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Petroleum Geochemistry of Alaskan North Slope—An Update

When the U.S. Geological Survey took over the drilling program in the National Petroleum Reserve in Alaska (NPRA), many explorationists expected that a major oil accumulation would be found on or adjacent to the Barrow arch. This expectation was based on the presumption that the oil source rocks are buried to great depths in the Colville trough and that the oil generated would have migrated north to be trapped in sandstone or carbonate reservoir rocks near the Barrow arch. Subsequent drilling failed to confirm this model for oil occurrence in NPRA. To date, commercial oil generated in the Colville trough appears to be limited to the Prudhoe Bay area. Understanding the geological reasons for localization of major oil occurrence has important implications for oil exploration in northern Alaska, both onshore and offshore.

Consideration of the basic requirements for oil occurrence (source, migration pathway, reservoir, trap, and seal) suggests that source rock adequacy may be a limiting factor in NPRA. Two geochemically distinct types of North Slope oil have been recognized: the Simpson-Umiat type (associated with a "pebble-shale" unit/Torok Formation source) and the Barrow-Prudhoe type (associated with a Shublik Formation/Kingak Shale source). Except for the oil from the Fish Creek 1 well and the reservoirs of Cretaceous age in the Prudhoe area, the Barrow-Prudhoe oil reservoirs are in Ellesmerian sequence rocks on the Barrow arch. The source-reservoir thermal-maturity patterns, the inferred timing of oil generation, and the structural configuration of the Ellesmerian rocks all suggest that the oil should have migrated to the Barrow area as well as to the Prudhoe area. The presence of subcommercial Barrow-Prudhoe–type oil in NPRA also suggests that deficiencies in the "oil plumbing system" do not explain the lack of oil accumulations along the Barrow arch.

The large volumes of oil in the Prudhoe area, as compared to only "oil shows" in the Barrow area, are best explained by the greater amount and better quality of organic matter in the Shublik Formation and the Kingak Shale to the east of NPRA.

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Facies Correlation and Basin Analysis of Ivishak Formation, Arctic National Wildlife Refuge (ANWR), Alaska

The Ivishak Formation forms a regressive-transgressive deposit. The stratigraphic divisions are (1) a lower prograding deltaic unit of massive sandstone; (2) a middle fluvial unit of sandstone, shale, and minor conglomerate; and (3) an upper destructive deltaic unit of thin-bedded to massive sandstone. These Ivishak units defined in ANWR are recognized in the subsurface and traced over much of the North Slope.

Basin analysis consisted of isopach and percent-sandstone mapping and paleocurrent measurement of 15 outcrops. Formation thickness averages 400 ft (120 m) with a northeast-trending depocenter axis through the Romanzof Mountains. Paleocurrent data define two main provenances of quartz-chert sands: northwest and east. Paleocurrents are oriented normal to, and dip toward, the basin axis. Outcrops located within the axis record bidirectional transport.

A Lower Cretaceous unconformity (LCU) truncates the Ivishak in the Sadlerochit Mountains. Here, Neocomian "pebble shale" rests atop the Ivishak, with Shublik through Kingak formations missing. The LCU truncation is part of a regional unconformity that occurs along the north side of the North Slope.

Ivishak units thin near the unconformity, suggesting an older high, which we term the Nularvik high. This high is part of a regional trend extending through ANWR from the Point Thomson area to Bathtub syncline.

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Sedimentological Evolution of Mississippian Kekiktuk Formation, Sagavanirktok Delta Area, North Slope, Alaska

The reservoir interval in the Endicott field, located under the delta of the Sagavanirktok River east of Prudhoe Bay, is the Mississippian Kekiktuk formation. The rocks are quartzose, and lithofacies and sequence analysis of core material shows that the Kekiktuk in that area can be subdivided into three sedimentologically distinct intervals, each of which reflects a different fluviatile depositional environment. The lowermost interval (zone 1) rests directly on metamorphic basement and comprises interbedded coal, mudstones, siltstones, and fine-grained sandstones. These rocks were deposited in a very low-lying swamp plain containing local lakes and sluggish, highly sinuous streams. Zone 1 is overlain sharply by zone 2, which comprises medium to coarse-grained, multistory sandstone that was deposited within an unconstrained braided river system. The braid plain contained both ephemeral and permanent lakes, and periodic gravity flows deposited coarser sediment into the latter. That sequence passes gradationally upward into zone 3, which is composed of coarse-, medium-, and fine-grained sandstones, as well as siltstones, mudstones, and coals. The lower part of zone 3 is dominated by upward-fining sandstone sequences, interpreted as channel bars deposited within a moderately sinuous fluvial system. They pass gradationally upward into other, distinct upward-fining sequences, which differ in having higher proportions of siltstone, mudstone, and coal. Those rocks were deposited in a more highly sinuous (meandering) fluvial environment. The rocks grade upward into shallow marine sediments of the Kayak/Itkilyariak formations. The vertical sequence within the Kekiktuk in this area permits an interpretation of the structural history of the basin during Kekiktuk time.

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Jurassic-Neocomian Biostratigraphy, North Slope, Alaska

The foraminiferal and palynological biostratigraphy of subsurface Jurassic and Neocomian (Early Cretaceous) age strata from the North Slope were investigated to better define biostratigraphic zone boundaries and to help clarify the correlation of the stratigraphic units in the National Petroleum Reserve in Alaska (NPRA). Through use of micropaleontologic data, eight principal biostratigraphic units have been identified. The Neocomian and Jurassic strata have each been subdivided into four main units.

The gamma-ray zone (GRZ), or "hot zone," sediments include both northern and southern source starved-basin deposits. These deposits range from Barremian to possibly middle Albian age in NPRA. East of NPRA, these Early Cretaceous starved-basin deposits coalesce with Late Cretaceous starved-basin deposits and form a GRZ at least as young as Senonian.

Early Cretaceous starved-basin deposits of northern source are recognized by the presence of dispersed, rounded, frosted quartz sand grains. These sand grains, floating in a mudstone matrix, are essentially absent from the starved-basin deposits of southern source.

The Lower Cretaceous unconformity occurs within the Hauterivian to Barremian biostratigraphic interval in the Tunalik, Peard, and Inigok wells on the NPRA; it cannot be recognized through microfossil evidence in those particular areas. In most other areas of the North Slope, the unconformity occurs at the base of the Hauterivian to Barremian biostratigraphic interval. This unconformity truncates progressively older strata eastward along the present coastal region and onto the Barrow arch.

A mid-Jurassic sandstone unit appears to be of Early to Middle Jurassic rather than Late Jurassic (Oxfordian) age.

Lower to Middle Jurassic strata are characterized by southward depositional thinning and distal (starved-basin) deposition in certain areas.

The Sag River Sandstone is a time transgressive unit that ranges from Late Triassic in the north and northwestern NPRA to Early Jurassic on the Fish Creek platform to the east.

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Ophiolitic Rocks of Iditarod Quadrangle, West-Central Alaska

Reconnaissance geologic mapping during 1984 revealed previously unreported ultramafic rocks of probable ophiolitic origin in the northern