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"Source-reservoired Oil Resources, Alaskan North Slope"

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Two characteristics distinguish most "unconventional" oil and gas resource plays from their "conventional" counterparts: 1) hydrocarbons occur throughout a highly continuous fairway as opposed to being restricted to discrete, buoyancy-driven accumulations, and 2) massive stimulations are needed to sustain commercial flow rates. These generalizations apply whether the resource in question is coal bed methane, gas hydrates, tight gas sands, shale gas, or more recently, shale oil. Over the last few years, oil has commanded a higher market price relative to natural gas on an energy-equivalent basis. This price differential has driven producers to adapt shale gas drilling and completion technologies to exploit more lucrative oil- and condensate-prone shale plays, either by shifting their drilling up-dip in the same source rock system, or by divesting from gas-prone shale basins in favor of basins with previously untapped oil-prone source rock reservoirs. The success of multi-stage hydraulic fracturing in stimulating flow from source rocks, initially for gas production and more recently for oil recovery, has revolutionized the domestic petroleum industry.

October 2010 witnessed the first step in bringing the shale revolution to Alaska. Great Bear Petroleum submitted winning bids on more than 500,000 acres in the state's annual North Slope Areawide lease sale and announced plans to pursue oil production directly from the region's three principal source rock units. Since then, Department of Natural Resources geoscientists, engineers, economists, land managers, and permitting staff have been studying northern Alaska's shale resource potential and how to manage it appropriately.

The primary source rock of interest is the Late Triassic Shublik Formation, a heterogeneous unit consisting of phosphatic limestone, shale, sandstone, and siltstone. Deposited on a nutrient-rich, upwelling-influenced continental margin, the Shublik is commonly 150-250 ft thick, averages 2-3% total organic carbon, and contains highly oil-prone type I/IIS kerogen. The Shublik is identified as a major contributor to many oil accumulations, and has been interpreted as the nearly exclusive source for oils spanning a wide range of API gravities (e.g., 21-27° at the Kuparuk River field to 43-45° at Northstar). Slightly shallower than the Shublik is the Early Jurassic condensed shale facies of the lower Kingak Formation. Deposited on a sediment-starved, oxygen-depleted platform margin, the lower Kingak commonly ranges 175-550 ft in thickness, averages 5% total organic carbon, and contains oil- and gas prone type II/III kerogen. Oil-source rock correlations identify the lower Kingak as the source of the light oil at the Alpine field (40° API). In most areas, the Sag River sandstone lies between the Shublik and Kingak formations, offering a 20-50 ft-thick interval of low permeability clastics as a potential stimulation target for co-development with the overlying and underlying source rocks. The third source rock zone of interest is the Early to Late Cretaceous Hue Shale, including its basal unit, the gamma ray zone (GRZ). This composite source rock system represents the distal, condensed toes of Brookian clinoforms that fill the Colville foreland basin. As such, it consists of identifiable tongues that become

more organic-rich, oil-prone, and coalesce toward the east. Regionally, the Hue/GRZ system averages 3% total organic carbon, and contains a variable mix of type II/III kerogens capable of generating either oil or gas, depending on location and thermal maturity. The GRZ is identified as the primary source of light oil in the Tarn Bermuda reservoir (38° API).

This presentation will outline a wide range of issues relevant to the potential commercialization of North Slope shale oil resources. Numerous geologic factors control the productivity of source rocks as unconventional reservoirs. Organic geochemical properties, thermal and tectonic history, porosity and permeability characteristics, and geomechanical properties (brittleness) can each exert fundamental control on whether the resource can be commercially produced. Resource evaluation tools include a diverse suite of core and outcrop analyses, well log and wellbore analyses, and emerging advanced seismic techniques. Shale plays in the lower 48 states, especially the oil- and condensate-rich Bakken play in North Dakota and the Eagle Ford play in Texas, will be examined as potential analogues – but their geologic characteristics are only one consideration. Just as important will be anticipating the engineering, environmental, and economic challenges to be overcome before source-reservoired oil resources can help extend the operating life of the Trans-Alaska Pipeline System to ensure the maximum recovery from all North Slope reservoirs.