however, rocks of comparable age retain a paleomagnetic record of much lower paleolatitude. Geologic evidence bearing on the arrival time of the peninsular terrane are inconclusive and the implicated Tertiary tectonic boundary between indigenous and exotic components of Alaska is not known.

The paleomagnetism of a sequence of 30 Paleocene basalt flows just inboard of the peninsular terrane suggests a small amount of northward displacement and about 55° of counterclockwise rotation. Results from a nearby 44 Ma sequence suggest no displacement and no rotation. Collectively, our paleomagnetic data from seven volcanic sequences 30-40 Ma (about 70 flows), on the inboard part of the peninsular terrane, indicate that this region was in its present position with respect to North America when the lavas were extruded. The age of the unrotated localities indicates that the counterclockwise rotation of southern Alaska recorded by Late Cretaceous–early Tertiary rocks was completed about 44 Ma.

On the outboard side of the Alaska Peninsula, preliminary results from one sequence of Eocene or Oligocene volcanic rocks on the Kupreanof Peninsula also suggest no major latitudinal displacement or rotation. If this volcanic sequence adequately averages secular variation and if the Tertiary tectonic history of this region is representative of the rest of the outboard Alaska Peninsula, these paleomagnetic data preclude post-Eocene northward displacement of exotic southern Alaska along faults within the Alaska Peninsula. Additional data from other volcanic sequences in this region will test this hypothesis.

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Offshore Evidence of Glaciations in Lower Cook Inlet, Alaska

The Lower Cook Inlet is a northeast-trending tidal embayment of the North Pacific Ocean located in south-central Alaska between the Alaska-Aleutian Ranges on the west and the Chugach and Kenai Mountains on the east. Five major Pleistocene glaciations have been documented for the region. The first three glaciations completely filled the Cook Inlet trough, truncating Tertiary strata and creating an inlet-wide angular unconformity. In the last two glaciations, ice coalesced across the southern part of the inlet only, impounding fresh water from the north in a large proglacial lake.

High-resolution seismic-reflection records reveal many glacial and related features on the sea bottom and buried beneath Holocene marine sediments. Sea bottom features identified include sand waves, megaripples, sand ribbons, lag gravels, and ice-rafted boulders with associated comet marks. Subbottom features include terminal, lateral, and ground moraines; glacio-fluvial, glacio-marine, and lacustrine deposits; drainage channels and tunnel valleys; and eskers, outwash fans, and sand waves.

The sea floor may be divided into four morphological provinces separated by the 60-, 120-, and 190-m isobaths. The two deeper provinces are expressions of ice-erosional morphology, whereas the shallower provinces are dominantly expressions of ice-depositional morphology.

These buried features and the present sea-floor configuration reflect deposition and erosion during the last two glaciations and subsequent modification by tidal currents and marine deposition.

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Paleoenvironments of Forbes Formation

The Upper Cretaceous Forbes Formation of California's Great Valley is a sequence of mudstones, shales, and sandstones, interpreted as lower slope-fan fringe to midfan facies deposited in a forearc basin. It contains two different foraminiferal faunas: one is largely agglutinated; the other, restricted to the lowermost Dobbins Shale Member, is more diverse. These faunas are the result of turbiditic sedimentation and differential preservation.

The Dobbins—a limy, concretionary mudstone—represents low net accumulation rates above the carbonate compensation depth, but below the foraminiferal lysocline. Oxygen levels were low, but not continuously anaerobic. Sediment texture is nonlaminated, but the preservation of calcareous foraminifera suggests bioturbation was intermittent and not extensive.

An increase in sedimentation rates occurs in the middle Forbes, with an increase in the number and thickness of sand beds. The lack of calcareous species is largely the result of episodic sedimentation and increased bioturbation. In the upper member, the number of sand beds and the accumulation rate decrease. Paleobathymetric estimates, based on agglutinated foraminifera, suggest an upper abyssal-lower bathyal depth throughout the formation, with an indication of minor shallowing upsection.

The Santonian/Campanian boundary occurs at the top of the Dobbins shale, as marked by the first appearance of the calcareous nannofossil, *Broinsonia parca*. The Forbes Formation is included in the *Globotruncana arca* planktonic foraminifera zone.

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Suspect Terrains of Alaska: Evolution Without Microplate Accretion

Present interactions (subduction, translation, rifting) between the Pacific oceanic plates (PP) and the North American craton (NAC) are similar to earlier events and represent a continuation of the tectonic evolution of the Cordilleran orogen. The formation and breakup of Pangea also influenced Cordilleran evolution. Based on these observations, it is possible to model the tectonic evolution of Alaska without accreting "exotic microplates."

In early Phanerozoic time, a passive marine shelf was present along the western margin of NAC, which was the depositional site of a miogeoclinal clastic-carbonate sequence. Subduction of PP beneath NAC, coincident with the formation of Pangea, began in early Paleozoic time and generated an island-arc/back-arc rift. Miogeoclinal fragments were incorporated in the back-arc rift. A middle Paleozoic orogeny collapsed the back-arc rift and obducted the arc onto NAC.

The Tethys Rift split Pangea into Laurasia and Gondwana in the Triassic. As Laurasia moved northward, a continental margin rift with 1,000-km left-lateral offset developed along the NAC's western margin. In the Late Jurassic, Laurasia rifted apart, and NAC moved westward relative to PP. Subduction collapsed the lower Mesozoic continental margin rift, generated a continental arc, and culminated as a major orogeny in the Late Cretaceous.

Cenozoic subduction of ocean-spreading ridges shifted the relative movement between PP and NAC. Northwest subduction of PP generated the Aleutian arc, and a translational boundary was established in southeastern Alaska. NAC's obducted outboard terrains were offset northwestward by the Tintina and related faults.

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Transient Electromagnetic Detection of Subsea Permafrost near Prudhoe Bay, Alaska

Transient electromagnetic soundings were taken at several sites along a line from the North Prudhoe Bay State (NPBS) 1 well to Reindeer Island in the Beaufort Sea during the spring of 1984. The purpose of these soundings was to delineate the depth to, and the thickness of, the ice-bonded permafrost layer known to exist below the seabed.

Offshore, about 1.5-2 m of sea ice covers shallow (< 7-m or 22-ft) sea water underlain by saline, saturated sediments. Data reductions, appropriate for such high electrical conductivity, and subsequent interpretations suggest an unfrozen (or partially unfrozen) layer overlying a more resistive ice-bonded permafrost layer. Beneath the ice-bonded layer, the sediments are unfrozen and more conductive.

A permafrost profile along the line, showing the depths and thicknesses of ice-bonded permafrost, was inferred from the interpretations. The unfrozen sediments appear to increase in depth from zero onshore to a maximum of about 175 m at 6 km from shore. The thickness of ice-bonded permafrost steadily decreases with increasing distance offshore, from about 560 m onshore to 300 m at 6 km from shore; it displays an increasing complexity from 9 to 14 km.

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Placer and Lode Sources of Niobium: Tofty, Alaska

The Bureau of Mines, as part of a program to assess Alaskan reserves of certain critical and strategic minerals, has intermittently investigated niobium (Nb) associated with placer gold-tin deposits near Tofty, Hot Springs district, Alaska. These investigations have identified placer and lode sources that together contain inferred reserves of approximately 300,000 lb of Nb.

Splits of samples collected by the Bureau of Mines in the early 1950s from tailings piles of now-inactive drift mines were reanalyzed. Most of these samples contain between 0.2 and 4.5% Nb. The presence of relatively higher concentrations of Nb in the Deep Creek-Miller Gulch-Idaho Gulch area suggests proximity to an Nb lode source in that area.

In an effort to locate the lode source of the placer Nb, trenches excavated by the Bureau of Mines in 1956 on upper Idaho Gulch were reexamined. Between 0.02 and 0.10% Nb is present in two lenses of radioactive ferruginous regolith exposed in these trenches. In the regolith, the Nb mineral, aeschynite $[(Ce,Ca,Fe,Th)(Ti,Nb)_2(O,OH)_6]$, occurs with up to several percent apatite and zircon and trace amounts of monazite. The lenses persist 1,200 ft along strike, and drilling shows them to continue 150 ft downdip. Apparently, they are derived from the selective weathering of dolomite marble containing magnetite, pyrite, and pyrrhotite and traces of zircon and apatite. The inferred reserve of the regolith lenses is approximately 200,000 lb of Nb, which is twice that of the inferred placer reserves.

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West Sak and Ugnu Sands: Low-Gravity Oil Zones of the Kuparuk River Area, North Slope, Alaska

Low-gravity oil in Upper Cretaceous and Tertiary shallow marine and deltaic sands of the North Slope have been known since 1969. The majority of the oil occurs in two intervals informally named the West Sak sands (Maestrichtian) and the overlying Ugnu sands (Maestrichtian-Paleocene). These zones are oil-bearing primarily in the Kuparuk River and Milne Point units where they occur at depths ranging from 2,000 to 4,500 ft (610 to 1,370 m) subsea.

The West Sak consists of very fine-grained, unconsolidated sands with interbedded siltstone and mudstone that were deposited in an inner-shelf to delta-front environment. The oil in the West Sak is a less heavy to intermediate crude with gravities ranging 16°-22° API. The Ugnu consists of fine to medium-grained, unconsolidated sands with interbedded siltstone, mudstone, and coal that were deposited in fluvial and delta-plain environments. The oil in the Ugnu sands is bitumen and extra heavy crude with gravities between 8° and 12° API.

The total oil in place in the West Sak and Ugnu sands is estimated to be as large as 40 billion bbl. Geochemical work on these oils indicates that they have the same source as the oils in the deeper Kuparuk and Sadlerochit reservoirs but have been biodegraded.

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Paleomagnetism of Early Tertiary Alaska Peninsula Rocks and Implications for Docking of Peninsular Terrane

In order to refine the tectonic history of the peninsular terrane, Alaska, 22 sites (averaging 10 samples/site) in Paleogene Tertiary volcanic and sedimentary formations were sampled in the vicinity of Chignik, on the Pacific side of the Alaska Peninsula. Ten of the sites were drilled in the early Oligocene Meshik volcanics, ranging from andesite to basalt, and the other twelve sites were drilled in the late Eocene Tolstoi Formation sediments. Nine of the volcanic sites yielded stable R and/or N characteristic magnetization. Virtually no fine-grained, interbedded sediments occur with the Meshik volcanics at the sample sites, thus making reliable paleohorizontal determinations difficult. Although flow attitudes were tentatively used, it became rapidly apparent that problems of initial dip were insurmountable. As a result, all volcanic sites were considered unreliable for determining a meaningful paleomagnetic inclination.

Upon thermal demagnetization, five of the sedimentary sites were judged stable. The mode of the paleomagnetic direction was calculated, $D/I = 349.8/75.3$ ($\beta 95 = 8.5$), indicating no significant rotation. Uncertainties in structural corrections, however, may render only the inclination meaningful, which, from McFadden statistics, yields $I = 75.9$, $\alpha 95 = 7.9$, corresponding to a paleolatitude of 63.3°. This paleolatitude agrees with the expected value for the North American craton at 40 m.y. B.P., implying that the peninsular terrane had docked by at least that time.

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Method and Application of Faciolog Technique to Geological Problems

The Multiwell Faciolog (mark of Schlumberger) computer process is a data-reduction technique that uses multivariate analysis to integrate data from wireline logs, core data, and geologic knowledge into a geologically significant display of electrofacies. Electrofacies are defined by Serra and Abbott as the "set of log responses that characterizes a sediment and permits the sediment to be distinguished from others."

The computing chain begins with log normalization and correction for environmental effects. The corrected logs from a selected key well are then used to construct an n dimensional crossplot incorporating data from n number of input logs. The program selects n principal component axes through the resulting cloud of data points and automatically clusters the data into local modes, which are then displayed in two-dimensional principal component space. Each group of local modes represents intervals that have similar log response. Local modes are then clustered into a smaller number of terminal modes, which are identified by rock type, using core lithology data and geologic knowledge, and are manually clustered into a significant number of electrofacies. Once the electrofacies are defined in the key well, a data base is established, containing information on the average log values for each electrofacies, geologic descriptions, and display patterns. Each subsequent well with a similar logging suite is then compared to the data base. Those zones corresponding to electrofacies previously defined in the data base will be identified as the same electrofacies. Those zones with different average log values will be identified as different electrofacies and will be added to the data base.

The advantage of the Multiwell Faciolog technique is that voluminous data, including wireline, core, and geologic information, can be integrated into one or two key displays. This program is flexible and allows the interpreter to adjust and modify the data base, as necessary, with the addition of each new well. The data base does not require a unique data set and can be constructed from open-hole logs, cased-hole logs, or computed logs common to the study wells. The final cross-sectional displays can be an aid in tracing geologic characteristics from well to well.

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Some Palynological Aspects of Oligocene to Early Miocene Transition in Southern Alaska

The Oligocene to early Miocene transition in southern Alaska perhaps represents one of the most dramatic floristic changes in the entire Tertiary of Alaska. The basic modification is from a dominant deciduous, broad-leaved forest biome in the late Eocene-early Oligocene (early Zemorrian) to a dominant moist, temperate, coniferous forest biome in the early Miocene (Saucesian). A similar change can be seen between the deciduous broad-leaved forests and the montane boreal coniferous forest of China today.

This change in flora—and from a palynological perspective this change in microflora—reflects the onset of global cooling in the Neogene and the concurrent change from a dominant marine transgressive to a dominant nonmarine regressive mode of sedimentation.

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Comparison of Two Suites of Okpikruak Formation: A Point-Count Analysis

The Lower Cretaceous Okpikruak Formation lies unconformably on the Etivluk group in the Foothills thrust belt of the central Brooks Range. These deep marine sediments were shed northward during the first phases of Brookian deformation. The formation, as sampled, contains two petrographically distinct populations: the upper Kurupa-Oolamnagavik River drainage samples (KOR) of the Picnic Creek allochthon, and the Cobblestone Creek samples (CC) of the Endicott Mountains allochthon.

The KOR samples have an average Q:F:L of 49:21:30 and Qp:Lv:Ls of 46:37:17. Variations in total detrital grain populations are greater for