Julian, B.R., G.R. Foulger and F. Monastero, Microearthquake moment tensors from the Coso Geothermal area, Thirty-Second Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 22-24, 2007.

Microearthquake Moment Tensors from the Coso Geothermal Area

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The Coso geothermal area, California, has produced hot water and steam for electricity generation for more than 20 years, during which time intense microearthquake activity has occurred in the area, much of it induced by production activities. Seismicity is monitored by a high-quality permanent network of three-component digital borehole seismometers operated by the US Navy and supplemented by a ~ 14-station portable array of surface three-component digital instruments. The portable stations improve seismic coverage, providing seismic-wave polarity and amplitude data sets sufficient for determining full moment-tensor microearthquake mechanisms by the linear-programming inversion method. We have developed a GUI-based interface to this inversion software that greatly increases its ease of use and makes feasible analyzing larger numbers of earthquakes than previously was practical.

We show examples from an injection experiment conducted in well 34-9RD2, on the East Flank of the Coso geothermal area. This tight well was re-drilled February – March 2005 with the intention of hydrofracturing it, but instead, pervasive porosity and fractures were encountered at about 2660 m depth. Total drilling mud losses occurred, obviating the need to stimulate the well. These mud losses induced a 50-minute swarm of 44 microearthquakes, with magnitudes in the range -0.3 to 2.6. Most of the largest microearthquakes occurred in the first 2 minutes. Accurate relative relocations and moment tensors for the best-recorded subset reveal fine details of the fracture stimulated. This comprised a fault striking at N 20° E and dipping at 75° to the WNW, which propagated to the NNE and upward. Co-injection focal mechanisms reveal combined crack-opening and shear motion. Stress release and mode of failure differed between the pre-, co- and post-swarm periods. Some post-swarm events involved cavity collapse, suggesting that some of the cavity opening caused by the fluid injection was quickly reversed. Stress & mode of failure had not returned to pre-swarm conditions within 1 month following the injection, posing the question of how long stress perturbations persist following a stimulation experiment. This question may be answered by processing data spanning a longer post-injection period, work that is currently underway and will be reported in this presentation.