

THE GEOLOGICAL SETTING OF PRUDHOE BAY/NORTH SLOPE OIL FIELDS

Steven P. Edrich*
BP Alaska Exploration
San Francisco, CA 94111

ABSTRACT

The North Slope is a prolific hydrocarbon province with 60-70 billion reservoir barrels of oil and 30-40 trillion cubic feet of gas in place discovered to date.

Reservoirs and rich source rocks occur throughout the stratigraphic column. In the Ellesmerian megasequence major oil source rocks are the Kingak and Shublik Formations. Best reservoirs (Ivishak, Lisburne, Kekiktuk) are associated with secondary porosity development beneath a mid-Hauterivian (Early Cretaceous) unconformity.

Post-unconformity sands, associated with local erosion of Ellesmerian and basement strata are important reservoirs (Kuparuk, Point Thomson, Walakpa). The overlying "upper pebble shale" is locally a source rock.

Within the Brookian clastic cycles, rich oil-prone source rocks are developed in distal bottomset mudstones ("Highly Radioactive Zone/HRZ", Shale Wall Member). Shelf to fluvial/deltaic sands (West Sak, Ugnu) are the reservoirs for heavy oils at shallow depths.

Major hydrocarbon accumulations are associated with the 'Kuparuk' regional structural high. This high has developed by the interaction of two tectonic elements since the early Jurassic: rifting and passive subsidence of the Arctic Ocean margin; and Brooks Range tectonism/orogenic deposition.

The Kuparuk High acted as the focal point for migrating hydrocarbons. Three stages are recognized in the hydrocarbon generation/migration history:

1) ?Early Jurassic to Cenomanian - Arctic Ocean rift events culminate in mid-Hauterivian break-up. Subcrop unconformity generated on rift margin uplift. Brookian depocenter in west Colville Trough (=oil kitchen area). Generated oil migrates up-dip to western subcrop zone.

2) Senonian to Mid-Eocene - Passive subsidence of Arctic margin. Switching of Brookian depocenter to east initiates the Kuparuk High. Major oil charge to Prudhoe Field at this stage.

3) Late Eocene to Recent - Main depocentre in East Beaufort offshore and thrust loading in eastern Brooks Range cause regional tilting and remigration of hydrocarbons. Prudhoe spills to Kuparuk and to West Sak/Ugnu via Eileen fault swarm. Point Thomson charged from East Beaufort source kitchen.

*Present address: BP Petroleum Development (Norway Limited) Ltd., Stavanger, Norway.

NORTH SLOPE OIL AND GAS: THE BARROW ARCH PARADOX

Kenneth J. Bird
U. S. Geological Survey
345 Middlefield Road
Menlo Park, CA 94025
415-323-8111

ABSTRACT

In the 40-year history of hydrocarbon exploration on the Alaskan North Slope, about 21 accumulations with a total in-place volume of more than 60 billion barrels of oil and 35 trillion cubic feet of gas have been discovered. Although the density of exploratory drilling in this region is not uniform, enough drilling has been done to show a distinct concentration of oil and gas in the Prudhoe Bay area between the Colville and Canning Rivers. This concentration is also evident when the Prudhoe area resources are compared with the USGS estimates of undiscovered in-place oil and gas resources of the adjacent areas, the National Petroleum Reserve in Alaska and the Arctic National Wildlife Refuge. Most oil and gas in the Prudhoe area accumulated near the present coastline in reservoirs that overlie a southeasterly plunging basement ridge, the Barrow arch. The location of these accumulations, in low-relief structural-stratigraphic traps midway along the arch and downdip from its apex at Point Barrow, is the paradox.

An answer to this paradox is provided by analysis of two cross sections, one along the Barrow arch and one perpendicular, showing their original structural positions for the beginning, middle, and end of Cretaceous time. In Early Cretaceous (mid-Neocomian) time, the crest of the Barrow arch was near sea level along its entire length. Because of northeasterly sediment progradation during later Cretaceous time, the Barrow area became more deeply buried than the Prudhoe area, thus making the Prudhoe area the focal point for migrating oil and gas. Beginning in early(?) Tertiary time, the Barrow area was slowly uplifted while the Prudhoe area subsided, thus beginning the process which resulted in the reversal of their relative elevations and the focus for migrating oil and gas. Studies show that the Prudhoe Bay field was tilted during Tertiary time, that some oil and gas escaped, migrated toward Barrow, and was trapped in the Kuparuk, West Sak, and Ugnu fields. This analysis suggests that most North Slope oil and gas was generated during Cretaceous time.

