geoconvention
Calgary • Canada • May 12-14 2025

Cambrian Carbonate Transgressive-Regressive Cycles in the Southern WCSB

Greg Lynch[1], Patricio Desjardins[2]
1-Atlas 2027, 2-Shell, Houston

Abstract

Within the southern portion of the Western Canada Sedimentary Basin (WCSB, Mossop et al., 1994), spanning south-central Manitoba-Saskatchewan-Alberta and westward into the Canadian Rockies (Figure 1), the principal sequence-stratigraphic cycles for the Cambrian are defined for the first time, with work directed toward updating results from Atlas 1994 (Slind et al., 1994). Here the paleogeography of the Cambrian features a large multi-storied carbonate bank running along a north-south axis, separating the open ocean to the west (Panthalassa) from an inland sea rimmed with a sandy shoreline onlapping crystalline basement to the east. Extensive well log coverage across the extent of the basin, widespread core, as well as outcrop exposures and good map coverage in the mountains provide an abundance of data for discerning the stacking architecture of the principal transgressive-regressive cycles, maximum flooding surfaces, and sequence boundaries. Furthermore, Cambrian biostratigraphy and trilobite zonation demonstrate the diachronous nature of lithostratigraphic formations, with equivalent timelines running across contrasting proximal and distal facies groupings.

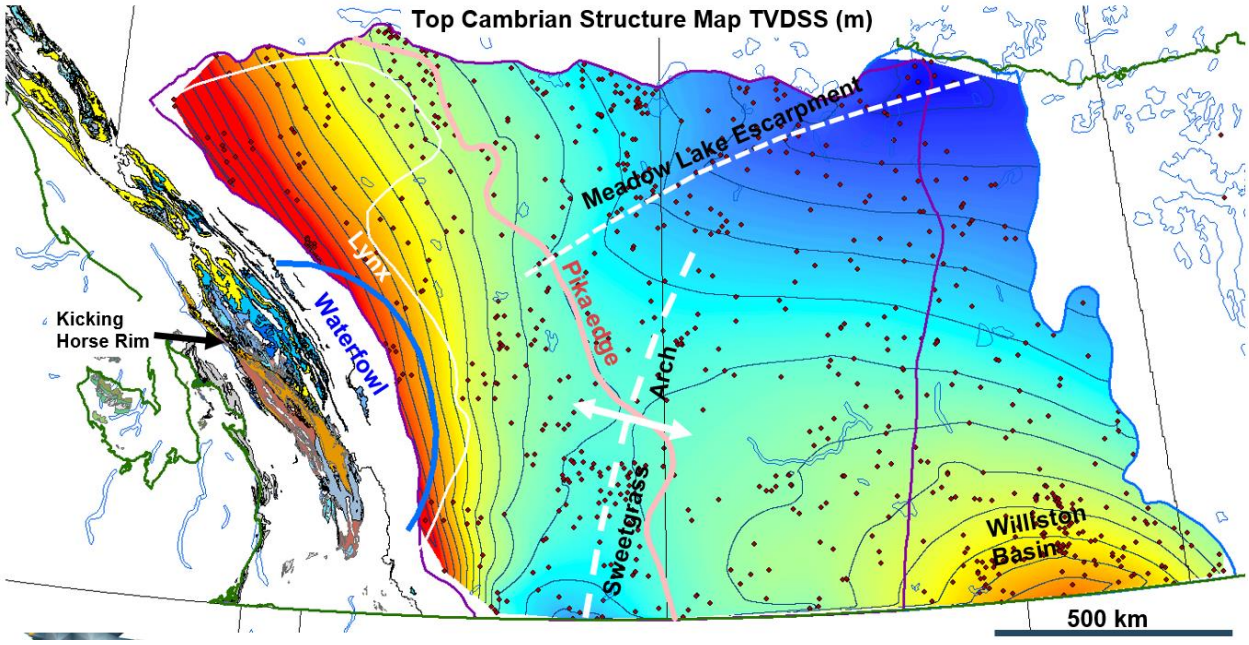

Figure 1. Base Devonian/top Cambrian-Ordovician structure map, showing carbonate edges and Cambrian carbonates in outcrop belt (blue).

In the Rockies and western Alberta plains, Middle Cambrian, to Upper Cambrian-Lower Ordovician carbonate edges (Aitken, 1987), alternately extend far into, or retreat from flanking shale accumulations, providing a clear record of transgression and regression. Contrasting tapered profiles of thick carbonate intervals in cross-section either overhang and interfinger with underlying shales (regression), or shrink upwards with a staircase morphology, adjacent to and beneath flooding shales (transgression). The E-W cross-section of Figure 2, illustrates the two principal lower-order unconformity-bound sequences running through the carbonate bank.

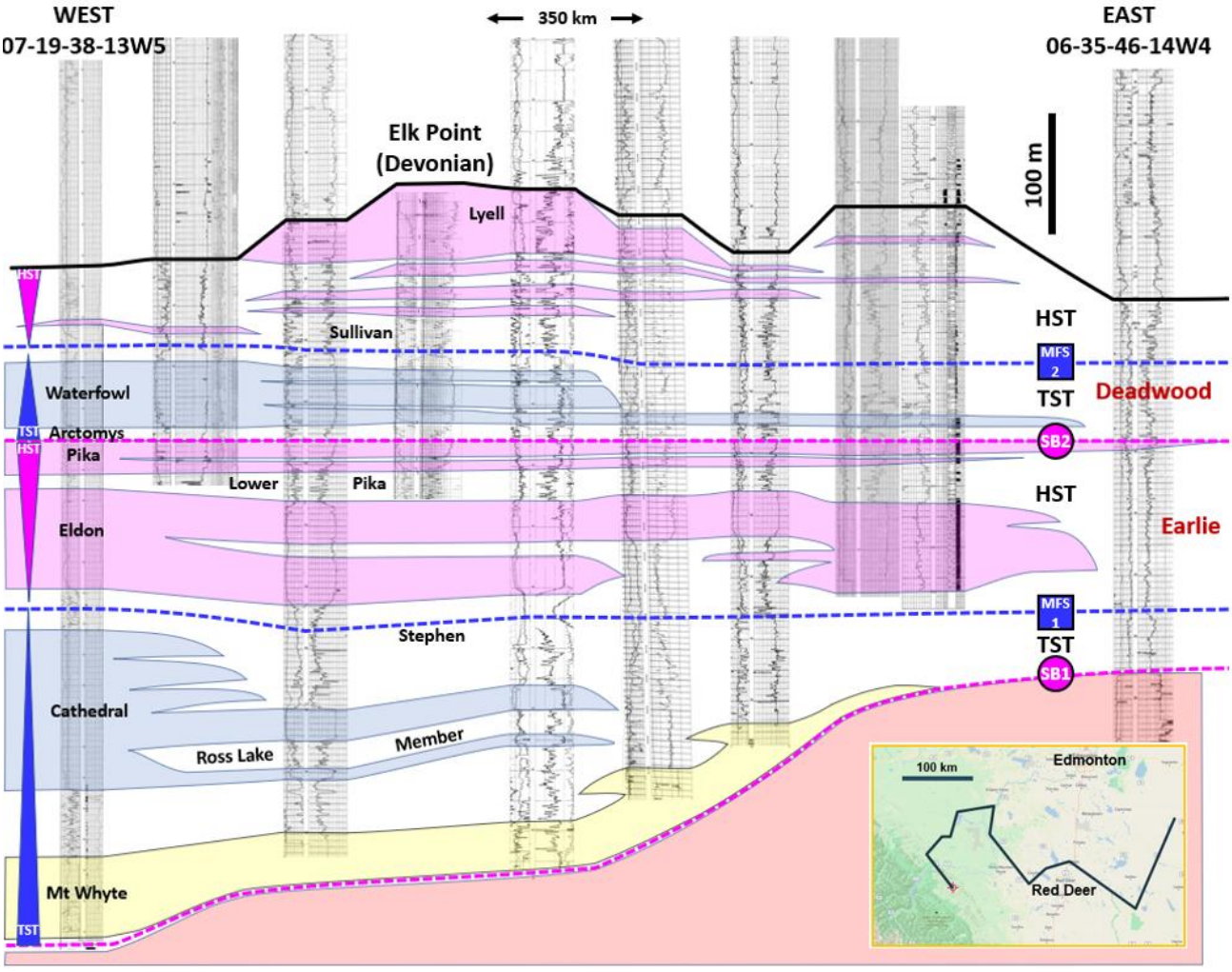

Figure 2. Well cross section through central Alberta, illustrating principal transgressive (blue), and regressive (pink) shale packages.

The lower grouping includes the Middle Cambrian Mt Whyte (“basal sand”), Cathedral carbonate, Stephen shale (MFS), Eldon carbonate, and Pika formations; silty shales of the Earlie Formation occur to the east on the inboard side of the carbonate bank, whereas off-bank shales of the Chancellor Formation occur oceanward in the mountains to the west of the

carbonate bank. The Cathedral Formation provides the most conspicuous example of carbonate retreat during sea-level rise within the transgressive systems tract (TST), shrinking upwards in a wedding-cake like stack before abandonment at peak flooding and envelopment in shales of the Stephen Formation (MFS). From the zero edge in the plains to a thickness of 160 m at the mountain front, and a maximum further west of up to 610 m at Mount Stephen, the carbonate build-up signals the importance of crustal subsidence along the continental margin at this time in order to accommodate the thickening. Crustal subsidence in this context along the edge of the continent appears to have been the main driver of the overall transgression. The Stephen Formation features shale that runs through the Rockies drowning the underlying Cathedral carbonates (Figure 3) during peak flooding, while linking inboard (Earlie Formation) and outboard (Chancellor Formation) deeper water settings across the top of the carbonate bank. The Stephen is a clear regional marker containing the maximum flooding surface (MFS) at the top of the transgressive systems tract (TST). Furthermore, the Burgess Shale is caught-up in this TST in front of the Cathedral escarpment along the Kicking Horse rim facing the Panthalassic ocean. The highstand systems tract (HST) above the Stephen Formation features two transgressive-regressive cycles beginning with progradational Eldon Formation carbonates, then capped by Pika Formation carbonates containing intertidal stromatolites at the top, defining the sequence boundary.

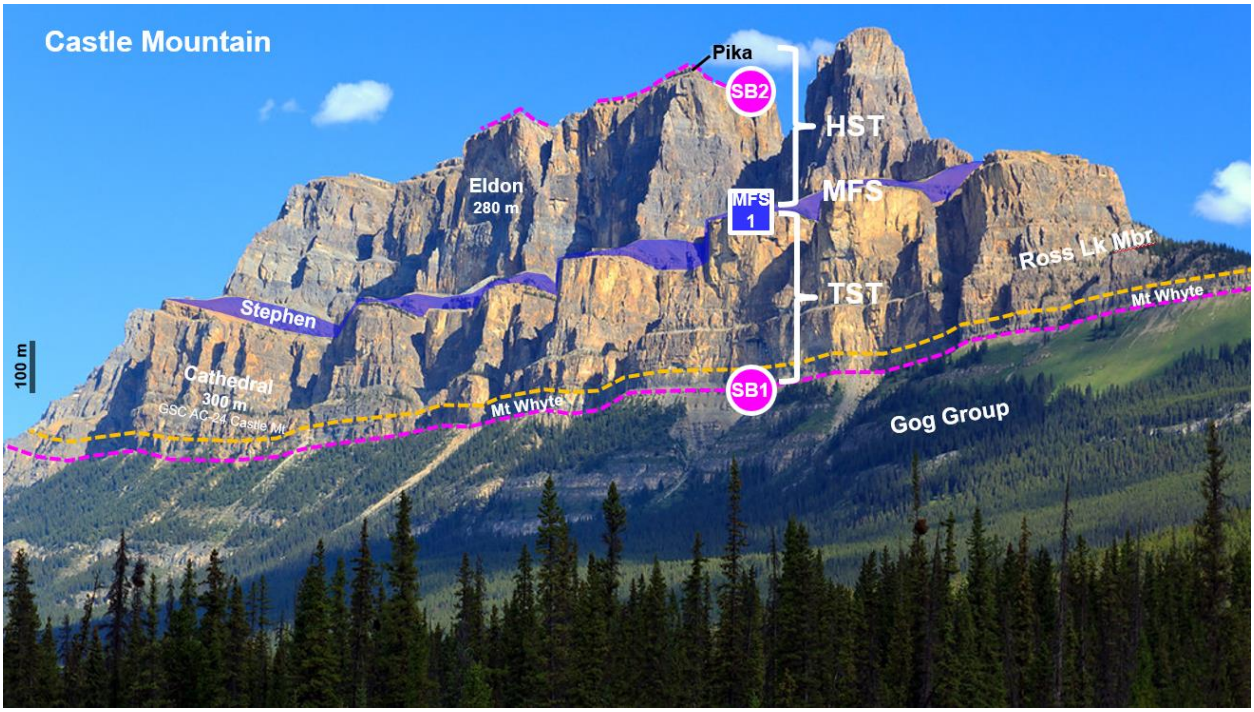

Figure 3. Castle Mountain showing TST-HST cycle in middle Cambrian carbonates in outcrop, separated by Stphen Formation MFS (blue shading).

A second major TST-HST cycle above the Pika is defined, spanning the Middle Cambrian, Upper Cambrian, to Lower Ordovician stratigraphy (Figure 4). This upper grouping includes the Middle Cambrian Arctomys Formation, transgressive Upper Cambrian Waterfowl carbonates, Sullivan Formation shales with MFS, and overlying regressive HST Lynx Formation carbonates. Carbonate edges extend outward and interfinger with diachronous outboard silty shales of the Deadwood Formation to the east.

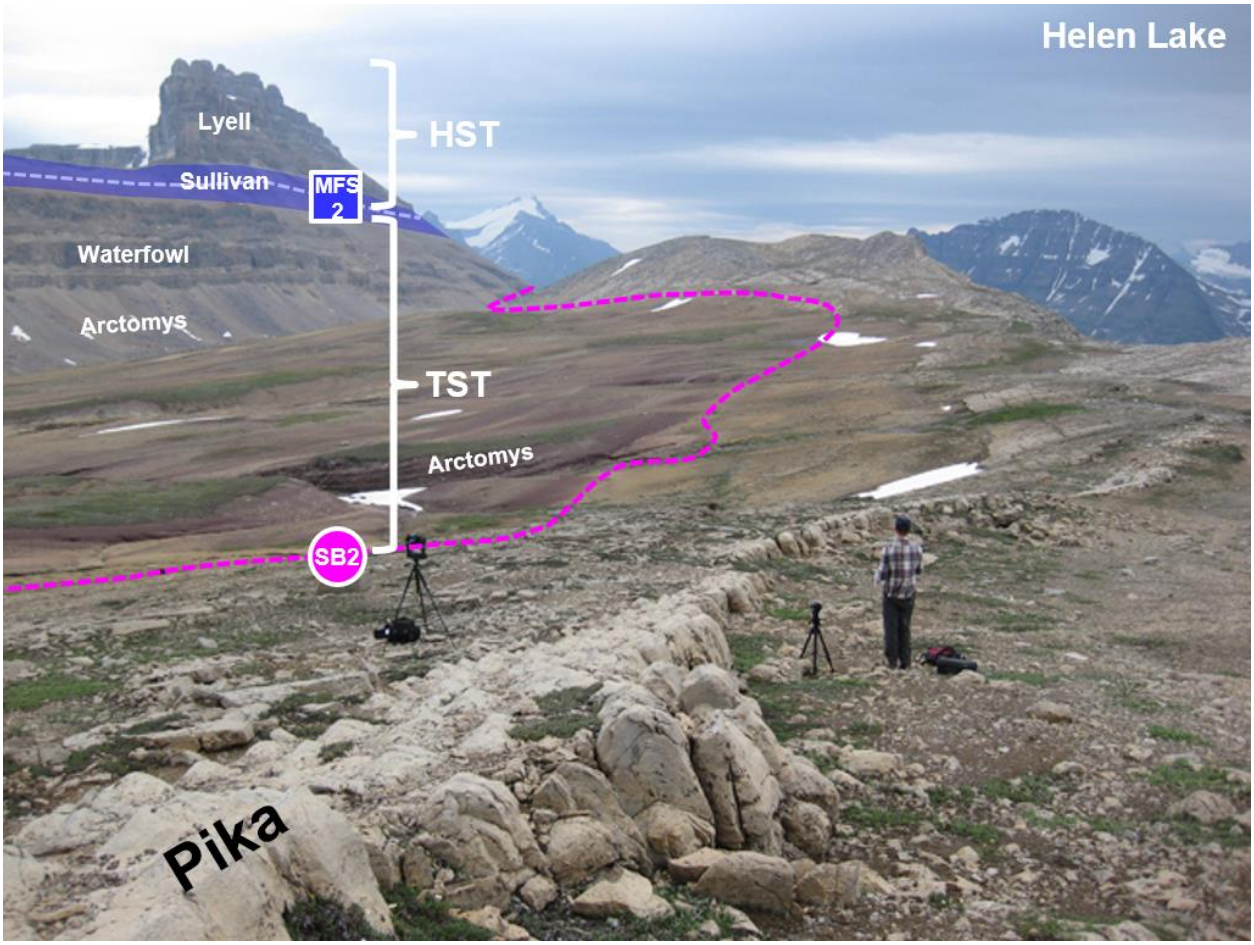

Figure 4. Helen Lake showing TST-HST cycle in Upper Cambrian carbonates in outcrop, separated by Sullivan Formation MFS (blue shading). Note well developed stromatolite mounds at top of Pika Formation.

Acknowledgements

The Atlas 2027 chapter on the “Cambrian to Lower Ordovician Strata” is an ambitious endeavor, garnering input from a broad range of experts participating in collaborative meetings, discussions, and workshops. We would like to acknowledge Andrei Ichaso, Brian Pratt, Chad Morgan, Dave Herbers, Jim Dixon, Karen Fallas, Lauren Mandronich, Neil Handkamer, Pawel Kuczaj, and Tyler Hauck for their input.

References

Aitken, J.D.,1978. Revised models for depositional Grand Cycles, Cambrian of the southern Rocky Mountains, Canada. Bulletin of Canadian Petroleum Geology, 26: 515-542.

Mossop, G.D., Shetsen, I., and Madunicky, M. 1994: Geological Atlas of the Western Canada Sedimentary Basin. Calgary, AB: Canadian Society of Petroleum Geologists, 510 p.

Slind, O.L., Andrews, G.D., Murray, D.L., Norford, B.S., Paterson, D.F., Salas, C.J., Tawadros, E.E., 1994. Chapter 8 - Middle Cambrian to Lower Ordovician Strata: In, Mossop, G.D., Shetsen, I., and Madunicky, M., Geological Atlas of the Western Canada Sedimentary Basin. Calgary, AB, Canadian Society of Petroleum Geologists, 510 p.