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Geothermal Opportunities in the Williston Basin, Canada

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INTRODUCTION

Geothermal energy development in sedimentary basins has been successfully implemented in Europe, particularly for district heating applications near population centers. The Paris Basin, an intracratonic sedimentary basin covering approximately 110,000 km^2 of northern France and extending beneath the English Channel, has been producing geothermal energy for over fifty years (Lopez et al., 2010). In Canada, however, geothermal development remains limited despite the presence of some of the world's largest sedimentary basins. This is largely due to the widespread availability of inexpensive natural gas, as well as geological and investment uncertainties that have hindered targeted studies to identify optimal geothermal reservoirs.

Nonetheless, with Canada's commitment to reducing greenhouse gas emissions and achieving net-zero targets, a diverse suite of renewable energy resources is being considered, including solutions for remote communities that require both power and heat (Hedhli et al., 2025), even where temperatures are insufficient for electricity generation. At lower enthalpy, direct-use geothermal energy has been widely adopted for district heating systems (Limberger et al., 2018; Lund et al., 2021).

Here, we investigate Paleozoic strata with varying temperature gradients and lithologies within the Canadian analogue to the Paris Basin, the Williston Basin: an intracratonic sedimentary basin extending over approximately 300,000 km^2, making it Canada's second-largest sedimentary basin. Owing to its size, nearly three times that of the Paris Basin, and the abundance of high-quality oil and gas subsurface data, the Williston Basin offers substantial potential for geothermal heat production, exceeding that of many European counterparts.

Recent developments further highlight the basin's geothermal promise. The Deep Earth Energy Production (DEEP) project in southeast Saskatchewan, commonly referred to as DEEP-1, represents Canada's first successful geothermal power initiative within the Williston Basin. The project targets permeable intervals within the Deadwood Basal Clastics, where formation temperatures exceed 100 °C, underscoring their suitability as high-temperature geothermal reservoirs. This demonstrates that the deep saline systems of the Williston Basin are capable of sustaining commercial-scale heat extraction. Furthermore, younger sedimentary units located closer to communities with district-heating needs can also be investigated as potential sources of low- to medium-temperature geothermal energy, even in less porous rocks, through the application of closed-loop geothermal systems.

GEOLOGICAL CONTEXT

The Williston Basin is a large intracratonic depression beneath the central part of North America. Although centered in North Dakota, it extends across northern South Dakota and eastern Montana, and into southwestern Manitoba, southeastern Alberta, and much of southern Saskatchewan (Fig. 1) (Gerhard and Anderson, 1988). From the Middle Devonian through the Mississippian, this basin occupied the eastern portion of the ancestral Laurentian continental margin (Kent and Christopher, 1994) and lay near the equator at approximately 10° N (Scotese, 2018). Its western edge aligns with the modern Alberta–Saskatchewan boundary, where it transitions into the Western Canada Sedimentary Basin (WCSB), a region influenced by tectonism related to the Antler orogeny during the mid-Paleozoic (Hedhli et al., 2022; Root, 2001). In contrast, the interior position of the Williston Basin shielded it from deformation associated with the Antler and later Phanerozoic orogenic events.



Figure 1. Map showing the geographic location and extent of the Williston basin (Scotese 2018; Ardakani et al., 2024)

As a result, the basin preserves a relatively undeformed, layer-cake style stratigraphy characterized by substantial successions of mid- to late-Paleozoic clastic units together with thick carbonate and evaporite deposits (Fig. 2). Recent developments also underscore the basin's geothermal promise. The Deep Earth Energy Production (DEEP) project in southeast Saskatchewan, commonly known as DEEP-1, represents Canada's first successful geothermal power initiative within the Williston Basin. The project targets permeable intervals within the Deadwood Basal Clastics, where formation temperatures exceed 100 °C, underscoring their suitability as high-temperature geothermal reservoirs. This development demonstrates that the deep saline systems of the Williston Basin can sustain commercial-scale heat extraction.

STUDY OBJECTIVES AND METHODS

This study assesses the geothermal potential of the Williston Basin. Three stratigraphic horizons with distinct lithological, thermal, and hydraulic characteristics are investigated: (i) the deep Cambrian Deadwood Formation (H1), consisting of clastic sediments at depths of 1.5–2.5 km, exhibiting formation temperatures ranging from 70 to 125 °C, indicative of high-temperature geothermal potential; (ii) the Prairie evaporite succession (H2), comprising halite, anhydrite, and gypsum at 1.2–1.8 km depth, exhibiting temperatures of 50–90 °C; and (iii) the shallower Devonian Duperow–Bridbear Formations (H3), which are primarily carbonate units occurring at 0.9–1.5 km depth, with temperatures ranging from 40 to 80 °C.

The clastic Deadwood Formation (H1) and carbonate Duperow–Bridbear units (H3) host aquifers with variable porosity, permeability, and thermal properties, which will be simulated using conventional doublet wellbore systems (Kong et al., 2017). However, the evaporitic interval (H2) will be assessed using a U-shaped closed-loop geothermal system (Yuan et al., 2021), enabling thermal energy extraction from low-porosity or low-permeability formations. For all three horizons, critical reservoir parameters—including porosity, permeability, thickness, thermal conductivity, temperature, and flow rate—will be integrated into numerical models to evaluate both technical performance and economic feasibility.

This study aims to identify the most viable geothermal targets for potential deployment in nearby communities, particularly those reliant on diesel-generated power or suitable for closed-loop systems. The results are expected to advance the understanding of geothermal resources within Canada's sedimentary basins and to inform the development of sustainable, low-carbon energy solutions.

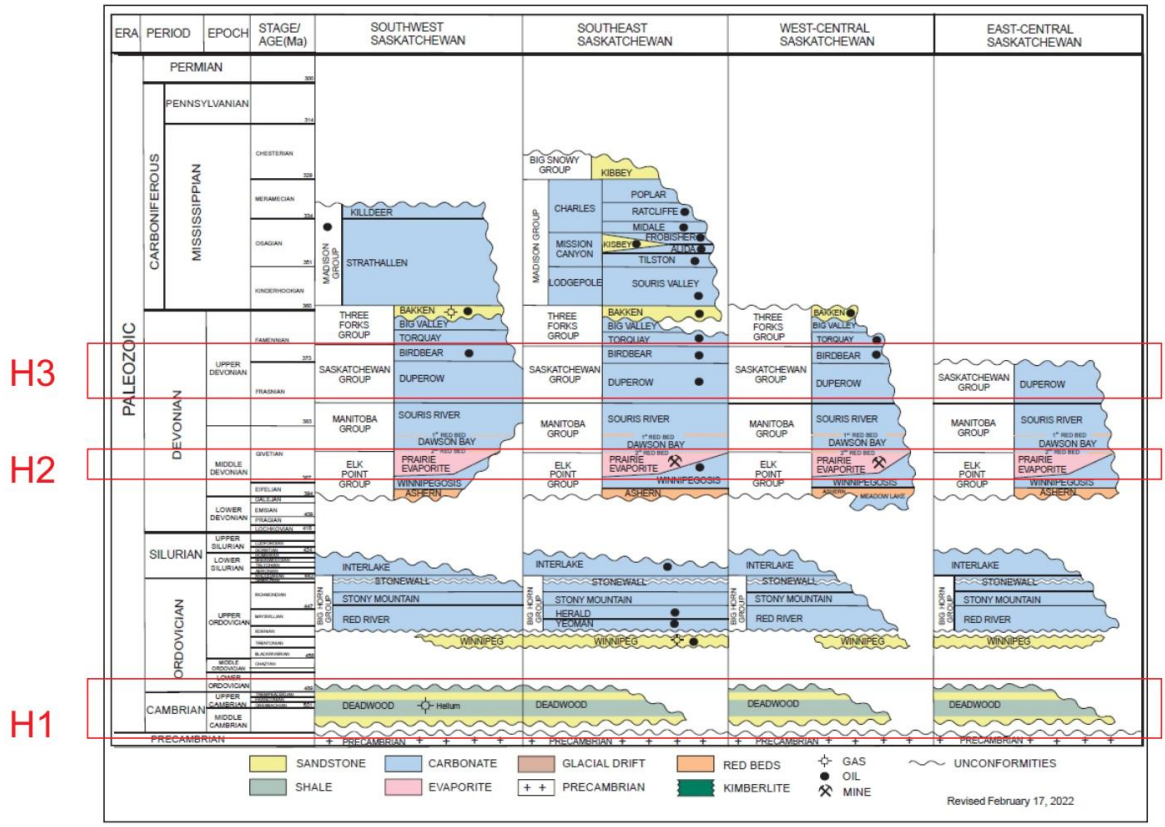


Figure 2. Edited stratigraphic chart from Saskatchewan Ministry of Energy and Resources Stratigraphic chart of the Williston basin (2022) showing the studied stratigraphic horizons in this study.

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REFERENCES

Ardakani, O.H., Gadd, M.G., Hedhli, M., Petts, D. and Jensen, G., 2024. Organic matter the major sink of redox-sensitive trace elements in Upper Devonian black shale. *Chemical Geology*, *670*, p.122385.

Gerhard, L.C., Anderson, S.B., 1988. Geology of the Williston Basin (United States portion). In: Sedimentary Cover—North American Craton. Geological Society of America, Boulder, Colorado, pp. 221–241.

Hedhli, M., Matthews, W.A., Hadlari, T., Alonso-Torres, D., Grasby, S.E. and Beauchamp, B., 2022. Detrital zircon U-Pb geochronology of upper devonian and lower carboniferous strata of western Laurentia (North America): a record of transition from passive to convergent margin. *Lithosphere*, *2022*(1), p.9585729.

Hedhli, M., Yuan, W., Grasby, S.E. and Mort, A., 2025. Geothermal potential of low enthalpy reservoirs in the Western Canada Sedimentary Basin. *Geoenergy Science and Engineering*, *251*, p.213876.

Kent, D.M., Christopher, J.E., 1994. In: Mossop, G.D., Shesten, I. (Eds.), Geological History of the Williston Basin and Sweetgrass Arch. Canadian Society of Petroleum Geologists and Alberta Research Council, Atlas of Western Canada Sedimentary Basin, pp. 421–429.

Kong, Y., Pang, Z., Shao, H. and Kolditz, O., 2017. Optimization of well-doublet placement in geothermal reservoirs using numerical simulation and economic analysis. *Environmental Earth Sciences*, *76*(3), p.118.

Limberger, J., Boxem, T., Pluymaekers, M., Bruhn, D., Manzella, A., Calcagno, P., Beekman, F., Cloetingh, S. and van Wees, J.D., 2018. Geothermal energy in deep aquifers: A global assessment of the resource base for direct heat utilization. *Renewable and Sustainable Energy Reviews*, *82*, pp.961-975.

Lopez, S., Hamm, V., Le Brun, M., Schaper, L., Boissier, F., Cotiche, C. and Giuglaris, E., 2010. 40 years of Dogger aquifer management in Ile-de-France, Paris Basin, France. *Geothermics*, *39*(4), pp.339-356.

Lund, J.W. and Toth, A.N., 2021. Direct utilization of geothermal energy 2020 worldwide review. *Geothermics*, *90*, p.101915.

Root, K.G., 2001. Devonian Antler fold and thrust belt and foreland basin development in the southern Canadian Cordillera: implications for the Western Canada Sedimentary Basin. *Bulletin of Canadian Petroleum Geology*, *49*(1), pp.7-36.

Saskatchewan Ministry of Energy and Resources. Saskatchewan Stratigraphic Correlation Chart (revised Feb 2022)

Scotese, C.R., 2018. PALEOMAP Paleodigital Elevation Models (PaleoDEMS) for the Phanerozoic. Northwestern University.

Yuan, W., Chen, Z., Grasby, S.E. and Little, E., 2021. Closed-loop geothermal energy recovery from deep high enthalpy systems. *Renewable Energy*, *177*, pp.976-991.