“Glauconitic” Oil Reservoirs in Southern Alberta – Creating the Correct Geological Model to Guide Development Drilling

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Summary

Many oil fields in southern Alberta produce from the Glauconitic member of the Upper Mannville Formation. Examination of core and detailed mapping reveal important stratigraphic differences among these reservoirs, and show that some do not belong to the Glauconitic at all. Understanding these differences is critical in efficient modeling and development of full productive potential.

In this core display, we contrast a true Glauconitic reservoir at Taber South with the Medicine Hat “Glauconitic” reservoir – which actually belongs to the Basal Quartz.

Glauconitic Member Stratigraphy and Distribution

Sherwin (1996) mapped Glauconitic valley trends from Township 14 north to the Hoadley and Pembina Barriers (Township 50), which delineate a basin-scale drainage system, flowing northward to the Boreal Sea. Petrel Robertson Consulting Ltd. (1998) extended regional Glauconitic valley trend mapping southward through Taber, Taber South, Wrentham, and Philp to the Montana border. Notably, Glauconitic valley trends have not been mapped into the Medicine Hat area of southeastern Alberta, where Smith (1994) documented Mannville thinning across the Medicine Hat - Swift Current Highlands.

Glauconitic valleys were filled as sea level rose during mid-Mannville transgression of the Wilrich / Clearwater sea. High-quality reservoirs were deposited as clean, sublithic estuarine valley-fill sandstones, sealed by equivalent estuarine muds. Several generations of younger Upper Mannville fluvial valley-fill sandstones, exhibiting a distinct volcanic / feldspathic composition and poor reservoir quality, dissect the Glauconitic.

Focused studies of several Glauconitic oil pools in southern Alberta document estuarine valley-fill environments, and map out reservoir stratigraphy in intricate detail. A series of papers by Wood and

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Hopkins at Little Bow (Twp. 11-16, Rge. 17-19W4), building upon Wood and Hopkins (1989), is an excellent example.

Taber South Glauconitic Reservoirs

At Wrentham / Taber South (Twp. 6-7, Rge. 16-17W4), a major northward-trending Glauconitic valley hosts several medium-gravity oil pools. However, they are not clearly distinguished in the official pool nomenclature from older Cut Bank / Basal Quartz reservoirs, which are incised locally by Glauconitic valleys.

Core from 12-9-7-16W4 (Fig. 1) illustrates a well-developed Glauconitic reservoir succession. Estuarine channel sandstones exhibiting mud couplets and flaser bedding lie sharply on the basal contact. They are truncated sharply by middle estuarine mudstones grading up to heterolithic sandstone/shale with soft-sediment deformation and locally intense bioturbation. Near the top of the core, these strata grade upward into estuarine shoal sandstones, within which flaser bedding highlights stacked ripple sets.

Glauconitic sandstones are clean, fine- to medium-grained sublitharenites, exhibiting excellent reservoir quality. Detailed mapping demonstrates substantial lateral continuity of specific estuarine channel and shoal reservoir elements, particularly where individual sandstone bodies range up to 10 metres thick (Petrel Robertson, 1998). Cumulative production of more than one million barrels of oil from individual wells is a good indicator of substantial drainage areas and reservoir continuity.

Medicine Hat "Glauconitic" Reservoir

Core from 02/8-7-13-5W4 (Fig. 2) illustrates a typical "Glauconitic" reservoir at Medicine Hat. The 13-metre reservoir section consists of several stacked, metre-scale fining-upward successions. A typical unit lies on a sharp, scoured base, and consists of clean, medium-grained, cross-bedded litharenite, grading upward to finer sandstones with more matrix clays and thin light green-grey mud beds and/or thin, angular mud clasts. A fully-developed succession may be capped by a sandy mudstone with root traces, interpreted as a paleosol.

Estuarine facies such as those observed at Taber South and Little Bow – tidal channels, burrowed shales and heterolithic successions, and sandier-upward shoals – are conspicuously absent. Correlation of individual depositional units from well to well is very difficult. Cumulative production from individual wellbores, while influenced by many operational factors such as reservoir management, well density, and length of time on production, is generally fairly low, suggesting that only limited reservoir volumes are being drained.

Thus, reservoir facies and regional paleogeography both argue against the Medicine Hat "Glauconitic C" pool having been deposited as a true Glauconitic valley fill reservoir. Instead, we suggest deposition occurred as thin, stacked fluvial sandstones in a more continental setting. Zaitlin et al (2002) described these facies as components of the Mesa Incised Valley subdivision of the Basal Quartz member, and mapped a regional north-south Mesa I.V. trend through the Medicine Hat area. We conclude that the Medicine Hat "Glauconitic C" pool is thus better assigned to the Basal Quartz.

Reservoir Continuity and Development Planning Implications

Despite intensive development drilling to date at both Taber South and Medicine Hat, considerable scope remains to further optimize recovery.

At Taber South, recognition of discrete facies assemblages with predictable vertical and lateral reservoir quality distributions within the Glauconitic can guide reservoir mapping. Production histories of individual wells add valuable information about reservoir body size and drainage efficiency. Detailed mapping, best done within the framework of a well-constructed geological model incorporating a substantial degree of geological interpretation (i.e., predictive facies mapping), would support targeted drilling to optimize reservoir exploitation.

At Medicine Hat, stacked Basal Quartz fluvial sandstone bodies have very poor lateral and vertical continuity. Individual reservoir sandstones were deposited in metre-scale beds over limited areas, and capping paleosols further isolate reservoir-quality sandstones. Thus, the geocellular model we build of this reservoir exhibits abrupt vertical and lateral variations in reservoir quality. distributed on the basis of geostatistics, rather than imposed by specific facies concepts.

Acknowledgements

This project arose from construction of a geological reservoir model of the Medicine Hat “Glauconitic C” Pool by Petrel Robertson Consulting Ltd., for Enerplus Resources Fund and their partner, the City of Medicine Hat. We thank Enerplus, the City of Medicine Hat, and PRCL for providing resources and permission to publish.

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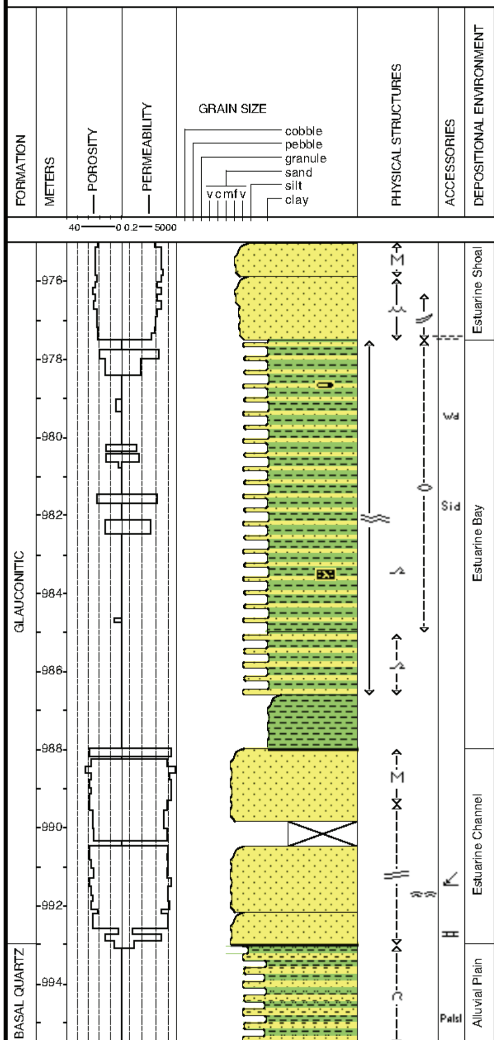
Zaitlin, B.A., M.J. Warren, D. Potocki, L. Rosenthal, and R. Boyd, 2002. Depositional styles in a low accommodation foreland basin setting: an example from the Basal Quartz (Lower Cretaceous), southern Alberta. Bulletin of Canadian Petroleum Geology, v. 50, #1, p. 31-72.

Amoco et al TABER SOUTH

12-9-7-16W4

Remarks: **Core #1: 975 – 990.5 (Rec. 14.85 m)**
Core #2: 990.5 – 997.5 (Rec. 5.1 m)



REMARKS

Massive, homogeneous. Moderate oil staining except where extracted for core analysis.

Flasers and mud drapes on small ripples increase to base

Scattered mm-scale mud partings to base

Med. grey silty mudstone with finely-laminated sandy (heterolithic) intervals at decimetre scale; sandy beds are rippled, with light oil stain and minor soft-sediment deformation
Scattered wood fragments, minor diffusely-bounded sideritic patches
Small burrow clusters

Sharply-bounded sandy intervals, more cemented, more notable soft-sediment deformation and faulting

Med. grey pure mudstone, becoming subfissile to base

Sharp base with minor erosional / bedding relief

Homogeneous, clean, heavily oil-stained
Massive at top, with better low-angle large-scale crossbeds developming to base, highlighted by a few mud couplets

Similar sandstone, with two - 15 cm calcite-cemented intervals occluding oil stain

Silty mudstone and muddy sandstone, light grey-green, low contrast bedding
Some loading / deformation - small burrows / roots (?)

LEGEND

LITHOLOGY

SANDSTONE | Argillaceous Sst | SHALE/MUDSTONE | Silty Shale | Lost Core

CONTACTS

Sharp

PHYSICAL STRUCTURES

Low Angle Tabular Bedding | Flaser Bedding | Wavy Parallel Bedding | Lenticular Bedding | Double Mud Drapes
Slump, Flow Structure | Massive | Undifferentiated Ripples | Soft sed. def.

LITHOLOGIC ACCESSORIES

Shale Lamina | Calcareous | Sid Siderite | Wd Wood Fragments | Palsl Paleosol Horizon
Carbonaceous Partings

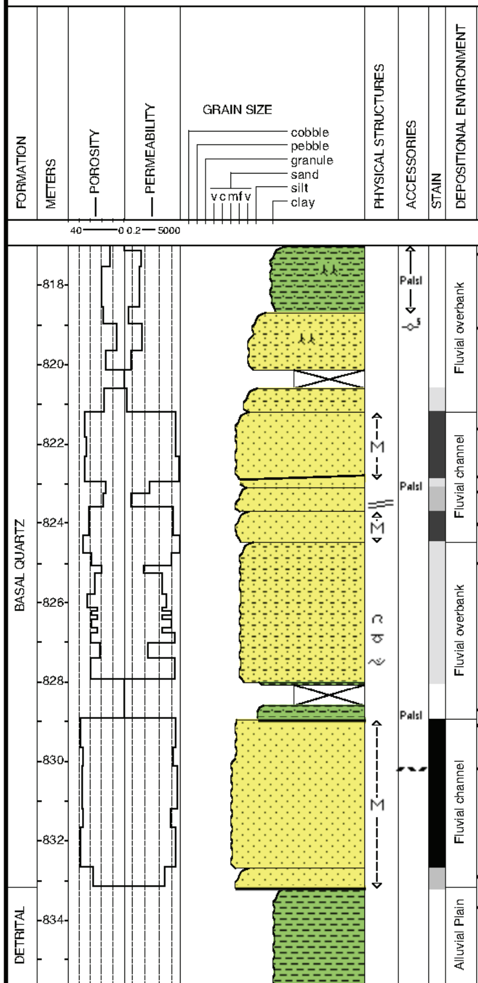
ICHNOFOSSILS

Planolites | Chondrites

City of Medicine Hat

02 / 8-7-13-5W4

Remarks: **Core #1 : 817 – 820.6 (Rec. 3.15 m)**
Core #2: 820.6 – 828.6 (Rec. 7.5 m)
Core #3: 828.6 – 835.7 (Rec. 7.1 m)



REMARKS

- Light grey-green sandy/silty mudstone - heavily rooted, paleosol aspect
  Competent at top becoming rubbled to base
- Sandy mudstone grading down to muddy fine sandstone, buff colour
  Abundant small sideritic spherules at tope
  819.1-819.9 - Abundant dark subvertical traces - preferential oil staining along root traces?
- Homogeneous, heavy oil stain, bedding obscured
- Basal contact sharp, cuts across core at high angle - slumping?
- Muddy sst at top, little oil stain, fractured
  Becoming cleaner, more uniformly stained to base
- Massive, heavily oil-stained sst
- Muddy and cleaner sst beds, interbedded on cm-dm scale
  Dominantly clay-rich, lightly oil-stained sands
  Abund. scour and fill, sharp contacts; scattered soft-sediment deformation
- More clay rich, paleosol appearance to base
- Massive sst, bedding obscured by heavy, pervasive oil stain
  Rubbled, uncemented to base - last two lengths in sleeves
- 10 cm interval platy rounded mud clasts
- More cemented, less stained
  Basal contact difficult to pick - loaded?
- Pure to slightly silty mudstone, subfissile to small-scale conchoidal fracturing
  Varicoloured - mustard yellow to light grey-green

LEGEND

LITHOLOGY

SANDSTONE | Argillaceous Sst | SHALE/MUDSTONE | Sandy Shale | Lost Core

CONTACTS

Sharp | Inclined

PHYSICAL STRUCTURES

Low Angle Tabular Bedding | Load Casts | Massive | Scour and Fill | Soft sed. def.

LITHOLOGIC ACCESSORIES

Rip Up Clasts | Palsl Paleosol Horizon | Nodule, Siderite

ICHNOFOSSILS

Rootlets