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 100mD.

Second-order



Core Analysis Summary 00/07-13-067-13W5/0

4-9-64-10 w5m



Transgressive Systems Tract, Slave Point and Swan Hills Formation

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

8215 to 8172 ft. Reef to reef flat envionment. Massive encrusting stromatoporoid boundstone with a lime grainstone matrix. Common abraded stromatoporoid fragments in skeletal / peloidal matrix.

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.



Core Analysis Summary 00/04-09-064-10W5/0

10-10-64-11 w5m



Transgressive Systems Tract, Swan Hills Formation Limestone

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.



10-24-63-12 w5m



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.

Core Analysis Summary 00/10-24-063-12W5/0



10-32-63-11 w5m

Transgressive Systems Tract Waterways Formation



9090 ft – Base of Beaverhill Lake 3, Waterways Formation.

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.











14-05-59-15 w5m



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.

11-27-51-27 w4m

Early Highstand Systems Tract, Leduc Formation, Limestone



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.

Phi, % 2.8 m 12.0 m Phi, s 5000.0mD @1832.3 m @1826.9 m 81 81 91 Core: Porosity Statistics [mts] 91 Samples 80, 1764.6 - 1844.2 Samples 80, 1764.6 - 1844.2 90 Total Porous Thickness: 14 10 10 10 10 10 10 10 14 Core: Perm.Kmax vs Phi. ĽΟ **Z**1 Maximum Readings: Phi > 10.0 [SS CUTOFF] Phi > 5.0 [LS CUTOFF] s١ 14.4% 01 s١ 8 **7**1 Max Phi Max Perm 9 81 Þ 113 Z 611 01.0 **Hra**a аша, Meters per Grade CRB W/C M/V ARGLOIL NOT ANALYSED - DENSE NOT ANALYSED - DENSE CRB W/C M/V ARGLSH OIL NOT ANALYSED - DENSE CRB W/C M/V ARGLSH OIL CRB W/C M/V ARGLSH OIL CRB W/C V ARGLOIL CRB W/C V OIL CRB W/C V ARGLSH OIL NOT ANALYSED - DENSE CRB W/C M/V I/F OIL CRB W/C V I/F OIL CRB W/C M/V SH OIL NOT ANALYSED - DENSE CRB W/C M/V OIL CRB W/C V OIL CRB W/C V OIL CR8 W/C V SH CR8 W/C V I/F CR8 W/C V NOT ANALYSED - DENSE NOT ANALYSED - DENSE CR8 W/C V OIL CR8 W/C V OIL CR8 W/C V OIL CR8 W/C V ARGLOIL CR8 W/C V 5H OIL CR8 W/C V ARGLOIL CR8 W/C V 1/F OIL CRB NOT ANALYSED - DENSE NOT ANALYSED - DENSE CRB W/C V NOT ANALYSED - DENSE CRB W/C M/V 1/F OIL CRB W/C M/V 1/F OIL NOT AMALYSED - DEMSE CRB W/C M/V I/F OIL CRB W/C V SH OIL CRB W/C V I/F 1950-10-21 1950-10-27 1950-12-12 716.6 Rig Rel: KB El(m): Gr El(m): License: Spud 3100 DL MATRIX GrDens. 2710 2710 2710 Ê 2710 2710 88 274 2 E Ē 8 <u>ں</u> 2600 ន . ResOil.v/v GOLDEN SPIKE Abd Zone/Oil 0 10000 LEDUC A Ň Status: Lahee: Field: Pool: Unit: ģ Kmax.mD - 16 0 140 1 12.0 14.0 9 Ň. ţ 1 00/11-27-051-27W4/0 [100112705127W400] IMP GOLDEN SPIKE IN 11-27 N- 51-27 8 5 IMPERIAL OIL RESOURCES LIMITED IMPERIAL OIL RESOURCES LIMITED Dpt.m 1764 1818 1766 1768 1770 112 1774 1776 1778 1780 1782 1784 1786 88 621 792 5 1796 1798 8 8 <u>8</u> 8 8 1810 1812 1814 1816 1820 1822 1824 1826 1828 1830 1832 1834 1836 1838 8 1842 <u>48</u> 우 PHI CUTOFFS 1950-12-17 Phi.% 4 F -9 ņ 2 ន 9 Operator: Licensee: On Prod: ÷ **C1** Name: Ĭ 5 T

Core Analysis Summary 00/11-27-051-27W4/0

11-23-51-27 w4m



Neut

Early Highstand Systems Tract, Leduc Formation, Limestone

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.

11-23-51-27 w4m - continued



Leduc

5607 ft – 5720 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.

GR

depth (ft)

Neut



16-18-61-15 w5m

Early Highstand Systems Tract, Lower Leduc Formation, Dolostone

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.





Core Analysis Summary 00/16-18-061-15W5/0

5-11-60-18 w5m



Transgressive Systems Tract, Woodbend Sequence 2, Duvernay Formation

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.

WDBD 1?



XRD Mineralogy (Wt %) vs Depth

- Clinochlore
- 🗖 Illite
- Pyrite
- 🗖 Kaolinite
- Albite
- Orthoclase
- Dolomite
- Ankerite
- Calcite
- 🗖 Quartz



AA 8-17-50-26 w4m



Highstand Systems Tract, Nisku Formation, Dolostone

Well is from the Leduc-Woodbend Nisku A Pool 462 producing wells 51 Injectors Cum Oil 14.5 million m3 Cum Gas 3144 million m3 Cum Oil 91.6 million barrels Cum Gas 111 Bcf This location 317 kbo

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. Peritital 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 dolowackestone 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 anydrite replacement and cementation. Middle to upper foreslope environment.

1597 m Base of Winterburn 1 sequence. *Tripanites* (?) bored firmground . Sealing facies.

Core Analysis Summary AA/08-17-050-26W4/0



6-3-51-7 w5m

Highstand Systems Tract, Nisku Formation, Graminia Formation Dolostone







7-4-49-12 w5m

Highstand Systems Tract, Nisku Formation, Dolostone



Top of Second-Order Sequence

Off-reef well in west Pembina pinnacle reef trend .

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.

7-20-49-11 w5m

Highstand Systems Tract, Nisku Formation, Dolostone



Top of Second-Order Sequence

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 coralbearing 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

6-03-55-9 w5m



