Basin Centered Geothermal in the Basin and Range: Using Outcrop Characterization to Better Predict Subsurface Flow Properties

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Abstract

The Basin and Range provides unique opportunities for geothermal resource development due to crustal extension resulting in anomalously high geothermal gradients. Extensional basins within the region may prove suitable for basin-centered sedimentary geothermal energy production in high porosity/permeability siliciclastic reservoirs. Utilizing a basin centered approach could expand the geothermal footprint and production of this region dramatically. This study characterizes potential Mesozoic siliciclastic reservoirs within an extensional basin along the Basin and Range/Colorado Plateau transition using detailed outcrop characterization, basin modeling and quantitative analysis of porosity and permeability to assess suitability for basin-centered sedimentary geothermal exploration. Eighty-nine rock samples were collected from outcrops near the basin of interest for detailed reservoir characterization. Samples were taken from twelve key stratigraphic intervals at five locations, covering the stratigraphic units of interest within the nearby basin. Additionally, detailed outcrop descriptions, and tri-spectral gamma-ray measurements were taken for correlation to nearby oil and gas wells. To quantify porosity and permeability from outcrop samples, 164 one-inch core plugs were drilled from eighty-two samples. Each sample was cored both horizontally and vertically to understand anisotropy of flow properties. To further constrain lithological parameters impacting flow properties, twenty-eight samples were analyzed petrographically in thin section. Parameters such as grain size distribution, cementation, grain sorting, and lithology were combined with quantitative measurements of fluid flow properties for multifactor analysis. Based on quantitative results, we identify three units of siliciclastic strata as prospective reservoir targets that sit within a thermal zone of interest. These three units have median porosities of 15.1%, 15.7% and 11.4 % with horizontal permeabilities of 11.4 mD, 20.6 mD and 7.1 mD, respectively. Regression analysis of porosity/permeability shows a strong correlation, suggesting that permeability values within basin-center strata can be predicted using porosity and other petrophysical parameters from nearby geothermal and oil wells. It is important to note stratigraphic anisotropy within target units. Petrographic investigation of thin sections demonstrates that variance of porosity and permeability within units is due to heterogeneity in textural and compositional maturity, diagenetic alteration, and cementation. This highlights the need for detailed petrographic characterization of potential sedimentary geothermal reservoirs to understand lithological factors impacting spatial distribution of porosity and permeability. This understanding will lead to a better understanding of the flow efficiency of geothermal fluids, allowing for effective exploration and development of basin-centered sedimentary geothermal systems.