2026

The Core Continuum: Subsurface Knowledge Driving Innovation

PROGRAM BOOK

CEGA

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CORE *CONFERENCE*

May 7-8, 2026 • AER Core Research Centre

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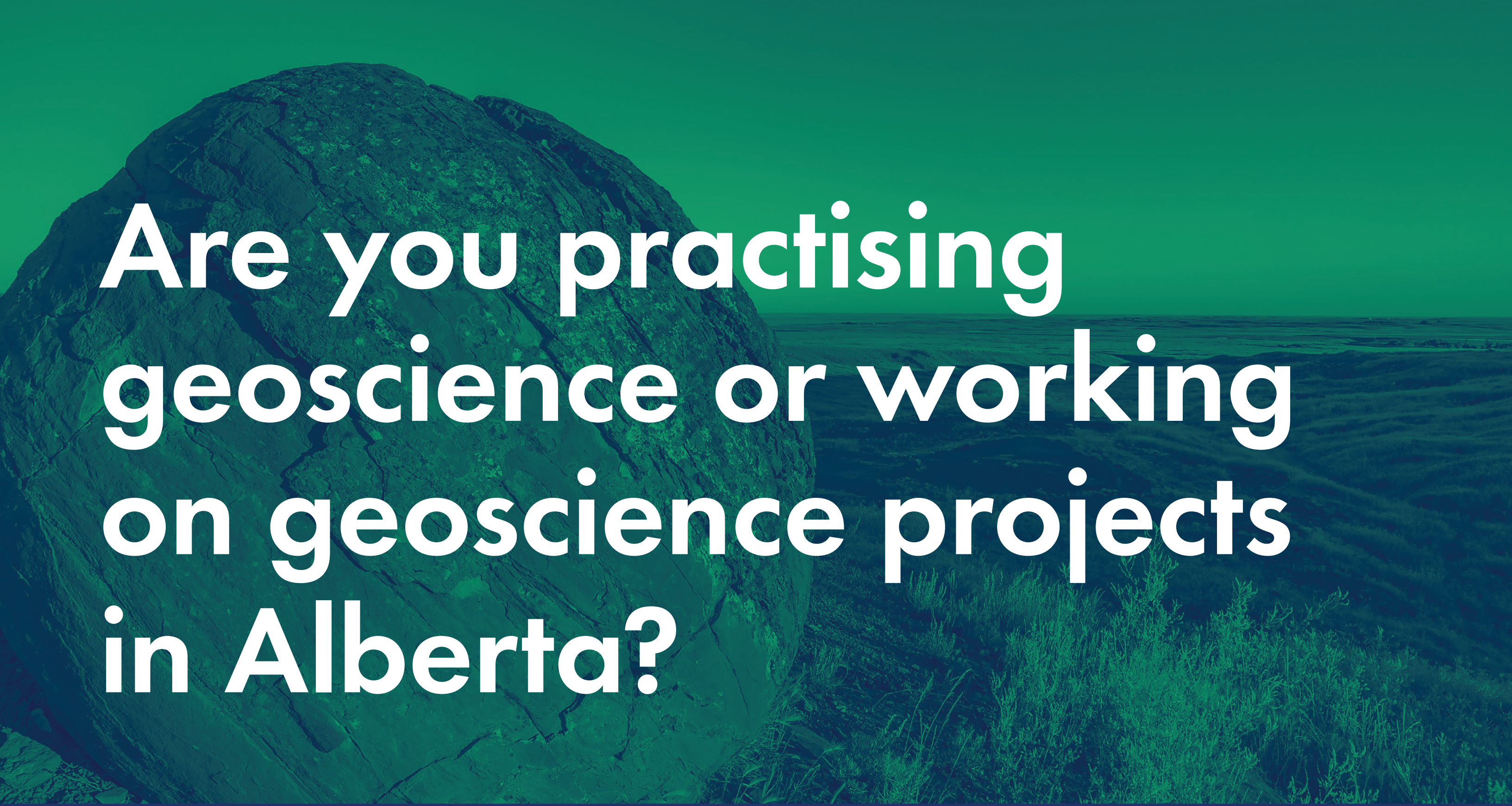

Welcome to Core Conference!

Conference Co-Chairs: Daniela Beccera, *SLB* & Carolyn Currie, *Cenovus Energy*

On behalf of the organizing committee, we are pleased to welcome you to the 2026 CEGA Core Conference. Once again, it is a privilege to gather at the AER Core Research Centre, a world-class facility that continues to support and highlight the importance of core-based geoscience across Canada.

The theme of the 2026 conference, “The Core Continuum: Subsurface Knowledge Driving Innovation,” reflects the role of core studies as the foundation of geological understanding and their ongoing contribution to innovation. We plan on taking you on a journey this year - from the oldest rocks in the subsurface to the youngest sedimentary systems, core data links past discoveries with today’s applications and future opportunities. As our industry continues to adapt to changing energy, storage, and environmental needs, strong subsurface knowledge remains essential for sound technical decisions.

This year’s program features 23 talks delivered over two days, organized into four technical sessions that span the full geological timeline and highlight the variety of core-based research across Canada. We begin with Session One, “Precambrian–Cambrian: The Dawn of Time,” which presents new research on western Canada’s earliest geological record and its relevance to modern exploration, carbon storage, and emerging energy technologies. Session Two, “Ordovician–Devonian: Roots, Reefs, and Fishes,” focuses on carbonate reservoirs and evaporite systems across the Prairies, highlighting depositional environments, reservoir characteristics, and mineral resources. The conference continues with Session Three, “Mississippian–Cretaceous: The Rise of the Western Interior Basin,” featuring data-driven studies of mixed carbonate and siliciclastic systems that support both resource development and CCS evaluations. We conclude with Session Four, “Cretaceous – Miocene: Shallow Seas to Modern Margins,” which showcases how core observations, stratigraphy, geochemistry, and monitoring data improve interpretations of younger depositional systems.

Across these sessions, the conference provides an opportunity to share ideas, discuss interpretations, and recognize the high-quality geological work being carried out by our geoscience community. Inside this booklet, you will find the presentation schedule, core table layout, and access to presenter abstracts.

We are pleased to once again host the Core Meltdown social at the Canadian Brewhouse in the University District. This event offers a relaxed setting to reconnect with colleagues and continue conversations from the conference. The recipients of the George Pemberton Award for Best Overall Presentation and the Baillie Award for Best Student Presentation will be announced during the Core Meltdown.

This conference would not be possible without the generous support of our sponsors, presenters, and volunteers.

We extend our sincere thanks to Tourmaline Oil Corp., AGAT Laboratories, Chinook Consulting, Weatherford, Cenovus Energy, Core Laboratories, APEGA, ProGeo Consultants, Vidence Inc., Saturn Oil + Gas, Spur Petroleum Ltd., Strathcona Resources Ltd., Baker Hughes, Canamera Coring, Canadian Discovery, and Imperial Oil, as well as to the Alberta Energy Regulator (AER) for providing access to this exceptional facility. Most importantly, we thank you! our geoscience community, for your continued support and engagement. As a volunteer-driven organization, CEGA thrives because of your participation.

We look forward to a conference that advances technical knowledge and strengthens the connections that continue to move our industry forward.

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AGAT Laboratories

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Session Overviews

TECHNICAL SESSION 1

Precambrian-Cambrian: The Dawn of Time

Explores early western Canada geology and its impact on modern exploration and CCS, including basement reinterpretations, the Cold Lake puzzle, and storage potential in Cambrian and evaporite systems.

TECHNICAL SESSION 2

Ordovician–Devonian: Roots, Reefs and Fishes

Highlights carbonate reservoir complexity and evaporite resources across the Prairies, with insights into Red River–Beaverhill systems, Prairie Evaporite minerals, and Bakken stratigraphy.

TECHNICAL SESSION 3

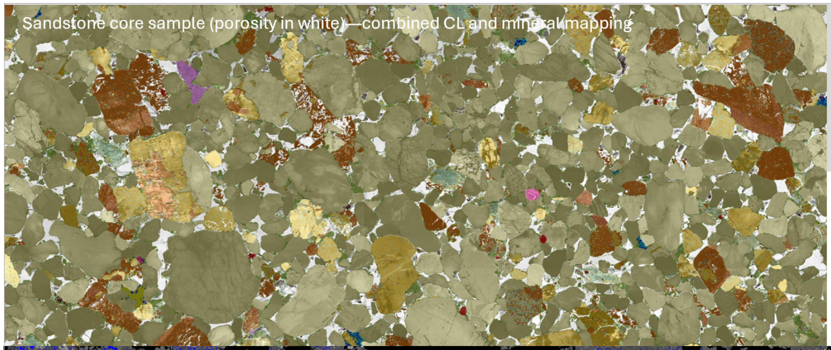
Mississippian-Cretaceous: The Rise of the Western Interior Basin

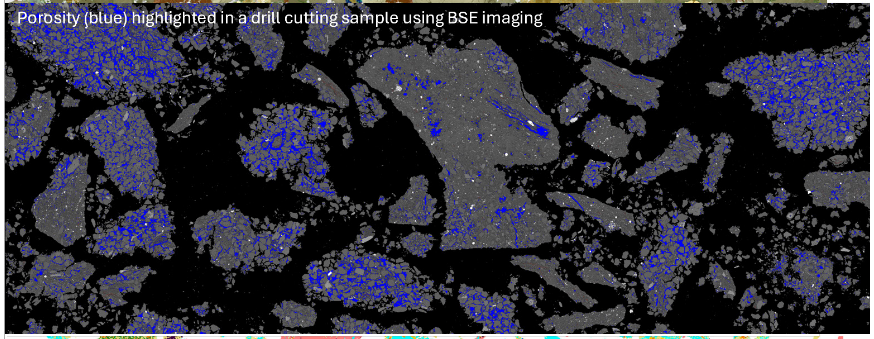
Examines sedimentological complexity across the WCSB, from Pekisko carbonates to Charlie Lake mixed systems. Case studies highlight reservoir characterization, horizontal drilling insights, and CCS evaluation for modern subsurface applications.

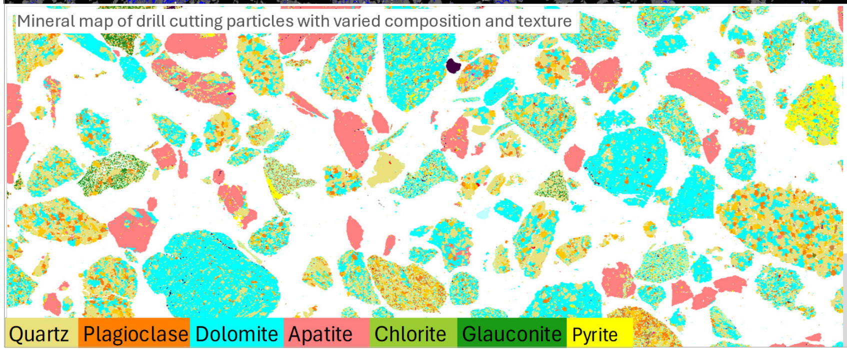
TECHNICAL SESSION 4

Cretaceous-Miocene: Shallow Seas to Modern Margins

Showcases younger stratigraphy from deltaic to deep-water settings. Emphasizes integrating core, geochemistry, stratigraphy, and time-lapse data to refine interpretations of key reservoirs.


Sandstone core sample (porosity in white)—combined CL and mineral mapping


Porosity (blue) highlighted in a drill cutting sample using BSE imaging


Mineral map of drill cutting particles with varied composition and texture

Day 1 - Thursday, May 7, 2026

SESSION ONE:

Precambrian-Cambrian: The Dawn of Time

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VIDENCE

8:30am **WELCOME & SESSION ONE INTRODUCTION**

Planning Committee Co-Chairs:
Daniela Beccera, *SLB* & Carolyn Currie, *Cenovus Energy*
Session One Co-Chairs:
Mastaneh Liseroudi, *Natural Resources Canada* & Bob Riopel, *Ronin*

8:45am **Eric Morley,** *Alberta Geological Survey*
Co-author: Arif Rabbani | Alberta Energy Regulator
TABLE 95-96

Alberta's Precambrian Basement: Novel Data and Preliminary Interpretations

9:10am **David Herbers,** *Alberta Geological Survey*
Co-author: Tyler Hauck | Alberta Energy Regulator
TABLE 93-94

The Cambrian Cold Lake Conundrum: New Models for Old Rocks

9:35am **Becky Rogala,** *Imperial Oil*
Co-author: Breanna Uzelman | Imperial Oil
TABLE 91-92

Sand and Deliver: Testing the limits of CCS potential in the Basal Cambrian near Medicine Hat, AB

10:00am **COFFEE BREAK & CORE VIEWING**

Core Lab
RESERVOIR OPTIMIZATION

10:30am **Magnus Roland Marun,** *University of Calgary*
Co-authors: Davood Zivar, Guanhua Li, Hassan Dehghanpour | University of Alberta, Pavel Kabanov | Geological Survey of Canada
TABLE 85-86

Cores from halites and associated evaporitic beds of Alberta and Newfoundland: Considerations for salt caverns and notes on geochemistry

10:55am **Paula Ramirez Lopez,** *Vidence Inc., Simon Fraser University*
Co-authors: Marc Enter, Matthew Power | Vidence Inc., Shahin Dashtgard, Maziyar Nazemi | Simon Fraser University
TABLE 83-84

Reservoir Quality and CO_2 Mineral Trapping Potential of Subsurface Strata in Metro Vancouver: An Automated Mineralogy Approach

11:20am **BBQ LUNCH**

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SESSION TWO:

Ordovician–Devonian: Roots, Reefs and Fishes

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12:40pm **SESSION TWO INTRODUCTION**

Session Two Co-Chairs:
Celine Chow, *Saturn Oil + Gas Inc.* & Lauren Eggie, *Imperial Oil*

12:45pm **Ashlee D. Thomas,** *Saskatchewan Geological Survey, Univ. of Regina* TABLE 81-82
Co-author: Hairuo Qing | University of Regina

Lithofacies, Depositional Environments and Petroleum Reservoir Characteristics of the Ordovician Red River Formation, Williston Basin, Southeastern Saskatchewan

1:10pm **Patricia Fraino,** *Manitoba Geological Survey* TABLE 75-76
Co-author: Michelle P.B. Nicolas | Manitoba Geological Survey

Sedimentology and stratigraphic architecture of the Wymark Member, Duperow Formation, SW Manitoba

1:35pm **Peter Hill,** *Saskatchewan Geological Survey* TABLE 73-74

Critical Mineral Resources within Middle Devonian Strata in Saskatchewan

2:00pm **COFFEE BREAK & CORE VIEWING**

Core Lab
RESERVOIR OPTIMIZATION

2:30pm **John Lake,** *Lake Geological* TABLE 71-72

Reefs and salts of the Devonian Souris River Formation and their lateral distribution in southeast Saskatchewan

2:55pm **Joel Collins** TABLE 61-62

Beaverhill Lake Group Carbonate Complexes: Middle-Upper Devonian Stratigraphy and Subsidence in the Western Canada Basin

3:20pm **Solange Angulo S.,** *University of Saskatchewan* TABLE 63-64
Co-author: Luis Buatois | University of Saskatchewan

How Late Devonian-Early Carboniferous Little Creatures Rewrote the Bakken Paleogeography, Reframed Reservoir Architecture, and Shifted Its Development Strategy in SE Saskatchewan

3:45pm **DAY ONE CLOSING REMARKS**

Day 2 - Friday, May 8, 2026

SESSION THREE:

Mississippian-Cretaceous: The Rise of the Western Interior Basin

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8:30am **WELCOME & SESSION THREE INTRODUCTION**

Planning Committee Co-Chairs:
Daniela Beccera, *SLB* & Carolyn Currie, *Cenovus Energy*
Session Three Co-Chairs:
Carolyn Furlong, *MacEwan University* & Ozzy Ofoegbu, *Cenovus Energy*

8:45am **Alisha Fridrich,** *Islander Oil and Gas Inc.*
Co-author: Chris Young | Islander Oil and Gas Inc.
TABLE 51-52

Vertical vs. Horizontal Drilling in Waulsortian Mud Mound Reservoirs of the Lower Mississippian Pekisko Fm.

9:10am **Holly Shoulak,** *Saskatchewan Geological Survey, University of Regina*
Co-author: Hairuo Qing | University of Regina
TABLE 55-56

Reservoir Characterization of the Frobisher Bed Pools in Southeast Saskatchewan

9:35am **Matthew Braun,** *Natural Resources Canada, Geological Survey of Canada*
Co-author: Daniel Bell | Ovintiv Canada, Per Pedersen | University of Calgary,
Omid Ardakani | Natural Resources Canada, Geological Survey of Canada
TABLE 65-68

Re-Evaluation of the Valhalla Field: Can Montney Formation Turbidites Serve as a Non-Traditional CO_2 Reservoir?

10:00am **COFFEE BREAK & CORE VIEWING**

10:20am **Thomas F. Moslow,** *Moslow Geoscience Consulting*
Greg Baniak, *PETRONAS Canada*
TABLE 41-42

Sedimentologic and Stratigraphic Characterization of Montney Bioclastic Facies: Implications to Reservoir Quality and Well Performance

10:45am **Jon White,** *Sproule ERCE*
Co-authors: Ian Kirkland, Alexander Minev, Ivan Iuferov | Sproule ERCE
TABLE 53-54

Unconformity Expressions in the Upper Triassic Charlie Lake Formation- WCSB, Canada

11:10am **James MacEachern,** *Simon Fraser University*
Co-author: Kerrie Bann | Ichnofacies Analysis Inc.
TABLE 43-44

Integrating Ichnology and Sedimentology to Recognize Delta Types: Case studies from the Cretaceous of the Alberta Basin

11:35am **BBQ LUNCH**

SESSION FOUR:

Cretaceous-Miocene: Shallow Seas to Modern Margins

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12:50pm **SESSION FOUR INTRODUCTION**

Session Four Co-Chairs: James Burr, *Spur Petroleum Ltd.* &
Michael Webb, *Michael Webb GeoConsulting*

12:55pm **Mark Smith,** *Strathcona Resources Ltd.* TABLE 25-28

Co-authors: Andrew Iverson, Steve Quan, Allison Altenhof, Katey Roberts, Ashley Saunders, Stephanie Schmidt, Andrew Tomlinson, Tammy Wilmer | Strathcona Resources Ltd.

Once Upon a Time in Cold Lake: re-evaluation of time-significant surfaces from time-lapse monitoring of the Clearwater Formation

1:20pm **Cynthia Hagstrom,** *Nova Geoscience* TABLE 45-48

Beyond the sweet spots: Core-based insights into the variability and complexity of marginal SAGD reservoirs in the Wabiskaw Member, Athabasca Oil Sands

1:45pm **Bogdan Varban,** *Imperial Oil Ltd.* TABLE 23-24

Co-author: Bram Komaromi | Imperial Oil Ltd.

Stratigraphy of the Wabiskaw Member at Kearl Oil Sands Mine: Depositional Controls and Operational Challenges Ahead

2:10pm **COFFEE BREAK & CORE VIEWING**

Core Lab
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2:30pm **Sarah Schultz,** *Simon Fraser University, Yukon Geological Survey* TABLE 33-34

Co-authors: James MacEachern | Simon Fraser University, Octavian Catuneanu | University of Alberta, John Gordon | Spectrum Geosciences Ltd.

Geochemical Signatures of Subtle Sequence Stratigraphic Depositional Boundaries: A Case Study from the Late Albian Viking Formation

2:55pm **Thomas F. Moslow,** *Moslow Geoscience Consulting* TABLE 31-32

Co-authors: Tristan Euzen | IFP Technologies Canada Inc., Dusty Baldree, Steve Power, Mark Urban | Lotus Creek Exploration Ltd., Amir Iqbal | Artile Analytica Inc.

Sedimentology and Reservoir Facies Heterogeneity of the Basal Belly River Oil Play, Wilson Creek, Alberta

3:20pm **Gareth Williams,** *Touchstone Exploration Inc.*
Gavin Elsley, *Touchstone Exploration Inc.* TABLE 21-22

Co-author: Xavier Moonan | Touchstone Exploration Trinidad Ltd.

Traveling Turbidite: The Herrera Sandstone Member, A Deep-Water Middle Miocene Turbidite System, Central Block, Trinidad

3:45pm **DAY TWO CLOSING REMARKS**

4:00pm **CORE MELTDOWN**

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Session One

Precambrian-Cambrian: The Dawn of Time

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Alberta's Precambrian Basement: Novel Data and Preliminary Interpretations

Eric C. Morley, Arif Rabbani
Alberta Geological Survey / Alberta Energy Regulator

ABSTRACT

Introduction

Beneath the Western Canada Sedimentary Basin (WCSB), the Precambrian basement of the North American Craton, is geologically diverse with at least 17 distinct tectonic domains in Alberta. The basement has a fundamental impact on the geology of the province and influences resources as varied as geothermal, helium, lithium, base metals, and more. Despite its importance, there is a stark scarcity of geological data in Alberta on the basement, largely due its depth beneath the WCSB. Although limited by available core data, the Alberta Geological Survey has undertaken a program to study many of these intercepts for analysis of whole rock lithogeochemistry, U-Pb geochronology, isotope geochemistry, thermal conductivity, and rock geomechanical properties. New data is facilitating an enhanced tectonic interpretation of the basement, its geomechanical and thermal properties, and our understanding of its relationship with a diverse range of resources.

Background

Beneath the much younger rocks of the WCSB, the Precambrian basement of Alberta is composed of igneous and metamorphic rocks with complex tectonic histories. The basement of Alberta belongs to the North American Craton which was formed in the Paleoproterozoic by the amalgamation and suturing of older, Archean components (Hoffman, 1988). Consequently, the Precambrian basement is primarily a mosaic of Archean and Proterozoic terranes welded together by Proterozoic magmatic arcs. In Alberta, major crustal discontinuities, such as the Vulcan Low, the Snowbird tectonic zone (STZ), and the Great Slave Lake shear zone (GSLSZ), juxtapose terranes often with different ages and geological histories (Ross et al., 1991; Pană, 2021).

In southern Alberta, the Archean Medicine Hat Block, suggested to be cogenetic with the Wyoming Province, is separated from the Archean Hearne Province to the north by the enigmatic Vulcan Low (Figure 1; Gifford et al., 2021; Pană, 2021). The east-trending Vulcan Low, defined by a stark magnetic and gravity anomaly, has been interpreted as a Proterozoic suture zone between these Archean domains, although it apparently lacks an expected syntectonic magmatic arc (Pană, 2021).

To the north of the Hearne Province (composed of the Matzhiwin domain, Eyehill domain, and Loverna block), lies the STZ with several splays that transect the province at a northeast orientation (Ross et al., 1991). The STZ is a major crustal discontinuity which runs from Hudson Bay through to Alberta and critically separates the Hearne Province to the south from the Rae Province to the north. Some authors have suggested that the STZ represents southeast-dipping Proterozoic plate convergence resulting in the development of a magmatic arc to the south of the STZ (Rimbey domain), and a subsequent back-arc basin (Lacombe domain) (Hoffman 1988; Hoffman, 1989; Ross et al., 1991, Pană, 2001). To the north and within splays of the STZ, the poorly understood Thorsby and Wabamun domains have been interpreted as remnants of oceanic basin and a tectonic escape wedge, respectively (Ross et al., 1991; Pană, 2021; Lopez et al., 2026).

North of the STZ on the eastern edge of the province, the Proterozoic Taltson Magmatic Zone (TMZ) sits along the western rim of the Archean Rae Province. The genesis of the TMZ is debated by different authors with some suggesting development through arc magmatism (Hoffman, 1988; Ross et al., 1991; Card et al., 2014) while others postulate intracratonic crustal thickening is more likely (De et al., 2000). In the north-central portion of the province, the Proterozoic Buffalo Head and Chinchaga domains are flanked by the TMZ to the east and the Proterozoic Ksituan domain to the west which is interpreted as a magmatic arc resulting from west-dipping subduction (Ross et al., 1991; Pană, 2021).

In the northwest corner of the province, the GSLSZ represents a significant northeast-trending dextral shear zone which has offset the bulk of the Slave Province from a thin sliver southeast of the GSLSZ, known as the Nova domain. Northwest of the GSLSZ, the Proterozoic Great Bear and Hottah domains are associated with the Wopmay Orogen when Proterozoic terranes accreted to the western margin of the Slave Province (Pană, 2021).

Despite scarce available sources of data, impressive previous work has been completed on the Precambrian basement of Alberta from several key authors. Through the 1960’s and 1970’s, R.A. Burwash with other authors examined available oil and gas core intercepts of the basement to collect physical, geochemical, and geochronological data (Burwash et al., 1962; Burwash & Krupicka, 1969; Burwash & Krupicka, 1970; Burwash & Cumming, 1975; Burwash, 1978). Following Hoffman’s seminal work on the assembly of the North American craton (Hoffman, 1988), an assortment of authors used potential field geophysical data to define unexposed basement domains beneath the WCSB in addition to completing petrographic and U-Pb geochronological work on basement samples (Ross et al., 1991; Villeneuve et al., 1993; Burwash et al., 1994; Ross et al., 1994). Through the late 1990’s and early 2000’s, work focused on refining interpretations of potential field data (Lemieux et al., 2000; Pilkington et al., 2000) as well as using newly acquired seismic data (Ross, 2002; Ross & Eaton, 2002) to delineate domains and understand their tectonic histories. Through the rest of the 2000’s to the 2020’s, several studies, generally more regionally focused, were conducted on the Precambrian basement using a variety of geoscientific methods, such as geochronology (Walsh, 2013; Gifford et al., 2021), magnetotellurics (Nieuwenhuis et al., 2014; Wang & Unsworth, 2022), and geophysical potential field data (Lytasky et al., 2005; Johnson et al., 2022). In the last several years, several reports were published interpreting refined basement domains using newly available aeromagnetic data (Brem et al., 2024; Lopez et al., 2024a; Lopez et al., 2024b; Lopez et al., 2026). Despite extensive geological and geophysical studies of Alberta’s Precambrian basement, its application to resource assessment, including geothermal, remains limited. Existing evaluations largely rely on regional heat flow maps derived from sparse deep well temperature data, with limited integration of deep crustal thermal structure, petrographic analysis, laboratory measured thermal and petrophysical properties, or geomechanical constraints (e.g., Bachu and Burwash, 1994; Weides and Majorowicz, 2014).

Methods

This study, conducted by the AGS, focused on describing core intercepts of the Precambrian basement from across the province and conducting analytical work, such as whole rock lithogeochemistry, geochronology, isotope geochemistry, radiogenic heat generation, thermal conductivity, and rock mechanics tests, to increase understanding of tectonics and potential relationships with various resources. For example, mineralogical contents of basement rocks and therefore elemental concentrations may influence production of helium which is trapped in overlying reservoirs (Yurkowski, 2001) and radiogenic heat production for geothermal systems. Additionally, the basement’s domain boundaries and structural features (e.g., GSLSZ) can be linked to kimberlite emplacement through basement faults (Eccles et al., 2002) and carbonate-hosted lead-zinc mineralization by reactivation of shear zones (Pană, 2006).

Oil and gas core intercepts were selected based on their locations within basement domains and the scarcity of core data for the specific hole or region although limitations remain due to the lack of basement intercepts in certain areas of the province. All the core used in this study are housed at the Core Research Centre where it was logged and sampled for analysis.

Ninety samples were sent to a commercial laboratory for whole rock lithogeochemical analysis for a full suite of analytes, including major and trace elements. Additionally, thin sections were prepared from billets, sampled from the same core locations, and detailed petrographic descriptions were produced by AGS staff. In situ LA-ICP-MS U-Pb geochronology on zircons within the thin sections is on-going and will produce crystallization ages for the samples. Additionally, whole rock Sm-Nd isotope work on a subset of samples is pending to produce model ages and epsilon Nd values.

Sixty rock samples were sent for thermal conductivity measurements using a mixture of steady-state divided bar method, optical scanning method, and transient plane source method. To test rock mechanics, twenty-three samples were sent for multi-stage triaxial compressive tests while ten samples were sent for thermal expansion and ultrasonic acoustic velocity tests.

Results & Interpretations

Core logging and petrographic descriptions allowed AGS staff to ascertain mineralogy and lithology at discrete spatial points within basement domains. Generally, the findings supported historic data (Villeneuve et al., 1993) regarding lithological make-up of the Precambrian basement which suggests that the basement is primarily composed of granitoids and gneisses with lesser metavolcanic rocks, metasedimentary rocks, and other lithologies. However, poor sample density over a large portion of the domains limits our ability to correlate lithologies to specific domains. Nevertheless, based on our recent data combined with the newly published domain boundaries (Brem et al., 2024; Lopez et al., 2024a; Lopez et al., 2024b; Lopez et al., 2026), we can make some initial inferences about certain basement domains (Figure 2).

All samples collected from the Lacombe domain (n=3) are metavolcanic which supports the interpretation that the Lacombe domain developed as a back-arc basin to the Rimbey domain magmatic arc (Ross et al., 1991, Pană, 2001). Similarly, the Chinchaga Domain (n=5) is mainly (60%) comprised of metavolcanic rocks and amphibolites with lesser granitoids along its eastern margin. This observation may support the theory of back-arc extension within the Chinchaga Domain (Johnson et al., 2022). In contrast, samples collected from the magmatic arcs of the Rimbey domain (n=5), Ksituan domain (n=4), and the southern extension of the TMZ (n=11), are exclusively granitoids and gneisses. Samples from other domains, such as the Loverna Block (n=14) and the Buffalo Head domain (n=36), include a wide range of lithologies, likely reflecting the complex tectonic history of these areas.

The whole rock lithogeochemical dataset produced through this project has multiple applications, including gaining insight into the tectonic histories of basement domains and identifying anomalous concentrations of specific elements which could influence mineral systems. Initial interpretations of geochemical data returned from the metavolcanic rocks of the Lacombe and Chinchaga domains help to refine tectonic emplacement environments (Figure 3). Most of the samples have relatively high Th/Yb ratios with moderate Nb/Yb ratios and plot near the calc-alkaline basalt field of the basalt Ti-Zr-Y plot indicating that enriched arc mantle is a plausible source for these rocks. One sample of amphibolite from the Chinchaga domain has a more MORB-like geochemical signature with lower Th/Nb ratio values which could suggest the development of a back-arc spreading centre in this domain (Johnson et al., 2022). Overall, trace element geochemistry seems to support the idea that the Lacombe and Chinchaga domains could represent back-arc tectonic settings. Initial interpretations of granitoid and gneissic rocks using discriminant diagrams reveal a wide range of possible tectonic settings throughout the basement domains of the province (Figure 4). Interpreted magmatic arcs, such as the Rimbey domain and the Ksituan domain, generally returned relatively low concentrations of HFSE (e.g., Nb and Ta) and plot within the volcanic arc granite fields of the discriminant diagrams, reinforcing the interpretation of these domains as magmatic arcs. Samples from other domains, such as the Buffalo Head domain and the Archean provinces, plotted over various fields of discriminant diagrams indicating more varied and complex tectonic settings and histories which will require more in-depth interpretation.

The whole rock geochemical data can also provide insight into different mineral systems that may be hosted or influenced by the Precambrian basement. Uranium and thorium concentrations are particularly important as they may provide sources of helium and natural hydrogen to reservoirs in the overlying WCSB (Yurkowski, 2021) as well as directly correlating to radiogenic heat production for geothermal systems. From this sample set, the highest returned result for uranium concentrations was 33.9 ppm U with granitoids returning the highest median of the different lithologies (4.05 ppm U). This dataset also returned several anomalous base metal results with up to 0.11% Cu from one sample although further work is required to elucidate the mineralization process resulting in this enrichment.

Thermal conductivity measurements and rock mechanics testing, coupled with whole-rock geochemistry and petrography, were used to create robust data on heat transfer, heat generation, and geomechanical behaviour of the Precambrian basement to evaluate crustal heat flow and geothermal potential. Thermal conductivity (TC) measurements of basement samples range from 1.5 to 5.6 $W \cdot m^{-1} \cdot K^{-1}$, consistent with values reported for crystalline crust in Alberta and comparable cratonic settings (Walsh, 2013). Variability in TC is primarily controlled by mineral composition and fabric rather than porosity, with felsic granitoids and gneisses exhibiting higher conductivities than mafic rocks. Directional anisotropy ratios of up to ~1.3 observed in foliated gneisses and granites reflect mineral alignment developed during high-grade metamorphism and deformation, particularly within arc-related and reworked domains.

Rock mechanical testing provides a practical approach to assessing drillability of the basement which is an important factor for estimating drilling costs. Testing conducted indicates that basement samples are generally strong, stiff, and brittle, with unconfined compressive strengths typically ranging from ~90 to 230 MPa and Young's modulus values between ~20 and 95 GPa. Higher strength and stiffness are commonly associated with granitoid and high-grade gneissic rocks, whereas lower strengths occur in more altered or mafic lithologies. Thermal expansion coefficients (4.58×10^{-6} to 7.87×10^{-6} $°C^{-1}$) fall within the expected range for crystalline crust. These geomechanical properties reflect the tectonic and metamorphic evolution of the basement and suggest limited natural permeability in intact rock, but favourable conditions for fracture stability where stimulation or reactivation occurs. Correlation of these results with indices such as the Drilling Rate Index (DRI) and the mechanical specific energy (MSE) required for bit penetration (Teale, 1965) indicates, for representative samples, systematically lower inferred DRI values for granitoids (≈35–45), consistent with more difficult drilling, compared to higher inferred DRI values for gneisses (≈55–65), reflecting more favourable drillability. Scenario-based MSE estimates derived from UCS further suggest that rocks with well-developed fabrics require less energy for penetration than massive, intact granitoids under comparable drilling conditions. In addition, a positive relationship between UCS and framework silicate content indicates that gneisses with reduced effective framework silicate strength tend to require less energy for penetration than intact granitoids, despite broadly similar quartzofeldspathic bulk compositions (Figure 5). These integrated geomechanical–mineralogical relationships provide a quantitative foundation for forecasting drilling performance in the Precambrian basement and support ongoing evaluation of basement drillability in Alberta.

Uranium, thorium, and potassium concentrations from whole rock lithogeochemical analyses were used to determine radiogenic heat production (RHP). Low-radiation mafic rocks, typically from back arc domains, yield less than 1 $\mu W/m^3$, while U- and Th-rich granitic rocks, from felsic plutonic domains, reach 5–6+ $\mu W/m^3$. An important caveat is that basement cores commonly sample felsic intrusive or high-grade metamorphic rocks at the top of basement that may be more enriched in heat-producing elements than deeper crustal levels, which can transition to more intermediate or mafic compositions. Taken together, the thermal, geochemical, and geomechanical datasets demonstrate that basement tectonic domains exert a first-order control on physical properties relevant to crustal heat flow and geothermal systems.

Conclusions

The Precambrian basement of Alberta is geologically complex with sparse available data, however it has a profound influence on the overall geological history and makeup of the province. This study aimed to accumulate relevant, modern data on available core intercepts of the basement to further refine our understanding of its tectonic history as well as provide commentary on resource potential. Core logging and petrographic descriptions combined with a full suite of whole rock lithogeochemistry revealed general lithologic trends, correlations to tectonic settings, and indications of potential minerals systems. Thermal conductivity measurements coupled with rock mechanics testing allowed us to perform initial investigations of deep geothermal potential. Further work, including U-Pb geochronology and Sm-Nd isotope geochemistry, combined with continuing interpretations will further reveal the Precambrian basement’s geological history and potential resources.

Figures

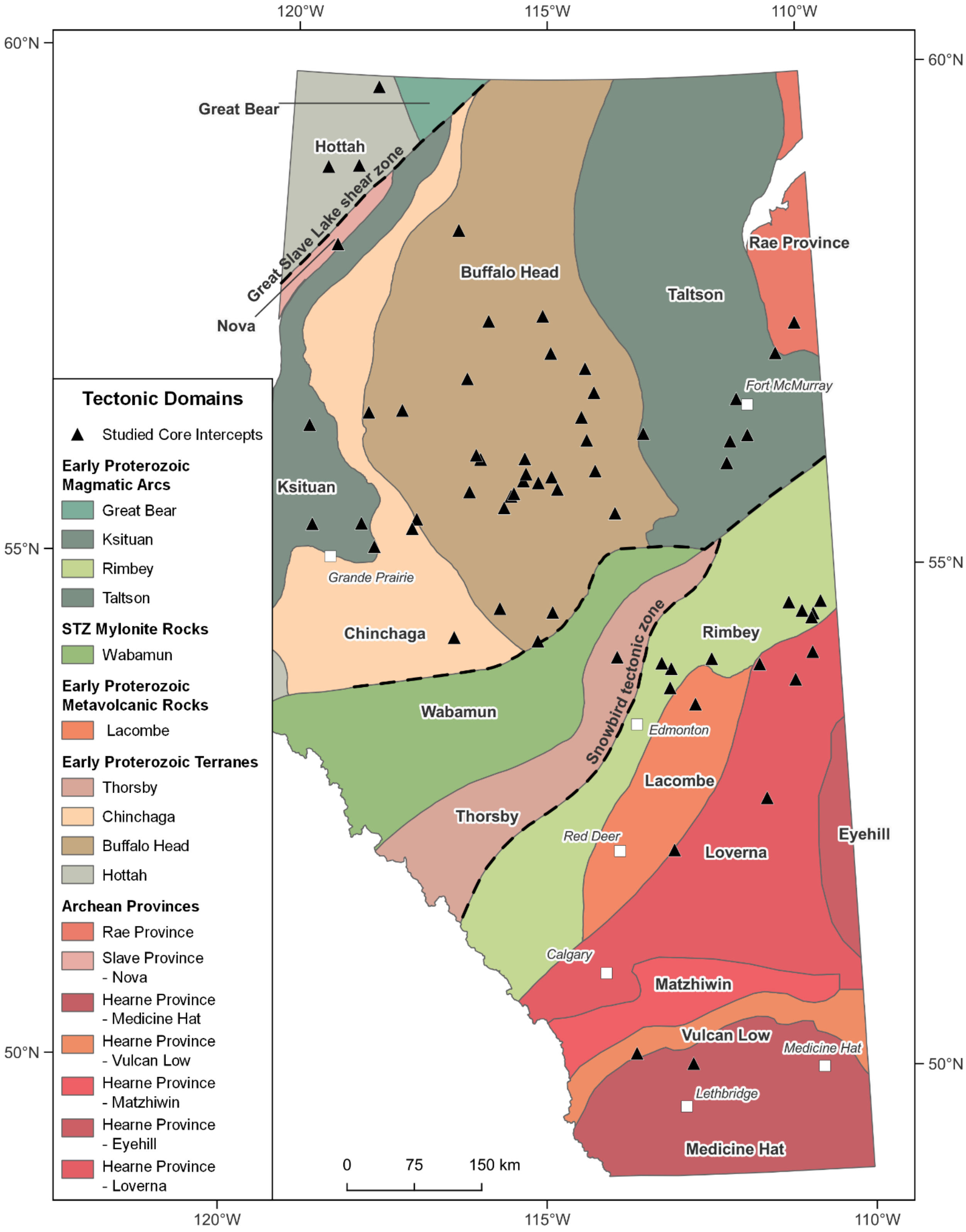


Figure 1 – Core intercepts studied for this project with tectonic domains of the Precambrian basement in Alberta (including Archean provinces, Proterozoic terranes, magmatic arcs, and major shear zones). Domain boundaries and lithological units reflect distinct geophysical signatures and tectonic histories (modified from Ross et al., 1991).

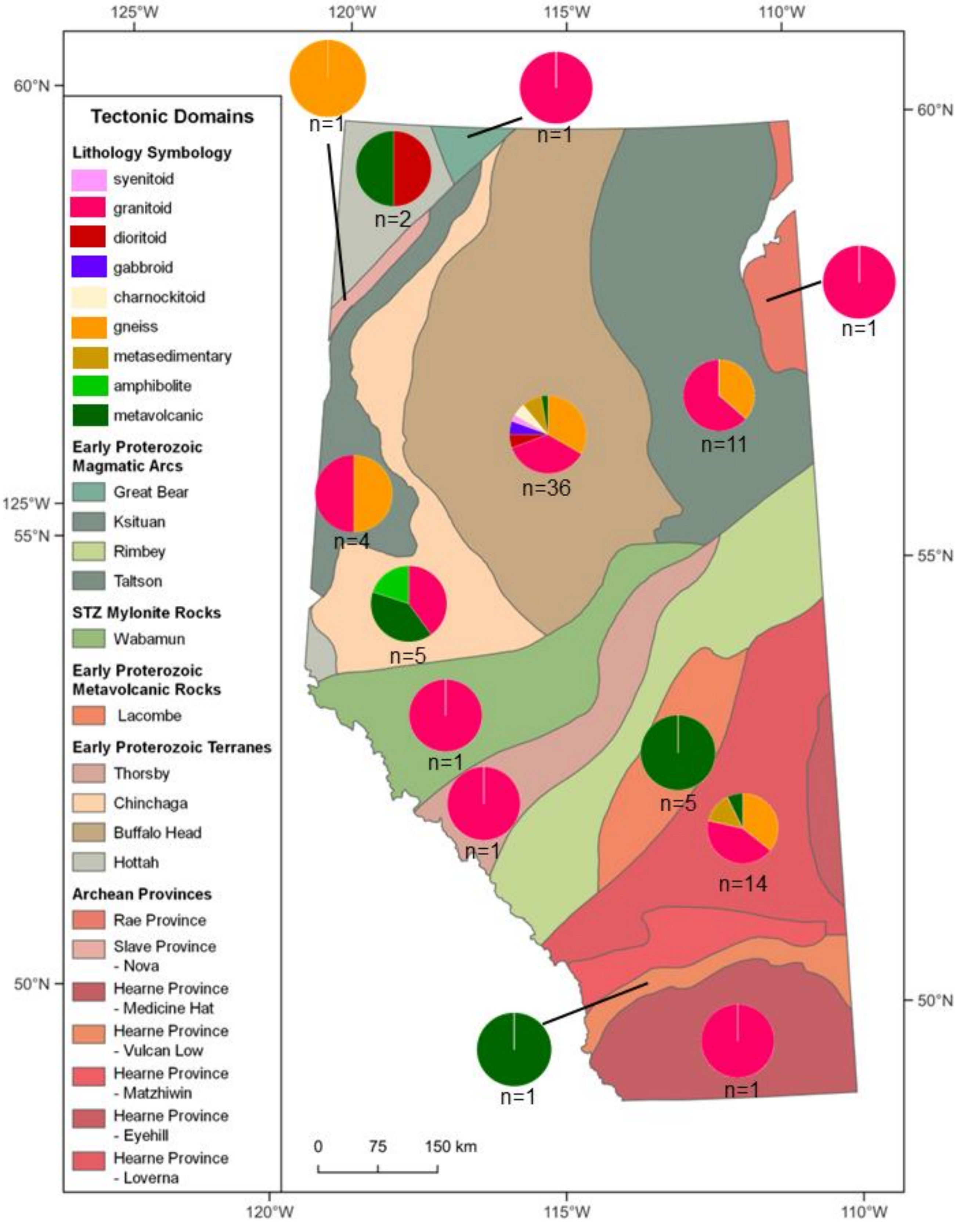
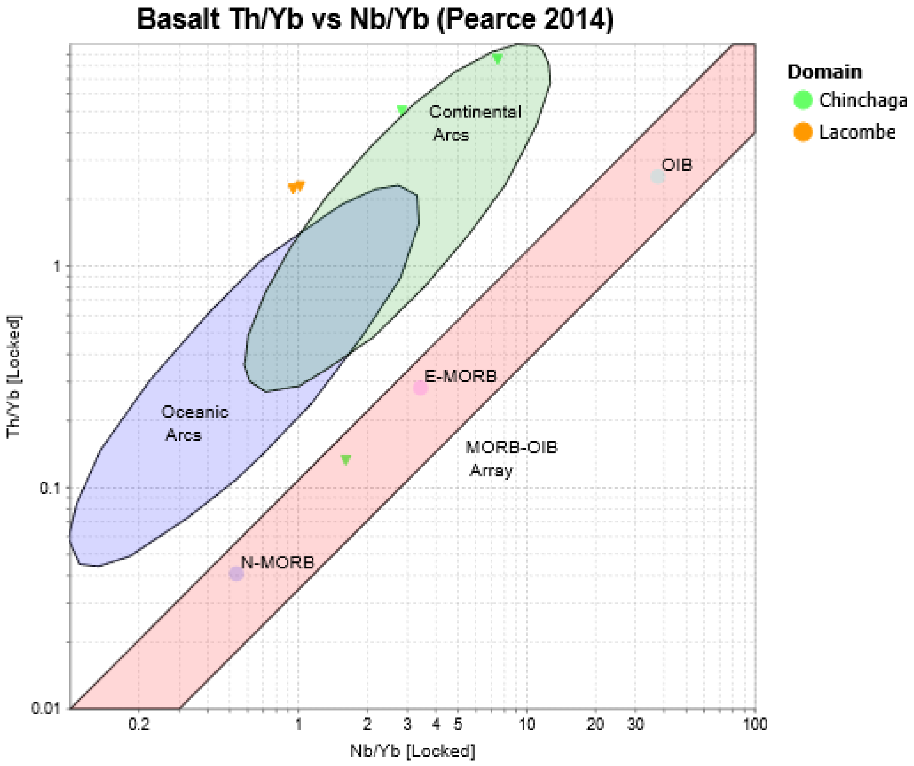


Figure 2 – Pie charts displaying lithology of samples studied in each domain overlaying tectonic domains of the Precambrian basement in Alberta (including Archean provinces, Proterozoic terranes, magmatic arcs, and major shear zones). Domain boundaries and lithological units reflect distinct geophysical signatures and tectonic histories (modified from Ross et al., 1991).



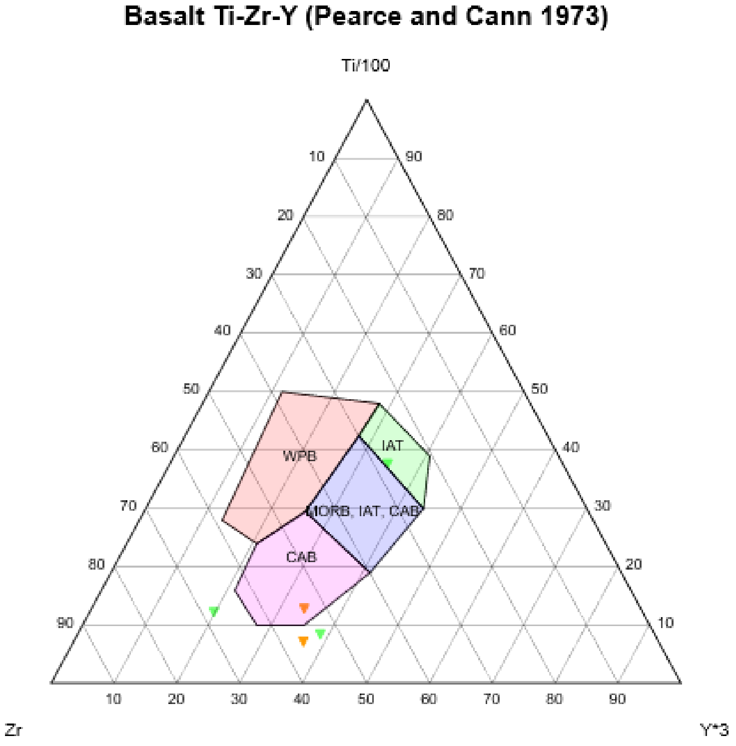


Figure 3 – A Th/Yb versus Nb/Yb trace-element rock classification diagram (after Pearce, 2014) and a Zr versus Ti/100 versus Y*3 ternary trace-element rock classification diagram (after Pearce and Cann, 1973) displaying metavolcanic and amphibolite rock samples from the Chinchaga and Lacombe domains. Abbreviations: CAB, calc alkaline basalt; MORB, mid-ocean ridge basalt; IAT, island arc tholeiite; WPB, within plate basalt; OIB, ocean island basalt; E-MORB, enriched mid-ocean ridge basalt; N-MORB, normal mid-ocean ridge basalt

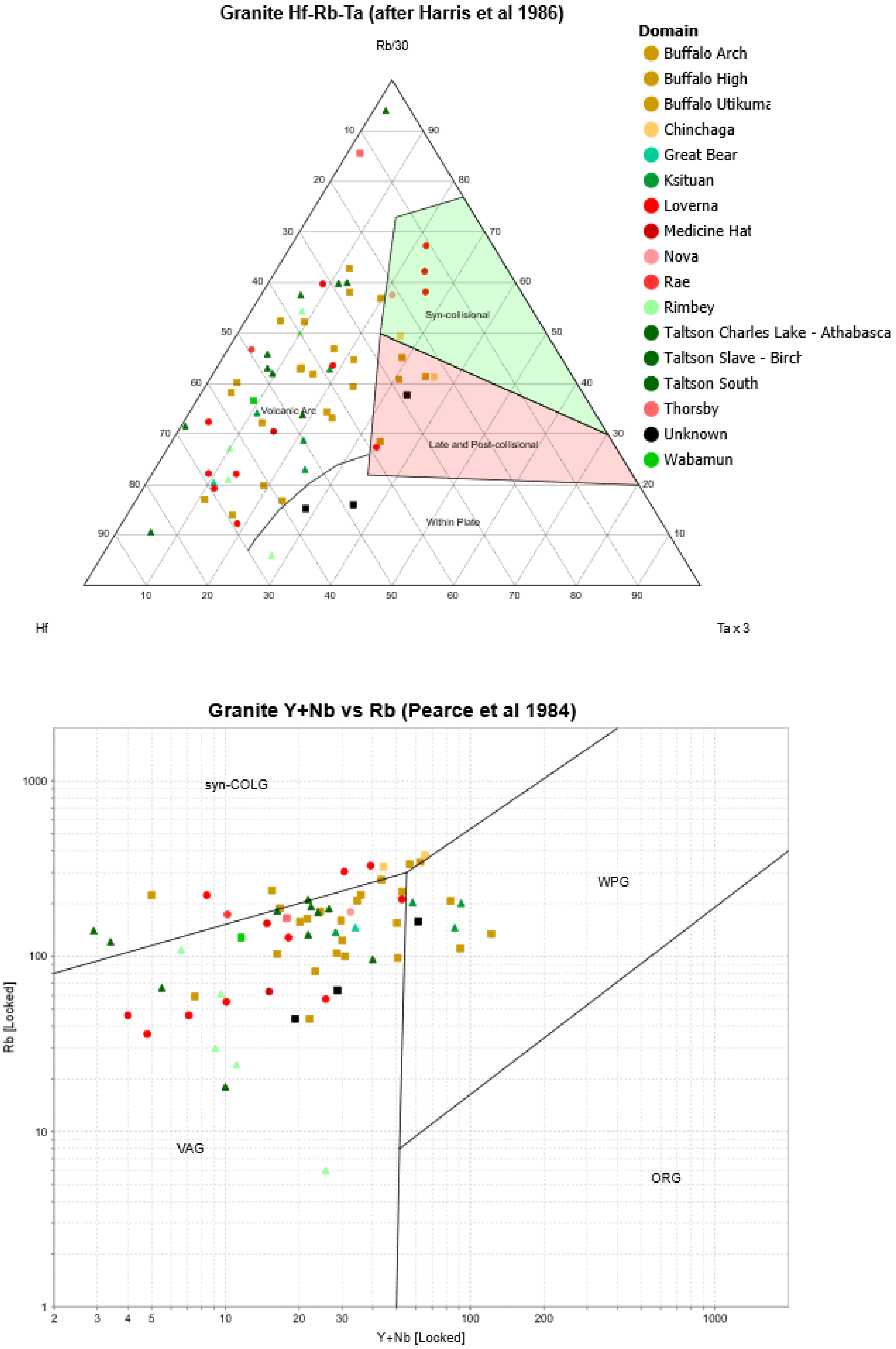


Figure 4 – A Hf versus Rb/30 versus Ta*3 ternary trace-element rock classification diagram (after Harris et al., 1986) and a Rb versus Y+Nb trace-element rock classification diagram (after Pearce et al., 1984) displaying granitoids and gneisses from across various basement domains. Abbreviations: syn-COLG, syncollisional granite; VAG, volcanic arc granite; ORG, ocean ridge granite; WPG, within plate granite

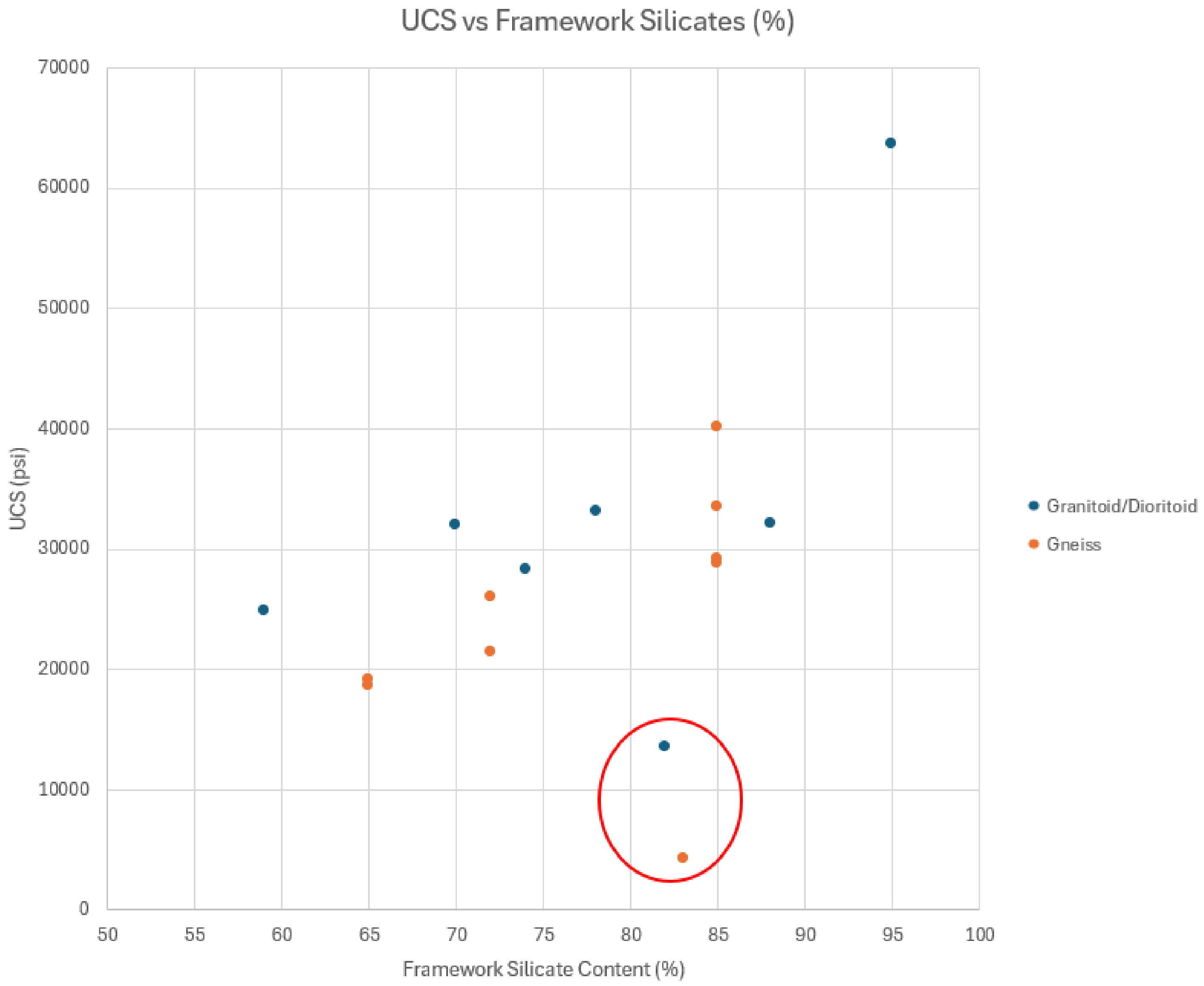


Figure 5 - Relationship between unconfined compressive strength (UCS) and framework silicate content for basement lithologies. Granitoids/dioritoids (blue) and gneisses (orange) show increasing UCS with framework silicates; altered samples (circled in red) deviate from this trend.

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The Cambrian Cold Lake Conundrum: New Models for Old Rocks

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ABSTRACT

The Basal Cambrian Sandstone (BCS) in the Cold Lake area of east-central Alberta is characterized by an anomalously thick (80–100 m), clean, coarse-grained sandstone succession. The Cold Lake BCS contrasts sharply with the regional BCS, which is typically thinner (~30–40 m) and more heterolithic. Recently acquired well and core data obtained over the last two years from a sparsely drilled region provide critical data correlating the well-characterized Shell Quest asset to the Cold Lake area. This new dataset includes a complete suite of modern wireline logs and continuous core coverage through the BCS and the overlying Earlie Formation that allow for a view of this anomalous sand package in a sequence stratigraphic context.

We propose two competing models to explain these overthickened and clean sandstone deposits.

Model 1 (Highstand Progradation) proposes that the thick Cold Lake BCS section is a result of highstand progradation within the Earlie Formation. In this scenario, the Cold Lake area records the proximal reaches of this system, where shallow marine sands of the Earlie Formation are indistinguishable from the underlying BCS sands. The maximum flooding surface (MFSx) separating the two sandstone intervals is thus interpreted as being eroded or poorly expressed. However, this model is inconsistent with the transgressive facies stacking patterns observed in the upper portion of the Cold Lake section, as highstand deposition should be characterized by strongly progradational to aggradational stacking patterns

Model 2 (Incised Valley Fill) proposes that the thick sandstone body in the Cold Lake region represents an incised valley fill (IVF) related to a 3rd-order sequence boundary within the Earlie Formation. This potential N–S trending valley would have eroded the MFSx, thereby amalgamating the Earlie sands with the BCS. The observed transgressive facies stacking patterns align more closely with a classic IVF model than with highstand progradation. A key challenge to this model, however, is that the incised valley margins (i.e., a definitive container) have not yet been delineated.

Both models imply that a majority of the sandstone-dominant interval (BCS) at Cold Lake is Earlie Formation in age and, therefore, chronostratigraphically much younger than the BCS sands typically found elsewhere in Alberta.

CORE CONFERENCE

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Sand and Deliver: Testing the limits of CCS potential in the Basal Cambrian near Medicine Hat, AB

Becky Rogala, Breanna Uzelman
Imperial Oil

ABSTRACT

The Clear Horizon project was initiated by the City of Medicine Hat in 2021 to evaluate the feasibility for a carbon storage hub to support local industry emission reductions, and the permit was subsequently transferred to Imperial Oil in 2025. Imperial, with partial NRCan funding, conducted a two-well appraisal program approximately 20km west of Medicine Hat to advance the assessment of the pore space. Appraisal drilling and the first phase of core testing are complete, and these results have been incorporated into a geomodel with preliminary simulation of carbon storage. This study expands the knowledge of the Basal Cambrian Sand and explores the range of what can be considered for viable carbon storage.

The Basal Cambrian Sandstone (BCS) is a geographically expansive, non-hydrocarbon bearing sandstone that has been used for disposal operations in the Western Canadian Sedimentary Basin for over 40 years. At the Clear Horizon project, the BCS aquifer is ~2100m deep, 20-40 m thick and interpreted to be a thinner equivalent to the fluvio-tidal BCS described at the Quest and Pathways project areas to the north. Regional analysis indicates that porosity and permeability of the BCS decreases toward the Medicine Hat area. Prior to drilling, the closest core calibration was ~50 km northwest of the Clear Horizon area, thus further appraisal was required to address key subsurface uncertainty. Imperial drilled two appraisal wells with a comprehensive evaluation program at Clear Horizon: 100/13.02.014.07W4 and 100/13.30.013.08W4 (13-2 and 13-30, respectively). Well locations (Figure 1) were chosen to test aquifer variability across the lease.

The drilling program successfully fulfilled all program objectives, despite some delays to the first well due to extreme cold weather and mechanical issues. Hole instability in the Cambrian seal section prompted changes to the well design (additional casing string, mud system) for the second well. Core samples were used for analytical tests, and the core was described for incorporation into a subsurface model. Imperial collected a basic log suite over the Cretaceous section in both wells and then ran a comprehensive logging suite over the Devonian and Cambrian sections. Additionally, Imperial conducted a drill stem test (DST) and diagnostic fracture injectivity tests (DFIT) within the aquifer and DFITs in the overlying baffling and sealing section. BCS water samples were collected as part of the DST process.

High quality data was acquired across both the reservoir and caprock intervals, confirming both the presence of viable reservoir in the Basal Cambrian Sand and the integrity of the Cambrian sealing complex. Aquifer porosity and permeability, known to be lower than established CO2 injection areas to the north, still exceeded expectations for the Medicine Hat area. A geomodel was constructed integrating this new data with existing

regional data and used to simulate carbon storage. Initial simulation indicated that suitable injection rates for commercial storage could potentially be achieved, although additional sensitivity analysis is recommended to confirm the robustness of this result and optimize a potential development plan. This study has helped expand the definitions of suitable carbon storage reservoirs by testing a lower quality end member relative to what has previously been explored. As this work is disseminated it will potentially open carbon storage opportunities more broadly in Canada.

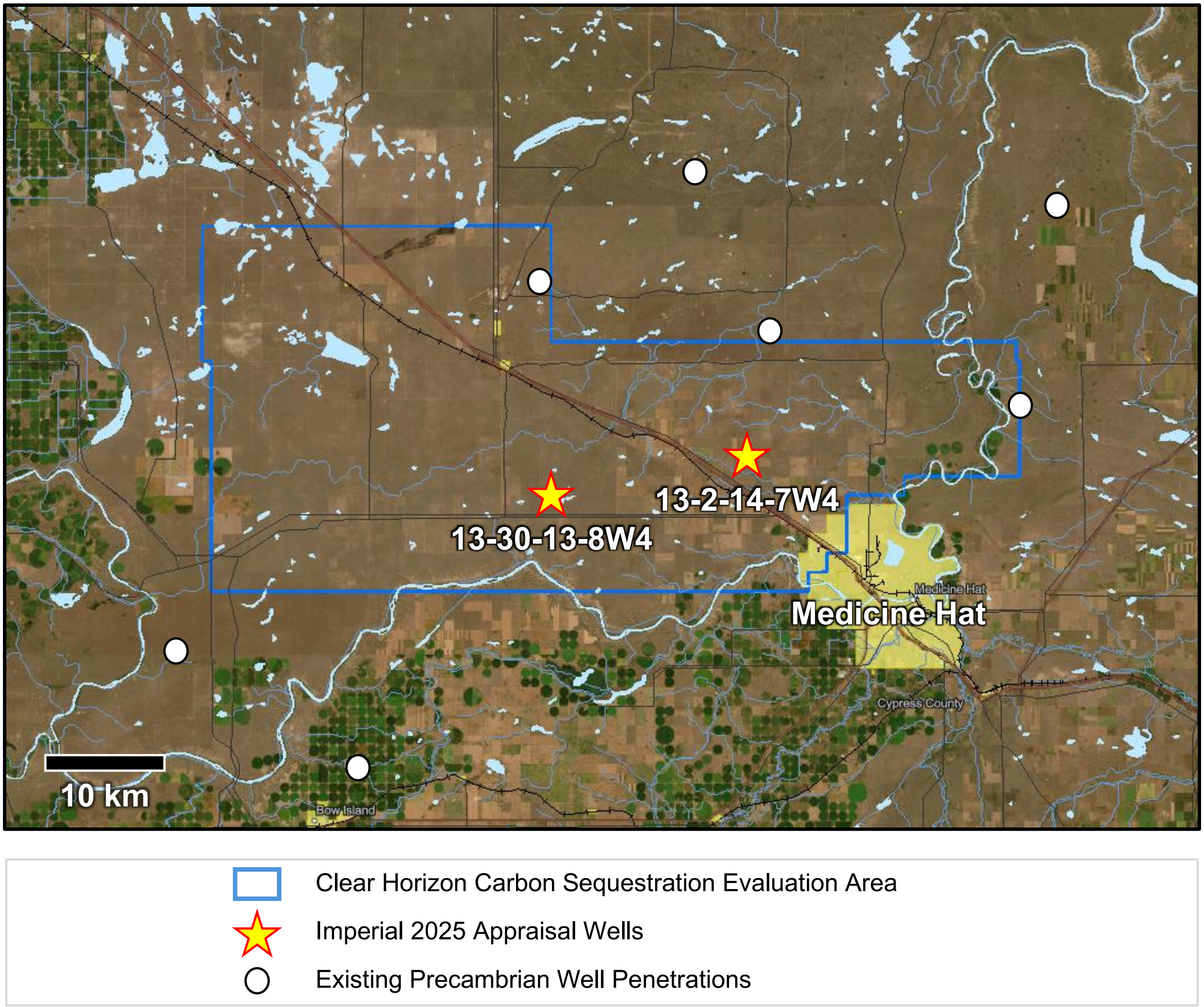

Figure 1. Location map of appraisal wells for Clear Horizon CCS evaluation, Medicine Hat, AB

Cores from halites and associated evaporitic beds of Alberta and Newfoundland: Considerations for salt caverns and notes on geochemistry

Magnus Roland Marun[1], Davood Zivar[2], Guanhua Li[2], Hassan Dehghanpour[2], Pavel Kabanov[3]

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ABSTRACT

Salt solution mining in Alberta has historically targeted Devonian Elk Point Group evaporites (Fig. 1). Salt caverns are now being evaluated for underground hydrogen storage (UHS), though challenges related to hydrogen reactivity, diffusivity, and hydrogen sulphide (H_2S) generation require careful site characterisation. This presentation examines core material from halite and associated evaporitic beds across the two Canadian provinces of Alberta and Newfoundland, with a focus on mineralogy, textural heterogeneity, and implications for salt cavern development and UHS feasibility. In Alberta, three formations of the Devonian Elk Point Group are described from continuous cores: the Upper Lotsberg Halite (UWI: SASK 7-23-55-22), the Cold Lake Formation (UWI: 00/09-06-066-01W4/00), and the Prairie Evaporite Formation (UWI: 00/02-10-70-04W4). These units have been, or are actively being, evaluated for solution-mined cavern storage of natural gas and hydrogen, with key considerations including sulphate mineral content, impurity distribution, and cavern-scale heterogeneity, as well as their respective consequences for hydrogen reactivity and H_2S generation. In contrast, halokinetic salt structures such as the Robinson River salt dome in the Bay St. George area of southwestern Newfoundland (presented here as intersected by well VW242 at 48°12′19.42″N, 58°41′1.37″W) represent Carboniferous Codroy Group evaporites with fundamentally different internal fabrics and structural settings, which present distinct opportunities and challenges for the assessment of industrial salt cavern feasibility. Finally, we present the first Canada-wide compilation of geochemical and XRD data from evaporite systems of current and potential economic importance, incorporating new data collected since 2022 alongside published and secondary datasets, in support of both ongoing Government of Canada research and broader geoenergy industry applications in solution mining and energy storage.

UPPER LOTSBERG HALITE OF ALBERTA

Continuous core through the Lotsberg Formation and overlying Ernestina Lake red beds in the PMC at 140 FT, SASK 7-23-55-22 shows upper Lotsberg halite with cavern-scale quality, heterogeneity, and specific hydrogen storage opportunities and risks. For decades, the Lotsberg Formation has been the top choice for solution-mined caverns used for gas storage and industrial waste disposal in Alberta, owing to its thickness of up to about 170 meters near Cold Lake, AB, and its intervals of clean, homogeneous halite (Kabanov et al., 2024). The upper Lotsberg halite includes thick, very coarsely crystalline, visually homogeneous halite (LH1 to LH3), with only minor dolomarl partings in places and very low non-halite volume in LH1. Internally, the interval includes stratigraphic markers and impurity-bearing breaks, including the L2 marker of dolostone and breccia with anhydrite nodules and a dolomite-rich interval separating LH2 and LH3 that also contains anhydrite nodules. Considering this mineralogy is important when evaluating hazards related to hydrogen storage. Design constraints for cavern storage operations are therefore dominated by the presence of sulphate since H_2 can drive sulphate dissolution and promote H_2S generation via bacterial sulphate reduction.

COLD LAKE FORMATION OF ALBERTA

Core samples from examined well (UWI 00/09-06-066-01W4/00), provide the basis for the following description of the Cold Lake Formation, a halite-dominated unit of the Elk Point Group stratigraphically situated between the Contact Rapid Formation and Ernestina Lake Formation. Compared with the Prairie Evaporite (shallower salt formation), the Cold Lake Formation contains lower sulphate content and exhibits textural characteristics more similar to the Lotsberg halite, though it generally carries a higher proportion of marly-dolomitic impurities than the Upper Lotsberg (Hauck, 2020). Although it has not yet been utilised for cavern storage, the Cold Lake Formation is an anhydrite-lean halite unit with a broader geographic distribution than the Lotsberg, extending across northern Alberta and western Saskatchewan and northward beyond 60°N. The examined core reveals a 43 m thick, predominantly euhedral halite interval with less than 5 wt.% impurities, consisting mainly of carbonates. This low impurity burden and anhydrite-lean character suggest favourable characteristics for hydrogen storage applications, with limited potential for H_2S generation relative to more sulphate-rich evaporite units

PRAIRIE EVAPORITE FORMATION OF ALBERTA

The Fisher 2 core provides an opportunity to view a continuous cross-section through the internal architecture and post-depositional modifications of the laterally bedded, potash-rich, Prairie Evaporite succession. ECA ECOG SALT-2 FISHER (UWI 00/02-10-70-04W4) includes parts of the Watt Mountain Formation and the Prairie Evaporite. The Watt Mountain Formation overlies the Prairie Evaporite Formation and transitions east-southeast into the Dawson Bay Formation, bounded above and below by the First and Second Red Beds, respectively (Figure 1; Dunn, 1982). The Watt Mountain Formation is relatively thin and uniform in thickness, comprising argillaceous shale, siltstone, and anhydritic dolomites and limestones (Law, 1955). The formations overlie the Prairie Evaporite Formation (Fig. 1), which hosts extensive halite and potash (Sylvite/Carnallite) deposits (Meijer Drees, 1986). The logged intervals demonstrate potash mineralisation of carnallite and sylvite, organic-rich dark-banded halite, and very pure crystalline white halite, with massive pink halite and intervals disrupted by marl and silt-sized argillaceous interbeds, pervasive fracturing, and locally intense brecciation and dissolution. Of specific note in this presentation is the occurrence of the Conklin bed, a shale layer which represents a major bottleneck in solution mining.

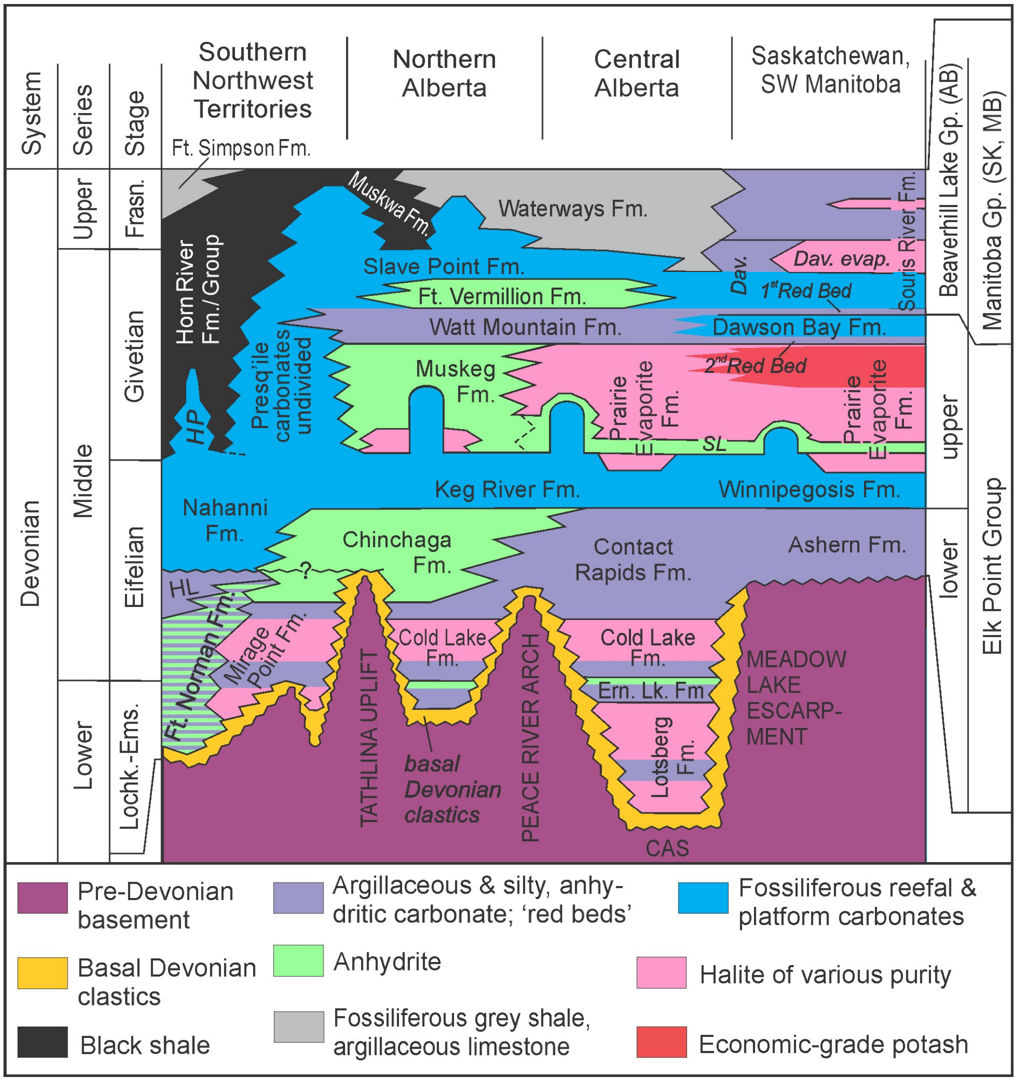

Figure 1. Lower-Middle Devonian stratigraphy of Western Canada Sedimentary Basin (Canadian part, excluding central-northern Northwest Territories). Based on Meijer Drees (1986) and Grobe (2000), with major updates. Abbreviations: Lochk.-Ems. = Lochkovian-Emsian; Frasn. = Frasnian; CAS = Central Alberta Sub-basin; NAS = Northern Alberta sub-basin; Dav. Evap. = Davidson Evaporite unit of the Souris River Formation; HP = Horn Plateau reefs; HL = Headless Formation; Ern Lk. = Ernestina Lake Formation; SL = Shell Lake Member of Prairie Evaporite Formation (Yap et al., 2026 [In review])

SALT DOMES IN CODROY ROAD FORMATION, NEWFOUNDLAND

In contrast to laterally continuous bedded salts in WCSB, halokinetic salt domes of the Bay St. George area in southwestern Newfoundland represent vertically extensive evaporite bodies with complex internal fabrics (Lemieux et al., 2020; Snyder and Waldron, 2021).The Robinson River salt dome is located in the southwestern part of the island of Newfoundland in eastern Canada, along the St. George's Bay region, and is among the largest halokinetic salt formations in Canada (See Fig. 2). Based on initial estimates, the Robinson River salt dome could store up to 800,000 tonnes of hydrogen in more than 60 caverns across the 235 km² claimed area. The VW242 well is located at 48°12′19.42″N, 58°41′1.37″W and intersects a thick salt succession within the Robinson River salt dome. Approximately 400 m of continuous core were recovered from this well. Regionally, this succession is assigned to the Codroy Group, including the Codroy Road Formation; core observations indicate that drilling extended downward into the underlying Ship Cove Formation. Both formations are of Carboniferous (Mississippian) age.

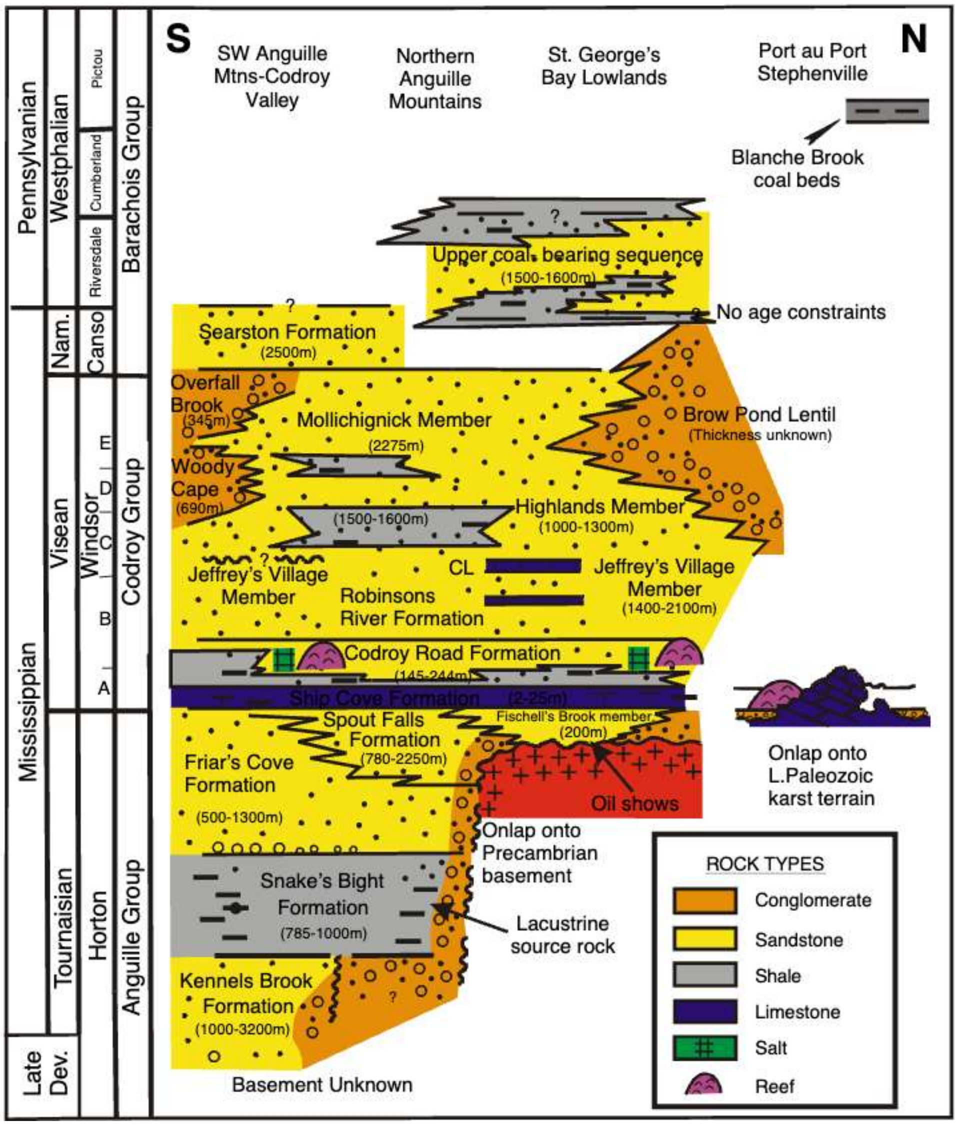

Figure 2. Carboniferous lithostratigraphy of the Bay St. George Sub-basin (Modified form Knight, 1983; Shano, 2022).

Core observations show repeated alternations between dark grey to grey-black halite-rich salt intervals and brownish-yellow to yellow-green salt-bearing clastic intervals. The dark-coloured halite-rich intervals are dominated by halite and locally contain thin interlayers or laminae of fine-grained detrital material occurring as discrete bands within the salt. By comparison, the brownish-yellow to yellow-green salt-bearing clastic intervals display greater lithological and textural complexity, commonly containing angular to subangular impurity clasts spanning a broad size range, from a few centimetres to more than ten centimetres. These intervals also include massive embedded impurity layers with thicknesses reaching several tens of centimetres, clearly distinguished from the surrounding halite-cemented matrix, and locally developed layered structures. In the lower part of the core, multiple light-coloured halite-filled veins occur, oriented vertically or at steep angles relative to the core axis. XRD analyses show that the evaporite mineral assemblage is dominated by halite, with halite content reaching approximately 90%, accompanied by subordinate potash minerals, while detrital impurities consist mainly of quartz, dolomite, and clay minerals.

GEOCHEMICAL DATA COMPILATION

In this presentation, we also showcase the first cross-provincial, Canada-wide compilation of geochemical data from rock salt deposits of current and potential economic importance. This includes new data as well as a compilation of previously published and secondary data (Yap et al., in revision). This compilation encompasses both previously published and newly obtained elemental geochemistry and XRD data collected from 2022 onward at the University of Calgary and the Geological Survey of Canada. The compilation includes recent project data (collected since 2022), published research data, and non-confidential information from national and provincial databases. This data supports ongoing Government of Canada research projects and publications and aims to serve broader industry applications, such as solution mining and public access. It focuses on geochemical data from significant salt formations and related beds located in the subsurface (~200-2000 m) of sedimentary basins in onshore Canada. New analyses were performed to assess trace and major elements in lithic impurities within salts. Much of the lithogeochemical data comes from non-salt beds associated with salt deposits, such as silty marls, carbonates (“red beds”), and anhydrites. The report includes a wide range of geochemical data, such as whole-rock ICP lithogeochemistry with 4-acid digestion (near-total), brined salt cores, and data from industrial brines (salt and potash mines, salt storage caverns). The brined core data simulate the chemical makeup of brines produced via industrial solution mining.

ACKNOWLEDGEMENTS

This work is funded in part by the Critical Minerals Geoscience and Data (CMGD) Program of Natural Resources Canada with management support from Eric Potter, Benjamin Trerice, Victoria Tschirhart, and Clarivel NaChampassak. New geochemical data from cores were acquired with AER sampling authorisations GOS-5885, 5892, 5897, 5899, 6023, and GOS-7296; as well as OROGO (Govt. of the Northwest Territories) sampling authorisation SR-2024-001. The authors would further like to thank Vortex Energy Corp., Alberta Innovates Hydrogen Centre of Excellence, Future Energy Systems, Natural Resources Canada (NRCan), Mitacs, and the Natural Sciences and Engineering Research Council of Canada (NSERC) for funding the work associated with this project. The CRC facility staff, and in particular Susan Co and Lukus Wagstaff, are cordially thanked for their continued support of our salt project work since 2022.

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CORE CONFERENCE

May 7-8, 2026 • AER Core Research Centre

Reservoir Quality and CO_2 Mineral Trapping Potential of Subsurface Strata in Metro Vancouver: An Automated Mineralogy Approach

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ABSTRACT

Mineral trapping is a key long-term mechanism for secure geological storage of CO_2, yet its assessment is often limited by insufficient characterization of reactive mineral phases, their spatial distribution, and pore-scale associations. This study applies automated mineralogy to evaluate reservoir quality and CO_2 mineral trapping potential within subsurface sedimentary strata underlying Metro Vancouver (Lower Mainland of British Columbia, LMBC) in the Georgia Basin. High-resolution automated mineralogical analysis (AMICS system) was conducted on 88 polished core samples to quantify mineral composition, grain size, textures, and pore–mineral associations. Quantitative results are integrated with petrographic observations, SEM images, and core-plug porosity–permeability measurements to assess diagenetic controls on reservoir quality and to define four mineral reactivity categories relevant to CO_2–rock interactions: Smectite pore-lining, Calcite-cemented, Kaolinite pore-filling, and Partial zeolite pore-filling.

Mineral trapping potential was estimated by combining quantitative mineral abundance data with stoichiometric CO_2 consumption capacities. Pore–mineral association data, supported by SEM observations, are used to evaluate mineral accessibility and to identify key limitations, advantages, and uncertainties associated with different reactive-diagenetic mineral categories. This workflow provides a more realistic interpretation of potential mineral reactivity than bulk mineralogical approaches alone. Results highlight the strong influence of diagenetic alteration and cementation on both reservoir properties and mineral trapping efficiency, with significant spatial variability observed across stratigraphic intervals.

The study demonstrates that automated mineralogy offers a robust, scalable framework for linking reservoir quality assessment with mineral trapping potential, providing fit-for-purpose datasets for CO_2 storage screening in sedimentary basins. The workflow is transferable to other subsurface settings and supports improved risk reduction in carbon capture and storage site evaluation.

Acknowledgements

This study was funded through grants to S.E. Dashtgard from the BC Ministry of Energy, Mines, and Low-Carbon Innovation and the Natural Sciences and Engineering Research Council of Canada (RGPIN-2019-04528 and ALLRPP 581340-23).

Quantitative mineralogy analysis using AMICS was conducted in collaboration with Vidence Inc.

Session Two

Ordovician – Devonian: Roots, Reefs and Fishes

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CORE CONFERENCE

May 7-8, 2026 • AER Core Research Centre

Lithofacies, Depositional Environments and Petroleum Reservoir Characteristics of the Ordovician Red River Formation, Williston Basin, Southeastern Saskatchewan

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[1]Saskatchewan Geological Survey, [2]University of Regina

ABSTRACT

INTRODUCTION

The Ordovician Red River Formation in the Williston Basin of southeastern Saskatchewan was a modest conventional oil producer in the province during the mid-late 1990s to early 2000s. The success was limited and short-lived as most wells targeted discrete structures observed on 2D seismic data (Potter and St. Onge, 1991; Kreis and Kent, 2000; Pu and Qing, 2003; Potter, 2006). Due to the inherent complexity of the carbonate reservoirs and the presence of shallower targets with less geological and economical risk, exploration in the Red River Formation has not recovered. With an overarching goal in the province of Saskatchewan to significantly increase oil production in the very near future and theoretical calculations suggesting a substantial amount of oil remaining in the subsurface in the Red River Formation, a geological reconnaissance was undertaken.

The study area is in the Williston Basin of southeastern Saskatchewan and encompasses an area northeast of Weyburn from Township 8, Range 5 west of the Second Meridian (Tp. 8, Rge. 5W2M) to Tp. 16, Rge. 15W2M, spanning 99 townships and approximately 9000 km^2 (Figure 1; Thomas and Qing, 2025). Generally, the Red River Formation is composed of three shallowing-upward sequences consisting of fossiliferous, burrow-mottled limestones, overlain by laminated dolostones, and an anhydrite cap (Kent, 1960; Kendall, 1976; Figure 2). The lowest anhydrite (Lake Alma/C anhydrite) and the strata below are the focus of this study (Figure 2 red outline). All data, including wireline logs for 143 wells, 63 core descriptions, 50 thin sections, several cross-sections and maps, and >1800 routine core analysis (RCA) values, were integrated to interpret depositional environments and facilitate reservoir characterization to identify areas of resource potential.

DISCUSSION

In total, nine re-occurring lithofacies (Lf) were identified: anhydrite (Lf1); massive dolomudstone (Lf2); algal boundstone (Lf3); algal-peloidal dolowackestone (Lf4); burrow-mottled skeletal lime mudstone (Lf5); nodular lime mudstone (Lf6); organic-rich, skeletal, burrowed wackestone (Lf7); burrow-mottled crinoidal dolomud-wackestone (Lf8); and planar-laminated calcareous or dolomitic mudstone (Lf9). Based on the dominance of micrite, monotony and microscopic size of biota, stacking patterns and areal distribution, the lithofacies were collocated into four facies associations (FA) representative of a low energy, carbonate mud-dominated tidal flat system. The four facies associations are: subaqueous to supratidal restricted inner flat (FA1); intertidal lagoon to restricted inner flat (FA2); protected shallow subtidal to subtidal outer flat (FA3); and intertidal, inner flat (FA4).

Lithofacies 3, 4, 8 and sometimes 9, have the best reservoir characteristics (e.g., elevated porosity). These lithofacies were interpreted to have been deposited proximal to land within the intertidal zone that is more susceptible to dolomitization and therefore, the creation and preservation of intercrystalline porosity. With just over one well per township on average, an apparent drilling bias to structural targets, and a lack of publicly available seismic data, it is difficult to accurately assess hydrocarbon trapping mechanisms. Despite this, the complex nature (e.g., high-frequency lateral and vertical variation) of the tidal flat facies and the extensive diagenesis (e.g., dolomitization) they have endured, suggest that stratigraphic pinch-outs should be present.

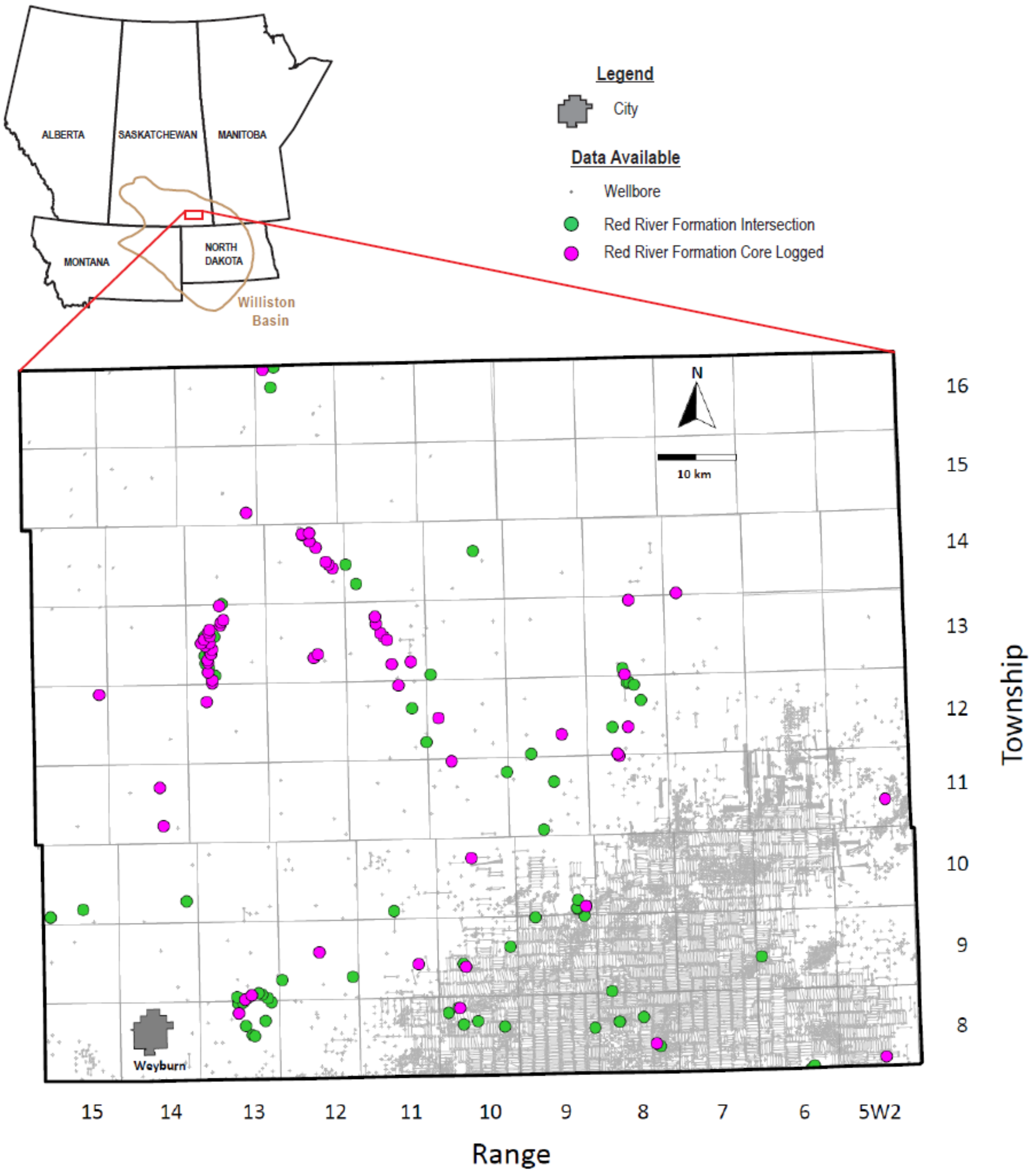

Figure 1: Map of the study location within the Williston Basin of southeastern Saskatchewan (top inset) and a detailed map showing data available for the Red River Formation (bottom). There are 143 wells (green circles) that intersect the Red River Formation, and 63 cored intervals (pink circles) were described (Thomas and Qing, 2025).

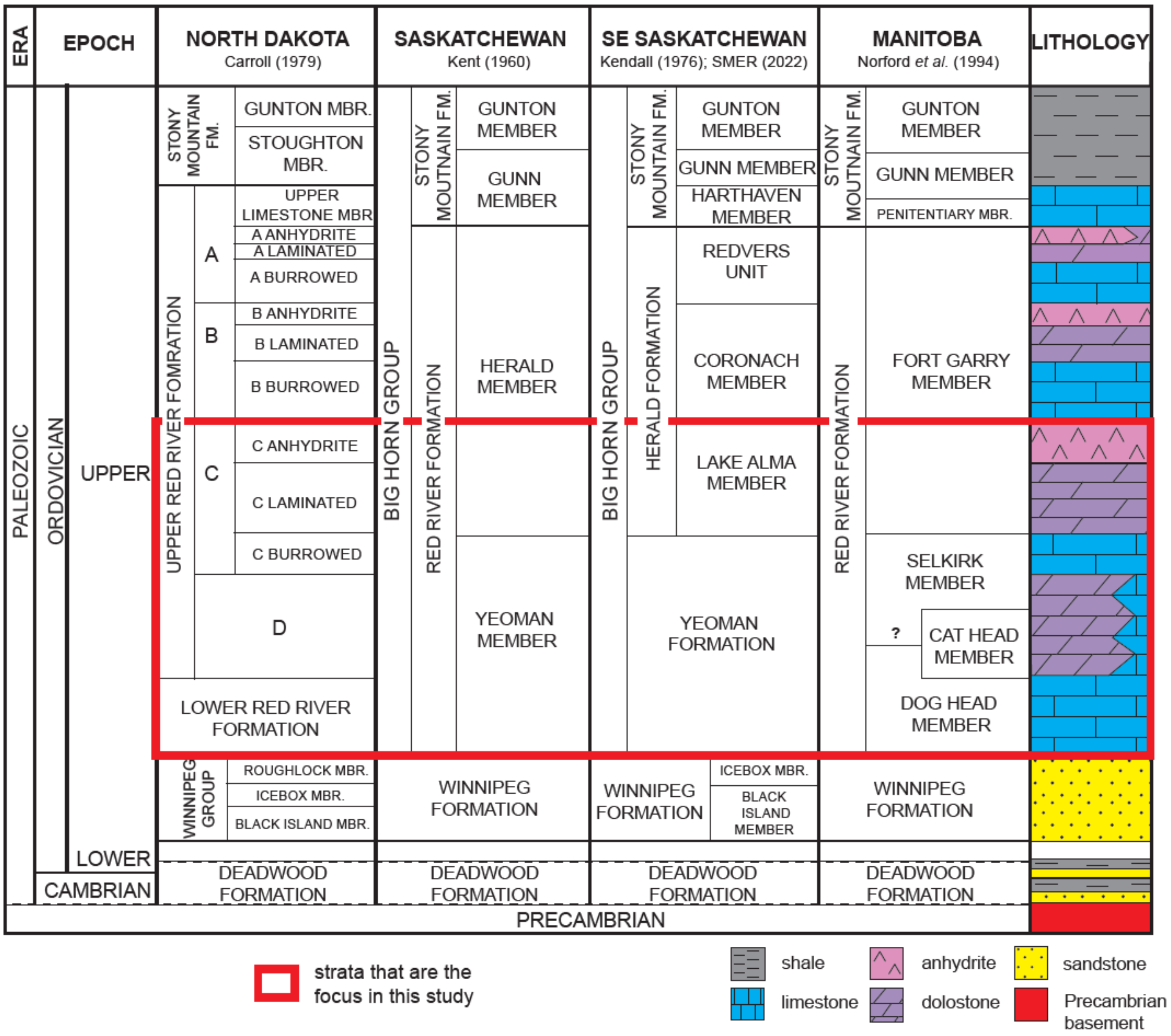

Figure 2: Stratigraphic nomenclature and comparison for the Red River Formation across North Dakota, Saskatchewan and Manitoba. The nomenclature defined by Kent (1960) is adapted for this study and only the strata below the oldest anhydrite (Lake Alma/C anhydrite) were considered (red outline). Generalized lithology is displayed in the far right. Abbreviations: SE – southeast; MBR. – Member; FM. – Formation; S.M.E.R. – Saskatchewan Ministry of Energy and Resources.

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Sedimentology and stratigraphic architecture of the Wymark Member, Duperow Formation, SW Manitoba

Patricia E. Fraino and Michelle P.B. Nicolas
Manitoba Geological Survey

ABSTRACT

The Upper Devonian Duperow Formation is a regionally extensive carbonate–evaporite succession deposited across the Williston Basin, reaching up to 220 m thick in southwestern Manitoba. The formation is subdivided into the Saskatoon, Wymark, and Seward members, with the Wymark Member informally divided into lower, middle, and upper units. Recent interest in lithium-bearing brines within the Duperow Formation as a key exploration target in Manitoba has highlighted the need for an updated geological framework integrating the lithostratigraphy and stratigraphic architecture of the formation. This study refines the sedimentological framework of the Duperow Formation, with emphasis on the Wymark Member, which has the most extensive core coverage in Manitoba.

Detailed lithofacies analysis is based on representative cores from wells 100/04-27-011-22W1/00, 100/13-04-010-20W1/00, and 100/07-18-010-27W1/00 to capture temporal and spatial variability across the Wymark Member. Three facies associations (FA) record deposition in an arid, shallow-marine, platform-interior peritidal setting. Subtidal deposits (FA1) comprise skeletal and intraclast wackestone–packstone, stromatoporoid–coral floatstone and framestone, and massive dolostone. Intertidal deposits (FA2) are characterized by microbial bindstone, bioturbated dolomudstone, and massive dolostone. Supratidal deposits (FA3) consist of interlaminated dolostone and anhydrite, chickenwire anhydrite, clastic mudstone, and patterned dolostone deposited in sabkha and mud flat environments.

Within the Wymark Member, these facies associations organize into meter-scale, shallowing-upward cycles that are mappable across the basin. Each cycle progresses from subtidal facies at the base through intertidal deposits to supratidal deposits at the top, though cycle distribution and thickness vary spatially and temporally. The lower to basal middle Wymark Member records transgressive subtidal deposition. This transgressive interval is overlain by a basinward-stepping regressive sequence of intertidal and supratidal facies that comprises the highest-quality reservoir rocks in the Duperow Formation. Specifically, partially to pervasively dolomitized subtidal and intertidal facies exhibit porosity exceeding 25% and permeability reaching 173 mD. This extensive dolomitization resulted from enhanced seepage-reflux of saline brines and evaporation in supratidal environments, which promoted dolomite precipitation and recrystallization in adjacent settings. Overlying this regressive sequence, facies shift to bioclastic wackestone-packstone and coral framestone/floatstone at the top of the middle unit, marking renewed transgression that continued into the upper Wymark Member.

This stratigraphic architecture controls facies distribution, lithological heterogeneity, and potential for reservoir compartmentalization. These results provide a comprehensive geological framework for contextualizing lithium brine exploration and resource assessment within the Duperow Formation in southwestern Manitoba.

Acknowledgements

The authors would like to thank C. Epp, P. Belanger and E. Ralph (Manitoba Geological Survey) for their assistance with coordinating the logistics of core retrieval. The author would like to thank J. Gellert (University of Manitoba) for geological assistance in measuring and sampling the studied cores.

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Critical Mineral Resources within Middle Devonian Strata in Saskatchewan

Peter Hill
Saskatchewan Geological Survey

ABSTRACT

Saskatchewan's Middle Devonian Prairie Evaporite Formation is host to world-class potash deposits. In addition to potash, recent studies have identified critical mineral potential not only in the Prairie Evaporite Formation, but throughout the rest of the Middle Devonian strata. Among the critical minerals identified, lithium has the greatest economic potential due to its abundance. This is the first known study that sampled for rare earth elements in the Middle Devonian strata discounting the Prairie Evaporite.

Yang's (2024) evaluation identified the potential for critical minerals within water-insoluble beds in the potash-rich Prairie Evaporite Formation. These water-insoluble materials consist primarily of dolomite, anhydrite, quartz, muscovite and most notably clay minerals. Due to their high cation exchange capacity, certain clay minerals are exceptionally attractive to critical minerals.

Beginning in 2024, the Saskatchewan Geological Survey undertook an extensive two-year sampling program to assess the potential for critical minerals throughout the entirety of Middle Devonian sediments. This presentation will highlight results from that sampling program.

METHODS

In total, 344 geoanalytical and 52 x-ray diffraction (XRD) samples were collected from 21 cores across the province. All geochemical analyses were submitted to the Saskatchewan Research Council's (SRC) Geoanalytical Laboratory in Saskatoon, Saskatchewan. Samples were analyzed using inductively coupled plasma–mass spectrometry (ICP-MS) analysis. XRD samples were sent to SRC and AGAT Laboratories. Samples were pulverized and prepared in a random-oriented back-packed mount and subsequently analyzed using a Bruker D4 or D8 X-ray diffractometer.

RESULTS

Geoanalytical results show that among the critical minerals tested, lithium, praseodymium, neodymium, scandium and molybdenum occur in high concentrations when compared with average crustal abundance. Lithium has the greatest economic potential. The highest concentration of lithium was 506 ppm in a sample from the Second Red Bed Member of the Dawson Bay Formation. Elevated concentrations of lithium were also identified in the Souris River Formation First Red Bed Member (341 ppm) and the Prairie Evaporite (179 ppm).

The highest lithium concentrations as determined from XRD are typically associated with elevated amounts of magnesium-rich clay minerals such as dolomite, chlorite and sepiolite, combined with the presence of Illite, kaolinite and various feldspars.

DISCUSSION

The Second Red Bed Member has the highest concentration of critical minerals of all Devonian strata. This is the result of large amounts of clay minerals such as chlorite, dolomite, Illite, sepiolite and kaolinite. Lithium concentrations within the Second Red Bed Member are typically elevated up dip and located along structural noses.

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Reefs and salts of the Devonian Souris River Formation and their lateral distribution in southeast Saskatchewan.

J.H. Lake, Swift Current, Saskatchewan.

ABSTRACT

Who says that Saskatchewan Geology is layer cake and boring? Extensional Tectonics in the Devonian? The Saskatchewan Devonian Dawson Bay Formation has been regarded as overburden with potential to leak formation fluids into the underground operations of active Potash Mines. Because of the mining depth being restricted to 1 km because of the hoist cable weight and the shape of the Williston Basin, most of the Devonian cores come from the Saskatoon Area. Hydrocarbon exploration was very discouraging and ended in the 1960s-70s heyday of the Devonian in Western Canada. Lucky for us that Saskatchewan recently removed the permanent confidentiality status of the 15 Potash Pilot holes which mostly cored from surface casing shoe down to the top of the Prairie Evaporite and are available for research from Cretaceous to Middle Devonian (Yang, 2025 list of cores). This study logged the Devonian section in seven of those cores. The results were surprising and showed the way for further study. Work by D. Lane (1964) mapped out a sequence of three thick stacked halites which are deposited in an asymmetric pull apart feature restricted to the Davidson Subbasin (see Atlas cross-section 27 drafted by Joel Collins). Lane's work was backed up by geophysics as the Saskatchewan Geological Survey required operators to submit all of their seismic. He did not interpret the origins of the pull apart as this was the pre-Plate Tectonics and Continental Drift era. Both Kim Kreis and Sven Egenhoff argue for the existence of the Brockton-Froid Lineament, a northeast-trending fault system trending northeastward from Montana and applying extensional stress to create the Davidson Subbasin pullapart. The Davidson Subbasin represented the centre of the Elk Point Basin in Southern Saskatchewan during Souris River Time. The basin centre took a dramatic shift to Williston, North Dakota during Bakken deposition.

More core work will be required in order to uncover the depositional history of the thick salt accumulation within the Davidson Subbasin.

The cross-section of five wells along the Saskatchewan-Manitoba border helped define the Swift Current Platform Reef Margin of the Dawson Bay Formation. The 8-34-22-33W1M PCS Bredenbury core sits on the outer margin of the Dawson Bay Formation on the Swift Current Platform and is key to understanding the platform margin depositional events. The section outlines a Transgressive Surface of Erosion upon which the Reefs developed. The original modern analogue that envisioned a wide Florida Keys Tidal Flat, Tidal Channel and active Reef Margin needs modification to include reef growth on a TSE (Joel Collins terms this Open Marine Bank to Rimmed Complex on a TSE). A Sequence Boundary defines a younger interval also onlapping the Reef Margin and is noted by the presence of the Hubbard Evaporite (halite). The hypersaline lagoon is quickly desiccated and subaerially exposed

in response to an early break in the flooding event, resulting in halite being precipitated (Logan, 1987) and following the deepening-upward model of Lake (2015) termed Carbonate Fear Factor. The Hubbard Evaporite was extrapolated from the Manitoba border to just east of Saskatoon (Dunn, 1982) and marks the outer margin of the Dawson Bay Reef and also the initiation of the next Sequence, suggesting the Elk Point/Williston Basin is not symmetric with reefs rimming the margins on all sides and the Manitoba Shelf is a Souris River feature.

The First Red Beds were deposited on land and mark the end of the Middle Devonian Dawson Bay sedimentation. The Upper Devonian Souris River started with flooding of the Swift Current Platform and a return to normal salinity Patch Reefs, Tidal Channels and Reefs proper. The Souris River includes several lateral deepening-upwards cycles that are continuous across the basin and are terminated by a low angle regional unconformity and topped by soil development. Correlation of the Souris River stratigraphy from the Manitoba border to Saskatoon shows a much thinner Dawson Bay section and a corresponding much thicker Souris River section going west, in response to preferential basin sag (including additional section not present in the east).

The Duperow and Birdbear Formations are layer cake and blanket the tectonically active Souris River and Dawson Bay Formations (the calm after the storm). An exposure surface and soil development separates the two. Reduced subsidence and more frequent exposures mark the Duperow and Birdbear package. Final uplift and severe erosion of the Upper Devonian carbonate section over the entire Western Canada Sedimentary Basin results in the formation of the Saskatoon Escarpment in Saskatchewan. Drainage is influenced by the new geomorphology as outlined by Lake, (2025) and there is a dramatic basin shift from southern Saskatchewan to Williston, North Dakota as a first response to the docking of Laurentia and Gondwana to form Pangaea. The Bakken and Mississippian are left with the responsibility of filling up the mess created by post-Upper Devonian Carbonate erosional fiasco when the sea returns.

Rules of Engagement:

1) Carbonates are normally Transgressive
2) The “Brining Upwards Model is upside down: evaporites are deposited on Sequence Boundaries and grade upwards into Deeper Water Carbonates.
3) Primary dolomitization is restricted to the inner tidal flat.
4) Epeiric Seas depend on normal salinity seawater In order to be productive carbonate platforms.
5) The Continental Crust was locally unstable during Upper Devonian time. Evidence of crustal extension/rifting is restricted to the Davidson Subbasin (with up to 60 metres of downwarping).
6) Facies distribution relies on water depth.
7) The inner tidal flat environment is the most susceptible to erosion in the event of a sea level drop and hence is not always preserved.
8) The Great American Carbonate platform flooded most of North America during the Ordovician and became much shallower and evaporitic during the Upper Devonian.

Conclusions:

The Dawson Bay reef margin corresponds to the edge of the Hubbard Evaporite. The Souris River Formation flooded southwards over the Swift Current Platform into North Dakota with reef and tidal channels being deposited. Hypersaline standing water evaporites were followed by extensive tidal flats terminating in a low angle unconformity due to uplift to the south. Extensional rifting within the Davidson Subbasin disturbed the normal cycles of Carbonate Sedimentation resulting in precipitation of thick halite beds during Souris River time. Development of a laterally extensive soil marks the end of the Souris River deposition. Thick accumulations of the Souris River halites (Davidson, Harris and Hatfield in ascending order) are largely restricted to the extensional Davidson Subbasin. The overlying Duperow and Birdbear Formations bury the depression in layer cake fashion. Reactivation of the fault on the southern margin of the Davidson Subbasin occurred during the Cretaceous and work by the Saskatchewan Research Council groundwater studies indicate there has seen movement since the last glaciation (Arden Marsh, pers. comm.).

Acknowledgements:

Thanks to Steve Halabura for referring me to the importance of the 8-34-22-33W1M PCS Bredenbury core. Thanks to Chao Yang for providing us with the list of 15 key Potash Pilot wells with core through the Devonian section. These cores were on permanent confidentiality status up until recently. Thanks to Dan Kohlruss and his staff at the Saskatchewan Ministry of the Economy Subsurface Geological Lab in Regina for access to the core and many stimulating Geological conversations (Pete Hill. Meagan Gilbert, Gavin Jensen, Dan Kohlruss, Arden Marsh and Melinda Yurkowski,) plus Megan Love and Tyler Music for help with the figures and stitching core photos. Thanks to Joel Collins for providing a Geological framework of his Beaverhill Lake research extending into Saskatchewan. Thanks to Celine Chow and Lauren Egge and the CEGA Core Workshop Committee for organizing the Core Workshop and allowing us the opportunity to share our knowledge.

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Licence	CPA Pretty Well ID	twp sort	rge sort	Well Name	TVD (m)	Oldest Fm Drilled	Core boxes	lx	lsd	sec	twp	Rge	Mer	Re
67F016	131/12-22-017-30W1/00	101730221213100	130017221213100	SYLVITE STE. MARTHE 12 22 17 30	935.7	Dprair_ev	core	131	12	22	017	30	1	00
67B038	121/13-22-017-30W1/00	101730221312100	130017221312100	SYLVITE STE. MARTHE 13 22 17 30	1036.3	Dprair_ev	core	121	13	22	017	30	1	00
90L069	111/05-17-020-31W1/00	102031170511100	131020170511100	IMC GERALD 5-17-20-31	1010	Dprair_ev	223	111	05	17	020	31	1	00
92F060	121/05-17-020-31W1/00	102031170512100	131020170512100	IMC GERALD B5-17-20-31	1016	Dprair_ev	116	121	05	17	020	31	1	00
63E008	131/07-27-019-32W1/00	101932270713100	132019270713100	I M C GERALD NO 7 27 19 32	1053.7	Ddawsonby	core	131	07	27	019	32	1	00
90A034	131/01-13-020-32W1/00	102032130113100	132020130113100	IMC GERALD 1-13-20-32	1008	Dprair_ev	core	131	01	13	020	32	1	00
90G145	141/10-13-020-32W1/00	102032131014100	132020131014100	IMC GERALD 10-13-20-32	1005.9	Dprair_ev	core	141	10	13	020	32	1	00
10E268	141/12-22-019-33W1/00	101933221214100	133019221214100	MOSAIC ESTERHAZY 2 SH 12-22-19-33	1099.7	Dprair_ev	core	141	12	22	019	33	1	00
10E269	142/12-22-019-33W1/00	101933221214200	133019221214200	MOSAIC ESTERHAZY 1 SH 12-22-19-33	1115.9	Dprair_ev	core	142	12	22	019	33	1	00
81F031	111/08-34-022-33W1/00	102233340811100	133022340811100	PCS BREDENBURY 8 34 22 33	961.3	Ddawsonby	core	111	08	34	022	33	1	00
81F030	121/05-35-022-33W1/00	102233350512100	133022350512100	PCS BREDENBURY 5 35 22 33	979.6	Dprair_ev	core	121	05	35	022	33	1	00
67G009	101/15-29-030-13W2/00	203013291510100	213030291510100	DOME PROVO FOAM LK 15 29 30 13	1443.2	preCamb	core	101	15	29	030	13	2	00
09H045	131/03-12-034-20W2/00	203420120313100	220034120313100	BHPB JANSEN 3-12-34-20	1036	Dprair_ev	866 m recovery	131	03	12	034	20	2	00
10J222	132/03-12-034-20W2/00	203420120313200	220034120313200	BHPB JANSEN 1FH 3-12-34-20	719.7	Dsouris_r	no core	132	03	12	034	20	2	00
10J223	132/04-12-034-20W2/00	203420120413200	220034120413200	BHPB JANSEN 1FH 4-12-34-20	717	Dsouris_r	no core	132	04	12	034	20	2	00
08B136	191/03-21-017-23W2/00 (0000)	201723210319100	223017210319100	MOSAIC BELLE PLAINE DD 3B2-21-4D3-21-17-23	1694.5	Dprair_ev	no core	191	03	21	017	23	2	00
10K106	191/02-22-017-23W2/00 (0000)	201723220219100	223017220219100	MOSAIC BELLE PLAINE DD 4A3-22-2B2-22-17-23	1687.6	Dprair_ev	no core	191	02	22	017	23	2	00
12B405	191/04-27-017-23W2/00 (0000)	201723270419100	223017270419100	MOSAIC BELLE PLAINE 39032 DD 4B14-22-4B4-27-17-23	1673.8	Dprair_ev	no core	191	04	27	017	23	2	00
09E128	191/02-28-017-23W2/00 (0000)	201723280219100	223017280219100	MOSAIC BELLE PLAINE DD 2C15-21-1D2-28-17-23	1665.1	Dprair_ev	no core	191	02	28	017	23	2	00
61H046	131/12-04-033-23W2/00	203323041213100	223033041213100	ALWINSAL MIC MAC 12 4	1009.3	Ddawsonby	core	131	12	04	033	23	2	00
61H044	111/04-28-033-23W2/00	203323280411100	223033280411100	ALWINSAL SARCEE 4 28	976.1	Ddawsonby	core	111	04	28	033	23	2	00
68E096	131/09-24-017-24W2/00 (0000)	201724240913100	224017240913100	KALIUM BELLE PLAINE 9-24-17-24	1681.9	Dprair_ev	core	131	09	24	017	24	2	00
65E022	121/16-21-034-27W2/00	203427211612100	227034211612100	NORANDA NEELY 16 21 34 27	1066.8	Dprair_ev	core	121	16	21	034	27	2	00
62C008	131/05-33-034-27W2/00	203427330513100	227034330513100	CONS MORRISON COLONSAY 5 33 34 27	1056.1	Dprair_ev	core	131	05	33	034	27	2	00
61J055	141/05-22-034-01W3/00	303401220514100	301034220514100	US BORAX CHEM CORP ELSTOW 5 22A 34 1	1097.3	Ddawsonby	core	141	05	22	034	01	3	00
65F069	181/06-18-036-06W3/00	303606180618100	306036180618100	DUVAL SASKATOON 6 18 36 6	1207.3	Dwinnipegosis	core	181	06	18	036	06	3	00
65B065	101/11-16-035-08W3/00	303508161110100	308035161110100	C. M. AND S. VANSCOY 11 16 35 8	1129.6	Dprair_ev	core	101	11	16	035	08	3	00

List of Potash Pilot Test Holes with continuous core from surface casing shoe to the Potash Beds for the Province of Saskatchewan. These wells were recently removed from permanent confidentiality (courtesy of Chao Yang, Saskatchewan Geological Survey)

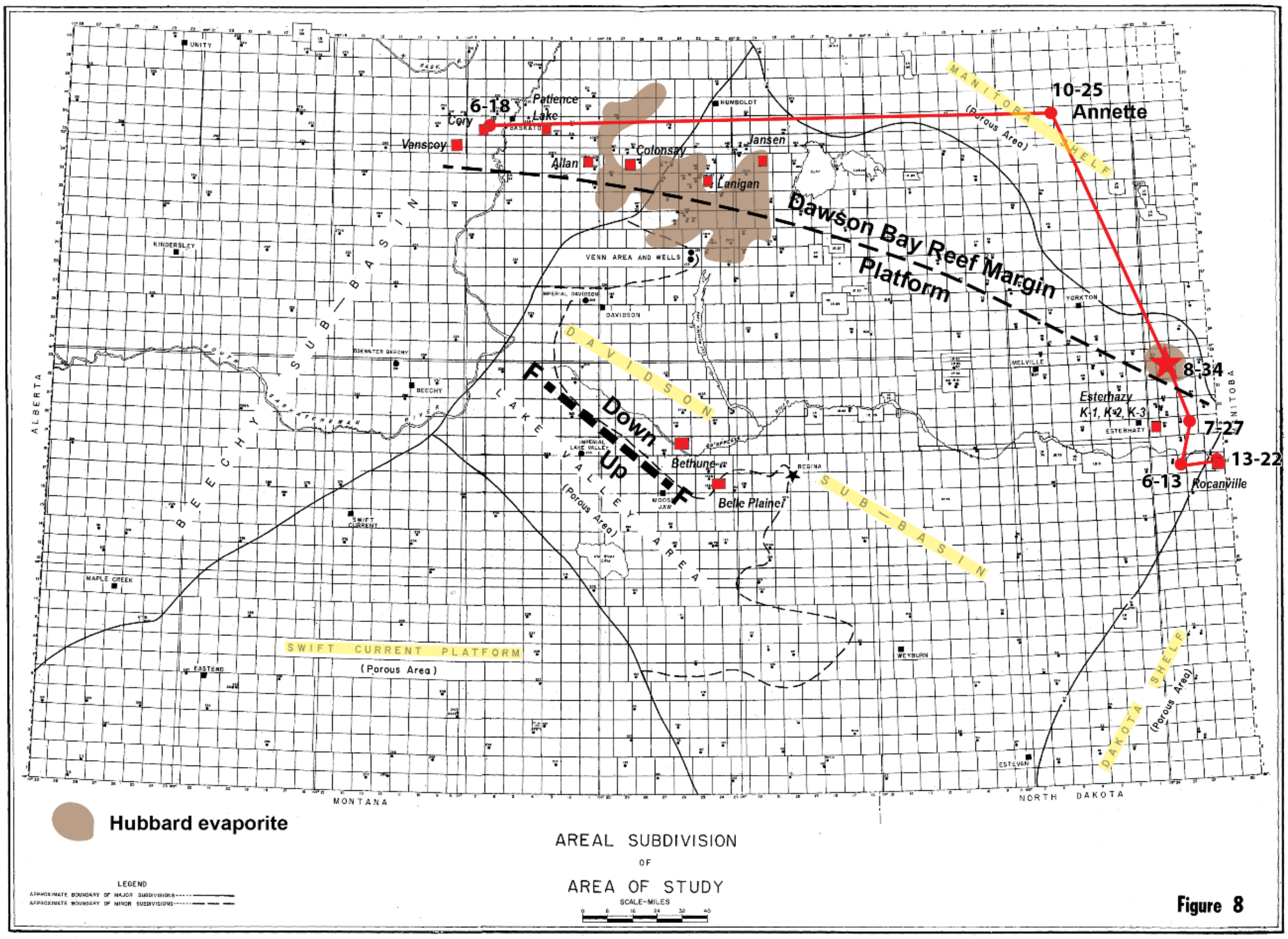
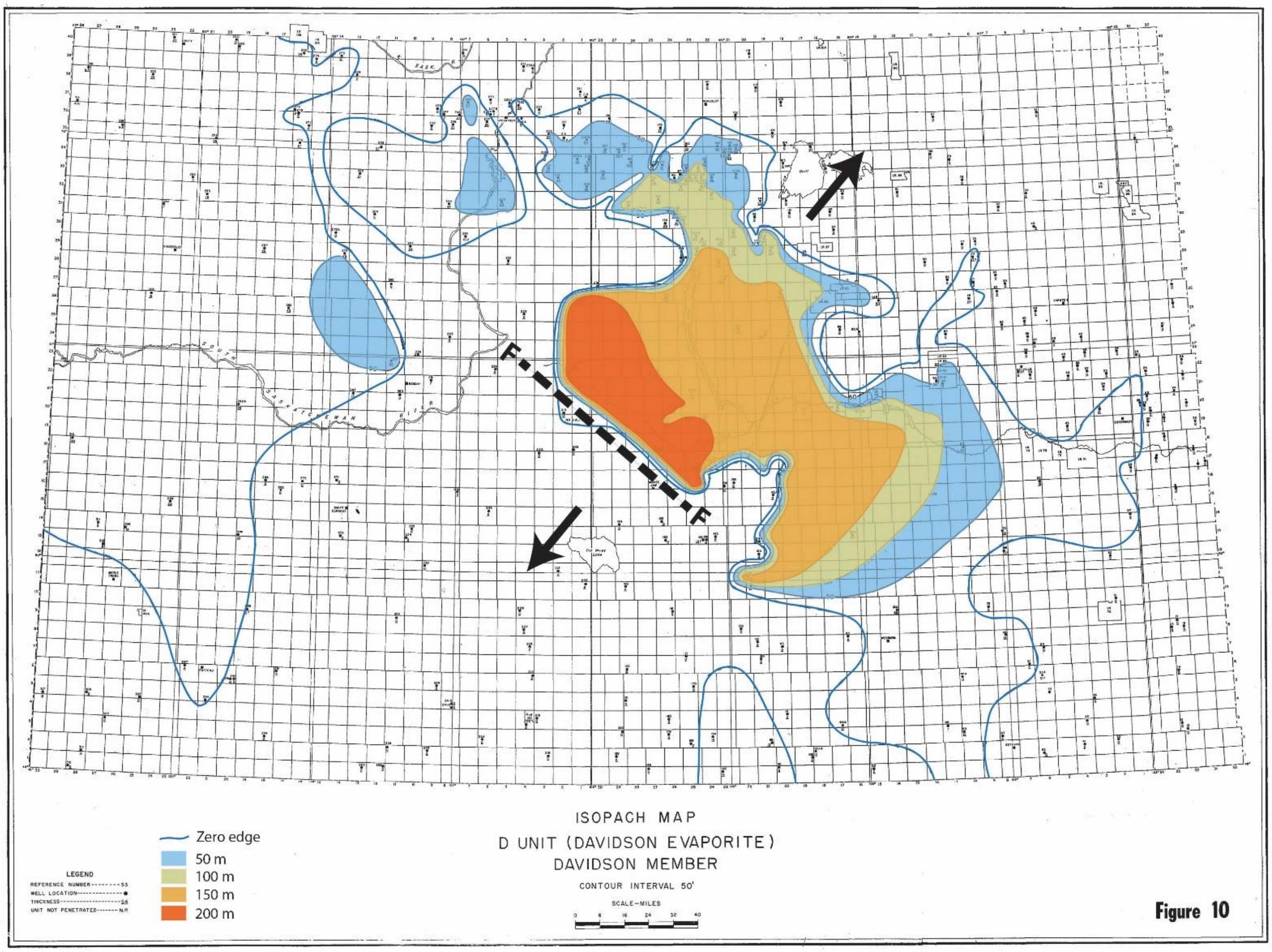
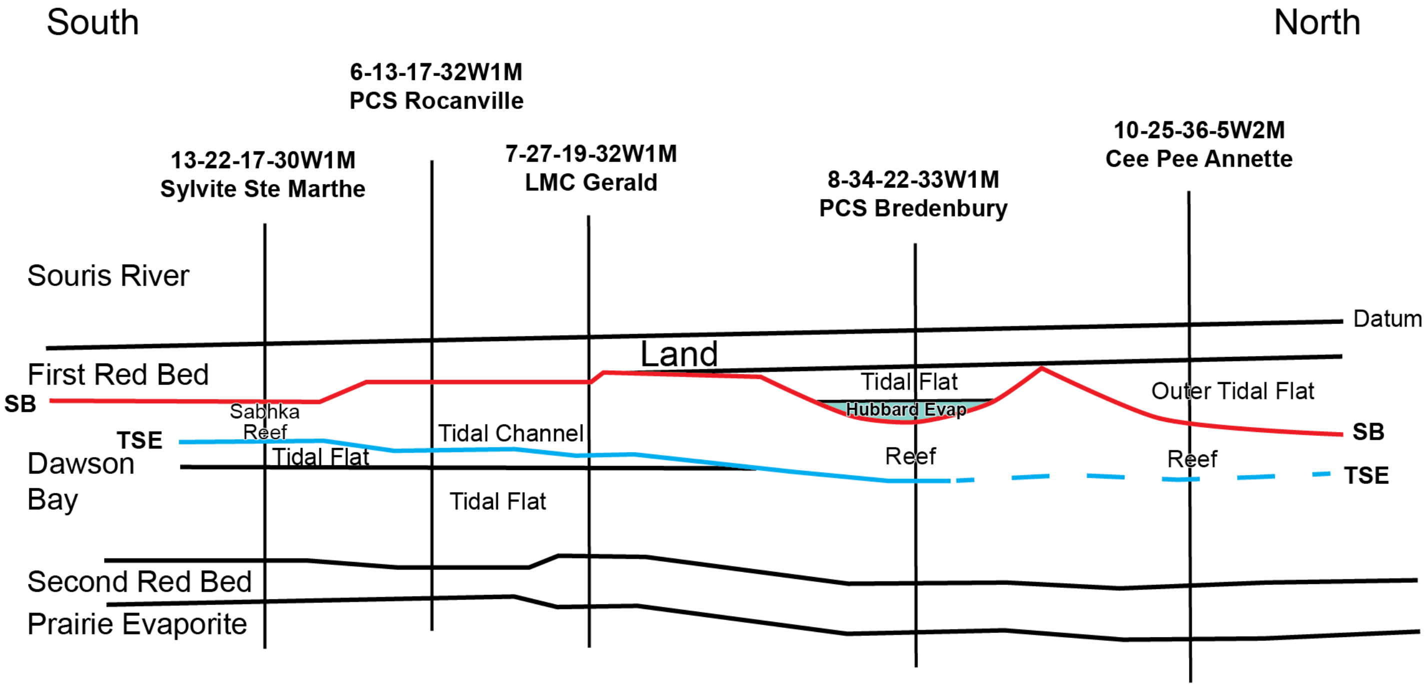


Figure 8

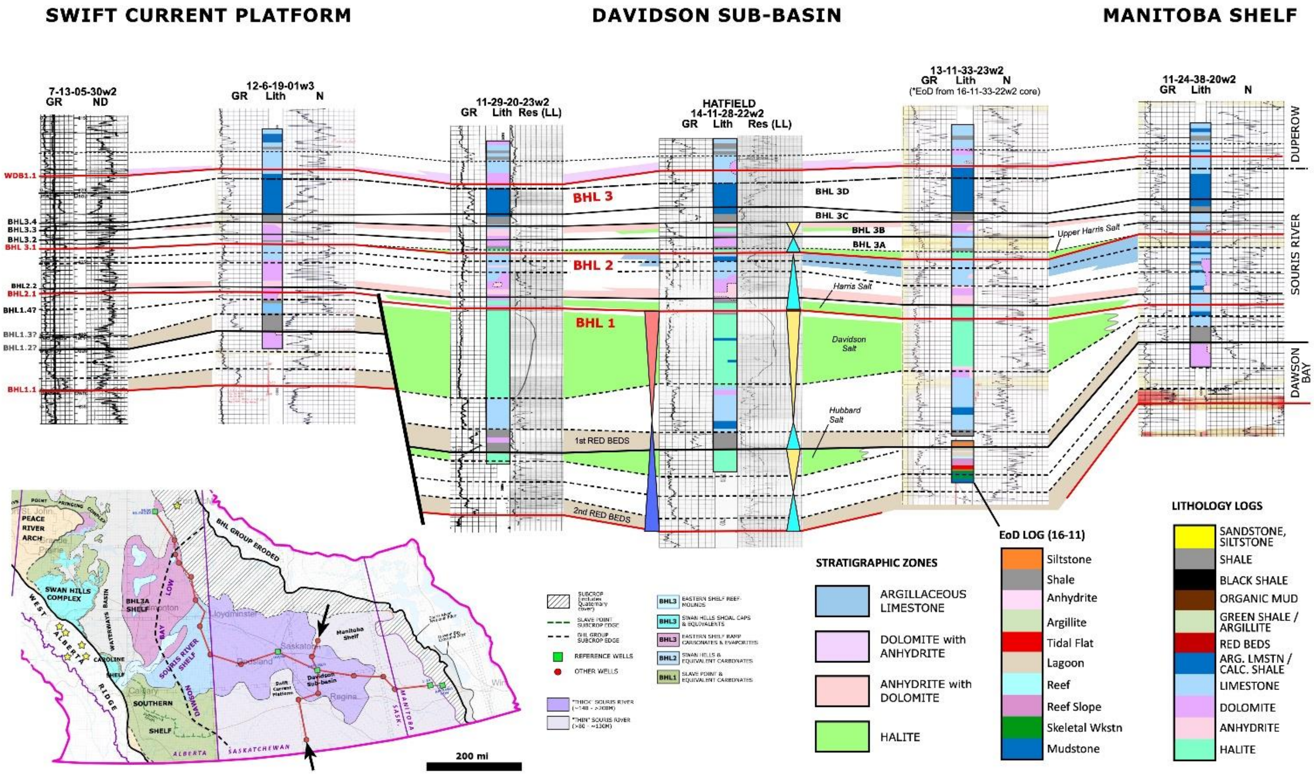
Map of Saskatchewan showing location of 8-34-22-33W1M PCS Bredenbury well near the Manitoba border (star). The Dawson Bay Reef Margin is extrapolated to the Saskatoon area based on the presence of the Hubbard Evaporite marking the location of the Reef Margin at 8-32. Note the location of the Swift Current Platform, Dakota Shelf and Manitoba Shelf as defined by Lane, (1964). Interpreted Fault within the Souris River Formation defining the southern margin of the Davidson Subbasin is subparallel to the Dawson Bay Reef Margin.



Isopach map of basal Souris River Formation Davidson Evaporite salt within the Davidson Subbasin . Thickness is controlled by extensional tectonics along the southwest faulted margin (after Lane, 1964, Figure 10). The Davidson Member halite is the lowest of three stacked cycles within the Davidson Subbasin (Davidson, Harris and Hatfield Members in ascending order).



The cross-section represents the Dawson Bay Formation Reef Margin along the Saskatchewan-Manitoba boundary. The sequence boundary between the Reef Margin and the overlying younger sequence is marked by the presence of the Hubbard Evaporite (halite). The core over this interval at 8-34-22-33W1M PCS Bredenbury shows a hypersaline lagoon composed of stromatolites and standing water evaporites (anhydrite) reminiscent of Shark Bay, Western Australia and is the initial phase of marine transgression as outlined by Lake, 2015 (Carbonate Fear Factor). In this case, the sea level dropped early after initial flooding, resulting in exposure, soil development and erosion above sea level. Following the model of Logan (1983) in MacLeod Evaporite Basin in Western Australia, the Hubbard Evaporite was deposited above sea level. As the transgression returned, the Hubbard Halite was encased in inner tidal flat laminated dolomites. The Hubbard Halite correlates with outer tidal flat crinoid Thallasanoides mudstones and wackestones in the 10-25-36-5W2M Cee Pee Annette core to the north. Hence the Dawson Bay Formation is interpreted to extend beyond Lane's Manitoba Shelf boundary.



This north-south cross-section was drafted by Joel Collins and shows the faulted southern margin of the Davidson Subbasin within the Souris River Formation. Lane (1964) originally recognized this feature in his mapping probably backed up by interpretations from the Saskatchewan Provincial Staff Geophysists. The asymmetry of the subbasin infill and wedging of the three stacked halites (Davidson, Harris and Hatfield in ascending order) is attributed to its extensional pull apart origin. The Canning Basin in Western Australia also experienced extensional tectonics during the Upper Devonian. This time marked the initial phases of Laurasia docking with Gondwana to form Pangaea in earth history.

8-34-22-33W1M PCS Bredenbury
First Red Beds to Dawson Bay Reef.

First Red Beds/Land

Hubbard Halite/Deposited above Sea Level

Hypersaline Stromatolites and Standing Water Evaporite

Dawson Bay Formation Highstand Tidal Flat and Reef

Bottom

Top

Top of Deepening-Upward Highstand Cycle/Inner Tidal Flat

Erosion. Exposure, Soil

Sequence Boundary

Core photos of the Reef Margin of the Dawson Bay Formation within the 8-34-22-33W1M PCS Bredenbury well. The margin is overlain by a Sequence Boundary marked by a short-lived hypersaline lagoonal package of stromatolites and standing water evaporites (anhydrite) which underwent exposure and erosion in a subaerial setting, resulting in Hubbard halite precipitation (Logan, 1983, Lake, 2015). The presence of another sequence occurring north of the Reef Margin precludes this being the Manitoba Shelf during Dawson Bay deposition.

CORE CONFERENCE
May 7-8, 2026 • AER Core Research Centre

Beaverhill Lake Group Carbonate Complexes: Middle-Upper Devonian Stratigraphy and Subsidence in the Western Canada Basin

Joel F. Collins
Geologist (retired)

ABSTRACT

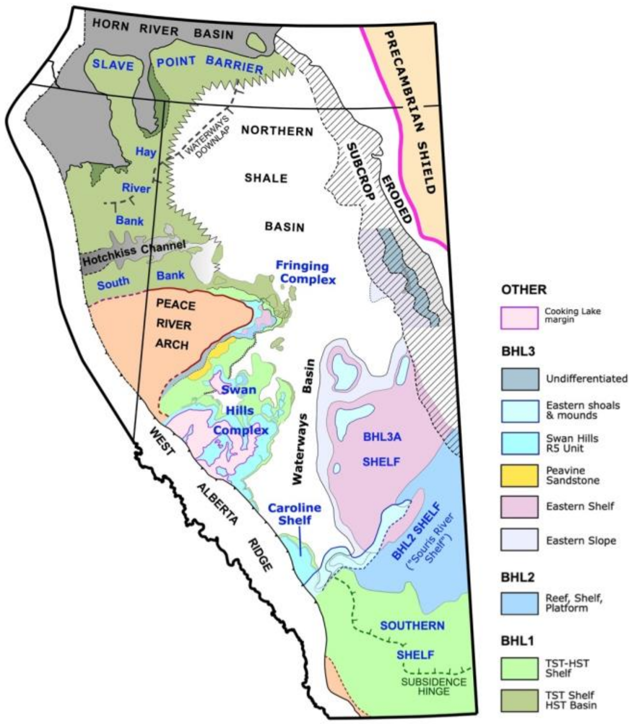


Figure 1: Beaverhill Lake paleogeography, with carbonate complexes colored according to 3rd-order sequences.

Major carbonate complexes in the Beaverhill Lake Group include the Slave Point Hay River Bank (northeast B.C. and northern Alberta), the Slave Point Fringing Complex (Peace River Arch), the Swan Hills Complex and the Caroline Shelf (west-central Alberta), and the Southern Shelf Complex (southern Alberta). Their distribution (Figure 1) represents a response to two subsidence phases in the Western Canada Basin combined with second-order sea level rise.

The Beaverhill Lake contains three third-order sequences (BHL1, BHL2, BHL3). BHL1 was deposited during an early basin phase characterized by high rates of subsidence in some areas and not others, enhancing apparent topography on an initially low-relief basin floor. The history of early subsidence is indicated by thickness and facies contrasts in the transgressive (TST) and highstand (HST) systems tracts of BHL1, and by the distribution of a regional transgressive-regressive cycle representing a time of maximum flooding (TMF). The BHL1 TST demonstrates that initially the highest subsidence rates were along the north flank of the Peace River Arch, where Ft. Vermillion Fm. evaporites and the Hay River Bank are replaced by a thick basinal succession in the Hotchkiss Channel. The regional TMF is a transgressive-regressive cycle in the BHL1 TST separating shallow-water facies in the Ft. Vermillion Fm. from overlying Slave Point carbonates (Figure 2). The TMF cycle is present in the Fringing Complex and the Swan Hills Complex but is thin or absent in eastern and southern Alberta, indicating an early pattern of greater subsidence in the northern part of the basin. The BHL1 HST represents a change in the early

subsidence pattern in which areas of continuous shallow-water carbonate accumulation into the HST were limited to the Swan Hills Complex, the Caroline Shelf, and the Southern Shelf, while adjacent areas to the east and north became basins. Slave Point carbonates to the north (Hay River Bank, Fringing Complex) drowned and were buried by basinal BHL1 HST shales. In the Waterways Basin, BHL1 HST shales onlap Swan Hills platform-to-basin profiles locally offset by subsidence.

Following BHL1 deposition, BHL2 shallow-water carbonates continued to accumulate in areas of low subsidence (Swan Hills Complex, Southern Shelf). A major sea level fall at the end of BHL2 resulted in exposure and erosion on the tops of Swan Hills Fm. reefs and shelves, contemporaneous with deposition of a regional lowstand (BHL3A shelf) in the eastern part of the basin. The eastern BHL2 and BHL3A shelf margins advanced toward the northwest above the BHL1 HST shales along the depositional axis of the basin, reducing the size of the Waterways Basin to a narrow north-south trending region between the Swan Hills Complex and the BHL3A margin. Subsequent cycles of sea level rise during BHL3 resulted in deposition of local buildups and shoals with transgressive architecture above the BHL3A lowstand shelf and the Swan Hills Complex. BHL3 shoals in the Swan Hills Complex eventually merge toward the shelf interior with the Cooking Lake platform (Woodbend Group). In the Waterways Basin, the Cooking Lake platform formed along the crest of a northwest-southeast trending transverse shale clinoform at the top of BHL3.

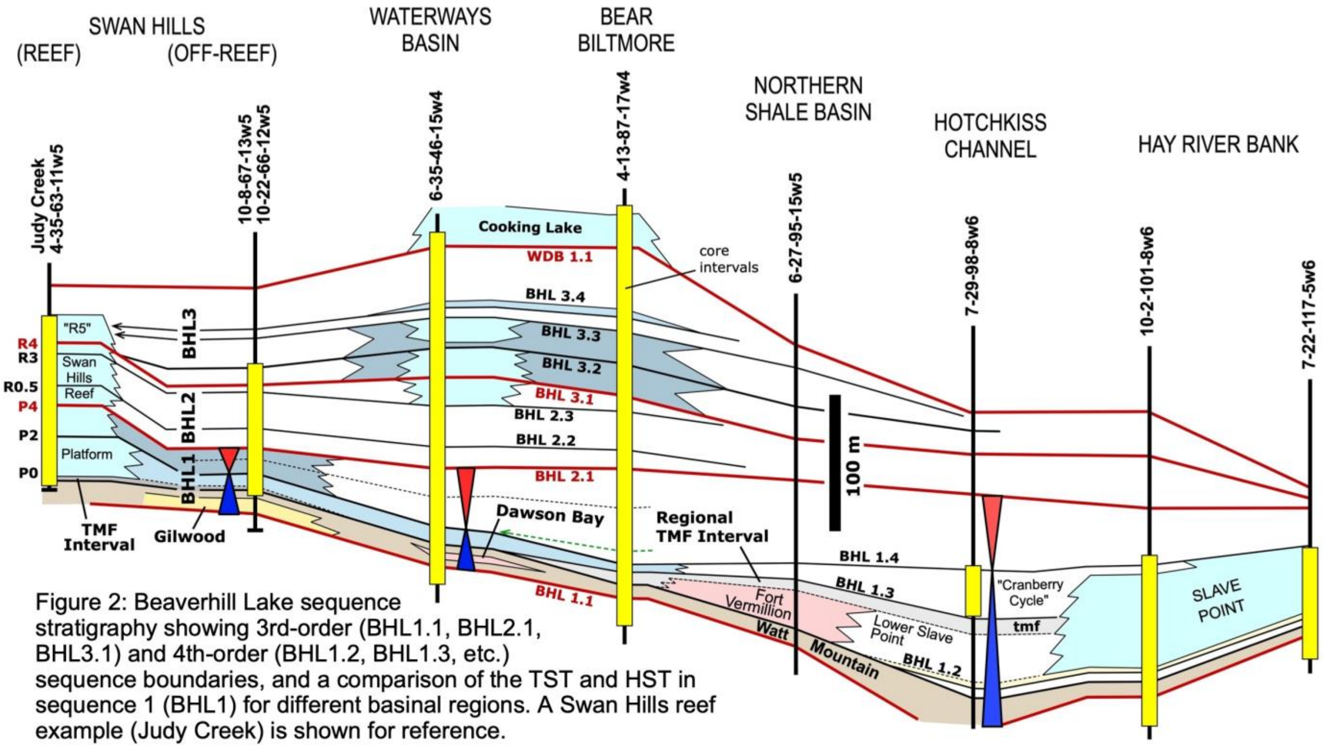


Figure 2: Beaverhill Lake sequence stratigraphy showing 3rd-order (BHL1.1, BHL2.1, BHL3.1) and 4th-order (BHL1.2, BHL1.3, etc.) sequence boundaries, and a comparison of the TST and HST in sequence 1 (BHL1) for different basinal regions. A Swan Hills reef example (Judy Creek) is shown for reference.

How Late Devonian-Early Carboniferous Little Creatures Rewrote the Bakken Paleogeography, Reframed Reservoir Architecture, and Shifted Its Development Strategy in SE Saskatchewan

Solange Angulo Saldina and Luis Buatois
University of Saskatchewan

ABSTRACT

The Bakken Formation transformed the global oil market by unlocking commercial volumes of crude oil from low-permeability rocks through long-reach horizontal drilling, multi-stage fracturing, and high-density completions. Production rose from ~1,500 barrels of oil per day (bopd) in 2004 to more than 400,000 bopd by 2011, establishing the Bakken as a premier unconventional tight-oil play.

The Bakken is composed of a lower organic-rich shale, a dolomitic–silty–sandy middle member, and an upper organic-rich shale. In this study, the middle member is subdivided into Units A, B, and C. Early work interpreted the entire formation as fully open marine. However, integration of ichnological data reveals that Unit B records brackish marginal-marine conditions, characterized by a stressed ichnofauna (low diversity, small burrows, and low–moderate bioturbation index), while Unit A and C reflect fully marine conditions.

A key finding of this study is that the contact between Units A and B is not conformable, as previously proposed, but instead represents a sequence boundary/coplanar surface with a significant hiatus caused by bypass and erosion. The erosive surface, mantled by sandstone intraclasts derived from Unit A, indicates that the underlying sandstones were already consolidated prior to deposition of the overlying brackish deposits. This reinterpretation reshapes the depositional history of the Bakken.

Early horizontal wells in southeastern Saskatchewan targeted the clean, coarse sandstone at the base of Unit B, originally interpreted as shoreface deposits. Core-based petrophysical data, however, show highly variable reservoir quality due to localized calcite cementation, high water saturation, and limited lateral continuity — resulting in inconsistent well performance. In contrast, the offshore-transition deposits at the top of Unit A exhibit superior and laterally extensive reservoir quality, making them the most reliable target interval within the middle Bakken. Localized reservoir-quality facies do occur within Unit B, but their distribution is limited.

This study demonstrates the critical value of integrating core observations with ichnological analysis to refine depositional and stratigraphic interpretations. These insights not only improve our understanding of the Bakken but also highlight the fundamental value of combining sedimentology with ichnology and petrophysical data to advance our knowledge of paleogeography, reservoir architecture, and the evolution of any reservoir.

Session Three

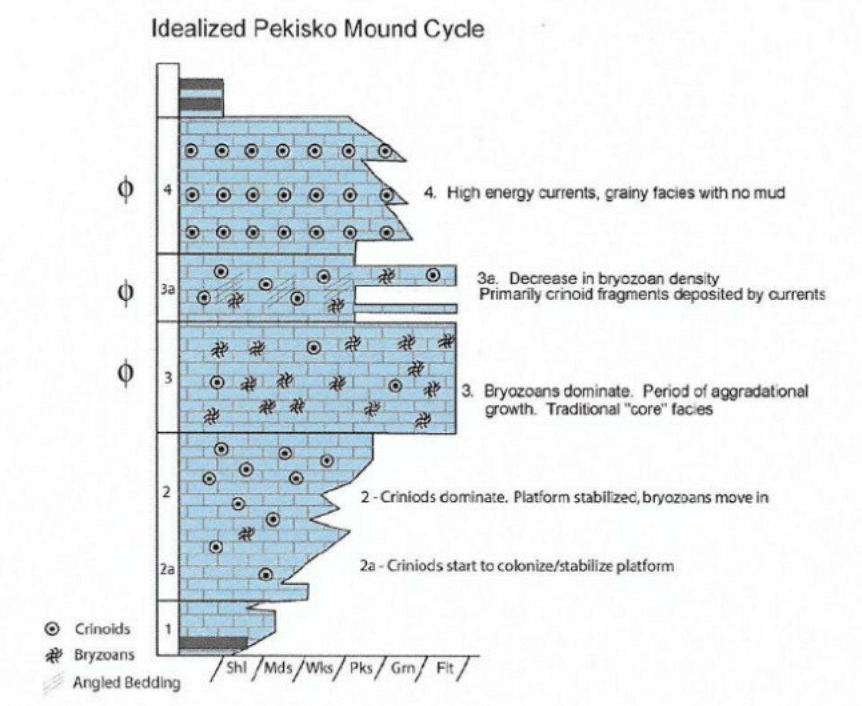
Mississippian-Cretaceous: The Rise of the Western Interior Basin

Vertical vs Horizontal Drilling in Waulsortian Mud Mound Reservoirs of the Lower Mississippian Pekisko Fm.

Alisha Fridrich P.GEOL., Chris Young P.GEOL
Islander Oil and Gas Inc.

ABSTRACT

The Tournasian age Pekisko carbonates of the Chipmunk Field (northwestern Alberta) form Waulsortian mud mounds. Mud mounds comprising bryozoan-crinoid accumulations that developed in relatively deep, low-energy settings along the Pekisko ramp. Deposition begins as an accumulation of fine and coarse sediments below storm wave base. Localized highs enabled the crinoid-bryozoan community to develop within the deeper water settings. Once started, the mounds are self-generating, and each mound is an aggregation of several growth cycles. Mound growth is halted by drowning, as deep water pekisko shale can be observed in the core. Each mound is composed of one or more growth cycles. Each cycle is composed of repeatable lithology of depositional facies.



These Waulsortian Mounds of the Chipmunk Field are currently being targeted for heavy oil. Given that the best reservoir occurs within the individual growth cycles comprising the bryozoan-crinoid boundstones, do horizontal well bores maximize the intersection of individual colonies?

Below describes the facies and how they relate to each other within a particular mound (Figure 2.)

Facies 1. Basal Argillaceous Micritic Mudstone

Dark gray argillaceous and cherty, bioclastic wackestones and mudstones commonly with crinoidal hash throughout.

Facies 2. Lower Mound Flank

Allochthonous, bryozoan and crinoidal packestone and wackestones. Bedding planes are sometimes recognizable but do not dip over 20 degrees.

Facies 2a. Basal Micrite

Dark gray micrite with argillaceous material. Differentiated from Facies 1 as the matrix is composed of lime-micrite instead of mudstone.

Facies 3. Mound Core

Submarine, rim cemented, bryozoan boundstones sometimes intercalated with bryozoan wackestones. The bryozoans are commonly cemented by recrystallized isopachous rims of fibrous calcite. These cement rims can be up to 60% of the entire rock volume.

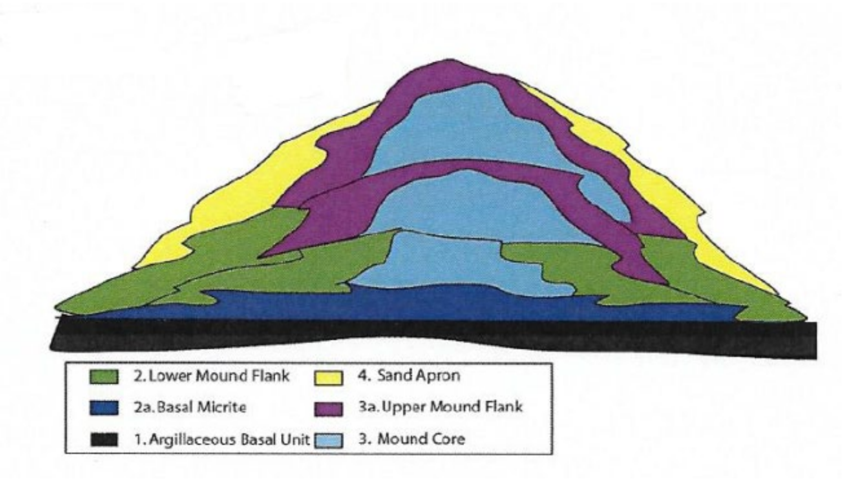
Facies 3a. Upper Mound Flank

Very similar to the lower mound flank but differentiated by the higher angle bedding. Allochthonous, crinoid to bryozoan packestone to wackestone. This facies is commonly interbedded with the mound core facies.

Facies 4. Sand Apron

Spar-cemented bryozoan to crinoidal packestone to grainstone with minimal mud concentration. Can even appear as a “coquina” of crinoids with minimal matrix.

Figure 2.



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Reservoir Characterization of Mississippian Frobisher Bed Pools in Southeast Saskatchewan

Holly Shoulak[1,2] and Hairuo Qing[2]
[1] Saskatchewan Geological Survey, [2] University of Regina

ABSTRACT

Introduction

The Mississippian Frobisher Beds have been an established oil producer in southeast Saskatchewan since it's discovery in the 1950s and have produced 144 million m^3 (~908 million barrels) of oil as of December 2025. The Frobisher Beds are located on the northeastern flank of the Williston Basin and are composed of carbonates, evaporites and siliciclastic lenses.

The study area extends from Township 1, Range 30 west of the First Meridian (Tp. 1, Rge. 30W1M) in the southeast to Tp. 2, Rge. 32W1M in the northwest (Figure 1). Core from 78 wells were described, 54 thin sections from 10 wells were prepared and evaluated, and over 600 geophysical well logs were interpreted. Reservoir characterization was completed for five oil pools in the study area: Elmore Frobisher, Sherwood Frobisher, Workman Frobisher, Winmore Frobisher and Gainsborough West Frobisher.

Geological Framework

The Frobisher Beds are part of the Mission Canyon Formation and were deposited between 351 to 334 million years ago. Following deposition, subsidence of the Williston Basin caused the strata to dip to the south, towards the centre of the basin. Strata were then subjected to intense erosion which caused progressively older strata to be truncated outward from the centre of the basin creating a major angular unconformity, called the sub-Mesozoic unconformity.

Lithofacies Associations

From the analysis, 16 lithologies (L) have been identified that were grouped into 5 lithofacies associations (LFA) based on their depositional environments. These lithofacies associations cyclically recur and consist of marker beds (LFA1 and LFA2) that separate carbonate (LFA3 and LFA4) and evaporite (LFA5) sequences. Marker beds are dolomitic mudstones and are characterized by high gamma ray response on geophysical logs. Carbonate sequences are comprised of microbial and coated grain mudstones to grainstones; evaporite sequences are comprised of laminated, nodular or massive anhydrite. These lithologies and lithofacies associations are described in detail in Shoulak and Qing (in press). Based on areal distribution and stacking patterns these lithologies and lithofacies associations are indicative of a cyclical intertidal to supratidal depositional setting with lagoon, embayment, saline lake, sabkha and mudflats environments.

Reservoirs and Discussion

The Frobisher Beds in the study area contain multiple stacked reservoirs resulting from a complex depositional and diagenetic history. This has resulted in multiple productive horizons and traps within the same oil pool. The porosity values of the carbonate sequences and the marker beds are comparable, but the carbonate sequences have higher permeability values. The evaporites as well as the alteration zone at the sub-Mesozoic unconformity create effective seals for these reservoirs. Oil accumulation in these reservoirs is controlled by structural, stratigraphic and diagenetic traps or a combination of these mechanisms.

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Shoulak, H. and Qing, H. (in press): Lithological and lithofacies analysis of the Mississippian Frobisher beds in southeast Saskatchewan; Saskatchewan Geological Survey, Saskatchewan Ministry of Energy and Resources, Geoscience Report GR2026-x.

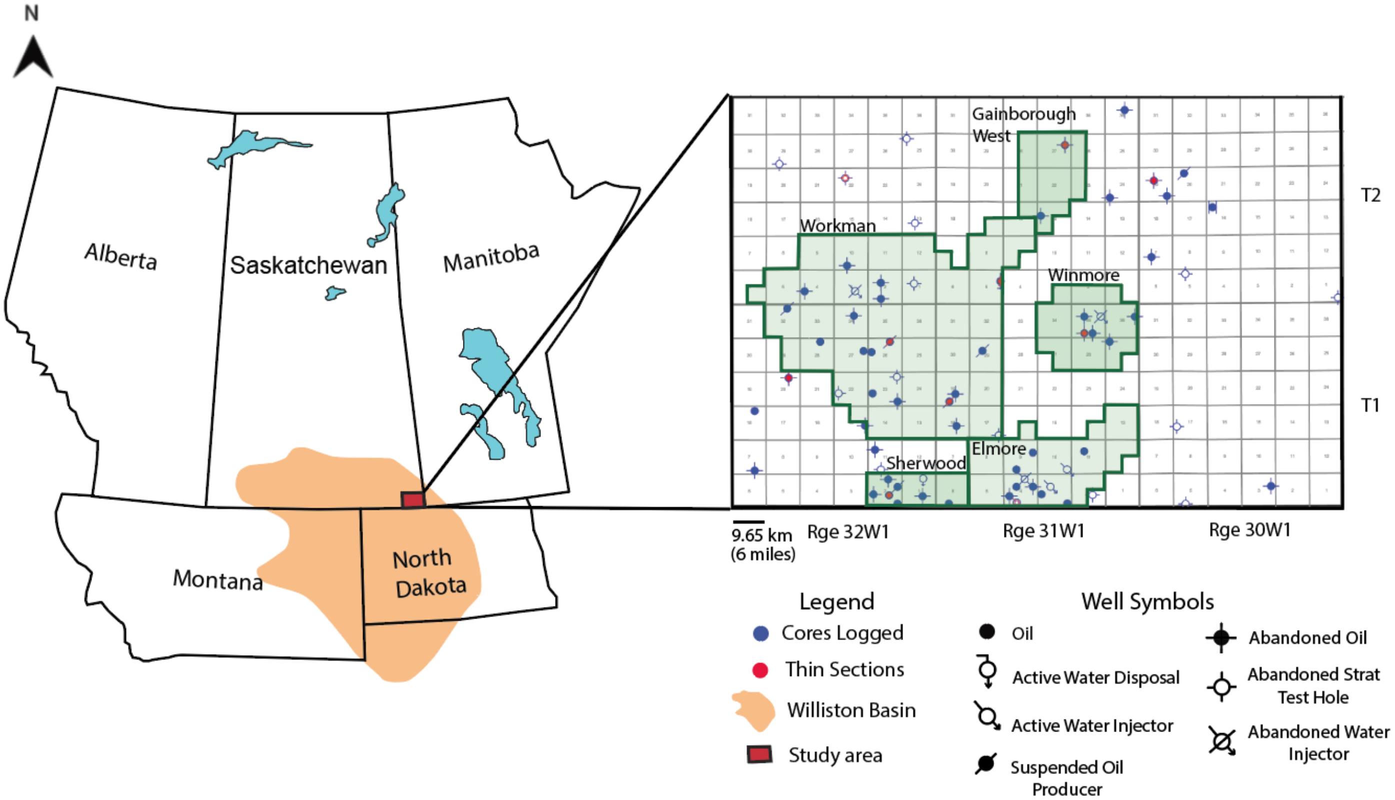

Figure 1 *- A location map of* the study area in southeast Saskatchewan. The green polygons are outlines of the studied oil pools. Rge – Range; T – Township; W – west

Re-Evaluation of the Valhalla Field: Can Montney Formation Turbidites Serve as a Non-Traditional CO_2 Reservoir?

Matthew G. Braun[1*], Daniel Bell[2], Per K. Pedersen[3], and Omid H. Ardakani[1]

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[2]Ovintiv Canada, 500 Centre St SE, Calgary
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ABSTRACT

To reach net-zero goals by 2050, Canada needs to make substantial efforts to explore and develop new reservoirs for carbon capture, utilization and storage (CCUS) operations. Currently, the main targets for CCUS development in Alberta are deep saline aquifers and depleted hydrocarbon reservoirs such as the Basal Cambrian Sandstone and Middle to Upper Devonian carbonates (Bachu et al., 2000). However, the scale of the WCSB means there are likely numerous secondary, or non-traditional, CCUS targets that have yet to be recognized.

The Lower Triassic Montney Formation is a world-class reservoir and contains the only documented turbidite reservoirs within the WCSB. Channel-fill and lobe turbidite sandstone facies are present in the play across Western Alberta and Northeastern British Columbia and have been targeted for hydrocarbon extraction since the early 1990s (Moslow, 2000; Zonneveld and Moslow, 2018). Turbidite plays like the Valhalla, La Glace, and Pouce Coupe fields are well developed and well connected to existing pipeline networks and point-source emitters like gas plants.

As part of an effort to understand the CCUS potential of turbidites within the Montney Formation, we are completing a re-evaluation of the architecture and facies distribution Valhalla Field reservoir sandstones utilizing core and well log data. Preliminary results reveal that a southeast-northwest striking channel fed a series confined lobes within fault-bound "mini-basins". These mini-basins exert a first-order control on sandstone presence and thickness, reaching >30 m in the axis to <3 m at the margins, with corresponding changes in reservoir quality. Later reactivation of these faults may have further compartmentalized the reservoir, as wells drilled as close as 600 m together show no evidence of connectivity. The turbidite system gradually filled this accommodation to form less-confined lobes which gradually pinchout onto a topographic high to the northeast. Together, these observations demonstrate a reservoir with effective, but complicated, trapping mechanisms which as a depleted reservoir, could play host to CO_2 storage.

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Zonneveld, J.P. and Moslow, T.F., 2018. Palaeogeographic setting, lithostratigraphy, and sedimentary framework of the Lower Triassic Montney Formation of western Alberta and northeastern British Columbia. Bulletin of Canadian Petroleum Geology, 66(1), pp.93-127.

Sedimentologic and Stratigraphic Characterization of Montney Bioclastic Facies: Implications to Reservoir Quality and Well Performance

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ABSTRACT

Within the Lower Triassic Montney Formation in northeastern British Columbia, active horizontal drilling is currently targeting reservoirs contained within three primary stratigraphic sequences. These third-order sequences and associated substages are: Sequence 1 (Griesbachian-Dienerian, lower Montney), Sequence 2 (Smithian, middle Montney), and Sequence 3 (Spathian, upper Montney). Of these three, Sequences 1 and 2 are commonly characterized by parasequences that contain large quantities of millimeter to decimeter scale carbonate bioclastic beds. In Sequence 1, carbonate laminae sets, beds and bed sets are in the form of *Claraia* bivalves of biostrome origin. In Sequence 2, parasequences are comprised of a reworked assemblage of bivalves and brachiopods deposited as tempestites. The hydrocarbon deliverability, and lack thereof in many instances, of these carbonate dominated parasequences is a function of facies heterogeneity, minimal reservoir quality, diagenesis from calcite cementation, and geomechanical rock properties.

Using slabbed full-diameter core and associated well-logs, best exemplified by core from d-40-H/94-G-7 well, these carbonate-rich parasequences have been mapped across large portions of northeastern British Columbia. Investigation of reservoir quality includes thin-section petrology and scanning electron microscopy. From facies mapping within the study area, an inverse relationship of estimated ultimate recovery (EUR) to carbonate content occurs in many instances. Conversely, lower carbonate content as observed in cored wells, is directly proportional to higher EURs per well. Reservoir quality in these carbonate-rich parasequences is marked by fabric anisotropy attributable to abrupt contrasts in lithology, grain size, matrix composition, density, and differential compaction. Reservoir quality is significantly impeded by pervasive calcite and/or dolomite cement thus resulting in highly restricted porosity and permeability preservation. The high frequency interbedding of brittle-ductile facies results in significant permeability and geomechanical anisotropy leading to less effective reservoir stimulation through hydraulic fracturing. Understanding the lateral and horizontal heterogeneity of these parasequences has proven critical to optimizing drilling programs and forecasting recovery factors (RF) within Sequences 1 and 2.

INTRODUCTION

The Lower Triassic Montney Formation in western Canada is host to massive deposits of hydrocarbons and has attracted active development for over 60 years. Due to the variable nature of subsurface parameters such as reservoir quality, pressures, and depths across the basin, production strategies have evolved significantly over the last half-century. For instance, initial vertical exploration and development wells targeted conventional systems that were buoyancy-driven, contained depositional fairways observable in core and seismic, and had porosity and permeability relationships that could be traced on petrophysical well-logs. Most exploration targets were shoreline coquinas, shoreface sandstone successions, and fine-grained turbidites present within west-central Alberta (Moslow and Davies, 1997; Davies et al., 1997; Moslow, 2000). Further basinward into northeastern British Columbia, Montney distal facies equivalents were encountered (e.g., bituminous siltstones) by operators who were targeting deeper Devonian-aged hydrocarbon deposits. Due to the extremely low permeabilities of these distal siltstone packages, operators were unable to access the hydrocarbons and were therefore deemed uneconomic. In the early 2000s, operators in the United States began demonstrating the effectiveness of using multi-stage hydraulic fracturing in horizontal wells to access hydrocarbons contained within these nanodarcy siltstone reservoir systems. As a result, companies in western Canada began adopting these methodologies and have encountered great success technically over the past 20 years. Since 2010, the Montney Formation has grown from less than 10% to over 50% of Canada's annual natural gas production (currently at over 10 BCF/day as of 2025) and is now the primary feedstock for LNG on the Canadian Pacific coastline.

Herein, we present a case study of the Montney Formation that exists paleo-geographically basinward from the subcrop margin and is dominated by bituminous siltstone reservoirs (Figure 1). Of particular importance in these reservoirs is the presence of bioclastic carbonates. Commonly found within the lower (Sequence 1) and middle (Sequence 2) Montney, these carbonates contain vastly different reservoir and geomechanical properties relative to the adjacent siltstones. Sequence 1, as defined by Baniak et al. (2023), contains three siliciclastic-rich parasequence sets and one carbonate-rich parasequence (Figure 2). The carbonate parasequence, dominated by in situ *Claraia* flat clams, was deposited during a regional transgression in the later phase of the Dienerian substage and is equivalent to the Pocketknife Member of Zonneveld and Moslow (2018). Sequence 2, as defined by Baniak et al. (2023), contains two siliciclastic-rich and two carbonate-rich parasequence sets and is capped by one separate dolomitic, carbonate-rich parasequence (Figure 2). The carbonate-rich beds within Sequence 2 are interpreted as tempestites that are preserved as bioclastic assemblages (Moslow et al., 2018). Equivalent to the Altares Member of Sanders et al. (2018) and Zonneveld and Moslow (2018), these bioclastic units often increase in thickness and frequency in a paleo-landward direction within the study area. For uncertain reasons likely attributable to subsurface preservation, these bioclastic beds within age-equivalent strata are rarely observed further up-dip depositionally in west-central Alberta (Zonneveld and Moslow, 2018).

The primary aim herein is to provide an overview of the sedimentology, stratigraphy, and petrology of the lower and middle Montney carbonates to identify the controls on reservoir quality and provide a predictive framework for economically viable future drilling of these two intervals.

OBJECTIVES

The primary objectives are to examine the depositional origin of carbonate facies present in the study area and their stratigraphic relationships. An evaluation of core data from a petrographic perspective was also conducted in order to identify reservoir characteristics of sedimentary facies and determine their fabric-related anisotropy. Results are ultimately used to map the distribution of higher and lower reservoir quality fairways in the lower and middle Montney. From this, one can then better understand reservoir quality that will ultimately aid future drilling target selection and allow for the ranking of reservoir trend areas.

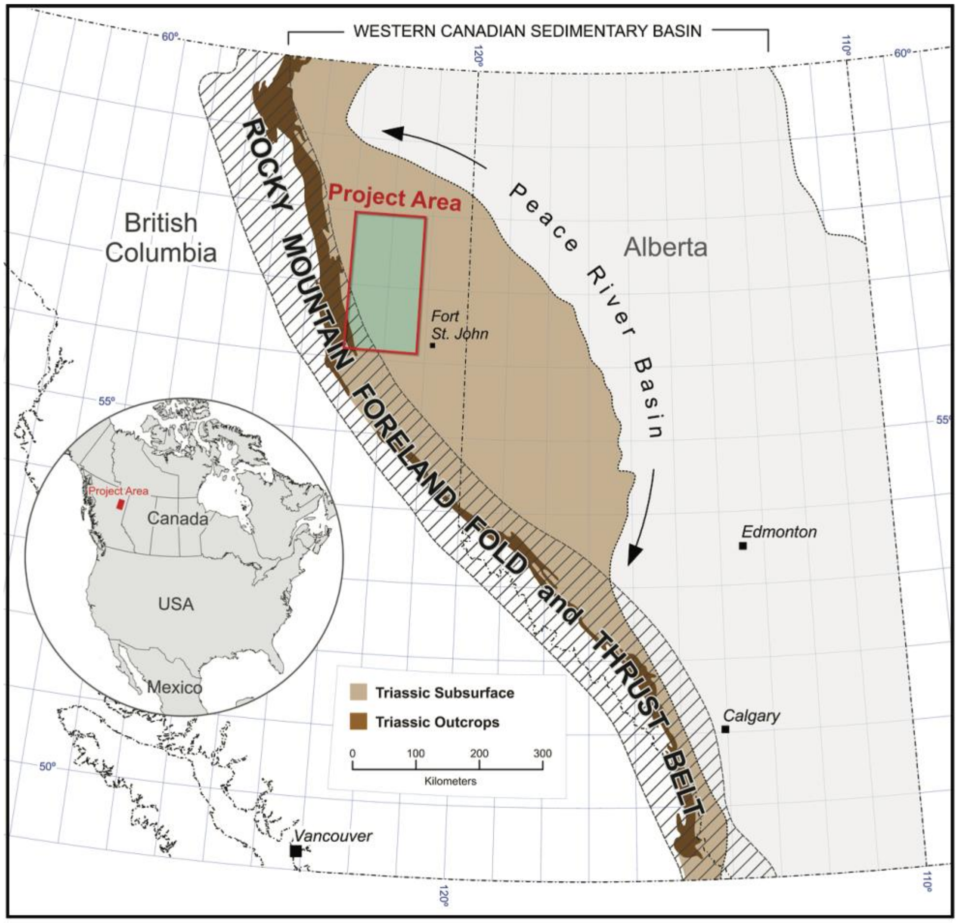

Figure 1: Location map in western Canada of the Montney Formation and its geographic coverage. The project area is located in northeastern British Columbia.

PROJECT AREA AND DATA BASE

The project area encompasses approximately 23,500 km^2 in northeastern British Columbia, Canada. It is located roughly 20 km from the town of Fort St. John relative to the southeastern boundary of the study area (Figure 1). The project database includes in excess of 500 vertical wells which have penetrated the underlying Paleozoic carbonates. Gamma ray, neutron-density, and resistivity logs were available for most wells. Stratigraphic correlation of distinct petrophysical log responses to sequence boundaries and parasequences noted in adjacent full diameter core has been achieved by Baniak et al. (2023). Within the project area, 48 wells had recovered full diameter cores of various lengths and over 4500 m in total. Average amount of core per well is approximately 100 m, with a maximum core length of 395 m in the c-65-F/94-B-8 well (Moslow et al., 2018). There are over 30 wells with core that cover either partial or full portions of the lower and middle Montney, enabling a comprehensive evaluation of lithology, grain size, primary and secondary sedimentary structures, and significant stratigraphic surfaces. Ichnological interpretation included identification of ichnogenera, and visual approximations of bioturbation index. Identification of non-vertebrate and vertebrate fossils and their habitats provided valuable information towards the paleo-environmental interpretation of sedimentary facies. For the core presentation, d-40-H/94-G-7 will be used as a case study (Figure 3). Cores from different wells were also extensively sampled for petrologic evaluation, which enabled a detailed understanding of the rock fabric and associated reservoir components (e.g., cements, visible porosity).

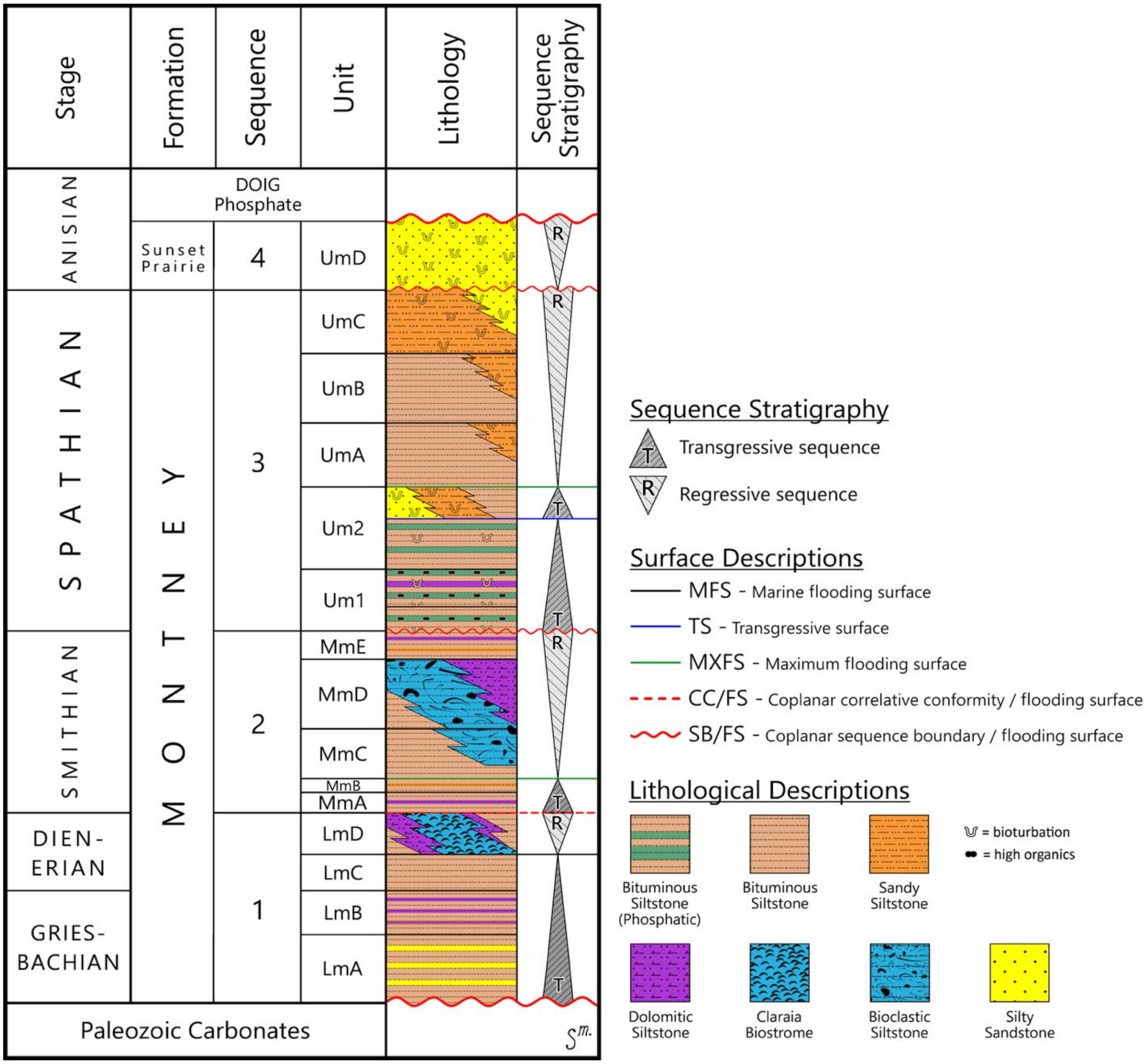

Figure 2: Stratigraphic column for the study area, after Baniak et al. (2023).

STRATIGRAPHIC FRAMEWORK AND FACIES HETEROGENEITY

The Montney Formation within British Columbia can be broken into lower (Griesbachian-Dienerian), middle (Smithian), and upper (Spathian) members (Golding et al., 2014; Davies and Hume, 2016; Henderson et al., 2018) (see Figure 2). Details of the sequence stratigraphy and sedimentary characteristics of the interbedded carbonate-rich facies in the lower and middle Montney are provided below.

Lower Montney Stratigraphy (Sequence 1)

The lower Montney is Griesbachian-Dienerian in age and is composed of three parasequence sets (LmA-LmC) and one separate parasequence (LmD) based on Baniak et al. (2023). The three lowermost parasequence sets (LmA-LmC) are mainly siliciclastic and reflect a retrogradational to aggradational depositional setting. The uppermost parasequence (LmD) is a mixed siliciclastic-carbonate unit deposited during a regional highstand of sea level. The stratigraphic surface between Sequence 1 and Sequence 2 is a correlative conformity coplanar with a flooding surface (Baniak et al., 2023).

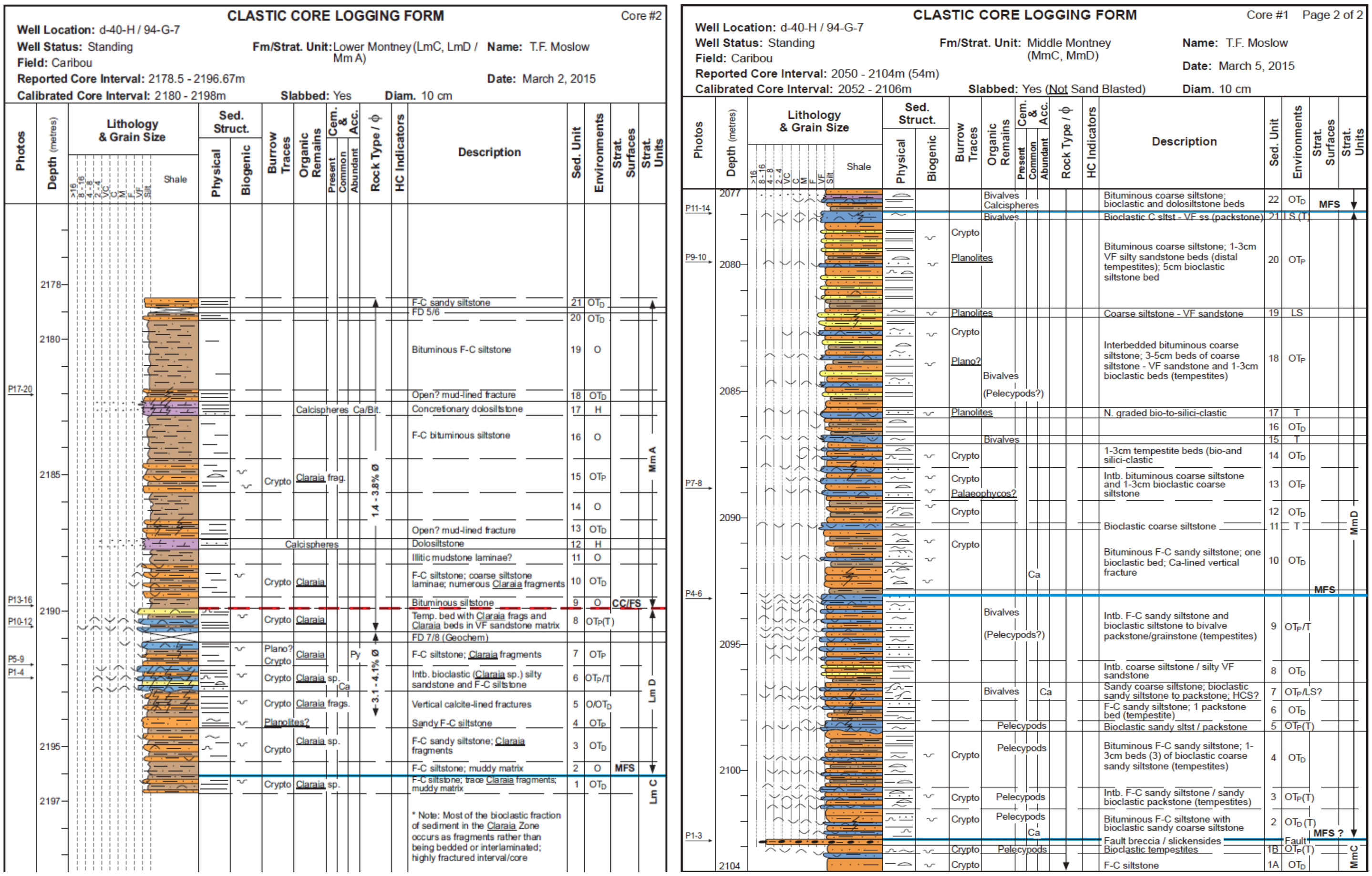

Figure 3: Detailed sedimentological descriptions of the two carbonate bioclastic zones in Sequence 1 (LmD) (on left) and Sequence 2 (MmD) (right) for d-40-H/94-G-7.

Parasequence LmD

The LmD, equivalent to the Pocketknife Member of Zonneveld and Moslow (2018), is a singular parasequence composed of an in-situ, low-diversity biocenosis dominated by a near-monospecific assemblage of *Claraia* flat clams (Figure 4). The *Claraia* beds are often inversely graded and interbedded with parallel laminated bituminous siltstones that average 2% TOC (Moslow et al., 2018). Deposition of individual *Claraia sp.* bioherms likely occurred in a setting dominated by suspension fallout at or near storm-weather wave base (McRoberts, 2001; Komatsu et al., 2010; Moslow et al., 2016). On a more regional basis, the LmD will often grade laterally in a basinward direction into calcispheric dolosiltstone facies. Conversely, the LmD will grade in a paleolandward direction to the east-northeast and transition from a *Claraia* dominated bioclastic succession into an interbedded coarse siltstone and silty very-fine-grained sandstone. Within the study area, *Claraia* bioherm accumulations within the LmD parasequence are commonly aligned in an NNW-SSE orientation and sub-parallel to Lower Triassic high-angle normal fault lineaments which infers a cause- and -effect relationship. It is theorized that those normal faults active at the time of deposition served as conduits for hydrothermal fluids escaping to the seafloor. Such fluids would have resulted in the emission of nutrient rich bottom waters enhancing the ecological niche of the *Claraia*.

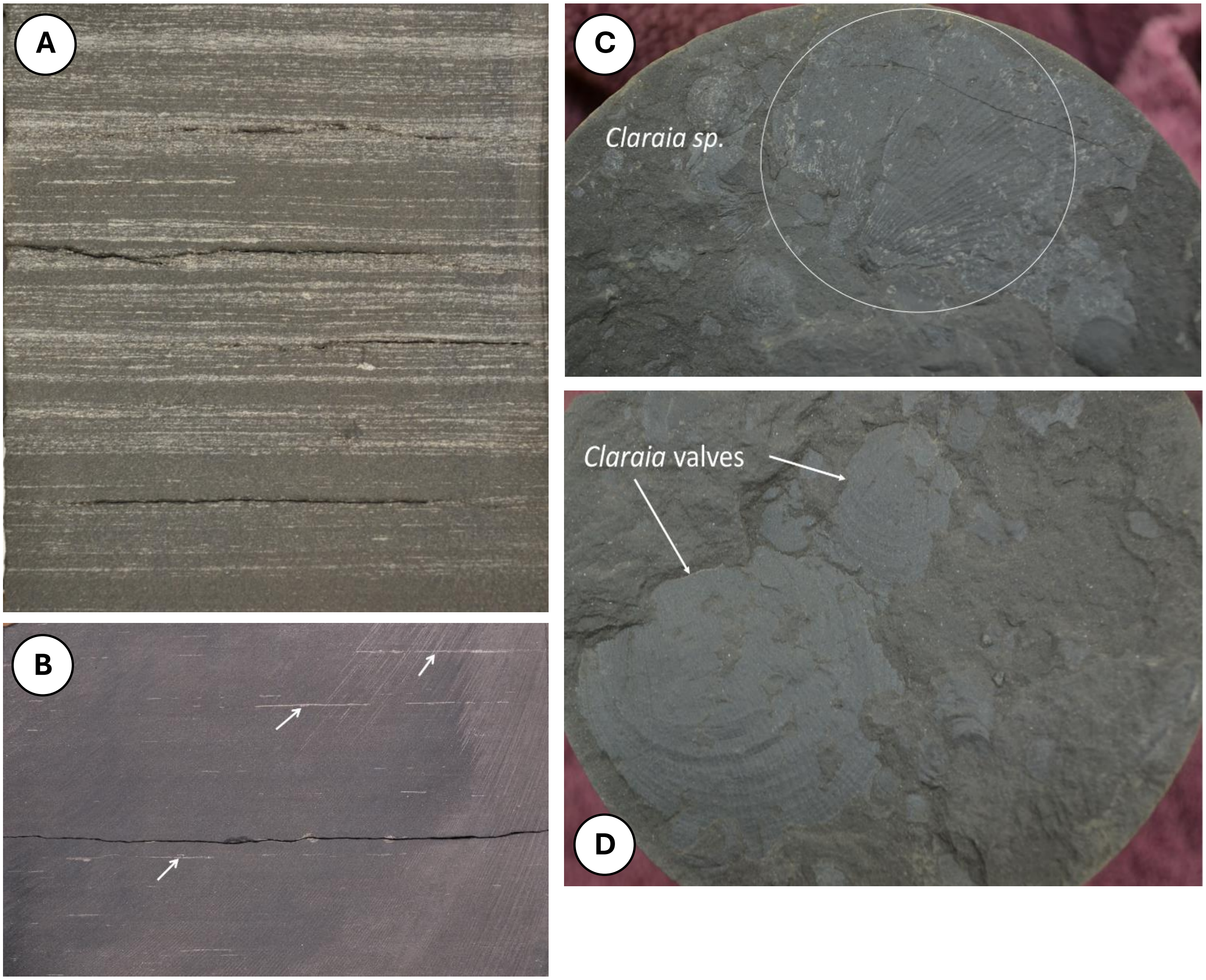

Figure 4: Examples of parasequence LmD (Pocketknife Member of Zonneveld of Moslow, 2018) in core samples. **A)** Bioclastic laminae and laminae sets of *Claraia sp.* valves interbedded within bituminous coarse-grained siltstone. Photo is 10 cm width. **B)** Close up core photograph of *Claraia sp.* valves (white arrows) and clasts within a fine-to-coarse- grained siltstone matrix. Photo is 10 cm width. **C** and **D)** Bedding plane examples of *Claraia* molds.

Middle Montney Stratigraphy (Sequence 2)

The middle Montney is Smithian in age and is comprised of four parasequence sets (MmA to MmD) and one separate upper parasequence (MmE) based on work completed by Baniak et al. (2023) (Figure 2). The lower two parasequence sets, MmA and MmB, are mainly siliciclastic in nature and are comprised of retrogradational to aggradational parasequences deposited during regional marine transgression following the Dienerian/Smithian lowstand. The overlying MmC and MmD parasequence sets are progradational and composed of a mixed or hybrid lithology of interbedded siliciclastic and bioclastic deposits. The uppermost MmE is a separate parasequence of mostly bituminous siltstone deposited during a period of regional sea level fall preceding the Smithian/Spathian lowstand. The stratigraphic surface between Sequences 2 and 3 is a basin-wide coplanar sequence boundary - flooding surface (Baniak et al., 2023).

Parasequence Set MmC

The MmC parasequence set reflects the first phase of regression within the Smithian and immediately overlies a regional maximum flooding surface at the top of the underlying MmB stratigraphic unit. In core, the MmC is represented by a series of offlapping parasequences. Each one displays a shoaling/shallowing upwards succession of thin-bedded (5 to 20 cm) sandy coarse siltstone and thicker bedded (20 to 50 cm) fine-coarse grained bituminous siltstone. Coarse siltstone beds increase in thickness and frequency upwards, reflecting progressively shallower water deposition within individual parasequences. Infrequent bioclastic siltstone beds of reworked and transported bivalves occur near the top of the MmC and mark the first beginnings of the regional Altares Member (Sanders et al., 2018; Zonneveld and Moslow, 2018). These bioclastic deposits are far more common in the overlying MmD parasequence sets and are discussed in greater detail below.

Parasequence Set MmD

MmD parasequences, also equivalent to the Altares Member of Zonneveld and Moslow (2018) and Sanders et al. (2018), are composed of interbedded siliciclastic and bioclastic deposits (Figures 5 and 6). The MmD is characterized by 5 to 20 cm thick bioclastic event beds (Figure 6A), interpreted as tempestites, that are sharp-based and normally graded with undulating wave-formed tops. A low diversity assemblage of bivalve fragments and occasional phosphatic bone fragments can be seen in core (Figures 6B and 6C). Deposition was inferred to occur on the distal through medial portions of a clastic or mixed clastic/carbonate ramp. The observed increase in the thickness and frequency of bioclastic beds in the paleo-landward direction within the study area is consistent with a lateral gradation eastward from distal through proximal positioning on the mixed clastic-carbonate ramp depositional profile. A series of parasequences occur within the MmD, grading basinward into interbedded bituminous siltstone and hemipelagic dolosiltstone. Paleo-landward (east-northeast), the MmD thins through erosion from the overlying regional unconformity coincident with the Smithian-Spathian sequence boundary.

Parasequence MmE

The MmE is a relatively thin, separate, parasequence composed mainly of fine- to coarse-grained, massive to indistinctly parallel-laminated bituminous siltstone with dolosiltstone and coarse siltstone beds. Highly fragmented bioclasts as well as relatively large well-preserved bivalves and ammonoids in a bituminous siltstone matrix are commonly observed. The MmE parasequence, although thin, reflects the end of bioclastic deposition within the project area. Parasequence MmE is bounded above by the Smithian-Spathian sequence boundary that terminates Sequence 2 deposition (Figure 2). Significant erosion, brecciation, and truncation of underlying strata is common at this sequence boundary. Parasequence MmE is conformable below with the MmD parasequence sets via a sub-regionally correlatable marine flooding surface. The MmE stratigraphic unit is interpreted as the falling stage system tract at the initiation of the global eustatic drop in sea-level that culminated in the regional unconformity at the Smithian-Spathian boundary (Crombez et al., 2017; Euzen et al., 2018).

Figure 5: Bioclastic laminae and nodules in core representative of parasequence sets MmC and MmD (Altares Member of Sanders et al., 2018 and Zonneveld and Moslow, 2018). The examples on the left show close up photographs of very thin mm-scale beds that grade laterally into thick (10 to 30 cm) concretionary nodules. Each photo is 10 cm width. On the right is a core mosaic showing the interbedded nature of the bioclastic beds.

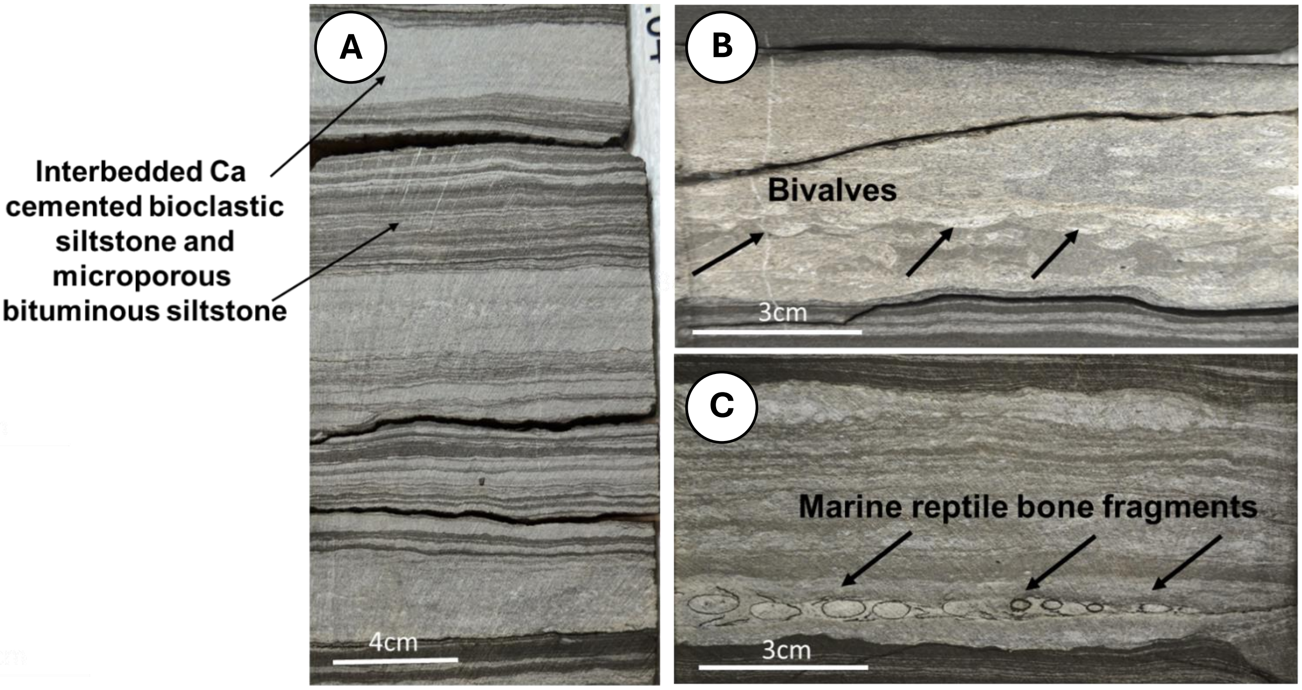

Figure 6: Examples of bioclastic tempestites from MmD parasequence set. **A)** Demonstrative, highly cemented, bioclastic successions. **B and C)** Low diversity assemblage of bivalve fragments and occasional phosphatic bone fragments observed from core samples.

PETROGRAPHIC ANALYSIS

Within the LmD parasequence, the individual bivalves are observed macroscopically and microscopically to be aligned parallel to bedding (Figure 7), thus suggesting minimal mechanical transport. The inverse grading common to the majority of individual beds is consistent with a life assemblage accumulation at the sediment-water interface (McRoberts, 2010). Additionally, the *Claraia* valves are interbedded within a fine- to coarse-grained siltstone matrix. The siltstone matrix often contains favorable reservoir properties (3 to 5% porosity) whereas the *Claraia* valves are densely calcite-cemented and contain no observable porosity.

In the overlying Sequence 2 bioclastic parasequence sets, individual bioclasts of bivalves and brachiopods are commonly highly fragmented. Whole valves occur along bedding planes in variable orientations (both concave up and down) suggesting fluidal transport and redeposition (Figures 8A and 8B). Bioclastic detritus consists mostly of macroscopic disarticulated and occasionally articulated bivalve fragments. Diminutive ammonoids and brachiopods are rarely observed. Most individual bioclasts are recrystallized by dense calcite cement that masks the original shell architecture. Three different carbonate phases were identified within core samples. Calcite occurs as a cement in beds containing calcite shell fragments and in fractures (Figure 9A). Dolomite occurs as detrital framework grains intermixed with quartz, feldspar, mica, clay, and organics (Figure 9B). Iron-rich dolomite forms thin authigenic rims, occurs as a pore-filling cement, and as a replacement for detrital dolomite grains (Figure 9C). In core, the calcite-rich bioclastic beds are often very thin mm-scale beds that grade laterally into thick (10 to 30 cm) concretionary nodules (Figure 5). Of particular importance, petrographic analysis shows these bioclastic intervals to be pervasively cemented and diagenetically altered. As outlined above, parasequence sets were deposited within a progradational setting on a mixed clastic-carbonate wave-dominated ramp. Interbedded siliciclastic siltstones and laminated silty very-fine grained sandstones do contain favorable porosity (4 to 5 %) and between 100 to 500 nanodarcies permeability (Figure 8C). Conversely, due to their highly calcite cemented nature, porosity is negligible (0 to 2.5 %) and permeability is well below 100 nanodarcies in the highly cemented bioclastic beds.

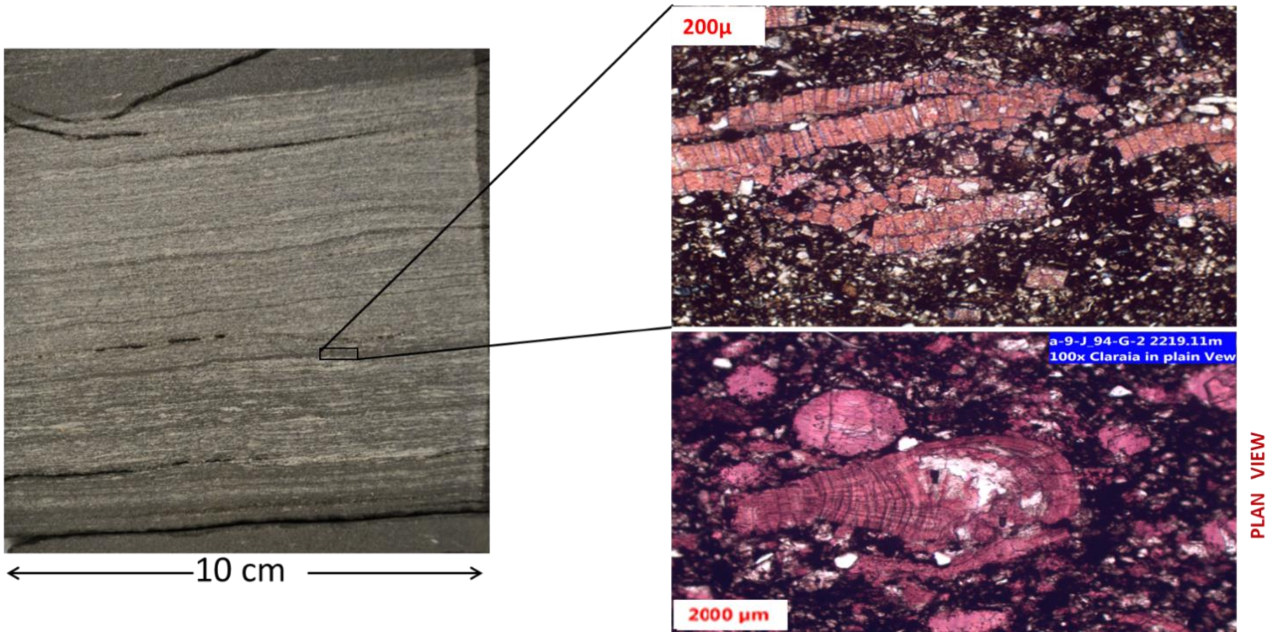

Figure 7: Examples of *Claraia sp.* valves and beds from core and thin-section. A laminated bed of *Claraia* shown on the left from core. Petrographic thin-sections in cross-sectional view (upper right) and plan view (lower right) highlight the bivalve's orientation and architecture relative to bedding. Notably, no visible porosity is present within the calcite-cemented valves nor beds. Photomicrographs by A. Terzuoli.

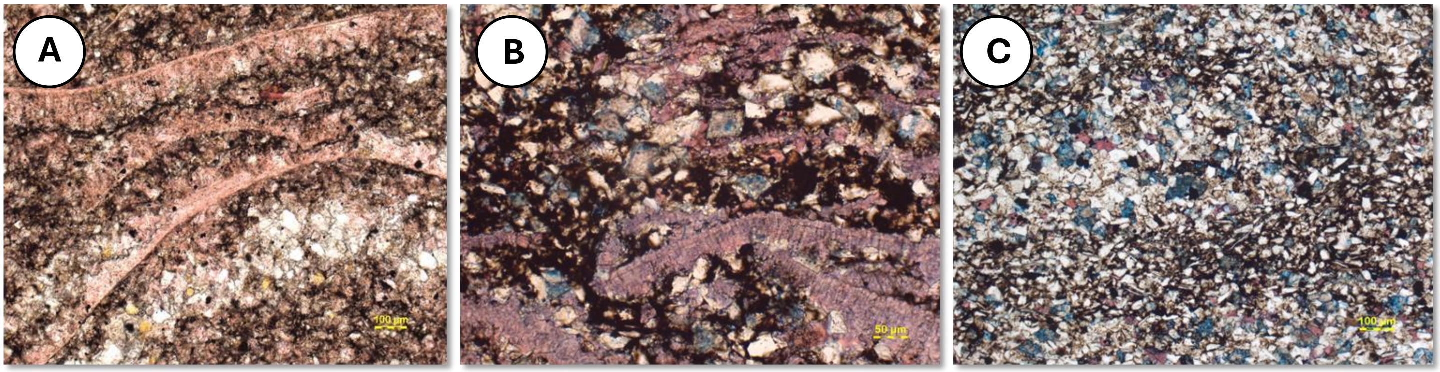

Figure 8: Bioclastic assemblages and associated reservoir facies from parasequence set MmD in thin-sections. **A** and **B)** Whole, highly-cemented, valves occurring along bedding planes in variable orientations (in stark contrast to *Claraia sp.* examples that are parallel to bedding, as per Figure 7). **C)** A moderately sorted, coarse-grained siltstone commonly adjacent to, or interbedded, with the bioclastic detritus material. Favorable porosity (4 to 5 %) is commonly observed within these siltstones. Photomicrographs by J. Welton.

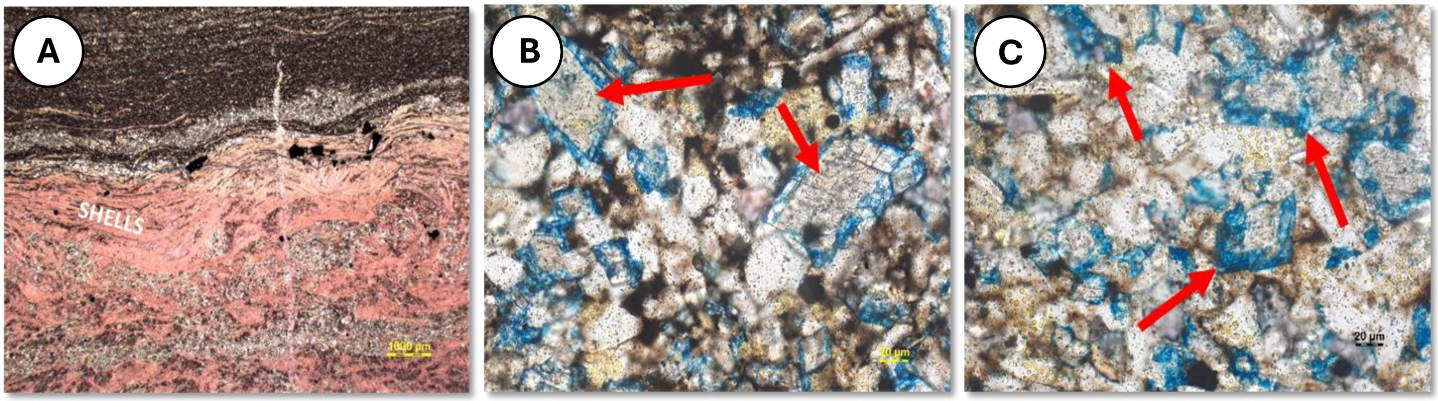

Figure 9: Examples of cement seen in thin-sections from the MmD parasequence set. **A)** Calcite occurring as a cement in beds containing calcite replaced shell fragments. **B)** Dolomite occurring as detrital framework grains (red arrows). **C)** Iron-rich dolomite forming thin authigenic rims (red arrows). Photomicrographs by J. Welton.

FABRIC ANISOTROPY

Based on the results of this investigation, it is assumed that the heterogeneous nature of the lower and middle Montney carbonate facies has a profound effect on geomechanical rock properties for a variety of reasons. Most important of these is the increase in fabric anisotropy. The sharp contrast in lithology, mineralogy, bedding and composition of interbedded bioclastic and siliciclastic beds and bed sets results in enhanced heterogeneity and sharply contrasting brittleness and ductility in relatively thin to thick intervals of strata. The fabric anisotropy is almost assuredly responsible for increased inefficiency in the hydraulic fracturing and proppant placement in units of this nature. The high degree of heterogenicity is likely the principal reason for the lack of hydrocarbon recovery and lower EUR's associated with the middle Montney and specifically the MmC, MmD and MmE where bioclastic facies are prevalent. Conversely, stratal units in the Montney that have more isotropic rock properties, attributable to minimal compositional and bedding variability, have greater similarity geomechanically (e.g., MmB and MmA). The homogeneity of the units translates into greater efficiency in hydraulic fracturing and proppant placement.

IMPACT ON PRODUCTION STRATEGIES

Over the past decade, a constant theme in western Canada has been the presence of low commodity prices. A by-product that has emerged from this challenge is the recognition from operators that the Montney Formation is not homogenous and therefore requires detailed core and stratigraphic studies to optimize production strategies. For example, prior to 2020, many operators drilled horizontal production wells that often cross-cut multiple stratigraphic units. A primary reason was because operators often did not geo-steer the wells to align with dipping patterns caused by faulting. Additionally, horizontal wells were landed to avoid placing hydraulic fractures into the overlying Doig or Sunset Prairie Formations in the Upper Montney and the underlying Paleozoic carbonates in the lower Montney. Since 2020, there has been an appreciation that certain stratigraphic units have better reservoir properties within each of the three Montney sequences. Perhaps more importantly, operators have begun to geo-steer their horizontal wells in real-time to land their wells within these optimized stratigraphic units and also align the wells with the structural dip caused by adjacent fault patterns. With regards to the carbonate-rich successions outlined herein, there has been a recognition industry-wide that poor production results (i.e., lower recoveries) often occur in packages containing elevated amounts of carbonate material. Conversely, lower carbonate content, as observed in cored wells, is directly proportional to higher recovery factors per well.

As outlined above, and likely attributable to lateral facies variability, instances where improved reservoir quality occurs within a time-equivalent parasequence are still probable and thus requires additional mapping efforts. For example, the LmD will grade in a paleolandward direction and transition from a *Claraia* succession into an interbedded coarse siltstone and silty very-fine-grained sandstone. These siltstone-sandstone reservoir packages contain very favorable porosity and permeability trends and are often targeted for landing zone purposes. The onus on the operator, however, will be to identify the proverbial “sweet spot” where this transition occurs and ensure proper data is collected to map the *Claraia* zero-edges.

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CORE CONFERENCE

May 7-8, 2026 • AER Core Research Centre

UNCONFORMITY EXPRESSIONS IN THE UPPER TRIASSIC CHARLIE LAKE FORMATION – WCSB, CANADA

Jonathan White, Ian Kirkland, Ivan Iuferov, Alexander Minev
Sproule ERCE

ABSTRACT

The Upper Triassic (Carnian) Charlie Lake Formation is a complex heterolithic sedimentary sequence in the Peace River Arch (PRA) area of the Western Canada Sedimentary Basin (WCSB). It includes variable successions of clastics, carbonates and evaporites deposited in a range of environments – from marginal marine to supratidal. The Charlie Lake formation members (formal and informal) are separated by several stratigraphically significant unconformities that reflect episodic tectonic activity, changes in relative sea-level and local structural realignments of the PRA during the Carnian period.

The goal of this core presentation is to highlight the lithologic and stratigraphic expressions of three significant unconformities within the Charlie Lake Formation: The Boundary Lake disconformity and the Worsley and the Coplin angular unconformities. A map showing the locations of the described cores is shown in Figure 1 below.

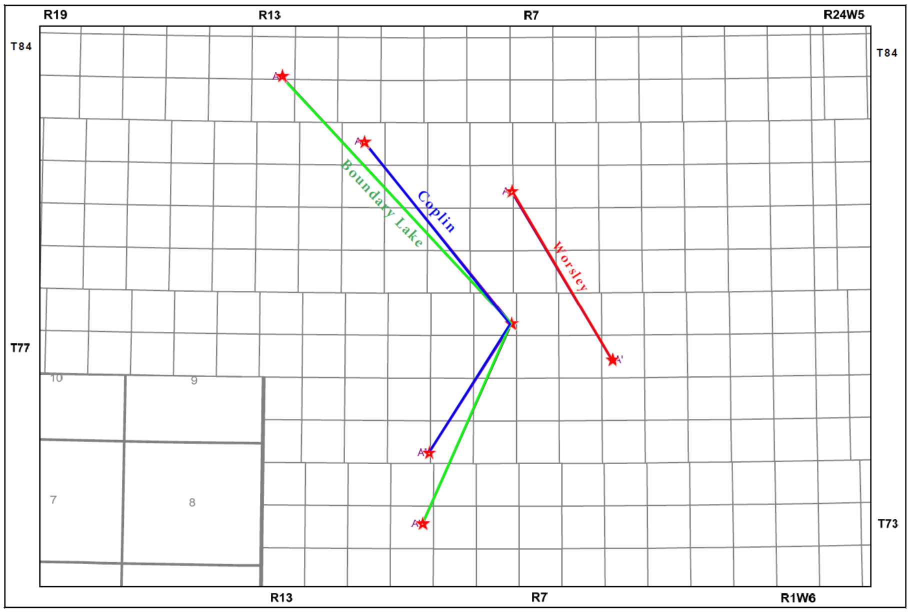
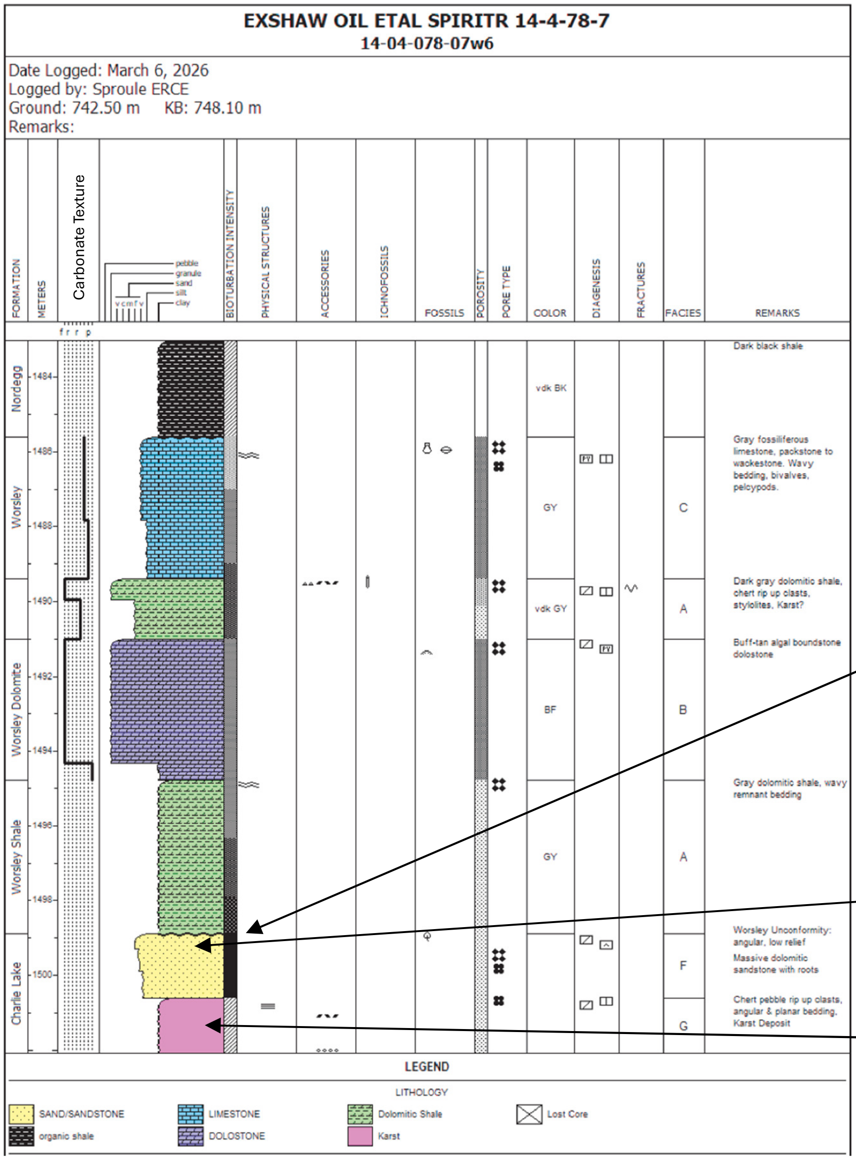
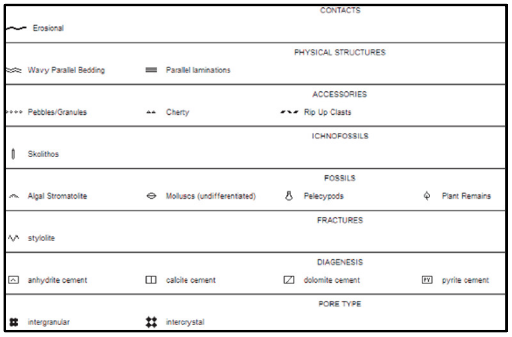


Figure 1 – Core Locations for Worsley, Boundary Lake and Coplin

The Worsley angular unconformity represents a regionally significant stratigraphic surface within the Fort St. John Graben to the east of the Baldonnel subcrop. It marks a pronounced hiatus between the Upper Charlie Lake or Montney formations and the overlying Worsley Member. This unconformity is interpreted as a subaerial exposure surface developed during a period of relative sea-level fall and tectonically influenced uplift, resulting in erosion prior to deposition of the Worsley. It is characterized by an abrupt facies shift from marginal-marine deposits of the Upper Charlie Lake into the Worsley shale that is conformably overlain by algal dolomites and fossiliferous coquinas of the Worsley dolomite.

Biostratigraphic evidence as to the age of the Worsley unconformity is In Press but the unit is currently interpreted to be coeval to younger than the Baldonnel formation (Triassic Carnian to Jurassic Hettangian in age). The Worsley–Charlie Lake unconformity provides an important stratigraphic marker and has implications for regional correlation, sequence stratigraphic interpretation, and hydrocarbon reservoir distribution within northwestern Alberta. Because the Worsley member subcrops near the Cretaceous aged Peace River Oil Sands and may have provided a conduit for migrating Jurassic hydrocarbons into those deposits.





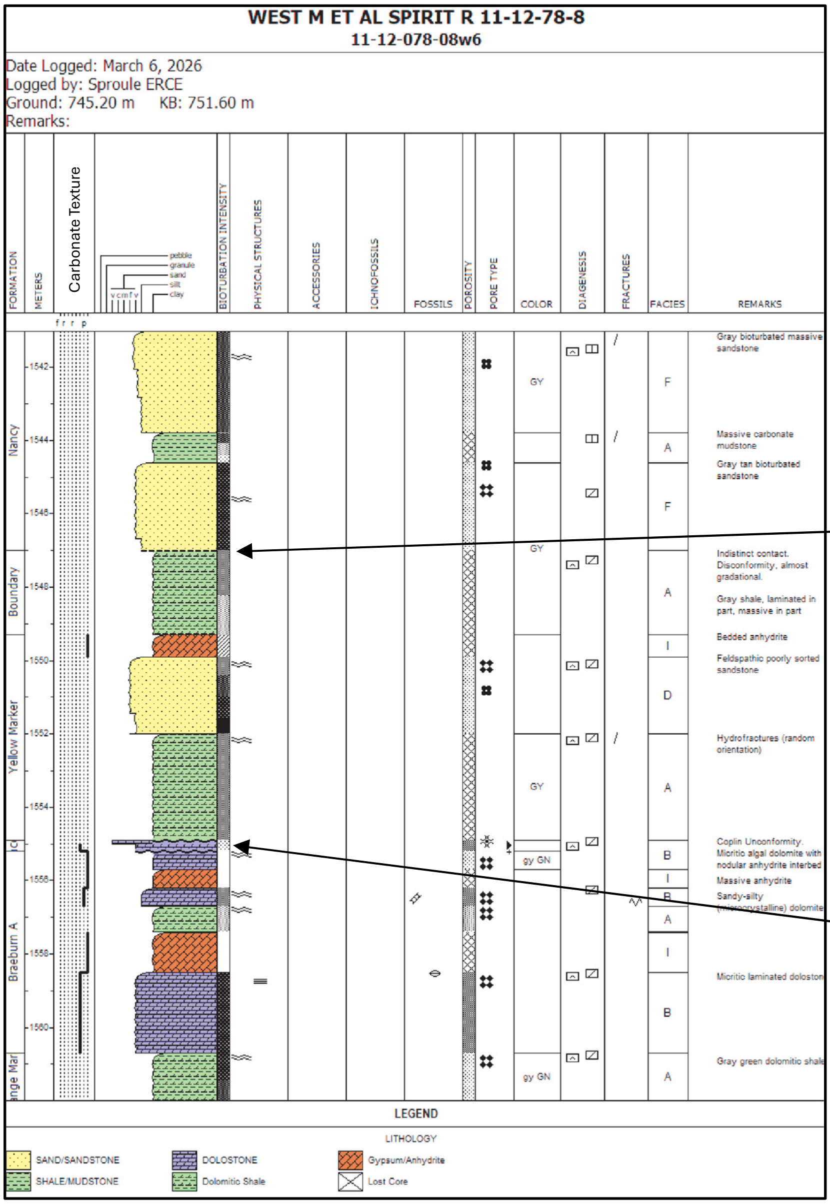
Worsley Unconformity
1499 m

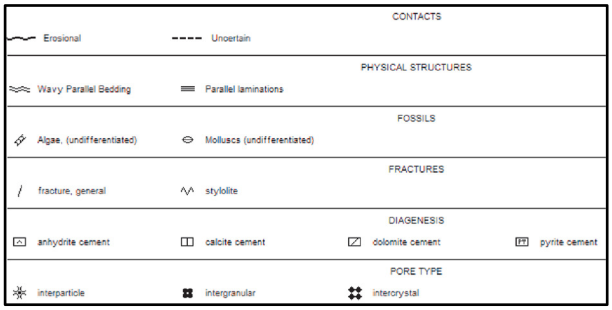
Pyritized Rootlets
Below1499 m

Worsley Unconformity
1499 m

The 14-04-078-08W6 core description and accompanying core photos above shows the dark grey shale at the Worsley Unconformity overlying the dolomitic sandstones of Charlie Lake formation. The Worsley Unconformity contact is sharp, angular and low relief with the dark grey dolomitic mudstone of the Worsley overlying the rooted (pyritized) dolomitic sandstones of the uppermost Charlie Lake. Immediately below the top of the Charlie Lake are interpreted karst deposits (brecciated flowstones interbedded with carbonaceous material). The presence of the rooted horizon and karst deposits immediately below the Worsley Unconformity provide evidence that this horizon experienced an extended period of subaerial exposure prior to deposition of the Worsley member. The presence of carbonaceous material and rootlets within these sediments also confirms resurgence of plant life towards the end of the Triassic period and may indicate the Worsley member could be as young as Jurassic in age.

The Boundary Lake disconformity separates the Boundary Member algal and micritic dolomites from the overlying marginal marine calcareous silt and sandstones of the Upper Charlie Lake, Nancy member generally with a sharp lithologic and stratigraphic contrast. The disconformity reflects an abrupt transgressive episode and rise in relative sea level that terminated carbonate deposition and led to erosion of previously deposited tidal-flat and near-shore sediments. The unconformity is regionally significant as it bounds one of the major depositional sequences in the Charlie Lake and helps subdivide the formation into lower Charlie Lake, Boundary Lake, and upper Charlie Lake intervals with implications for sequence stratigraphic interpretation, reservoir distribution, and correlation across the Peace River Embayment (PRE).





Boundary Lake Unconformity
1547 m

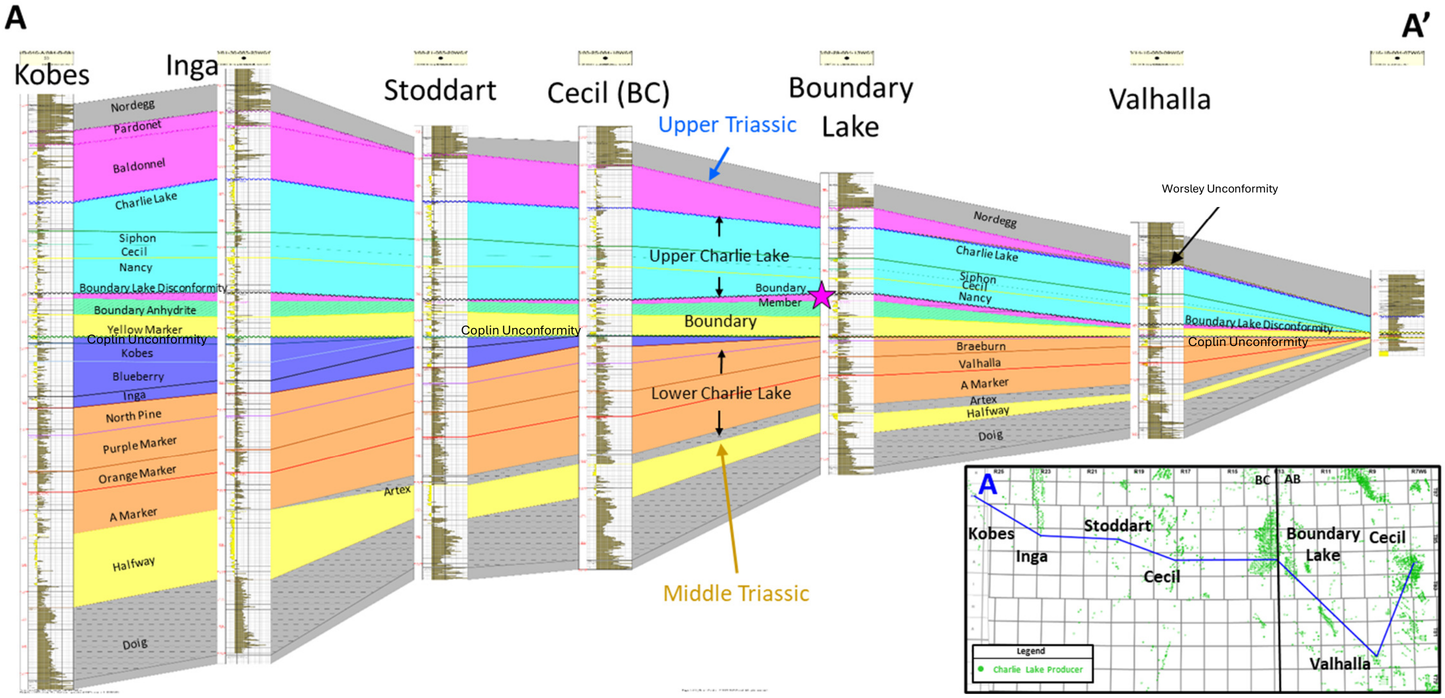
Coplin Unconformity
1555 m

The 11-12-078-08W6 core description and accompanying core photos above show the lenticular bedded, dolomitic sandstones of Charlie Lake formation at the Boundary Lake Disconformity overlying the grey shales of the Boundary Lake below. Most of the Boundary member has been eroded or not deposited in this locale. The Boundary Lake Disconformity contact is somewhat transitional, low angle and low relief with subtle contrast between the sediments above and below.

The most significant and regionally extensive angular unconformity is the Coplin Unconformity. It informally subdivides the Charlie Lake into Upper and Lower units. To the east it eroded through the entire Lower Charlie Lake Formation, the Halfway Formation and into the Doig Formation resulting in the erosional removal of tens to hundreds of metres of section (Fefchak 2011). This unconformity represents an abrupt transgressive episode from supratidal dolomites and anhydrites into anhydrite and dolomite cemented shales, siltstones and sandstones of the overlying Coplin and Yellow Marker members. The angular nature of the unconformity suggests significant tectonic influence in its formation with implications for sequence stratigraphic interpretation, reservoir distribution, and correlation across the Peace River Embayment (PRE).

The 11-12-078-08W6 core description and accompanying core photos above show the anhydrite cemented breccias of the lower Boundary Lake overlying the micritic dolostones of the Lower Charlie Lake at the Coplin Unconformity surface. The Coplin Unconformity contact is abrupt, angular with high relief showing a distinct contrast between the sediments above and below.

To the east the Boundary and Coplin unconformities coalesce into a single unconformity surface separating the Worsley or Upper Charlie Lake from Middle Triassic Halfway and Doig sediments as shown in the stratigraphic cross section below.



AKNOWLEDGEMENTS

The authors would like to acknowledge the contribution of the entire Sproule ERCE team to this core display including Kendal Hourd and Doug Ashton.

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May 7-8, 2026 • AER Core Research Centre

Integrating Ichnology and Sedimentology to Recognize Delta Types: Case Studies from the Cretaceous of the Alberta Basin

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ABSTRACT

INTRODUCTION

New Seilacherian ichnofacies have been developed for depositional environments subject to recurring temporal and spatial variations in physico-chemical stress. In marine deltaic settings, these correspond to the *Phycosiphon* Ichnofacies for mudstone-dominated prodeltaic deposits and the *Rosselia* Ichnofacies for sandstone-dominated delta-front successions (Fig. 1; MacEachern and Bann, 2020). The archetypal expressions of these ichnofacies were founded on deposits of mixed river- and wave-influenced systems, because the juxtaposition of ambient marine conditions during fairweather wave activity with evidence of elevated physico-chemical stress during heightened fluvial discharge best expresses the deltaic signal. As such, deltaic facies are readily discerned owing to the complex but predictable interplay of biogenic (e.g., bioturbation patterns and trace fossil diversity) and sedimentologic (*e.g.*, heterolithic bedding styles and physical stratification) characteristics. However, as deltaic settings shift towards end-member processes (e.g., river domination, wave domination and tide domination), or towards mixed-process conditions other than river and fairweather wave influence, the resulting facies characteristics depart from those reflecting the recently published archetypes (MacEachern and Bann, 2023).

Figure 1: Block diagrams of archetypal expression of the *Phycosiphon* Ichnofacies (A) and the *Rosselia* Ichnofacies (B) characterizing mixed river- and wave-influenced delta types (after MacEachern and Bann, 2020).

DEPARTURES FROM THE DELTA ARCHETYPE

River-Dominated Delta Successions

The Cretaceous of the Western Interior Seaway records numerous examples of deltaic successions whose sedimentology and ichnology adhere to the mixed river- and wave-influenced archetypes (*e.g.*, Viking Fm of the Fox Creek Field), as well as those that depart in predictable ways from the archetypes, demonstrating their distinct physico-chemical stresses. Examples of river-dominated delta successions (*e.g.*, Allomember E of the Dunvegan Fm; Bhattacharya and MacEachern, 2009; Bhattacharya and Walker, 1991; Gingras et al., 1998; MacEachern *et al*., 2005) show elevated deposition rates, periods of salinity reduction, slumping and dewatering, elevated water turbidity, flood-induced hyperpycnites and hypopycnal-generated fluid mud (Fig. 2). As a result, such successions are largely devoid of bioturbation. Evidence of marine conditions is commonly restricted to rare and isolated dwelling structures such as *Arenicolites*, *Ophiomorpha* or *Rosselia* in sandstone, and *Chondrites*, *Phycosiphon* or *Zoophycos* in mudstone beds of prodeltaic intervals.

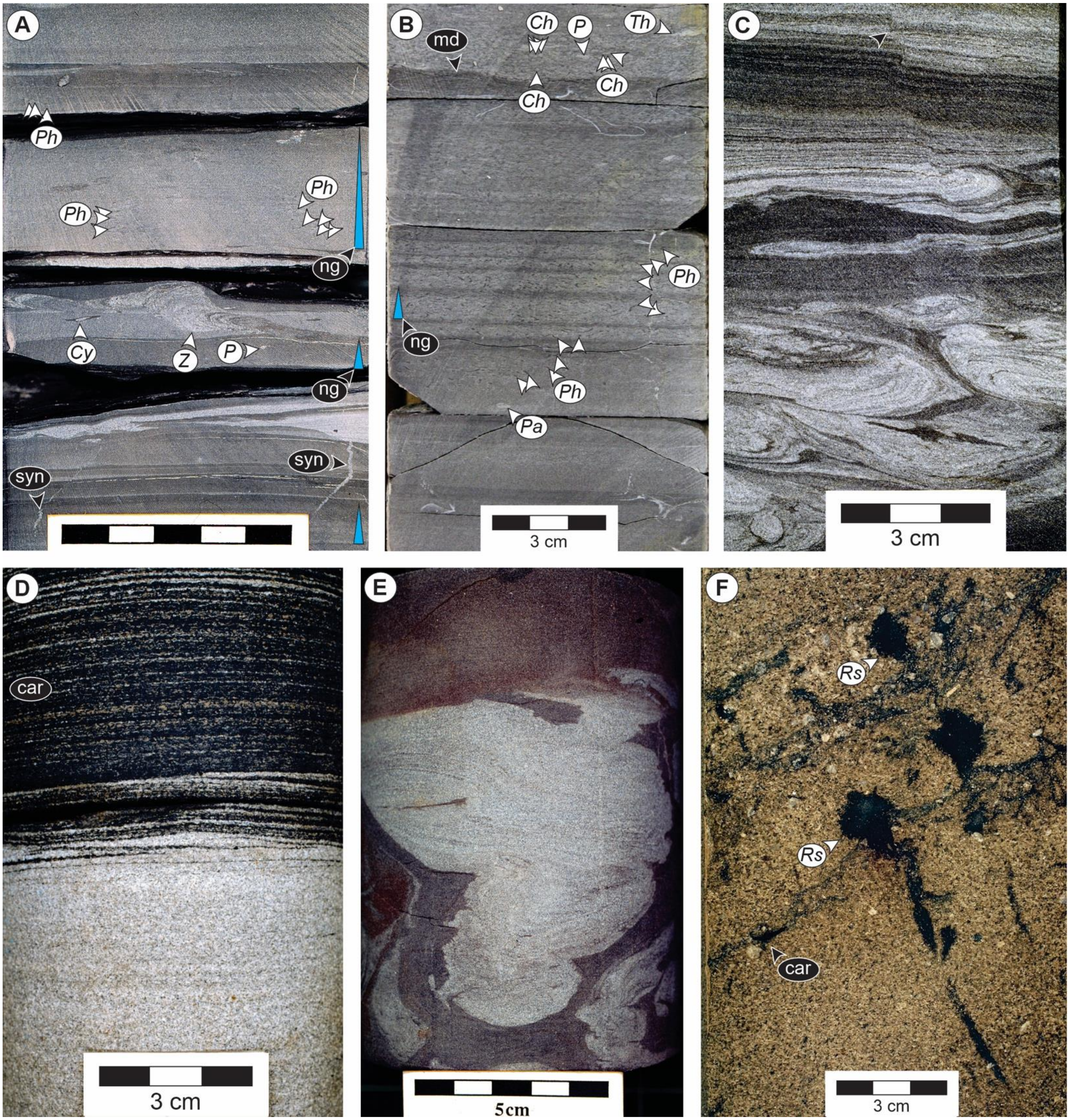

Figure 2: Photos of representative prodelta (A-C) and delta-front (D-F) deposits of river-dominated delta successions. Abbreviations are carbonaceous detritus (car), *Chondrites* (*Ch*), *Cylindrichnus* (*Cy*), mudstone drape (md), normal grading (ng), *Palaeophycus* (*Pa*), *Phycosiphon* (*Ph*), *Planolites* (*P*), *Thalassinoides* (*Th*), syneresis cracks (syn) and *Zoophycos* (*Z*).

Storm- and River Flood-Dominated Delta Successions

Storm- and river flood-dominated deltaic successions are widespread and commonly misidentified as shoreface deposits (*e.g.*, Bluesky Member, Falher Member, Cadotte Member, Viking Formation). The deltaic expressions of these units are characterized by HCS and micro-HCS tempestites that are typically interstratified with river flood-induced sediment-gravity flow deposits and/or mantled by largely unburrowed mudstone drapes derived from hypopycnal plumes associated with river floods (MacEachern *et al*., 2005, Collins *et al*., 2017; Lin and Bhattacharya, 2021). Where these storm-flood couplets are interstratified with fairweather beds, assignment to the archetypal deltaic ichnofacies is straightforward. However, as storm beds become increasingly erosionally amalgamated, the preservation potential of the fairweather beds is reduced and the resulting trace fossil suites are biased towards opportunistic colonization of the event beds (Fig 3). The presence of mudstone layers displaying low bioturbation intensities containing small numbers of ichnogenera positively correlated with marine conditions (*e.g.*, *Chondrites*, *Phycosiphon* and/or *Zoophycos*) may be the only facies evidence that the interval should be interpreted as deltaic (*e.g.*, Fig. 3A; MacEachern and Bann, 2023).

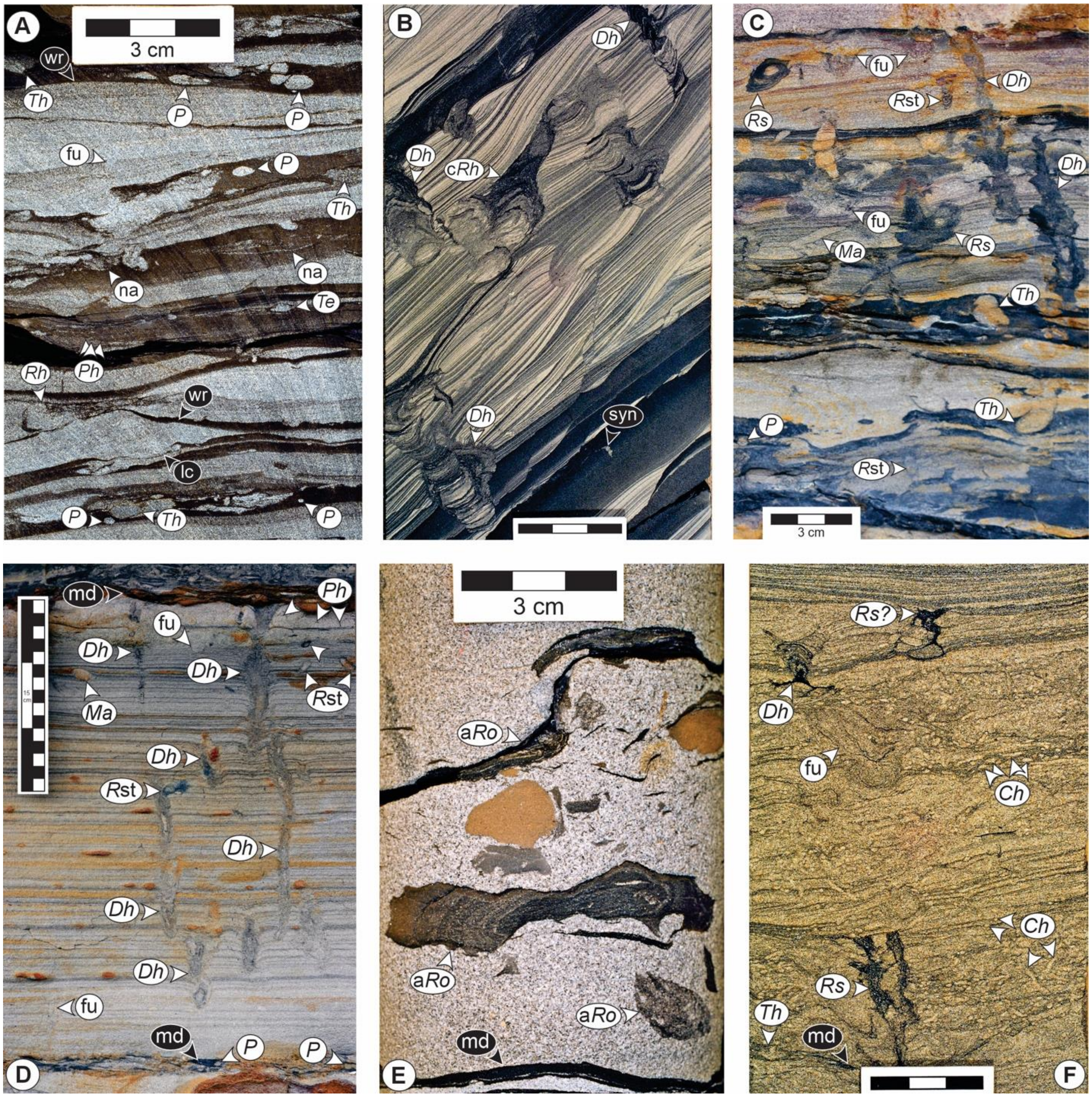

Figure 3: Photos of representative prodelta (A-C) and delta-front (D-F) deposits of storm- and river flood-dominated delta successions. Abbreviations are allochthonous *Rosselia* (a*Ro*), *Chondrites* (*Ch*), *Diplocraterion* (*Dh*), fugichnia (fu), mudstone drape (md), load cast (lc), *Macaronichnus* (*Ma*), navichnia (na), *Phycosiphon* (*Ph*), *Planolites* (*P*), *Rhizocorallium* (*Rh*), *Rosselia* (*Rs*), *Rosselia* dwelling stalk (*R*st), *Teichichnus* (*Te*), *Thalassinoides* (*Th*), syneresis cracks (syn) and wave ripples (wr).

Wave-Dominated Delta Successions

Finally, wave-dominated deltas lacking major storm influence (e.g., Viking Fm of the Kaybob field and Doe Creek Member) are typically challenging to differentiate from their archetypal strandplain shoreface counterparts and, correspondingly, the resulting trace fossil suites are broadly intergradational with those of the archetypal *Cruziana* and *Skolithos* ichnofacies (Bann and Fielding, 2004; MacEachern and Bann, 2008, 2020). Most of the preserved record of wave-dominated delta successions is related to fairweather ambient conditions, and so facies typically show elevated BI values and more uniformly distributed bioturbation, locally punctuated by tempestites (Fig. 4). Key to recognizing the facies as deltaic are the presence of thin, river-generated mudstone and sandstone layers that display evidence of physico-chemical stress (*e.g.*, Fig. 4G) and/or the paucity of ichnogenera typically attributed to suspension-feeding organisms and predominance of structures recording deposit-feeding behaviours (*e.g.*, Fig. 4F).

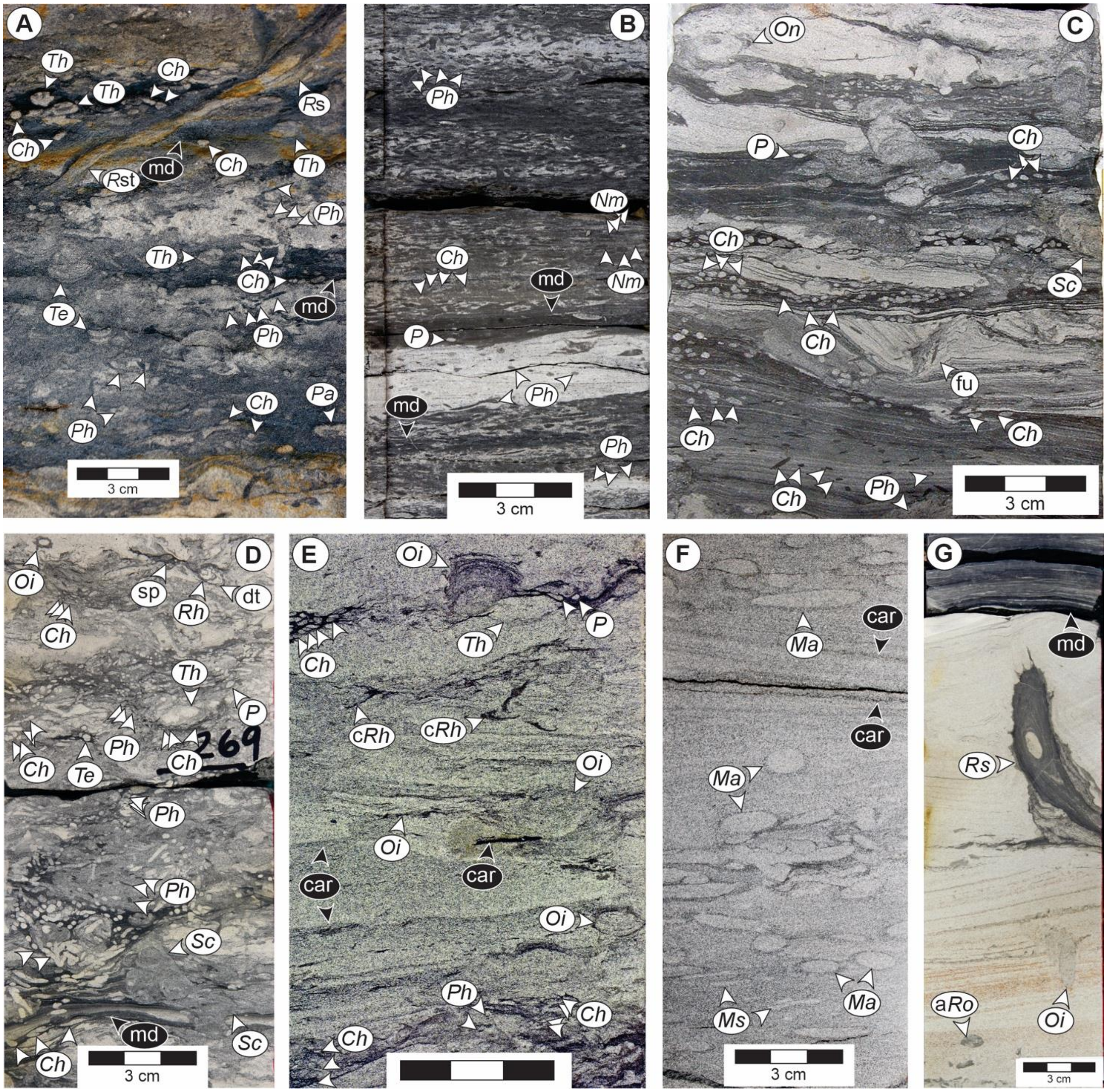

Figure 4: Photos of representative prodelta (A-C) and delta-front (D-G) deposits of wave-dominated delta successions. Abbreviations are allochthonous *Rosselia* (a*Ro*), carbonaceous detritus (car), *Chondrites* (*Ch*), complex *Rhizocorallium* (c*Rh*), dwelling tube (dt), fugichnia (fu), mudstone drape (md), *Macaronichnus* (*Ma, Ms*), *Nereites* (*Nm*), *Ophiomorpha* (*Oi*, *On*), *Phycosiphon* (*Ph*), *Planolites* (*P*), *Rhizocorallium* (*Rh*), *Rosselia* (*Rs*), *Rosselia* dwelling stalk (*R*st), *Teichichnus* (*Te*), *Scolicia* (*Sc*), spreiten (sp), and *Thalassinoides* (*Th*).

Tide-Dominated Delta Successions

To the authors' knowledge, the Cretaceous of the Alberta Basin does not possess successions characteristic of tide-dominated deltas, although such deposits do occur within the Western Interior Seaway of Wyoming and Utah (*e.g.*, Frewens Sandstone; Willis *et al*., 1999). Some intervals of the Clearwater Fm in the Cold Lake area have been interpreted as "estuarine deltas" and bear tidal signatures (Feldman *et al*., 2008). Tide-dominated deltaic successions can be recognized by their markedly heterolithic expressions, typified by tidally bundled dune-scale cross-stratification, bi-directional current ripples and abundant fluid mud commonly containing syneresis cracks (Willis *et al*., 1999; MacEachern *et al*., 2005; MacEachern and Bann, 2023). Facies show marked changes in salinity and water turbidity, leading to exceedingly low intensities of bioturbation and sporadically distributed ichnogenera. Most trace fossils reflect deposit-feeding and consist of deeply penetrating dwelling structures, as well as fugichnia and navichnia.

The Significance of Prodeltaic Facies

For most successions, regardless of delta type, it is the prodeltaic facies that tend to be the most diagnostic of a deltaic origin (MacEachern and Bann, 2020, 2023). Prodeltas are readily identified at the facies level, owing to the higher preservation potential of all depositional processes, including marine fairweather beds, river-supplied hyperpycnites and other sediment gravity flow deposits, tempestites and fluid mud derived from river flood-related hypopycnal plumes (*e.g*., Figs. 2A-C, 3A-C, 4A-C). Delta-front deposits, by contrast, tend to be the most readily misidentified as non-deltaic shorefaces, owing to the prevalence of higher energy conditions, erosional amalgamation of beds, and increasing wave energy as the succession transits into shallower water.

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Session Four

Cretaceous-Miocene: Shallow Seas to Modern Margins

CEGA TOURMALINE OIL CORP.

CORE CONFERENCE

May 7-8, 2026 • AER Core Research Centre

Once Upon a Time in Cold Lake: re-evaluation of time-significant surfaces from time-lapse monitoring of the Clearwater Formation.

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Strathcona Resources Ltd

ABSTRACT

The Clearwater Formation in northeastern Alberta is a world-class oil sands deposit developed by using thermal in-situ processes such as cyclic steam stimulation (CSS) in the mid-1980s and more recently with steam assisted gravity drainage (SAGD) recovery technologies. Strathcona Resources Ltd (SRC) currently owns and operates the Orion and Tucker projects in the Cold Lake region that have produced bitumen from the Clearwater Formation utilizing SAGD for over 20 years. Identification and mapping of key facies changes and time surfaces for proper reservoir characterization continues to be important when integrating subsurface monitoring and dynamic data to maximize recovery and predict performance on future development opportunities.

In northeastern Alberta, the Albian Clearwater Formation reservoir is dominated by high quality, fine grained feldspathic litharenites with excellent porosity (33–35%) and oil saturation (55–65%). Total net pay thickness across the producing pads of the SRC assets ranges from 25 to 50 metres. Although these are remarkable reservoir characteristics, the prevalence of non-unique, high-energy, sand-prone facies makes it difficult to recognize diagnostic sedimentological features in core and consistently link to a muted well log signature from the feldspar-rich sands (e.g. gamma ray, density, spontaneous potential). The region has thousands of wells approximately 500 m apart, with hundreds of cores and multiple regional high-resolution 3D seismic surveys, but across these datasets common sand-on-sand contacts obscure stacking pattern classification, correlation of key surfaces, and mapping of stratal geometries. As a result, there are several contrasting genetic model interpretations for the large (>50 km) Clearwater system that deposited in range of fluvial to marginal marine environments.

Post-production subsurface surveillance at Orion and Tucker is a critical component of the SAGD operations to understand the dynamic performance of the reservoir. Integrating post-steam cores, repeat reservoir saturation logs and time lapse (4D) seismic has proven essential for evaluating steam conformance, fluid distribution, and reservoir heterogeneities. The Clearwater Formation is dominated by high-quality reservoir units, but steam chamber development and production efficiency appears to be impacted by the different sand facies and subtle lithological heterogeneities separated by key time surfaces. Any interpretation uncertainty is further amplified away from stratigraphic well control when trying to understand performance differences between kilometre-long horizontal wells spaced less than 100 m apart. Revised geological interpretations

integrating the full-suite of time-lapse analyses have delivered better inputs to reservoir simulations leading to an improved understanding of well pair production and enabling better economic decisions on executing enhanced recovery strategies or developing future pads.

Beyond the sweet spots: Core-based insights into the variability and complexity of marginal SAGD reservoirs in the Wabiskaw Member, Athabasca Oil Sands

Cynthia Hagstrom, Nova Geoscience

ABSTRACT

The Alberta government has set an ambitious goal to double provincial oil production. Growth will largely depend on additional recovery from the oil sands, which already accounts for more than half of Alberta’s total oil output. Twenty-five years of SAGD development has proven the process works best in thick, clean, bitumen-saturated sands with fining-upward grain-size trends. Most of the best reservoirs in the Athabasca oil sands have already been developed; therefore, future production increases will likely rely on more marginal reservoirs within the McMurray-Wabiskaw interval. These units commonly present challenges for SAGD development due to thin pay zones (<10 m thick), lithological heterogeneity, inconsistent bitumen and gas saturations, and unfavorable vertical permeability trends, such as coarsening-upward grain-size profiles.

This presentation focuses on a series of Wabiskaw Member cores to illustrate the variability and complexity of these marginal reservoirs. Examples include the Wabiskaw A in the MacKay area, the Wabiskaw B from Kirby, and the Wabiskaw D from both the MacKay and Christina Lake regions. Core and petrophysical data are used to document vertical and lateral heterogeneities in lithology, porosity, permeability, and bitumen saturation, along with their implications for reservoir quality and steam-chamber development. As Alberta looks to expand oil production, these cores provide valuable insight into the limits of SAGD applicability and highlight the need for alternative recovery approaches tailored to thin, heterogeneous reservoirs.

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Stratigraphy of the Wabiskaw Member at Kearl Oil Sands Mine: Depositional Controls and Operational Challenges Ahead

Bogdan L. Varban and Bram A. Komaromi
Kearl Geoscience Team, Imperial Oil Limited

ABSTRACT

Imperial Oil's production at the Kearl Oil Sands Mine has, to date, almost entirely come from the late Lower Cretaceous McMurray Formation, mining from north to south through an ore body informally known as the *Middle* McMurray. This interval consists of stacked fluvial meandering channel belts overlain by Quaternary glacial deposits. As the mine progresses southward, away (and structurally deeper) from the erosional edge of the Cretaceous deposits in Athabasca, the stratigraphic succession at Kearl expands to include the overlying Wabiskaw Member of the marginal- to open-marine Clearwater Formation. The Wabiskaw Member at Kearl was deposited in marginal marine settings (deltaic/estuarine) and is bound at top and base by erosional transgressive surfaces that are readily identified in core. During the next phase of southern mine expansion, the Wabiskaw will comprise nearly half of the total mineable deposit. Ongoing delineation efforts aim to achieve the optimal data density required for production planning, allowing us to ultimately finalize a robust stratigraphic framework, characterize stratigraphic heterogeneities, and anticipate the operational challenges that lay ahead.

In this presentation, we integrate detailed core observations, laboratory data, facies analysis, and stratigraphic correlations aided by 2D seismic data and airborne electromagnetic surveys (AEM) to illustrate the internal architecture of the Wabiskaw and the depositional controls governing its heterogeneity across the lease. We present three cores that each exhibit a distinct stratigraphic style over a relatively short distance: i) a thin offshore parasequence, ii) a several meter-thick sand-rich delta front deposit, and iii) a tens-of-meters deeply incised deltaic succession. Each of these examples illustrates the range of mining-related challenges associated with the Wabiskaw including the environment of deposition, fines content variation (mud abundance and composition across facies), sand and oil saturation distribution (ore-waste discrimination/selectivity), and mud thickness and stability (geotechnical considerations). Collectively, these results demonstrate how the Wabiskaw Member is fundamentally different from the McMurray Formation, not only in its distribution of ore and waste but also in the nature of its ore quality. These factors will have important implications for mine planning, extraction performance and processability as Kearl continues to expand its operation southward.

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Geochemical Signatures of Subtle Sequence Stratigraphic Depositional Boundaries: A Case Study from the Late Albian Viking Formation

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INTRODUCTION

The late Albian Viking Formation is a sequence stratigraphically complex succession that is intersected throughout much of the subsurface of central Alberta. In that area, a sequence stratigraphic model has been proposed, consisting of 4 sequences of deposition (Schultz et al., 2022) and mapped using the 4-systems tract nomenclature (*sensu* Catuneanu et al., 2011). Surfaces that are erosional in paleogeographically proximal areas of the basin have correlative gradational contacts in more distal parts of the basin (Fig. 1A). The basal surface of forced regression (BSFR; *sensu* Hunt and Tucker, 1992) is one such surface, which marks the onset of forced regression in the basin. It is commonly expressed as a “sand-on-sand” or “mud-on-mud” contact, making its recognition challenging. The BSFR is typically identified in core through subtle changes in the sedimentology, trace fossil suites, and a subtle increase in grain size across the contact. Likewise, the correlative conformity (CC), which marks the onset of normal regression following the relative sea-level fall that initiated the forced regression, has a similar gradational expression and is identified in core by a decrease in grain size before it increases again, as well as a subtle change in the sedimentology and trace fossil suites across the contact.

Presently, there are no studies that identify a set of criteria to use when identifying gradational stratigraphic contacts that form during the onset of forced and lowstand normal regression. Many geochemical studies focus on deep-water successions that are mudstone-dominated. These studies generally do not differentiate between the types of regression (see Lagrange et al., 2020 for a discussion) and as such, criteria are not proposed for identifying the differences between highstand normal regression, forced regression and lowstand normal regression. This study builds upon the work of MacEachern et al. (2012).

STUDY AREA/METHODS

This study has identified candidate BSFR and CC in core of the Viking Formation at the Kaybob and Judy Creek fields (Fig. 1B), based on changes in sedimentology and trace fossil suites (MacEachern et al., 2012). The Viking Formation in these fields records deposition in a low accommodation setting, resulting in thin sequences of deposition that transition rapidly down dip throughout the basin. Surfaces that were proposed to represent these surfaces were tested geochemically through an x-ray fluorescence (XRF) study on five cores at these fields. The three cores that were analyzed from the Kaybob region preserve three different expressions of the basal surface of forced regression in a proximal setting. The two cores from Judy Creek preserve the basal surface of forced regression in a distal setting, as well as the overlying correlative conformity.

Cores were analyzed by XRF at a 10 cm interval through the mudstone and muddy sandstone facies. Sandstone-dominated facies were analyzed at a 20 cm spacing. The XRF analyzed light elements under vacuum to improve detection limits and minimize spectral inference. Heavy elements were analyzed under air as a second measurement. The results of the XRF were compared to shale standards that were run every 10 samples to ensure that there was no elemental drift recorded from the instrument. Samples for x-ray diffraction (XRD) were selected at the BSFR contacts in the 10-35-64-13W5 and 10-20-62-08W5 cores from the Judy Creek fields. Thin sections were made at these sample points to validate the results of the XRD.

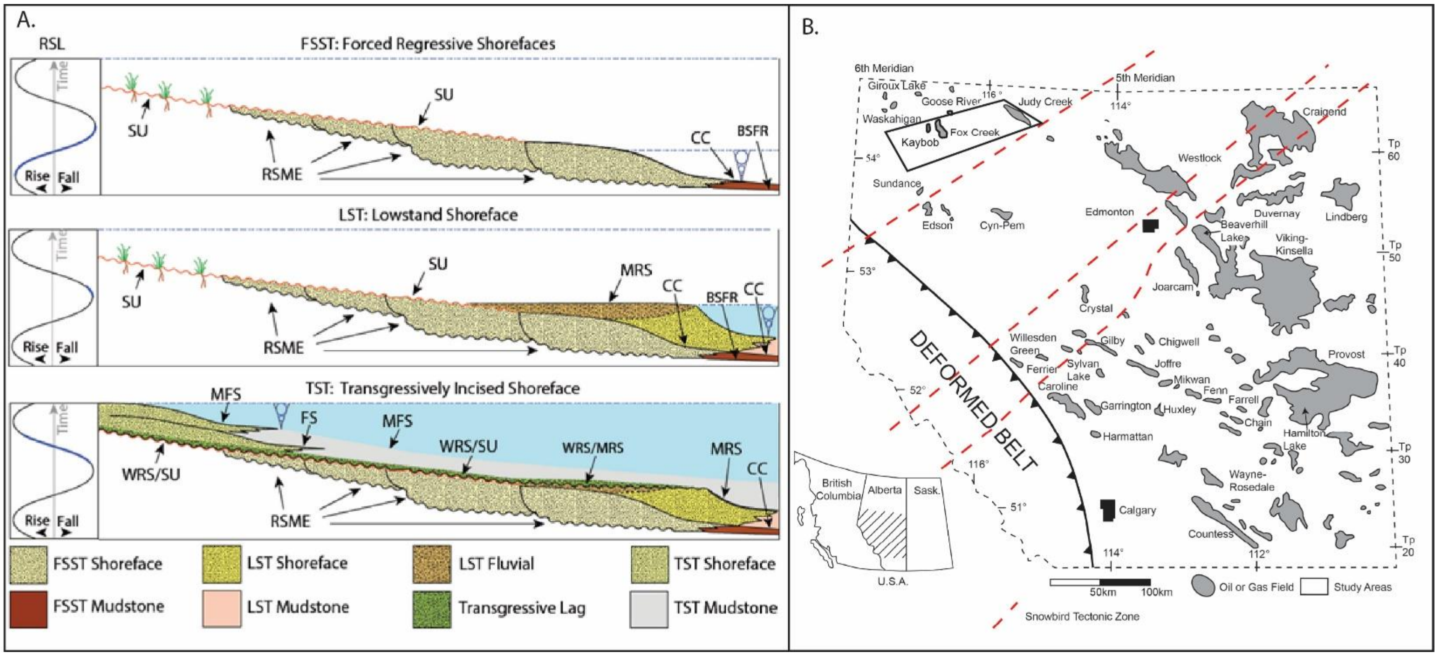

Figure 1: A. Conceptual model for the 4-systems tract framework in shallow-marine clastic systems (MacEachern et al., 2012). B. Study area map detailing the locations of the major oil and gas fields that produce from the Viking Formation (modified from Pattison, 1991). The Kaybob and Judy Creek fields are in the black box and occur to the NW of the Snowbird Tectonic Zone.

RESULTS

Basal Surface of Forced Regression

The surfaces that were identified in core as the BSFR display a similar distinct geochemical signature in all five cores. The XRF data at this surface display a pronounced decrease in Si, Al, Zr and U. Increases in the terrigenous input proxy (TIP), Co and the proxies for feldspar (K/Rb) and chlorite (Mg/Al) also occur (Fig. 2). The XRD data from the 10-35-64-13W5 core shows a significant increase in quartz in the forced regressive package of rocks coupled with a decrease in feldspar and illite contents (Fig. 3).

Correlative Conformity

The CC was identified in the cores from the Judy Creek region in the 10-35-64-13W5 and 10-20-62-08W5 cores. At this surface, an increase in the silt proxy (Si/Al) is noted before it abruptly decreases above the contact. There is a subtle decrease in the TIP values before it increases again above the CC (Fig. 2). Redox proxies (Mo, U and V) also drop at the CC. The XRD data from the 10-20-62-08W5 core show a significant decrease in quartz and an increase in feldspar and illite contents in the lowstand deposits (Fig. 3).

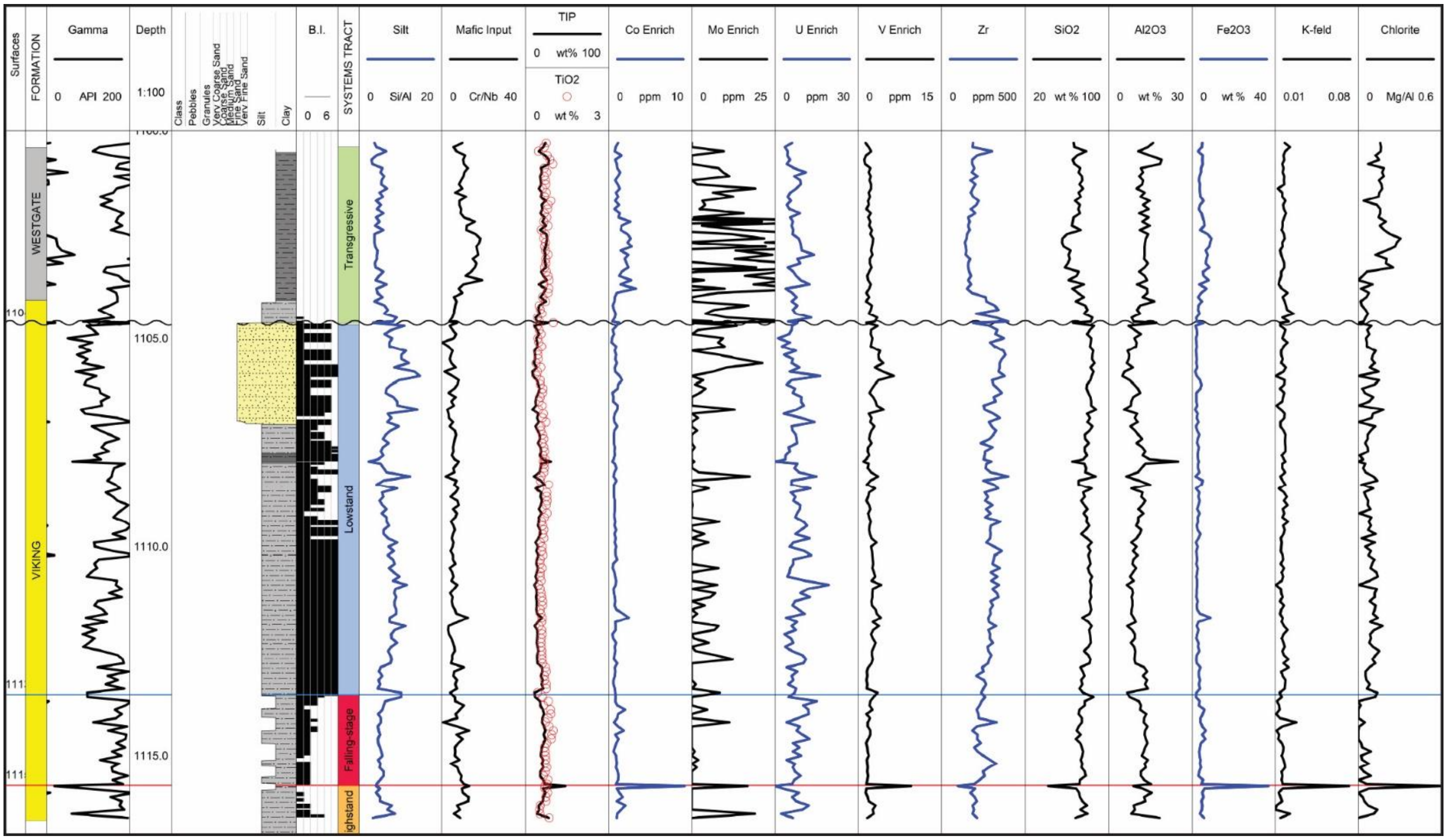

Figure 2: 10-20-062-08W5 core log and XRF dataset for select tracks. The red line is the basal surface of forced regression. The blue line is the correlative conformity. The erosional black line is a co-planar wave-ravinement surface/subaerial unconformity. The gamma ray was calculated from the XRF dataset. B.I. = bioturbation index. TIP = terrigenous input. K-feld = potassium feldspar proxy.

DISCUSSION

The results indicate that even for shallow-water successions there are pronounced geochemical signatures that are consistent at the proposed BSFR and CC in these cores. At the BSFR, the sharp reductions in detrital proxies (e.g., Si and Zr) occur alongside enrichment of sorting-sensitive mineralogical indicators (e.g., feldspar and mafic proxies), recording sediment partitioning during forced regression, with quartz-rich material concentrated proximally and finer-grained sediment concentrating with heavy elements in more distal settings. Additionally, authigenic trace-metal proxies (e.g., Mo, V and Co) show subdued enrichment responses, highlighting that the BSFR is primarily a physical sequence stratigraphic horizon rather than a redox-driven horizon or a simple facies boundary.

By contrast, the CC is expressed geochemically by muted and gradational shifts in detrital proxies (e.g., subtle increases in Si and Zr), grain size (e.g., an initial decrease in the Si/Al proxy before an increase) and trace-element proxies (e.g., decreases in the enrichment of Mo, V and Co), reflecting the initial trapping of coarser-grained material in proximal locations such as fluvial valley conduits prior to renewed normal regressive progradation during lowstand conditions.

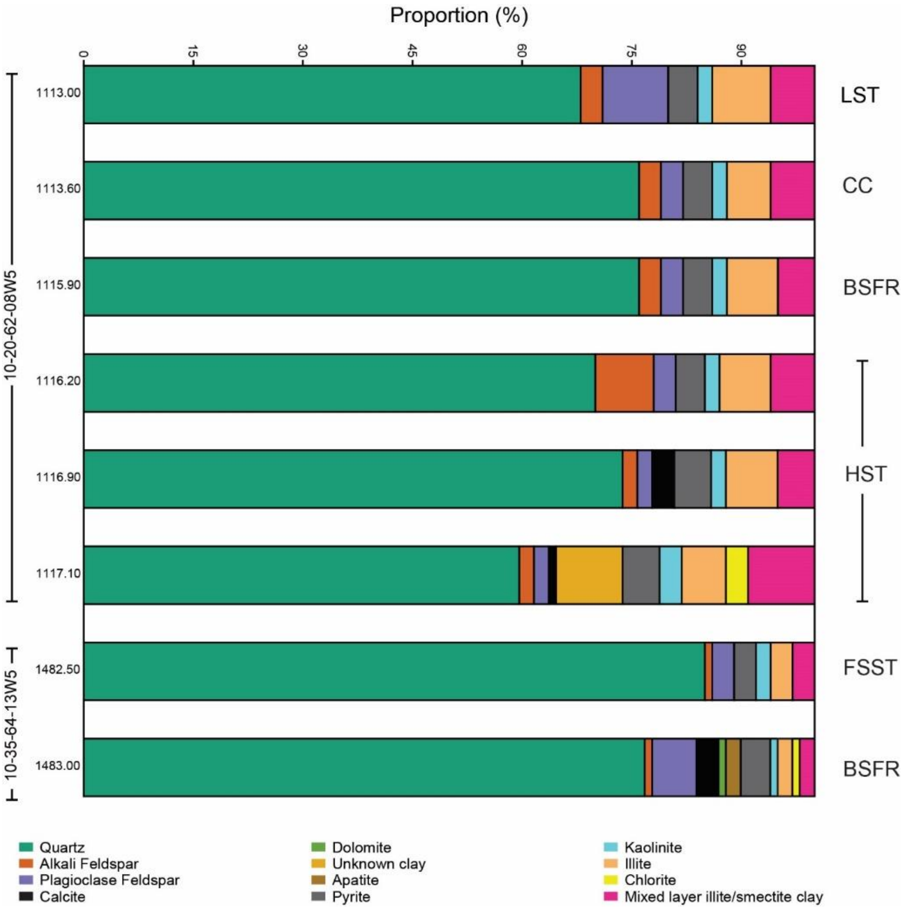

Figure 3: XRD data from the 10-20-62-08W5 and 10-35-64-13W5 cores. Samples were taken below, above and as close to the sequence stratigraphic surfaces as possible.

CONCLUSIONS

The late Albian Viking Formation serves as a case study for testing the applicability of employing geochemistry as a tool for identifying gradational stratigraphic contacts in shallow-marine successions. The basal surface of forced regression (BSFR) and correlative conformity (CC) were first interpreted in core from the Kaybob and Judy Creek fields based on changes in the sedimentology and trace fossil assemblages across subtle stratigraphic contacts (MacEachern et al., 2012). These interpretations have been subsequently tested using high-resolution XRF geochemical data collected across the proposed contacts.

These results demonstrate that geochemical trends can provide supporting evidence for identifying these stratigraphic surfaces, particularly in successions where lithological contrasts are subtle. Variations in elemental abundances across the proposed contacts dovetail with the changes in sedimentology, grain size and trace fossil suites observed in core, suggesting that shifts in sediment supply and depositional processes associated with forced regression and subsequent lowstand normal regression are reflected in the geochemical record. These trends were further evaluated using XRD at select Viking Fm intervals at Judy Creek, confirming mineralogical changes associated with the proposed surfaces.

Although the geochemical signatures are subtle, the integration of these datasets improves confidence in recognizing the BSFR and CC in the Viking Formation. This approach provides a useful supplementary tool for identifying gradational sequence stratigraphic surfaces in shallow-marine successions where traditional sedimentological facies criteria alone may be ambiguous.

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Sedimentology and Reservoir Facies Heterogeneity of the Basal Belly River Oil Play, Wilson Creek, Alberta

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ABSTRACT

A detailed sedimentologic description was conducted on 312m of siliciclastic sedimentary facies in slabbed cores of the Basal Belly River from 21 wells in the Wilson Creek study area as part of a broader investigation into the lateral variability and heterogeneity of reservoir properties and net pay determinations. Calibrations to down-hole log suites and core analysis data was conducted for each core. Significant surfaces of allo- and autocyclic origin were calibrated to downhole logs as part of the construction of a sequence stratigraphic framework.

Seven sedimentary facies are interpreted to have been deposited in 12 environments of a mixed wave-fluvial dominated deltaic depositional system. All observed facies are a product of combined wave, tidal and fluvial processes of deposition and occur within two main facies associations: Deltaic and Marine. Paleo-strandline morphology and gross thickness of deltaic and marine facies are a function of sediment supply, relative sea-level and wave reworking of fluvial deposited sediment. A regional sequence stratigraphic framework was established employing sedimentologic observations from core that sub-divides the Basal Belly River Fm. into five stratigraphic units, termed BR-0 to BBR-4, of which three occur in the Wilson Creek area (BBR-0, 1 and 2). All three units are erosionally bounded by maximum regressive surfaces.

A relative reservoir quality determination was made for all cored sedimentary facies based on porosity and permeability as observed in routine core analysis, open-hole log measurements and thin section petrology. Within BBR-0 and BBR-1, greatest reservoir quality is associated with: 1.) lowstand systems tract, distributary channel chert arenite, a carbonaceous VF-M grained sandstone characterized by flaser and ripple laminations, planar cross-bedding and variable amounts of cryptobioturbation with 5-20% porosity and 0.1-15md Kmax, best displayed in the 7-8-43-8W5 core in BBR-0; and 2.) lowstand systems tract, delta front chert sublitharenite, a mostly massive-appearing to bioturbated VF-M grained sandstone with robust traces of *Macaronichnus*, resedimented plant detritus on bedding plane surfaces and diffuse planar cross-bedding with 4-15% porosity and 0.1- 2.5md Kmax. An example of this facies association will be displayed from the 102/6-34-42-6W5 core in BBR-1. The latter is the principal target of horizontal drilling in the Wilson Creek study area. In contrast, hummocky

cross-stratified shoreface facies are typically densely calcite cemented with permeability rarely exceeding 1.0md Kmax, as exemplified in the 8-29-43-4W5 core from the BBR-2 stratigraphic unit. Calcite cementation is not limited to these facies but is attributed to paleo-fresh and- saline water mixing interfaces within reservoir quality rock. Petrophysical observations, thin section petrology and calibration of routine core analysis suggests that bioturbation plays a significant role in preserving a greater component of primary porosity and enhancement of vertical permeability. As would be expected in deltaic depositional systems, a high degree of facies heterogeneity is observed in core and cross-section correlations. The greatest degree of lateral and vertical facies variability is attributable to distributary channel sandstone incision into delta front sandstones creating vertical reservoir continuity yet lateral facies discontinuity.

STUDY AREA LOCATION AND GEOLOGIC SETTING

The Wilson Creek strike area is one of several prolific Belly River pools in south-central Alberta. Others include Ferrybank, Pembina and Brazeau River in a subregional area (T39 - T50; R24W4 -16W5) where 16,900 Belly River penetrations have been correlated (Figure 1). Historically, and until recently, play development was focused on conventional reservoir intervals through vertical drilling. Over the past few years, stratigraphic units with unconventional reservoirs have become the target of horizontal drilling for oil and natural gas liquids. In that regard, Lotus Creek has had a significant involvement advancing the play. The focus of investigation for this study is a 15-township area at Wilson Creek bounded by T41-43, R4W5 - R8W5 (Fig. 2). Recent horizontal drilling in the Belly River Fm. has been mostly in the northwest quadrant of the study area and in close proximity to previously producing Belly River vertical oil wells. Well results of particular note include the Lotus Creek Hzl 15-15-42-5W5 drilled in the BBR-1 stratigraphic unit with an IP (1st 100 days) of 660bbls light oil and 1.18MMCFD gas.

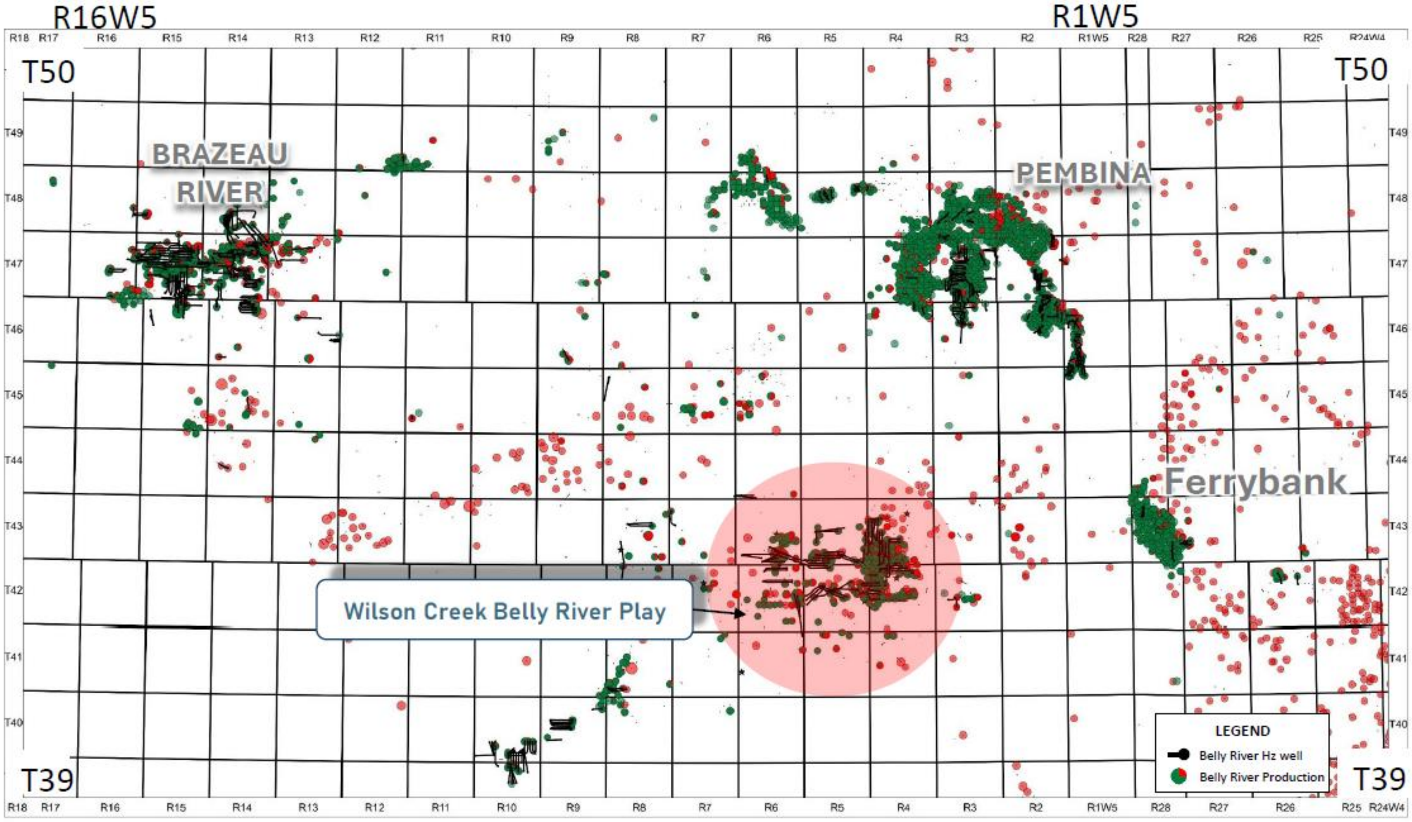


Figure 1. Region of interest in south-central Alberta showing major Belly River pools and plays. There are over 16,960 Belly River penetrations in this map area. Wells with Belly River gas (red) and oil (green) production are shown. This investigation is focused on the Wilson Creek strike area (shaded in red).

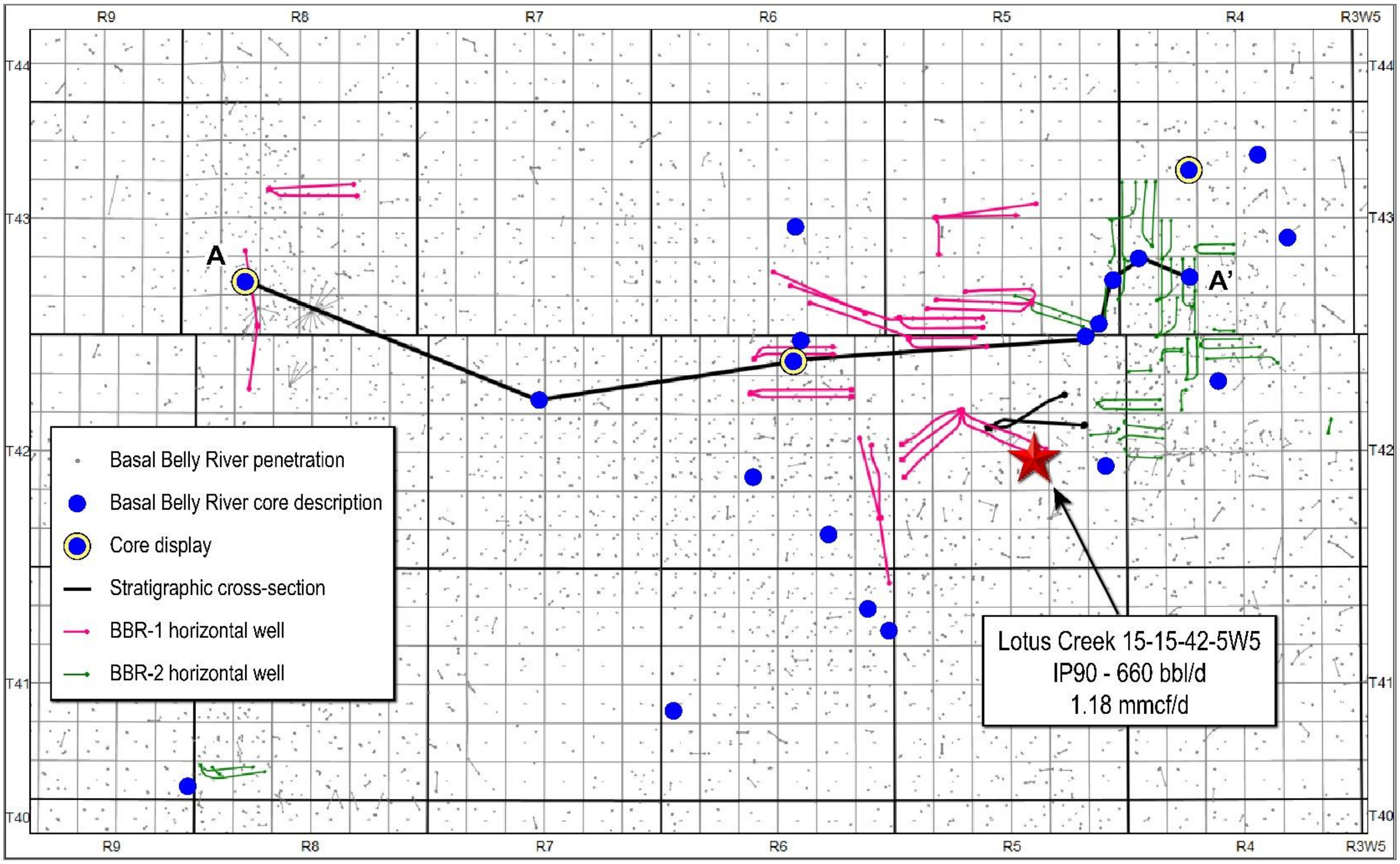
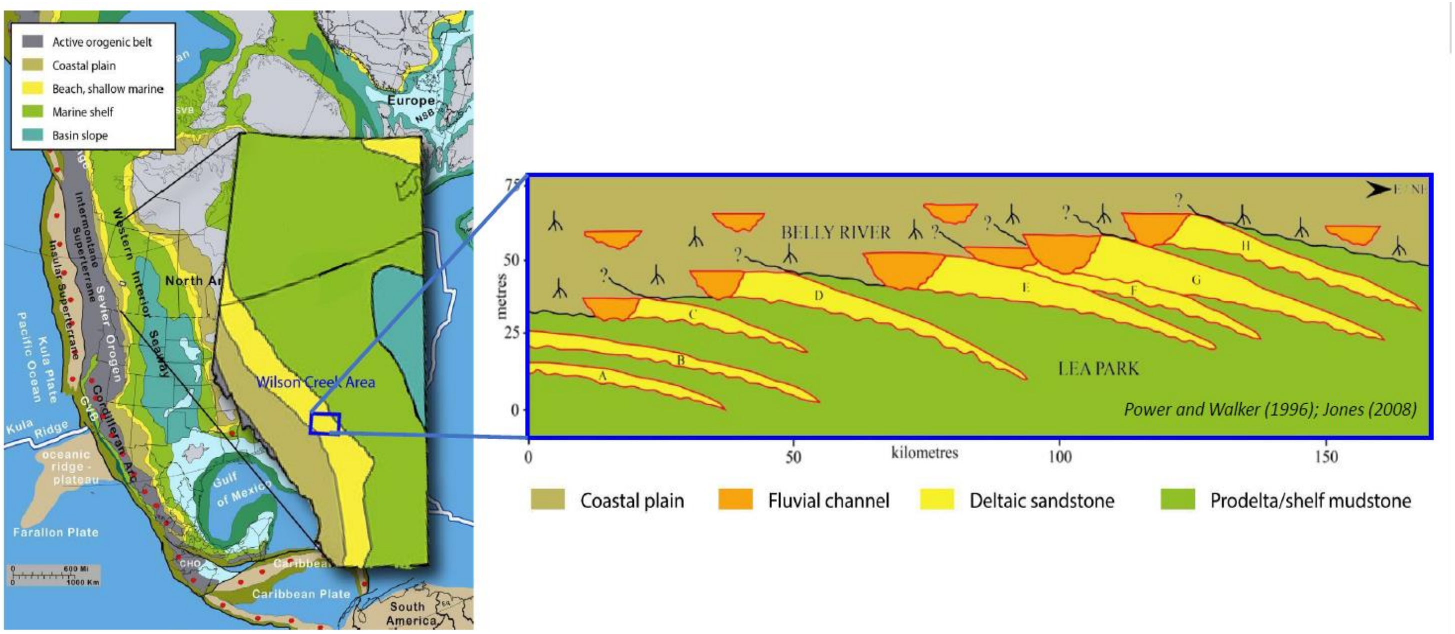


Figure 2. Map of the Wilson Creek study area showing Belly River penetrations, vertical and horizontal producing wells and location of the 21 wells with Belly River core described as part of this study. The three cored wells chosen for display are also shown along with the orientation of cross-section A-A' (see Fig. 6).

The Belly River Formation was deposited during the late Cretaceous (Lower Campanian) approximately 80Ma on the western margin of the Western Interior Seaway with a northwest-southeast shoreline orientation (Fig. 3). The Basal Belly River (BBR) succession consists of deltaic (delta front, delta plain, distributary channel) and shallow marine (shoreface, offshore transition) deposits that rapidly prograded eastward with limited aggradation. Due to a low accommodation setting in the late Cretaceous of south-central Alberta, these shoreline sandstone units tend to amalgamate, requiring careful and detailed correlation work to separate and map them individually. Based on regional correlations and mapping complemented with detailed sedimentological core descriptions from 21 wells in the Wilson Creek area (Fig. 2), we have constructed a depositional history and built a sequence stratigraphic model for the BBR shoreline units. Our work builds on previously constructed Belly River stratigraphic frameworks especially those of Power and Walker (1986) and Jones (2008) which subdivided the Belly River regionally into eight unconformity bounded Allomembers (A to H) of deltaic origin (Fig. 3).

SEQUENCE STRATIGRAPHIC FRAMEWORK AND REGIONAL FACIES ARCHITECTURE

In this study, the loosely defined "Basal" Belly River Formation is subdivided into three sequence stratigraphic units termed BBR-0, BBR-1 and BBR-2 (Fig. 4). The focus of this investigation, as well as recent horizontal drilling at Wison Creek, is on the BBR-1. Due to the low accommodation setting during Basal Belly River deposition, the transition from one shoreline unit to the next can be challenging to identify on well logs attributable to the vertical amalgamation of sandstone units. To overcome this challenge, we took advantage of the large number and high density of wells with BBR penetrations to correlate over 18,000 wells in the sub-regional area (about 80 wells per township on average). Gamma ray and resistivity logs are most commonly available and were used to build a



Miall and Blakey (2019)

Figure 3. Paleogeographic tectonic map (left) of North America during the Late Cretaceous (Campanian) approximately 80 million years ago during time of Belly River deposition (from Miall and Blakey, 2019). Paleogeographic map of Alberta is superimposed showing the orientation of the Belly River shoreline (in yellow) along the western flank of the Cretaceous Interior Seaway. Schematic stratigraphic framework for the Belly River showing Allomembers A through H is shown at right (modified form from Power and Walker, 2008).

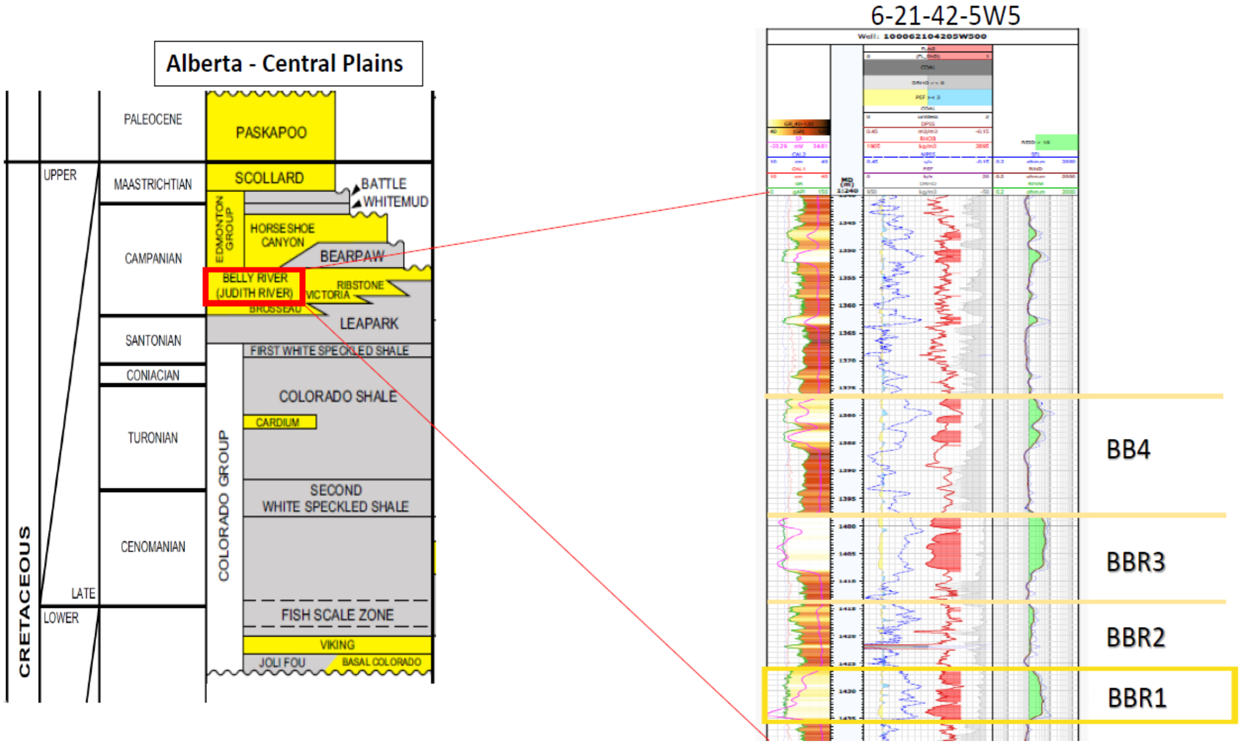


Figure 4. Stratigraphic column (left) and type well (right) for the Belly River in the Wilson Creek study area. Type well is the 6-21-42-5W5. The Basal Belly River (BBR) stratal units 1 through 4 are shown relative to the Belly River type well. The BBR1 is the focus of this investigation.

dense grid of stratigraphic cross-sections, approaching wells from multiple directions to insure consistency in correlations.

A sequence stratigraphic framework of the Basal Belly River in the study area is provided in Figure 5. Two distinct stratigraphic units are schematically represented. These sequences are bounded by laterally correlatable erosional surfaces that are readily recognizable in core and on well logs. These surfaces are interpreted as a maximum regressive surface (MRS) marking the end of the sea level fall (forced regression). A regressive surface of marine erosion (RSME) is frequently observed at the base of prograding delta front and distributary channel sandstones. RSME is a diachronous surface typically formed by wave erosion during forced regression and occasionally during normal regression in a low accommodation setting (Catuneanu et al, 2009). At the end of the forced regression, the system starts aggrading again with the development of remarkably linear shoreline deposits during a highstand of sea level.

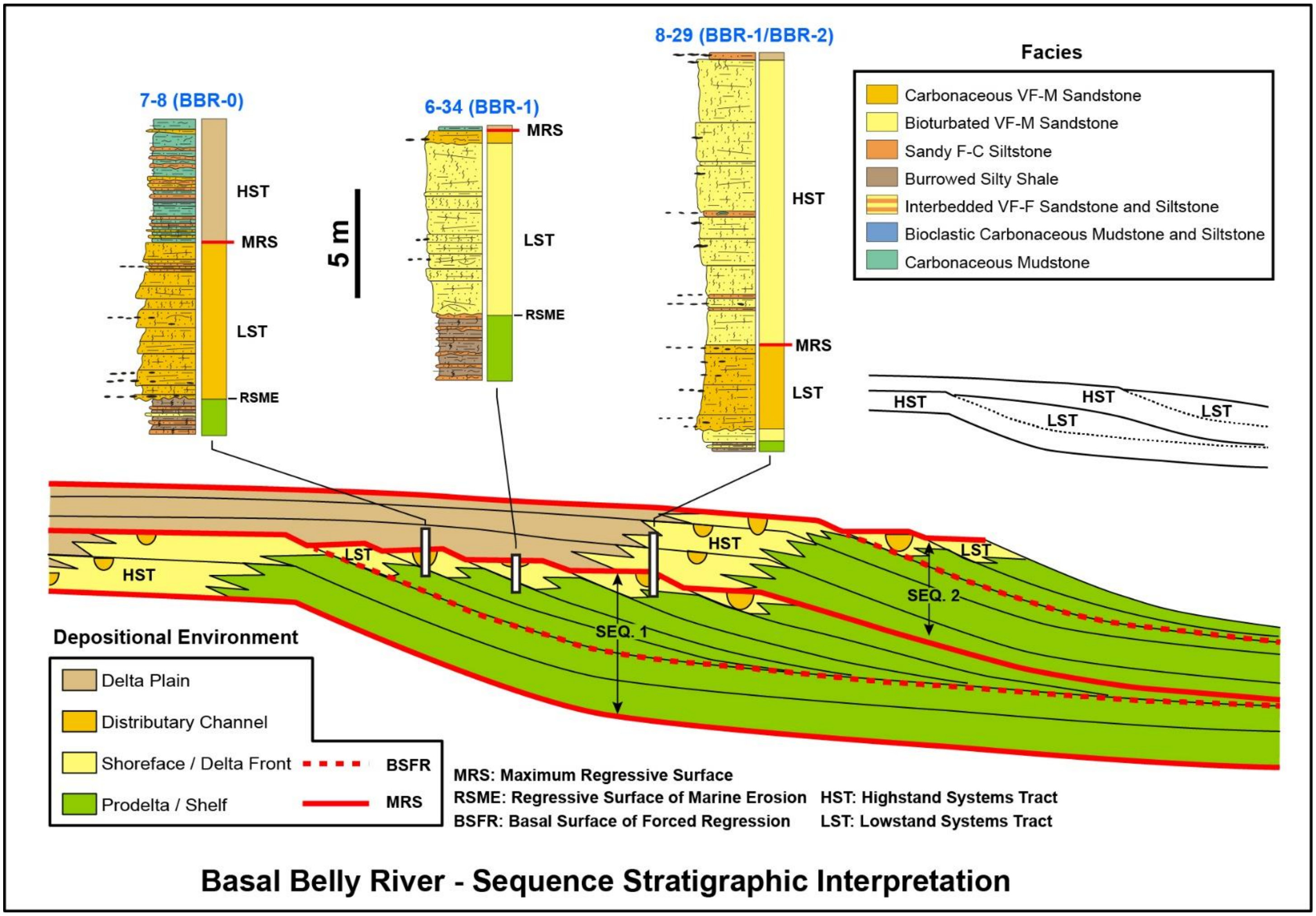


Figure 5. Schematic cross-section providing a sequence stratigraphic interpretation of Belly River units BBR-1 and BBR-2 in the Wilson Creek study area. The graphic logs and relative stratigraphic position of the three cores on display are shown for the 7-8-43-8W5, 6-34-42-6W5 and 8-29-43-4W5. Black lines denote marine flooding surfaces. In the core graphic logs, HST = highstand systems tract, LST= lowstand systems tract (Compiled by T. Euzen).

Gross sandstone isopach maps of the three correlated shoreline units reveal well-defined, north-south trending paleo-strandlines. The seaward shift of the shoreline is approximately 25 km eastward from one sequence to the next. More irregularly shaped and laterally discontinuous sandstone bodies are observed in a more distal (paleoseaward) position within each stratigraphic unit. Based on their geometry, distribution and facies analysis from core descriptions, we interpret linear shoreline sandstone bodies as strandplain to wave-dominated deltaic deposits, while irregular shaped sandstone bodies are interpreted as fluvial-dominated deltaic deposits (Fig. 6). Wave-dominated deltaic shoreline deposits form the thickest sand accumulations (up to 25 m) and are interpreted as the product of deposition in a highstand systems tract with maximum vertical aggradation and lateral continuity alongshore (N-S azimuth). Fluvial-dominated deltaic sandstone bodies are laterally discontinuous and interpreted as part of the lowstand systems tract associated with forced regression due to the low accommodation setting (Fig. 6).

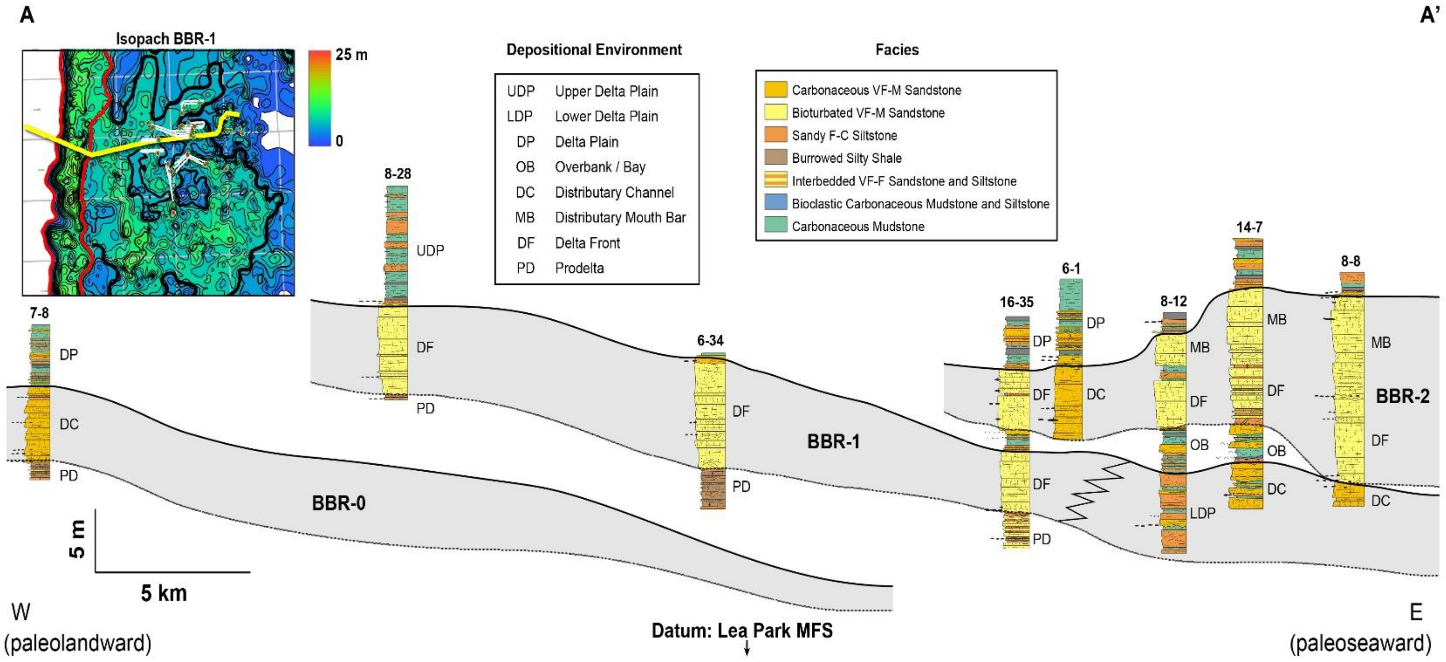


Figure 6. Sedimentologic cross-section of Basal Belly River units BBR-0, 1 and 2 showing the lateral variability of sedimentary facies associations within the study area. Paleoseaward is to the east (right). Datum is a marine flooding surface (MFS) within the Lea Park Fm. Cross-section orientation and gross isopach of the BBR-1 unit is shown to the upper left. Note the significant increase in accommodation space and parasequence thickness for the BBR-2 unit at the eastern (paleoseaward) end of the cross-section. See inset map and Fig. 2 for location. Cross-section constructed by T. Euzen.

The Basal Belly River was likely deposited over a period of about 2 My (Eberth, 2024). This means that individual shoreline units probably lasted about 200 to 400 Ky, which fits within the time scale of Milankovitch cycles and parasequences (Catuneanu et al, 2009). There is no obvious evidence from stratigraphic correlations nor in core of major transgressions. Rather, minor flooding surfaces between deltaic shoreline facies associations punctuate the overall progradational succession (see Fig. 5). Marine flooding surfaces observed on a sedimentologic basis in core descriptions seem to be associated with either deltaic avulsion and subsequent sub-regional sea level rise (autocyclic) or end of regression on a regional level (allocyclic). Sandstone body geometry as inferred from isopach maps (Fig. 6), strongly suggests rectilinear, aggrading, wave-dominated, highstand deltaic facies associations possibly influenced by longshore transport (Bhattacharya and Giosan, 2003). This deposition was followed by forced regression in the form of fluvial dominated, off-lapping, lowstand deltaic sand deposits (Posamentier and Morris, 2000).

SEDIMENTARY FACIES AND FACIES ASSOCIATIONS

All observed sedimentary facies are a product of combined wave, tidal and fluvial processes of deposition in a wave dominated deltaic depositional system. There are two main facies associations: deltaic and marine. Paleo-strandline morphology and gross thickness of deltaic and marine facies are a function of sediment supply, relative sea-level fluctuations and wave reworking of fluvial deposited sediment. The five most prevalent facies and their sedimentary characteristics and relative reservoir quality are provided in Figure 7. Prodelta deposits are densely burrowed, interbedded, lenticular to wavy bedded, sandy siltstone and carbonaceous mudstone. While there is minimal data from routine core analysis, density log response would suggest that the prodelta facies is non-reservoir. Delta front deposits are cross- to climbing ripple laminated, VF-F grained chert sublitharenite. Resedimented plant detritus is commonly observed on bedding plane surfaces and foreset laminae. Moderate reservoir quality is observed within the delta front facies of BBR-0 and BBR-1 units. Best reservoir quality occurs in the proximal delta front facies, interpreted as being deposited in a distributary mouth bar environment, and characterized by cryptobioturbated and *Macaronichnus* burrowed F-M grained chert sublitharenite. Distributary channel facies consist of normally graded beds of cross-bedded to ripple laminated and variably cryptobioturbated F-M sublitharenite sandstone with abundant carbonaceous detritus and lithic rip-up clasts. Lastly, interdistributary bay, overbank and crevasse play facies are characteristically soft-sediment deformed, heterolithic, interbedded sandy siltstone and carbonaceous mudstone with resedimented plant detritus and root traces. These deposits are also non-reservoir (see Fig. 7). Combined, and through progradational offlap, a shoaling and shallowing upward association of facies is generated (Figs. 7 and 8).

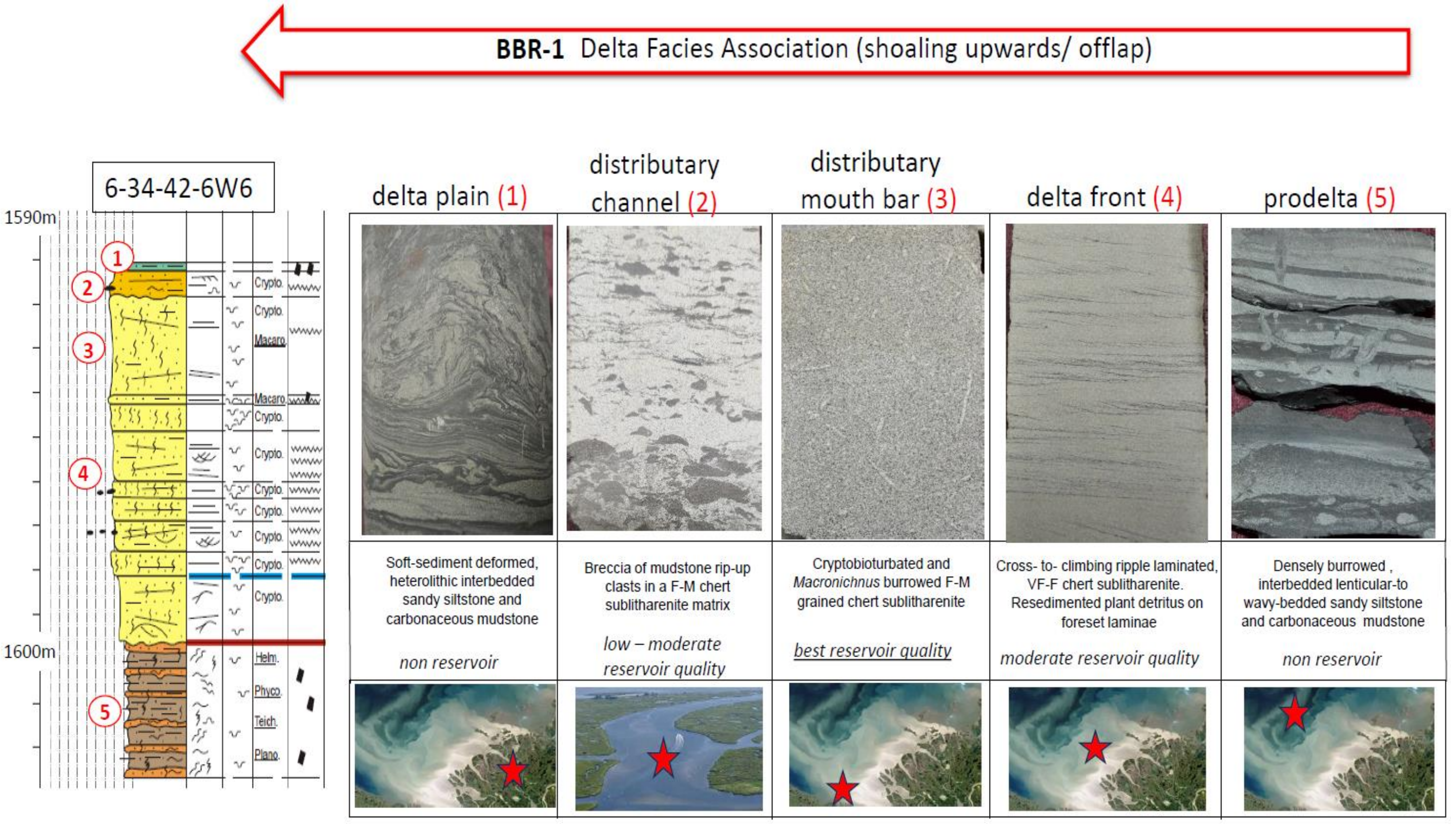


Figure 7. Mosaic of close-up core photographs showing sedimentologic characteristics of sedimentary facies in unit BBR-1 as observed in the 102/6-34-42-6W5. Facies description and relative reservoir quality are shown beneath the core photographs. Red stars in the photographs at bottom provide the relative position of depositional environments within a deltaic depositional system. Shoreline progradation and offlap has resulted in a shoaling/shallowing upwards association of sedimentary facies. Core photos by T. Moslow

There are four commonly occurring facies associations:

- Delta Front: As described above, this facies association includes distributary mouth bar, delta front, and prodelta deposits. It is dominant in BBR-1 and BBR-2 highstand systems tracts but can also be present in lowstand systems tracts.

- Distributary Channel: This includes distributary channel, abandoned channel, channel lag and distributary mouth bar (as in 7-8-43-8W5; Fig. 9) deposits. As a product mostly of channel abandonment through stream piracy and/or deltaic avulsion, this facies association yields a fining- and bed-thinning upwards succession. It is the dominant facies association in BBR-0, BBR-1 and BBR-2 lowstand systems tracts. commonly in an inter-deltaic setting and as an along-strike lateral facies transition to delta front deposits.

- Delta Plain: This facies association includes bay, overbank (levees), crevasse splay, crevasse channel, paleosol and swamp deposits. It occurs most commonly at the top of prograding delta front facies but is also present at the top of lowstand distributary channel or delta front deposits. The delta plain facies association can also occur in interdistributary areas within lowstand systems tracts.

- Shoreface: This includes both lower shoreface and offshore transition deposits characterized by planar laminated to hummocky cross-stratified VF-F grained sublitharenite sandstone (Fig. 10). Cryptobioturbation and robust traces of *Palaeophycus*, *Teichichnus* and *Planolites* are common. Reservoir quality is minimal due to dense calcite cementation associated with paleo fresh-saline water mixing interfaces. This facies association is present at the base of both lowstand and highstand systems tracts occurring most commonly in an inter-deltaic setting and as an along-strike lateral facies transition to delta front deposits.

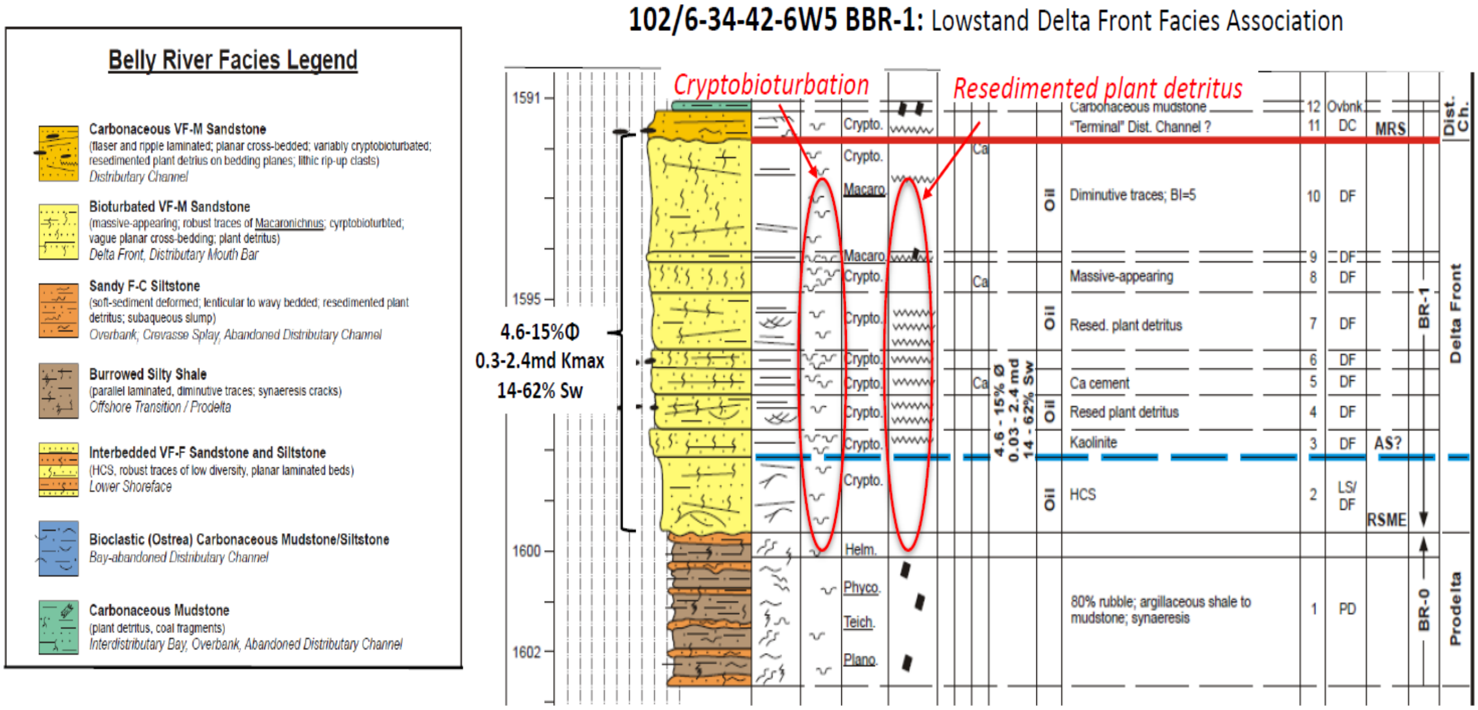

102/6-34-42-6W5 BBR-1: Lowstand Delta Front Facies Association

Figure 8. Core description graphic log of the delta front facies association in the BBR-1 strat unit in the 102/6-34-42-6W5. Note the identification of pervasive Cryptobioturbation and abundant resedimented plant detritus on bedding plane surfaces (red annotation). Facies legend is shown at left. Routine core analysis derived porosity ranges from 4.6 to 15%, permeability from 0.3 to 2.4md Kmax and Sw from 14-62%. The BBR-1 is the principal target for horizontal drilling at Wilson Creek. MRS = marine regressive surface.

7-8-43-8W5 BR-0: Lowstand Distributary Channel Facies Association

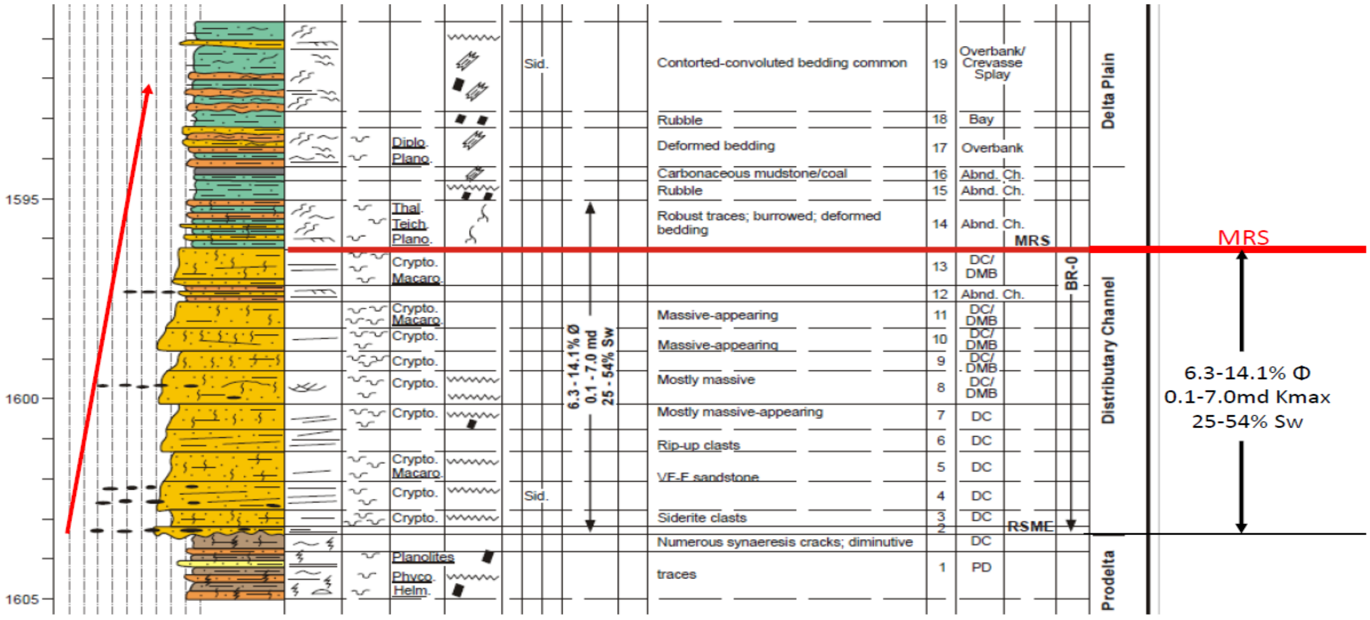


Figure 9. Core description graphic log from the BBR-0 strat unit of a distributary channel facies association in the 7-8-43-8W5. The distributary channel facies are eroded into prodelta deposits bounded by an RSME (regressive surface of marine erosion) below and marine regressive surface (MRS) above. See Fig. 8 for legend to sedimentary facies.

8-29-43-4W5 BBR-2: Highstand Delta Front Facies Association

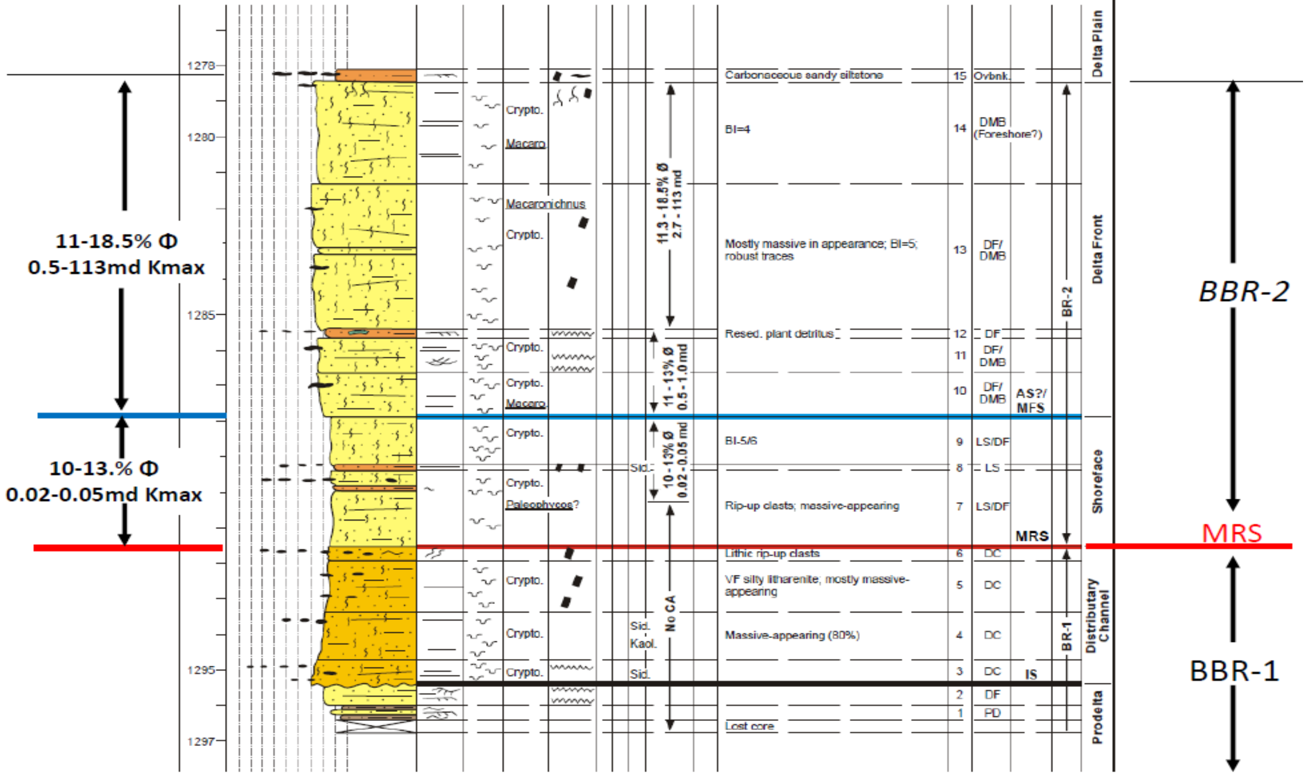


Figure 10. Core description graphic log of the BBR-2 strat unit delta front facies association in the 8-29-43-4W5. The underlying distributary channel facies association interval lies within the BBR-1. The BBR-2 unit is of conventional reservoir quality and more a target of vertical drilling. See Fig. 8 for legend to sedimentary facies. MRS = marine regressive surface.

RESERVOIR QUALITY AND FACIES HETEROGENEITY

A relative reservoir quality determination was made for all cored sedimentary facies based on primary porosity, permeability and water (Sw) vs. oil (So) saturations observed in routine core analysis, open-hole logs and thin section petrology. Moderate to good reservoir quality is associated with: 1.) BBR-1 delta front facies with a range of values between 4-15% porosity and 0.3 - 2.4md Kmax. An example of this facies association will be displayed from the 102/6-34-42-6W5 cored interval (Fig. 8). and 2.) BBR-0 distributary channel facies with a range of 6-14% porosity and 0.1-7.0md Kmax, best displayed in the 7-8-43-8W5 core (Fig. 9). In contrast, shoreface facies are typically densely calcite cemented with permeability rarely exceeding 1.0md Kmax, as exemplified in the middle one-third of the BBR-2 8-29-43-4W5 core (Fig. 10). Thin section petrology and calibration to routine core analysis suggests that cryptobioturbation plays a significant role in preserving a greater component of primary porosity and enhancement of vertical permeability.

Reservoir quality also varies significantly between stratigraphic units. This is displayed in the cross-plot of porosity and Kmax permeability data derived from routine core analysis for the three cored wells representative of BBR-0, BBR-1 and BBR-2 (Fig. 11). Unit BBR-1, exemplified by the 102/16-34-42-6W5 core, is the main target of horizontal drilling in the Wilson Creek study area and has the lowest range of porosity and permeability values. It is by comparison a low permeability and moderate porosity unconventional reservoir target. BBR-1 has a broad range of porosity values with minimal variation in Kmax permeability. Unit BBR-0 has the lowest range of porosity and permeability (Fig. 11) consistent with minimal facies heterogeneity observed in core. Conversely, the BBR-2 sequence has both the greatest range and highest values of porosity and permeability amongst the three stratigraphic units. As exemplified by the 8-29-43-4W5 core (Fig. 10), porosity and Kmax permeability values range from 3.5 -18% and 0.1 – 100md (Fig. 11) making it the most common vertical well target in the Wilson Creek study area. Worthy of note is that the range of porosity and permeability values for the same reservoir facies, delta front and distributary channel sandstones, vary proportionately amongst the three stratigraphic units and in descending order from BBR-2 to BBR-1 (Fig. 11).

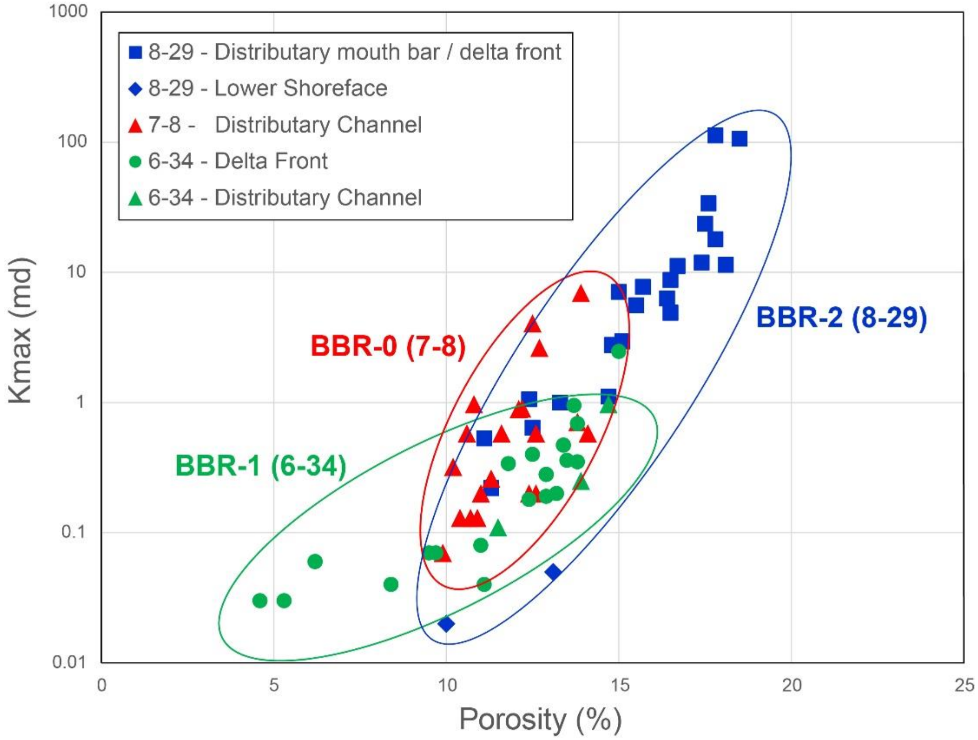


Figure 11. Cross plot of routine core analysis derived porosity and Kmax permeability for the three cored wells on display in the BBR-0, BBR-1 and BBR-2. Note that reservoir facies are identified by color coded symbols for each cored well. The BBR-1stratigraphic unit in the Wilson Creek area routinely has the lowest range of porosity and permeability values and is therefore a target of horizontal drilling and multistage hydraulic fracturing.

On a sedimentary facies level, the distributary channel sandstone in the 7-8-43-8W5 well is F-M grained and slightly coarser than the VF-F grained delta front sandstone in the 102/6-34-42-6W5 core. Both are moderately sorted. Hence porosity preservation and pore throat apertures may be greater in the 7-8 due to a coarser grain size. Petrographically the 7-8 distributary channel facies is prone to chert grain dissolution and precipitation of chlorite. Chlorite is observed to rim chert and other framework grains which inhibits silica quartz overgrowth cement and hence greater preservation of primary porosity and permeability. This has been observed in other Belly River reservoir sandstones regionally. Thus, diagenesis plays a role in explaining the observed contrast in reservoir facies quality of facies in the BBR-0 and BBR-1.

A high degree of facies heterogeneity is observed in both core and cross-section correlations for all three stratigraphic units. The greatest degree of lateral and vertical facies variability is attributable to distributary channel sandstone incision into delta front sandstones creating vertical reservoir continuity yet lateral facies discontinuity. This is best displayed in the correlation of core descriptions and their relation to downhole logs of the 16-35-42-5W5 and 6-1-43-5W5 wells (Fig. 12). As observed in the BBR-2 unit, a distributary channel facies association in the 6-1 well occurs on the same horizon as a delta front facies association in the 16-35 well. This lateral facies change occurs over a distance of 750m which is well within the reach of most, if not all, horizontal wells drilled in the Basal Belly River Fm. It should be expected that such lateral variability in facies is the norm, not the exception, consistent with the variability of depositional environments in a deltaic depositional system. In all three stratigraphic units, delta front and distributary channel facies associations display similar thickness and relative reservoir quality. Thus, while lateral variability in sedimentary facies is to be expected, lateral and vertical continuity in reservoir parameters should be the norm in Basal Belly River horizontal wells at Wilson Creek.

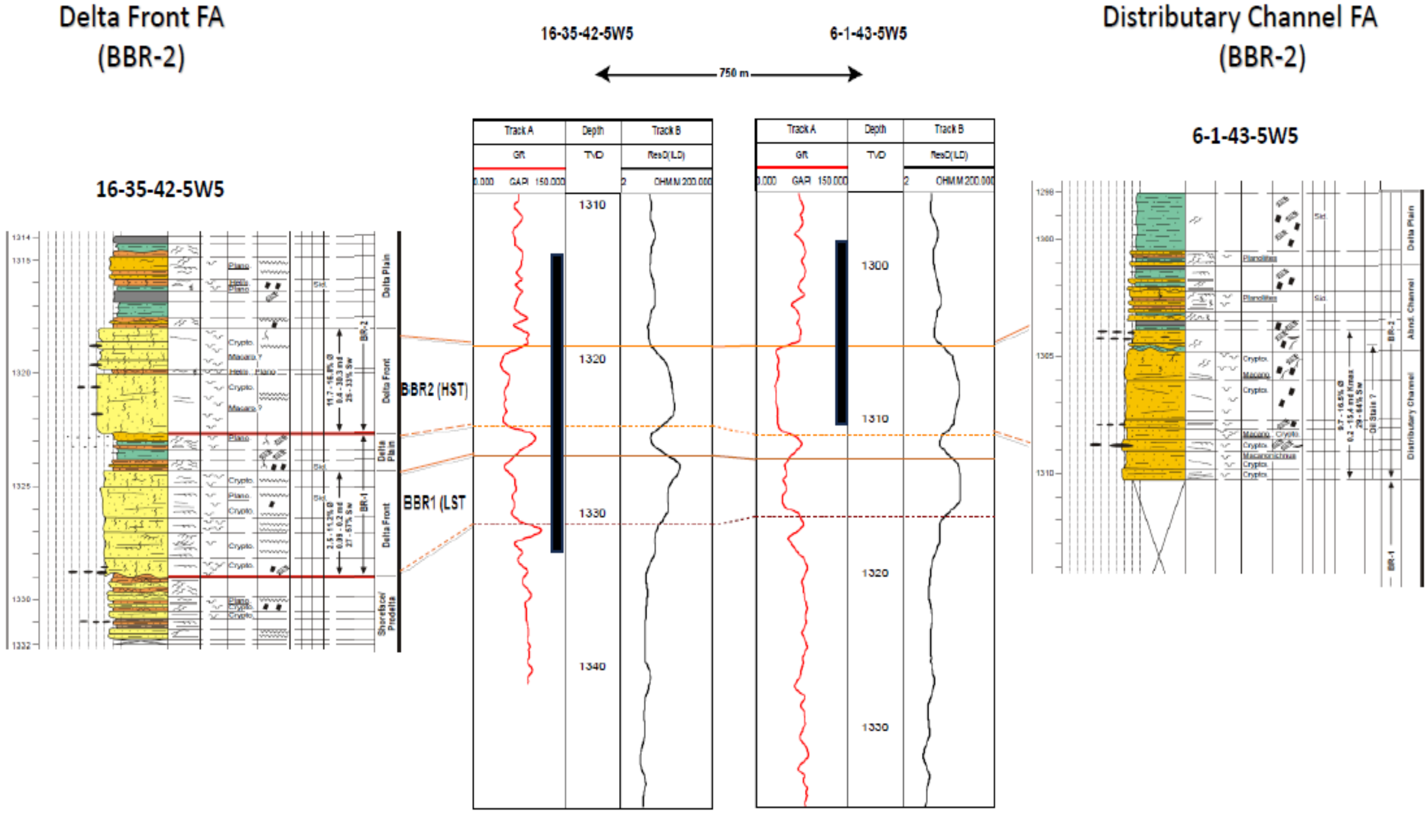


Figure 12. Correlation of the core descriptions and calibrated downhole logs between two wells in relatively close proximity (750m) within the BBR-2. The lateral variability of delta front and distributary channel facies associations (FA's) attests to the heterogeneity inherent to the Belly River stratigraphic units. This lateral distance is well within the reach of most Belly River horizontal wells in the Wilson Creek study area. Core interval indicted by black bars on well logs. (Compiled by T. Euzen).

PETROGRAPHY

Detailed descriptions were conducted on approximately 50 thin section samples from cored wells of the Basal Belly River within the study area. Based on these results, sedimentary facies are classified as sublithic arenite, lithic arenite and chert-dominated chert arenite. Dominate reservoir framework grains include detrital monocrystalline quartz, cryptocrystalline chert and feldspars (mainly albite) (Fig. 13 A, B). Matrix clays are significantly low. Reservoir quality is closey linked to facies mineralogy and composition. Moderate to good reservoir quality, as determined by higher effective porosity and permeability, is observed within chert-rich, medium- to lower coarse-grained sandstones which occur most often in the disitributary channel and delta front facies (Fig. 13A). In contrast, fine-grained sublithic arenites are associated with the poorest reservoir quality and occur most commonly within the shoreface and offshore transition facies.

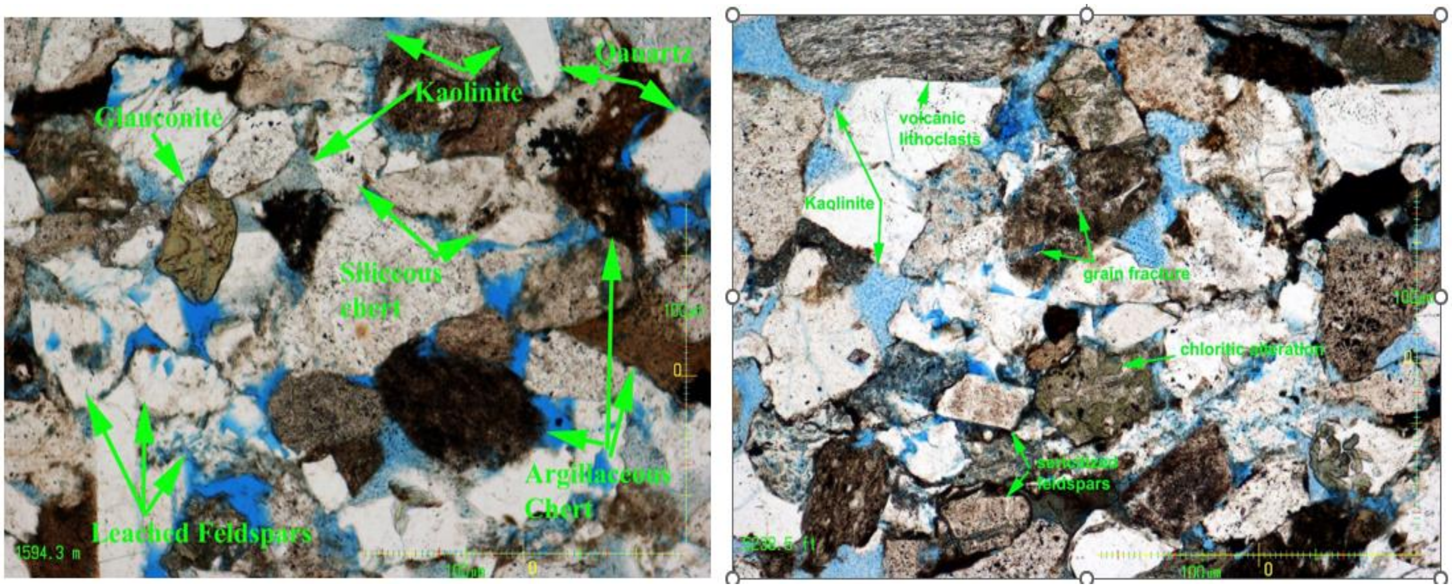


Fig. 13A (left). Thin section photomicrograph of BBR-1 delta front facies in the 02/6-34-42-6W5 core (1594.3m). Rock type is chert arenite with framework grains of chert (dark brown and beige), detrital quartz and feldspar (white) and volcanic and metamorphic lithoclasts. Authigenic minerals are dominated by pore-filling kaolinite (milky white; top middle). Grain dissolution in chert is replaced by chlorite clay. Note well preserved intergranular (effective) porosity (blue epoxy), mainly preserved around chert grains. Relative reservoir quality is considered good to moderate (13.4%Φ, 0.47md Kmax. (photo by A. Iqbal). B (right). Thin section photomicrograph of BBR-0 distributary channel facies in the 7-8-43-8W5 core (1602.6m) . Rock type is chert sublitharenite with framework grains of quartz, chert, feldspar and volcanic and minor volcanic and metamorphic lithoclasts. Leaching of feldspars and micas resulted in precipitation of authigenic pore-filling kaolinite. Grain dissolution in chert is replaced by chlorite. There is only a minor component of intergranular (effective) porosity (blue epoxy), mainly preserved around chert grains. Relative reservoir quality is considered good (14%Φ, 7.0md Kmax. (photo by A. Iqbal).

Burial diagenesis has altered the original sedimentary fabric of sandstone lithofacies and thus played an important role in enhancing, or diminishing, reservoir quality. Feldspars dissolved due to meteoric water flushing at a shallower burial depth. Noticeable amounts of authigenic kaolinite and chlorite clays formed after framework grain dissolution This dissolution created secondary porosity and the precipitation of authigenic, pore-filling kaolinite (Fig. 13B). Petrographic observations suggest that feldspars are a more common constituent in shoreface facies and less common in delta front and distributary channel sandstones. Supporting XRD analysis in select wells indicates that even in relatively clean sands total clay volume can be in the range of 10-30% volumetrically. Allogenic illite-mica usually makes up only 10-30% of the total clay volume. The other 70-90% of total clay is attributed to authigenic chlorite and kaolinite in which kaolinite is the dominate fraction.

The products of late stage diagenesis also play an important role in preserving or reducing primary porosity and permeability. For example, chlorite coatings are observed to help preserve intergranular (effective) porosity by inhibiting the precipitation of silica cement and mitigating the negative impacts of sediment compaction. Also, silica cement is observed less commonly within chert- rich, sandstones. Authigenic albite and calcite cement are minor components in general. However, thin beds cemented with calcite and/or volumetrically minor siderite were observed throughout the studied samples.

PETROPHYSICS

Petrophysical log plots were generated for all the cored wells in the study area, an example of which is provided for the BBR-1 delta front facies association in the 102/6-34-42-6W5 well (Fig. 14). Vertical wells with open-hole logs were dominantly drilled for deeper targets often resulting in poor borehole quality. This impacted log measurement accuracy and utility, especially over non-reservoir shalier zones. Sandstone density porosity measurements were often noticed to underestimate core porosity due to: a) dense mud invasion; and b) average grain densities exceeding the normal 2650 kg/m3 sandstone matrix density. Within the general Wilson Creek area, the average mud density used at the time of logging exceeds 1100 kg/m3 and the average core grain density is approximately 2670 kg/m3 as derived from available core analysis over the BBR1 and BBR-2. The dense mud invasion together with higher grain density could lead to the originally logged sandstone density porosity being underestimated by 20%. This is not evident in the 102/6-34 well (Fig. 14), but the higher-than-normal sandstone grain densities are seen. Additionally, the presence of gas has been noted to impact the original sandstone density porosity as is evidenced in the 8-29 well which is a BBR-2 gas producer.

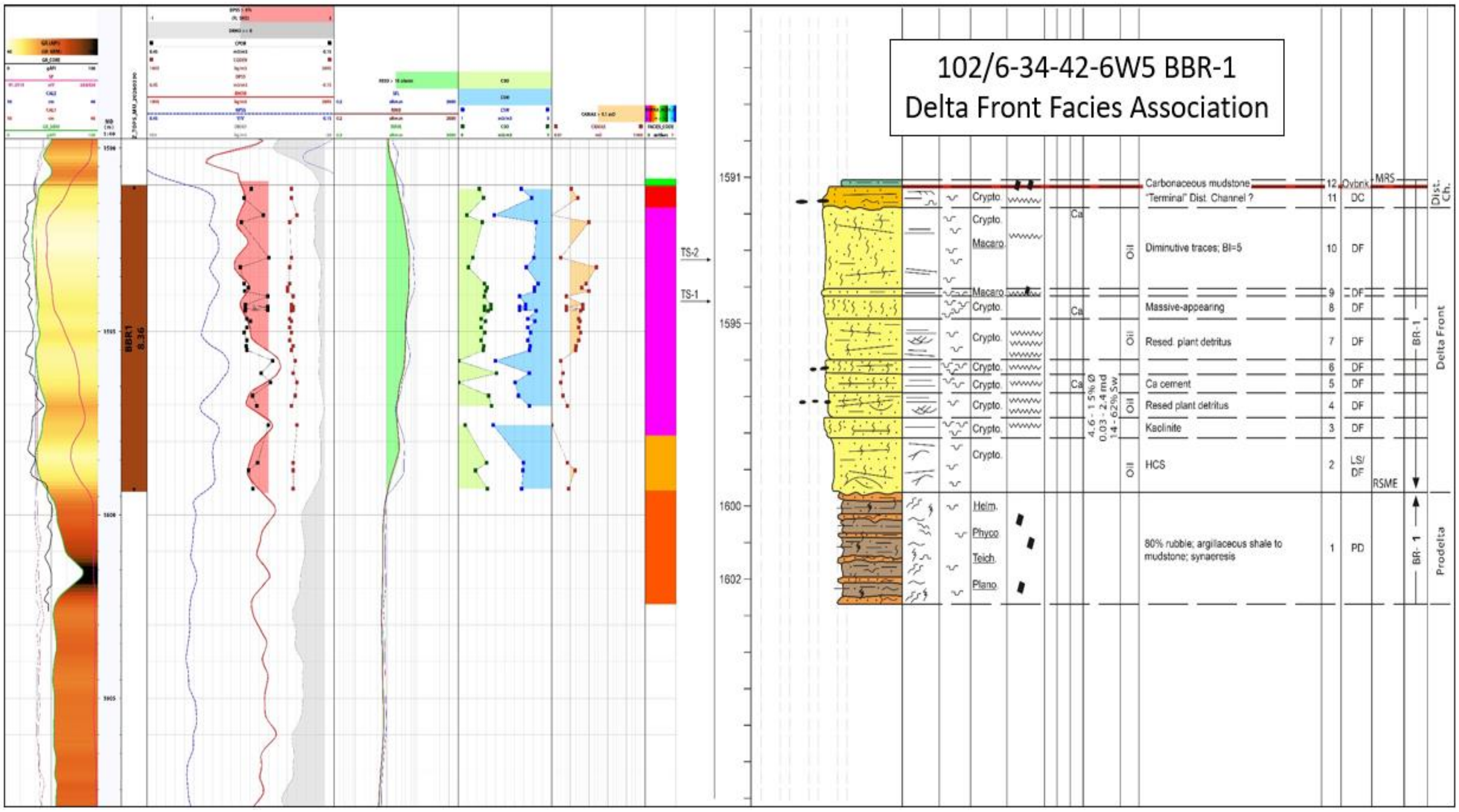


Figure 14. Calibration of the 6-34-42-6W5 core description graphic log (right) to the generated petrophysical log highlighting the reservoir characteristics for the BBR-1 delta front facies association. From left to right the petrophysical log displays core gamma and SP (track 1), density log and core porosity (track 2), induction log (track 3), core analysis derived oil-water saturations (track 4), Kmax (track 5) and calibrated facies color code (Track 6). (Compiled by D. Baldree).

Core-derived water and oil saturations have been measured over the BBR-0, BBR-1 and BBR-2 intervals. These saturations aren't always reliable due to many core capture, exhumation, fluid volatility, handling, cleaning and measurement methodology issues. Nonetheless, these saturations are notionally indicative of what's in the subsurface prior to disturbance. Most of the core water saturations are in the range of 20-60% with the mean being 44%. Most of the core oil saturations are in the range of 0-30% with the mean being 14%, excluding zero values. Horizontal wells placed in the BBR-1 reservoir facies in and around Lotus Creek Exploration's acreage have not produced any formation water due to placement in the up-dip position within the overall BBR-1 stratigraphic trap. The BBR-2 wells produce formation water where development has occurred in close proximity to the down-dip water leg. On its own, the BBR-1 core water saturation mode is 32% versus the BBR-2 core water saturation mode of 44%. It is reasonable to assume that water saturations are irreducible in reservoir rock when they are equal to or less than 30-40%. The lowest core water saturations in the Basal Belly River, by statistical modes, are associated with the distributary mouth bar, delta front and distributary channel facies.

The highest core permeabilities, based on statistical means, were associated with coarser grained sandstones within the overall deltaic complex, the same sandstones associated with the lower water saturations noted above. Core-measured reservoir facies permeability within the BBR-0, BBR-1, and BBR-2 is firstly a function of current pore throat sizes and their distributions. However, the initial controlling factors to primary permeability were facies-related grain size, sorting, shape and packing. In addition, mechanical and diagenetic alterations have both enhanced, through chemical dissolution, and reduced permeability through compaction and precipitation of authigenic clays, quartz, and calcite within primary porosity. Though core permeabilities can get as high as approximately 100mD, in the Wilson Creek area they dominantly range from 0.05 to 10mD; the BBR-2 has a higher average permeability of 3.75md than the BBR-1 which has an average permeability of 1.04md.

DEPOSITIONAL MODEL AND MODERN ANALOGUE

Depositional models and gross isopach maps for the BBR-0 and BBR-1 highstand (HST) and lowstand (LST) systems tracts are shown in Figure 15. Wave-dominated processes of deposition prevail during progradational offlap and aggradation during the BBR-0 and BBR-1 highstand systems tract. A strandplain depositional system prevailed during the evolution of BBR-0 which resulted in a remarkably linear, north -south oriented gross sand isopach that defines the orientation of the paleo-strandline. The lowstand systems tract of BBR-0 was dominated by down-stepping during sea-level fall and prevalence of fluvial-dominated deltaic sedimentation (Fig. 15). As observed in gross sand isopach, the geometry of distributary channel and delta front sandstones is highly irregular and non-linear. BBR-1 highstand systems tract was also dominated by wave processes of deposition. However, and in contrast to BBR-0, deltaic sedimentation prevailed. Facies examination in core infers that deltaic sedimentation occurred in a series of mixed wave- and fluvial- dominated deltas. Relative sea-level rise resulted in an increasing accommodation space and subsequent aggradation of parasequences. A morphologic modern analogue to BBR-1, albeit finer grained, is provided from the central Louisiana coastline in Figure 16. The Atchafalaya and Wax Lake deltas have prograded rapidly into the Gulf of Mexico over the past 50 years and are dominated by fluvial sediment input (Van Heerden and Roberts, 1998). Reworking from wave and storm processes however have yielded an overall lobate geometry, similar to the geometry of deltaic sand bodies inferred in gross sand isopach map of the BBR-1 highstand systems tract (Fig. 15). Conversely, fluvial dominated processes of deposition prevailed during BBR-1 lowstand systems tract. Relative sea level fall and subsequent decrease in accommodation space resulted in down-stepping of shoreline parasequences.

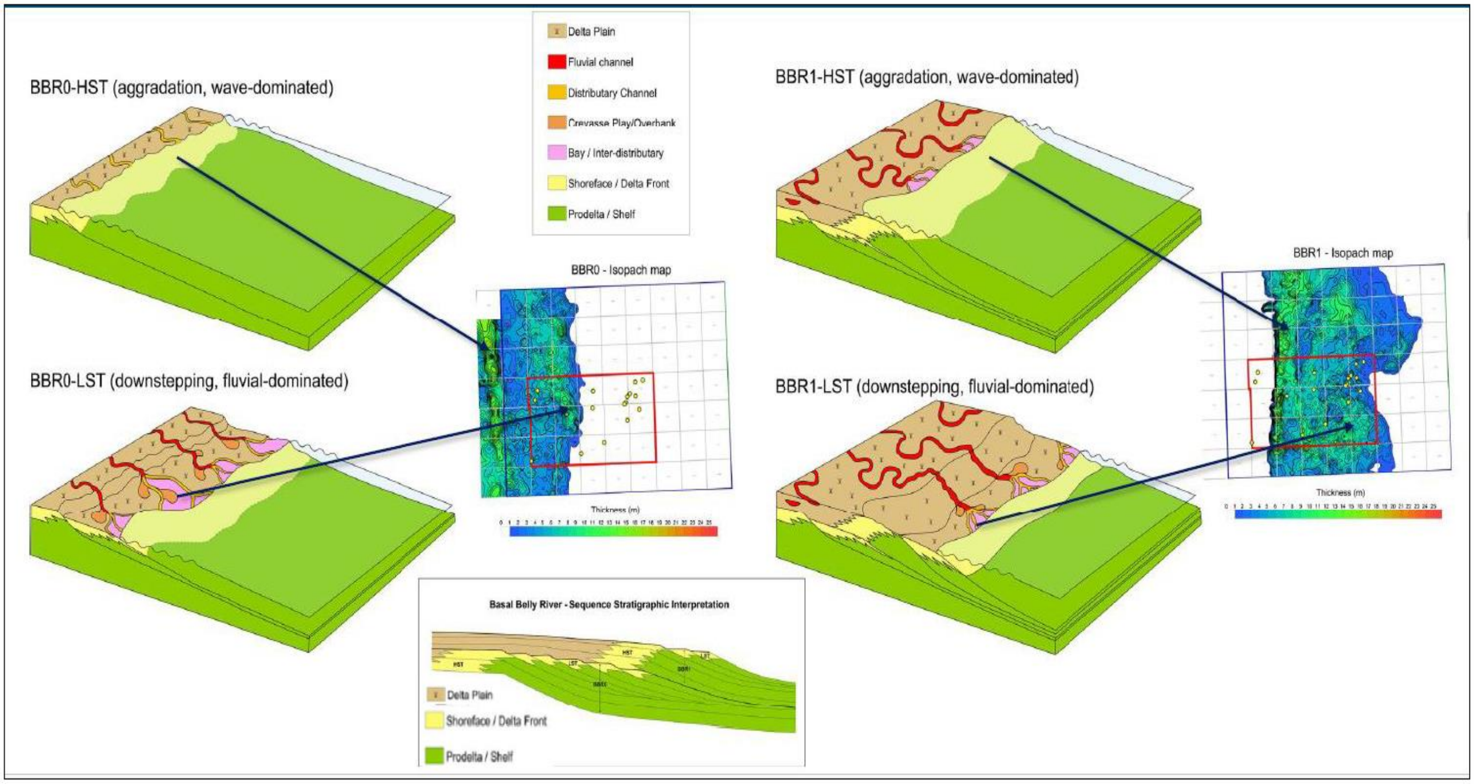


Figure 15. Depositional models and gross isopach maps for the BBR-0 and BBR-1 highstand (HST) and lowstand (LST) systems tracts. Facies legend is provided at top of diagram. Wave-dominated processes of deposition prevail during progradational offlap. Relative sea-level rise results in an increasing accommodation space and subsequent aggradation of parasequences. Conversely, fluvial dominated processes of deposition prevail during relative sea level fall and subsequent decrease in accommodation space and down-stepping of shoreline parasequences.

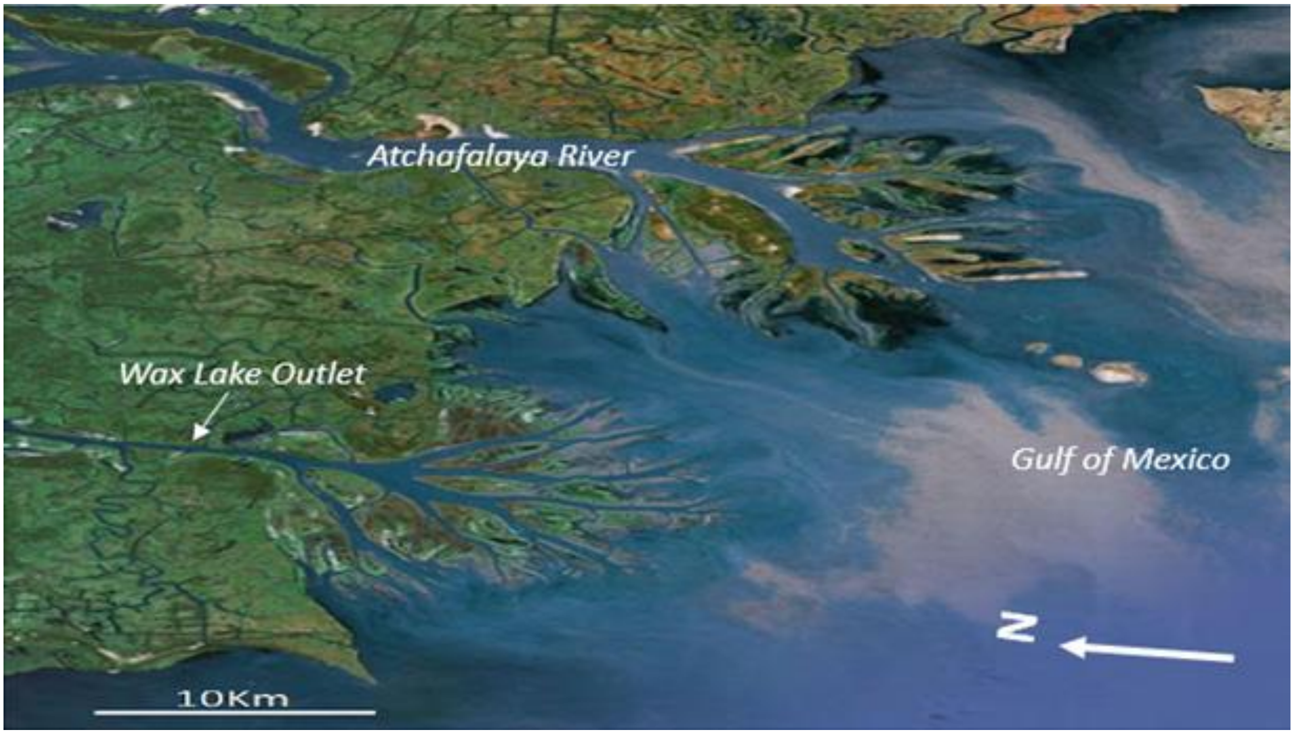


Figure 16. Satellite image of the Atchafalaya and Wax Lake river deltas, southwest Louisiana. Both are examples of fluvial-to wave-dominated deltas that serve as potential modern analogues to the BBR-1 highstand system tract facies associations (see Fig. 15). Both deltas are approximately the size of one township. (source Google Earth Pro).

ACKNOWLEDGEMENTS

The senior management of Lotus Creek Exploration is thanked for their permission to publish the results of this investigation. Lukus Wagstaff at the AER Core Research Centre, and Jackie Urban and Cory Twemlow of AGAT Laboratories are thanked for their professionalism in the transport and slabbing of all cores examined in this study.

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Traveling Turbidite: The Herrera Sandstone Member – A Deep-Water Middle Miocene Turbidite System, Central Block, Trinidad

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The Central Block is situated within Trinidad's Southern Basin and is the largest onshore gas field spanning 6,699 acres. The block comprises three established fields, Carapal Ridge, Baraka, and Baraka East, with a total of 4 wells currently producing ~15 mmscf/day, and a gas facility capable of processing 80 mmscf/day. At surface, the Central block occurs within the Ortoire Syncline and is flanked by the NE-SW trending Penal/Barrackpore/Balata Anticline to the north, and by the Lizard/Rock Dome Anticline to the south. Buried within the Ortoire syncline is the Middle Miocene Carapal Ridge anticline. Seismic imaging and mapping defines the Carapal Ridge as a thrust-fault stacked anticline which is dissected by down-to-the-east extensional tear faults, creating a stair stepping effect as you move eastward, setting up the three established fields. Some of the thrust faults that formed these anticlines extend well into the Cretaceous-aged source rock providing the migration pathway from the source to the overlying reservoirs. Hydrocarbons remain trapped within these reservoirs by a combination of structural and stratigraphic trapping mechanisms. Vertical and lateral seals are provided by the thick overlying clay formations. The three established fields in the block target, and currently produce from, the Herrera sandstone member of the Cipero Formation, a Middle Miocene deep-water turbidite deposit that has been described from 90.85' of core cut in the Carapal Ridge-2 (CR-2) well. Outcrops of the Herrera sandstone are extremely rare and not well exposed, which significantly increases the value of the CR-2 core.

Altogether, 17 lithofacies and 6 facies associations were recognized in the core. The depositional processes recorded comprise a range of high-density and low-density gravity-driven processes operating in a deep-water setting. The core is dominated by meter-scale, 'blocky' sandy turbidites, with minor sandy and muddy debris-flow deposits, and muddy turbidites. The dominant lithofacies seen in the CR-2 core are moderately to well sorted, lower fine grained, horizontal planar-laminated sandstone (Sp), with subordinate very fine to lower fine grained current-rippled sandstones (Sr and SMr).These sandstones were deposited from low-density ('classical') turbidity currents, lateral to the main channelised depositional fairway. When the current decelerated to a critical point, sand began to settle to the base of the flow, increasing the sediment concentration to a point where conditions were no longer fully turbulent. Most of the sediments (Sp and Sr) record tractional shearing of sediment that was no longer supported within the flow but instead settled to the base to form a concentrated bedload layer. Some of these sediments were subsequently deformed by fluid escape (Sd), disrupting the original lamination. In some cases, sediment fallout at the base of the flow was sufficiently rapid to raise the sediment concentration to a point where tractional shearing was suppressed. Sands deposited by such flows therefore lack tractional bedforms or lamination (Sm), although subsequent fluid escape is locally observed (Sf), mainly recorded by thin silty laminae. The turbulent base of a turbidity current is typically overlain and followed by a less concentrated flow containing clay and silt that has separated from the more energetic, sandy head of the turbidite. This low-concentration flow spills out of channels to deposit muddy turbidites. Such deposits are dominated by current-rippled, very fine sandstones and siltstones and poorly-stratified mudstones, forming a variety of heterolithic intervals (SMs2 (h,p and r) and MSs(h and r)). The deceleration of muddy flows may increase the sediment concentration of muddy turbidites and suppress turbulence, forming a range of more highly-concentrated density flows. Such flows have sufficient matrix strength to support entrained clasts, forming muddy debris flow deposits. In the cored interval, weakly stratified, heterogeneously banded, internally deformed siltstones are seen that occasionally contain mudstone or coal pebbles (Mh and MSh). Siltstones and claystones present in the core are occasionally seen to be laminated (Mp and Cl), although it is commonly difficult to recognize such features in the mudrocks due to their swelling response to water. Some of the mudrocks are heterogeneous, wispy-laminated and internally deformed (Mh) and are interpreted as non-cohesive muddy debris flow. Occasional bioturbation in these deposits by *Planolites*, *Nereites*, *Scolicia* and *Chondrites* indicates that the sea floor was generally oxygenated, allowing opportunist colonisation by a deposit-feeding infauna. Most of the mudrocks are weakly to non-bioturbated, perhaps because sediment accumulated too rapidly to allow more intense burrowing to develop.

During the Middle Miocene, based on published tectonic maps, the sea-floor in the Trinidad area was likely deformed by active thrust faults forming ENE-oriented depressions that were linked up-dip into ESE-oriented transfer faults. These depressions guided the sediment laden flows through a deformed belt of locally-emergent thrust sheets, in a narrowing basin, producing a network of depo-centers across the basin. Wireline log interpretation suggests that one of these blocky, low-GR units extended more or less unchanged across 1-2 km from SE to NW (possibly parallel to the depositional axis) and was later stacked vertically by a low-angle thrusts. Other ‘blocky’ units do not correlate between CR-1 and CR-2, suggesting that they do not have a sheet-like or SE-NW elongated geometry, and were perhaps confined within the ENE-orientated sea-floor depressions between active thrust faults.

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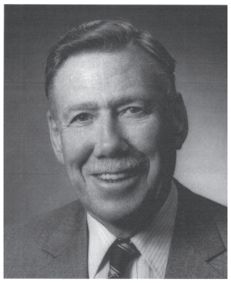
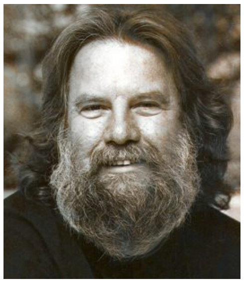


Baillie Award

The Baillie family has been involved in the upstream oil industry for over six decades. Dr. Andrew Dollar Baillie (1912-2001) was an inspiration to literally hundreds of geologists who came under his influence, however fleetingly, during his life. Andy was an active member of the CSPG and had a particular interest in the CSPG Educational Trust Fund (now the CSPG Foundation). This award is presented for the Best Student Geological Presentation at the Core Conference and consists of a $1000 prize and a commemorative trophy.



Pemberton Award

During his career, Dr. Pemberton focused his research interests on animal-sediment relationships, clastic sedimentology, genetic stratigraphy, petroleum geology, and carbonate bioerosion. Dr. Pemberton was a member of 16 professional and technical organizations and was an extraordinarily active volunteer in each of them. In recognition of Dr. George Pemberton the Pemberton award is given out each year to the best core presentation at the CEGA Core Conference. The award consists of a hand crafted commemorative trophy.

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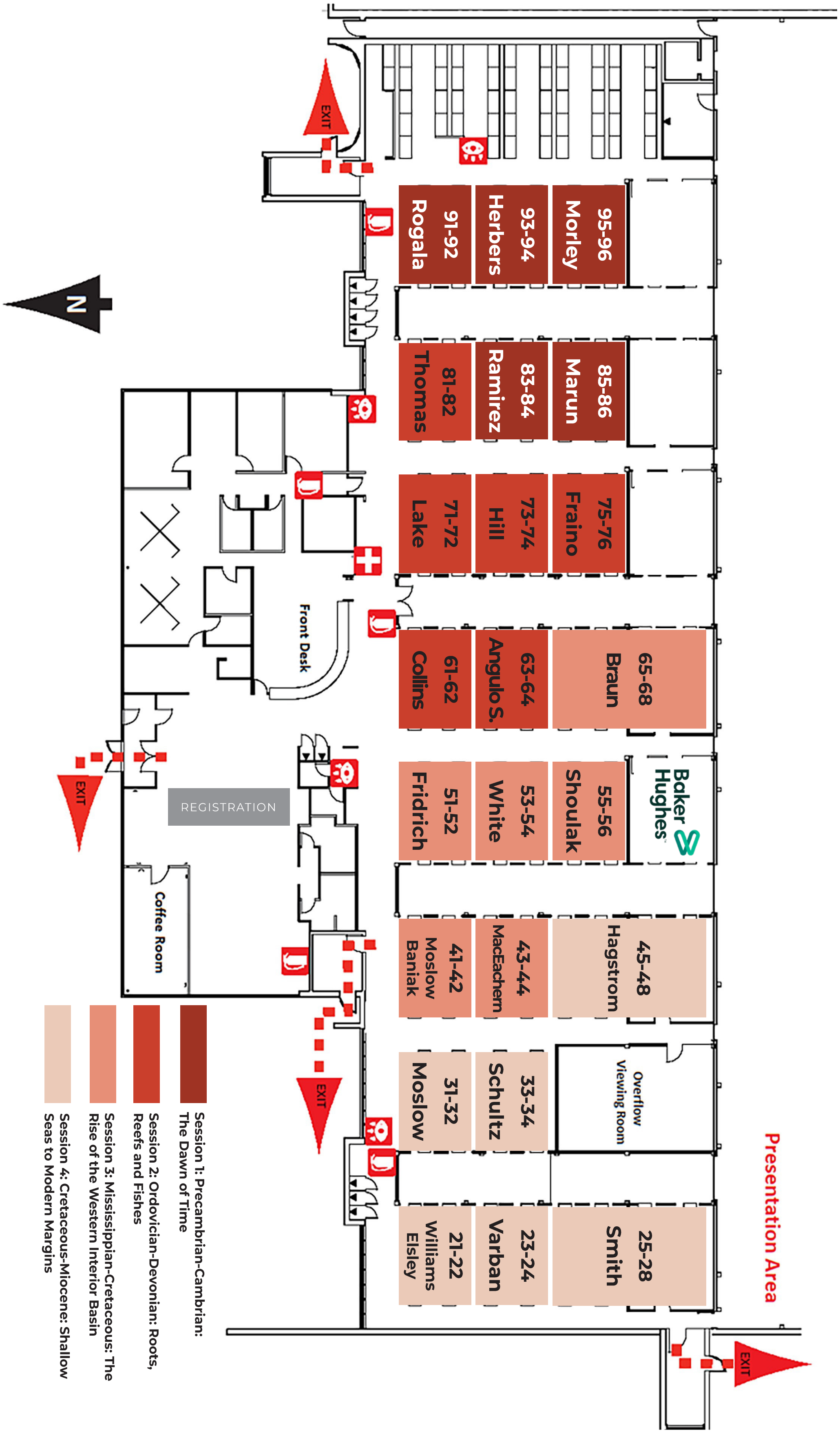

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