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Seismic source parameters of the induced seismicity at The Geysers geothermal area, California, by a generalized inversion approach

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Following the global demand for energy increases, the potential contribution from geothermal energy has progressively become extremely important, particularly if resources developed with Enhanced Geothermal Systems (EGS) technology are incorporated in the total energy picture. EGS started in the early ‘70s in the U.S.A. and since then other EGS worldwide projects developed further the concept of creating a reservoir in crystalline rock in other geological settings. Unfortunately, the spread of EGS technology is slacked by induced seismicity and anthropogenic environmental influence issues. Induced seismicity, in particular, raised serious concerns in Europe after the high-pressure hydraulic fracturing in the EGS in Basel Switzerland caused seismic events that were large enough to be felt, and culminated with a 3.4 ML event that caused panic in surrounding population, with very large associated total insurance claims.

The rapid determination of the event source parameters, especially the stress drop and seismic efficiency, as well as their space-time evolution are fundamental pieces of information for the mitigation of the seismic risk associated to triggered earthquakes in EGS areas, since these parameters are potentially useful for the identification of areas prone to larger events.

The Geysers EGS field is the largest geothermal system in the world. The dataset considered in this study consists of 1317 events recorded by the 32 three-component stations of the Lawrence Berkeley National Laboratory Geysers/Calpine surface seismic network between 2007/07/24 and 2011/10/30. The magnitude range is $2 \leq$ MW ≤ 4.5 and the epicentral distances range is from 2 km to 30 km.

In this work, we applied a nonparametric spectral inversion scheme (i.e. the generalize inversion technique, GIT) to evaluate the S-wave source spectra, attenuation, and site transfer functions for recordings of induced earthquakes collected at The Geysers EGS field in California. In particular, our study focuses on the in-depth analysis of the source spectra derived by the GIT approach, which have been inverted by a genetic algorithm aiming at the estimation of the seismic source parameters seismic moment, corner frequency and the parameter γ controlling the high-frequency spectral fall-off.

The comparison of results obtained in this study with those obtained by other parametric methods previously applied to the same data-set, and most importantly the correlation of our results with the operational information (temperature, wellhead pressure, gross steam, steam production rate, water production rate, water injected rate, gross injected), allowed to assess the potential of the GIT approach for studying the induced seismicity at The Geysers field.