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Geothermal energy extraction in a volcanic caldera: from seismic imaging to fluid flow modelling

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Unrest episodes at calderas result from the complex interplay between magma dynamics, pre-existing structures, and lithological controls on fluid migration. Despite their importance in eruption forecasting, both the sub-surface faults/fractures and the time evolution of the rupture processes during unrest are still poorly constrained. Novel seismic attenuation and lapse-time source models of Campi Flegrei (Italy) 1983-84 unrest reveal that it is possible to track and characterise structurally-controlled fluid migration by coupling seismology with the rock deformation and reactive fluid transport.

Here, we show how the results of recent seismic attenuation imaging and time-dependent localisations at the caldera can be employed to model fluid and magma migration in the volcanic subsurface. We use pre-existing structural and geochemical information, embedding it in the practice of volcano monitoring institutions, and discovering new applications to hydrocarbon and geothermal energy exploration. We present the preliminary attenuation model, showing how in the 80s the volcanic unrest fed the geothermal reservoir exploited by giant Italian retailers. The results of the fluid flow modelling are based on Continuum Coupled thermal-hydrological-mechanical-chemical modelling. They will provide fundamental insights into the way fluid-induced unrest at calderas develop and evolve; more importantly, they will contribute to forecasting how geothermal reservoirs are supplied in areas where geothermal exploration is currently active, and economic revenues are relevant.