Natural Hazards Assessment

Appiah E., Aringoli D., Arzilli F., Bendia F., Bufalini M., Carroll M.R., Farabollini P., Gentilucci M., Gironelli V., Lampa F., Materazzi M., Pambianchi G., Pino N.A., Tondi E., Valentini G., Volatili T., Zambrano M.

UNICAM, Scuola di Scienze e Tecnologie, Sezione di Geologia

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SEISMIC HAZARD

Fault Interaction and Historical Earthquake Scenarios

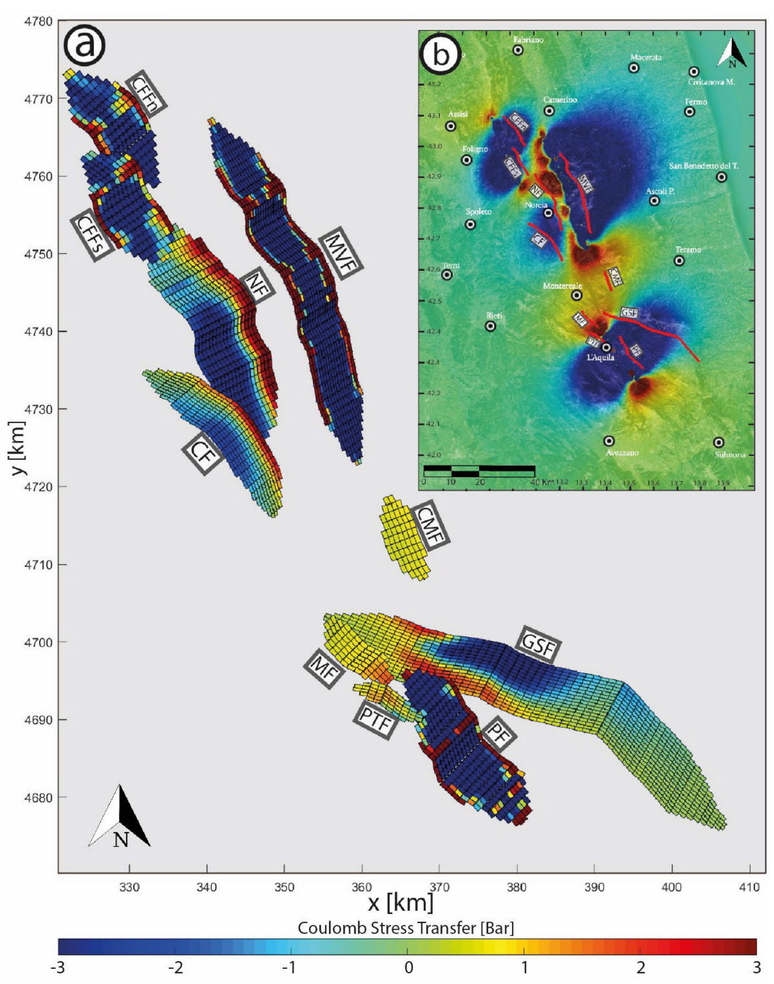


Fig.1. Cumulative Coulomb Stress Transfer (CST) in the Central Apennine Fault System following the 1997, 2009 and 2016 seismic sequences.

Stress transfer between faults following an earthquake is one of the most influential factors driving the evolution of seismicity in fault systems like those of the Central Apennines. Fault interaction is crucial in identifying the faults currently most prone to slip, thereby helping to pinpoint the most hazardous areas. However, many seismogenic sources of historical earthquakes in the Central Apennines remain poorly constrained, despite having generated destructive events over the last millennium. Characterizing these seismogenic sources integrating structural, geological, and seismological data is essential for determining ground motion and assessing seismic hazard in areas affected by these poorly understood earthquakes.

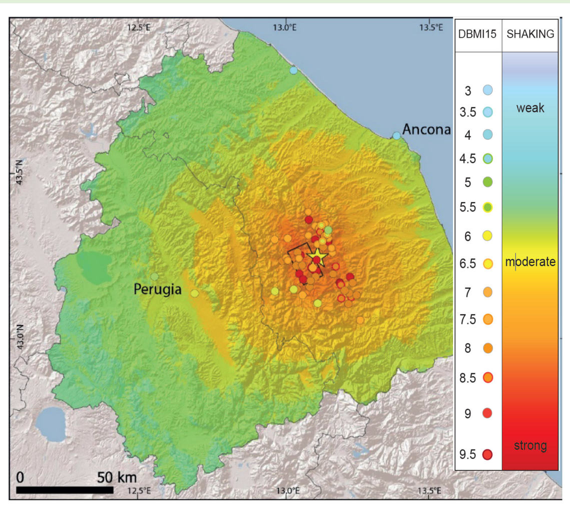


Fig.2. Macroseismic intensity shaking scenarios of 1799 Mw6.18 Camerino earthquake using a normal fault source geometry by varying the hypocentral depths.

The Strongest Campi Flegrei Earthquake Ever Recorded

Campi Flegrei has been experiencing unrest since 2005 – with ground uplift >130 cm – culminating in the largest local earthquake ever instrumentally recorded (Md=4.4), which occurred on May 20, 2024. The seismogram analysis allowed to retrieve the source characteristics and to estimate submillimetric coseismic subsidence (below the sensitivity of standard geodetic technique). The results indicate that rupture directivity and local amplification determined the damage distribution and highlight the crucial role of deep pressurized fluids in the generation of local earthquakes

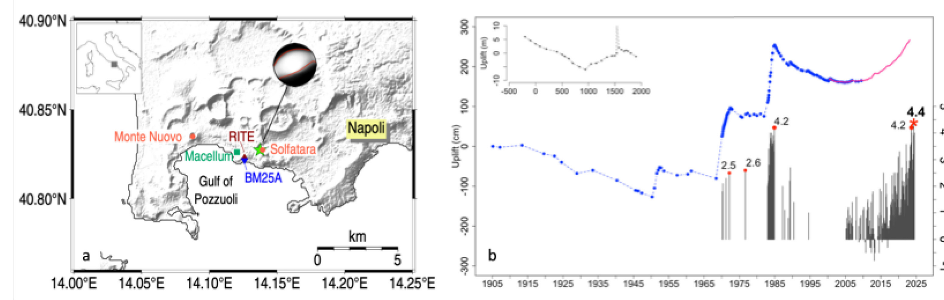


Figure 3. Campi Flegrei and twenty centuries of unrest. Left: Campi Flegrei caldera (B25A and RITE geodetic sites; Macellum is the ancient Roman age market). The May, 20, earthquake location (green star) and the focal mechanism are displayed. Right: vertical ground movements: 1905-2009 (at B25A, blue) 2000-present (at RITE, magenta). 200 BC-1900 vertical movements at Macellum (inset). Black vertical bars indicate the maximum monthly earthquake magnitude

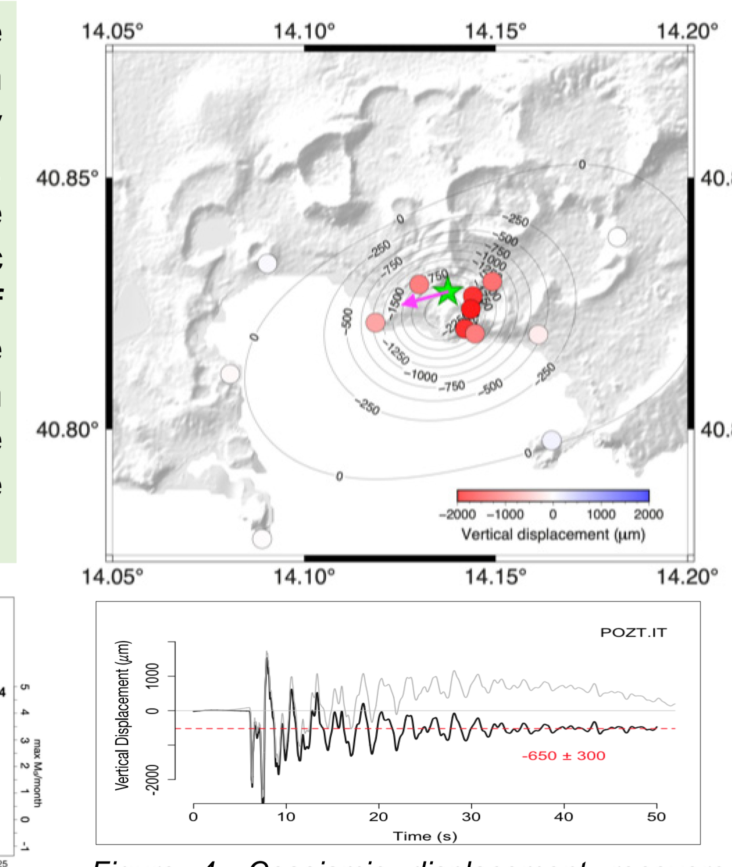


Figure 4. Coseismic displacement recovered from seismograms. Top: Observed (circles) and predicted vertical permanent displacement (contours). The arrow indicates the direction of the rupture propagation. Bottom: Example of the processing. Recorded displacement (grey) and retrieved permanent vertical displacement waveform (black). The coseismic static vertical offset (red line) also reported in μm.

HYDROGEOLOGICAL HAZARD

Climate Change and Human Impact

The combination of the intensification of meteorological events in recent decades and the strong anthropization of the territory leads to increasingly frequent flooding phenomena, landslides on slopes and erosion phenomena on the coast. Remote sensing analysis, drone surveys and field investigations, which are then translated into traditional and digital maps, are now the most advanced systems for detecting, classifying and mapping such phenomena. Hazard assessments are carried out with the help of advanced climate analyzes and the use of hydrological-hydraulic or slope stability models. The research group working in this area collaborates with regional and national agencies to develop new protocols and methods for the assessment of such hazards, receiving funding in the form of research contracts or Community-funded tenders.

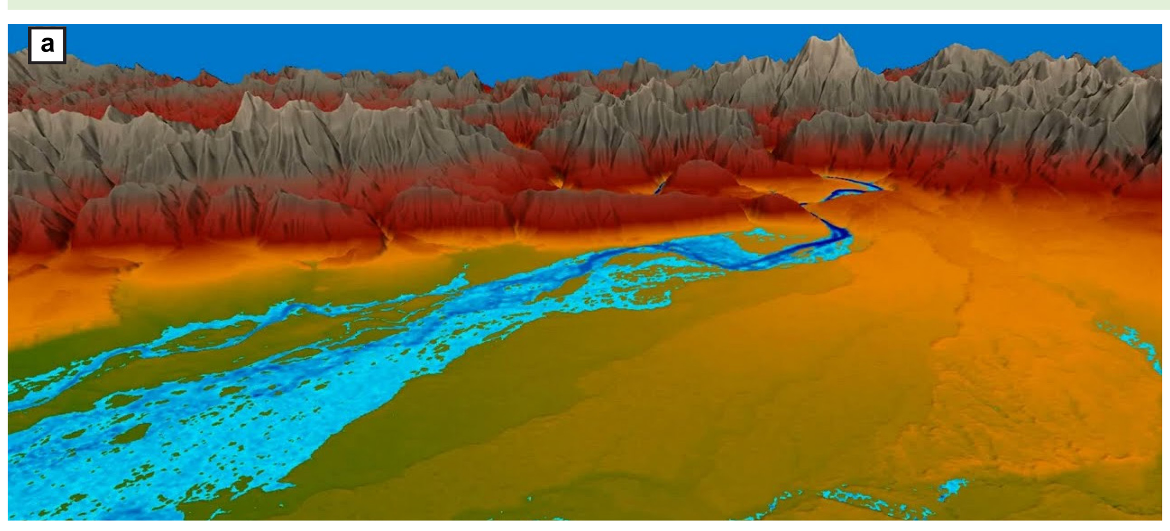
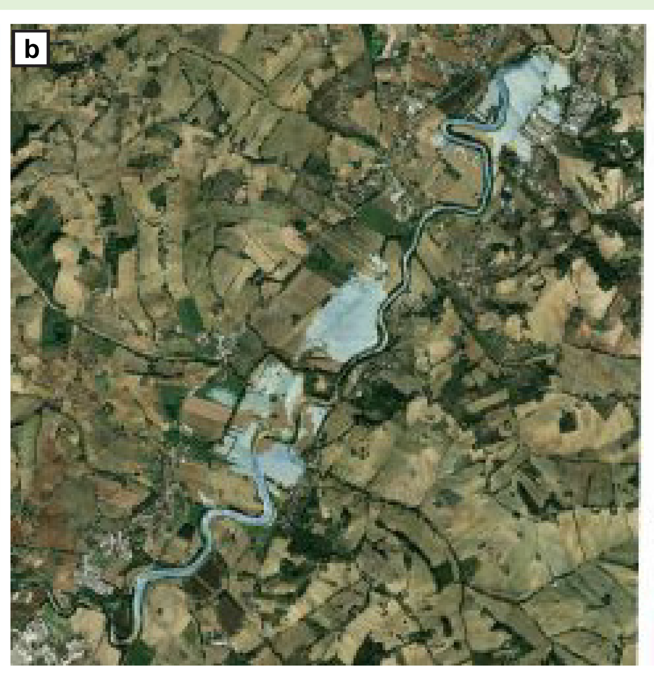


Figure 5. a), b) and c) Result of 3D Hydrologic-Hydraulic numerical models.



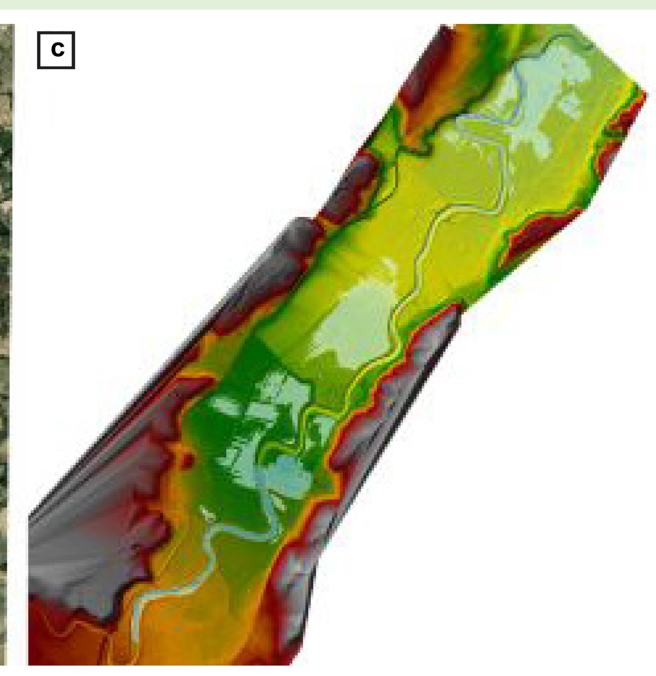
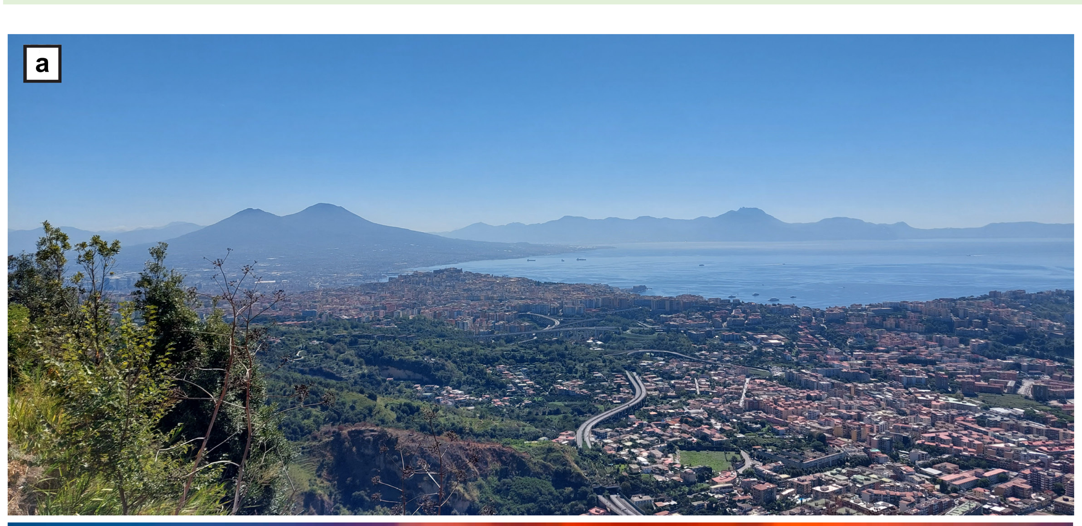


Figure 6. Rotational slide phenomena at Boschetto (Parma).

VOLCANIC HAZARD

Blow or Flow - what controls volcano eruptive behaviour?

Eruption dynamics and eruptive style are controlled by an interplay and feedback of non-linear conduit processes during magma ascent, such as crystallisation, gas exsolution, bubble expansion, melt composition changes. These processes control the magma viscosity evolution and how easily gas and magma decouple during ascent. The relationships between crystallinity, rheology and eruptibility remain uncertain because it is difficult to observe magma crystallization in real time. New experimental work provides in-situ 4D data for crystal and bubble growth kinetics in basaltic magmas in high-temperature and high-pressure experiments. Such data, combined with other experiments on more viscous magmas at high P-T allow development of new models concerning volcanic eruption dynamics.



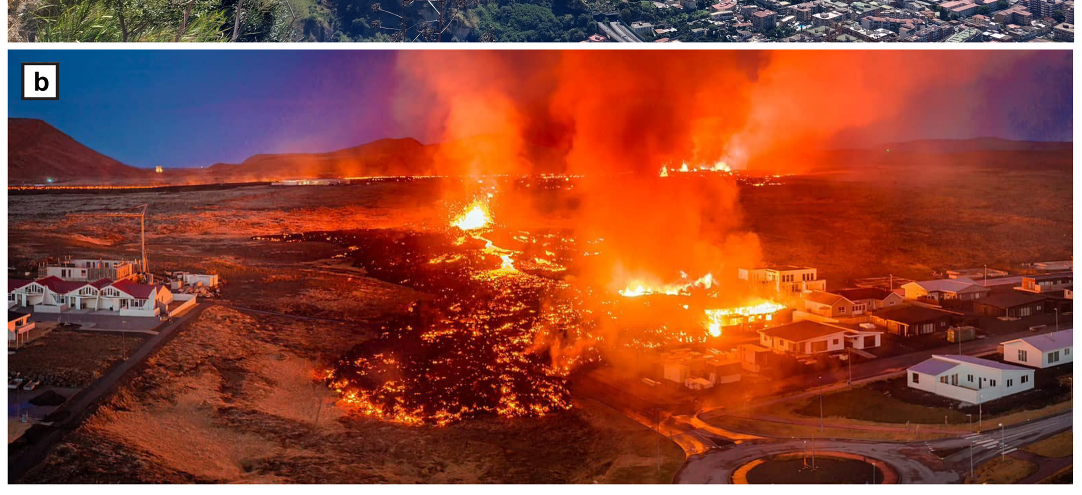


Figure 7. (a) Vesuvio and Campi Flegrei (Napoli, Italy). (b) 2024 eruption in Iceland. (c) 2015 Calbuco explosive eruption in Chile.

Figure 8. Evolution of bubble and crystal growth through time at high temperature and high pressure. These experiments were performed combining X-ray microtomography with a high temperature high pressure furnace to reproduce magmatic conditions in volcanic conduits and simulating magma ascent. These and other experimental data provide quantitative constraints for volcanic eruption models.