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Micro-seismicity and hydrologic compartmentalization in the Coso geothermal reservoir, Inyo County, California

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High precision seismic locations and subsurface velocity structure provide potential insights into fracture system geometry, fluid conduits/compartmentalization, and reservoir mechanics critical to geothermal exploration and reservoir management. We analyze 16 years of seismicity to improve hypocentral locations of micro-seismicity and simultaneously invert for seismic velocity structure within the Coso geothermal reservoir. The Coso geothermal reservoir has been continuously producing since the 1980's and is separated into two main producing compartments: the main field and the east flank. We use differential travel times of adjacent micro-seismic events to remove path-dependent errors in relative hypocentral locations and simultaneously invert for the three-dimensional velocity structure within the reservoir. We find that relocated seismicity in the main field is shallower than in the east flank and occurs at the same depths as the injection and production wells, while the east flank seismicity extends about a kilometer below the injection and production wells. In the east flank, many of the earthquakes appear to align along planar features, suggesting through-going, pre-existing faults that may act as conduits for fluid and heat transport. The seismic velocity structure reveals heterogeneous distributions of compressional (Vp) and shear (Vs) wave speed, with Vp generally lower in the main field when compared to the east flank and Vs varying more significantly in the shallow portions of the reservoir. The Vp/Vs ratio appears to outline the two main compartments of the reservoir at depths of $\sim$ -0.5 to 1.5 km, with a narrow zone of relatively high Vp/Vs separating the main field from the east flank. In the deeper portion of the reservoir this zone becomes less prominent. Comparison of the distribution of Vp/Vs ratios with a temperature model generated from well logs reveals a significant correlation between regions of low Vp/Vs and high temperature. However, since variables such as fracture geometry/density and fluid saturation can also effect Vp/Vs, the physical cause of these variations cannot be uniquely determined. Nevertheless, these findings suggest that low Vp/Vs ratios may correlate with regions of high geothermal production at Coso. In summary, our results suggest that simultaneous, high-precision earthquake relocations and velocity inversions in active geothermal reservoirs can serve two distinct and important purposes: 1) help identify faults that serve as fluid and heat conduits, and 2) delineate the nature and extent of hydrothermal compartmentalization within these reservoirs.