Tyler E. Hauck

Alberta Geological Survey
402, Twin Atria Building
4999-98 Avenue
Edmonton, AB
www.ags.gov.ab.ca

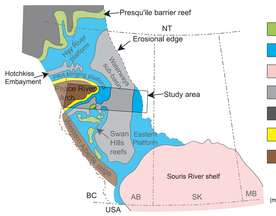
Deposition of the Peavine Sandstone on the Peace River Arch and its Relationship to Transgressive-Regressive Cycles within the Beaverhill Lake Group, North-Central Alberta

Introduction

Lithostratigraphic mapping was supplemented with sequence stratigraphic methods to enhance lithostratigraphic correlations and to relate the timing of events between distinct depositional realms within the Beaverhill Lake Group across the province. Transgressive-regressive (T-R) cycles within the Waterways Formation in the east were correlated westward across the province to the southern flank of the Peace River Arch (PRA) and northern Swan Hills area. T-R cycles downlap or onlap Slave Point and Swan Hills carbonate complexes. Younger T-R cycles interfinger with siliciclastics shed from the PRA. One such T-R cycle merges with a marked regressive sandstone package, known in industry reports as the Peavine sandstone (also the Beaverhill Lake sandstone). This particular T-R cycle is significant because its upper contact displays evidence for subaerial exposure on the Eastern Platform and has been correlated to similar exposure surfaces within the carbonate complexes of the Swan Hills area, suggesting that relative sea level fell during this time. In the study area, this event is recognized as one of a few times during which sea level fell low enough to subaerially expose Frasnian-aged Beaverhill Lake Group carbonates. Evidence for the lowering of relative sea level is further supported by linking this event with regressive Peavine sandstone deposition on the southern flank of the Peace River Arch.

Geological Setting

In the study area, the PRA is a complex basement structure that was emergent during the late Givetian, early Frasnian. Around this feature, carbonates of the Slave Point Formation form the PRA fringing platform. Other carbonate depositional realms to the south and east include the Swan Hills platform/reefs and the Eastern Platform. Whereas the Eastern Platform prograded westward into the Waterways sub-basin and inter-reef areas in the Swan Hills area, the PRA fringing platform and Swan Hills complexes back-stepped westward.

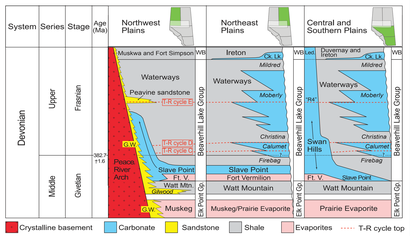


(modified from Campbell, 1992)

- The PRA was a constant source of siliciclastics, such as the highly diachronous Granite Wash lithosome and the stratigraphically distinct Gilwood Member (Watt Mountain Fm).
- Another stratigraphically distinct sandstone (less areally expansive) is the Peavine sandstone which was deposited along the southern flank of the PRA and sits within Waterways strata.

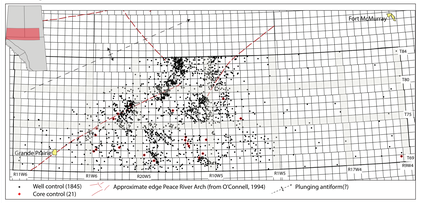
Stratigraphic Nomenclature

- Biohermal strata of the Moberly and Calumet members in the east comprise the Eastern Platform; the Swan Hills and Slave Point formations form carbonate complexes on the west side of the basin, with intervening slope to basinal strata of the Waterways Formation.
- Peavine sandstone was deposited during relative sea level fall at the top of T-R cycle E (see below), which correlates to the Moberly Member on the Eastern Platform and "R4" in Swan Hills (Wendte and Uyeno, 2005).



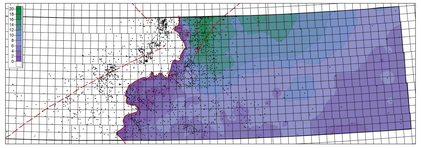
Schematic stratigraphic column for upper Givetian to lower Frasnian Alberta Basin. A few of the T-R cycle tops that were mapped in central to northern Alberta are shown. Abbreviations: WD, Woodbend Group; G.W., Granite Wash; Ft. V., Fort Vermilion; Ck. Lk., Cooking Lake; Led., Leduc. Age of Givetian-Frasnian boundary from International Stratigraphic Chart (www.stratigraphy.org).

Study Area and Data Distribution



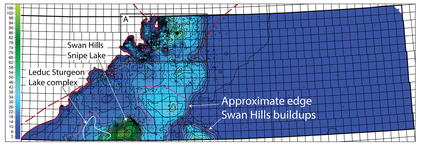
Mapping of Formal Lithostratigraphic Units

Thickness of Fort Vermilion Formation

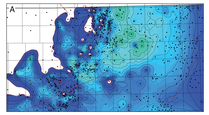


- Thickness at data points ranges from 0.6 m near western depositional edge, to 18.3 m in north-central part of study area.
- Areas of thick Fort Vermilion represent the southern edge of a large depocenter to the north.

Thickness of Slave Point and Swan Hills Formations

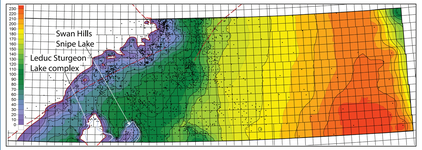


- The northern boundary of the Swan Hills Fm. is arbitrary; more work is needed to define the relationship between the Slave Point and Swan Hills formations in this area.
- Slave Point thickness at data points ranges from 1.1 m in 'stressed' areas in the east to 58 m in north-central part of study area (Seal Field).
- Swan Hills thickness at data points ranges from 13.9 m west of the Leduc Sturgeon Lake complex, to greater than 107 m at the western edge of the Snipe Lake buildup.



- There is a strong correlation of Slave Point buildups with Precambrian basement highs (inselbergs).

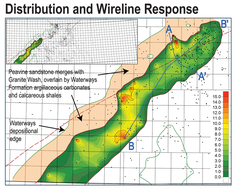
Thickness of Waterways Formation



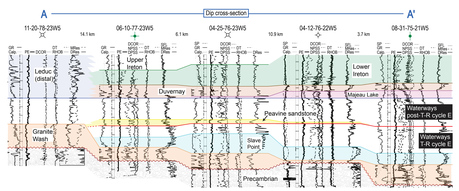
- Thickness at data points ranges from 0.6 m overlying the western edge of the Swan Hills Snipe Lake buildup to greater than 234 m in the southeast of the study area (Eastern Platform).
- At the Leduc Sturgeon Lake complex, Waterways strata are present (but not included here) in the form of an embayment that separates lower Swan Hills from upper Swan Hills; the upper Swan Hills prograded westward out from the Snipe Lake complex, which formed the site for later Leduc Sturgeon Lake growth.

Peavine Sandstone

Distribution and Wireline Response

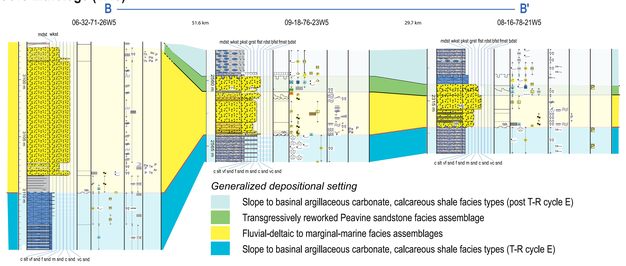


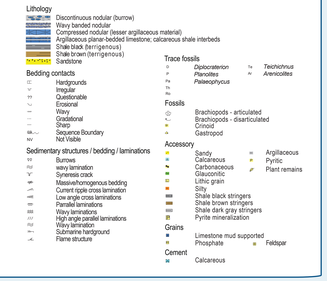
- Peavine sandstone trends SW–NE, parallel to axis of the PRA, and covers approximately 34 townships in the study area.



- Recognition of Peavine sandstone on logs relies on neutron-density and photoelectric logs.
- Close proximity to the exposed PRA (source) means that gamma-ray values are commonly higher than Waterways sediments, but can vary depending on feldspathic content of sand and amount of fine siliciclastics.

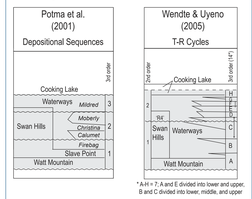
Core Lithologs (1:48)





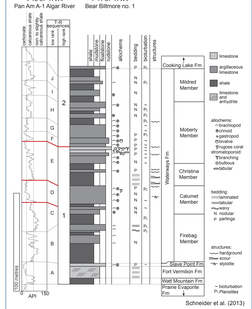
Transgressive-Regressive Cycles and the Peavine Sandstone

Background



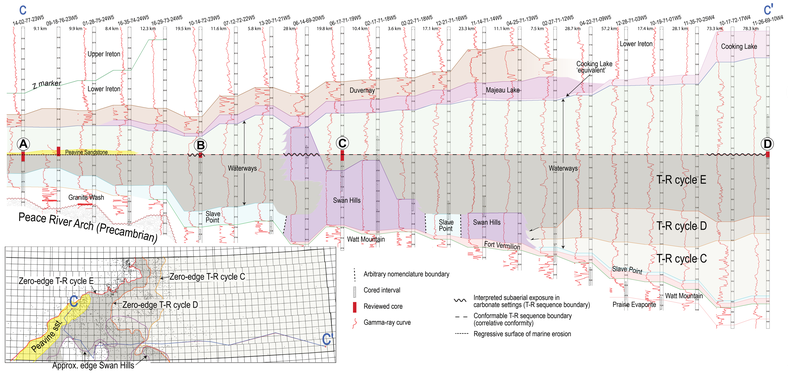
* A-H = ?; A and E divided into lower and upper, B and C divided into lower, middle, and upper

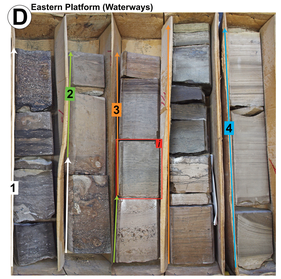
- Widely varying interpretation of sequence stratigraphy within the Beaverhill Lake Group.
- Potma et al. describe three third-order depositional sequences.
- Wendte and Uyeno describe fourteen third-order T-R sequences.

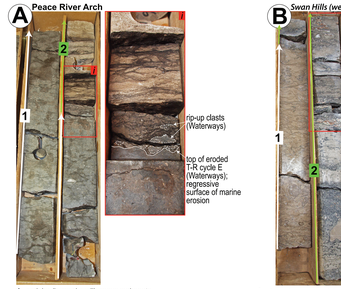


Schneider et al. (2013)

- Previous AGS work: recognition of a number of T-R cycles bounded by maximum regressive surfaces.
- Three highlighted here in red are discussed.
- Top of T-R cycle E represents max. regression of the Eastern Platform, as seen in Bear Biltmore core.

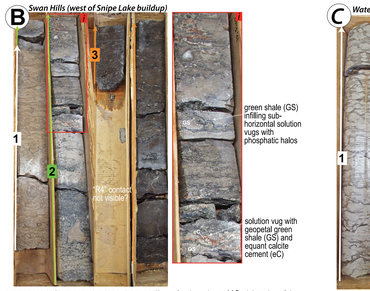






1 nodular (burrow) argillaceous carbonate and calcareous shale: Waterways T-R cycle E

2 bioturbated subarkosic sandstone with dark brown terrigenous mudstone: Peavine sandstone



1 stromatoporoid floatstone; abraded bulbous and branching stroms, *Amphipora* and minor *Thamnopora* in beige lime mudstone matrix: Swan Hills reef flat

2 *Amphipora* rudstone to floatstone with beige lime mudstone matrix; some abraded stromatoporoids; evidence for subaerial exposure (inset i): Swan Hills lagoon / back reef

3 stromatoporoid floatstone to rudstone; transported bulbous stroms, *Stachyodes* and *Amphipora*; partly nodular: Swan Hills middle to lower foreslope

1 nodular (burrow) argillaceous carbonate (bioclastic floatstone; inset i) and calcareous shale: Waterways T-R cycle E

2 discontinuous nodular (burrowed) argillaceous carbonate (lime mudstone) and calcareous shale: Waterways post T-R cycle E

1 *Amphipora-Idiostroma* floatstone to rudstone; abraded stroms in dark carbonaceous lime mudstone matrix: lagoon with back reef talus

2 burrowed light beige lime mudstone to bedded bioclastic/peloid packstone; shallowing upward with calcite laths after anhydrite near top; shallow subaqueous lagoon to tidal flat/beach

3 same as facies 2 (repeating) but with crystalgal laminations and diffuse green colouration in lime mudstone matrix (reworked green clay; inset i)

4 bedded to crossbedded(?) grainstone: foreslope sands/shoal

Conclusions

Beaverhill Lake Group Lithostratigraphy

- Distribution and thickness of Beaverhill Lake Group strata were highly influenced by antecedent Precambrian topography on the PRA.
- Slave Point Formation carbonate complexes formed preferentially around Precambrian inselbergs.
- The boundary between the Slave Point and Swan Hills formations is arbitrary—the northern extension of the Swan Hills platform appears to merge with carbonate strata considered to be of Slave Point affinity.
- The Peavine sandstone (also Beaverhill Lake sandstone) is a stratigraphically distinct unit within the Waterways Formation, located on—and sourced from—the southern flank of the PRA, where it produces light oil.

T-R Cycles and the Peavine Sandstone

- T-R cycle tops can be correlated westward from the Eastern Platform to the PRA, where they successively downlap or onlap older Beaverhill Lake Group strata or the Granite Wash.
- T-R cycle E is associated with a lowering of relative sea level as inferred from evidence of subaerial exposure on carbonate complexes on both east and west sides of the study area; in off-reef locations, facies successions across the contact record a deepening event with a submarine hardground developed during a hiatus in carbonate production/deposition.
- The top of T-R cycle E underlies the Peavine sandstone on the PRA, where it is a regressive surface of marine erosion.
- The Peavine sandstone records progradational siliciclastic deposition associated with the lowering of relative sea level responsible for subaerial exposure on carbonate complexes.
- Mapping of T-R cycles in Beaverhill Lake strata links a distinct siliciclastic depositional event on the flank of the PRA to relative sea-level history in the Frasnian of the Alberta Basin.

Acknowledgements

Thanks to Chris Schneider (formerly Alberta Geological Survey; AGS) for the introduction to Beaverhill Lake Group stratigraphy and many fruitful discussions thereof. Jack Wendte (Geological Survey of Canada), Hilary Corlett (AGS), and Matthias Grobe (AGS) are thanked for beneficial discussions on Beaverhill Lake strata.

References

Potma, K., Weissenberger, J.A.W., Wong, P.K. and Gilhooly, M.G. (2001): Toward a sequence stratigraphic framework for the Frasnian of the Western Canada Basin; Bulletin of Canadian Petroleum Geology, v. 49, p. 37–85.

Schneider, C.L., Hauck, T.E. and Grobe, M. (2013): Sequence stratigraphic architecture and evolution of platform margin to basin sedimentation: the Devonian Beaverhill Lake Group in Alberta, Canada; *in* Deposits, architecture, and controls of carbonate margin, slope, and basinal settings, K. Verwer, T.E. Playton and P.M. Harris (ed.), Special Publication 105, Society for Sedimentary Geology, Tulsa, OK, doi:10.2110/sepmsp.105.15.

Wendte, J. and Uyeno, T. (2005): Sequence stratigraphy and evolution of Middle to Upper Devonian Beaverhill Lake strata, south-central Alberta; Bulletin of Canadian Petroleum Geology, v. 53, p. 250–354.