Geothermal Resource Characterization of the Middle Devonian Slave Point Formation at Clarke Lake Field, Fort Nelson, British Columbia, Canada

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Abstract

Clarke Lake field is a now-depleted gas field in northeastern British Columbia that displays anomalously high reservoir temperature and strong water drive, making it suitable to investigate for repurposing as a source of geothermal power. The development of porous and permeable reservoir resulted from hydrothermal alteration of parent limestone to dolomite due to the movement of halite- and gypsum-saturated brines through aquifers toward the reef margin. The Slave Point Formation can be separated into stratigraphic units that influenced dolomitization: Beaverhill Lake 1, representing a third-order depositional sequence, which includes one shoal unit and three reef growth units; and the overlying Beaverhill Lake 2 sequence, with aerially restricted, transgressive shoals. Depositional and diagenetic facies are related them to petrophysical properties develop a flow model for the reservoir. These include 9 depositional facies and 2 diagenetic facies. Dolomitized units of back-reef and reef margin facies show enhanced porosity and permeability due to dissolved stromatoporoid bioclasts leaving mouldic and vuggy porosity. Diagenetic facies show high permeability but reduced porosity from precipitation of porosity-occluding dolomite, fluorite, and sulphide minerals. High quality reservoir zones exist at the reef margin due to hydrothermal alteration preferentially occurring in more porous and permeable sediments trapped between shales of the Horn River and Muskwa formations and unaltered, tight Slave Point Formation limestone. Clarke Lake field has shown water production

rates upward of 2800 m^3/day in two wells, with an average reservoir temperature from DST measurements of 98.2°C. We use these values to develop simple flow simulations to assess the viability of hot water production over a 25-year time span. Simulations show the rock properties inherent to the reservoir at Clarke Lake field are capable of sustaining 25 years of hot water production. Monte-Carlo simulations were conducted using geostatistical relationships between porosity and permeability as inputs to determine the temperature drop at the producer well after a 25-year period. With a mean temperature drop of 2.69°C (1.35°C standard deviation), the effects of thermal breakthrough are negligible. Estimates of geothermal power potential are 300 kW using a doublet well model and 2400 kW using a four injector-eight producer well model.