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Facies Architecture and Sequence Stratigraphy of the Triassic Montney Formation, Alberta Deep Basin: Fundamental Controls on the Distribution of Liquids-Rich Sweet Spots

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The Lower to Middle Triassic (Dienerian to Smithian) Montney Formation produces prolific oil and liquids-rich natural gas from stacked reservoir horizons in the Kakwa, Gold Creek, Wapiti, Elmworth, and Pipestone fields. Numerous studies (Davies *et al.*, 1997; Kendall, 1999; Crombez *et al.*, 2016; Davies *et al.*, 2018; Zonneveld *et al.*, 2018) have proposed sequence stratigraphic frameworks for the the Lower (Griesbachian-Dienerian) and Middle (Smithian) Montney Formation. The purpose of this study is to investigate the sedimentological and sequence stratigraphic controls on Middle Montney Formation reservoir geometry and distribution within the Alberta Deep Basin using high-resolution core description and XRF chemostratigraphy in the context of the four systems tract model (Plint and Nummedal, 2000; Catuneanu *et al.*, 2009).

Thirty cores from a variety of localities (Simonette, Lator, Kakwa, Karr, Redrock, Gold Creek, Wapiti, Elmworth, Bezanson, Pipestone, Wembley, and Sinclair) totalling 3000 meters were logged using an integrated ichnological and sedimentological approach to construct a facies framework. Two facies associations recording shoreface and wave-dominated deltaic deposition were identified. The Lower Montney Formation consists dominantly of offshore to shoreface sediments deposited under wave-agitated conditions with frequent storm influence. In contrast, the Middle Montney Formation contains abundant fluid mud hyperpycnites, sediment gravity-flow deposits, soft-sediment deformation, and rare syneresis cracks. Depositional environments recording relatively deep distal prodelta to more proximal, consistently wave-agitated lower delta front deposition were encountered.

High-resolution XRF measurements (~10 cm spacing) were collected from two complete Montney Formation long cores at Karr and Elmworth to evaluate geochemical changes across subtle conformable sequence stratigraphic surfaces represented by the basinal expression of the maximum flooding surface and correlative conformity. Heavy elements such as zirconium and titanium provided a proxy for detrital input with implications for potential base level changes. Calcium and magnesium provided an indicator for carbonate influence and were interpreted to record erosion and basinward transport of subaerially exposed

and karsted coquina units near the subcrop edge. Grain size estimations were inferred from the Si/Al ratio, which closely follows quartz content. Phosphorus provided a proxy for phosphate and was found to commonly track shallowing upward parasequences. Core observations showed phosphatic material was sourced from bioclastic material that becomes more abundant in shallow environments. This lends caution to the interpretation of upwelling events being the sole cause of phosphate within the Montney Formation. Integration of the geochemical data with the physical core sedimentology allowed a more precise identification and correlation of subtle sequence stratigraphic surfaces.

The Lower Montney Formation is interpreted to record deposition under shoreface conditions in the transgressive (TST) to highstand systems tract (HST). Middle Montney Formation deposition shifted abruptly into wave-dominated delta-influenced sedimentation within two sequences (one complete, one partial) recording falling stage (FSST), lowstand (LST), transgressive (TST), and highstand (HST) systems tract deposition. The base of the Middle Montney Formation is marked by a sharp, regionally recognizable unconformable contact abruptly overlain by thick (2-22 meters) wave reworked proximal prodeltaic sediment-gravity flow deposits. This contact is interpreted to be a regressive surface of marine erosion (RSME) that is equivalent to the base of the Mid-Montney coquina (Davies and Sherwin, 1997). In this context, the reservoir quality sandy sediment-gravity flow deposits above this contact are assigned to the FSST. Age equivalent incised valley systems recorded in Markhasin (1997) are interpreted to record fluvial systems on the subcrop edge incising and delivering sediment to these basinward proximal prodeltaic turbidite deposits of the FSST. Lowstand conditions are represented by a strongly progradational delta front succession (~30 meters thick) with a subtle but recognizable minor flooding surface at its base. This flooding surface is interpreted to record a coplanar correlative conformity that is equivalent to the karst surface on top of the Mid-Montney Coquina (Davies and Sherwin, 1997). Lowstand conditions are represented by distal turbidite deposition at Redrock, Elmworth, Pipestone, and Glacier-Valhalla. Subsequent transgressive conditions are represented by thin, retrogradational packages that culminate in the maximum flooding surface (MFS). Highstand conditions are represented by progressively shallower upward-coarsening parasequences recording prodelta to lower delta front environments. The HST is capped by a thin (~10 cm) distinctive sharp-based brecciated dolomitized coquina deposit inferred to be a sequence boundary/correlative conformity equivalent with the karst surface on top of the D5 coquina. This surface occurs in the uppermost 20m of the Middle Montney Formation in the more proximal areas of Kakwa, Karr, Simonette, and Gold Creek. Petrophysically it is identified by a clean gamma profile and sharp spike in the deep resistivity. This surface marks the base of the second lowstand systems tract observed in the Middle Montney Formation, and records a detached strongly progradational delta front and shoreface system that reaches its maximum thickness (~25 meters) in the Pipestone and Elmworth areas. Subsequent systems tracts within the second sequence are missing due to erosion at the Smithian-Spathian sequence boundary.

In summary, reservoir-quality rock is found in every systems tract depending on location within successive depositional systems. The most prolific Montney Formation sweet spots appear to be associated with fluvial point sources where reservoir quality and thickness is greatest. The characterization of sedimentary environments within a sequence stratigraphic framework is therefore critical to the prediction of reservoir geobody distribution and the placement of lateral wells.

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