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Geothermal Potential of the Eastern Edge of the Western Canada Sedimentary Basin

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Canada has set ambitious goals to reduce greenhouse gas emissions and reach net zero emissions by 2050. Part of this transition includes finding alternative energy resources, for both power and heat. Where temperatures are high enough, geothermal energy can be used for power generation. Alternatively, at lower temperatures direct use geothermal energy has been commonly used for district heating systems (e.g., Lund and Toth, 2021). Typically, district heating systems require fluid production rates >30 kg/s, using two or more geothermal wells with at least one production well and one injection well (Tester et al., 2006). This requires rocks with suitable permeability to supply sufficient water flow to a well. Such porous and permeable rocks are common in sedimentary basins and can form excellent geothermal aquifer units. A challenge with direct heat systems, however, is that transmitting hot fluids over large distances comes with significant energy loss for every km of insulated pipe distance (Kapil et al. 2012). Thus, the resources closest to energy demand need to be assessed, rather than a search for where the best quality resources may be located. This study examines the geothermal potential to support alternative energy supply for communities situated near the eastern edge of the Western Canada Sedimentary Basin (WCSB) such as Cold Lake area and at the vicinity of the oil sands. The sedimentary rocks underlying the region were chosen as the primary focus for assessment given their greater potential to form large permeable aquifer systems. Deeper granitic rocks of the underlying basement would provide higher temperatures, but at much lower permeability. While promising, development of these higher temperature resources awaits technological progress in Enhanced Geothermal Systems (e.g. Majorowicz and Grasby, 2010). As such basement were not included in this assessment. In this study Paleozoic and Mesozoic rock properties and potential geothermal aquifers are characterized and used to support development of geothermal resource models. These then provide insight into potential energy resource production in the region.

Methods

Geological data was screened using Petro Ninja and the GSC internal database within a 50 km radius of Cold Lake. Temperature data were extracted from well logs and regional reservoir fluid tests. Porosity data were extracted from routine core analysis from cored intervals around the Cold Lake study area at 250 km radius (N≈165,500 data point). Idealized geothermal reservoir models and heat production simulations using a conventional doublet geothermal well system and a deep U-shape closed-loop well system was applied in this study to provide insight into the geothermal heat production potential in this region.

Results and Conclusions

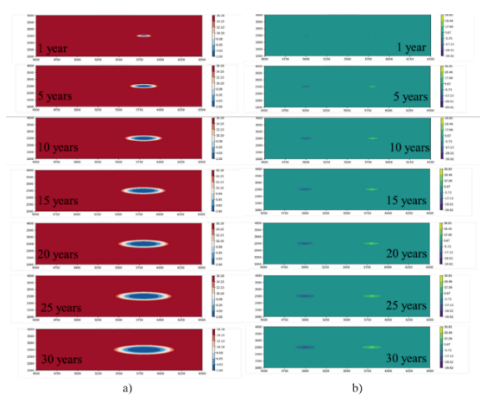
Based on evaluation of the stratigraphy and thermodynamic modeling in east central Alberta we found that:

- The Lower Cretaceous Mannville Group from 500-300 m depth and the lower Paleozoic interval (Cambrian to Devonian) from ≈1400-1200 m depth with main aquifer in the Middle

Cambrian Basal Sandstone Unit BSU and the Lower Devonian Basal Red Beds are promising rocks with considerable geothermal performance.

- A conventional doublet well system deployed in the Lower Cretaceous Mannville Group could generate 2.93 MW_{th} heat energy over 30 years of operation under optimum spacing distance with the base case parameters of 16 °C reservoir temperature, 1 D permeability, 0.3 porosity, 100 m thickness, and 180 m^3/hr flow rate. An 800 m well spacing is the optimum and safe spacing distance for a doublet wellbore system deployed from 500-300 m depth. Whereas a conventional doublet well system deployed in the lower Paleozoic interval could generate 6.9 MW_{th} heat energy over 30 years of operation due to the higher initial temperature with the base case parameters of 35 °C reservoir temperature, 10 mD permeability, 0.1 porosity, 100 m thickness, and 180 m^3/hr flow rate. A 400 m spacing is the optimum and safe spacing distance for doublet wellbore system deployed from 1400-1200 m depth.
- A closed-loop system could also generate the same or higher amount of heat as a shallow heat pump system. It needs multilateral wellbore systems with shorter total wellbore completion lengths. Under the same flow rate as the shallow heat pump system, the closed-loop system deployed in the Lower Cretaceous Mannville Group could provide the equivalent cumulative heat production with total wellbore length of 10,950 m, while it only needs a 5600 m total length wellbore for the system deployment in the Lower Paleozoic interval (Cambrian to Devonian). Although the total length could be less than the shallow heat pump system, drilling and completion costs need to be considered in further economic analysis.

Figure: *Distribution map of the base case in Mannville Group. a) temperature distribution of 30 years operation under the optimum 800 m well spacing distance; b) water table map of 30 years operation under the optimum 800 m well spacing.*



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