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Time-lapse integrated geophysical imaging of magmatic injections and fluid-induced fracturing causing Campi Flegrei 1983-84 Unrest

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Geophysical precursors measured during Unrest episodes are a primary source of geophysical information to forecast eruptions at the largest and most potentially destructive volcanic calderas. Despite their importance and uniqueness, these precursors are also considered difficult to interpret and unrepresentative of larger eruptive events. Here, we show how novel geophysical imaging and monitoring techniques are instead able to represent the dynamic evolution of magmatic- and fluid-induced fracturing during the largest period of Unrest at Campi Flegrei caldera, Italy (1983-1984). The time-dependent patterns drawn by microseismic locations and deformation, once integrated by 3D attenuation tomography and absorption/scattering mapping, model injections of magma- and fluid-related materials in the form of spatially punctual microseismic bursts at a depth of 3.5 km, west and offshore the city of Pozzuoli. The shallowest four kilometres of the crust work as a deformation-based dipolar system before and after each microseismic shock. Seismicity and deformation contemporaneously focus on the point of injection; patterns then progressively crack the medium directed towards the second focus, a region at depths 1-1.5 km south of Solfatara. A single high-absorption and high-scattering aseismic anomaly marks zones of fluid storage overlying the first dipolar centre. These results provide the first direct geophysical signature of the processes of aseismic fluid release at the top of the basaltic basement, producing pozzolanic activity and recently observed via rock-physics and well-rock experiments. The microseismicity caused by fluids and gasses rises to surface via high-absorption north-east rising paths connecting the two dipolar centres, finally beingq being generally expelled from the maar diatreme Solfatara structure. Geophysical precursors during Unrest depict how volcanic stress was released at the Campi Flegrei caldera during its period of highest recorded seismicity and deformation; they may work as a template for modelling future events in the case the volcano was approaching eruption conditions.