Appraisal and Development of the Moraine thin-bedded Turbidite Reservoir on the North Slope of Alaksa

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Recent exploration and development activity on Alaska's North Slope has focused on the Late Cretaceous Brookian mega-sequence, which consists of a set of progradational clinoform packages that infilled the Colville foreland basin, generally from west to east. The Nanushuk-Torok Formations represent the lower portion of this mega-sequence, with the Nanushuk being comprised of the marginal marine to deltaic "topset" deposits, and the Torok being the time equivalent slope to basin "toeset" portion of the system. Recent industry press has focused on topset discoveries within the Nanushuk Formation including Willow, and Pikka/Narwhal. This paper will focus on the "Moraine", a gravity driven deposit within the Torok Formation.

The Moraine reservoir is situated below the modern-day Colville River delta on the western edge of the Kuparuk River Field. It is characterized as a slope-attached apron, comprised of interlayered turbidite sands (primarily Tc facies), shaly silts, and slurry flow beds. Net to gross generally decreases from the base to the top of the reservoir interval, likely related to a shift of the deltaic input source away from the area through time. Several whole cores have been collected that form the basis of the depositional interpretation. Typical of Brookian reservoirs, the Moraine is texturally dominated by poorly sorted fine to very fine-grained sand to coarse silt litharenites. It is at a shallow depth of burial (~5200ft TVD present day) and shows little cementation overprint. The combination of grain size, sorting, mineralogy, and depth results in an average porosity of ~18% and permeability of ~10mD. The oil, derived from the Triassic Shublik source rock, is of moderate viscosity. While no gas cap has been identified, the reservoir is in a broad transition zone, leading to high initial water-cut, especially in the structurally downdip wells.

The reservoir was discovered by a series of vertical exploration wells drilled by Texaco in the early 1980's and ARCO in the 1990's. At that time the play was determined to be challenged due to the thin-bedded nature of the reservoir and high-water cuts witnessed in flow tests of the initial vertical wells. In the 2010's, Pioneer Natural Resources drilled the first dedicated horizontal multi-stage fracture stimulated wells in the play. ConocoPhillips Alaska's (CPAI's) entry into the play was the result of a successful flow test from an up-hole recompletion in an existing well drilled to the Kuparuk Formation. The recompleted well flowed ~600 BLPD with a 55% WC. This led to CPAI's initial appraisal of the reservoir with a 4000ft horizontal injector/producer pair. These wells were drilled parallel to the maximum horizontal stress direction, to promote longitudinal fractures, at 1,500 ft inter-well spacing. Both the producer and injector were stimulated to facilitate water flooding for enhanced oil recovery due to zero vertical permeability in the interbedded reservoir. The waterflood proved to be an efficient mechanism for reservoir pressure support. Subsequent appraisal well pairs successfully tested the scalability of production by increasing lateral length first to 6000' and then up to 12,000', while also down spacing injector/producer inter-well spacing to 1,050 ft to accelerate production and hydrocarbon pore volumes injected through the reservoir. Current development focuses on optimization of lateral placement within the reservoir to maximize fracture height across the thin bedded reservoir while maintaining distance from the oil water contact.

The development of thin bedded, low permeability conventional reservoirs presents a unique development challenge that transcends conventional and unconventional methods. The fluid properties, combined with a relatively low permeability and low reservoir pressure close to the bubble point of the Moraine reservoir necessitates a water flood for enhanced oil recovery, while the thin bedded nature of the reservoir creates the need to fracture stimulate the wells to allow vertical access to the reservoir sands. Similar to unconventional reservoirs, lateral placement, completions design, and well spacing are key development parameters that must be optimized.