Geophysical Research Abstracts
Vol. 14, EGU2012-2235, 2012
EGU General Assembly 2012

High-resolution analysis of seismicity induced at Berlín geothermal field, El Salvador

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We investigate induced microseismic activity monitored at Berlín Geothermal Field (BGF), El Salvador, during a hydraulic stimulation. The site was monitored for a time period of 17 months using 13 3-component seismic stations located in shallow boreholes. Three stimulations were performed in the well TR8A with a maximum injection rate and well head pressure of 160 l/s and 130 bar, respectively. For the entire time period of our analysis, the acquisition system recorded 581 events with moment magnitudes ranging between -0.5 and 3.7. The initial seismic catalog provided by the operator was substantially improved: 1) We re-picked P- and S-wave onsets and relocated the seismic events using the double-difference relocation algorithm based on cross-correlation derived differential arrival time data. Forward modeling was performed using a local 1D velocity model instead of homogeneous full-space. 2) We recalculated source parameters using the spectral fitting method and refined the results applying the spectral ratio method. We investigated the source parameters and spatial and temporal changes of the seismic activity based on the refined dataset and studied the correlation between seismic activity and production. The achieved hypocentral precision allowed resolving the spatiotemporal changes in seismic activity down to a scale of a few meters. Of special interest is the largest event ($M_{\mathrm{W}}3.7$) and its nucleation process. This event occurred in the center of the BGF about two weeks after the termination of the second injection in TR8A and is interpreted to be related or even triggered by the shut-in of the wells. This characteristics is in accordance with the occurrence of induced "larger magnitude events" in a number of other geothermal sites.