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Updates to the Bedrock Topography and Stratigraphic Modelling of Materials above Bedrock in the South Athabasca Oil Sands Region, northeast Alberta

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Summary

Beneath the Stony Mountain Upland in the South Athabasca Oil Sands region (Figure 1) lies a complex network of deep preglacial valleys, buried under hundreds of meters of glacial, lacustrine, and fluvial deposits. To the north, across the adjacent lowland, narrow, deep subglacial channels—lacking surface expression—are concealed beneath glacial sediments. The characteristics of the sediments in these buried paleovalleys and channels are critical to the region's hydrogeology. Recent efforts by the Alberta Geological Survey (AGS) have focused on refining bedrock topographic models to elucidate preglacial morphology and locate subglacially eroded channels. Additionally, stratigraphic units above the bedrock unconformity have been identified and mapped to determine their thickness and spatial distribution. Key data sources include oil and gas geophysical logs, water well lithologs, and industry reports, supplemented by core examinations where available to enhance lithological interpretation.

Results

The bedrock topography was modelled using a machine-learning approach as described by Pawley et al. (2024). Key updates over previous AGS models include not only overall refinement through the integration of additional point-source picks but also the incorporation of the north and south Hangingstone and Sunday Creek channels (Figure 2), identified by industry surveys. A further significant change is the model does not show the connection of the Christina and Wiau valleys. Furthermore, the bedrock topography was extrapolated eastward into Saskatchewan, guided by the extension of major physiographic features such as the Wiau and Christina valleys, supplemented by limited borehole data.

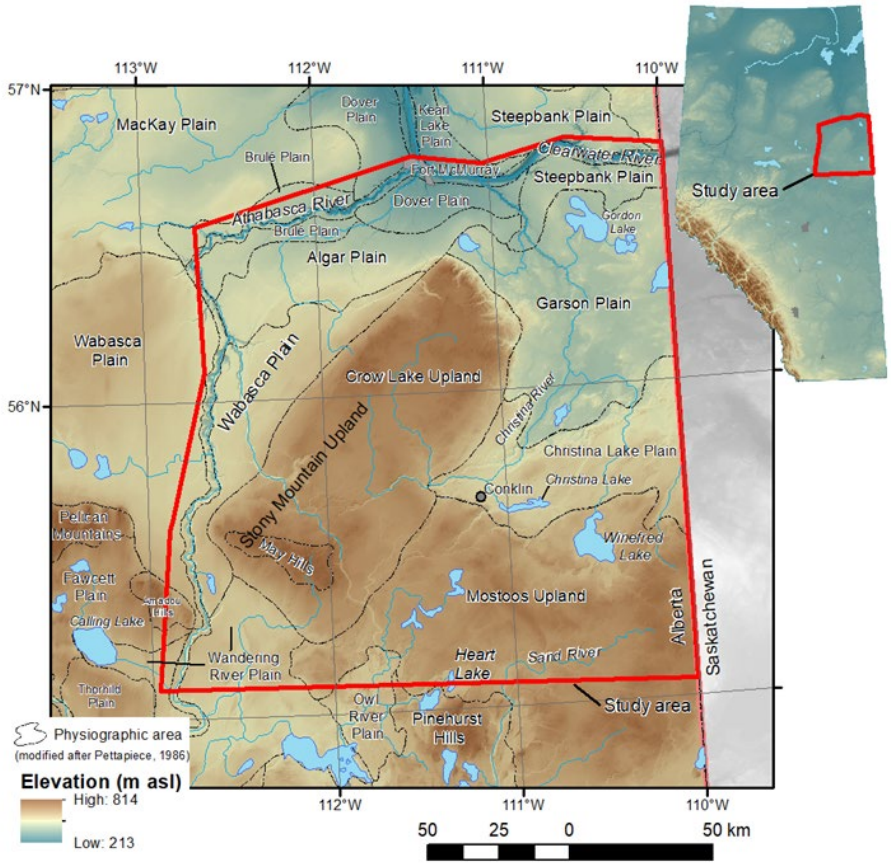

Figure 1. Location and physiography of the South Athabasca Oil Sands region shown on a bare earth LiDAR (light detection and ranging) digital elevation model (Utting, 2023).

In conjunction with stratigraphic modelling, the Empress Formation was recently formally elevated to Group status by Hartman et al. (2023). This revision involved refining its definition, as well as designating and naming specific units at the formation level. Moreover, strict adherence to the stratigraphic code necessitated discontinuing the use of Empress Formation to classify sediments infilling subglacial channels.

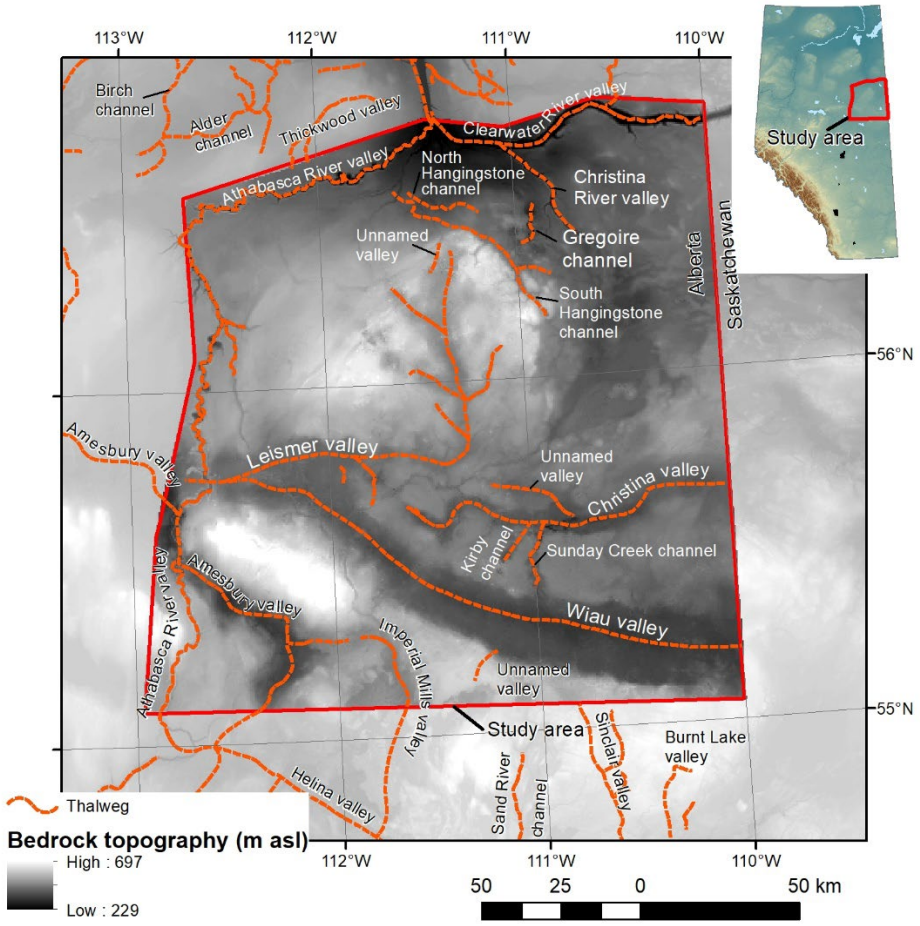

Figure 2. Updated bedrock topography and thalwegs of the South Athabasca Oil Sands region (Utting, 2023).

The deposits at the base of the buried preglacial valleys belong to the Ipiatik Formation of the Empress Group. These include the preglacial basal gravels of the House Member, overlain by glaciolacustrine deposits of the Wappau Member and capped by the glaciofluvial deposits of the Calder Member. On a higher topographic level are the glaciofluvial deposits of the Winefred Formation. Both the Ipiatik and Winefred formations are buried by the reversely magnetized till of the Bronson Lake Formation, indicating they are at least 780 ka old (Andriashek and Barendregt, 2016). Overlying units comprise the fluvial Muriel Lake Formation, and tills of the Bonnyville Formation units 1 and 2, which in places have an intervening sand deposit. The Ethel Lake Formation, a glaciolacustrine and glaciofluvial package, rests on the Bonnyville Formation, likely within low-lying areas that existed prior to its deposition. The Marie Creek, Sand River, and Grand Centre formations cap the

succession, but these were not differentiated in this study due to limited data. Presently glaciofluvial material in the subglacial channels is referred to as either Hangingstone- or Gregoire-Channel sands and is likely associated with the last glaciation, although no ages are available.

Conclusion

The integration of machine-learning techniques, refined stratigraphic models, and diverse geophysical data sources has significantly enhanced the understanding of bedrock topography and sedimentary stratigraphy in the South Athabasca Oil Sands region. These data will allow for more accurate and consistent allocations of water well completions to the correct geological unit and enhance hydrogeological modelling of the area.

Acknowledgments

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