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# Faults strengthening and seismicity induced by geothermal exploitation on a spreading volcano, Mt. Amiata, Italia

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## Highlights

- 1 year seismic recording at Mt. Amiata highlighted events with hydro-fracturing-like seismic signature.
- Hypocentral depths increase away from volcano' axis toward the base: a sign of active spreading?
- Gravitational spreading of volcanoes recharges basal faults with shear stress released through seismicity.
- Geothermal exploitation can enhance a nearby fault' resistance to slip.
- In the area, M ≈ 5.5 events with a recurrence time of about 100 yrs may occur later and be stronger.

## Abstract

Seismogenic structures such as faults play a primary role in geothermal system generation, recharge and output. They are also the most susceptible to release seismic energy over fluid injection/extraction operations during anthropic exploitation. We describe the microseismic activity recorded in 2000–2001 in the Piancastagnaio geothermal field, on the SE flank of Mt. Amiata volcano, southern Tuscany, Italy. From our field observations we find that a relatively high percentage (i.e. about 5%) of the recorded events are of hydro-fracturing origin and have a distinct waveform seismic signature when compared to the recorded events of tectonic shear-fracturing origin. While hydrofracturing events are mostly concentrated around the geothermal fields, the spatial distribution of hypocenters shows a deepening and a density increase of the micro-seismic activity from the volcanic axis toward the exploited geothermal reservoir, suggesting that volcanic spreading at Amiata is still active. The study of different data-sets from different time periods together with the knowledge from Terzaghi's law that production of large quantity of pore-fluid with the associated fluid pressure reduction could augment the stress normal to faults' surfaces (and thus their resistance to slip), make us argue that the process of volcanic spreading affecting the edifice of Amiata may allow augmented accumulation of stresses on faults, eventually leading to the release of higher stress drops, once ruptures occur. The Gutenberg–Richter magnitude–frequency distribution shows that the strongest events on record have a local magnitude in the 5–5.5 $M_L$ range, for 100-year recurrence time. In conclusions, we infer that geothermal exploitation at Mt. Amiata should be closely monitored in order to understand how fluid injection/production is responsible for the hydrofracturing seismic activity and affects stress accumulation on and rupture of faults within and in the neighborhood of the geothermal fields. This understanding may allow a geothermal field management that will hopefully reduce the risk for inducing larger seismic events in the area.

## Keywords

Induced seismicity; Geothermal exploitation; Critically-stressed faults; Fault strengthening; Tectonic vs hydro-fracturing events; Amiata volcano

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