Time-dependent seismic tomography and its Application to the Coso geothermal area, 1996-2006

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Measurements of temporal changes in Earth structure are commonly determined using local-earthquake tomography computer programs that invert multiple seismic-wave arrival time data sets separately and assume that any differences in the structural results arise from real temporal variations. This assumption is dangerous because the results of repeated tomography experiments would differ even if the structure did not change, simply because of variation in the seismic ray distribution caused by the natural variation in earthquake locations. Even if the source locations did not change (if only explosion data were used, for example), derived structures would inevitably differ because of observational errors. A better approach is to invert multiple data sets simultaneously, which makes it possible to determine what changes are truly required by the data. This problem is similar to that of seeking models consistent with initial assumptions, and techniques similar to the "damped least squares" method can solve it. We have developed a computer program, *dtomo*, that inverts multiple epochs of arrival-time measurements to determine hypocentral parameters and structural changes between epochs. We are applying this work to data from the seismically active Coso geothermal area, California. The permanent network operated there by the US Navy, supplemented by temporary stations, has provided excellent earthquake arrival-time data covering a span of more than a decade. Furthermore, structural change is expected in the area as a result of geothermal exploitation of the resource. We have studied the period 1996 through 2006. Our results show, for a 2-km horizontal grid spacing, an irregular strengthening with time of a negative V_P/V_S anomaly in the upper ~ 2 km of the reservoir. This progressive reduction in V_P/V_S results predominately from an increase of V_S with respect to V_P. Such a change is expected to result from effects of geothermal operations such as decreasing fluid pressure and the drying of argillaceous minerals such as illite.