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Monitoring geothermal reservoir depletion using seismic tomography

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The Coso geothermal area is the seventh largest exploited geothermal area in the world. It is 28 km2 in area, and has a water-dominated reservoir with temperatures up to $\sim$ 345ºC. It has been under production for two decades, and now has $\sim$ 177 boreholes up to 4 km deep and produces 300 Mw of electricity, sufficient for the needs of $\sim$1 million people. We have studied the crustal structure of the reservoir, and the change in structure with time, to understand the geological setting and to determine how and where production activities are depleting the reservoir. We calculated the three-dimensional structure of the upper $\sim$ 4 km of the crust using local earthquake tomography. The Coso geothermal area is highly seismically active as a result of the heavy geothermal production there, and thousands of earthquakes typically occur per year. We performed separate tomographic inversions for each year from 1996-2007. Up to 600 earthquakes, selected from the best-quality events, were used for each inversion. These earthquakes were recorded on 21 stations. The inversions were performed using program simulps12 [Thurber, 1983]. Our initial results suggest that a Vp/Vs anomaly beneath the eastern part of the geothermal area is growing with time. This may indicate progressive depletion of water in the reservoir, pressure decline, and possibly mineralogical changes due to drying. The signal is subtle, however, and our ongoing work will focus on critically testing this conclusion by performing tomographic inversions for the years 2008 - 2012. We will also invert pairs of years simultaneously using a new program, tomo4d [Julian and Foulger, 2010]. Instead of performing inversions merely for structure, this program inverts for the differences in structure between two epochs that are required by the data only. It thus eliminates artifacts that result from the differences in experimental setup from year to year, and can provide a more reliable measure of structural change than simply differencing independently performed inversions of individual years of data.