7-13-67-13 w5m

Lowstand Systems Tract
Base Beaverhill Lake
Sequence and base of
Second-order Sequence.

Gilwood Member of Watt
Mountain Formation, Fort
Vermillion Formation, Slave
Point Formation.

2970m - Flooding surface with
nodular, slightly fossiliferous lime
mudstone above.

2972m - Fossiliferous lime
wackestone to boundstone with
cylindrical and tabular
stromatoporoids, crinoids
brachiopods and branching corals.

2977m – Microbially laminated,
anhydritic and dolomitic mudstone;
locally brecciated.

2982m – Illitic green-grey shale.

2980 – Cross-bedded, very coarse to
conglomeratic arkosic sandstone.
Porosity 5-20%, permeability 100-
md.
BHL A Pool
219 producing wells, 150 injectors
Cum oil 58.4 e6m3
Cum gas 13.3 e9m3
Cum oil 367.8 million barrels
Cum gas 473 bcf
Pattern Waterflood, Miscible Flood
This well 1.67 million m3, 10.5 million barrels


8240 ft. Cylindrical stromatoporoid / coral lime wackestone with grainy peloidal matrix; overlain by dark coloured lamellar stromatoporoid coral wackestone.

8282 ft. Prominent flooding surface with nodular lime wackestone above containing brachipods, corals and tabular stromatoporoids.

8300 to 8282 ft. Alternating deeper to shallower lagoon cycles. Amphipora lime wackestones to packstones with bulbous stromatoporoids.
Judy Creek BHL A Pool
219 producing wells, 150 injectors
Cum oil 58.5 e6m3
Cum gas 13,331 e6m3
Cum oil 367.8 million barrels
Cum gas 473 bcf
Pattern Waterflood, Miscible Flood
This well 560 e3m3 (3.5 million barrels)

8832 - 8800 ft – Basal Beaverhill Lake 2, Swan Hills Formation. Cylindrical stromatoporoid wackestone to floatstone overlying sequence boundary. Progressive deepening above with tabular stromatoporoid wackestone to boundstone overlain by coral wackestone to packstone with dark coloured matrix.

8832 ft – Base of Beaverhill Lake 2 Sequence. Fenestral lime mudstone with Amphipora. Dissolution cavities with greenish illitic lime mud fill are present up to one metre below the sequence boundary.

8850 – 8832 ft - Uppermost Beaverhill Lake 1, Slave Point Formation. Lagoonal cycles composed of Amphipora in a packstone matrix with occasional bulbous stromatoporoids. Fenestral mudstone caps some cycles.
Transgressive Systems Tract, Swan Hills Formation Limestone

Judy Creek BHL B Pool
76 producing wells, 39 injectors
Cum oil 18.7 e6m3
Cum gas 4545 e6m3
Cum oil 118 million barrels
Cum gas 161 bcf
Pattern Waterflood, Miscible Flood
This well 22401 m3 (141 kbo)

8716 ft - dk coloured calc mudstone overlying a *Tripanites* bored hardground that forms the top of the reef.

8746 ft - Stromatoporoid rudstones of the upper BHL2 are erosionally overlain by green argillaceous mudstones of the basal BHL3. Extensive percolation of the shale into solution features below the sequence boundary. Greenish mudstones overlain by some organic layers (*stromatolites* colonizing the surface following initial flooding?) and then tidal flat fabrics.

8746-8775 ft - bulbous and cylindrical stromatoporoid upper foreslope and reef flat grainstones with excellent porosity and permeability. 8830 – 8873 feet – Beaverhill Lake 2, Swan Hills Formation. 8906 feet shoal facies are overlain by lower foreslope facies that shoal up through reef margin to lagoonal cycles.

8957 ft – Base of Beaverhill Lake 2 Sequence. Fenestral lime mudstone with *Amphipora*. Overlain by oncolitic, bulbous and stromatoporoid shoal facies.

8995 – 8957 feet - Uppermost Beaverhill Lake 1, Slave Point Formation. Lagoonal cycles composed of *Amphipora* packstone with occasional bulbous stromatoporoids. Fenestral mudstone caps some cycles.
Pyritized, abraded fossil wackestone sharply overlies nodular lime mudstone to calcareous shale with crinoids.

Overlain in turn by medium to dark grey nodular lime mudstone to calcareous shale with brachiopods and crinoids. Mudstone lithofacies are typical seal units.

9090 ft – Base of Beaverhill Lake 3, Waterways Formation.
Limestone, partially dolomitized and dolostone interval of the Swan Hills Formation with vuggy and intercrystalline porosity 5-15% and permeability 10 to 160 mD.
Transgressive Systems Tract, Top of Waterways Formation of the Beaverhill Lake Group
Basal Cooking Lake Formation of the Woodbend Group

3075 ft – base of Woodbend 1 sequence boundary. Peloidal, oncolitic grainy packstones of the basal WD1 (Cooking Lake Fm.) containing abundant charophytes abruptly overly nodular argillaceous wackestones of the Beaverhill Lake 3 (Waterways Fm.). Note the rounded green mudstone clasts of the BHL3 incorporated into oncolites of the WD1.
Flank well Golden Spike reef.

5920 ft – 6009 ft Above the sequence boundary there are several backstepping parasequences consisting of sandy open platform lithofacies. These shoal cycles are overlain by two thicker parasequences that contain dark coloured tabular stromatoporoid boundstone facies at their bases and then shallow upwards into more proximal facies. The dark coloured boundstones reflect significant backstepping of the Woodbend 2 reef from the underlying more extensive Woodbend 1 platform.

6040 ft - 6009 ft - fenestral mudstones of the uppermost Woodbend 1 are overlain by subtidal peloidal mudstones of the basal Woodbend 2. Unfortunately the contact has not been preserved. The interval at about 6010 feet, immediately below the sequence boundary, consists of shallow subtidal mudstones of the upper WB1 with extensive solution cavities filled with minor argillaceous mudstone and abundant sparry calcite cement.
Golden Spike Leduc A Pool
64 producing wells, 12 injectors
Cum Oil 36.5 e6m3
Cum Gas 23.6 e9m3 gas
Cum Oil 229.6 million barrels
Cum Gas 840.6 BCF gas (includes injected gas)

Primary prod followed by vertical miscible flood.

The 11-23-51-27 w4m well is located in the heart of the Golden Spike Leduc A pool. The cored intervals selected illustrate several important sequence boundaries and also highlight the reservoir properties of a major limestone Woodbend reef pool (Leduc Formation). Discovered in 1949, the pool had an original oil column of 190 metres (620 feet) and an area of 1420 acres. The recovery was enhanced by crestal injection that was later augmented with the addition of a solvent bank between the gas and oil. However the tertiary recovery scheme failed when the bank encountered a tight barrier across the pool that results from cementation associated with the Woodbend 3 basal sequence boundary.

5570 ft to 5607 ft - The initial parasequence of Sequence 3 is dominated by fenestral lithofacies deposited during the initial re-flooding of the reef and then is overlain by several reef flat sand and tidal flat dominated reef cycles.

5607 feet. Base of Woodbend 3 sequence boundary. Fenestral mudstones below the sequence boundary show extensive dissolution and several stages of infilling by green argillaceous mudstones. Solution pipes infilled by green argillaceous mudstones and later stage calcispar extend downwards several metres from the sequence boundary.

5607 ft – 5700 ft Several parasequences are evident in the Woodbend 2. These are largely aggradational and dominated by reef flat and open lagoon carbonate sands with associated stromatoporoid debris. The parasequences are often capped by fenestral fabrics reflecting an origin on a tidal flat depositional environment. The reservoir quality is good with average porosity of around 8 % (maximum 20%) and permeability up to several darcies.
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Windfall Leduc C

2 producing wells
Cum Oil 51.5 e3m3
Cum Gas 162.1 e6m3 gas
Cum Oil 324 thousand barrels
Cum Gas 5.7 BCF gas

Primary Production

8982 to 9028 ft. Bulbous and cylindrical stromatoporoid dolopackstone deposited in a reef margin to reef flat environment. Extensive leaching of fossil allochems to form the characteristic “vuggy” porosity of the dolostone Leduc Formation reefs. Sparry dolomite and anhydrite vug fill. Extensive pyrobitumen lining of pores.
Adjacent Horizontal wells are capable of several hundred barrels of condensate a day.

3055-3076m – Weakly laminated, biosiliceous, organic-rich mudstone with thin calcareous bioclastic laminae and concretions. Residual TOC (wet gas maturity window) ranges from less than 1 to 5 weight percent (~2 to 10 volume percent). Porosity in the organic matter ranges from 3 to 8 percent. The rocks have favourable mineralogy; biosilica 40-60% and 10-20% illite, and are brittle (Poisson’s ratio .14 to .19 Young’s modulus 25 to 45). Despite permeability that is the nanodarcy range, these rocks can flow gas and oil when fracture-stimulated.

3086.6m – Finely laminated biosiliceous, organic lime mudstone with fine fossil debris.
XRD Mineralogy (Wt %) vs Depth

- Clinohlore
- Illite
- Pyrite
- Kaolinite
- Albite
- Orthoclase
- Dolomite
- Ankerite
- Calcite
- Quartz

TOC (Wt %) vs Effective Porosity

TOC (Wt %) vs Depth
1549m. Red-green mottled laminated siltstone. Coastal plain environment. Top seal.

1555m. Base of Winterburn 3 sequence. Clasts of underlying dolostone unit and displacive anhydrite nodules. Early dolostone?

1557m. Dolowackstone to Dolopackstone with interbeds of stylolitized greenish and reddish shale. Replacement anhydrite. Minor porosity 5-7% and permeability 2-10 mD. Restricted lagoon environment.

1559m Base of Winterburn 2 sequence. Peritidal dolomudstones overlain by laminated green siltstone.

1569m. Burrowed dolopackstone with vugs after Amphipora. 5 to 8% porosity and 1-20 mD permeability.

1583m. Microbial doloboundstone and leached amphipora dolofloatstone. Replacement and vug-filling anhydrite cement. Some intervals of burrowed dolowackstone to dolopackstone. Porosity 5 to 10% permeability 1 to 100 mD. Lagoon environment.

1589m. Branching coral and tabular stromatoporoid dolowackestone overlain by tabular stromatoporoid boundstone. Significant anhydrite replacement and cementation. Middle to upper foreslope environment.

1597 m Base of Winterburn 1 sequence. Tripanites (?) bored firmground. Sealing facies.
Highstand Systems Tract, Nisku Formation, Graminia Formation Dolostone

Well is located on the Nisku outer bank in the west Pembina area. Dry hole (wet porosity). Similar wells produce several hundred BOPD.

7340-7493 ft lower ramp cycle. Blueridge Member

7400-7420 ft shallow subtidal ramp interior and tidal flats Wolf Lake Member.

7420-7479 ft dolostone stromataporoid patch reef. 10 to 20% vuggy porosity with permeability of 100 mD to 1 darcy. Anhydritic.

7479 ft Contact, enhanced by stylolitization, consists of tabular stromatoporoid dolomudstones abruptly overlying dark coral wackestones. Candidate for base of WI1. Alternate interpretation normal contact between Bigoray Ramp and Zeta Lake shelf build-up.

7479 ft – 7530 ft Several lower ramp cycles.
7-4-49-12 w5m

Highstand Systems Tract, Nisku Formation, Dolostone

Off-reef well in west Pembina pinnacle reef trend.

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10080 ft – Sequence boundary with partly dolomitized coral-brachiopod wackestones of the basal Winterburn 2 (Wolf Lake Mbr.) abruptly overlying nodular green argillaceous mudstones and shales of the WI1 basin fill (Cynthia Mbr.).

10241 ft - Marine flooding surface with dark calcareous mudstones of the Bigoray ramp overly the peloidal-crinoidal mudstones of the Lobstick outer platform.

10241-10300 ft - Nodular calcareous mudstones with crinoids, brachiopods and occasional oncolites commonly with burrowed bed tops.

The base of the Winterburn I sequence is not cored but the gamma ray logs displays an abrupt cleaning upward signature at 10352 feet.
This core is from a Winterburn pinnacle reef pool. The Nisku G pool has produced 2.3 million m³ (14.5 million barrels) out of an OOIP of 2.65 million m³ (16 million barrels). The high recovery (87%) results from favourable reservoir properties of 8% porosity and Darcy permeability and the implementation of a gravity-stable vertical miscible flood. This well 436 km³ oil (2.7 Mbo).

2894 m - Base Winterburn 3 sequence. Variably brecciated silty dolopackstones overlies coral dolowackestone. This unit is overlain by Amphipora-bearing mudstones to wackestones and then by fenestral mudstones (Blueridge Member).

2914 m – Base of the Winterburn 2 sequence. Consists of a breccia of peloidal dolopackstone with a green shaley-siltstone matrix. This is overlain by a coral-bearing dolograinstone with good reservoir properties reflecting re-establishment of the carbonate factory following transgression (Wolf Lake Mbr.).

2925 m - The coral floatstone with a muddy matrix seen at the base of the core is typical of these pinnacle reefs (Zeta Lake Mbr.).
Lowstand Systems Tract, Graminia Member, Siltstone

Dolomitic siltstones of the Graminia Member overly relatively tight anhydritic dolostones of the Blueridge Member.

Top of Second-Order Sequence