Alberta #1: The Province's First Electrical Geothermal Project

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Abstract

The Western Canada Sedimentary Basin (WCSB) is known to have warm to hot brines in large extractable volumes from permeable, hydrocarbon-bearing units. The WCSB encompasses the Municipal District of Greenview (MDGV), located in Alberta's northwestern region. Preliminary resource investigations indicated that there was an economically viable resource under the MDGV. Alberta #1, as the project has been named, will provide the Tri-Municipal Industrial Park (TMIP) with electrical and thermal energy. The research suggests that temperatures above 120°C are attainable at depths of 3,500 m and below. The target formations at these depths are the Swan Hills, Granite Wash, Gilwood, the basement unconformity, and the basement itself, all which lie below the hydrocarbon and shale-rich Duvernay Formation. Very few wells within the TMIP have been drilled to the basement or below the Duvernay Formation. There is limited flow rate test data on the target formations but, extrapolating from similar target formations elsewhere, flow rates in 7-inch pipe are anticipated to exceed 30 l/s, with 300 l/s required for 8MWe (gross) generation. Fluid chemistry modelling of existing analytical data suggests that there will be no major issues with mixing of formation waters and proposed injection into the Leduc Formation. The project is poised to begin the exploration phase as, in August 2019, the Honourable Amarjeet Sohi, Minister of Natural Resources announced funding of $25.45 million for the project from Natural Resources Canada's Emerging Renewable Power Program.

Background

There have been more than 60,000 wells drilled within the MDGV since the 1950s. The possibility of co-production is limited by narrow well bore diameters, small upper casing, and potential unforeseen issues with abandoned or orphaned wells. However, there may be options for waste heat generation with more efficient wellhead generators and/or built infrastructure in close proximity to heating requirements. Re-entering wells for flow testing and BHT measurements will also be important for the exploration phase. Figure 1 illustrates the oil and gas wells and corresponding infrastructure in the area. The TMIP lies ~20 km south of Grande Prairie (Figure 2). Geologically, it lies on the southern flank of the Peace River Arch which has influenced deposition in the target area (Figure 3). The TMIP is a partnership between the MDGV, the City of Grande Prairie and the County of Grande Prairie and will require significant electrical and thermal energy. Alberta #1 will focus on attracting specific heavy industrial users that directly benefit from co-location with a hydrocarbon source and infrastructure.

Target Strata

Subsurface data was extracted from hydrocarbon operations data of the 3011 wells drilled within the TMIP and additional wells. The hydrocarbon-rich Duvernay Formation overlies the Devonian Beaverhill Lake Group, comprised of limestone, shale and various other types of sediments (Figure 4). Within this group, the Leduc, Swan Hills, Gilwood and Granite Wash formations have been targeted as prospective geothermal resources (cf. Banks2017; Gray et al. 2012; Majorowicz and Grasby 2010, 2014, 2019, Weides et al. 2014). The unconformity between the overlying sedimentary sequence and the metamorphic basement may be an important aquifer.

Core sampling of these units indicates good porosity and, in addition to the formation's thickness and high borehole temperatures, it can be concluded that this formation is a good candidate for geothermal fluid production.

Although target formations have not been flowed, other data indicate that fluid flows will be sufficient for power generation.

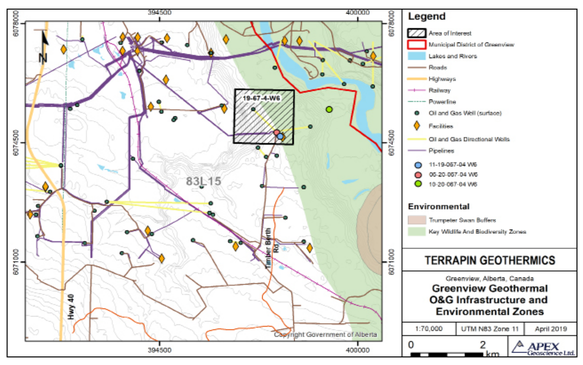

Figure 1. Area map of existing oil and gas wells and infrastructure in the target area.

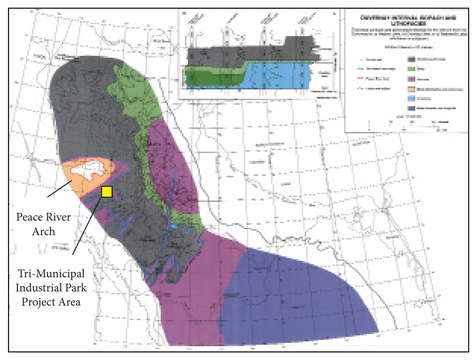

Figure 3. The TMIP lies on the southern edge of the Peace River Arch (AER 1994).

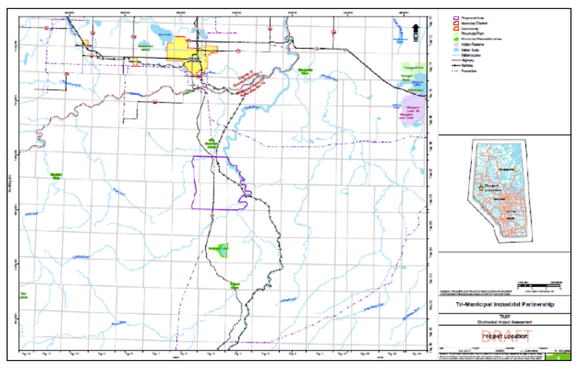

Figure 2. Regional Base Map of the TMIP (purple outline) south of the City of Grand Prairie (yellow block) within the boundaries of the MDGV.

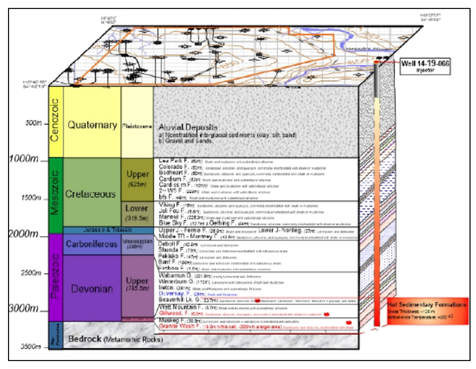

Figure 4. Stratigraphy column of formations in the TMIP. The sub-Duvernay formations make up the hot sedimentary aquifers.

Geochemistry

Production waters for Gilwood and Granite Wash do not show tendency to form minerals (Shevalier 2018) . Swan Hills water, however, does show potential to form calcite and siderite minerals, and Leduc water shows potential to form calcite. Depending on the degree of mixing, (volume of disposal water), precipitation is likely to occur when disposing Swan Hills, Gilwood and Granite Wash into the Leduc Formation. With declining water temperature, scaling of calcium carbonate is likely to occur.

Temperature Gradient

BHTs of oil and gas wells in the area measured after 2000 were used to construct temperature gradient profiles of the area using a modification of the Horner Correction method by conservatively adding 4-8°C to the measured BHTs according to the depth (Figure 5a). Based on the calculated gradients, temperatures above 130°C are expected at 4000 m (Figure 5b). This depth is also below the Duvernay Formation and within

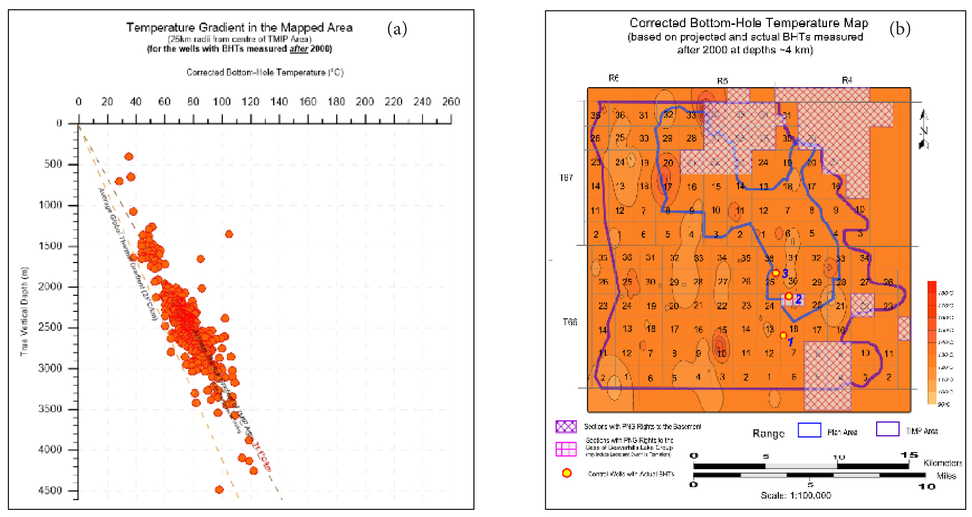

Figure 5. Temperature gradient plot (a) was used to plot corrected BHT calculations (b).

Depth to Formation and Isopach Map

Figure 6a shows the depth to the Precambrian basement in the area interpreted from 14 deep wells. The surface dips westward towards the mountain front. The expected depth to bedrock is 3,200 m.a.s.l. or a drilled depth of 3,900 m. There is a distinct subsidence area in the SE quadrant and overall the formation dips to the SSW. An isopach map for the TMIP area shows the variation in the thickness of the sub-Duvernay Formations (Figure 6b). Only two wells within the TMIP area have penetrated to bedrock; therefore, the thicknesses shown are the minimum but expected to range from 100-150m.

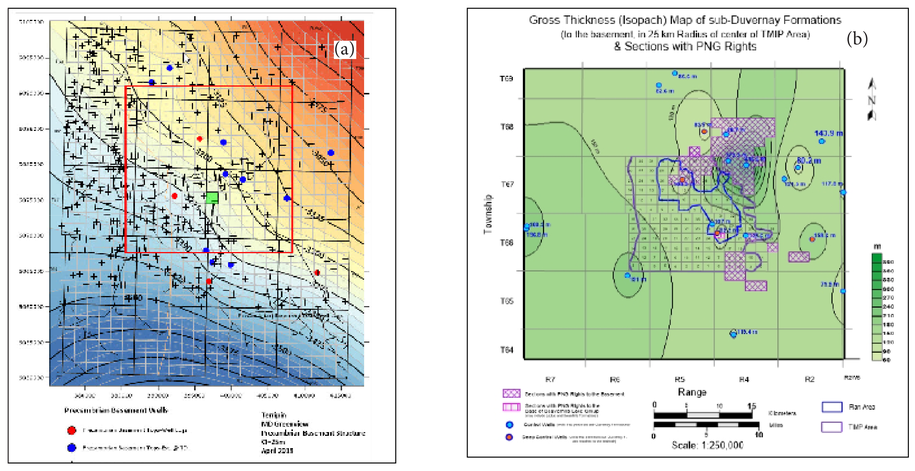

Figure 6. Maps created for depth-to-top-of-formation (a) and gross thickness (b).

Conclusions

Alberta #1 is poised to change the geothermal landscape in Alberta by demonstrating the value of geothermal energy as a transformative industry. The data gathered through early stage drilling will provide the scientific foundation for the actual flow rates achievable in the target formations as well as the true BHT. Only when the exploration drilling is completed will the commercial value of the resource be known. The project anticipates starting to drill early in 2020. If successful, production drilling will follow and power generation could be as early as 2023.

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