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Geothermal Technologies Program

The Role of Low-Angle Extensional Tectonics, Flat Fracture Domains, and Gravity Slides in Hydrothermal and EGS Resources of the Western United States

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PROJECT SUMMARY

Increasing the viable U.S geothermal power-production resource from the currently (and liberally) estimated 23,000 megawatts (MWe) to the 40,000 MWe desired by the DOE within the foreseeable future calls for massive advances in geothermal science and technology. On the scientific front, one of the big challenges will be to improve significantly our fundamental understanding of the origins and time-dependent configurations of fractures and fracture networks, which provide the principal thermal-fluid conduits and percolation pathways in the majority of high-temperature geothermal systems. On the technological side, reaching 40,000 MWe within a meaningful time frame will clearly involve the routine commercial implementation of Engineered Geothermal System (EGS) technology. We propose to contribute to the advancement of both of these agendas by improving knowledge of low-angle fracture domains and gravity-slide blocks as reservoir controls in natural-hydrothermal and EGS regimes in the Basin and Range province of the western U.S.

These clearly extensional low-angle structural features are somewhat enigmatic, because in such tectonic regimes, flat-lying fracture zones theoretically should be prone to closure and unlikely to undergo permeability rejuvenation (the greatest principal stress direction is vertically oriented). Nonetheless, sub-horizontal thermal aquifers are a relatively common phenomenon requiring a rational explanation. We propose to address this requirement by investigating carefully selected hydrothermal systems with both low-angle fracture control and significant potential for EGS development in the U.S. Basin and Range. The study will focus on the Steamboat Springs system in the western part of the province, as Steamboat provides perhaps the best example of a crystalline-rock-hosted but flat-lying thermal-fluid aquifer in the province. Additional details for proposed site-specific and comprehensive conceptual geologic and hydrologic models incorporating these low-angle features will arise from parallel but less detailed investigations of the (in many ways) allied Roosevelt Hot Springs and Cove Fort geothermal systems in southern Utah (Roosevelt was once considered by Los Alamos National Laboratory as the premier candidate site for hot-dry-rock development in the country). Input for the models will come from a balanced mix of fundamental and novel research techniques including, but not limited to: geologic mapping; detailed logging of borehole rock samples; fracture characterization and stress analysis from core and imaging logs; fluid-inclusion microthermometry; $^{40}Ar/^{39}Ar$ age-dating and thermal-history modeling; X-ray diffraction analysis; and SEM and electron-microprobe analysis. The work will draw upon the PI's extensive experience in the low-angle extensional terrains of eastern Nevada, where such features are common in the region's shallower Carlin-type gold deposits and geothermally generated petroleum reservoirs. The project will benefit all geothermal companies in the region exploring for natural hydrothermal or EGS resources: (1) by realistically formulating new geothermal target types involving low-angle fracture domains; (2) by evaluating and quantifying the means by which these domains preserve permeability even in the presence of (seemingly) unfavorably oriented stresses; and (3) by predicting the responses of buried gravity-slide blocks and low-angle fracture networks to artificial hydraulic stimulation.