Abstract

Horizontal drilling and multi-frac completions have greatly augmented British Columbia gas and liquids resources by providing economic access to unconventional (low permeability) reservoirs. However, relatively little new unconventional oil production has been brought on stream in this gas-prone area of the Western Canada Sedimentary Basin. We identified exploration and exploitation fairways for oil in unconventional reservoirs throughout the stratigraphic column, except for the Montney Formation, as it is already an active oil and liquids drilling target. Regional geological assessment of reservoir and production trends identified potential in conventional, tight, and shale reservoirs. We reviewed existing files of analytical data submitted to the Regulator - standard core analysis, geochemistry / maturity, mineralogy, geomechanical properties - and tabulated them to support future detailed analyses. Where analytical data were lacking on promising plays, we sampled cores and completed comprehensive laboratory analyses to fill the gaps. Finally, we analyzed test and production data from a reservoir engineering perspective to better understand the scope and quality of potential resource oil fairways. Of 19 reservoir intervals deemed suitable for analysis, 10 demonstrated little prospectivity for reasons including: lack of extensive low-permeability reservoir facies, poor geomechanical properties (low “frackability”), and lack of viable oil charge. Six demonstrated some resource oil potential based on existing oil shows and favourable geological / geomechanical characteristics, but lacked either substantial horizontal / multi-frac testing, or evidence of substantive resource oil fairways. Only two reservoirs showed potential to be top-priority unconventional oil targets. Cretaceous Chinkeh Formation sandstones are prospective for tight oil across a broad, poorly defined fairway downdip from the existing Maxhamish gas field. The Triassic Halfway Formation presents halo oil potential in limited-permeability shoreface sandstones offsetting conventional production, which has been focused on higher-quality tidal channel sandstones. New Halfway production could be brought on stream quickly using existing infrastructure but developing the Chinkeh would require new processing and pipeline construction in a relatively remote part of the province.
References Cited


The Lower Cretaceous Chinkeh Formation lies on the pre-Cretaceous unconformity, which cuts strata ranging from Mississippian carbonates in the east to Triassic siltstones over most of the Liard Basin. The Chinkeh was deposited in basal fluvial through marine shoreface and shallow shelfal settings, then was transgressed more or less conformably by marine shales of the Gattutt Formation.

Chinkeh sandstones host a hydrocarbon-saturated (Deep Basin) petroleum system on the eastern flank of the Liard Basin. The large (400 BCF) Maxhamish Chinkeh ‘A’ gas pool is largely depleted, but nine oil wells on its western (down dip) flank exhibit variable production behaviour, and do not appear to have been drawn down by updip gas production. Only a small percentage of the oil in place has been produced, and geological mapping suggests reservoir sandstones extend westward and southward to form an areally-extensive, oil-saturated, low-permeability sandstone fairway. Jiang et al. (2015) projected 400-500 million barrels of light oil in place. Production analysis suggests pressure support from updip hydrocarbons, but no associated aquifer.

We recommend the western flank of the Chinkeh gas and oil pools be mapped in detail to support new Chinkeh horizontal drilling in the best-quality and thickest sandstones. Well control is very poor, and additional stratigraphic testing may be necessary. Both poorer-quality Chinkeh sandstones above the basal clean sandstone and underlying Toad-Grayling sandstones should be assessed for their potential contribution.

Production Analysis

Oil production began in 2003, and as of November 2017 the nine oil wells have produced about 368 MBO. Water production continues to be very low, and there does not appear to be water drive or aquifer support.

BCOOGC (2016) assigned 5.6 MMBO in place and a recovery factor of 10% to the concurrent production area, which they measured as 326 ha. Looking at the present distribution of oil wells, we estimated a 1250 ha productive area with oil in place of about 30 MMBO, using parameters similar to BCOOGC (2016) but with a thicker net pay (3.1m vs OGC 2.1m). Production to date is thus only 1.2% of the oil in place. The oil gravity is 42 API, and at reservoir conditions, industry correlations give a Bo of 1.25 and a saturation pressure (bubble point) of 1200 to 1600 psia. Original reservoir pressure is 1334 psia, indicating that the gas and oil areas were likely originally in pressure and phase equilibrium.

We performed decline analysis on all nine oil wells, and on some gas wells adjacent to the oil leg. Production is extremely flat, and it was difficult in some cases to get the decline analysis routine to converge to an answer. The four horizontal wells averaged initial production of 58 BOPD and estimated ultimate recovery of 152 MBO. Two vertical wells averaged 47 BOPD and EUR 138 MBO. Three deviated, almost-vertical wells performed poorly, with average 17 BOPD and EUR 21 MBO. One additional vertical well is listed as producing, but has never produced. Total EUR for the nine wells is 1.1 MMBO, or 4% of volumetric OOIP, indicating potential for infill drilling.
ABSTRACT

In the Horn River Basin, it is a productive shale gas reservoir. Southeastward, Stratigraphic Relationships, Horn River Basin Cordova Embayment and eastward, towards the Peace River Block, the Horseshoe Reservoir is a prolific gas producer, with significant volumes of gas in place. The potential for hydrocarbon production from the Horseshoe Reservoir is supported by the presence of organic-rich source rocks, which have the potential to generate sufficient quantities of hydrocarbons to fill the reservoir.

The Horseshoe Reservoir is a critical component of the Horseshoe Complex, which includes the Slave Point and Waterways Formations. The Slave Point Formation is a source rock and plays a significant role in the hydrocarbon generation and migration in the Horn River Basin. The Waterways Formation is a regional source rock that contributes to the hydrocarbon generation in the basin.

The Horseshoe Reservoir is characterized by a combination of organic-rich sediments and a favorable geologic setting, which has led to the development of a significant gas reservoir. The reservoir is composed of a combination of sandstone, mudstone, and shale, which have been deformed and fractured during the tectonic history of the basin.

The reservoir is underlain by the Slave Point/Waterways fms and is overlain by the Leduc Formation. The reservoir is bounded on the north by the Horn Mountain Fault and on the south by the Peace River Fault. The reservoir is divided into several smaller reservoirs, each with its own unique geologic characteristics.

The Horseshoe Reservoir is a promising target for exploration and production in the Horn River Basin. The reservoir has the potential to contribute significantly to the gas supply in the region, and its development will have a positive impact on the local economy and energy sector.

REFERENCES


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In order to assess "halo" oil potential in the Halfway, we examined production from tidal channel facies in core. Typical Halfway tidal channel and shoreface facies in core are characterized in detail, and detailed structural mapping should be undertaken to identify reservoir compartments. Halfway "halo" oil reservoirs are strongly compartmentalized by structural and stratigraphic elements. Most Halfway exploration and development was undertaken in the 1980s and earlier, and oil pools are developed almost exclusively with conventional vertical wells.

Flanking tidal channel reservoirs, Halfway regional shoreface reservoirs exhibit consistent reservoir quality, are regionally charged with oil, and are capable of oil production from vertical wells in isolated cases. Detailed reservoir and production analysis in the Peejay area demonstrates that there may be abundant opportunity to develop lower-quality Halfway "halo" shoreface reservoirs in areas undrained or not significantly drained by existing vertical producers.

Halfway "halo" oil prospectivity should be assessed offsetting conventional production along the oil fairway, where abundant historical data are available. Shoreface reservoir quality, thickness, and in-place oil resources should be characterized in detail, and detailed structural mapping should be undertaken to identify reservoir compartments. Horizontal wells may not only enable economic development of marginal-quality sandstones, but may tap into isolated small tidal channel or better-quality coquinaid sandstone developments in the shoreface.

At well d-89-C/94-A-16, a Halfway shoreface section was cored, and showed permeabilities of 4mD or less throughout. An eight-foot section was acidized and frac’d, and 164,730 barrels of oil produced at rates up to 100 BOPD between 1986 and 1987. A reservoir pressure of 1312 psia was taken shortly after production commenced; a measurement in 1988 showed a decline to 435 psia.

Surveying seven offsetting Halfway wells (five producers and two water injectors, all completed in tidal channel facies), we saw fairly consistent pressure behaviour and good waterflood responses, with reservoir pressures mostly within a fairly narrow band of 1100-1400 psia. The five producers show limited gas/oil ratio increases and water breakthrough with increasing water/oil ratios.

Production behaviour at d-89-C demonstrates that it is in a separate reservoir compartment; besides the declining reservoir pressures, we see little water production and generally smoothly-declining oil production rates. Compartmentalization results from stratigraphic separation of the shoreface reservoir at d-89-C from tidal channel reservoirs producing in the offsetting wells.

Effective horizontal drilling and multi-fracturing completion of low-permeability shoreface sandstone "halo" facies could substantially improve oil recovery from the Halfway Fm at Peejay. In the broad fairway of Halfway oil production trending across NEBC, high-quality tidal channel and upper shoreface reservoirs have been developed in many pools strongly compartmentalized by structural and stratigraphic elements. Most Halfway exploration and development was undertaken in the 1980s and earlier, and oil pools are developed almost exclusively with conventional vertical wells.

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