geoconvention
Calgary • Canada • May 15-17 2023

Atlas 2027 Project: A Modern Framework for the WCSB

Greg Lynch, Neil Watson[1], Ben McKenzie[2], Alex MacNeil[3]
[1]Enlighten Geoscience
[2]Tarheel Exploration
[3]Alberta Energy Regulator

Summary

The 'Geological Atlas of the Western Canada Sedimentary Basin' (Mossop and Shetsen., 1994) is an iconic 510-page treatise of geological maps, cross-sections, and thematic diagrams, that established a comprehensive stratigraphic framework for the basin across the four western provinces. Although completed thirty years ago, the Atlas is still widely used today recording hundreds of daily hits from where it is presently stored on a server at the Alberta Geological Survey (https://ags.aer.ca/reports/atlas-western-canada-sedimentary-basin). Through the years the Atlas has opened doors and made basin entry accessible to all, attracting investment from within and outside of Canada. Countless scoping exercises, as well as planning and strategic discussions, have found people huddled around the Atlas to map a way forward for explorers and resource development. The Atlas also acts as a fundamental scientific document underpinning some of the basic research done at Universities and Geological Surveys. Nonetheless, with all of the advances in geoscience and computing over the last three decades, and ongoing accumulation of new data, as well as shifts in interests, the time has come for an update and modernization of the Atlas. Furthermore, the immeasurable importance of the original Atlas as an example, provides all of the incentive needed for the approximately 200 participants involved in the current update. Essentially, the Atlas provides a geologic synthesis in maps, while addressing the big picture.

In terms of global classification schemes from the oil and gas sector, the WCSB can be categorized as a top-tier "Super Basin" (Fryklund and Stark, 2019), and ticks all of the boxes, including: 5 Billion BOE production and >5 Billion BOE recoverable reserves; two or more source rocks; stacked reservoirs; mature infrastructure; established service sectors; large amounts of data; multiple operators; and access to markets (with this last point likely being the only weak spot in the basin's pedigree).

As an action item embedded within the CEGA's 2016 Five-Year Strategic Plan, the wheels were set in motion in 2020 for Atlas 2027. A Steering Committee was created with representation from the four western provinces, as well as both the Yukon and Northwest territories, the federal government, and industry (Figure 1). With a robust show of interest from the numerous potential authors who were solicited, and agreement between partnering agencies in the Steering Committee, official launch was announced in January 2021. Much of the impetus for this at the CEGA has also emerged from special events planning for the Centennial celebrations coming

up in 2027, which serves as the target date for delivery of the revised Atlas, and provided a six-year window to get the work done and published. General information, data and resource availability, as well as committee details are available from the Atlas website at: (https://atlas2027.ca/).

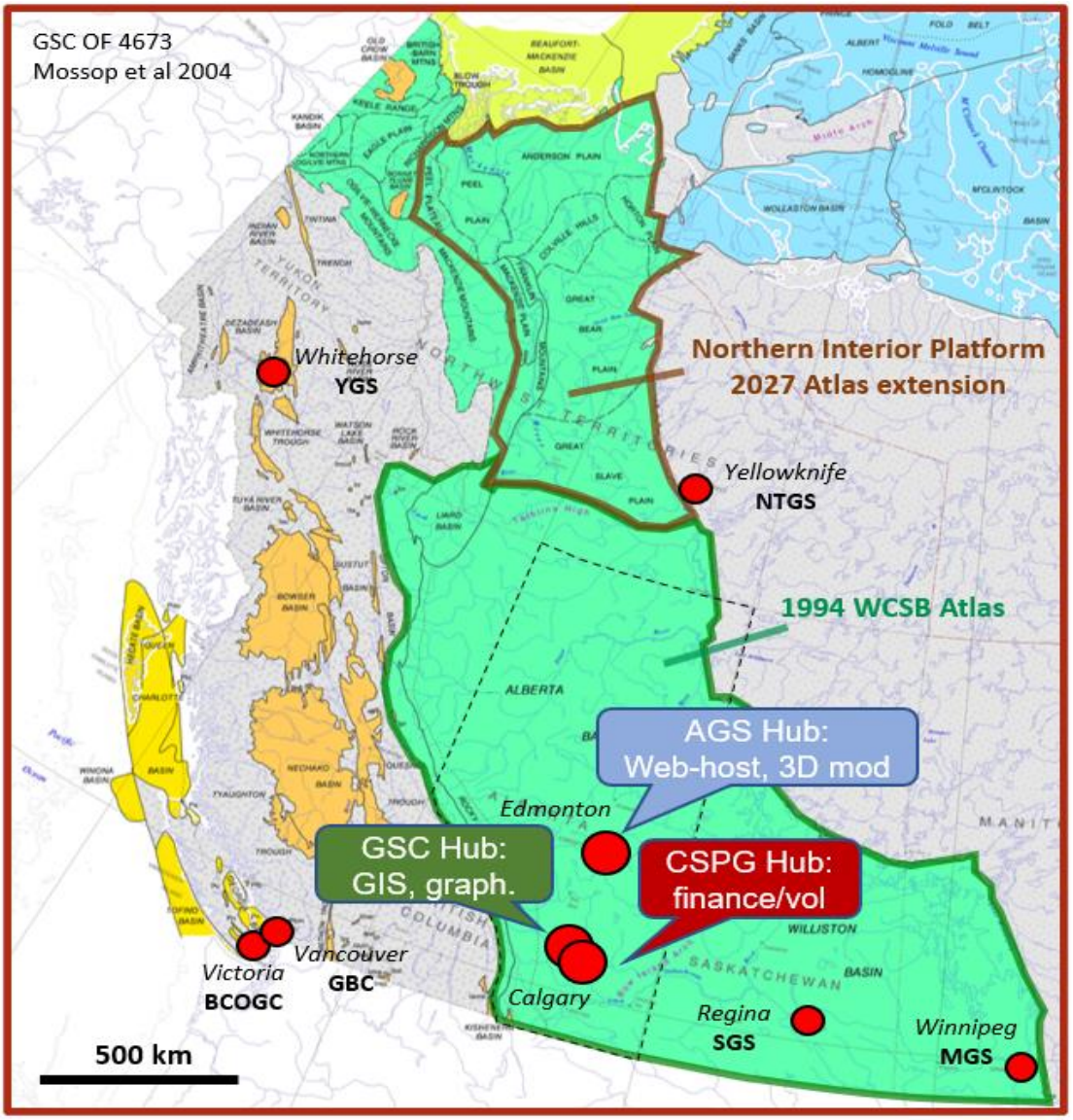

Figure 1. Outline of the Western Canada Sedimentary Basin (Mossop and Shetsen, 1994) Atlas 2027 project, with new extension into the Mackenzie Corridor NWT. Red dots are participating hubs, Surveys, and agencies from the four western provinces, and territories.

Unquestionably, a 30-year shelf life is a good run indeed, but 100s of thousands of wells have been drilled since 1994, and although the rocks are the same, the science has unabashedly moved forward and a revisit is in order. The first point of departure begins with the new Atlas extending its geographic reach along the entire length of the Mackenzie Corridor to the Arctic coast, including correlative stratigraphy of the Northern Interior Platform (Figure 1). Also, since 1994, unforeseen paradigm shifts have occurred, such as the emergence of unconventional plays and horizontal drilling technology, as well as large-scale oilsands developments and thermal bitumen plays coming online. New Atlas chapters are planned for capturing the explosion of knowledge and insight that have emerged as a result, in key intervals such as the Triassic Montney Formation, or from Devonian organic shales such as the Duvernay, Muskwa, and Canol formations. The Lower Cretaceous will be revisited for similar reasons. Furthermore, a more comprehensive treatment of the Proterozoic is underway. The modern digital revolution is also facilitating changes in the way we capture, analyze, and display data in the basin; for instance, one of the objectives of the Atlas, spearheaded by the Alberta Geological Survey (AGS) and partnering Surveys, is to extend the current 3D model of Alberta into neighboring provinces and territories to cover the entire basin. As well as stratigraphic updates, a number of new thematic chapters are planned spanning a broad range of topics. These include abnormal pressures, microseismicity, basin modelling, geodynamics and paleogeography, sequence stratigraphy, significant dinosaur and fossil sites, impact structures, carbon capture use and storage, geothermal energy, hydrogeology, formation waters, as well as hydrogen, helium, and lithium resources, and a chapter dedicated to critical minerals. Emerging green energy themes which are garnering more and more attention, are noted here. Known and projected onlap of stratigraphic edges onto the eastern craton (Figure 2) will also serve to generate a WCSB-specific sea-level curve for the entire Phanerozoic (Figure 3), providing an integrative baseline for sequence stratigraphy analysis and discussions across the entire succession.

The geographic extent of Atlas 2027 has also been pushed west, into the mountains, to include all rocks with a North American designation. The western limit is largely marked by the outer edge of thick deep water or continental-margin derived Proterozoic rocks (Figure 4), positioned along the rifted margin of the ancient Iapetus Ocean. Furthermore, the western Proterozoic belt also defines the structural hinterland to the eastern fold and thrust belt. The hinterland is characterized by the inversion of these Proterozoic grabens and entrainment as thick-skinned thrust sheets up-against and over the Cordilleran Hingeline, forward into the higher-level thin-skinned fold and thrust belt to the east. In front of the thrust system extending to the east into the plains, a thick terraced clastic wedge was developed, spanning much of the Jurassic to early Paleogene interval. The distribution of the clastic wedge, from the Late Cretaceous to Paleocene, suggests the likelihood that younger thrusting persisted in the southern Rocky Mountain system relative to the northern Mackenzie Mountain system (Figure 5).

Another conspicuous feature of the WCSB is the occurrence of long-wavelength/low-amplitude dome and basin structures observed at various levels in the plains (Figure 6). These are typically elliptical doubly plunging structures, creating broad egg-crate dimples with an irregular distribution. The structures are variable in age, though principally Paleozoic, with sub-basins in some cases having accommodated active sedimentation, whereas others exist as folds with the stratigraphy truncated along sub-crop edges. Prominent amongst such features are the Williston Basin, the Central Alberta Sub-Basin, the Peace River Arch, and the Athabasca Basin.

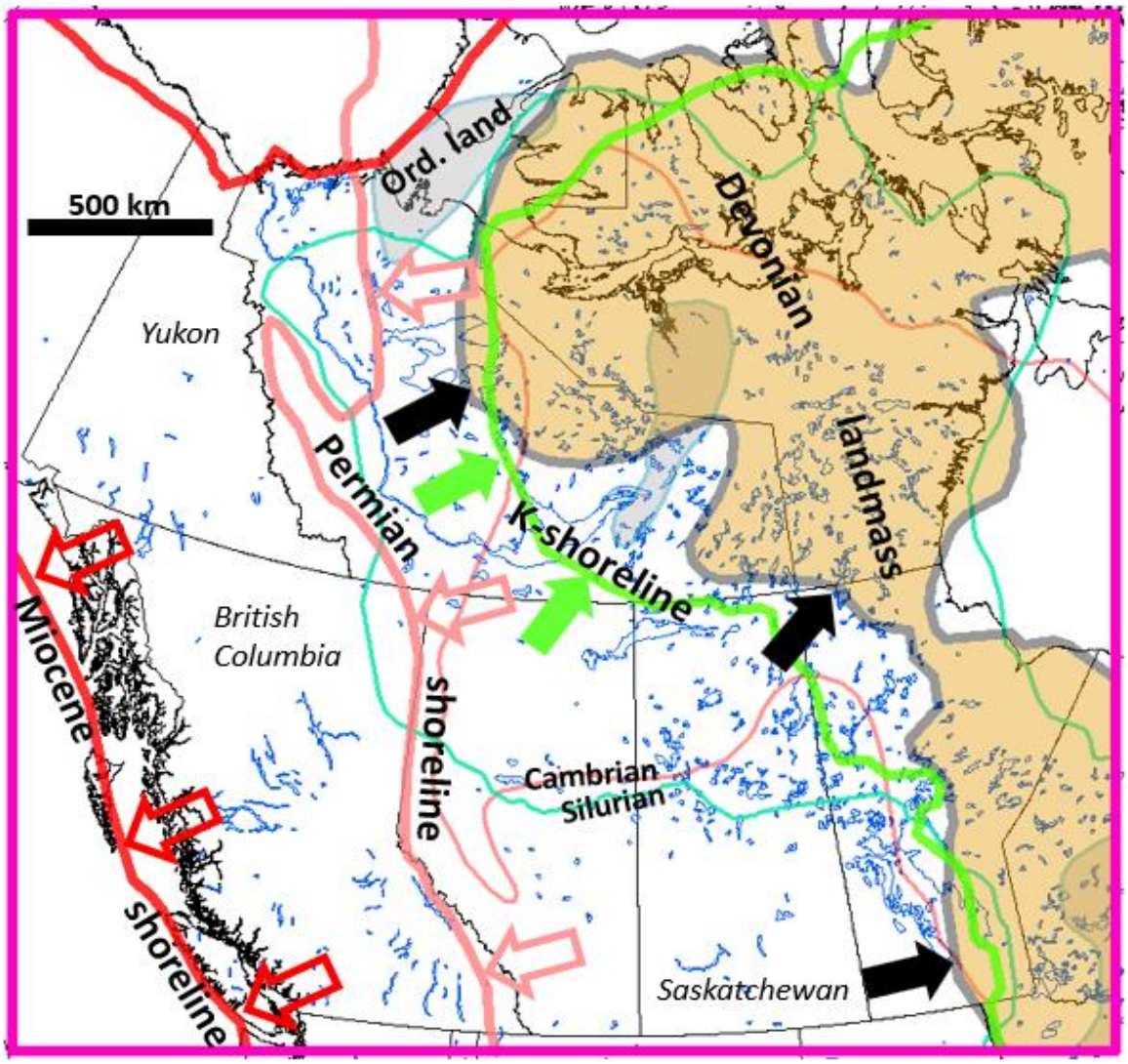

Figure 2. Paleo-shorelines with arrows depicting episodes of maximum retreat or transgression, as well as episodes of maximum advance or regression. Adapted from Mossop and Shetsen (1994) and Miall and Blakey (2019).

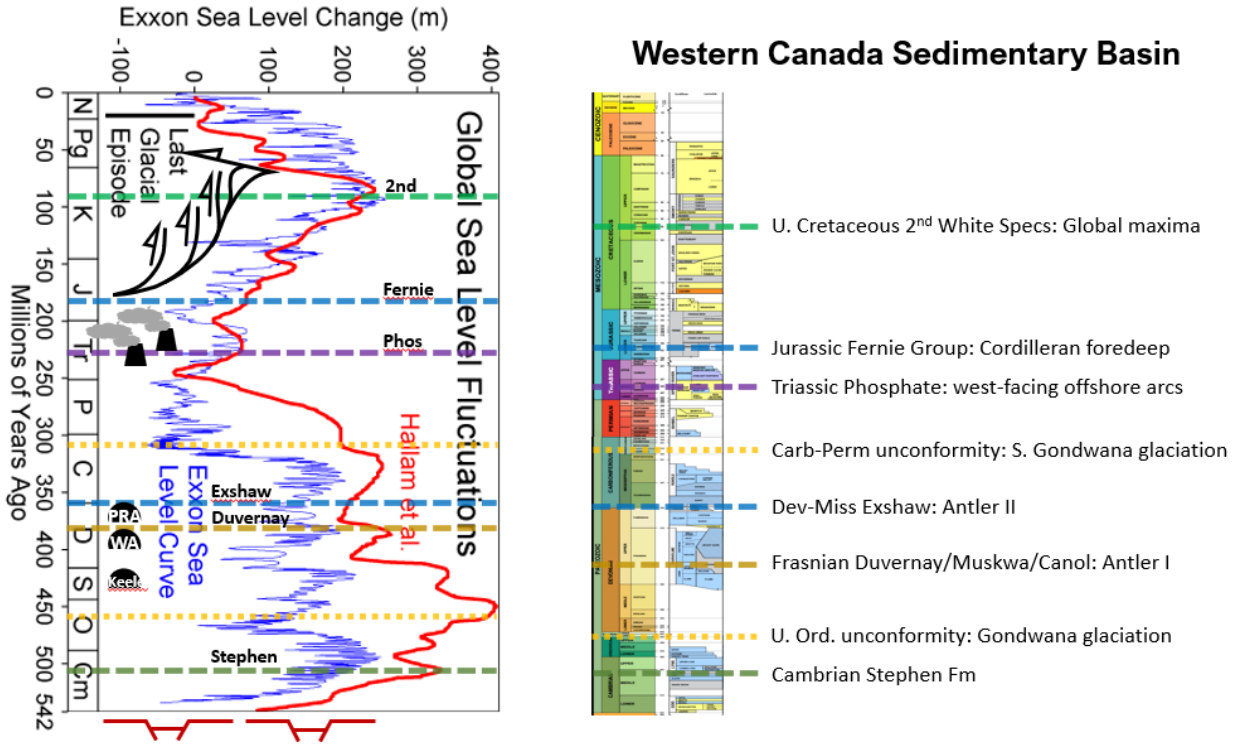

Figure 3. Phanerozoic sea level curves matched to stratigraphy and major tectonic events of the Western Canada Sedimentary Basin

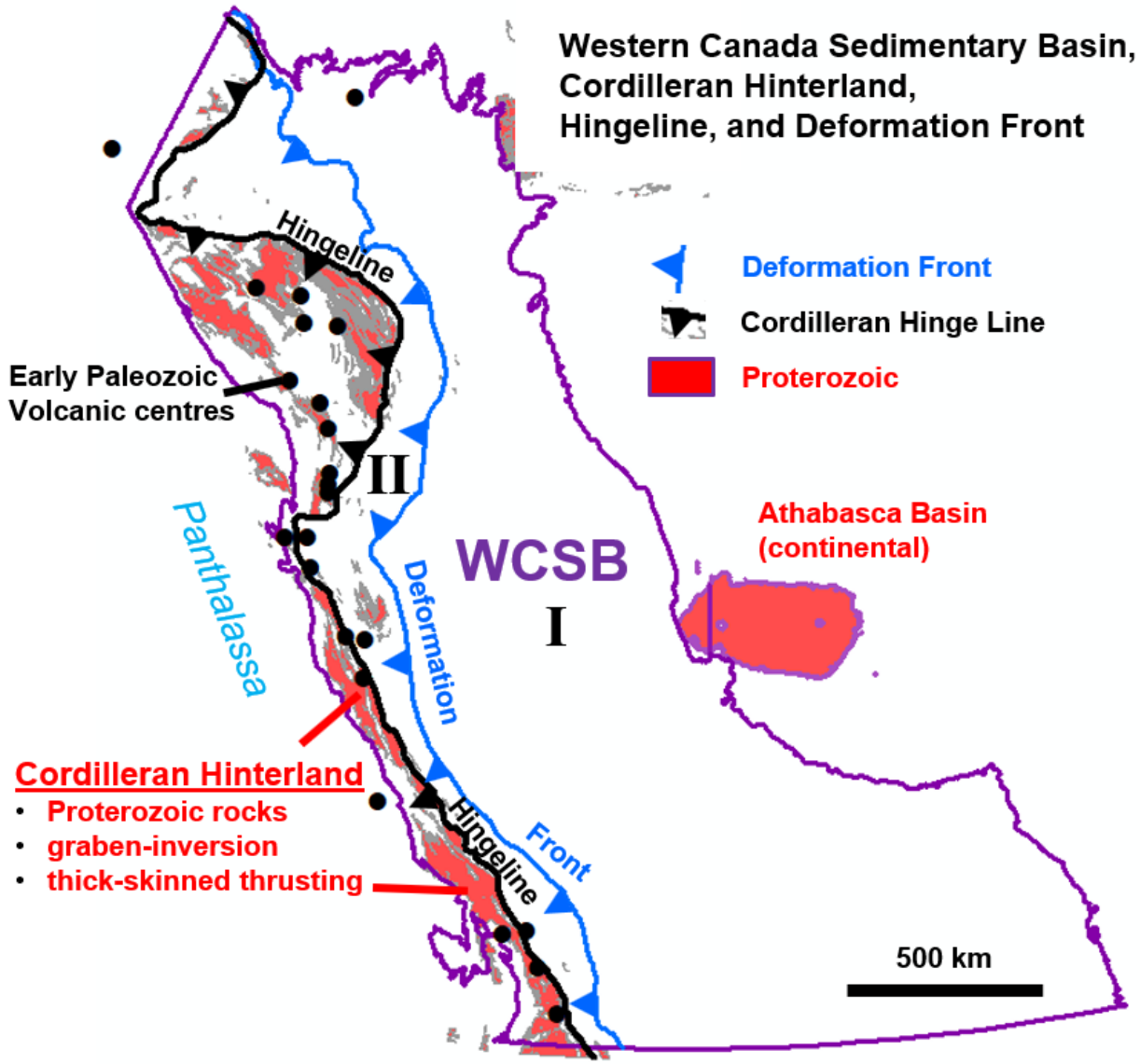

Figure 4. Cordilleran hinge-line separating continental margin Proterozoic rocks of the hinterland, and thick-skinned inversion tectonics, from thin-skinned foreland deformation and thrusting. Black dots are early Paleozoic volcanic centers (Goodfellow et al., 1995) which further define the hinterland and hinge-line. Domain "I" incorporates extensive sub-surface drill-hole data, whereas domain "II" relies more on surface outcrop maps.

In the resource sector there are some things we have little control over, such as global market cycles, shifting commodity prices, the political pendulum both national and beyond, or the fate of ambitious infrastructure projects. However, in the interim, as geoscientists, engineers, and

technical workers we can work in a coordinated manner to provide the best possible understanding of this Super Basin, both for the sake of science, and in order to stay ready for, or even initiate the next big thing, whatever that looks like. A refresh of the Atlas strives to do just that.

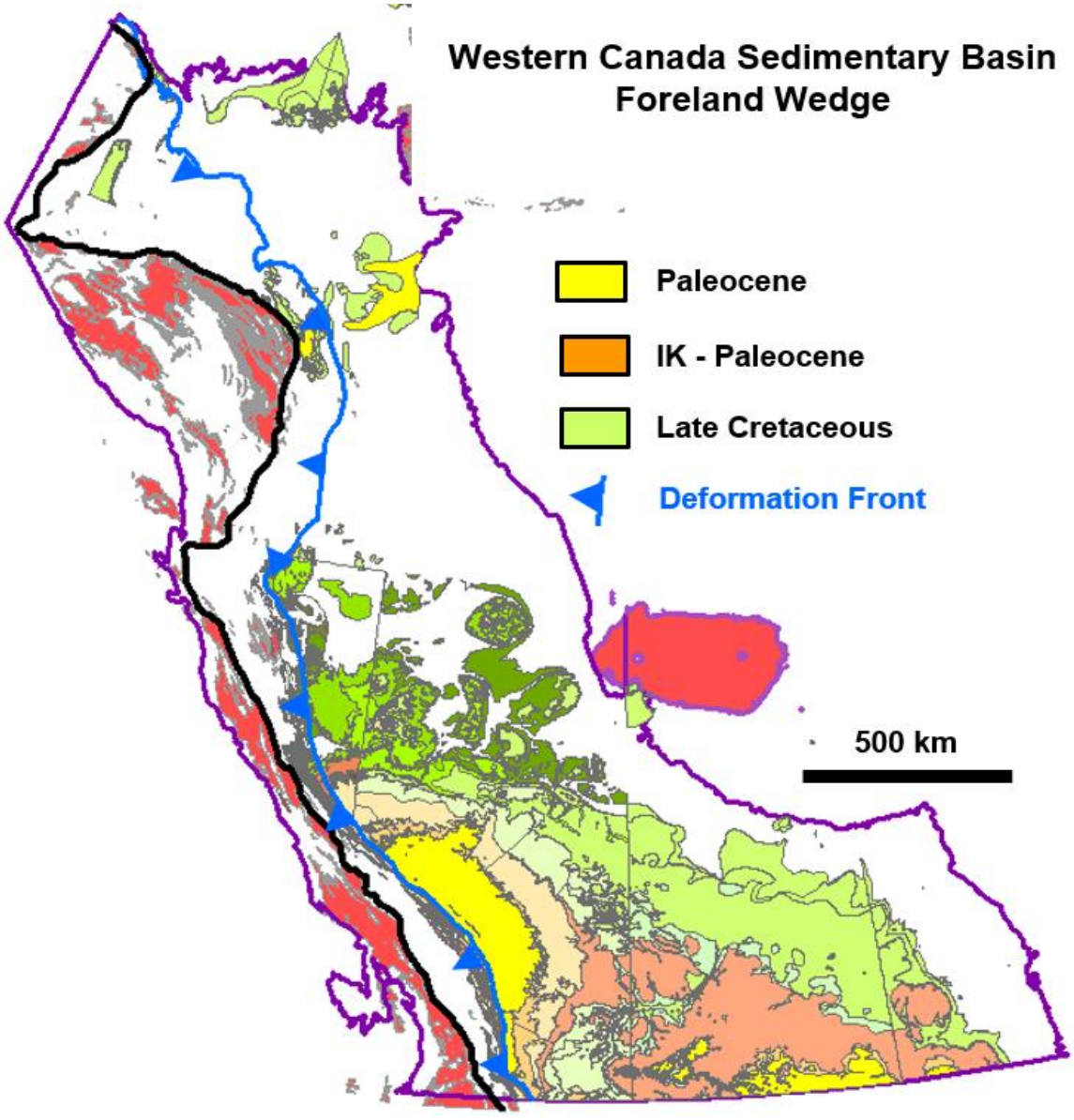

Figure 5. Late Cretaceous to Paleocene foreland wedge. From a basin forming and active thrusting perspective, the distribution appears to suggest a southward younging of the thrust belt.

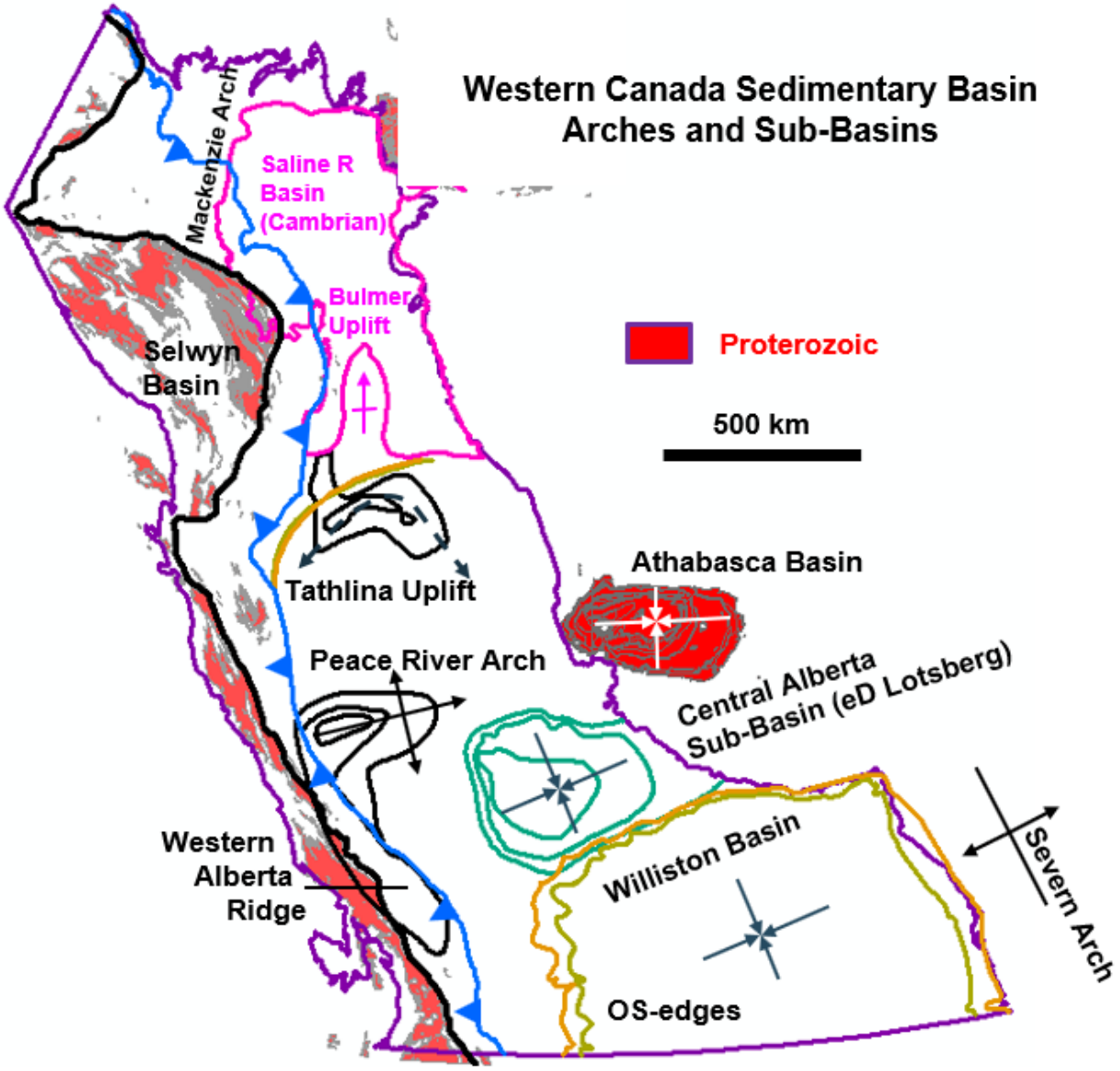

Figure 6. Long-wavelength and low-amplitude cratonic arches and sub-basins of various ages distributed across the plains, basement, as well as into the mountains.

Acknowledgements

We would like to acknowledge the Atlas 2027 Steering Committee, with representation from across the four western provinces and two territories, who meet monthly contributing valuable time and knowledge in guiding and shaping the new atlas. We would also like to acknowledge the many Atlas authors and contributors working on their chapters, numbering approximately two-hundred.

References

Fryklund B. and Stark P., 2020: Super basins—New paradigm for oil and gas supply. AAPG Bulletin, v. 104, no. 12, p. 2507–2519.

Goodfellow, W.D., Cecile, M.P., and Leybourne, M.I., 1995: Geochemistry, petrogenesis, and tectonic setting of lower Paleozoic alkalic and potassic volcanic rocks, Northern Canadian Cordilleran Miogeocline. Can. J. Earth Sci., v. 32: p. 1236-1254.

Miall, A.D. and Blakey, R.C., 2019: The Sedimentary Basins of the United States and Canada. https://doi.org/10.1016/B978-0-444-63895-3.00001-2.

Mossop, G.D., and Shetsen, I., (compilers), 1994: Geological Atlas of the Western Canada Sedimentary Basin. Calgary, AB: Canadian Society of Petroleum Geologists and Alberta Research Council, 510 p.

Mossop, G.D., Wallace-Dudley, K.E., Smith, G.G., and Harrison, J.C. (compilers), 2004: Sedimentary Basins of Canada; Geological Survey of Canada, Open File Map 4673.