

Seismic Monitoring of EGS Stimulation Tests at the Coso Geothermal Field, California, Using Microearthquake Locations and Moment Tensors

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We calculated high-resolution relative locations and full moment tensors for microearthquakes which occurred before, during and following EGS stimulation experiments in two wells at the Coso Geothermal Field, California. Our objective was to map new fractures, determine the mode and sense of failure, and characterize the stress cycle associated with reservoir stimulation. As part of this work, we developed new and improved software to combine waveform cross-correlation measurements of arrival times with relative relocation methods, and to assess confidence regions for moment tensors derived using linear-programming methods. This software was applied for the first time to data from the Coso geothermal area. We used data from the US Navy's permanent network of three-component digital borehole seismometers, which was supplemented by 14 surface-mounted portable three-component digital instruments. We studied injection experiments in well 34A-9 in 2004 and well 34-9RD2 in 2005. These injectors are both on the same surface well pad but they are deviated in different directions so their bottoms are ~ 1 km apart. Despite this, both injections activated the same region, a well-defined planar structure, 700 m long, 600 m high in the depth range 0.8 to 1.4 km below sea level, striking N 20 degrees E and dipping 75 degrees to the WNW. The moment tensors show that this structure corresponds to a mode I (opening) crack. Perturbations to the seismicity rate and source orientations near the bottom of the well persisted for at least two months following the injection. These results show that significant flow of injection fluids across the dominant NE tectonic trend of the area. This result is a proof-of-concept that microearthquake analysis techniques are now of sufficient quality to provide the detailed and comprehensive information about stimulated fractures to comprise a useful guide to operational decision making.