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Atlas 2027: Regional Cambrian-Lower Ordovician Maps Integrating the Northern and Southern Reaches of the WCSB

Greg Lynch, Robert MacNaughton[1]

[1]Geological Survey of Canada (Calgary), Natural Resources Canada

Summary

The Geological Atlas of the Western Canada Sedimentary Basin (Mossop et al., 1994) provides a comprehensive synthesis of the Phanerozoic through the four western provinces, in the form of geologic maps, cross-sections, charts, and figures. Maps are scaled to 1:5,000,000 and are geared to addressing the big picture in the form of structure, isopach, and facies maps, supported with regional cross-sections. However, with the forward advance of science and geologic concepts in the past thirty years, as well as the ongoing accumulation of data through drilling and research, an initiative is afoot to update and refresh the Atlas, with a 2027 target date for completion.

For the Cambrian, significant new research and mapping during the time in between has occurred most notably in the northern segment of the basin, extending through the Northwest Territories, including the sub-basins of the Northern Interior Platform (Dixon and Stasiuk, 1998; MacLean, 2011; Turner, 2011; MacNaughton and Fallas, 2014). This northern region was not included in the 1994 edition, providing an opportunity for expanding the scope of the 2027 edition, which has a geographic coverage which now includes the entire Mackenzie corridor north to the Arctic coast. So, from the Cambrian perspective Atlas 2027 benefits greatly from added insights from new research, as well as from an expansion of the coverage to the north. From the south, covering a swath across Alberta, Saskatchewan, and Manitoba, the previous edition of the Atlas provides a strong legacy from which to build on (Aitken, 1978; Slind et al, 1994). The opportunity for advancement in Atlas 2027 lies in the basin-scale integration of the two regions, in order to address the big picture. Another change is that Atlas 2027 will treat the entirety of the Cambrian as well as the Lower Ordovician (essentially the Sauk Sequence) in a single chapter, whereas in the 1994 edition the Lower Cambrian was included with the Neoproterozoic.

Maps are the key document to any atlas. Considering the scale of the intended maps for Atlas 2027, large stratigraphic intervals or what might be considered first or second order sequences need to be defined for this purpose. Here, in both the north and south, the Middle Cambrian, to Upper Cambrian-Lower Ordovician intervals can be compartmentalized into two large separate unconformity-bound sequences, providing a basis for mapping across the full extent of the project. Furthermore, the eight “grand cycles” as defined in the south (Aitken, 1978; Slind et al, 1994) comprise higher order sequences as separate formations contained within these two thicker groupings. In the north, there has been significant recent progress in delineating the sequence stratigraphy of parts of the Cambrian succession (Dilliard et al., 2010; Sommers et al., 2020), and comparing the two regions will be a significant contribution of the chapter.

In the south, the lower grouping includes the Middle Cambrian Mt Whyte, Cathedral, Stephen, Eldon, and Pika formations to the west, with outboard silty shales of the Earlie Formation further east, as well as the Basal Sandstone which may locally be equivalent to the Lower Cambrian

Gog. Thick carbonate banks alternate with shale intervals defining transgressive-regressive cycles, with maximum flooding proposed here at the level of the Stephen Formation. In the north the Lower Cambrian Mount Clark Formation and Middle Cambrian Mount Cap Formation are grouped together. North-south correlative bounding unconformities are proposed at the top of the Pika (south) and top of the Mount Cap (north) formations. From a chronostratigraphic standpoint, the *Glossopleura* trilobite zone in the upper part of the Mount Cap Formation in the north (MacNaughton et al, 2013; Handkamer et al., 2022) correlates to the Stephen Formation in the south which also contains *Glossopleura* (Morris and Collins, 1996).

For the purposes of regional mapping a second grouping is proposed, spanning the Middle Cambrian, Upper Cambrian, to Lower Ordovician interval. In the south, this upper grouping includes the Middle Cambrian Arctomys Formation, the Upper Cambrian Waterfowl, Sullivan, and Lynx formations, as well as the diachronous outboard silty shales of the Deadwood Formation. In the north the grouping includes Middle Cambrian mudrocks and evaporites of the Saline River Formation and correlative, coarser-grained siliciclastic strata of the Nainlin Formation, as well as carbonate-dominated Upper Cambrian to Lower Ordovician Franklin Mountain Formation. Between bounding unconformities, peak flooding for these is proposed along the Sullivan Formation in the south, and is likely to be recorded within the Franklin Mountain Formation in the north.

Structural mapping from well-tops database and outcropping edges provides coverage and insights in northern and southern domains. The well-known Williston Basin, Sweetgrass Arch and Meadow Lake Escarpment standout in the south (Figure 1); the north features a broad regional dome hosting the Colville Hills gas accumulations, as well as sharp westerly dip toward the fold and thrust belt to the west. Of particular note is the very broad erosional gap between the northern and southern segments of the Cambrian basin; truncation and angular unconformity occur at the base of the Devonian, defining a broad pre-cordilleran super-arch spanning the southern flank of the Peace River Arch in central Alberta, all the way north to the Tathlina Arch in the Northwest Territories. Apparent embayment of the Cambrian may be an artifact of structural erosion. However, a number of older basement arches did influence the original depositional setting. In particular, these, combined with sea level fluctuations, partitioned northern region into a relatively isolated or silled basin at the time of deposition of the evaporite-bearing Saline River Formation. This gave way to a more interconnected and open system during the Upper Cambrian and Lower Ordovician.

Also new to Atlas 2027 is the inclusion of outcrop belts available from digital GIS datasets; Cambrian to Lower Ordovician polygons are shown on Figure 1, and in this way outcrop data are used in refining the maps. The western outcrop belts show a thick Cambrian agradational carbonate bank positioned along the ancient continental shelf, giving way to deeper water outer-shelf to upper-slope facies, such as in the Chancellor Formation in the south, or possibly the upper Narchilla Formation in the north. The relatively abrupt western transition from carbonate bank to shale basin in the Cambrian, can be used as a demarcation of the Cordilleran Hingeline, running along the edge of the Laurentian margin facing the Iapetus Ocean. Furthermore, a number of Cambrian-Ordovician mafic volcanic and intrusive rock units are distributed along both sides of the hingeline, within platformal and basinal sucessions (Goodfellow et al., 1995) (Figure 1).

On the other hand, the eastern side of the carbonate bank features a restricted inland continental sea, where the carbonate bodies interfinger more closely with fine grained clastics according to cycles of transgression and regression governed mostly by local sediment budgets and inland accommodation space.

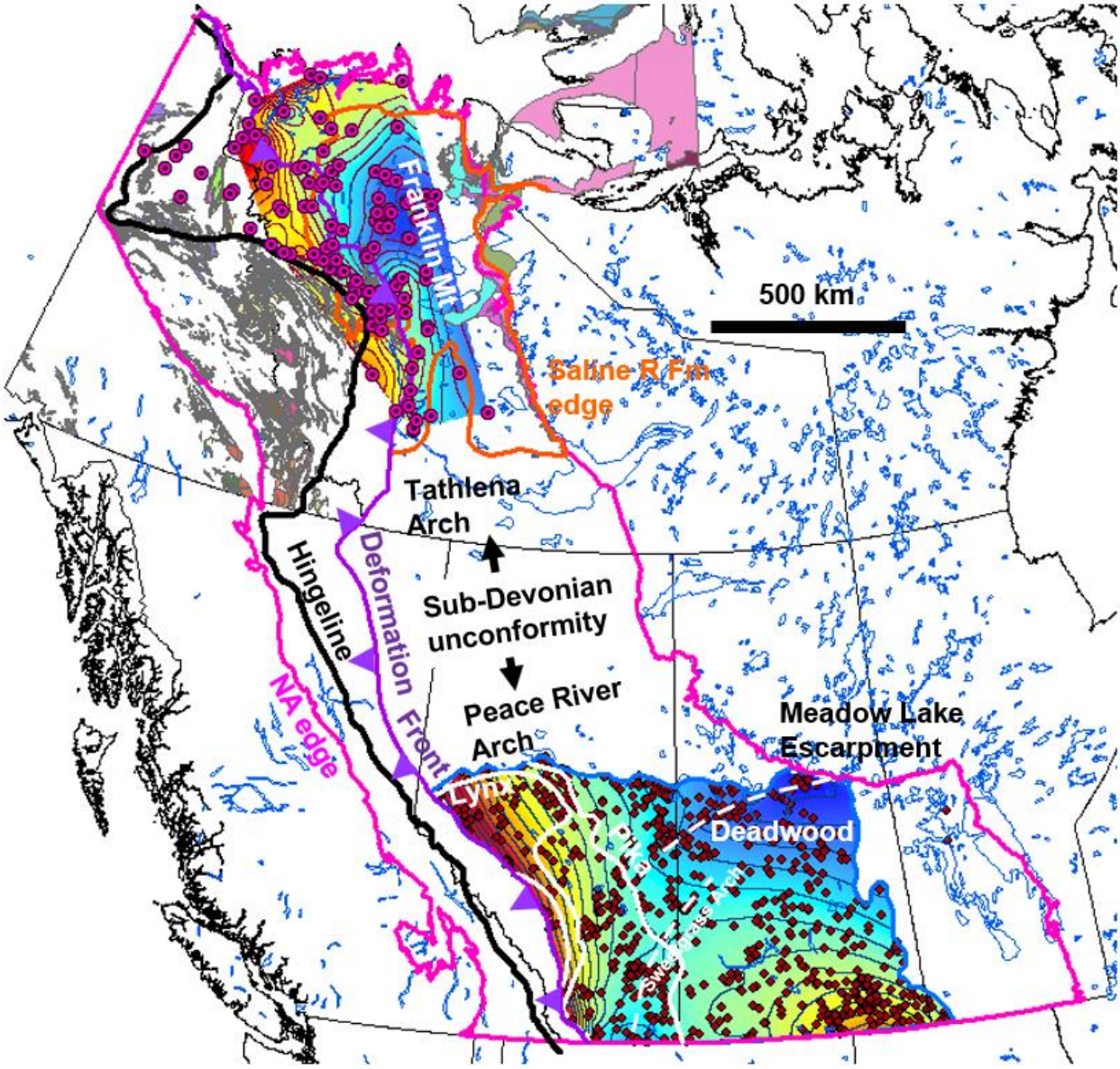

Figure 1. Top Cambrian-Lower Ordovician structure contour map with 250 m contour intervals. Dots are well tops control points; outcrop polygons are flanking the map.

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