Physico-chemical processes in hydrothermal environment associated with seismic cycles at the Campi Flegrei (Italy)*

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We propose to study the mechanical behavior of rocks under hydrothermal conditions as a way to identify the factors responsible for natural and induced seismic and aseismic fracturing processes within geothermal reservoirs of active volcanoes. For the purpose, we have chosen the active volcanic caldera of the Campi Flegrei that includes the western cities of Naples, Italy (**Figs. 1a-b**). Here, seismicity is associated with ground uplift, up to at the least a net 4 m in the last seventy years (Del Gaudio et al., 2010). Most of the seismicity, up to magnitude M_L 4.2 (D'Auria et al. 2015; Scotto di Uccio et al., 2023), occurs at ≤ 3 km depth and it is probably driven by the circulation of hot (< 400°C; Chiodini et al., 2010; Piochi et al., 2014) and pressurized fluids in the caldera (Danesi et al., 2024) (**Figs. 1a-b**).

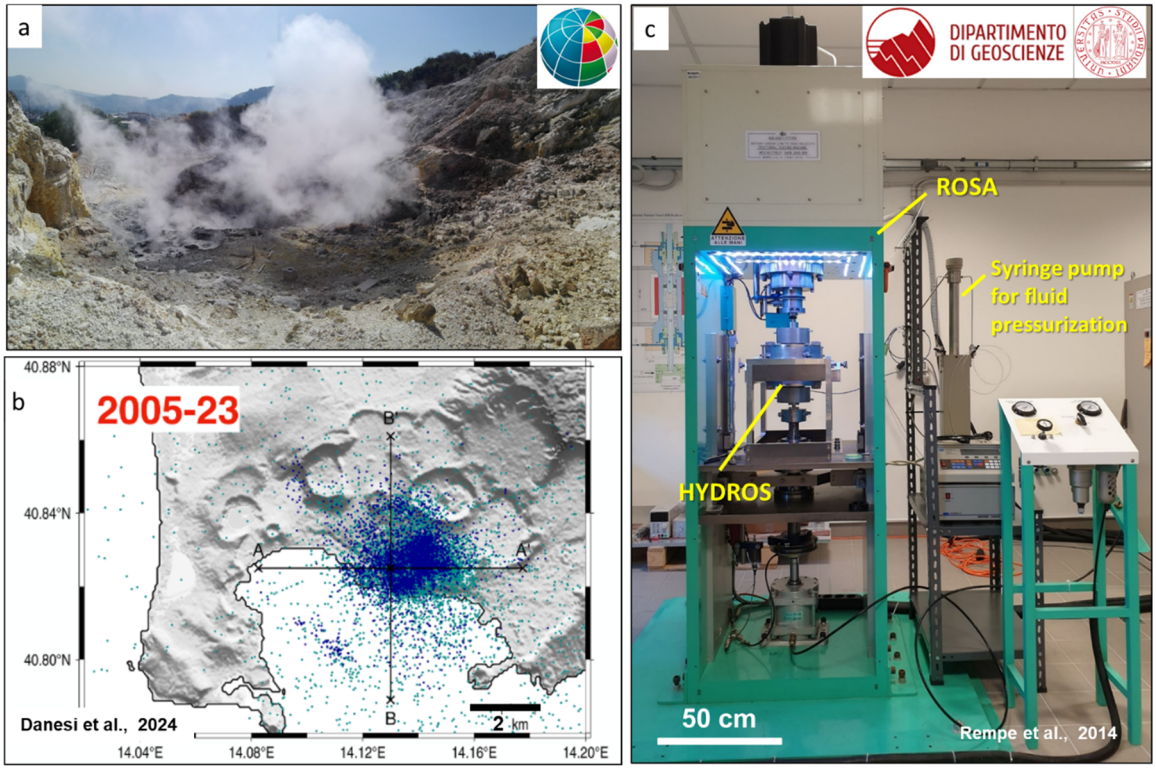

Fig. 1. Project's topics. **(a)** Hydrothermal activity in the Campi Flegrei (Fumarole Pisciarelli). **(b)** Seismicity in the Campi Flegrei area in the period 2005-2023 recorded by the seismic network of INGV (Danesi et al., 2024). **(c)** RoSA & HYDROS apparatus at the Department of Geosciences at Padua University (Rempe et al., 2014; Gomila et al., 2023).

The main goal of this Ph.D. project is to determine the frictional properties of the reservoir rocks and to identify the physical and chemical processes associated with the seismic cycle at the Campi Flegrei. This goal will be achieved through a multidisciplinary approach including investigations to be conducted at the *Dipartimento di Geoscienze* of the *Università di Padova* (DG-UNIPD) and at the INGV in Naples (*Osservatorio Vesuviano,* OV-INGV), Rome (*Roma 1,* RM1-INGV) and Palermo (PA-INGV). The research activities will include:

- collection of lithotypes representative of the volcano subsurface from field surveys and from deep cores we intend to obtain from AGIP that performed drilling geothermal exploration activities in '70s-80s years (OV-INGV);
- experiments reproducing aseismic to seismic deformation in the presence of hot and pressurized fluids (hydrothermal conditions up to 450°C and 70 MPa) of the Campi Flegrei geothermal reservoir using the RoSA & HYDROS experimental apparatus (**Fig. 1c**). The experiments will allow the determination of friction and healing properties of natural faults in the presence of liquid to supercritical H_2O and, if possible, H_2O+CO_2 mixtures (DG-UNIPD);
- analysis of natural and experimental products by:
  - He-picnometer and permeameter to determine porosity and permeability (RM1-INGV);
  - 2D and 3D imaging techniques (FESEM-BSE-SE-CL-EDS-WDS and μMCT) of solid samples to establish geometries of fractures, pores, grains, etc. of dissected samples and its *in-toto* structure (DG-UNIPD; OV-INGV);
  - mineralogical analyses (XRD, μRaman and FTIR) of solid samples to establish association, abundance and type of phases (DG-UNIPD; OV-INGV);
  - chemical analyses (FESEM-EDS-WDS, XRF, ICPMS-Laser Ablation) of solid and fluid samples to determine major and minor element content and type of fluid-rock interaction at various realistic experimental conditions of the Phlegraean geothermal reservoir (DG-UNIPD; OV-INGV; RM1-INGV; PA-INGV);
- numerical modeling (EOS2-TOUGHREACT) of fluid-rock interaction (calibrated from solid and fluid analyses) under subcritical to supercritical water conditions to transfer experimental observations to natural ones (RM1-INGV).

The Ph.D. project will include field work and periods at the INGV laboratories of Roma 1, Napoli (*Osservatorio Vesuviano*) and Palermo to carry out research activities in collaboration with petrologists, volcanologists, geochemists, geophysicists and seismologists. Based on results, the project could include activities in laboratories in Europe and non-EU countries.

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