The Historical Resource and Recovery Growth in Developed Fields on the Arctic Slope of Alaska

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Introduction

Early exploration and oil prospecting in Alaska was driven by surface oil seeps noted on the Alaska Peninsula, Western Cook Inlet and on the North Slope. Historically, oil seeps were observed by Inupiat Eskimos, and according to archaeological evidence, oil shale was used for fuel by the indigenous peoples of the Arctic. As early as 1853, during the Russian period, oil was reported on the west side of Cook Inlet in the vicinity of the Iniskin Peninsula and in 1882, a Russian named Paveloff took the first samples of oil. Early traders on the North Slope also reported seeps along the Arctic coast.

On the North Slope, the first geologic and topographic studies date back to 1901 and the first formal descriptions were recorded by the U.S. Geological Survey in 1919. By 1921, prospecting permits were filed, and in 1923 President Harding established by executive order the Naval Petroleum Reserve No. 4 (NPR-4), now known as the National Petroleum Reserve-Alaska (NPR-A). The Geological Survey conducted reconnaissance mapping 1923 through 1926 and published the results in 1930.

On the Arctic Slope, the first exploration phase of NPR-4 started in 1943 and ended in 1953. The United States Navy drilled 35 core test and exploration wells and found three oil accumulations and six gas accumulations within the reserve. Only one of these discoveries was considered sizable, Umiat, with an estimated 50 million barrels (8 million cubic meters) of recoverable oil.

Alaska was granted statehood in 1959 and began selecting lands as part of its statehood entitlement. Land selection was sometimes controversial and subject to delays for issue resolution with federal agencies. In 1964 Alaska was granted 1.5 million acres on the North Slope and immediately conducted its first lease sale. From 1964 through 1978, 123 exploration wells were drilled in the Arctic areas resulting in 22 oil discoveries. The next 25 years, 1979 through 2004, saw 263 exploration wells drilled and 31 oil discoveries documented. Through the end of 2004, 26 of 53 oil discoveries had begun development and production.

Current Known Recovery as of 12/31/2004

The focus of this poster is on the developed reservoirs and fields on the Arctic Slope of Alaska. Fifty-three oil reservoir discoveries have been documented on the Arctic Slope since exploration drilling began in 1945. Through the end of 2004, 26 reservoirs in seven fields have begun development and are producing. The total resource under development from 26 discoveries is 44,000 million barrels (6,995 million cubic meters) oil in-place. Cumulative production from these reservoirs is 14,789 million barrels (2,351 million cubic meters) including natural gas liquids (494 million barrels, 79 million cubic meters), according to production data on file at the Alaska Oil & Gas Conservation Commission.

Ultimate recovery volumes were derived from public forecasts by the Alaska Department of Revenue[1] and Department of Natural Resources[2] - Division of Oil and Gas that are published on a periodic basis. Ultimate recovery is calculated by summation of Remaining Reserves and

Cumulative production at the end of each year. Latest ultimate recovery estimates from 26 developed reservoirs amounted to 20,790 million barrels of liquids (3,305 million cubic meters). In general, remaining reserves are based on projection of production history with additional increments added for known development projects. The latest definition of reserves is found in the Alaska Oil & Gas Report, May 2006 "…Remaining Reserves are oil or gas that are economic and technologically feasible to produce and are expected to produce revenue in the foreseeable future."[3] Details of the proved undeveloped and probable or possible reserve categories are not detailed in the forecasts. At year end 2004, Estimated Ultimate Recovery from the developed fields on the Arctic Slope totals 20,879 million barrels (3,319 million cubic meters) liquids.

Increased Known Recovery from 1980-2004

Additions to known reservoirs (Pre-1979)

The Prudhoe Bay reservoir was the only producing Arctic Slope reservoir prior to 1979. At that time the Estimated Ultimate Recovery was 9,600 million barrels (1,526 million cubic meters) including waterflood secondary recovery. Initial development plans at Prudhoe anticipated development only to the 100 foot light oil column contour as being economic or practical. Subsequent development has virtually exploited the entire light oil column. Through improved recovery techniques, reduced well spacing, enhanced recovery projects, expanded development, extended gas cycling, and improved drilling methods; an additional 4,267 million barrels (678 million cubic meters) will be recovered for a total of 13,867 million barrels (2,205 million cubic meters) of oil and natural gas liquids.

Development of Pre-1980 Discoveries

Prior to 1980 – 15 reservoirs had been discovered on the Arctic Slope including Prudhoe Bay. The other 14 reservoirs account for 5,202 million barrels (827 million cubic meters) for a total of 19,069 million barrels (3,032 million cubic meters) liquids for pre-1980 discoveries.

New Field Discoveries 1980-2004

Eleven reservoirs in six fields were discovered in the last 25 years. Estimated ultimate recovery is 1,836 million barrels (292 million cubic meters).

Summary of Province Composition by Field Size and Growth

Current known Recovery – Cumulative and EUR – Super Giant, Giant, Sub Giant

Arctic Slope Field	Cumulative Production 2004, Millions bbls (m3)	Estimated Ultimate Recovery, 2004 Millions bbls (m3)
Prudhoe Bay Field	11,827 (1,880)	15,273 (2,428)
Kuparuk River Field	2,074 (330)	3,616 (575)
Milne Point Field	220 (35)	529 (84)
Endicott Field	459 (73)	585 (93)
Colville River	138 (22)	675 (107)
Other	71 (11)	200 (32)
Totals	14,789 (2,351)	20,879 (3,319)

Viscous Oil Resource and Current Development

Shallow, cold, "heavy" viscous oil was discovered between 1969-1971 in the Cretaceous Schrader Bluff Formation, Tertiary Sagavanirktok Formation – Ugnu sands, and the Schrader Bluff Formation – West Sak Sands. These accumulations occur in and around the Prudhoe Bay, Kuparuk River and Milne Point Units at depths between 3500-4000 feet, below perma-frost that is located at 2000 feet. Resource estimates range from 23 to 36 billion barrels in place in those field areas. Current development in the viscous oil sands is being conducted in the West Sak pool (Kuparuk River Field); Schrader Bluff pool (Milne Point Field), Orion and Polaris pools (both in Prudhoe Bay Field). Resource estimates range from 4700 million to 6500 million barrels of oil in place in the areas under active development. The current Estimated Ultimate Recovery ranges from 900-1000 million barrels based on information through 2004 which yields a recovery factor of 15-20%.

Various industry experts have discussed the technical and economic challenges of viscous oil development in the Arctic. Activity has been cyclic, co-incident with strategic interests and oil price swings. The companies have been "experimenting and evaluating" techniques to drive cost down, increase recovery and generally improve recovery factors. The effort to date could be characterized as large scale pilot tests.

Today the industry has evolved their drilling practices from vertical and slanted to horizontal, multilateral and potentially fishbone type wells. Sand production has been an issue with screens and liners to keep sand in place evolving to producing sand and handling it on the surface. Recovery techniques have involved waterflood and are evolving to miscible gas injection, hot water injection and potential CO2 injection. Cumulative production through 2004 is 60 million barrels, only 1-1.5% of the in place resource.

Predicted recovery factors for the viscous projects have ranged for 10-15% primary, 20-25% with secondary and 2-6% incremental with enhanced recovery methods. Results of current evaluations and pilot tests will be important to future development and recovery of the viscous resource.

Additional Development/Investment necessary to produce current "booked" proved undeveloped Reserves in individual fields

- Selective infill drilling to drain by-passed oil
- Reduced spacing or increased reservoir contact per well
- Miscible Gas Injection
- Innovative application of Miscible gas injection
- Potential CO2 Injection
- Gas Cap Water Injection
- Accelerated production methods prior to gas blowdown
- Innovative Waterflood – Low Salinity
- Extension drilling around developed reservoirs
- Expanded Miscible Gas injection including CO2
- Horizontal, Multi-Lateral Drilling
- Oil Viscosity Reduction

Summary of Key Characteristics of Largest fields by Major Reservoirs

A comprehensive table and charts will be included in the poster to document the following:

- Size, Year of Discovery, Location (Latitude, Depth, Onshore/Offshore, Water Depth)
- Volumetric: Area, Net Thickness, Porosity, Initial Water Saturation, FVF, OOIP
- Rock: Permeability, Continuity, Original Pressure, Drive Mechanism, Trap and Seal
- Fluid: API Gravity, % Sulfur, Viscosity
- Production: Initial Year, Peak Year, Amount in Peak Year, Cumulative
- Development: Spacing and Spacing History, # Wells, Well Type (Vertical or Horizontal), Post-Primary Recovery Methods, Current Recovery Factor
- Estimated Ultimate Recovery Growth for Arctic Slope Fields
- Estimated Ultimate Reserve Recovery Growth Charts for Reservoirs

1. Alaska Department of Revenue Spring and Fall Forecast, <http://www.tax.state.ak.us/sourcesbook/index.asp>, accessed August-September, 2006.
2. Alaska Department of Natural Resources - Division of Oil & Gas, Historical and Projected Oil and Gas Consumption January 1979 – May 1999, Alaska Oil & Gas Report December 2000-May 2006, <http://www.dog.dnr.state.ak.us/oil/products/publications/annual/report.htm>
3. Alaska Department of Natural Resources - Division of Oil & Gas, Alaska Oil & Gas Report May 2006, page 3-1, <http://www.dog.dnr.state.ak.us/oil/products/publications/annual/report.htm>