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Assessment of an enhanced geothermal system targeting the Prairie Evaporite Formation of the Williston Basin in SW Manitoba

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Canada has a large potential for geothermal energy production. High thermal resources are recognized at the volcanic belt within the Canadian Cordillera due to the difference between the oceanic and the continental heat flux which creates a border with high heat flow (as high as 150°C/km) along the volcanic belt. However, also regions with lower heat flow such as the Western Canadian Sedimentary Basin (WCSB) is of interest for geothermal usage. The Williston Basin as part of the WCSB shows low thermal gradients of 25-40°C/km. The geology and lithology of Williston Basin show the presence of halite, potassium salts and carbonate wedges within the Prairie Evaporite formation. Halite is the mineral form (salt) of sodium chloride (NaCl) which decreases thermal resistance providing paths of heat transfer to the surface and has 2-3 times higher thermal conductivity comparing to other types of minerals.
The potential of a proposed enhanced geothermal system (EGS) to provide adequate energy to a 10-megawatt electricity production plant was investigated. Borehole data from the Manitoban part of the Williston Basin were collected, and two numerical models were built. One model was created for Tilston, SW Manitoba and the second at a generic site in southern Saskatchewan. Geology differs between the sites in terms of layer thicknesses and their depths. The geological sequence is identical. Both sites contain the Prairie Evaporite which consists mainly of halite. The low thermal resistance of the Prairie Evaporite is assumed to be the driving force behind a relatively high temperature at a low depth, which translates into a lower drilling cost to reach the desired layer. The Prairie Evaporite Formation is located at the Tilston site at a depth of 1.5 km with a reservoir thickness of 118 m, while the similar generic's reservoir is present at a depth of 3 km. The design suggested a two well system having one injection and one pumping well. Saline formations are impermeable and hydraulic fracturing is required to allow flow. However, saline formations are also highly soluble so that the heat transport fluid has to be saturated brine. A numerical model was built using FEFLOW 6.2 to predict the fluid and heat transfer within each well. Next, considering a brine injection at 15°C, the fluid's temperature surfaced at each well was determined. For the Tilston and the generic site, this was found to be at 43°C and 105°C respectively. Furthermore, to assess the impact of the halite formation with respect to the reservoir's thermal conductivity, different scenarios were investigated to identify the energy gain due to the high thermal conductivity of the Prairie Evaporite. The halite increases the available energy by 2% compared to other rocks consisting other minerals. It can be concluded that the generic site with a reservoir at 3 km deep can be a suitable candidate for an electricity production plant utilizing the geothermal technology since the temperature of its surfaced fluid exceeds the minimum required temperature of 80°C.