The influence of inherited paleotopography on the evolution of early to middle Albian sediment-routing systems in southeastern Alberta

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Summary

Sediment-routing systems in foreland basins commonly span large areas of continents, and transfer sediment from mountainous regions to continental margins in many areas globally (e.g., the Ganges River, India; Goodbred and Kuehl, 2000). Studies of ancient foreland basin deposits can help elucidate long-term changes to the configuration of ancient sediment-routing systems, and can provide insight into the factors that control sediment-routing in those basins over millions of years (e.g., Burbank, 1992). While sediment routing in foreland basins is thought to be primarily controlled by tectonic processes in a fold-thrust belt and related basin subsidence/uplift patterns (e.g., Heller et al., 1988; DeCelles and Giles, 1996), recent work has revealed that sediment-routing patterns in these basins can also be significantly impacted by inherited paleotopography (e.g., escarpments) from predecessor landscapes in certain instances (e.g., Vacherat et al., 2017; Horner et al., 2019). Since many ancient foreland basin successions contain significant volumes of natural resources (e.g., water and hydrocarbon resources; Kordi, 2019; Gómez-Moncada et al., 2022), characterizing the impact of inherited paleotopography on sediment routing may help geoscientists better understand the stratigraphic characteristics of natural resource reservoirs, as well as the distribution of resources within those reservoirs.

To assess the influence of inherited paleotopography on sediment dispersal in the Alberta sector of the Western Interior Basin, we examine strata of the Albian Glauconitic Member (Upper Mannville Group) in the subsurface of southeastern Alberta. Prior to the formation of this stratigraphic interval, the Alberta sector of the Western Interior Basin was partitioned into three separate paleovalleys that were bounded by inherited paleotopographic highs composed of resistant subcropping units (Benyon et al., 2016). As deposition associated with the Glauconitic Member carried on through time, paleotopographic relief is thought to have been healed, allowing for more direct sediment transfer from the ancestral North American Cordillera towards the opposing basin margin (Smith, 1994). This study is focused on investigating the role that inherited paleotopographic features played in influencing depositional patterns associated with the

Glauconitic Member, as well as constraining the timing associated with the final healing of the inherited paleotopographic features. The objectives of this study are to: (1) document changes in stratigraphic thickness in the Glauconitic Member across southeastern Alberta to examine the relationship between thickness changes and the position of documented paleotopographic highs; and (2) use stratigraphic information to investigate the timing of the healing of the paleotopographic relief that initially characterized Early Cretaceous Alberta.

Theory / Method / Workflow

Stratigraphic data for this study was derived from Glauconitic Member deposits that are present in the subsurface in southeastern Alberta (see Figure 1 for information on the extent of the study area). Analyzed subsurface data sets included 10 cores that contain Glauconitic Member strata, as well as hundreds of well logs that were accessed using AccuMap software. Observations and interpretations of lithologic characteristics from core and well logs were analyzed alongside previous interpretations of Upper Mannville Group stratigraphy in the region (e.g., Sherwin, 1996) to identify the basal surface and the top surface of the Glauconitic Member, which enabled regional correlation of the stratigraphic interval across the study area. Stratigraphic correlations were summarized in 20 stratigraphic cross-sections, which emphasized thickness changes within the Glauconitic Member in the vicinity of documented paleotopographic highs (see Figure 2 for an example of one of these cross-sections).

Results, Observations, Conclusions

Regional stratigraphic characterization and mapping efforts reveal that the thickness of the Glauconitic Member is highest in the axes of predecessor paleovalleys (maximum documented thickness = 35 m) and lowest in the vicinity of inherited paleotopographic highs (minimum documented thickness = 0 m). The absence of the Glauconitic Member in the vicinity of documented paleotopographic highs in many areas suggests that paleotopographic highs acted as barriers to sediment dispersal during the earliest part of the Albian (Figure 2). Stratigraphic correlations within overlying Upper Mannville Group units indicate that some of the youngest Upper Mannville Group units can be correlated across the top of inherited paleotopographic highs, which suggests that these highs had been healed by the middle Albian at the earliest (Figure 2).

Novel/Additive Information

This study offers a novel high-resolution analysis of stratigraphic thickness changes within the Glauconitic Member across a large area of southeastern Alberta. These new constraints on stratigraphic thickness provide new insight into the amount of accommodation available in the Alberta sector of the Western Interior Basin during the earliest part of the Albian, which may help refine existing models of natural resource reservoirs and/or assist with identifying new reservoirs in the vicinity of documented paleotopographic highs. Moreover, results from this study can be used as a stratigraphic template to investigate the absolute timing of the healing of inherited paleotopography in the Alberta sector of the Western Interior Basin during the Albian, which can be applied to elucidate the timing of paleotopographic healing in other foreland basins worldwide.

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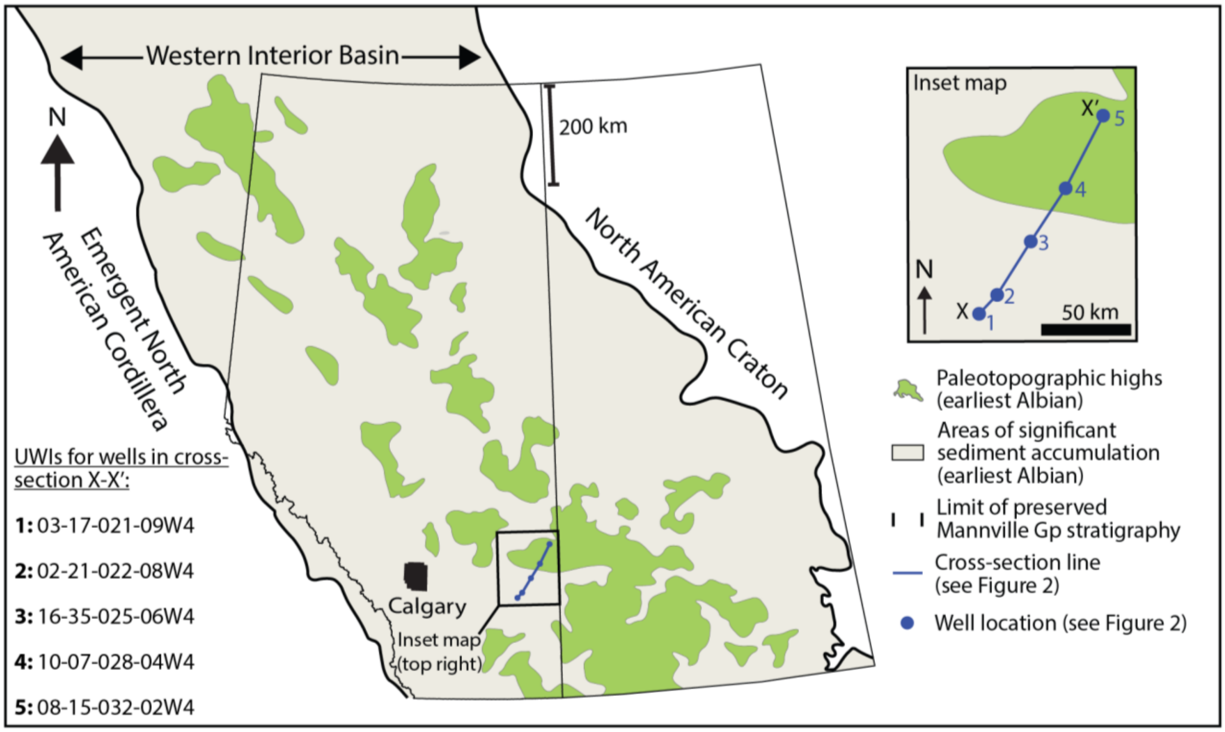

Figure 1. Simplified overview of paleotopographic features in the Western Canadian sector of the Western Interior Basin that were present at the start of the Albian. Locations of paleotopographic highs have been constrained via subsurface mapping, as well as using data from Hayes et al. (1994), Smith (1994), and Horner et al. (2019). The edges of the inset map box represent the boundaries of the study area considered for this research. Cross-section X-X' represents one of the stratigraphic cross-sections constructed as a part of this study (see Figure 2 for more information). Gp = Group; UWI = Unique Well Identifier.

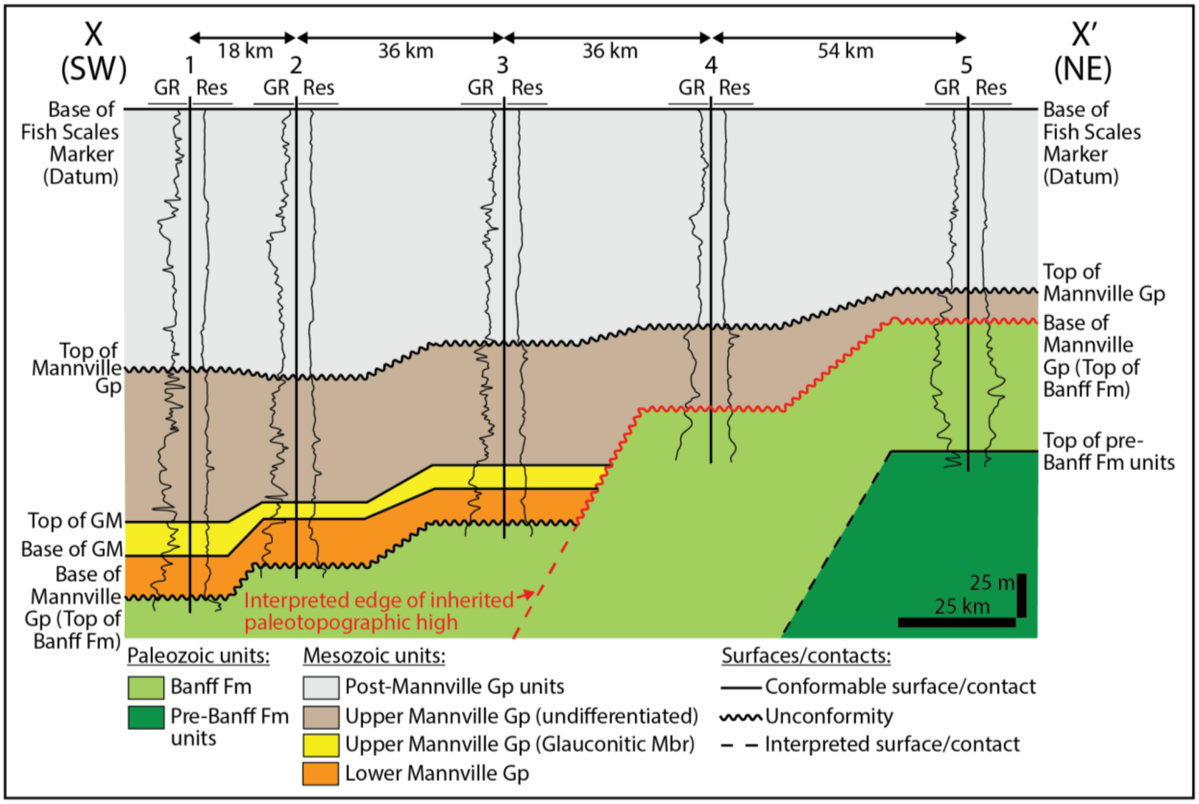

Figure 2. Overview of stratigraphic information associated with cross-section X-X' (see Figure 1 for specific cross-section orientation and well location information). Stratigraphic correlations reveal that Lower Mannville Group units and basal Upper Mannville Group units (i.e., the Glauconitic Member) terminate against a paleotopographic high composed of Banff Formation units (indicated with red lines) towards the northeastern end of the cross-section. Subsequent formation of overlying Upper Mannville Group units eventually resulted in the healing of the inherited paleotopography during the middle Albian. Fm = Formation; GM = Glauconitic Member; Gp = Group; GR = Gamma ray log; Mbr = Member, Res = Resistivity log. Gamma ray and resistivity readings both increase from left to right (gamma ray log scale range = 0-150 API; resistivity log scale range = 0.2 to 2000 Ωm).