Seismic Monitoring of EGS Tests at the Coso Geothermal Area, California, Using Accurate MEQ Locations and Full Moment Tensors

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We studied high-resolution relative locations and full moment tensors of microearthquakes occurring before, during and following Enhanced Geothermal Systems (EGS) experiments in three wells at the Coso geothermal area, California, with the objective of mapping new fractures, determining the mode and sense of failure, and characterizing the stress cycle associated with injection. New software developed for this work combines waveform cross-correlation measurement of arrival times with relative relocation methods, and assesses confidence regions for moment tensors derived using linear-programming methods. We show the first results from applying these new techniques to data from the US Navy's permanent network of three-component digital borehole seismometers and from 14 portable three-component digital instruments installed at the surface for a several-month interval spanning injection experiments in well 34A-9 in 2004, well 34-9RD2 in 2005, and pre-injection earthquakes near well 46A-19RD. In the experiment in well 34A-9, the co-injection earthquakes were more numerous, smaller, more explosive and had more horizontal motion, compared with the background earthquakes. Injection affected the stress orientation in the activated volume for at least two months after injection ceased. In the experiment in well 34-9RD2, the injection produced spatially coherent seismicity different from the scattered ongoing background activity. The relocated hypocenters reveal 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 it corresponds to a mode I (opening) crack. The seismicity rate and perturbed stress state in the neighborhood of the bottom of the well persisted for at least two months following the injection.