock types are graywacke, chert, pillow basalt, tuff, gabbro, ultramafic rocks, and limestone, each of which occur as tectonically bounded blocks; and argillite, which forms a foliated matrix that surrounds the blocks. The blocks-in-matrix structure, which is typical of tectonic melanges formed at subduction zones, appears to be similar at all scales from 1:250,000 down to that of a thin section. The geologic map shows the distribution of some of the larger tracts of basalt and chert, graywacke, and ultramafic rocks. The remaining parts of the McHugh Complex are mostly tectonic melange containing blocks that are too small to show at 1:250,000 scale. Despite structural disruption, locally preserved stratigraphic relations and fossil ages within the McHugh Complex permit a crude reconstruction of a diachronous oceanic-plate stratigraphy consisting, from base to top, of basalt, chert, argillite, and graywacke (Bradley and Kusky, 1992). Chert and the basalt on which it rests range in age from Middle Triassic (Ladinian) to mid-Cretaceous (Albian-Aptian; the graywacke is known to be as old as Early Jurassic (Pliensbachian) at the one locality where it is adequately dated, but the graywacke in other belts is likely to be as young as mid-Cretaceous. The Permian limestone blocks are inferred to represent the tops of seamounts that were clipped off a now-subducted tract of Paleozoic ocean floor (Stevens and others, 1997). The farthest-seaward and youngest accreted rocks belong to the Valdez Group of Late Cretaceous age, which is made up of weakly metamorphosed (chlorite-grade), isoclinally folded graywacke and slate. It is inferred to have been deposited along the axis of a deep-sea trench, and to have been immediately conveyed into the subduction zone, where it was deformed. The Valdez Group is separated from the McHugh Complex by the Chugach Bay thrust fault (Kusky and others, 1997). Along the thrust fault, the Valdez Group has been deformed into a tectonic melange of graywacke blocks in a slate matrix. The McHugh Complex and Valdez Group are cut by early Tertiary intrusive rocks in bodies ranging in size from batholiths down to dikes less than a meter thick. The larger plutons are granodiorite; the dikes include all compositions from rhyolite to basalt, the most abundant being dacite and rhyodacite. These igneous rocks were intruded anomalously close to the paleo-trench; they are inferred to mark the site where an oceanic spreading center between the Kula and Farallon plates was subducted beneath the Chugach terrane (Bradley and others, 1993).

Cross section A-A' is a schematic representation of the main geologic features of the Kenai Peninsula in the Seldovia quadrangle. In the Chugach terrane, bedding and foliation typically dip steeply landward; individual beds young landward, but owing to the broad-scale imbricate structure that is typical of accretionary wedges, the oldest rocks are farthest landward. In the McHugh Complex, fault slices of chert and basalt, and of graywacke, are shown schematically in the subsurface. The Nuka pluton is broadly concordant and hence is drawn with a steep landward dip. The relatively simple forearc basin structure ofKachemak Bay and the Kenai Lowlands is adapted from Fisher and Magoon (1978). Note that the Tertiary fill of Cook Inlet basin overlaps the fault contact between the Chugach and Peninsular terranes.

MINERAL DEPOSITS, PROSPECTS, AND OCCURRENCES

Podiform chromite has been mined at two ultramafic bodies: Red Mountain and Claim Point (Foley and Barker, 1985); a third body, the Snow Prospect, has seen exploration activity (Scott and Ellis, 1981). The chromite layers formed as magmatic cumulates in plutons consisting mostly of dunite and lesser pyroxenite. A placer chromite resource has been identified in the valley of Windy River, draining the Red Mountain ultramafic body (Foley and Barker, 1985). Small lode-gold deposits were mined quite extensively in the Nuka Bay mining district from 1920 to 1940 (Richter, 1970). Gold-bearing veins are hosted in turbidites of the Valdez Group or in Tertiary dikes; sericite from gold-bearing veins has yielded $^{40}Ar/^{39}Ar$ plateau ages of 52.9±0.1, 55.6+0.1, 55.9±0.1, and 57.3±0.1 Ma, coeval with the near-trench intrusive rocks (unit Tg) and presumably related to subduction of the Kula-Farallon spreading center (Haeussler and others, 1995). There are no significant placer gold deposits near any of the known lode sources in the Kenai Mountains, presumbly owing to the intensity of Pleistocene and Recent glacial scouring. Beach placers have been worked, unsuccessfully, at Anchor Point (Cobb, 1979, p.8). During geochemical sampling during the present study, placer gold was found, albeit in subeconomic concentrations, in many streams of the Kenai Lowlands (Cieutat and others, 1992). We discovered bedded manganese interlayered with Early Jurassic chert of the McHugh Complex at Grewingk Glacier; rhodonite occurs in a 65-cm-thick bed. The manganiferous horizon, unfortunately, cannot be traced more than a few meters owing to structural complications. The coal, oil, and gas resources of the Seldovia quadrangle were not investigated in the present study, but are discussed in reviews by Warhaftig and others (1994) and Magoon and others (1994).

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REFERENCES CITED

Barnes, F.F., and Cobb, E.H., 1959, Geology and coal resources of the Homer District, Kenai coal field, Alaska: U.S. Geological Survey Bulletin 1058-F, p. 217-260.

Bradley, D.C., and Kusky, T.M., 1992, Deformation history of the McHugh Complex, Seldovia quadrangle, south-central Alaska: U.S. Geological Survey Bulletin 1999, p. 17-32.

Bradley, D.C., Haeussler, P., and Kusky, T.M., 1993, Timing of Early Tertiary ridge subduction in southern Alaska: U.S. Geological Survey Bulletin 2068, p. 163-177.

Bradley, D.C., Kusky, T.M., Karl, S.M., and Haeussler, P.J., 1997, Field guide to the Mesozoic accretionary complex along Turnagain Arm and Kachemak Bay, south-central Alaska: *in* S.M. Karl, N.R. Vaughan, and T.J. Ryherd, eds., 1997 Guide to the Geology of the Kenai Peninsula, Alaska: Alaska Geological Society, Anchorage, Alaska, p. 2-12.

Burns, L., 1985, The Border Ranges ultramafic and mafic complex, south-central Alaska: Cumulate fractionates of island-arc volcanics: Canadian Journal of Earth Science, v. 22, p. 1020-1038.

Calderwood, K.W., and Fackler, W.C., 1972, Proposed stratigraphic nomenclature for Kenai Group, Cook Inlet Basin, Alaska: AAPG Bulletin, v. 56, p. 739-754.

Cieutat, B.A., Goldfarb, R.J., Bradley, D.C., and Roushey, B.H., 1992, Placer gold of the Kenai Lowland: U.S. Geological Survey Bulletin 2041, p. 23-29.

Cobb, E.H., 1979, Summary of mineral occurrences (other than mineral fuels and construction materials) in the Seldovia quadrangle, Alaska: U.S. Geological Survey Open-File Report 80-87, 47 p.

Cowan, D.S., and Boss, R.F., 1978, Tectonic framework of the southwestern Kenai Peninsula, Alaska: Geological Society of America Bulletin, v. 89, p.155-158.

Detterman, R.L., and Hartsock, J.K., 1966, Geology of the Iniskin-Tuxedni region, Alaska: U.S. Geological Survey Professional Paper 512, 78 p., scale 1:63,360.

Fisher, M.A., and Magoon, L.B., 1978, Geologic framework of lower Cook Inlet, Alaska: American Association of Petroleum Geologists Bulletin, v. 62, p. 373-402.

Flores, R.M., Stricker, G.D., and Bader, L.R., 1997, Stratigraphic architecture of the Tertiary alluvial Beluga and Sterling Formations, Kenai Peninsula, Alaska: *in* S.M. Karl, N.R. Vaughan, and T.J. Ryherd, eds., 1997 Guide to the Geology of the Kenai Peninsula, Alaska: Alaska Geological Society, Anchorage, Alaska, p. 36-53.

Foley, J.Y., and Barker, J.C., 1985, Chromite deposits along the Border Ranges fault, southern Alaska: Part 1, Field investigations and descriptions of chromite deposits: U.S.Bureau of Mines Information Circular 8990, 57 p.

Hartman, D.C., Pessel, G.H., and McGee, D.L., 1972, Preliminary report on the stratigraphy of the Kenai Group, upper Cook Inlet Basin, Alaska: Alaska Div. of Mines and Minerals, Spec. Rept. 5.

Haeussler, P., Bradley, D., Goldfarb, R., and Snee, L., 1995, Link between ridge subduction and gold mineralization in southern Alaska: Geology, v. 23, p. 995-998.

Haeussler, P., Bruhn, R.L., and Pratt, T.L., in press, Quaternary deformation in upper Cook Inlet, Alaska: Geological Society of America Bulletin, 36 MS pp., 3 tables, 9 figures.

Karl, S., Reger, R., Pinney, D., Bradley, D., Swenson, R., Combellick, R., Kurtak, J., Haeussler, P., and Brimberry, D., 1997, Road Log for the 1997 Guide to the Geology of the Kenai Peninsula, Alaska: *in* S.M. Karl, N.R. Vaughan, and T.J. Ryherd, eds., 1997 Guide to the Geology of the Kenai Peninsula, Alaska: Alaska Geological Society, Anchorage, Alaska, p. 2-12.

Kelley, J.S., 1980, Environment of deposition and petrography of Lower Jurassic volcaniclastic rocks, southwestern Kenai Peninsula, Alaska: Univ. of California, Davis, Ph.D. dissertation, 304 p.

Kelley, J.S., 1984, Geologic map and sections of the southwestern Kenai Peninsula west of Port Graham, Alaska: U.S. Geological Survey Open File Report 84-152, scale 1:63,360.

Kirschner, C.E., and Lyon, C.A., 1973, Stratigraphic and tectonic development of Cook Inlet petroleum province: AAPG Bulletin, Memoir 19, p. 396-407.

Kusky, T., Bradley, D., Haeussler, P., and Karl, S.J., 1997, Controls on accretion of flysch and melange belts at accretionary margins: Evidence from the Chugach Bay thrust and Iceworm melange, Chugach accretionary wedge, Alaska: Tectonics, v.16, p. 855-878.

Magoon, L.B., 1986, Stratigraphic units of the COST no. 1 well: U.S. Geological Survey Bulletin 1596. p. 17-22.

Magoon, L.B., 1994, Petroleum resources in Alaska, *in* Plafker, G., and Berg, H.C., eds., The Geology of Alaska: Geological Society of America, The Geology of North America, v. G1, p. 905-936.

Magoon, L.B., Adkison, W.L., and Egbert, R.M., 1976, Map showing geology, wildcat wells, Tertiary plant fossil localities, K-Ar age dates, and petroleum operations, Cook Inlet area, Alaska, U.S. Geological Survey Map I-1019, 1:250,000.

Magoon, L.B., Griesbach, F.B., and Egbert, R.M., 1980, Nonmarine Upper Cretaceous rocks, Cook Inlet, Alaska: AAPG Bulletin, v. 64, p. 1259-1266.

Martin, G.C., Johnson, B.L., and Grant, U.S., 1915, Geology and mineral resources of Kenai Peninsula, Alaska, U.S. Geological Survey Bulletin 587, 243 pp.

Nokleberg,W.J., Plafker, G., and Wilson, F.H., 1994, The geology of south-central Alaska: *in* Plafker, G., and Berg, H.C., eds., The Geology of Alaska: Geological Society of America, The Geology of North America, v. G1, p. 311-366.

Plafker, G., 1969, Tectonics of the March 27, 1964 Alaska earthquake: U.S. Geological Survey Professional Paper 543-I, I1-I74.

Plafker, G., Moore, J.C., and Winkler, G.R., 1994, Geology of the southern Alaska margin, *in* Plafker, G., and Berg, H.C., eds., The Geology of Alaska: Geological Society of America, The Geology of North America, v. G1, p. 389-449.

Richter, D.H., 1970, Geology and lode-gold deposits of the Nuka Bay area, Kenai Peninsula, Alaska: U.S. Geological Survey Professional Paper 625-B, 16 pp.

Scott, R.W., and Ellis, W.T., 1981, Snow Prospect: Anaconda Mineral Company internal report, 34 p.

Stevens, C.H., Davydov, V.I., and Bradley, D.C., 1997, Permian Tethyan fusilinids from the Kenai Peninsula, Alaska: Journal of Paleontology, v. 71, p. 985-994.

Tysdal, R.G., and Case, J.E., 1979, Geologic map of the Seward and Blying Sound quadrangles, Alaska, U.S. Geological Survey Map I-1150, 1:250,000.

Tysdal, R.G., and Plafker, G., 1978, Age and continuity of the Valdez Group, southern Alaska, U.S. Geological Survey Bulletin 1457-A, p. A120-A124.

Warhaftig, C., Bartsch-Winkler, S., and Stricker, G.D., 1994, Coal resources in Alaska, *in* Plafker, G., and Berg, H.C., eds., The Geology of Alaska: Geological Society of America, The Geology of North America, v. G1, p. 937-978.

Woodward-Clyde Consultants, 1979, Reconnaissance Geology, Bradley Lake Hydroelectric Project: Army Corps of Engineers, Contract No.85-79C-0045, 65 p., scale 1:24,000.

GEOLOGIC MAP OF THE SELDOVIA QUADRANGLE, SOUTH-CENTRAL ALASKA

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