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Lithological and Geochemical Facies of Shublik Formation (Triassic), North Slope, Alaska

The Shublik Formation is a heterogeneous unit consisting of several distinct facies, including: (1) fossiliferous sandstone or siltstone; (2) glauconitic sandstone or siltstone; (3) siltstone, calcareous mudstone, or limestone with phosphate nodules; and (4) black, calcareous mudstone or black limestone, usually fossiliferous. This sequence of lithologies is interpreted as having been deposited along an onshore-offshore (north to south) gradient. Bioturbation of the sediments is variable but generally decreases offshore. Organic carbon increases offshore, and phosphate increases from the paleoshoreline and decreases again farthest offshore.

The distribution of glauconite, phosphate, and organic-carbon–rich rock is consistent with the facies expected in an upwelling zone that has a well-developed oxygen minimum. Glauconite is consistent with dysoxic conditions, and well-laminated, organic-carbon–rich rock in the offshore facies is consistent with anoxic conditions. High biologic productivity coupled with normal oceanic circulation may have caused the basin's low-oxygen conditions, as indicated by the presence of phosphate nodules and the extreme abundance of bivalves that have been interpreted to be pelagic. Phosphate indicates a high rate of supply of organic matter to the sediment-water interface, where it was mobilized from the organic matter within the anoxic zone and reprecipitated at the zone's edges. Pelagic bivalves (*Monotis* and *Halobia*) are present in such large numbers as to suggest unusually abundant food supply; in addition, their distribution is consistent with mass kills, which are common among fish in upwelling zones.

Although an open-ocean divergence was predicted previously for the North Slope region in the Triassic, the distribution of the facies of the Shublik Formation relative to the paleoshoreline and the rapidity of the facies change onshore to offshore are more consistent with a coastal upwelling zone.

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Diagenetic Variations in Permo-Triassic Ivishak Sandstone in Prudhoe Bay Field and Central-Northeastern National Petroleum Reserve in Alaska (NPRA)

Porosity in the Ivishak sandstone on the North Slope is frequently cited as an example par excellence of secondary, or leached, porosity. In an attempt to corroborate and expand this contention, 100 thin sections were examined from representative wells in the Prudhoe Bay field and in NPRA. Monocrystalline quartz and biogenic chert are dominant framework grains in the two areas. Minor amounts of polycrystalline quartz, and sedimentary and metamorphic rock fragments are also present. Most of the chert in NPRA is nonporous, whereas Prudhoe Bay chert contains microscopic pores where siliceous biogenic debris, chalcedony, or dolomite formerly existed.

The diagenetic sequence of the NPRA samples includes: (1) initial porosity loss by either compaction or siderite, chlorite, or pedogenic calcite cementation; (2) minor carbonate dissolution; (3) localized chert dissolution; and (4) quartz overgrowth formation. The diagenetic sequence of the Prudhoe Bay samples includes: (1) chert dissolution; (2) quartz overgrowth, kaolin, pyrite, and siderite formation; and (3) siderite dissolution.

Some workers have suggested that an early carbonate cement maintained the large intergranular pore volumes in the Ivishak at Prudoe Bay. A more likely possibility is that a long, initial period of shallow burial maintained a loose packing density without early cementation. Later chert and siderite dissolution increased porosity. By contrast, the Ivishak in NPRA was subjected to deeper burial early in its history. This caused porosity reduction by relatively early compaction. The later diagenetic events, which ultimately control porosity and permeability variations between the two areas, are, in part, also controlled by the different burial regimes.

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Nuclear Well Logging in Permafrost

A Mount Sopris portable well logger was calibrated for gamma-gamma density and neutron porosity in dry geophysical-type boreholes in unfrozen materials. Since the hydrogen index of ice is less than that for water, the response of the neutron porosity for 100% ice reads as approximately 72% porosity. Thus, by cross plotting gamma-gamma density vs. neutron porosity, we can determine if the soils are frozen and estimate the unfrozen water contact.

Using this crossplotting technique, we believed that the hydrogen indices of natural gas hydrates, detected in oil wells on the North Slope of Alaska, provide a sufficient contrast with those of water and/or ice to provide a method of quantitative evaluation of hydrates in situ.

Logs of a hole drilled through a buried, artificial-ground ice mass showed that the natural gamma-log count rate decreases significantly in the vicinity of the ice, indicating that the natural gamma log could prove useful for detecting and delineating massive ice.

Calibrated logs were also used to estimate potential thaw consolidation and to follow seasonal variations in moisture content and bulk density.

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Late-Stage High-Angle Faulting, Eastern Doonerak Window, Central Brooks Range, Alaska

Three deformation phases are recognized in the eastern Doonerak window. From oldest to youngest, they are (1) an isoclinal folding event characterized by pervasive axial-planar slaty cleavage, (2) formation of kink bands and chevron-style folds of the slaty cleavage, and (3) development of gentle flexures with associated crenulation cleavage or close-spaced joint planes. First- and second-phase structures are related to thrust faulting. High-angle faulting may be related to third-phase deformation.

Most of these high-angle faults strike west to northwest, are subvertical, and exhibit slickenside striations that plunge gently west. Another set of high-angle faults strikes northeasterly and contains two generations of slickenside striations, a younger subhorizontal set and an older subvertical set. These perpendicular slip directions support the existence of two separate stress regimes: (1) a north-trending principal compressive stress axis, σ_1, and (2) a west-trending σ_1.

Structural analysis of several west-northwest–trending high-angle faults and associated extensional fractures demonstrates a stress regime with σ_1 plunging gently west-northwest. This regime is incompatible with north-directed thrusting and supports a separate late-stage deformational event. Two possible interpretations are that the high-angle faulting is (1) related to west-northwest thrusting or (2) is a separate phase of deformation involving significant east-west compression.

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Reconnaissance Oxygen Isotope Study of Gold-Bearing Quartz Veins Within Metasedimentary Rocks of Valdez Group, Alaska

A reconnaissance oxygen-isotope study of gold-bearing quartz veins within the metasedimentary rocks of the Valdez Group from around Prince William Sound was conducted to examine the variations and similarities within and between the different gold districts, and to investigate the origin of the ore-forming solutions. Analyses were made of mineralized samples from mines and prospects in the Port Valdez, Port Wells, Girdwood, Hope-Sunrise, and Moose Pass gold districts.

In the Hope-Sunrise district the $\delta^{18}O$ values of the gold-bearing veins are relatively constant, ranging from +16.0 to +16.7 ‰, whereas in the Port Valdez district, the vein values are more variable (+13.9 to +17.0 ‰), implying variations in temperature or fluid compositions. Within individual mines, the $\delta^{18}O$ values are constant to within 0.1 ‰ along strike in continuous veins, and vary by a maximum of 0.2 ‰ between bands of quartz in ribbon vein samples.

Petrographic and fluid inclusion data suggest a temperature of approximately 325°C for formation of the mineralized quartz veins. Calculated $\delta^{18}O$ values for fluids in equilibrium with the veins range from +8 to +12 ‰. A quartz separate from an altered quartz diorite intrusion at the Rough Tough mine in the Port Valdez district has a $\delta^{18}O$ value of +14.0 ‰; fluid in equilibrium with the intrusive at a reasonable temperature