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LOWSTAND / SLOPE-ONLAP WEDGES IN THE MONTNEY: STRATIGRAPHIC AND SEQUENCE FRAMEWORK, RESERVOIR SIGNIFICANCE

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Summary

There are at least two major lowstand wedges in the Montney in Alberta and NE BC (Figs. 1, 2). They also may be designated slope onlap wedges in the terminology of Ashton Embry (GSC emeritus, pers. comm., 2008). In this abstract, the two stratigraphically-separate slope-onlap wedges are referred to as the 'lower' and 'upper' wedges. Discussion of the stratigraphic and age placement of the wedges forces a review of the broader framework of the Montney. In an earlier publication on the Montney (Davies *et al*, 1997), focused on west-central Alberta, the first author and associates divided the Montney into Lower and Upper informal members. The Lower Montney, dated as Griesbachian-Dienerian (by mid-90's palynology alone), was bounded at top by the Dienerian-Smithian Third-Order (Embry, 1997) sequence boundary and unconformity, with eastward-increasing erosion of Lower Montney shoreface facies, overlain by thick dolocoquinas (Fig. 1). That boundary becomes a slope-onlap surface downslope to the west, overlain by a (lower) lowstand/slope onlap wedge (Fig. 2). That definition of the Lower Montney is retained in the following revision. Note, however, that sequence-stratigraphic interpretation places the Dienerian-Smithian SB at or near the top of the lower lowstand/slope onlap wedge, so that all or most of that wedge (Fig. 2) lies within the Lower Montney.

In the 1997 paper, the Upper Montney included all Montney section from the top of the Lower Montney up to the base of the phosphatic/black shale unit of the Doig (although that disagreed with the top of Montney defined in Alberta by the ERCB/AEB, but is consistent with the DEM-designated top of Montney in BC). Tentative dating (again, mid-90s palynology-based) showed that the Upper Montney, at least in west-central Alberta, was mainly Smithian in age. Also in that earlier work, a lithologically and petrophysically distinct, westward-thickening unit of laminated, phosphatic and microburrowed dolosiltstone, above the 'normal' Montney and below the phosphatic/black shale zone of the Doig in western Alberta, was designated the 'Lower Doig Siltstone' (LDS) because of its similarity in core to siltstones in the middle and upper Doig, rather than the underlying Montney. That designation is still used by the authors, and by various associates and companies. The LDS becomes a significant element of the lowstand wedge story.

With increased drilling in western Alberta and NE BC since the late 1990s, it is now apparent that there is a much thicker and more complex section in the upper part of the Montney in those areas, beyond that originally included undivided in the 'Upper Montney' of west-central Alberta. Many companies now adopt a 'Middle' Montney division between the Lower and Upper Montney, although boundaries often vary by geographic area and company.

Although no new biostratigraphic work on the Montney has been done by the first author since the mid/late 90s, use of other sources and reviews of the major Triassic sequence boundaries in Alberta and BC with Ashton Embry (pers. comm., 2015, 2016) have clarified stratigraphic relationships. The dominantly Smithian-aged Montney section from the top of the Lower Montney to the base of the Doig (to east) or base of the LDS (west: Fig. 2) now is placed in the *Middle* Montney. The boundary at the top of this Middle Montney unit now is recognized as the global Third Order Smithian-Spathian (Embry, 1997)

unconformity and SB (but without biostratigraphic dating). To the east, it may be marked by spectacular Montney-clast conglomerates; downdip/downslope to the west, this boundary becomes a slope-onlap surface, overlain by a (upper) lowstand wedge or slope-onlap wedge (Fig. 2).

With this change to *Middle* Montney up to the Smithian-Spathian boundary, all Montney section above that boundary to the base of the phosphatic zone of Doig is placed in the *Upper* Montney (Fig. 2). Because sequence-stratigraphic interpretations place the Smithian-Spathian SB for the upper wedge in westernmost Alberta and NE BC at or near the top of the wedge, the upper wedge by definition is part of the Middle Montney. With these revisions, the Lower, Middle and Upper divisions of the Montney fit within the three unconformity-bounded global Third-Order sequences of the Lower Triassic (Embry, 1997), a logical outcome.

Within this revised subregional framework for the Montney, the two main lowstand wedges now may be defined stratigraphically and (tentatively) by age. Applying sequence-stratigraphic 'rules', the stratigraphically-lower wedge south of the arch (Figs. 1, 2) probably is latest Dienerian in age. This wedge is confined between paleohighs underlain by Leduc reefs of the southern margin of the arch and the Gold Creek trend to the north, and the Simonette trend to the south (Fig. 1). Most log and core control for this early Smithian wedge comes from long cores through the entire Montney drilled by Seven Generations Energy in the extended Karr-Kakwa area (Fig. 1) and by other companies. The updip subcrop thin/pinchout of this wedge trends through T67 to 69, R1 to 2W6 (Fig. 1), but although a west-facing arcuate edge is expected, it has not yet been fully mapped out. Westward, the wedge reaches thicknesses (cored wells only) in the 70 m range. In many but not all cores in the lower wedge, the base of the wedge is marked by multiple event beds of cleaner dolosiltstone to sandy dolosiltstone correlative with a distinct cleaner gamma spike, and often with distinct density and resistivity responses. This basal silt/sand may be less than a metre thick (multievent) to many metres thick, becoming a productive turbidite or turbidite-like* target in the general Karr-Kakwa area, deposited classically at the toe of slope of the underlying slope (*there are many bedform anomalies in this base-wedge section). Internally, the wedge preserves a complex but often subtle, high frequency record of coarsening-up and fining-up fine-textured parasequences in variable progradational to retrogradational stacking patterns. Burrowing at parasequence tops/transgressive bases generally increases eastward as the wedge thins, shallows(?) and becomes more oxygenated. High/highest TOC values (with a few exceptions) typically occur in the wedge section, compared with overlying Montney facies.

In the Karr-Kakwa-Economy Creek area south of the arch (Fig. 1), the lower slope-onlap wedge is overlain by a distinctive 8 to 10 m thick unit of laminated dolosiltstone (Fig. 2), variably with small burrows, and with a rare but persistent synsedimentary shear structure that has rarely been recorded by the first author in any other Montney core other than the LDS (directly overlying the other major wedge in NE BC). This laminated siltstone unit is placed in a highstand depositional setting. In most cores in the extended Karr-Kakwa area, this laminated dolosiltstone unit is overlain sharply by the base of a thick interval of storm-wave dominated (HCS) event beds (the 'D2b' marker of CDL-GDGC report usage), the lower part of which has been the principal target for horizontal drilling in this area, at least in the earlier stages of exploration.

The second major (upper) lowstand/slope onlap wedge in the Montney (Figs. 1, 2) is thickest in NE BC, with a subcrop edge (below the LDS) in westernmost Alberta but following a westward-facing, paleostructurally-controlled arcuate trend around the Peace River block area (Fig. 1), and probably offset or influenced paleostructurally by the Hay River Fault Zone (HRFZ: Fig. 1). Within the revised sequence stratigraphic framework, this upper wedge is dated tentatively as latest Smithian, and thus, part of the Middle Montney. The wedge increases in thickness westward in NE BC, and (depending on top picks on logs) reaches thicknesses in the 30 to 80m range. Although no turbidites have been identified within this wedge to date (at least by the first author), they are an expected component of a lowstand wedge from a sequence-stratigraphic standpoint. There *may* be correlative turbidites in outcrop on the Rocky Mountains(?). Of direct reservoir significance, the Dawson Creek burrowed sandstone-siltstone play in NE BC lies within the thinned updip margin of this upper wedge (Fig. 2), where it is partly localized by

paleostructure and sediment sources connected to the western extension of the Ft. St. John Graben (and possibly other structural elements), best documented by third-order residual structure mapping.

The LDS overlies the upper wedge in NE BC at a boundary typically marked by a skeletal-granular phosphatic lag. The LDS, as for the very similar unit above the lower Smithian wedge south of the arch, is placed into a highstand systems tract. Eastward, beyond the pinchout edge of the upper wedge, the LDS overlies eroded *Middle* Montney section, and thins both depositionally and erosionally below the overlying Spathian-Anisian unconformity. Rare distal HCS bedforms occur in the LDS interval as it thins eastward into Alberta.

In overall summary, recognition of the two lowstand/slope onlap wedges in the Montney, and progressive unraveling of the complexities of the Montney and Montney-Doig transition by many people and organizations, contribute to the evolving understanding of this productive formation and its exploration potential and prospects.

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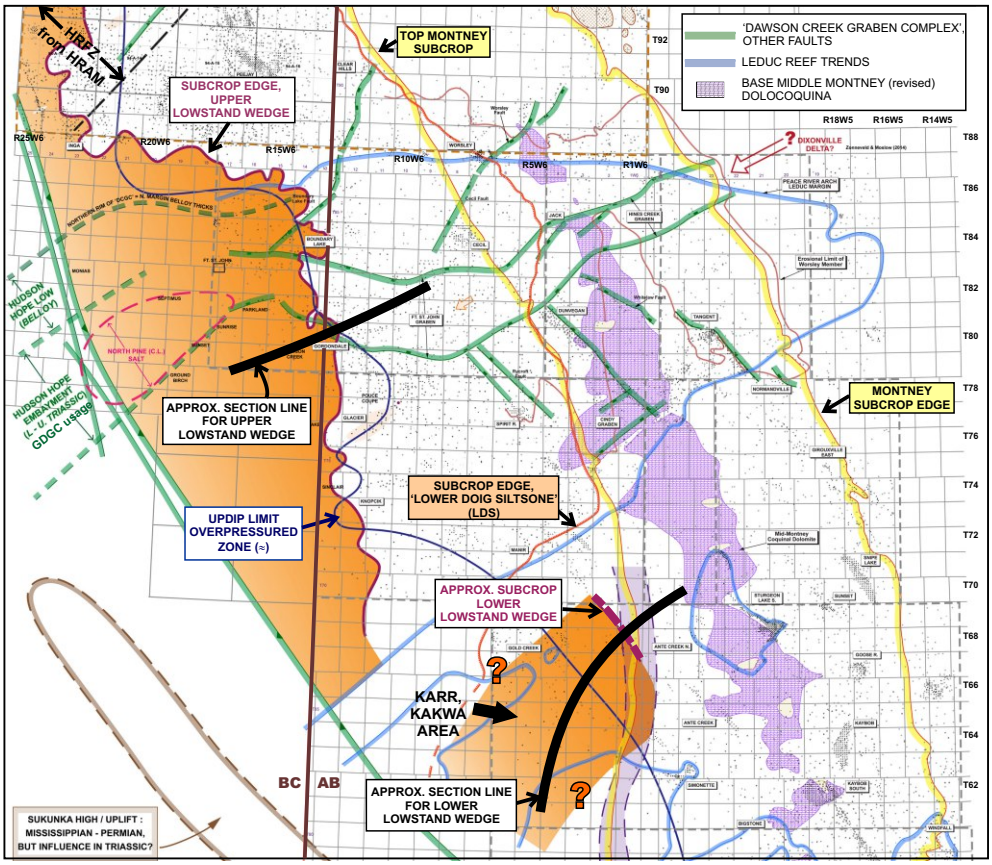

Fig. 1 Structural and depositional elements for area centred on Peace River arch and vicinity in west-central Alberta to NE BC, showing location of 'lower' and 'upper' lowstand / slope onlap wedges. Base map from GDGC Regional Montney Facies Map based on 1994-1998 Montney projects.

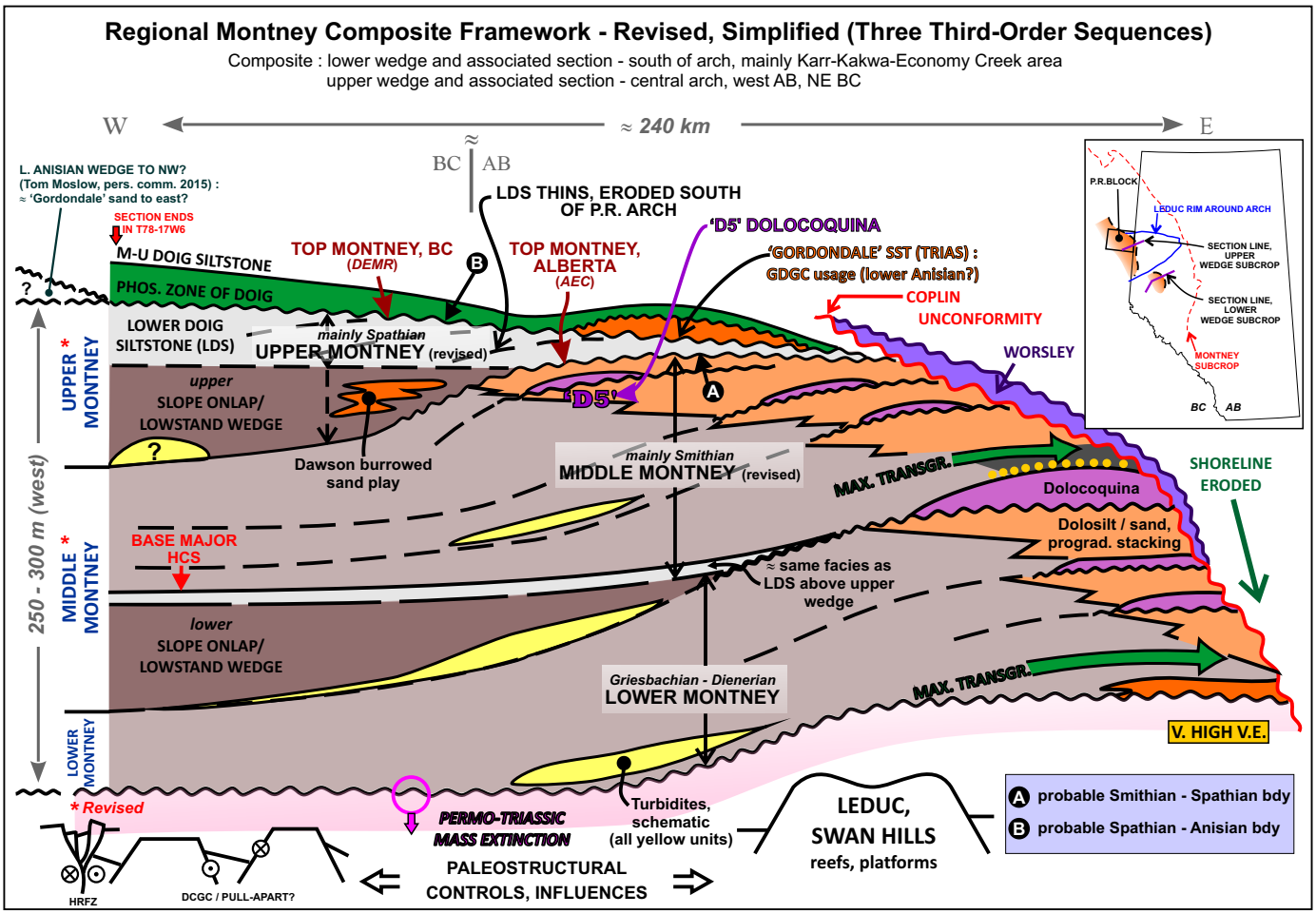

Fig. 2 Schematic regional Montney composite stratigraphic and sequence framework, using revised subdivision nomenclature based on three Third-Order sequences, and showing general relationships for lower and upper lowstand / slope onlap wedges.