Foreland Formation, were placed on production in September 1969. Significant gas reserves in shallower Tyonek Formation sandstone have only been used so far for platform power and gas lift. Development plans are currently being formulated for these reservoirs in response to the recent increasing demands for gas in Cook Inlet.

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Paleomagnetism, Paleolatitudes, and Magnetic Overprinting on the North Slope, Alaska

Several paleomagnetic studies have been made in Arctic Alaska, by industry, by the U.S. Geological Survey, and by the University of Alaska. In general, the results available to the public have been disappointing—most samples of pre-Cretaceous rocks give very steep magnetic inclinations with respect to present horizontal. This has been generally interpreted in terms of a Cretaceous overprinting event.

A study of the paleomagnetism of Cretaceous rocks from the North Slope shows that although the Cretaceous field was steeply inclined, it was not as steep as conventional paleogeographic reconstructions would indicate, and not as steep as the bulk of the apparently remagnetized older rocks. This finding leaves open the possibility that the steeper directions recorded by the older rocks are the result of regional tilt, or the result of a paleogeography that allowed an earlier, steeper remagnetizing field.

The shallower inclinations seen in the Cretaceous sediments of the Nanushuk Group (Albian-Cenomanian based on the fossil record with one K-Ar age of 100 Ma from an ash parting) give paleolatitudes of about 75°N. The predicted paleolatitude based on North American paleogeographic reconstructions is 80-85°N. Circumstantial evidence that the paleolatitude was shallower than 80-85°N comes from the enormous biogenic productivity needed to form the extensive coal deposits of the Nanushuk Group. Lower paleolatitudes also may be needed to explain the apparent existence of broad-leaved evergreens and the recently reported dinosaur tracks and skin imprints in the Nanushuk Group.

STUWE, KURT, Montanuniversitat, Leoben, Austria

Structural Features Controlling Emplacement of Gold-Bearing Quartz Veins in Port Wells Mining District, Prince William Sound, Alaska

Data collected in the Port Wells mining district confidently show that the present structural features developed in several stages. These stages were folding, intrusion, faulting, and emplacement of quartz veins. The oldest stage was folding and concomitant metamorphism of the Cretaceous Valdez Group flysch during accretion. The semilithified rocks were folded in at least two phases. An early phase (F1) resulted in a 50% shortening in a northwest-southeast direction; the second phase (F2) caused minor shortening in a northeast-southwest direction. The next stage involved the intrusion of Oligocene plutons (36 m.y.) that crosscut earlier structures. Fracturing and faulting of the plutons and flysch characterized the next stage. Initial faults and structures caused only minor right-lateral displacement. The fault and joint data show details of the time relationship between intrusion and deformation. Several generations of epigenic gold-bearing quartz veins were emplaced along these joint systems. Minor deformation continuing to the present caused some disruption of the veins.

SZUMIGALA, DAVID J., Univ. Alaska, Fairbanks, AK

Tin Creek Zinc, Lead, and Silver Skarn Prospects, Farewell Mineral Belt, Alaska

Several zinc, lead, silver, and copper skarn and replacement bodies occur in a 500 km^2 area near Farewell, in the McGrath quadrangle, Alaska. Detailed examination of the skarns in upper Tin Creek, one of the major mineralized areas, indicates ore and gangue zoning, which inversely follows dike density.

Host rocks for skarns are mid-Paleozoic sedimentary rocks that are contact-metamorphosed, folded, faulted, and overlain and intruded by Tertiary igneous rocks. Skarns in the Tin Creek area are small (up to 3 m wide), discontinuous bodies of exoskarn found along dike contacts and as endoskarn in the dikes. Skarn also forms mantos in marble and irregular bodies along thrust and high-angle faults. Semimassive to massive sulfide mantos are present in calc-silicate hornfels. Many dikes do not have skarn along their contacts while others have skarn along only one margin, indicating that dikes and faults are only structural conduits for later metasomatic fluids.

Sulfide distribution and deposition are intimately associated with calc-silicate metasomatism. The skarn prospects are areally zoned, with garnet- (Ad_{12-100}) and chalcopyrite-dominant skarns proximal and pyroxene- (Hd_{15-86}) and sphalerite-dominant skarns distal to the center of most intense dike swarms. Sphalerite is preferentially associated with pyroxene, while chalcopyrite is preferentially associated with garnet. Metamorphic garnet and pyroxene are devoid of sulfides and have the lowest iron compositions. Early metasomatic garnet and pyroxene are generally richer in iron and are accompanied by minor sphalerite + chalcopyrite. Late metasomatic (main-stage) garnet and pyroxene contain the highest iron contents for these minerals and are extensively replaced by sphalerite + chalcopyrite. Main-stage skarns are locally retrograded to amphibole or epidote + quartz. These calc-silicates may be replaced by sphalerite + chalcopyrite, with galena locally abundant as veins in pyroxene-dominant skarns.

Zinc, lead, and silver ore potential at Tin Creek exists at distances greater than 2 km from the dike swarm center. Zinc, lead, and silver ore is preferentially associated with pyroxene-dominant skarns formed during the main stage of metasomatism.

TAILLEUR, I. L., U.S. Geol. Survey, Menlo Park, CA

A Framework for North Slope Seminar II

This meeting focuses on a province with enormous potential for fuels and minerals. Oil reserves approach 10% of the total oil already produced in the rest of the country. Estimated coal resources could store a thousand times the 70-80 quads of energy the U.S. uses every year. Potential yields of silver, lead, and zinc range from 10 to 100% of the amounts produced domestically since the middle of the 19th century. Prospects for copper are also large.

The province is dominated by the east-trending Brooks Range, whose structures formed during the late Mesozoic Brookian orogeny and are now being shortened longitudinally. Flanking basins succeeded the uplift; the northern one is bounded by a passive continental margin. Early in the orogeny, a relatively thin early Paleozoic through Jurassic megasequence of clastic-wedge, carbonate, and siliceous sediments was telescoped into a fivefold stacking of allochthons and beneath allochthons of volcanic and mafic-ultramafic rocks. The greater than 500-km breadth of sialic crust that had underlain the allochthons disappeared. At about the same time, the Arctic Ocean basin replaced the northern provenance. A mid-Paleozoic sialic source area on the opposite margin of the megasequence disappeared by the end of the Carboniferous and near the beginning of siliceous deposition. Basement beneath the North Slope part of the megasequence was created when the Devonian Ellesmerian orogeny added to the crust the late Precambrian to early Paleozoic clastic, carbonate, and volcanic rocks of an older megasequence.

The northern successor basin accumulated large amounts of coal. Truncation and sealing of potential reservoir rocks on replacement of the northern landmass led to huge pools of hydrocarbons. Late Paleozoic rocks in the lowest allochthon host stratabound base-metal deposits. A narrow belt of reportedly Devonian shallow-seated felsic rocks contain deposits of copper.

John Maher foresaw the benefits that the first North Slope seminar has provided. That precedent and developments during the past 15 years promise similar benefits from this meeting.

THRUPP, GORDON A., and R. S. COE, Univ. California, Santa Cruz, CA

Tectonic Implications of Paleomagnetism of Paleogene Volcanic Rocks on the Alaska Peninsula

Paleontologic and paleomagnetic data demonstrate that the Alaska Peninsula lay far south of its present location relative to North America in the early Mesozoic. Paleomagnetic studies of Late Cretaceous–early Tertiary volcanic rocks inboard of the Alaska Peninsula indicate no major northward displacement. Outboard of the peninsular terrane, 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.

TROSPER, EDWARD, and ROBERT DOUGLAS, Univ. Southern California, Los Angeles, CA

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.

TURNER, THOMAS R., Calista Corp., Anchorage, AK

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.

WALKER, GERALD G., K. KAWASAKI, and T. E. OSTERKAMP, Univ. Alaska, Fairbanks, AK

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