The seismic sequence of 30th May - 9th June 2016 in the geothermal site of Torre Alfina (central Italy) and related variations in soil gas emissions

Thomas Braun[1], Marco Caciagli[2], Maria Luisa Carapezza[3], Daniela Famiani[3], Alessandro Gattuso[3], Arianna Lisi[3], Alessandro Marchetti[4], Giuliana Mele[3], Nicola Mauro Pagliuca[3], Massimo Ranaldi[5], Francesco Sortino[3], Luca Tarchini[5], Marius Kriegerowski[6], Simone Cesca[6]

[1]*Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio di Arezzo, Italy*
[2]*Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Bologna, Italy*
[3]*Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Roma 1, Italy*
[4]*Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Nazionale Terremoti, Roma, Italy*
[5]*Dipartimento di Scienze, Università di Roma Tre, Italy*
[6]*GFZ German Research Centre for Geosciences, Potsdam, Germany.*

In the framework of a medium-enthalpy geothermal exploitation project, seismicity and soil gas emissions have been monitored in the area of Castel Giorgio-Torre Alfina since 2014. A dedicated local seismic network deepened the knowledge of the natural local seismicity in terms of source mechanisms, high-quality event localization and magnitude estimation. From November 2014 to May 2016, 846 seismic events were recorded, with a magnitude range of M_d 0.1-2.8 and hypocentres 4-8 km depth. On 30th May 2016 a M_w 4.3 earthquake occurred near Castel Giorgio, followed by almost 1700 aftershocks; the moment tensor solution depicts a WNW-ESE oriented normal fault. An overview of the epicentral distributions since 2014, highlights that the active tectonic structures are NE-SW and WNW-ESE orientated. The diffuse soil CO_2 flux is monitored since 2013 in six target areas located around the future production and reinjection wells, in order to assess the level of background natural degassing. In all target areas the maximum value of soil CO_2 flux has been recorded during the 2016 seismic sequence. However, the values of $\delta^{13}C$ of the emitted CO_2 indicated a shallow biological origin of the gas. At Torre Alfina, the Solfanare natural gas emission, with a CO_2 dominated gas, has same composition of the gas hosted in the geothermal reservoir. Here, high values of diffuse soil CO_2 flux were recorded. During the 2016 seismic sequence, the Solfanare gas was continuously analysed by an automatic gas- chromatographic station. Results show that apart from small perturbations, no significant compositional variations were recorded. The significant contribution of CLVD and isotropic components suggest a possible opening of fluid cracks below the geothermal reservoir hosted in fractured Mesozoic limestones. The seismo-tectonic scenario indicates that the Solfanare fault was not activated. Kinematics and orientation of the activated faults suggest a relationship with the Bolsena caldera collapse.