AER/AGS Open File Report 2026-06

Alberta Energy Regulator

Cambrian Lithostratigraphy and Regional Correlations in the Alberta Basin

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Cambrian Lithostratigraphy and Regional Correlations in the Alberta Basin

T.E. Hauck and D.S. Herbers

Alberta Energy Regulator / Alberta Geological Survey

November 2026

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ISBN 978-1-4601-6608-6

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Hauck, T.E. and Herbers, D.S. (2026): Cambrian lithostratigraphy and regional correlations in the Alberta Basin; Alberta Energy Regulator / Alberta Geological Survey, AER/AGS Open File Report 2026-06, 28 p.

Publications in this series have undergone only limited review and are released essentially as submitted by the author.

Published November 2026 by:
Alberta Energy Regulator
Alberta Geological Survey
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Edmonton, AB T6B 2X3
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Acknowledgements

The authors acknowledge the ongoing support of the Subsurface Geology team at the Alberta Geological Survey (AGS), as well as cartographic expert Gil Abinal for mapping support, and Steve Lyster for geostatistical expertise. Reviewer Matt Grobe of the AGS is thanked for editing and significantly improving this contribution.

Abstract

Renewed interest in the Cambrian System of Alberta has been spurred by prospective CO_2 sequestration initiatives in deep saline aquifers. Over the last five years, fifteen new cored wells have been drilled within the Cambrian succession in the most prospective sequestration areas across eastern Alberta. Using wireline-log correlations, core observations, and existing regional stratigraphic frameworks, we update lithostratigraphic formation picks across the provincial extent of Cambrian strata. These correlations support the incorporation of the subdivided Cambrian succession into future versions of the Alberta Geological Survey's Geological Framework of Alberta 3D model. We also highlight several newly recognized sequence stratigraphic surfaces that provide important correlation markers within the mudstone-dominated parts of the Cambrian succession in east-central Alberta.

This report is accompanied by AGS Digital Data 2026-0012 which includes the lithostratigraphic picks dataset, high-resolution image files of stratigraphic cross-sections, and drillcore lithologs in WellCAD and image file formats.

1 Introduction

The Cambrian sedimentary succession of Alberta has become increasingly important in the last few decades due to increased interest in its basal sandstone strata—often referred to informally as the Basal Sandstone Unit (BSU) or the Basal Cambrian Sandstone (BCS)—for CO_2 sequestration and potential geothermal uses (Weides et al., 2014). However, outside of Slind et al. (1994) and a few other works (e.g., Norford, 1998; Ichaso, 2025), no regional studies of the Cambrian succession in the subsurface of Alberta have been published in recent years. Recently drilled Cambrian wells and newly recovered cores, especially from east-central Alberta, provide an opportunity to refine lithostratigraphic correlations that support formation-scale mapping. These correlations will form the basis for incorporating the Cambrian sedimentary succession into future versions of the Alberta Geological Survey's Geological Framework of Alberta 3D model which remains undivided in its latest published version (Alberta Geological Survey, 2021; https://gfa-v3-ags-aer.hub.arcgis.com/). Mapped lithostratigraphic surfaces/formations/units in this report are, in stratigraphically ascending order: 1) the Precambrian basement surface, 2) Basal Cambrian Sandstone, 3) Mount Whyte Formation, 4) Cathedral Formation, 5) Stephen Formation, 6) Eldon Formation, 7) Pika Formation, 8) Earlie Formation, 9) Arctomys Formation, 10) Waterfowl Formation of the Lynx Group, 11) Sullivan Formation of the Lynx Group, 12) undivided upper part of the Lynx Group ('Upper Lynx'), and 13) Deadwood Formation (Figure 1).

In addition, we provide a brief review of some important sequence stratigraphic surfaces recognized in east-central Alberta where the Cambrian was dominated by muddy sediment deposition. In these areas, correlations are hampered by the fine-grained nature of the units above the Basal Cambrian Sandstone. These sequence stratigraphic surfaces not only aid in general correlation of lithostratigraphic units, they also provide a means to tie sedimentary environment response to changing relative sea level in the basin.

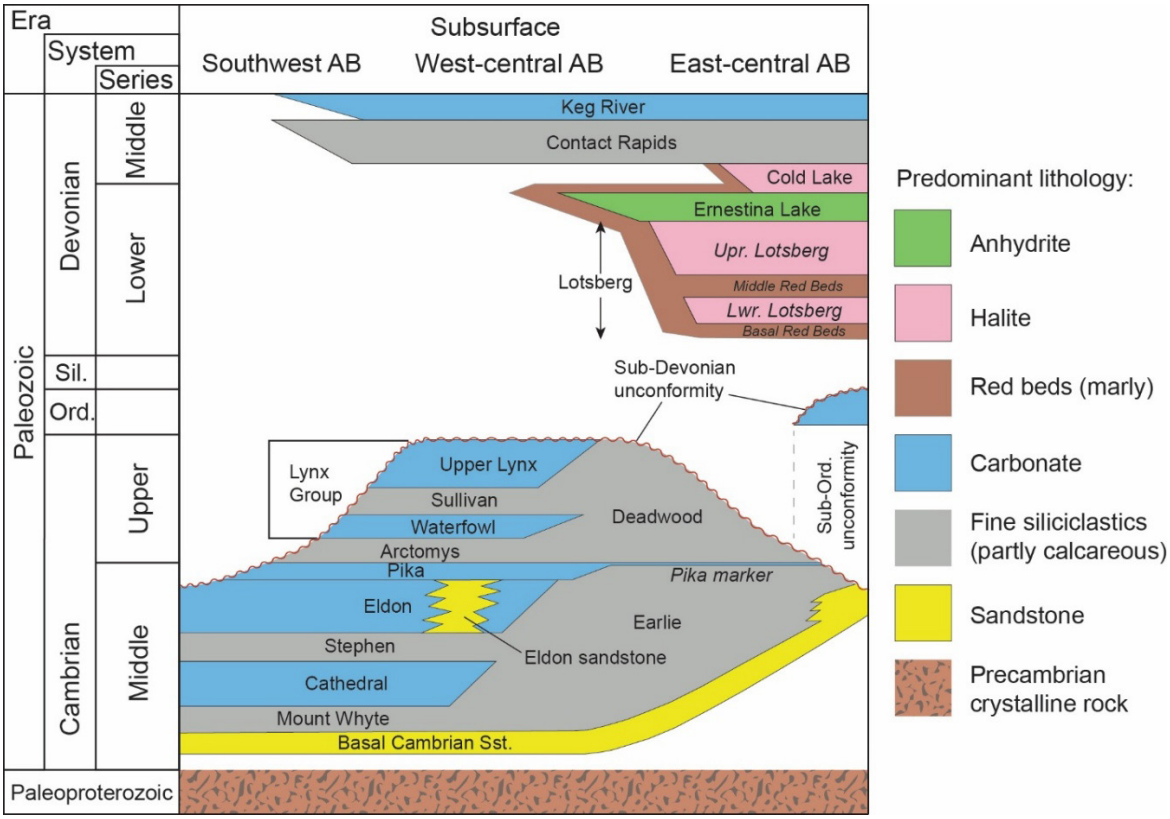


Figure 1. Schematic lithostratigraphic chart for Middle Cambrian to Middle Devonian strata in the southern half of Alberta (Lloydminster Embayment). Abbreviations: Ord., Ordovician; Sil., Silurian; Lwr., lower; Upr., upper; AB, Alberta.

1.1 Geological Setting

Cambrian sedimentary strata in Alberta record renewed deposition along the western margin of North America following the major hiatus that formed the "The Great Unconformity" (Peters and Gaines, 2012). As such, Cambrian strata rest unconformably on a significantly older Precambrian crystalline basement rocks of the continental craton. Deposition occurred during an overall transgression that progressively flooded the craton eastwards, reaching as far as the province of Manitoba. In Alberta's subsurface, the earliest deposits of this transgression are sandstones of the Basal Cambrian Sandstone (BCS) which record diachronous flooding of the craton. Because of this highly time-transgressive character, terminology for this widespread lowermost sandstone unit has remained informal and varied over the years, including "Basal Sandstone Unit" (e.g., Aitken, 1968; Pugh, 1971, 1973, 1975; Slind et al., 1994; Ichaso, 2024), "Basal Cambrian Sands" (e.g., Winkler, 2011), and "Basal Cambrian Sandstone" or "Basal Cambrian Sandstone unit" (e.g., Hauck et al., 2010; Desjardin and Smith, 2013; Shi et al., 2024). Herein, we use Basal Cambrian Sandstone (BCS).

As the seaway deepened, muddy strata overlying the BCS record more distal marine settings, starting with the Mount Whyte Formation (Figure 1). In the location of the present-day Rocky Mountains, the Cambrian succession consists of a series of alternating shales and carbonates, previously characterized as "Grand Cycles" (Aitken, 1966, 1978). This region has generally been characterized as a carbonate shoal belt (Aitken, 1966; Slind et al., 1994), where microbial carbonates aggraded along the present-day Rocky Mountains—the location of the Kicking Horse Rim during Cambrian times—and prograded eastwards mixing with fine siliciclastics of the inner detrital belt (Slind et al., 1994). The boundary between the inner detrital belt and the carbonate shoal belt in the subsurface of Alberta is interpreted from wireline-log signatures (Figure 2, Figure 4, and Figure 5). East of this interpreted boundary, the Cambrian succession above the BCS is dominated by mixed siliciclastics (partly calcareous) assigned to the Earlie Formation (Middle Cambrian) and Deadwood Formation (Upper Cambrian) (Figure 1 and Figure 2).

There are several paleogeographic elements that played a role in the deposition of the Cambrian succession in Alberta. Arguably the most important is the area of the present-day Rocky Mountains where the carbonate shoal belt nucleated and continued to grow through the Cambrian and into the Ordovician, known as the Kicking Horse Rim (Aitken, 1971). This rim is the location where a significant facies change occurs: west of this the carbonate platform transitions to deeper water equivalents (slope environments) near the margin of the craton and towards the open ocean (McMechan, 2022). This area promoted the continued growth of microbial carbonates that influenced the lithology of Cambrian strata further to the east as allochthonous carbonates were shed eastwards from the shoal belt.

In west-central Alberta, the Peace River Arch (PRA) was a positive topographic antiform during the Cambrian into the Devonian (Figure 3). The PRA separates two major depocenters where remaining Cambrian strata are present in Alberta: the northern Hay River Embayment and the southern Lloydminster Embayment (Pugh, 1973; Slind et al., 1994) (Figure 3). The PRA played a strong role in sourcing coarse to fine siliciclastics mixing with the formations of the carbonate shoal belt, especially during the Middle Cambrian. For example, south of the PRA, the Eldon Formation is composed completely of sandstones and lesser shales shed from the southern flank of the PRA (Figure 1). The eastward, more subdued, extension of the PRA, known as the Athabasca Arch, may have also influenced the Cambrian succession in east-central Alberta by sourcing siliciclastics to the basin fill in the form of an increasingly coarse Earlie-Deadwood succession (Figure 3).

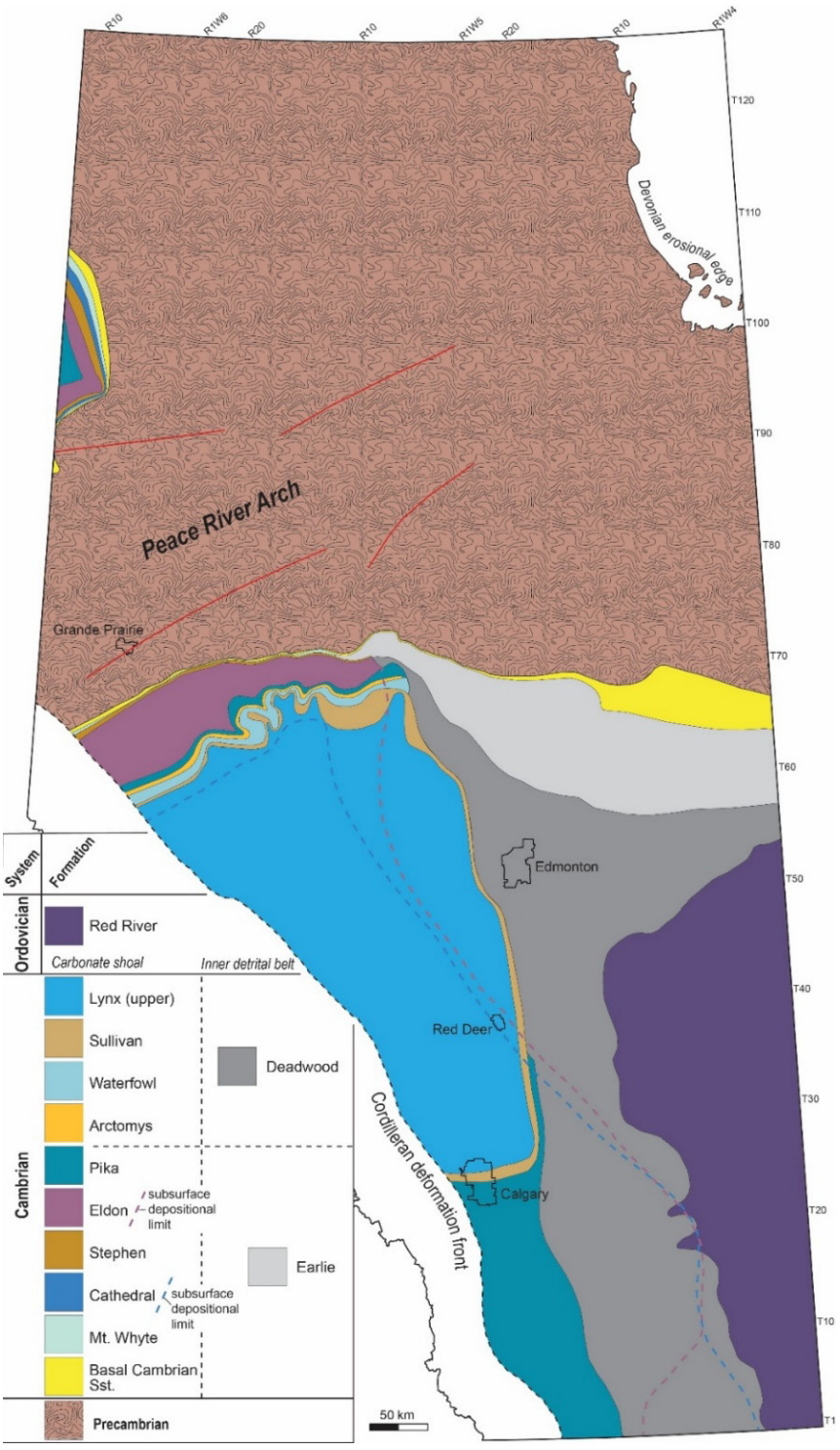


Figure 2. Map of subcropping Cambrian and Ordovician units at the sub-Devonian unconformity. The Cambrian unit below the sub-Ordovician unconformity is the Deadwood Formation. The approximate depositional limits for the Cathedral and Eldon formations are shown as dashed lines. Unlike the Eldon Formation, the Cathedral Formation south of the Peace River Arch does not subcrop as it pinches out and is replaced by siliciclastics near the southern margin of the Peace River Arch. Red lines are the approximate structural outlines of the Peace River Arch from O'Connell et al. (1994).

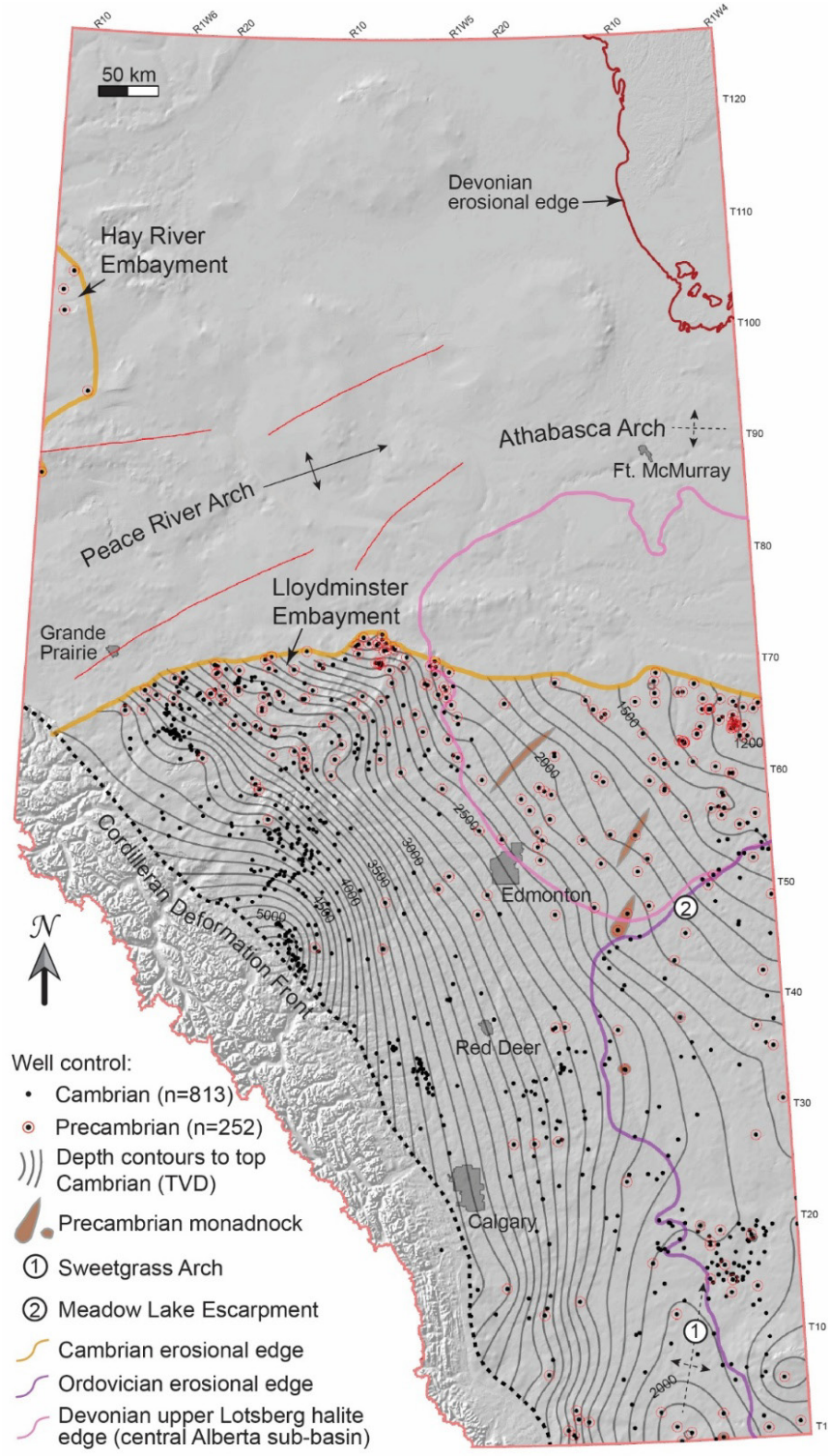


Figure 3. Map of the distribution of Cambrian strata in Alberta with relevant Ordovician and Devonian paleogeographic elements, well control, and total vertical depth (TVD) contours for the top of the Cambrian succession. The thin red lines represent the approximate border of the Peace River Arch (present-day structure) from O'Connell (1994). The background map is a shaded relief of the bedrock topography generated from AGS Digital Data 2020-0022 (Alberta Geological Survey, 2020).

Several relatively small erosional outliers, known as monadnocks, formed on the Precambrian basement (Figure 3). These positive paleotopographic features locally influenced BCS deposition in Alberta causing onlap and non-deposition, and possibly serving as local sources of sediment. The origin and extent of these features is unknown, but in southwestern Saskatchewan, some of these highs have been interpreted as having a structural origin (Slind et al., 1994; Ichaso, 2024). Without seismic, and where well penetrations hit elevated Precambrian basement rocks without BCS deposits (informally known as "bald highs"), these features have been interpreted as small erosional outliers (e.g., Slind et al., 1994). The three elongate forms trending NE in east-central Alberta shown in Figure 3 are interpretations based on seismic programs conducted by Carbon Hub proponents (e.g., Shell Canada Energy; Winkler, 2011). The southernmost elongated monadnock has been interpreted from two relatively closely-spaced wells that intersect the feature. The southwestern well encountered no BCS, whereas the northeastern well has only a thin BCS deposit. Therefore, the presence/absence of BCS across this feature suggest an elongate form that is more subdued to the northeast.

The present-day distribution of Cambrian strata is a result of deep erosion across several unconformities. In eastern Alberta the Cambrian is overlain by the erosional remnant of the Ordovician carbonate succession across the sub-Ordovician unconformity (Figure 1 and Figure 2). Elsewhere in Alberta, the Cambrian is truncated by the sub-Devonian unconformity (Figure 1 and Figure 2). In east-central Alberta, erosion at the sub-Devonian unconformity was significant, forming the central Alberta sub-basin in which a thick succession of Lower Devonian evaporites and red beds accumulated (Meijer Drees, 1994; Hauck, 2020). The southern margin of this sub-basin is formed by the erosional remnant of the Ordovician carbonate belt, which is known as the Meadow Lake Escarpment (Figure 3). Erosion at the sub-Devonian unconformity was also pronounced in southwestern Alberta, where the Cambrian strata were removed down to the Middle Cambrian Pika Formation (Figure 2).

2 Methods

Lithostratigraphic correlations were made using SLB's geological software Petra and Kingdom. These correlations benefited from previous subsurface studies in the basin (Pugh, 1971, 1973, 1975; Slind et al., 1994), and present new correlation interpretations based on new well control and core-based assessments. However, the few data points from the Hay River Embayment follow the work of Pugh (1973). Data and information from all deep wells completed to the Precambrian basement were used in the area where the Cambrian succession is present (i.e., Lloydminster and Hay River embayments; Figure 3). Due to the scarcity of wells, choosing only newer wells with modern log suites was not feasible, and wells of all ages were included to maximize the number of correlations. Lithostratigraphic picks from a total of 812 wells, of which only 253 reach the Precambrian basement (Figure 3), are provided in the stratigraphic pick dataset associated with this report (see AGS Digital Data 2026-0012; Hauck and Herbers, 2026).

Mapped lithostratigraphic units follow those outlined in the Alberta Table of Formations (https://ags.aer.ca/publications/all-publications/alberta-table-formations) (Figure 1). All formations were correlated across their respective depositional and eroded extents (e.g., the Eldon Formation has both an eastern depositional, and northern erosional extent within the Lloydminster Embayment). Given that the carbonate shoal belt prograded eastwards and interfingered with the inner detrital belt (Figure 2), the maximum eastward extent of a given carbonate-dominated formation (e.g., Cathedral Formation) is approximated based on well-log responses that may or may not represent the maximum eastward extent of true carbonate shoal facies. Nonetheless, the interpreted edges of the carbonate shoal belt formations represent the approximate boundary between the carbonates and the inner detrital belt. Informal marker beds—surfaces related to carbonate shoal formations with distinct log signatures that can be traced into the inner detrital belt—were used to support correlations eastwards. They are represented on the cross-section figures herein but are not included in the digital dataset (AGS Digital Data 2026-0012) that accompanies this Open File Report, with the exception of the Pika marker.

There are very few cores taken within the Cambrian succession outside of the Basal Cambrian Sandstone unit. The few cores that were completed within the inner detrital belt muddy strata were integral to correlating the boundary between the Middle and Upper Cambrian deposits, separated by the Pika marker (Figure 1). Handheld X-ray fluorescence (XRF) data contributed to making this pick in east-central Alberta, since the Pika marker is associated with an increase in carbonate content. The XRF data record elemental compositions measured from core and can be used for chemostratigraphic approaches to correlation of formations. A few cores were also important in picking the position of the sub-Devonian unconformity, including distinguishing the shales of the Cambrian Earlie and Deadwood formations from the overlying Devonian Basal Red Beds of the Lotsberg Formation (Figure 1).

Isopach maps are included to show thickness trends for a variety of intervals, including the Cambrian succession as a whole, the BCS, and the Eldon and Earlie sandstones. The Cambrian System isopach was mapped in Esri's ArcGIS Pro using the radial basis functions (RBF) gridding algorithm, whereas the BCS and Eldon sandstone isopach maps were hand contoured (digitized) in the geological software Kingdom and exported to ArcGIS Pro for final map production. The Earlie sandstone isopach map was generated using a 65 API cut-off on gamma-ray logs. The BCS isopach map is a gross-thickness map, including the entire interval from the top of the BCS to the Precambrian basement.

For the isopach map of the entire Cambrian succession, thickness data from wells penetrating into Precambrian monadnocks were excluded from the gridding dataset because sparse well control around these features can result in exaggerated areas of artificially thin Cambrian strata. The Basal Cambrian Sandstone isopach map shows the locations of known Precambrian monadnocks, because most of these basement highs likely precluded deposition of the BCS as they were positive topographic highs during deposition. However, because the monadnocks are mostly very small relative to the map scale and their true lateral extent is uncertain, they were not included as zero-thickness constraints during gridding. Instead, they are shown on the map as interpreted areas of non-deposition.

3 Results

3.1 Type Logs

We include two type logs to represent Cambrian lithostratigraphy: one in the western part of the province where the carbonate shoal belt is well developed (Figure 4), and one from the inner detrital belt of east-central Alberta where the succession overlying the BCS is dominated by fine siliciclastics (Figure 5). These type logs show the type of wireline log signatures of the various formations from relatively modern log suites.

The Precambrian basement signature is usually variable in gamma-ray response; however, it is typically very highly resistive due to a lack of porosity (Figure 4). Above this, the Basal Cambrian Sandstone (BCS) displays a low gamma-ray response, becoming higher upwards as facies transition from clean quartz arenites to sandstones interbedded with fine siliciclastics as deepening profiles progress. This "bell-shaped" profile is diagnostic of an overall transgressive signature. The coarsest grained deposits are typically concentrated within the few metres of sandstone immediately overlying the Precambrian basement. These coarse-grained sandstone deposits gradationally transition to muddier lithosomes with a hotter gamma-ray character. Ultimately, the marginal marine deposits of the BCS are flooded over and capped with marine offshore mudstone deposits. The BCS typically displays a low resistivity response due to brine-filled porosity but may display higher resistivity if porosity is occluded by cements, which is more common in deeper parts of the basin (Figure 4).

In the subsurface, the carbonate shoal belt is typified by high-gamma-ray shales and silty mudstones alternating with relatively low-gamma-ray carbonates (Figure 4). Distal to the locus of the Cambrian carbonate factory in the area of the present-day Rocky Mountains, the carbonate-dominant facies (e.g., Cathedral and Eldon formations) in the subsurface are also interbedded with shales and silts, highlighting the complex interplay between carbonates shed from the shoal belt and the inner detrital belt siliciclastics in response to relative sea-level changes.

In east-central Alberta, the inner detrital belt type log is represented by the relatively low gamma-ray and low resistivity (water-saturated) BCS overlain by high-gamma-ray mudstones with occasional interbedded sandstones (Figure 5). We correlate two important log markers that are integral to differentiating important intervals in the Earlie Formation, and the Earlie Formation from the overlying Deadwood Formation. First, the Pika maximum flooding surface (MFSx) corresponds to a significant transgressive event recorded in the inner detrital belt (see Section 3.4). The second surface is the Pika marker, which represents the boundary between the Middle Cambrian Earlie and Upper Cambrian Deadwood formations. This surface is commonly represented by a return to less-resistive shales and mudstones of the Deadwood Formation overlying the marker (Figure 5). However, the boundary may be more cryptic than the Pika MFSx. The Pika marker represents maximum progradation of carbonate shoal belt facies, and so beds underlying the marker can be associated with increased carbonate content. On wireline logs, these beds may be represented by a supressed gamma-ray and an increased resistivity response.

3.2 Cross-Sections

Cambrian lithostratigraphic correlations are presented in a series of east–west and north–south stratigraphic cross-sections across the Lloydminster Embayment (Figure 6–Figure 11). High-resolution image files of these cross-sections are available in AGS Digital Data 2026-0012 (Hauck and Herbers, 2026). Salient features and observations are discussed below.

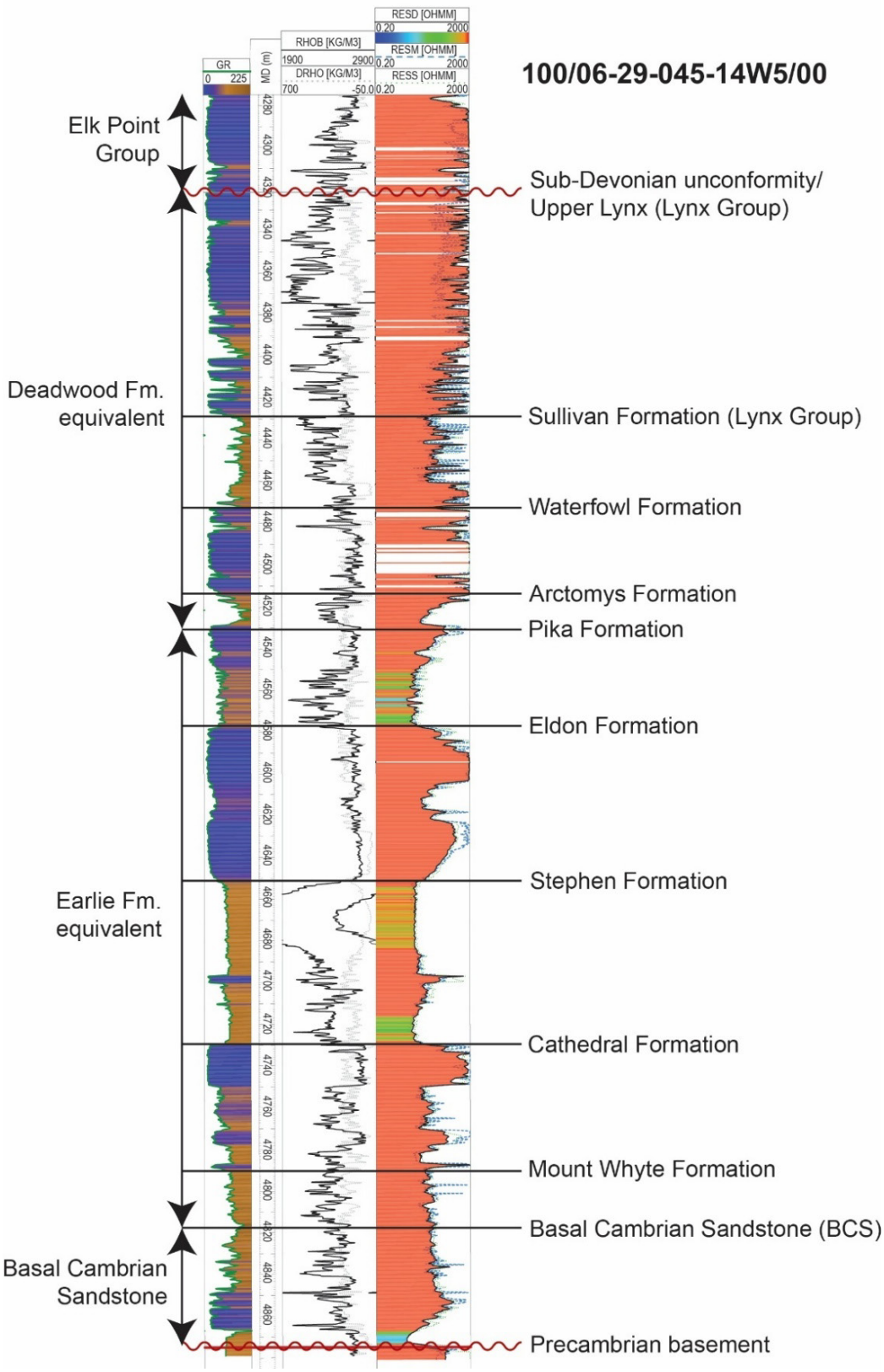


Figure 4. Type log for the carbonate shoal belt in western Alberta. Abbreviations: Fm., formation; GR, gamma ray; MD, measured depth; RHOB, bulk density; DRHO, density correction; RESD, deep resistivity; RESM, medium resistivity; RESS, shallow resistivity.

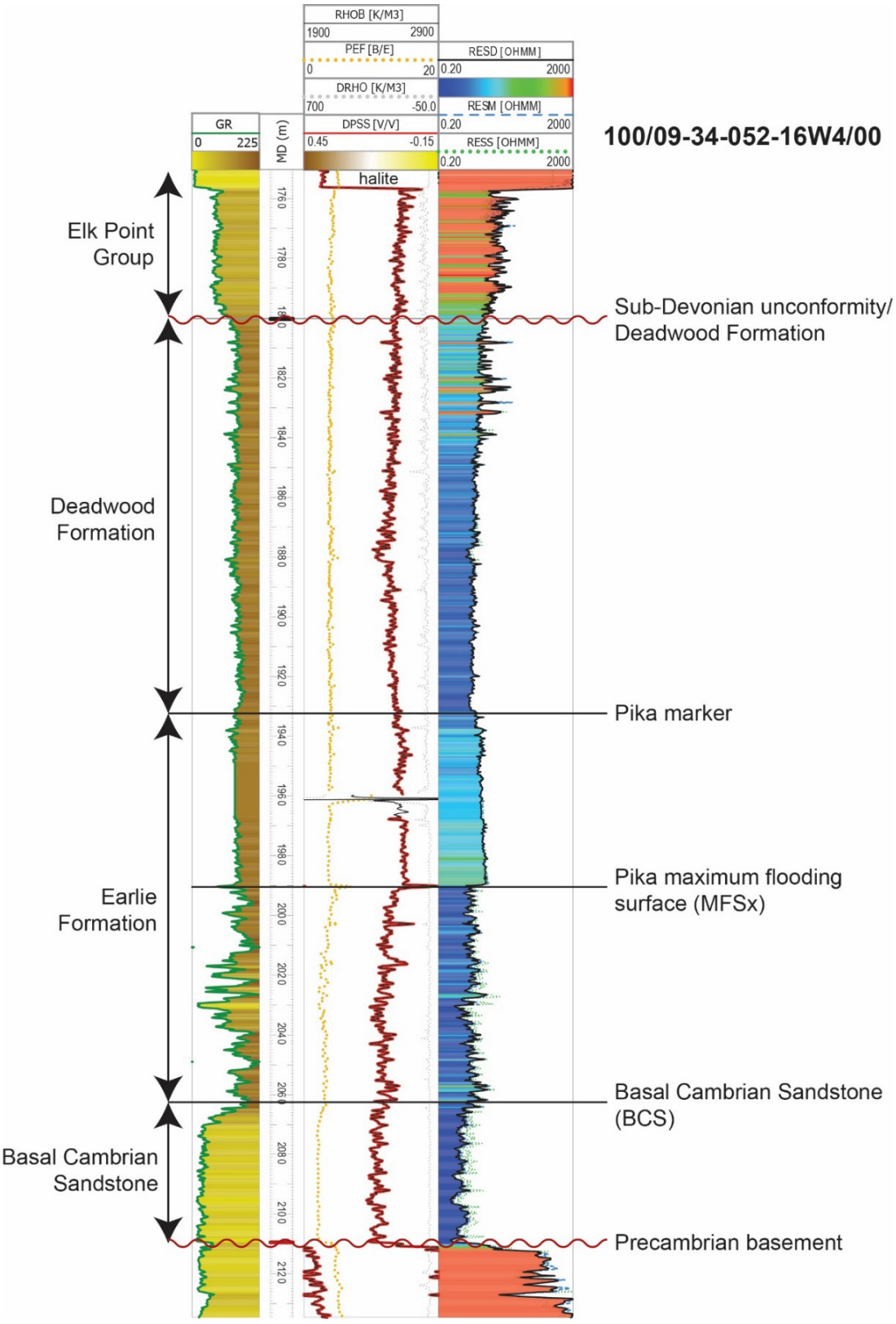


Figure 5. Type log for the inner detrital belt in eastern Alberta. Abbreviations: GR, gamma ray; MD, measured depth; RHOB, bulk density; DRHO, density correction; RESD, deep resistivity; RESM, medium resistivity; RESS, shallow resistivity.

3.2.1 Cross-Section A–A'

Cross-section A–A' runs west to east across southern Alberta, from near the deformation front to the Saskatchewan border (Figure 6). Two monadnocks are present in southernmost Alberta, where the BCS onlaps the basement highs and is missing over their crests. The BCS is relatively uniform in thickness along the section but is thinner than in the north. In the west, the carbonate shoal belt is represented by the carbonate-dominated strata from the Cathedral through Pika formations. Eastwards, these carbonate units gradually interfinger with the siliciclastic deposits of the inner detrital belt, with marly deposits extending towards the Saskatchewan border. Erosion at the sub-Devonian unconformity is much deeper in the west, where the Upper Cambrian (Deadwood equivalent) is completely removed and the unconformity cuts down to the Pika Formation (Figure 6). The easternmost three wells contain the erosional remnants of the Ordovician succession, with the top of the Cambrian forming the sub-Ordovician unconformity.

3.2.2 Cross-Section B–B'

Cross-section B–B' runs from northeast of Calgary to the Saskatchewan border. The section includes a conspicuous monadnock at well 16-16-034-15W4 that extends upward well into Eldon-equivalent strata (Figure 7). The BCS is thicker here than in the south and nearly doubles east of the monadnock, a thickness trend that continues northwards into the Cold Lake region in east-central Alberta. The three westernmost wells intersect strata from the carbonate shoal belt. Deep erosion at the sub-Devonian unconformity persists in the west but is shallower than farther south (compare with cross-section A-A' in Figure 6), with truncation only down to the upper Lynx interval.

3.2.3 Cross-Section C–C'

Cross-section C–C' runs west to east across central Alberta from near the deformation front to east-central Alberta, and traverses two Precambrian monadnocks (Figure 8). The BCS thickens eastwards, and the Earlie Formation becomes increasingly coarse grained, with distinct sandstone beds evident in well 11-19-050-06W4 (Figure 8). At well 02-18-055-24W4, the cross-section enters the central Alberta sub-basin (Figure 3), where deep erosion at the sub-Devonian unconformity defines a roughly bowl-shaped depocenter in which the red beds and evaporites of the Lower Elk Point subgroup accumulated (e.g., lower and upper Lotsberg halite).

3.2.4 Cross-Section D–D'

Cross-section D–D' runs south to north along eastern Alberta. In the south, only marly equivalents of the carbonate shoal belt are present. Northwards, the Earlie and Deadwood formations become increasingly sand-rich towards the Cold Lake region of east-central Alberta (Figure 9). The section also highlights the deep erosional truncation of the Cambrian succession north of the Meadow Lake Escarpment (Figure 9, well 11-19-050-06W4). This truncation corresponds to the Devonian depocenter filled by red beds and evaporites of the Lower Elk Point subgroup. Farther north, the BCS subcrops directly beneath Devonian strata, and just north of the D' (11-19) well, the Cambrian succession has been completely removed by erosion.

3.2.5 Cross-Section E–E'

Cross-section E–E' runs south to north through the central part of Alberta, from near the U.S. border to the northern erosional edge of the Cambrian. The southern half of the section includes formations of the carbonate shoal belt, which shale out towards the north. Because the section is not oriented strictly along depositional strike, the Precambrian basement shallows northwards. The Earlie Formation becomes increasingly coarse grained to the north, highlighting the influence of the southern margin of the Peace River Arch in this area. The section crosses the western half of the central Alberta sub-basin, where deep erosional truncation has removed much of the Cambrian interval starting at well 02-18-055-24W4 (Figure 10). Deep erosion is also evident in the southernmost part of the section, where Upper Cambrian strata have been removed.

3.2.6 Cross-Section F–F'

Cross-section F–F' runs roughly south to north from near the deformation front in west-central Alberta to the Cambrian erosional subcrop edge along the southern flank of the Peace River Arch (PRA). Along the section, Middle Cambrian Earlie Formation equivalents (Mount Whyte to Pika formations) are marly moving northwards, whereas Upper Cambrian Deadwood Formation equivalents (Waterfowl Formation to upper Lynx interval) appear more carbonate rich (Figure 11). In this area, the Eldon Formation is almost completely sandstone, highlighting the influence of sediment supply from the southern flank of the PRA. The Eldon sandstone is compositionally very similar to the BCS, comprising a quartz arenite sourced from the Precambrian basement rocks of the PRA.

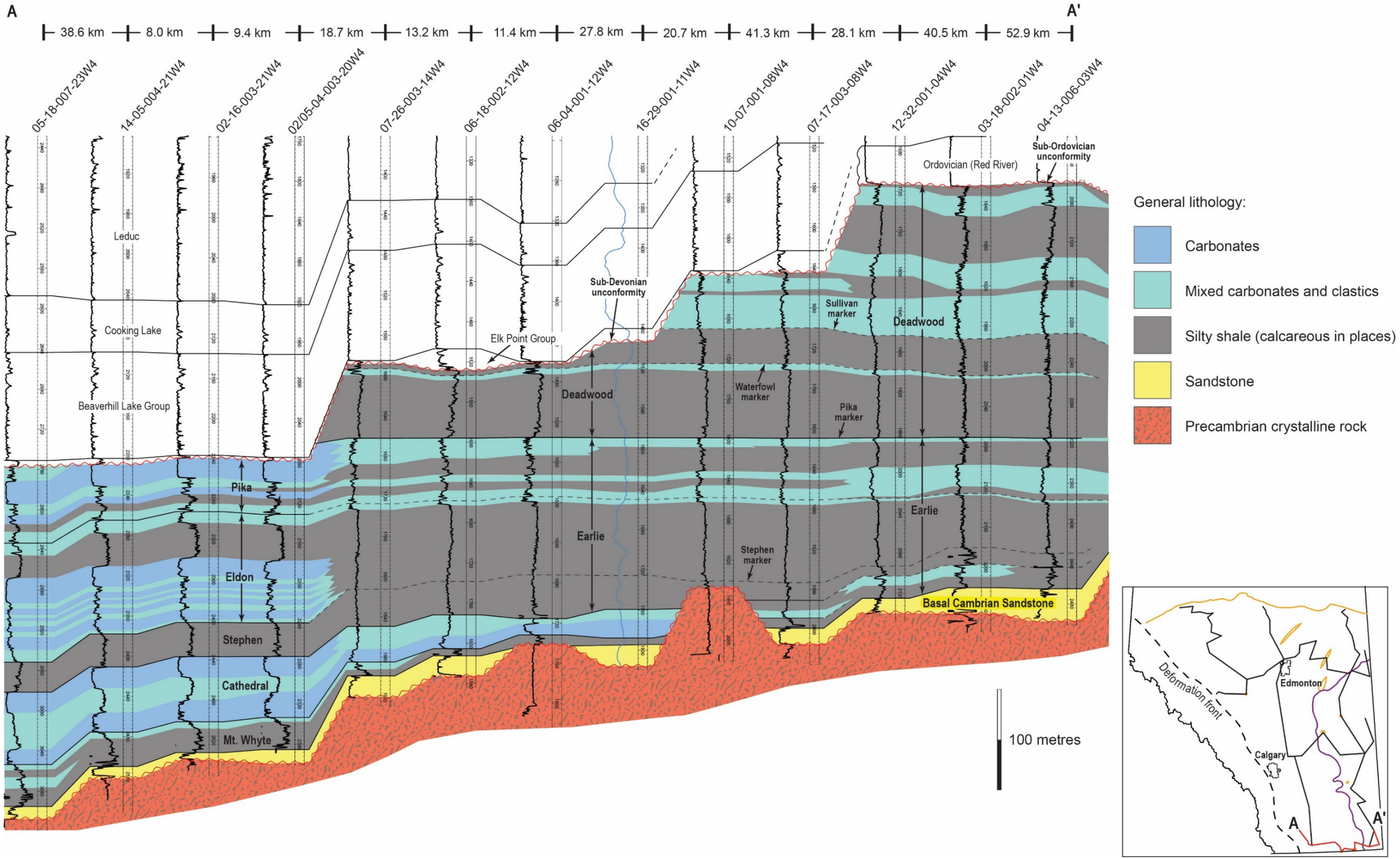
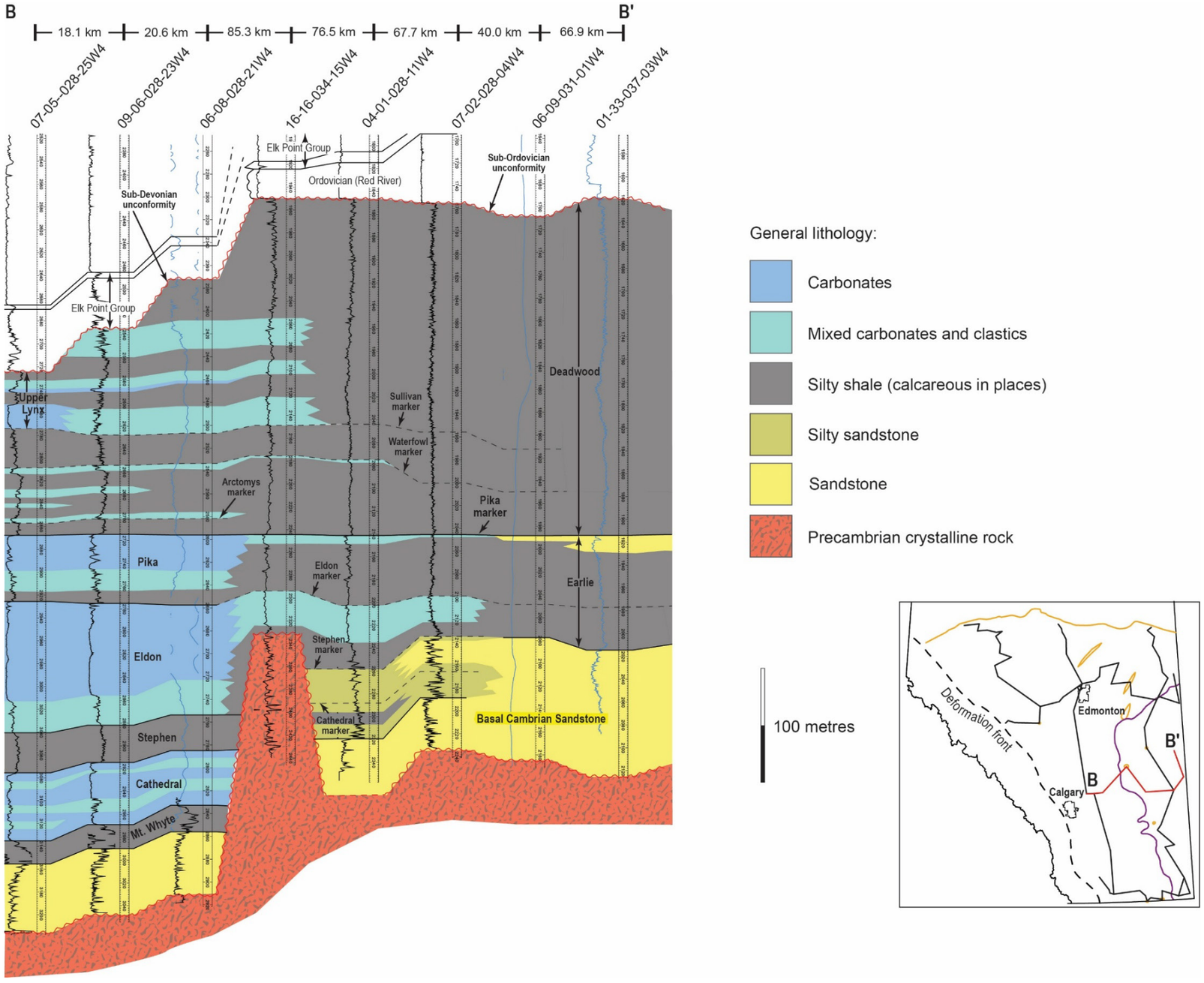


Figure 6. Stratigraphic cross-section A–A′ across southern Alberta. The inset map shows the Cambrian erosional edge in the north and Precambrian monadnocks in light orange, as well as the erosional edge of the Ordovician strata in purple. Wireline logs are gamma ray, or spontaneous potential (blue curve) if no gamma-ray log was available. Datum = Pika Formation/marker.



General lithology:

- Carbonates
- Mixed carbonates and clastics
- Silty shale (calcareous in places)
- Silty sandstone
- Sandstone
- Precambrian crystalline rock

100 metres

Figure 7. Stratigraphic cross-section B–B′ across south-central Alberta. The inset map shows the Cambrian erosional edge in the north and Precambrian monadnocks in light orange, as well as the erosional edge of the Ordovician strata in purple. Wireline logs are gamma ray, or spontaneous potential (blue curve) if no gamma-ray log available. Datum = Pika Formation/marker.

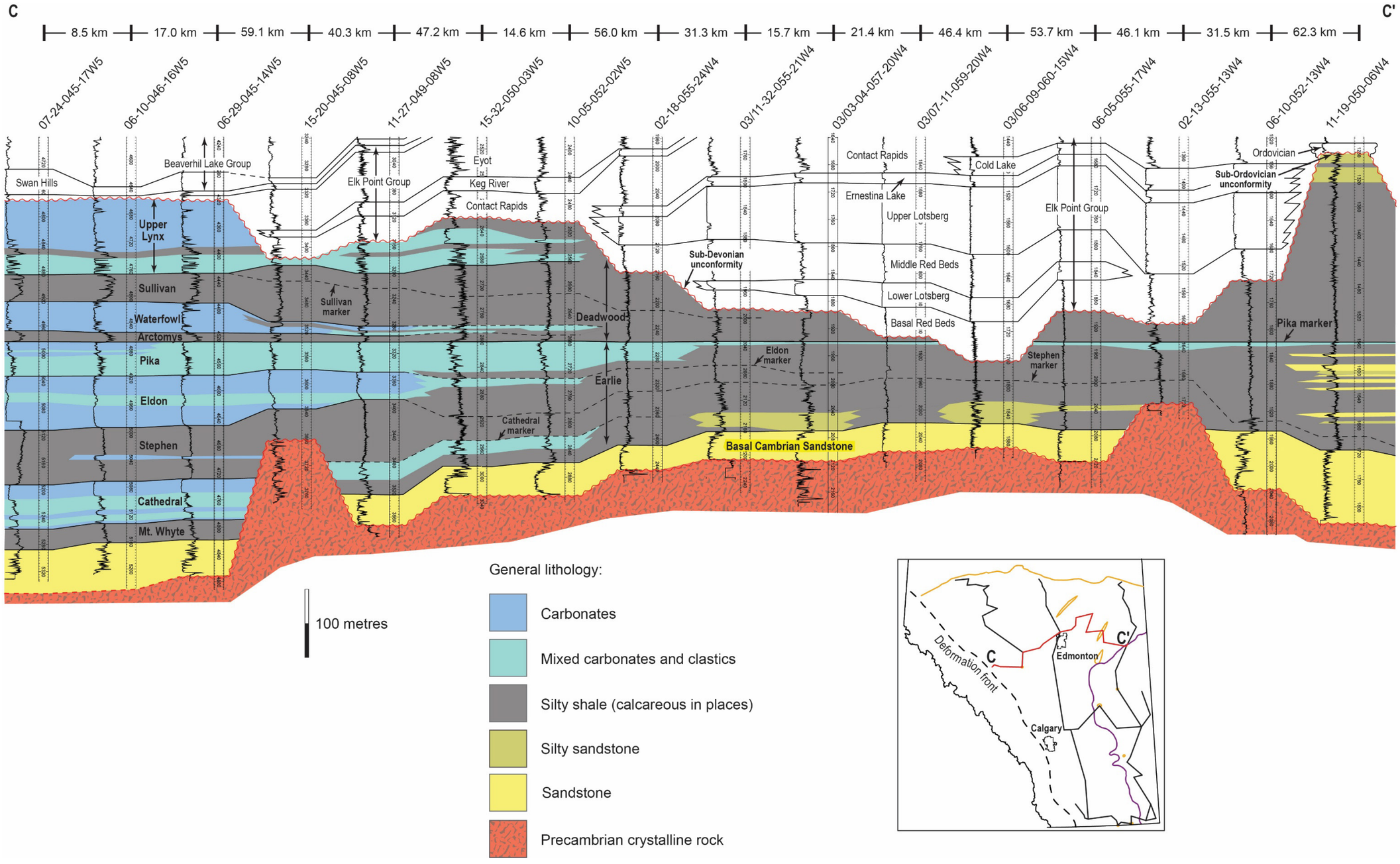


Figure 8. Stratigraphic cross-section C–C′ across central Alberta. The inset map shows the Cambrian erosional edge in the north and Precambrian monadnocks in light orange, as well as the erosional edge of the Ordovician strata in purple. Wireline logs are gamma ray. Datum = Pika Formation/marker.

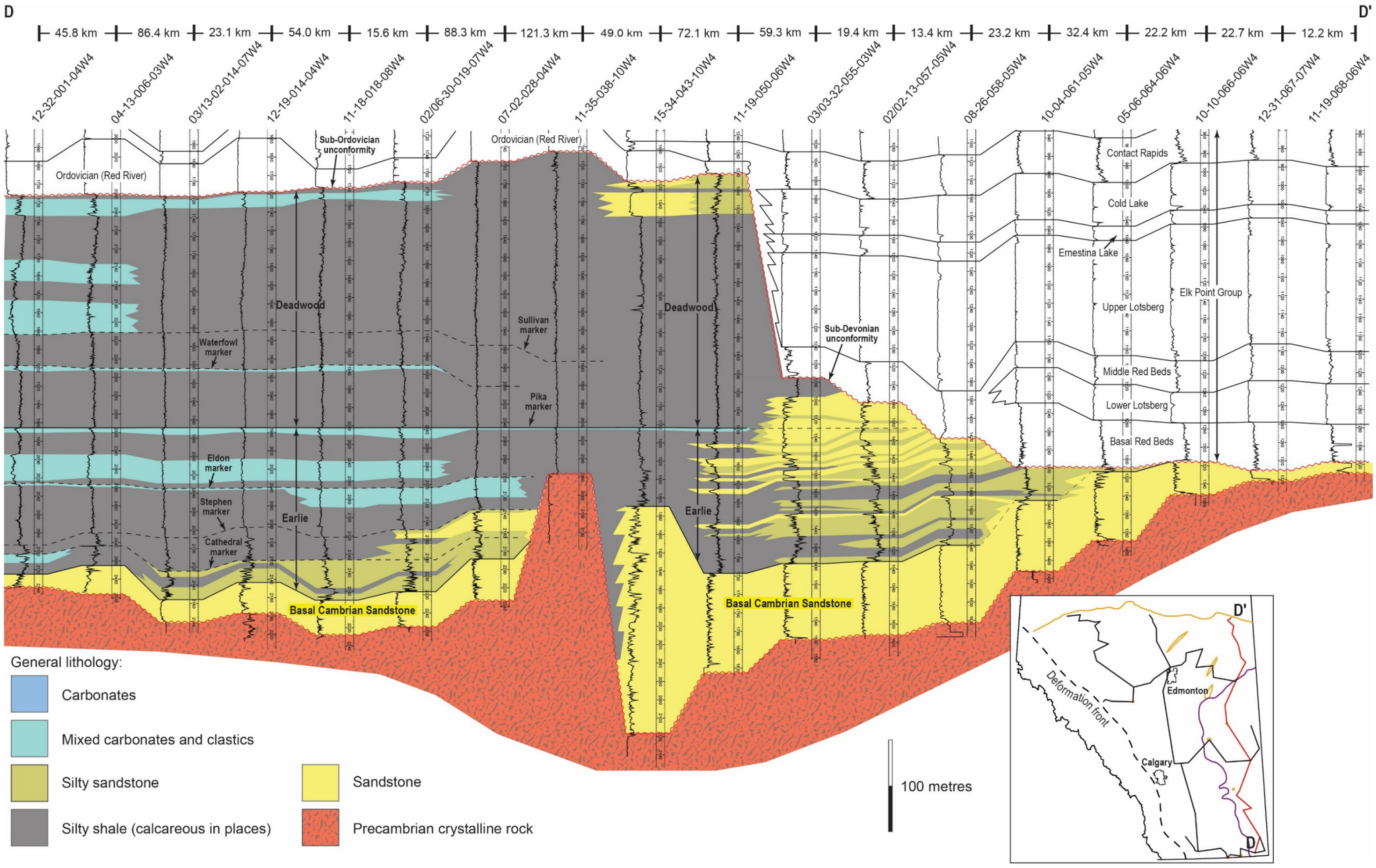


Figure 9. Stratigraphic cross-section D–D′ running north–south in eastern Alberta. The inset map shows the Cambrian erosional edge in the north and Precambrian monadnocks in light orange, as well as the erosional edge of the Ordovician strata in purple. Wireline logs are gamma ray. Datum = Pika Formation/marker.

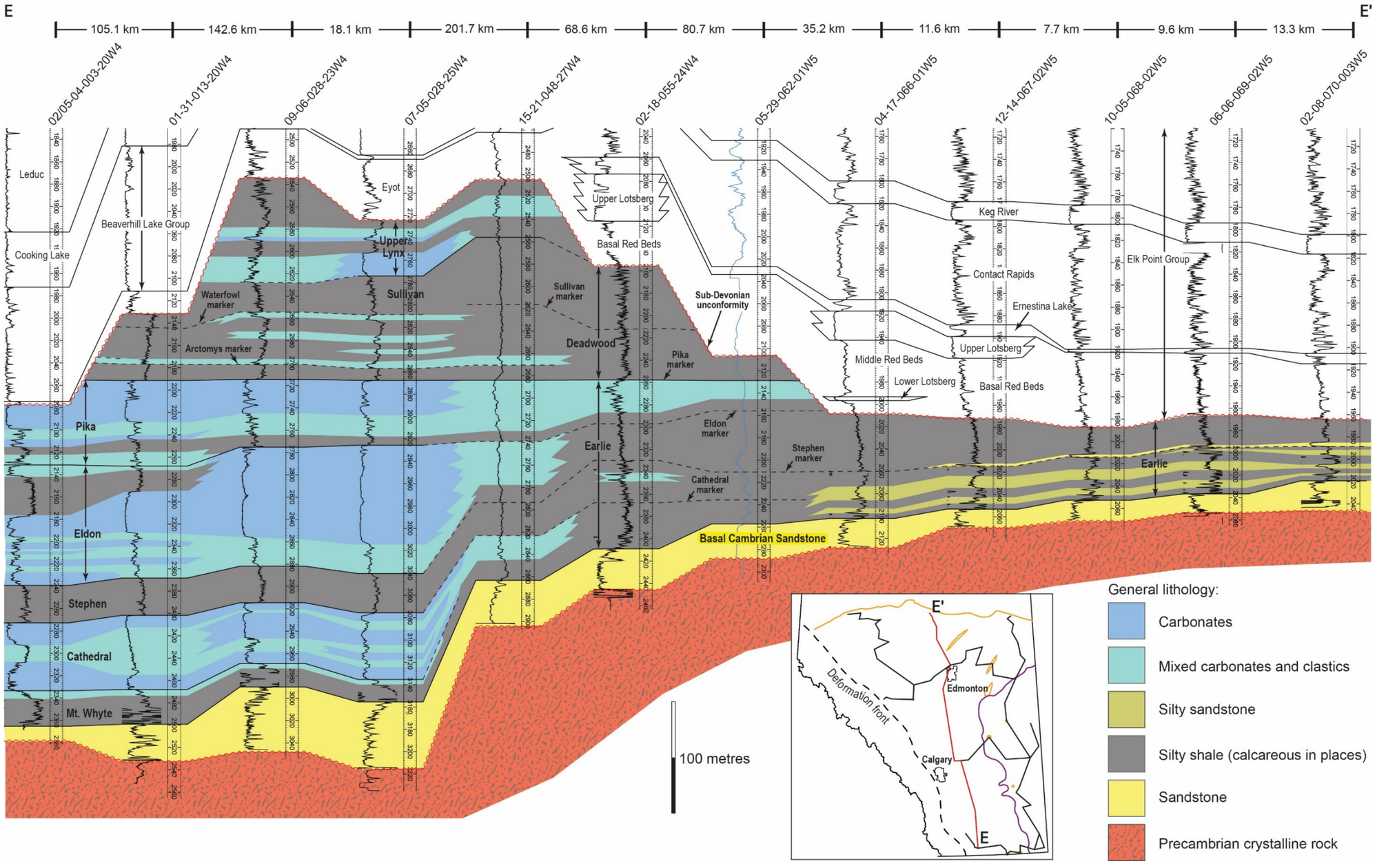


Figure 10. Stratigraphic cross-section E–E′ running north–south in central Alberta. The inset map shows the Cambrian erosional edge in the north and Precambrian monadnocks in light orange, as well as the erosional edge of the Ordovician strata in purple. Wireline logs are gamma ray, or spontaneous potential (blue curve) if no gamma-ray log available. Datum = Pika Formation/marker.

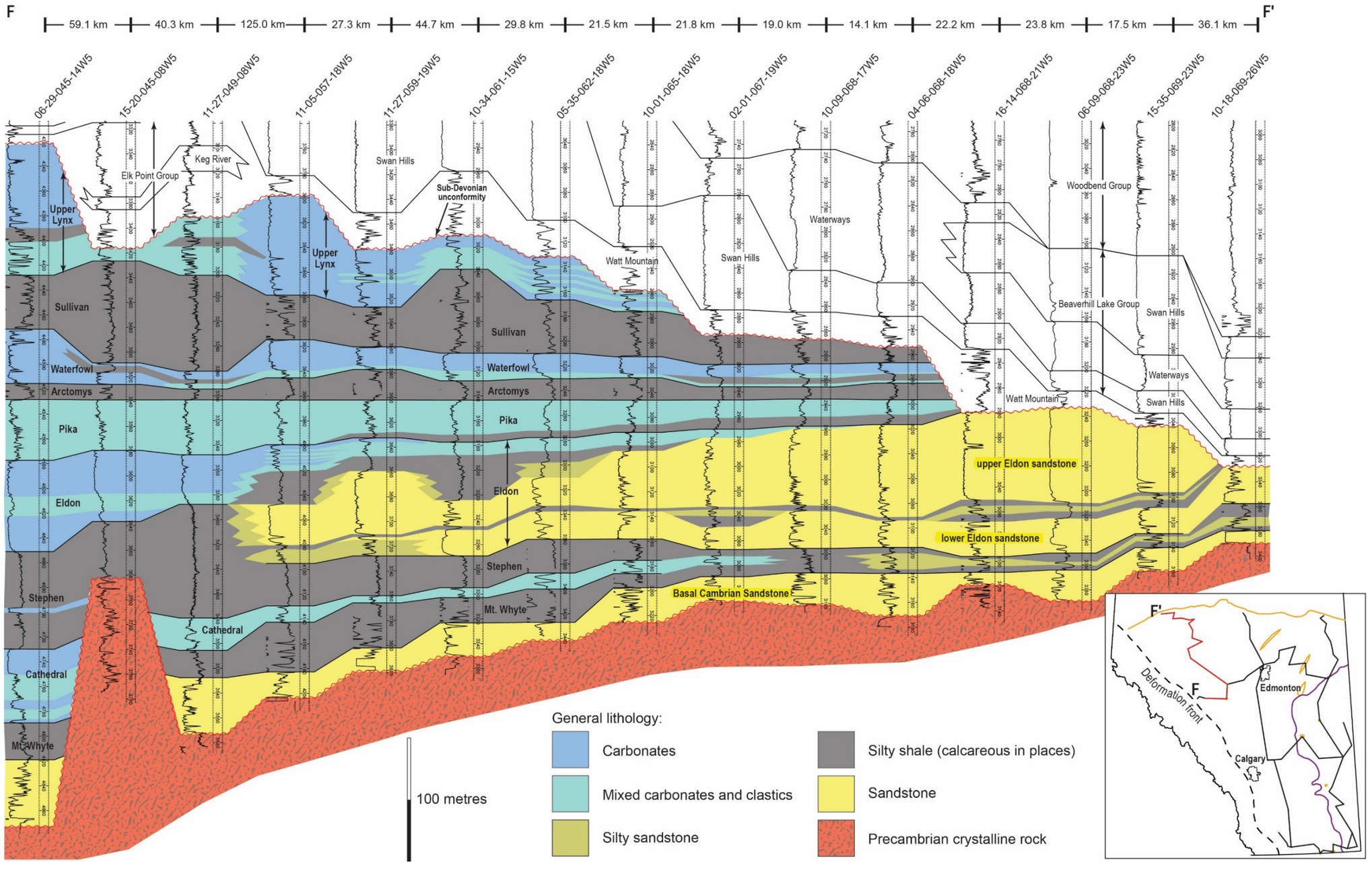


Figure 11. Stratigraphic cross-section F–F′ running roughly south–north in west-central Alberta. The inset map shows the Cambrian erosional edge in the north and Precambrian monadnocks in light orange, as well as the erosional edge of the Ordovician strata in purple. Wireline logs are gamma ray. Datum = Pika Formation.

3.3 Isopach Maps

Based on regional correlations, this report includes several isopach maps that highlight thickness trends within the Lloydminster Embayment. The Hay River Embayment is excluded because well control there is too sparse. Isopach maps include: 1) the whole Cambrian succession, 2) the Basal Cambrian Sandstone, 3) the Eldon sandstone on the southern flank of the Peace River Arch, and 4) the Earlie Formation sandstones in east-central Alberta.

3.3.1 Cambrian Isopach Map

The thickness of the Cambrian System ranges from zero at the northern erosional edge to greater than 600 metres around Township 40, Range 10 West of the 4th Meridian (Figure 12). Deep erosion north of the Ordovician erosional edge (i.e., the Meadow Lake Escarpment) corresponds to the central Alberta sub-basin that contains the evaporites of the Lower Elk Point subgroup (e.g., upper Lotsberg halite). In southwestern Alberta, near the deformation front, the Cambrian System progressively thins due to increased erosion at the sub-Devonian unconformity (see Figure 6 and Figure 10). Well control is very sparse in areas of the map up to at least 10 townships east of the deformation front where the basin is deepest, resulting in a greater degree of uncertainty in these areas.

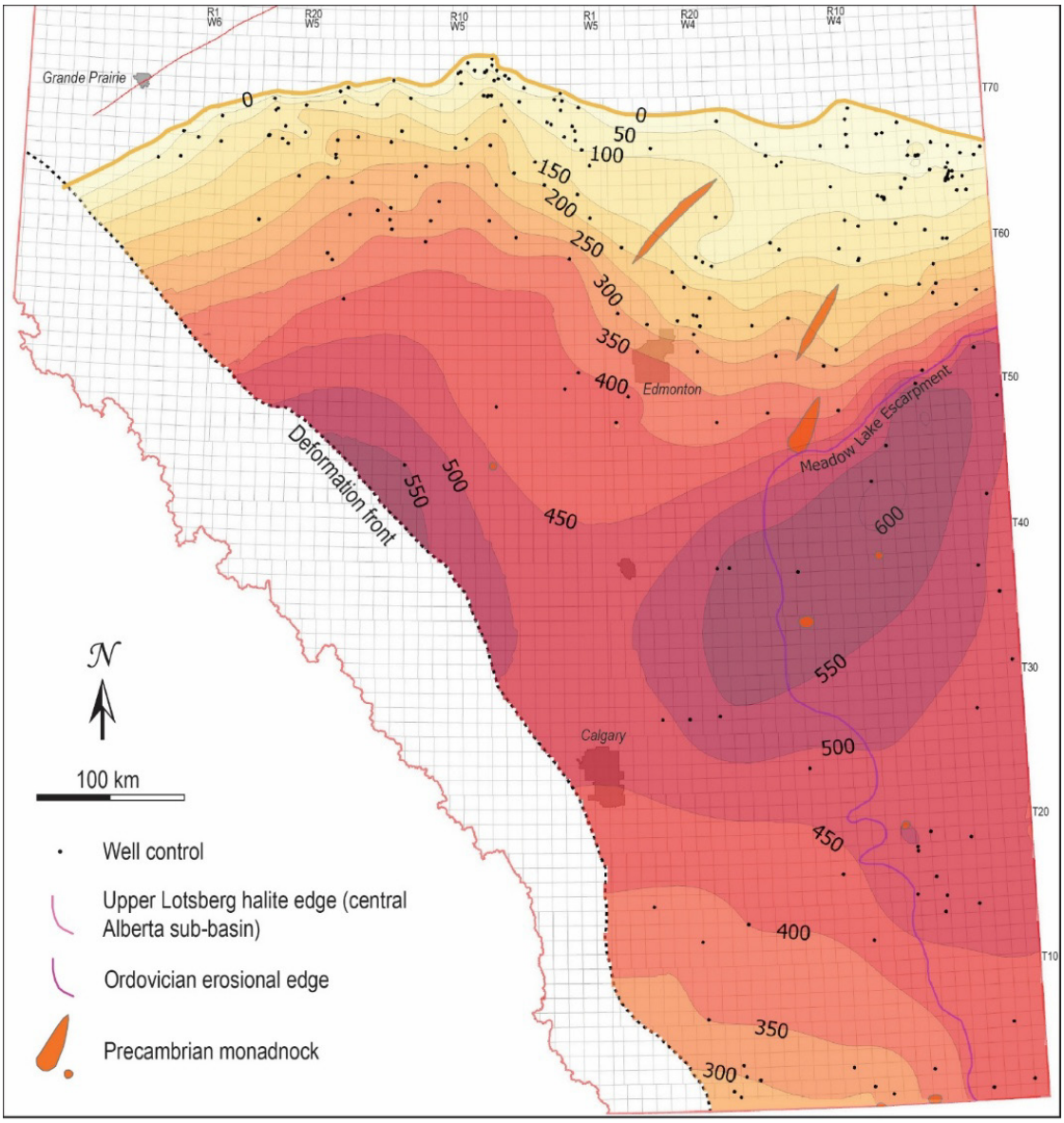


Figure 12. Isopach (thickness) map of the Cambrian System (Precambrian basement to top of the Cambrian) in the Lloydminster Embayment in the southern half of Alberta. Contour interval = 50 metres. The red line near Grande Prairie is the southern margin of the Peace River Arch (from O'Connell, 1994).

3.3.2 Basal Cambrian Sandstone Isopach Map

The isopach map of the BCS reveals that the unit is relatively uniform in thickness across much of the province, commonly ranging from 40 to 50 m (Figure 13). A notable exception occurs in east-central Alberta, where the unit more than doubles in thickness, reaching over 110 m. Along the northern margin, the BCS gradually thins towards its erosional edge at the sub-Devonian unconformity. One well in eastern Alberta (100/15-34-043-10W4/00; asterisk on Figure 13, also shown on cross-section D–D′ in Figure 9) contains an anomalously thick (>200 m) BCS interval. Facies analysis of cored intervals from this well indicates that the overthickened sandstones are consistent with BCS facies. This localized thickening points to substantial accommodation, likely due to syndepositional tectonic activity near the well—a suggestion supported by the observation of significant soft sediment deformation and micro-faulting in

core (see litholog of well 100/15-34-043-10W4/00 in AGS Digital Data 2026-0012; also described in Herbers et al., 2024).

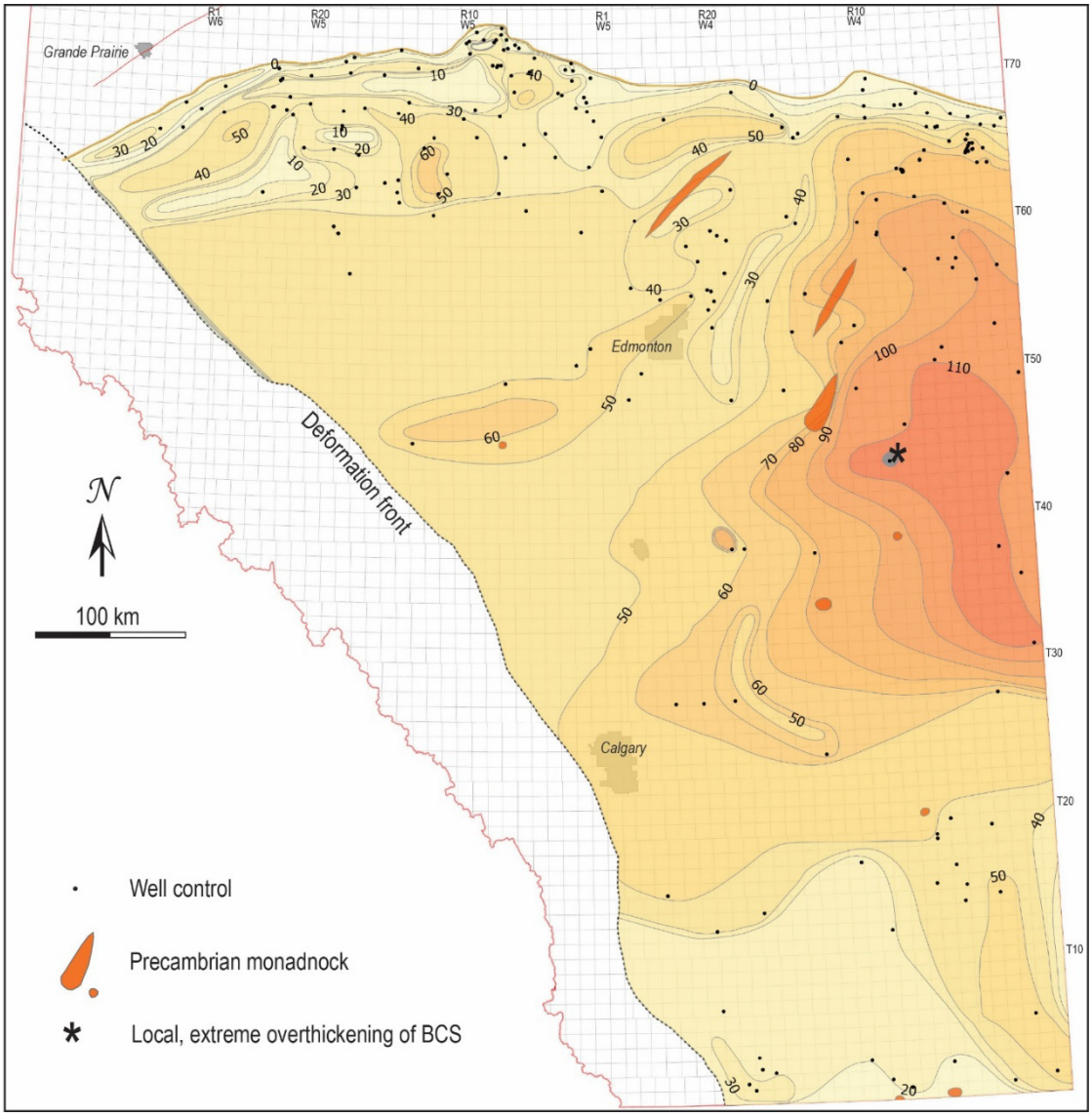


Figure 13. Isopach (thickness) map of the Basal Cambrian Sandstone (BCS) in the Lloydminster Embayment in the southern half of Alberta. Contour interval = 10 metres. The BCS is not deposited over the Precambrian monadnocks (see text for explanation). The red line near Grande Prairie is the southern margin of the Peace River Arch (from O'Connell, 1994).

3.3.3 Eldon Sandstone Isopach Map

In west-central Alberta, the Eldon Formation —typically comprising microbial carbonates—is replaced by quartz arenites derived from the southern flank of the Peace River Arch (see Figure 11). The sandstones can be just over 100 m in thickness in the north but thin southwards as they pinch out and are replaced by mudstones. To the north, the interval is abruptly truncated at the sub-Devonian unconformity (Figure 11 and Figure 14). We interpret the Eldon sandstone to record progradation of fluvially derived sediment from the Peace River Arch, resulting in the suppression of carbonate productivity and sedimentation.

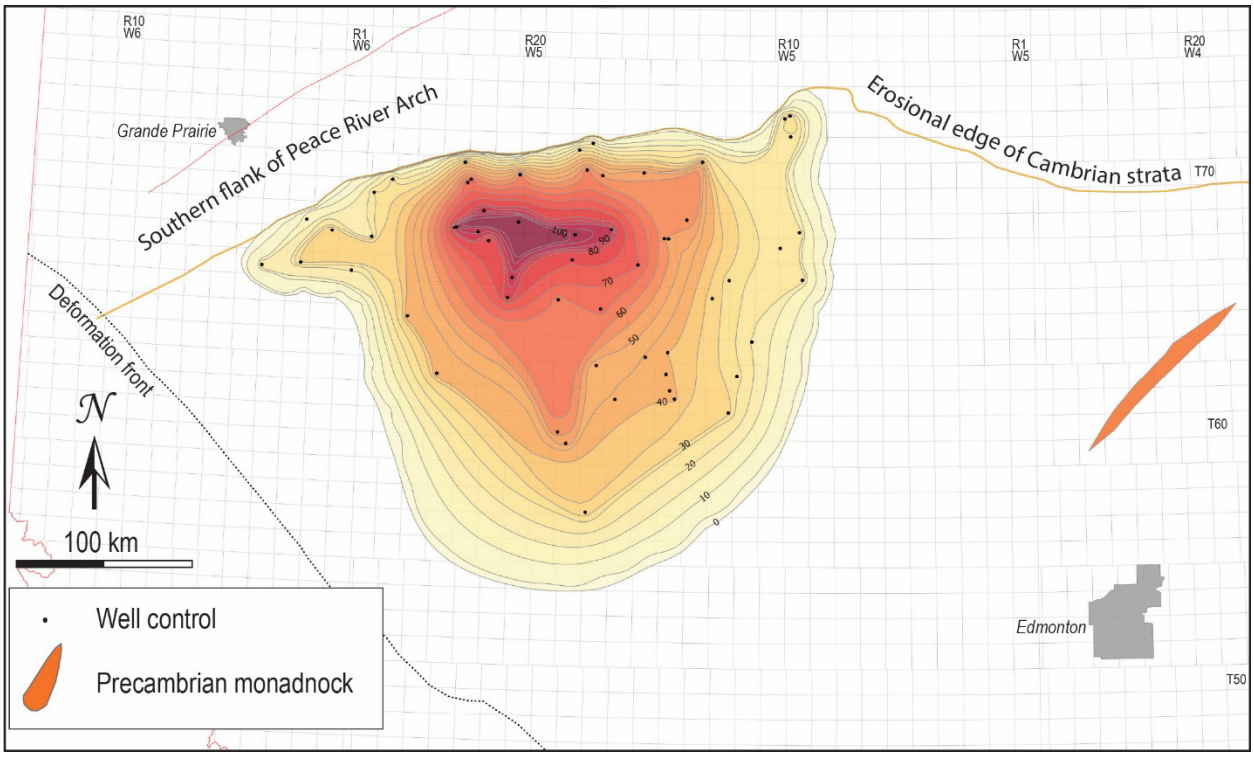


Figure 14. Isopach (thickness) map of the Eldon sandstone in the Lloydminster Embayment along the southern flank of the Peace River Arch in west-central Alberta. The Eldon sandstone makes up the majority of the Eldon Formation in this area (see Figure 12). Contour interval = 5 metres.

3.3.4 Earlie Sandstone Intervals Cumulative Isopach Map

The Earlie sandstone intervals record a series of progradational sandstone beds that progressively thicken towards the northern subcrop edge before they are truncated by the sub-Devonian unconformity (Figure 9). These sandstone beds continue into western Saskatchewan. Cumulatively, the sandstones can be over 70 metres thick and progressively thin westwards (Figure 15).

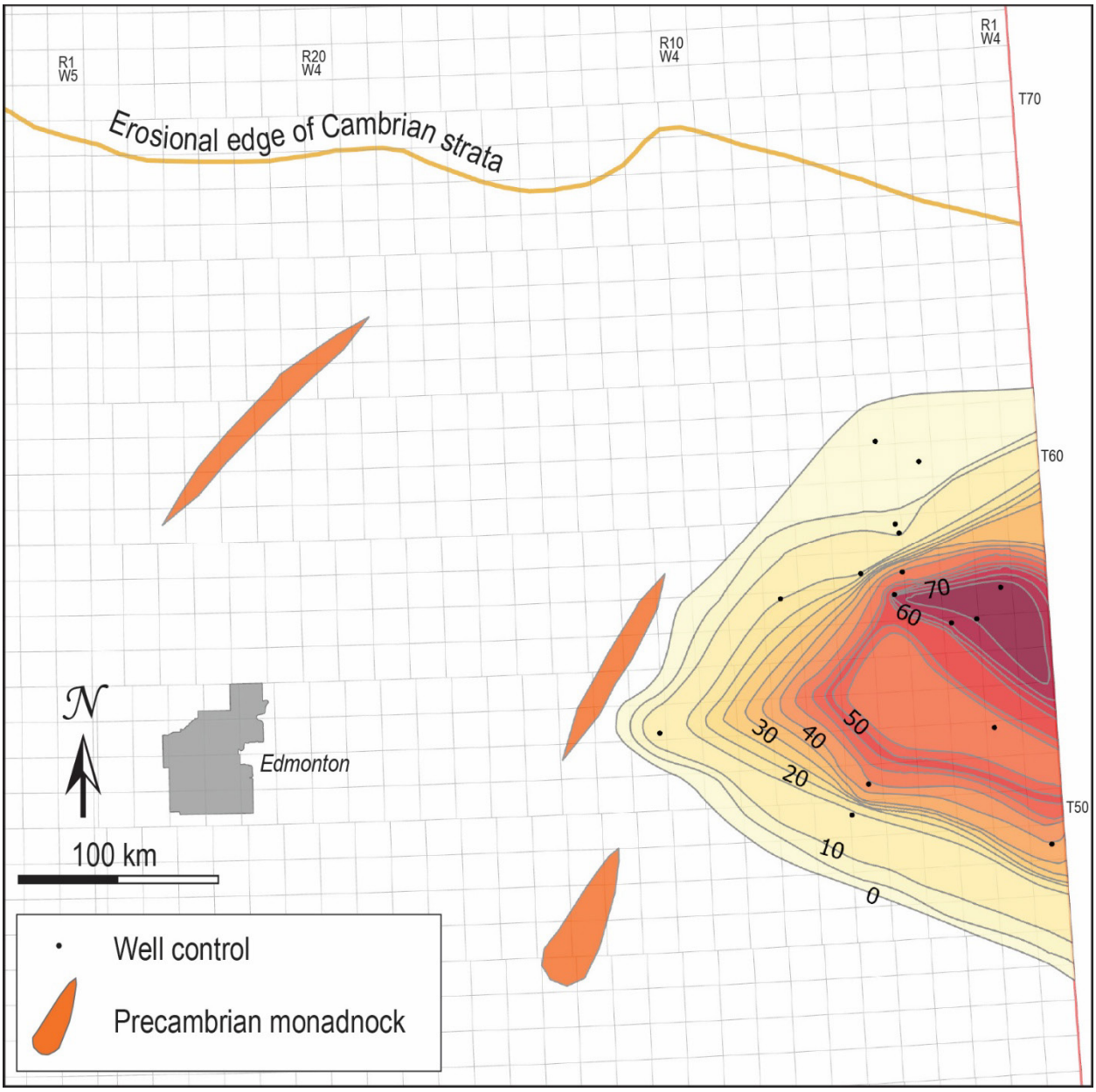


Figure 15. Cumulative isopach (thickness) map of the Earlie sandstone intervals in the Lloydminster Embayment in east-central Alberta. Contour interval = 5 metres.

3.4 Inner Detrital Belt Correlations: Surfaces of Sequence Stratigraphic Importance

Many new cores have been recently taken from Cambrian strata in the inner detrital belt of central to east-central Alberta, largely because of prospective carbon sequestration in the BCS. With caprock integrity an important factor in such projects, some cores have been collected from the overlying Earlie and Deadwood formations. Detailed core logging of these intervals has identified several surfaces of sequence stratigraphic importance, including a subaerial exposure surface within the Earlie Formation underlying the Pika maximum flooding surface (Figure 16). In core, this surface is recognized as a regolith (called such because Cambrian subaerial exposure predates land plants and lacks associated rhizoturbation). Evidence for subaerial exposure includes the presence of mudstones with abundant slickensides, dark

hematitic staining within otherwise mostly grey to grey-green coloured mudstone, and a massive to mottled appearance with a notable absence of primary sedimentary fabric (Figure 17). In every cored expression of this surface, several metres of sediments underlying it are stained heavily with hematite, which we interpret to reflect downward percolation of iron-rich fluids in a hot climate. Additionally, the surface is overlain by coarser grained sandstone intervals with transgressive affinity (Figure 17). Together, these observations support interpretation of this surface as a 3rd-order sequence boundary within the inner detrital belt. This Earlie-aged regolith has been directly observed in three cores from wells in the greater Edmonton area (103/11-32-055-21W4/00, 103/06-09-060-15W4/00, 103/03-04-057-20W4/00). This core control shows us the following; 1) this surface is regional in nature, ~100 km, 2) it occurs at the identical stratigraphic horizon with the same non-descript red mudstone facies, and 3) it caps a progradational cycle within the Earlie Formation, where a subaerial exposure surface is likely to be formed.

Above the sequence boundary, the 3rd-order maximum flooding surface is recognized as the "Pika maximum flooding surface" (Figure 16). This surface reflects a noticeable change in the fabric of the offshore sediments, with highly bioturbated, glauconitic sandy mudstones abruptly overlain by carbonate-rich mudstone with preserved primary lamination and bedding indicating a transition from a well-oxygenated to an anoxic depositional environment (Figure 18). This important marker bed represents a maximum flooding surface within the Earlie Formation. It is correlated across a wide area of the inner detrital belt and is commonly more easily recognized on wireline logs than the overlying Pika marker (e.g., Figure 5).

Recognition of the Earlie regolith sequence boundary and the overlying Pika maximum flooding surface improves our predictive capability for correlations within the Cambrian inner detrital belt strata and provides a framework for interpreting depositional responses to changes in relative sea level (Herbers et al., 2024). This is particularly important in the inner detrital belt, where sequence-stratigraphic interpretation is more difficult because lithological changes are subtler than in the carbonate shoal belt.

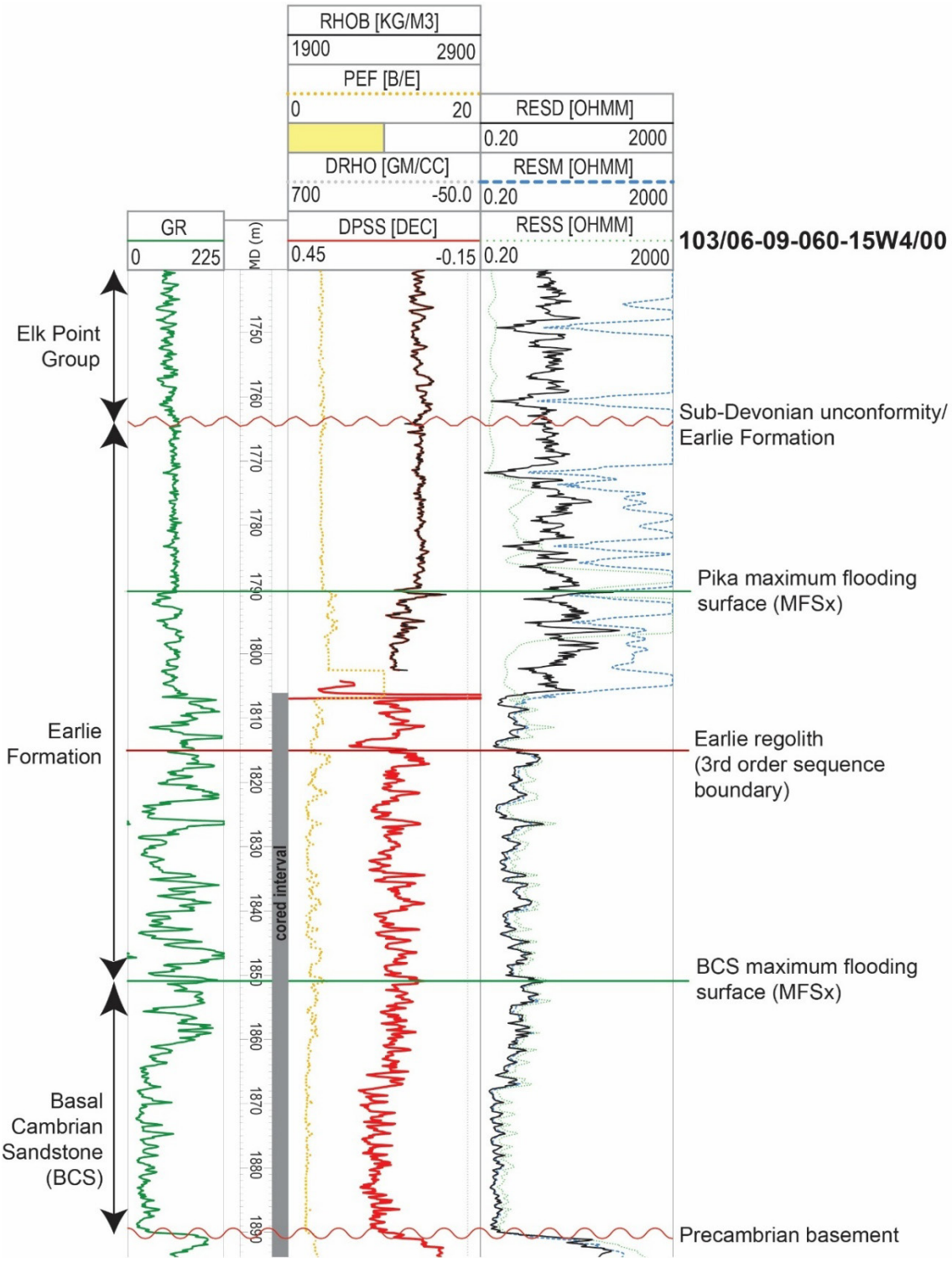


Figure 16. Wireline log and cored interval from central Alberta highlighting lithostratigraphic intervals and important 3rd-order sequence stratigraphic surfaces (e.g., Earlie regolith sequence boundary). Abbreviations: Fm., formation; GR, gamma ray; MD, measured depth; RHOB, bulk density; DRHO, density correction; RESD, deep resistivity; RESM, medium resistivity; RESS, shallow resistivity.



Figure 17. Core photos from well 103/06-09-060-15W4/00 (see Figure 16) showing the Earlie "regolith" (3rd-order sequence boundary) with hematitic staining, slickensides (white arrow), and massive/mottled appearance. Sediments above the subaerial exposure surface record marginal-marine sedimentation. Core sleeves are 75 cm long.

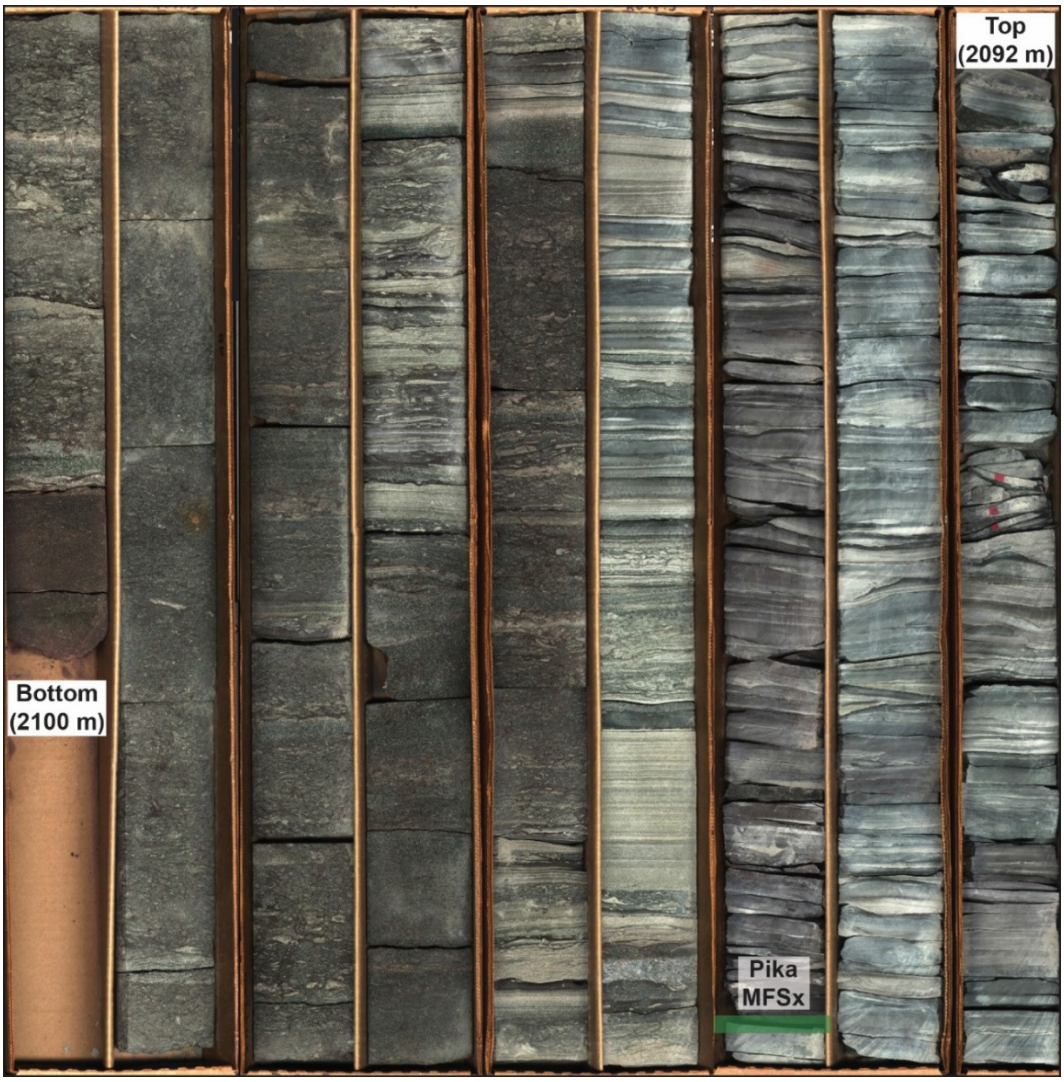


Figure 18. Core photos from well 103/11-32-055-21W4/00 showing the change in rock fabric across the Pika maximum flooding surface (MFSx). Note the abrupt change from highly bioturbated, glauconitic sandy mudstone, to carbonate-rich mudstone with preserved primary sedimentary structures, reflecting a transition from a well-oxygenated to an anoxic depositional environment. Core sleeves are 75 cm long.

4 Conclusions

Cambrian strata within Alberta record a complex history of carbonate and siliciclastic deposition across two broad depositional domains: a western carbonate-dominated shoal belt and an eastern mudstone-dominated inner detrital belt. At the base of the succession, the Basal Cambrian Sandstone (BCS) was deposited as a widespread quartz arenite during transgression across the Precambrian basement surface, with a general increasing thickness eastwards, and is absent locally over only a few Precambrian basement paleohighs. Carbonate-dominated formations of the western carbonate shoal belt (e.g., Cathedral, Eldon, and Pika formations) can be correlated eastwards into the basin where they progressively interfinger with, and are ultimately replaced by, siliciclastic-dominated strata of the inner detrital belt, assigned to the Middle Cambrian Earlie Formation and the Upper Cambrian Deadwood Formation. The Pika Formation represents the maximum progradation of the carbonate shoal belt and can be traced into the inner detrital belt as the Pika marker bed, which also approximates the boundary

between the Middle and Upper Cambrian intervals. The lithostratigraphic correlations presented in this report define formation and marker surfaces across the extent of the Cambrian succession in the Lloydminster Embayment of the southern half of Alberta and provide a framework for incorporating subdivided Cambrian strata into future versions of the Geological Framework of Alberta model. The present-day distribution and thickness of the Cambrian strata are affected by significant erosion at the sub-Ordovician and sub-Devonian unconformities, with the latter resulting in significant paleotopography on the top Cambrian surface.

Two regionally significant sandstone intervals are also mapped and presented in the cross-sections and isopach maps: the Eldon sandstone and Earlie sandstone intervals. In west-central Alberta, the otherwise carbonate-dominated Eldon Formation is replaced by quartz arenites sourced from the southern flank of the Peace River Arch, which was a paleohigh throughout the Paleozoic. The Earlie sandstones form a series of westward prograding sandstone beds that thicken towards the northern subcrop area and into western Saskatchewan, while thinning westwards and interfingering with mudstone of the inner detrital belt.

Two significant sequence stratigraphic surfaces within the inner detrital belt in east-central Alberta are highlighted: the Earlie regolith and the Pika maximum flooding surface. The former surface is interpreted as a 3rd-order sequence boundary, while the latter is the associated maximum flooding surface in the overlying 3rd order sequence. These surfaces facilitate improved correlations within the lithologically subtle inner detrital belt.

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