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The Alaska Peninsula Terrane; a definition

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This map is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

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The Alaska Peninsula Terrane; a definition

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Introduction

The Alaska Peninsula (fig. 1), long thought to be an area with a simple geologic and tectonic history, is proving to have had a long and involved history since Paleozoic time. Burk (1965) contributed fundamental data to our modern understanding of the region and laid out the basis for our tectonic reconstructions. Stone and Packer (1977) reported results of paleomagnetic investigations which suggested that since Jurassic time the Alaska Peninsula has migrated thousands of kilometers northward from a position south of the equator. Somewhat tongue-in-cheek, they called this allochthonous terrane "Baja Alaska" and left its geologic definition to others. Jones and Silberling (1979), in a report discussing allochthonous terranes of mainland Alaska, designated a Peninsular terrane and defined it briefly based on its Mesozoic stratigraphy. In this report we extend and largely redefine the terrane on the basis of a more complete stratigraphy and conceptually different framework. To reflect this redefinition we propose the terrane be called the Alaska Peninsula terrane. This is a preliminary report and reflects our current ideas on the Alaska Peninsula Terrane. It is intended that a more complete summary of the analysis of our data and investigations will be published in a formal manner, covering tectonic and stratigraphic revisions and additions. We suggest that the Alaska Peninsula terrane comprises two distinct but tectonically related sub-terranes. We use the concept of sub-terranes, introduced by Berg and others (1978) here in order to be able to distinguish between distinct but geologically related terranes. In this particular case, the two sub-terranes share a limited common geologic history; one has served from time to time as a source area for the other and some rock units are in common. The two sub-terranes have probably always been in close proximity.

These sub-terranes are: (1) Paleozoic and early Mesozoic rocks intruded by the Alaska-Aleutian Range batholith (Reed and Lanphere, 1973) of Jurassic to mid-Tertiary age and including the batholith itself, and (2) Permian to latest Cretaceous little deformed fossiliferous sedimentary rocks of the Alaska Peninsula proper and contiguous areas. These two sub-terranes, herein referred to as the "Iliamna" and "Chignik" sub-terranes, respectively. The Iliamna and Chignik sub-terranes are separated by the Bruin Bay fault system north of Becharof Lake. South of Becharof Lake, aeromagnetic and drillhole data suggest the continuation of the Iliamna sub-terrane. However, continuation of the Bruin Bay fault south of Becharof Lake has not been demonstrated on the surface or in the subsurface. Together these two sub-terranes constitute what is herein referred to as the Alaska Peninsula terrane.

Iliamna sub-terrane

The Iliamna sub-terrane, named after exposures in the Iliamna quadrangle, is composed of moderately deformed early Mesozoic marine sedimentary and volcanic rocks and schist, gneiss, and marble of Paleozoic and Mesozoic age.

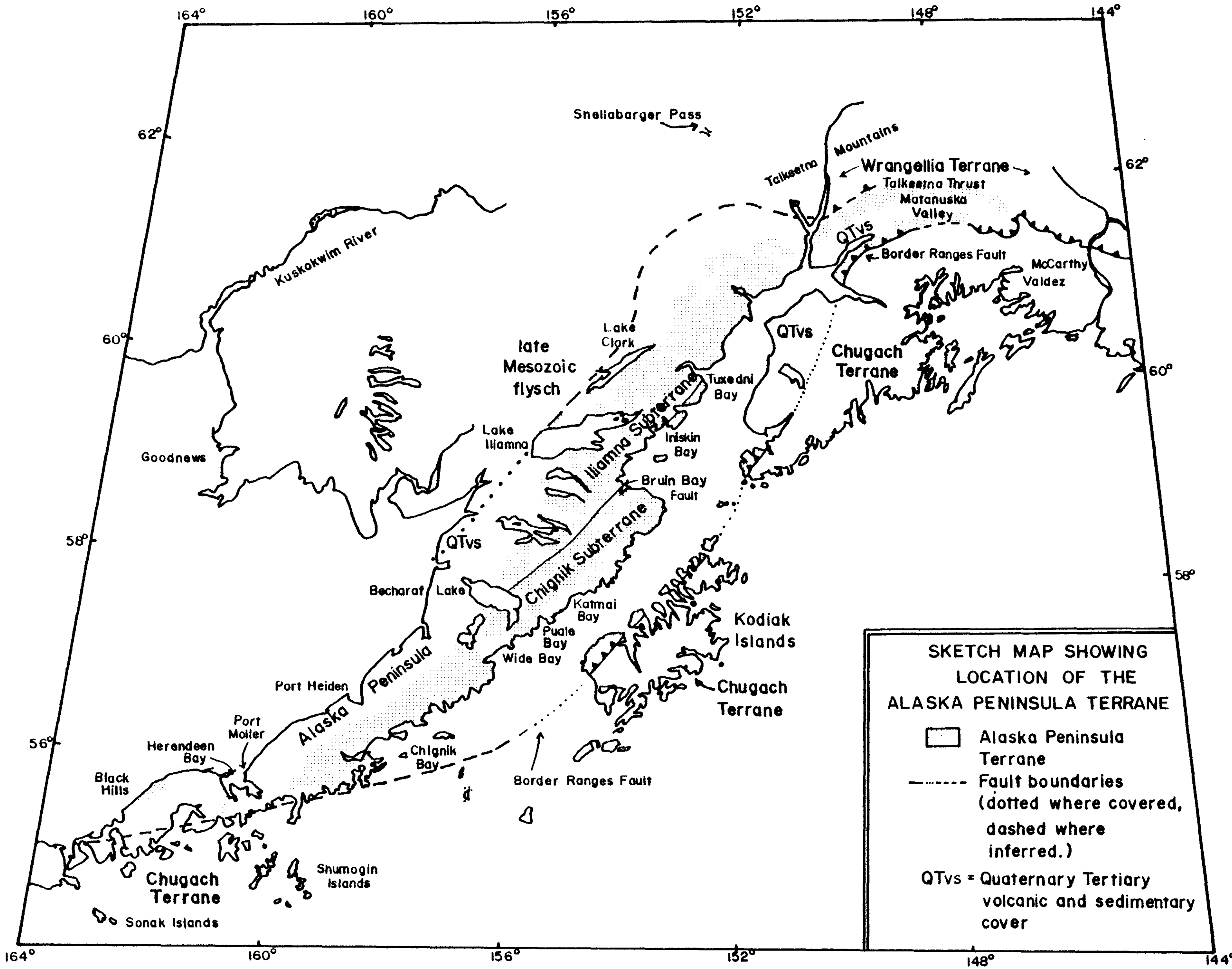

Figure 1. -- Sketch map showing location of the Alaska Peninsula terrane in southwestern Alaska

These rocks are usually located in close proximity to and intruded by plutonic rocks of the Alaska-Aleutian Range batholith. The batholith, which has been well described by Reed and Lanphere (1969, 1972, 1973, 1974) intrudes rocks of the Kakhonak Complex (Detterman and Reed, 1980), a metamorphic complex of Permian(?) to Jurassic age (fig. 2). These rocks include schist, gneiss, and other rocks ranging in metamorphic grade from lower greenschist to amphibolite facies.

The southern-most exposure of rocks of the Iliamna sub-terrane occurs in the vicinity of Becharof Lake. Here, quartz diorite of Jurassic age (Reed and Lanphere, 1972) is exposed on a small island on the south side of the lake and in the hills of the Naknek quadrangle to the north. North of Becharof Lake are a few outcrops of fossiliferous middle Paleozoic (probably Silurian or Devonian) limestone (Detterman and others, 1980). This limestone is lithologically similar to and contains the same coral as reported by Reed and Nelson (1977) at Shellabarger Pass, 550 km northeast. In the Lake Clark quadrangle, Silurian greenstone, sandstone, and limestone have been reported by Eakins and others (1978). These and other occurrences may not have been originally contiguous; however, the presence of Paleozoic rocks in widely scattered parts of the Iliamna sub-terrane suggests a large scale relationship of these rocks to a single Paleozoic block. Detterman and others (1980) mention the presence of lithologically similar Devonian limestone in the Goodnews and Hagemeister Island quadrangles in southwestern Alaska. This may indicate a dismemberment of this Paleozoic block at some later time, or a much larger original extent than suggested here.

Also scattered widely throughout the northern part of Iliamna sub-terrane and southwestern Alaska is an ill-defined unit of Paleozoic(?) and Mesozoic age (Eakins and others, 1978; Hoare and Coonrad, 1978; Beikman, 1980) that includes rocks similar to the Kakhonak Complex. Many different and probably unrelated rocks have been lumped in this unit and it is impossible at this time to distinguish those which belong to the Iliamna sub-terrane from those which may not.

Intruded by and partially coeval with the Jurassic portion of the Alaska-Aleutian Range batholith are rocks of the Cottonwood Bay Greenstone, Kamishak Formation (Detterman and Reed, 1980) and the Talkeetna Formation. Each of these units is correlative with portions of the Chignik sub-terrane or in the case of the Talkeetna Formation, is actually part of both sub-terranes.

Southwest of Becharof Lake the extent of the Iliamna sub-terrane is masked by younger rocks, though its presence may be inferred from geophysical and drill data. The batholith has been reached by drilling south of Becharof Lake on the Alaska Peninsula (Brockway and others, 1975), aeromagnetic data (Case and others, 1981) suggest that it continues at least as far south as Port Heiden. Pratt and others (1972) suggested its continuation into southern Bristol Bay. In no case though, is continuation of the Paleozoic rocks south of Becharof Lake known. Except for the uncertain relationship between Paleozoic rocks of the Goodnews area and those of the Iliamna sub-terrane, the sub-terrane apparently has a long, near-linear form extending some 900 km from the Talkeetna Mountains possibly to at least Port Heiden on the Alaska Peninsula.

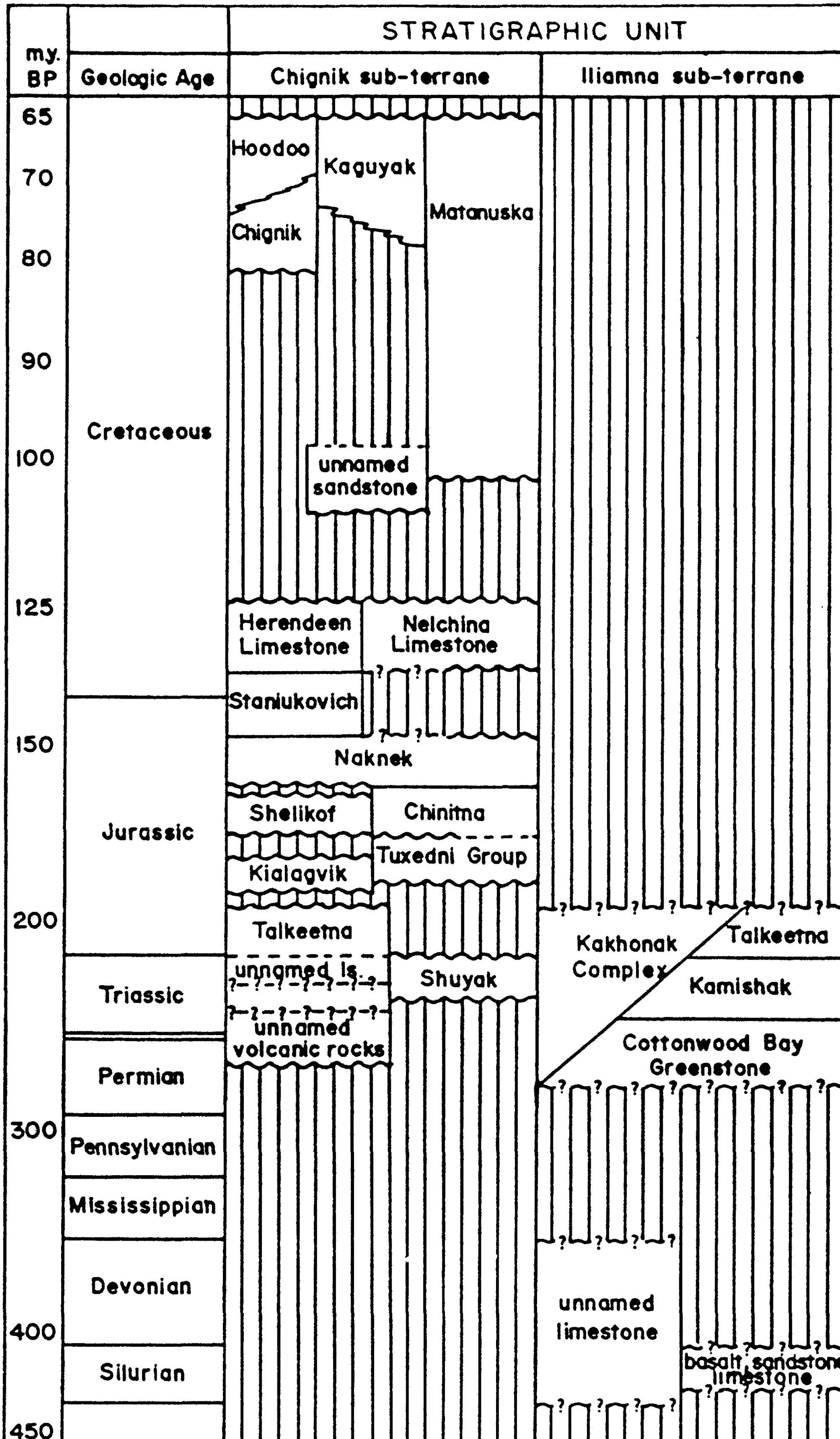

Figure 2. -- Stratigraphic column showing age and stratigraphic relationships between lithostratigraphic units of the Alaska Peninsula terrane

Chignik sub-terrane

Characteristic of the Chignik sub-terrane is a sequence of little deformed shallow marine to continental clastic sedimentary rocks. However, deep marine, volcaniclastic, and calcareous rocks are present as important components of the older rocks in the sub-terrane. The rocks range in age from Permian to latest Cretaceous and are found south or east of the Iliamna sub-terrane.

The oldest rocks known in the Chignik sub-terrane are found at Puale Bay and are unnamed Permian(?) volcanic and volcaniclastic rocks interbedded(?) with fossiliferous mid-Permian limestone (Burk, 1965, p. 11). The Permian(?) age assignment to the volcanic rocks is based on the interbedded(?) limestone; however, the stratigraphic position of the limestone in the volcanic rock section is uncertain. These Permian volcanic and volcaniclastic rocks are conformably overlain by unnamed Triassic volcanic and volcaniclastic rocks, carbonate, and chert which grade into Lower Jurassic tuffaceous sandstone and volcanic conglomerate (Talkeetna Formation). The Triassic carbonate and chert from Puale Bay and nearby Cape Kekurnoi are similar to Triassic rocks in the Lake Iliamna (Iliamna sub-terrane) area (Burk, 1965, Detterman and Reed, 1980). In the Lake Iliamna area, the Triassic sedimentary rocks are underlain by the Cottonwood Bay Greenstone of unknown but probable Triassic age (Detterman and Reed, 1980). It is possible this greenstone is correlative with the Triassic(?) volcanic rocks at Puale Bay. On western Kodiak Island, the Shuyak Formation (Connelly, 1978) is also a possible correlative of the Triassic volcanic and volcaniclastic rocks at Puale Bay. Triassic rocks are also known in the subsurface in the Herendeen Bay area (McLean, 1977).

Stratigraphically above the Triassic rocks at Puale Bay are Lower Jurassic volcanic conglomerate, tuffaceous sandstone, calcareous sandstone and shale, and limestone of the Talkeetna Formation (Detterman and others, 1985). The Talkeetna Formation is crops out from the Matanuska Valley and Talkeetna Mountains, to Puale Bay. Stratigraphically and lithologically equivalent rocks were reported from a drillhole in the Cold Bay quadrangle from the southwest Alaska Peninsula (McLean, 1977)

Unconformably overlying the Talkeetna Formation are the Kialagvik Formation and the correlative Tuxedni Group, a sequence of sandstone, shale, and conglomerate. Exposed in a limited area at Wide Bay, on the Alaska Peninsula, the Kialagvik is also known in the subsurface at Herendeen Bay (McLean, 1977). The shale is cyclically deposited in a reverse graded upward form, becoming sandy at the top (Burk, 1965). The Kialagvik Formation is early Bajocian in age and correlative with the lower part of the Tuxedni Group (Imlay, 1952). The Tuxedni Group is a thick sequence of graywacke, sandstone, conglomerate, siltstone, and shale of Middle Jurassic age. The conglomerate is composed mainly of volcanic rocks in a graywacke matrix. Outcrops of the Tuxedni Group are extend from Iniskin Bay to the Talkeetna Mountains (Imlay and Detterman, 1973).

Overlying these rocks, in most places unconformably, is the Shelikof Formation in the southern part of the sub-terrane or the equivalent Chinitna Formation in the north. The Shelikof Formation is fossiliferous siltstone, sandstone, and shale best exposed on the west side of Shelikof Strait but known to crop out as far south as the Chignik quadrangle (Detterman and others, 1981b), and in the subsurface in the Herendeen Bay area (McLean, 1977). Originally divided into three members (Capps, 1923), Allaway and others (1984) redefined the Shelikof Formation and described two members. The two members are: (1) A lower unit of "...mainly volcanic sandstone with lenses of conglomerate..., interbedded with minor siltstone. The upper half consists of volcanic sandstone interbedded with massive and laminated siltstone. The Chinitna Formation is divided into the Paveloff and Tonnie members and is fossiliferous dark-grey siltstone with abundant calcareous concretions (Detterman and Hartsock, 1966). It ranges in areal extent from the Talkeetna Mountains to the Iniskin Peninsula. The Shelikof and Chinitna Formations represent the same or similar depositional environments. Imlay (1953) and Burk (1965) describe the environment as nearshore on a steep slope in fairly deep water; however, recent work indicates non-marine and shallow marine rocks are present (Allaway and others, 1984). The source area supplied volcanic and granitic debris and lay to the present northwest of the sub-terrane.

Everywhere unconformably overlying the Shelikof and Chinitna Formations is the Upper Jurassic (Oxfordian to Tithonian) Naknek Formation. These rocks are generally arkosic sandstone, siltstone, and plutonic pebble and boulder conglomerate. Known occurrences of the Naknek Formation lie as far north as the Talkeetna Mountains. The southwesternmost exposure of the Formation lies in the Black Hills, in the Cold Bay quadrangle on the southwestern Alaska Peninsula. Vallier and others (1980) described dredging of Upper Jurassic sandstone and siltstone from near the Pribilof Islands in the southern Bering Sea. They correlated these rocks with the Naknek Formation and suggested that these rocks "underlie a large part of the continental margin on the St. George Basin region of the southern Bering Sea". On the southern part of the Alaska Peninsula, the Staniukovich Formation conformably overlies and is lithologically continuous with the Naknek. This formation ranges in age from Kimmeridgian (Late Jurassic) to Valanginian (Early Cretaceous). Recent work suggests that the Staniukovich should be considered part of the Naknek Formation, possibly an upper member (Wilson, 1980, R. L. Detterman, J. W. Miller, and F. H. Wilson, unpublished data, 1984). North of the Katmai area, rocks of this age are generally not known in the Chignik sub-terrane (J. Bolm, personal communication., 1981), though sandstone of Neocomian age was reported by Grantz (1965) in the Talkeetna Mountains quadrangle.

A thin calcarenite, of Valanginian and Hauterivian age, the Herendeen or Nelchina Limestone, conformably overlies the Staniukovich and equivalent age rocks. In the areas where this unit is called the Herendeen Limestone, it generally differs from the Staniukovich Formation only in its abundance of calcareous material. The calcareous portion of the formation is composed of fragments and prisms of Inoceramus shells; this constitutes anywhere from 1/4 to 3/4 of the rock (Burk, 1965). The Nelchina Limestone is a similar unit reported in the Talkeetna Mountains (Jones and Silberling, 1979, and Grantz, 1960). Jones and Detterman (1966) also reported the same rocks in the Katmai area. The present limited extent of this unit is an artifact of erosion; its presence in the Port Moller, Chignik, Katmai, Talkeetna Mountains, Goodnews (Hoare, and others, 1975), Talkeetna (Jones and Detterman, unpublished data), Valdez (Winkler and others, 1981), and western McCarthy (Berg Creek Formation, MacKevett, 1978) quadrangles suggest a formerly much wider extent. Since Kimmeridgian time, the source area for the sub-terrane was gradually eroded and the proportion of calcareous material being deposited increased. However, the Naknek and Staniukovich Formations and the Herendeen Limestone and their equivalents all indicate deposition in a medium to very high energy, nearshore marine environment.

Strata as old as Late Jurassic and as young as Santonian or Campanian are truncated by an unconformity, probably erosional, throughout the sub-terrane. Uplift through mid-Cretaceous time resulted in removal of much of the Herendeen Limestone and equivalents, the Staniukovich Formation and parts of the Naknek Formation. The uplift appears to have been most pronounced in the Puale Bay to Lake Iliamna area. However, Albian rocks have been reported from the Mt. Katmai area (Miller and others, 1981; George Petering, personal communication., 1981).

The stratigraphically uppermost portion of the Chignik sub-terrane consists of the Chignik, Hoodoo, Kaguyak, and Matanuska Formations. The Chignik and Hoodoo Formations are Campanian and Maestrichtian in age and exposed south of Puale Bay. The Chignik is a nearshore to non-marine accumulation of sandstone, shale, conglomerate, and minor coal. It is locally fossiliferous and contains an excellently preserved Upper Cretaceous fauna and flora. It is apparently in large part the result of reworking of earlier strata although a volcanic rock component may have been added. The Hoodoo Formation is a rhythmically bedded marine siltstone, generally younger than the Chignik and overlying it in most areas. The Hoodoo is very sparsely fossiliferous.

The Kaguyak Formation of the Mount Katmai and Lake Iliamna area is in part correlative with the Hoodoo Formation. Lithologically, the Kaguyak is a sequence of fossiliferous marine siltstone and sandstone. Originally the Kaguyak rocks were assigned to the Chignik Formation; however, their distinctive lithology and lack of coal-bearing intervals resulted in Keller and Reiser (1959) defining them as a new formation. The Kaguyak Formation, particularly the rhythmically bedded siltstone sequence, is similar to the Hoodoo. However, the Kaguyak is much more abundantly fossiliferous, in part due to its being an upper fan turbidite, whereas the Hoodoo is interpreted to be an interchannel slope turbidite.

The Matanuska Formation, named by Martin (1926), ranges in age from Albian to Maestrichtian. Its type area is the Matanuska Valley and is predominantly composed of dark-grey marine siltstone and shale with some conglomerate (Grantz and Jones, 1960). The much longer depositional history of the Matanuska Formation, compared to the other Upper Cretaceous Formations in the sub-terrane, indicates a return to a stable depositional environment sooner in the northern part of the sub-terrane than in more southerly parts. The Chignik Formation shows extensive evidence of a nearshore to non-marine environment, whereas conglomerate and coaly seams are known only locally in the Matanuska Formation. The cyclical depositional history documented by Detterman (1978) in the Chignik Formation may be indicative of the lesser stability in the Chignik region.

Terrane Boundaries

The boundaries separating the Alaska Peninsula terrane from other terranes are commonly indistinct. A few boundaries can be clearly defined at major faults yet even in the best cases the extensions of these faults are speculative through some areas. The most clearly defined boundary of the Alaska Peninsula terrane is the Border Ranges fault (MacKevett and Plafker, 1974) which separates it from the Chugach terrane (Plafker and others, 1977). This boundary is on the southeast and south side of the Alaska Peninsula terrane. It extends from the Matanuska Valley southwesterly, to a point southwest of Kodiak Island near longitude 156 degrees W (Fisher, 1981). Extending southwest from the known position of the Border Ranges fault, it is projected to form the southern boundary of the Alaska Peninsula terrane out to its western edge. Recent work near Sand Point in the Shumagin Islands suggests that the Border Ranges fault zone lies inland of the Shumagin Islands on the Alaska Peninsula mainland (Wilson and others, 1985). Fieldwork has defined a zone of structurally disrupted Oligocene to Miocene rocks that may overlie the extension of the fault. The position of the Border Ranges in the vicinity of the Sanak Islands, 160 km to the southwest can not be determined but may lie as far north as Cold Bay.

The northwestern boundary of the Alaska Peninsula terrane is largely speculative. In the northwestern part of the terrane, a terrane of upper Jurassic and Cretaceous flysch is west of and overlies the Iliamna sub-terrane. This flysch terrane is not well mapped and often is not separated from rocks of the Cretaceous Kuskokwim Group (Cady and others, 1955). In light of Reed and others (1983) reinterpretation of the polarity of the Jurassic magmatic arc, and recent mapping and interpretation by John Decker (oral communication, 1984) the older flysch may represent the forearc of the Jurassic magmatic arc. Similiarities between units of the Alaska Peninsula terrane with units in southwestern Alaska preclude a definite statement of where the physical end of the terrane may lie. However, one "boundary" of the terrane is the contact with the flysch.

On the Alaska Peninsula, the west side of the Alaska Peninsula terrane is overlapped by Tertiary sedimentary and volcanic rocks and Quaternary deposits (Burk, 1965) of the Nushagak-Bristol Bay Lowland physiographic province (Wahrhaftig, 1965). Although it is not now possible to define the northwest boundary of this part of the Alaska Peninsula terrane, extrapolation of structural trends and limited aeromagnetic data (U.S. Geological Survey, 1978) suggests that it is sub-parallel to Alaska Peninsula.

In the Talkeetna Mountains the northern boundary of the Alaska Peninsula terrane is a zone of intense shearing and possible thrusting (Csejtey and St. Aubin, 1981; Csejtey and others, 1978). There the Alaska Peninsula terrane is juxtaposed against the Wrangellia terrane (Jones and Silberling, 1979).

Structural Style

The two sub-terranes of the Alaska Peninsula terrane are characterized by radically different structural and metamorphic styles. At distance from the Bruin Bay fault, the Chignik sub-terrane is characterized by minor deformation and essentially no metamorphism except for contact metamorphic effects near the Tertiary igneous intrusions. The rocks are gently folded into a series of broad en echelon northeast trending anticlinal and synclinal structures. In some areas, the anticlinal structures are cut by axial-plane thrust or reverse faults (Detterman and thers, 1981). In the Iliamna area, the degree of deformation of the Chignik sub-terrane increases rapidly toward the Bruin Bay fault (Detterman and Reed, 1980). Near other faults beds may dip as much as

50 to 70 degrees, yet in general dips are commonly less than 30 degrees. Superimposed on this pattern is a series of northwest trending normal faults of relatively small displacement.

The rocks of Iliamna sub-terrane, which lie west of the Bruin Bay fault, are characterized by metamorphism up to amphibolite facies grade and intense folding. The severity of these effects is variable and is most intense nearest the Alaska-Aleutian Range batholith. Both of these effects are attributed to forcible intrusion of the batholith (B. L. Reed, personal communication, 1981).

Summary

The Alaska Peninsula terrane is a large terrane in southwestern Alaska composed of two distinct but related sub-terranes. Both these sub-terranes have a Paleozoic through Cretaceous history, and have probably migrated a large distance northward. The two sub-terranes, though they have distinct geologic histories, can be related since at least Early Jurassic time. A large component of the rocks of the Chignik sub-terrane are probably derived from the Iliamna sub-terrane. In many cases, distinct boundaries between the Alaska Peninsula terrane and other terranes in Alaska are difficult to define because they are covered by younger rocks or by water.

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APPENDIX 1

Formation Descriptions

Hoodoo Fm.= Black to gray, well-bedded siltstone and silty-shale, with some claystone, clay shale, and small amounts of very fine sandstone and conglomerate. Rhythmic layering and graded bedding characteristic (Burk, 1965). Overlies and to a minor extent grades into the Chignik Formation on the southern Alaska Peninsula. The formation top is unknown, the upper contact is an unconformity with the Paleocene and Eocene Tolstoi Formation (Burk, 1965). Known fauna include Acila sp., Entolium sp., Inoceramus balticus, Inoceramus kusiroensis, Lima sp., Mytilus sp., Nuculama sp., Neophylloceras ramosum, and Neophyllceras sp., Diplomoceras notabile (Detterman and others, 1981b) and an outer-neritic to bathyal foraminiferal assemblage (Mancini and others, 1978). Age ranges from Campanian to Maestrichtian.

Kaguyak Fm. = Dark to light-gray claystone, siltstone, and sandstone divided into three parts. Upper 260 m is prograding middle to upper fan sequence of massive lenticular upward-fining channel sandstone. Middle part is about 170 m of interbedded dark siltstone and thin sandstone with load casts, flute marks, flame structures, and locally convolute bedding, characteristic of a lower fan sequence. Lowest part is about 450 m of massive basin claystone and siltstone. Lowest part is fossiliferous with many Diplomoceras notabile Whiteaves, Didymoceras horbeyense (Whiteaves), Gaudryoceras tenuiliratum Yabe, Inoceramus balticus Nagao and Matsumoto, Pachydiscus hazzardi Jones, and Inoceramus subundatus Meek. Age ranges from Campanian to Maestrichtian. Formation top unknown, and unconformably overlies Herendeen Limestone and Naknek Formation (Keller and Reiser, 1959, Detterman and Miller, 1985).

Chignik Fm. = Dark greenish-gray, well-bedded argillaceous sandstone and siltstone comprise main portion of formation. Coal Valley member is non-marine carbonaceous to lignitic shale, siltstone, sandstone, and conglomerate, locally bentonitic and weathering to typical orange and reddish-brown. Conglomerate is composed of pebbles, cobbles, and boulders of plutonic, volcanic, sedimentary, and rare metamorphic rocks. Fauna includes ammonites, and pelecypods (including Canadoceras and Inoceramus). A rich fossil flora is also known from this formation. Age is Campanian to early Maestrichtian. Formation conformably underlies and grades into the Hoodoo Formation, lower boundary is unconformable with Herendeen Limestone, Staniukovich, and Naknek Formations. (Burk, 1965; Knappen, 1929; Detterman, 1978)

Matanuska Fm. = Dark lutite, greenish-gray sandstone, some conglomeratic sandstone and mudstone. Marine clastic sedimentary rocks which in the Nelchina area can be divided into a number of mappable units. The formation ranges in age from Albian to Maestrichtian with distinct intraformational unconformities. Units of Albian, Cenomanian and Turonian, Campanian, and late Campanian and Maestrichtian age are known. Upper and lower boundaries are unconformable. The late Campanian and Maestrichtian age portion may correlate with the Hoodoo and Kaguyak Formations (R. L. McMullin personal commun., 1981, Detterman and Miller, 1985). The Albian rocks were in part deformed before deposition of younger parts of the Matanuska Formation. (Grantz and Jones, 1960; Grantz, 1964; Martin, 1926)

Unnamed sandstone - "Thick-bedded fine- to medium-grained gray to green sandstone with abundant carbonaceous debris and a few calcareous concretions" (Miller and others, 1981). Exposed on Katmai Bay, lower contact is a fault, upper contact may be conformable with overlying Kaguyak Fm. Upper half of section contains siltstone and shale, the middle part contains a few pebbles to 4 cm in size. Fauna include Desmoceras (Pseudoughligella) dawsoni (Whiteaves), Mesopuzosia sp., Lytoceras? sp., Turrilites? sp., Calliphylloceras cf. C. aldersoni (Anderson), and Marshallites cumshewaensis (Whiteaves).

Herendeen and Nelchina Limestones = Light gray arenaceous limestone or calcarenite, locally cross-bedded and fossiliferous. Dissociated prisms from Inoceramus shells may locally constitute 50 per cent of the rock. The unit is widespread but only exposed in small patches. The Herendeen is generally considered Valanginian though it has been correlated with rocks of hauterivian and Barremian age in the Mantanuska Valley (Burk, 1965) and in the Kamishak Hills (Jones and Detterman, 1966). In the Katmai area, an equivalent unit is a rusty weathering, brownish-gray, bentonitic shale and siltstone with fossiliferous limestone concretions. Fauna include Acrioceras cf. A. starrdingi, Acroteuthis sp., and possibly Hoplocrioceras remondi (Gabb) (Jones and Detterman, 1966). Unconformably underlies Kaguyak or Matanuska Formations and conformably overlies the Staniukovich Formation.

Staniukovich Fm. = Generally buff weathering sandstone and siltstone, fine- to medium-grained, generally feldspathic or arkosic and fossiliferous. Hornblende and biotite are fairly abundant accessory minerals, together they may constitute as much as 15 per cent of the rock. Common fauna are Buchia crassicollis and B. piochii. Rare belemnites, Inoceramus and carbonaceous plant debris are also known. (Burk, 1965). Upper contact is conformable with the Herendeen Limestone, the lower contact is conformable with the Naknek Formation. It has been suggested that this unit be considered a member of the Naknek Formation (Wilson, 1980).

Naknek Fm. = In general consists of arkosic sandstone, siltstone, conglomerate, and claystone. Important lithologies are: 1. pale green fine-grained sandstone with thin laminae of magnetite; 2. coarse conglomerate composed of granitic clasts and minor metamorphic clasts in an arkosic matrix; 3. dark olive green siltstone, mudstone, and sandstone with Buchia, belemnites, and other mollusks. Age is earliest Oxfordian to early Tithonian. (Imlay and Detterman, 1973). Upper contact is conformable with the Staniukovich, the lower boundary is an unconformity with the Shelikof and partially conformable with the Chinitna Formation.

Shelikof Fm. - Consists of 1400 m of sandstone, siltstone, and conglomerate. Upper portion is "volcanic sandstone interbedded with massive and laminated siltstone" (Allaway and others, 1984). Lower portion is volcanic sandstone with conglomerate lenses, containing volcanic sandstone, and limy sandstone clasts, with minor interbedded siltstone (Allaway and others, 1984). Lower portion includes beds of white to yellowish-brown material thought to be volcanic ash (Imlay, 1953). Fossils are more abundant in lower half and include ammonites (Cadoceras, and Pseudocadoceras), belemnites, pelecypods, brachiopods, crustaceans and plant fragments (Imlay, 1953). Age is Callovian. Both upper and lower contacts are unconformities.

Chinitna Fm. = Two members, Tonnie Siltstone and Paveloff Siltstone. Tonnie Siltstone is massive arenaceous dark-gray to brownish-gray siltstone containing numerous small yellowish-brown-weathering limestone concretions. Fine-grained greenish-gray sandstone is present in thin interbeds. Fauna includes Lilloettia buckmani, L. milleri, Paracadoceras tonniense, Xenocephalites vacarius, and Kepplerites abruptus. Paveloff Siltstone generally has basal graywacke sandstone which is thin to massive bedded, fine to coarse-grained, and gray to greenish-gray. Remainder of Paveloff is massive dark-gray well-indurated siltstone. Weathers dark-gray, unlike Tonnie, owing to less abundant pyrite in the Paveloff. Fauna include Inoceramus, Littoettia, Xenocephalites, Pseudocadoceras, Stenocadoceras, and Cadoceras. Age is Callovian (Detterman and Hartsock, 1966). Upper contact is in part conformable with the overlying Naknek. Lower contact is in part conformable with the Tuxedni Group.

Kialagvik Fm. = Sandstone, sandy shale, and conglomerate. Several cycles of reverse-graded shale becoming sandy at the top (Burk, 1965). Abundantly fossiliferous, fauna reported by Capps (1922) include Tmetoceras, Eudmetoceras, Ercitoides, Docidoceras, Partschiceras, and others. Age is lower Bajocian (Burk, 1965). The top of the unit is unconformable with the Shelikof, the bottom is not exposed.

Tuxedni Group = Six formations included. From top is 1. Bowser Formation heterogeneous assemblage including massive cliff-forming graywacke sandstone and pebble cobble conglomerate, thin-bedded poorly consolidated shale, and massive siltstone, all showing rapid facies changes (560m); 2. Twist Creek Siltstone, soft poorly consolidated, thin-bedded to massive, dark- gray siltstone and silty shale, weathers dark rusty-brown, many thin beds of volcanic ash, poorly consolidated shale, and massive siltstone, shows rapid facies changes (125 m); 3. Cynthia Falls Sandstone, massive to thick-bedded graywacke-type sandstone and pebble-cobble conglomerate (200 m); 4. Fitz Creek Siltstone, massive bluish-gray arenaceous siltstone, commonly weathering rusty orange with many small ovoid fossiliferous limestone concretions (330 m); 5. Gaikema Sandstone, resistant cliff-forming sandstone, in part conglomeratic, with subordinate siltstone, shale, and cobble-boulder conglomerate (260 m); 6. Red Glacier Formation, massive dark-gray arenaceous siltstone with sandstone interbeds, tan arkosic sandstone and black silty shale (>1380 m). Group ranges in age from early Bajocian to Callovian (Detterman and Hartsock, 1966). In part, conformable with the Chinitna at top, the bottom is and unconformity.

Talkeetna Fm. = Divided into three stratigraphic units in Iniskin-Tuxedni region by Detterman and Hartsock (1966). The upper unit, the Horn Mountain Tuff, has bedded tuff and tuffaceous feldspathic sandstone dominant, with local porphyritic andesite flows. The Horn Mountain Tuff ranges between 550 and 850 m thick. The medial unit, the Portage Creek Agglomerate Member, is mainly fragmental volcanic ejecta, and differs in form and color from Marsh Creek Breccia Member. Fragments mostly rounded volcanic bomb-type detritus, rocks generally red or pink and more felsic than underlying rocks. The unit is about 680 m thick. Stratigraphically lowest is the Marsh Creek Breccia Member, a massive dark-green to green volcanic breccia with tuffaceous matrix. Individual massive units are as much as 300 m thick. Angular fragments in breccia range from 1 cm to nearly 1 m across. Interbedded lava flows. There is a general reverse-grading of breccias. Age ranges from Sinemurian to early Bajocian (?) (Detterman and Hartsock, 1966). Fossils include Crucilobiceras, Arnioceras, and Waeheroceras in type area. Also includes at Puale Bay a thick section of tuffaceous and calcareous sandstone and shale and volcanic breccia overlain by dark shale and thin beds of sandstone with numerous calcareous concretions. Fauna include Coroniceras, Arnioceras, and Waehneroceras in type area (Burk, 1965). The upper contact is an unconformity, the lower contact not exposed or conformable where exposed.

Unnamed limestone = Thin-bedded limestone with interbedded calcareous shale. Chert-rich zone in lower part of unit. Age considered Norian based on Monotis subcircularis (Burk, 1965). Occurs only at Puale Bay.

Shuyak Formation = Two members, upper sedimentary, lower volcanic. Sedimentary member consists of volcanic turbidites, conglomerate, siliceous tuff, and argillite. Graded bedding and complete Bouma sequences. Age Norian based on Halobia cf H. halorica. Volcanic member is vesicular pillowed greenstone with inter-pillow limestone. No fossils known in volcanic member (Connelly, 1978).

Kamishak Fm. = Three members, Bruin Limestone, middle member, and Ursus member. The uppermost, the Ursus member is thin-bedded light gray limestone with a few thin interbeds of gray chert. Middle and Bruin Limestone members are Norian, Ursus member may be Late Triassic or Early Jurassic (Detterman and Reed, 1980). Middle member is thin to medium-bedded dark-gray to black limestone and calcilutite with black chert and gray tuff. Dark calcareous siltstone is also important in some areas. The lowest member, the Bruin Limestone, is a massive to thin-bedded light to dark-gray limestone with minor green and white banded chert. Unnamed limestone at Puale Bay may be part of this formation. Lower contact not exposed, upper contact conformable to unconformable.

Kakhonak Complex = In part the metamorphic equivalent of Talkeetna, Kamishak, and Cottonwood Bay Greenstone Formations. Greenschist facies rocks, though higher grades are locally present. Includes argillite and slaty argillite, marble, quartzitic mica schist, and quartzite. In some areas, complex overlies conformably the Cottonwood Bay Greenstone, however the complex is mainly found as roof pendants in the Alaska-Aleutian Range batholith. May include rocks equivalent to Permian limestone at Paule Bay (Detterman and Reed, 1980).

Cottonwood Bay Greenstone = Mafic volcanic rocks altered to hornfels and chloritic greenschist. Age thought to be pre-Norian Late Triassic as it underlies Norian limestone and is probably age equivalent of the Nikolai Greenstone of the McCarthy area (Detterman and Reed, 1980).

Mid-Permian limestone and volcanic rocks = Very small exposure at Puale Bay of "tan-gray, medium crystalline thick-bedded gray-brown weathering limestone" interbedded with "massive, dark-green to black volcanic breccias, agglomerates, and basaltic flows". Abundant fossils in limestone including crinoid stems, foraminifera, ostracodes, brachiopod fragments and silicified corals (Burk, 1965).

Paleozoic limestone = Light-gray medium to coarse-grained, medium-bedded to massive crystalline limestone with small chert nodules. Contains poorly preserved corals and gastropods, probably of middle Paleozoic, Silurian or Devonian age. Roof pendants in the Alaska-Aleutian Range batholith (Detterman and others, 1979).

Upper Silurian basalt, sandstone, and limestone = Dark-green basalt with relict pillow structure, minor chert with interbedded gray shale, gray to volcaniclastic sandstone, purple basalt, and highly fractured dark-gray limestone and chert. Age on basis of stromatoporoids, undated solitary rugose coral, Pentamerus or Pentameroides sp., and undated rynchonelloid brachipods (Eakins and others, 1978).