A Preliminary Analysis of Geothermal Resources in the Denver-Julesburg Basin Evaluated using 3D Basin Modeling

Justin E. Birdwell[1], Rand D. Gardner[1], Scott A. Kinney[1], Holger Petermann[2], Patrick Sullivan[2], Annaka Clement[2], James Hagadorn[2], and Melia Eaton[3]

[1]U.S. Geological Survey
[2]Denver Museum of Nature and Science
[3]Colorado School of Mines

Abstract

A 3D basin model was developed to evaluate geothermal resources within the Denver-Julesburg Basin. Evaluation of geothermal resources in sedimentary basins can take advantage of legacy datasets generated by oil and gas developers as well as paleoenvironmental and geochemical studies of those basins to create three-dimensional (3D) basin models. A key benefit of basin modeling is that it provides lithology-based thermal properties that constrain and improve temperature-depth profiles for geothermal studies. Formation tops and bottom hole temperatures were used along with new paleoenvironmental and lithofacies maps as model inputs. Geochemical data was also incorporated to evaluate the influence of the Colorado Mineral Belt on the Permian Lyons Sandstone. Over 20,000 bottom hole temperature measurements from depths between 2,000 and 20,000 feet were corrected using a Förster-type model developed for the basin. Resulting corrected temperatures ranged from 130 up to 436°F and the deepest wells were at ~24,000 feet. Estimates from the resultant basement heat flow map are comparable to previous published studies and show highly elevated heat flow in the Wattenberg field area. Depth to temperature maps were created for moderate- (≥194°F) and high-temperature (≥302°F) geothermal resource cut-offs. These maps indicate that in the Colorado Mineral Belt area, moderate and high-temperature resources may be as shallow as 4,000 and 7,000 feet deep, respectively. Geothermal resources in other areas of the basin are deeper for both temperature cut-offs and many areas outside of the western part of the basin may lack any high-temperature resource in the sedimentary units examined. The Lyons Sandstone has been evaluated previously as a potential target for geothermal development. Geochemical data on pyrite composition and other ore emplacement and mineral thermal alterations in this unit indicate that hydrothermal fluid-rock interactions may have impacted permeability within the Lyons in the Colorado Mineral Belt area as recently as the late Miocene. This may affect resource recovery potential by degrading reservoir characteristics and could lead to other changes in brine properties due to temperature changes during thermal energy extraction. The resulting lithologic and temperature model for the Denver-Julesburg Basin identifies the depth ranges where potential geothermal resources are likely to be located, with lithology further informing whether or not permeability is likely to exist. In layers with limited permeability, development strategies for the creation of permeability using enhanced or engineered geothermal systems, deep closed-loop technologies, and other approaches may be viable.