Geothermal Reservoir Characterization at Wattenberg area in Denver basin

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Abstract

The geothermal potential of the Denver-Julesburg (D-J) Basin is largely unexplored. This study focuses on characterizing the geothermal potential in the greater Wattenberg area within the Denver Basin using available well data, subsurface information, and gas wells drilled to approximately 2500 m depth. The data reveals that the main structures in the Wattenberg area are comprised of ENE-trending wrench faults, along with NNE, N, and NNW-trending normal faults. A thermal anomaly is bounded by the Lafayette (La WFZ) and Longmont (Lo WFZ) wrench fault zones, overlying a vitrinite reflectance anomaly. The geometry of the thermal anomaly suggests influence from the Lo WFZ, La WFZ, and basin margin fault. Bottom-hole temperatures are estimated at 160°C, indicating a thermal gradient of 62°C/km. Reservoir temperature estimates suggest a range of >200°C at depths of 3 km.

Introduction

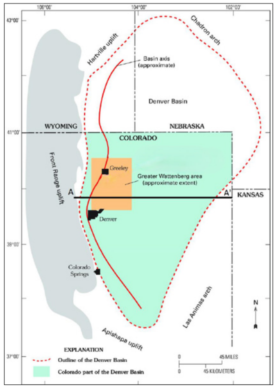

Figure 1: The Wattenberg (Denver Basin)-asymmetric foreland basin covers an area of 82,000 km². 60% of the basin is located in Colorado, with a gently dipping flank to the east and a steeply dipping flank to the west (Dixon, 2002).

Regional lithologic information was obtained from USGS Colorado geologic map (usgs.gov). Lithology range from Cretaceous, Tertiary and Quaternary periods (99 Ma to<1 Ma): Cretaceous rocks - claystone, sandstone, and major coal beds of the Pierre, Fox Hills, and Laramie units; Cretaceous-Tertiary rocks - sandstone, mudstone, claystone, and conglomerate; Tertiary rocks - arkosic sandstone, conglomerate, and shale, including the Green Mountain Conglomerate south of Golden and part of the Upper Dawson Arkose; Quaternary rocks - alluvium, sand, and silt.

Subsurface

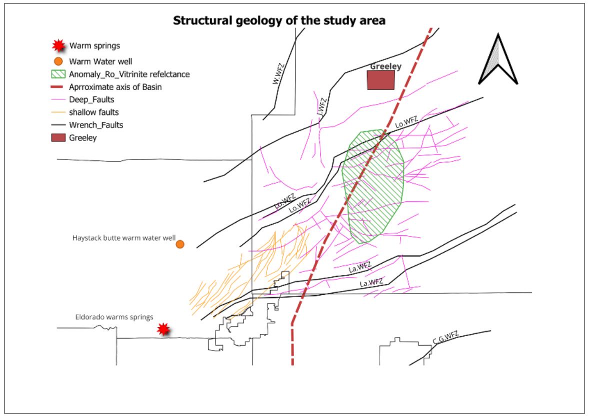

Figure 2: Structural geology of the Wattenberg area indicating Major fault zones (i.e., Windsor-, Johnstown, Longmont Lafayette and Cherry Gulch wrench fault zones), including the approximate N-S basin axis. Minor deep faults are denotated by purple lines and shallow minor faults are indicated by orange lines (Fishman, 2005; P. Weimer & Davis, 1996; R. J. Weimer & Sonnenberg, 1996).

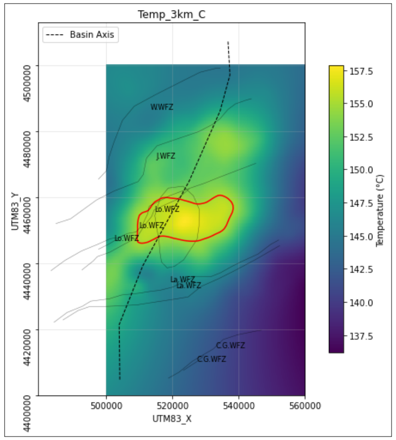

Figure 3: Red outline indicated the reservoir extent at 3 km. The 306 km² area contains the estimated reservoir domain, with 155°C isotherms calculated from thermal gradient.

Conclusion

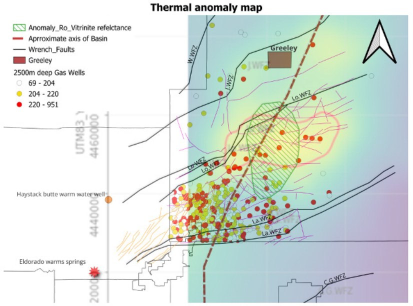

Figure 4: Integrated structural features and thermal anomalies features. Variation in corrected bottom hole temperatures (° F) from 2500 m deep Gas wells indicated by the different colored codes. The Haystack Butte Well is 2,932 feet discharging $NaHCO_3$ fluid composition, Na-K geothermometers indicate reservoir source temperatures of 140°F for Butte well and314-320 °F . For the Eldorado warm Springs (Barrett & Pearl, 1978)

Energy utilization and technoeconomic analysis

Optimized well design drilled to a depth of 5 km and employing a closed-loop system indicated the potential for extracting 19 MWt for direct use, with a calculated LCOH ranging from $10 to $18 per MWh. Alternatively, the system could generate 2.2 MWe of electric power, resulting in an LCOE of $112 to $153 per MWh. Analysis of the electricity surface plant using IPSEpro suggested that a water-cooled ORC plant with propane as the working fluid is most suitable for electricity generation.

References

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