Multi-parameter geophysical imaging of Santorini Volcano

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Background: A major caldera-forming eruption at Santorini in around 1600 BC has been linked to the demise of the Minoan civilization. Santorini is currently in a dome-forming phase, with the last eruption occurring in 1939-1941. A seismic crisis accompanied by inflation in 2011-2012 showed that magma is accumulating in a shallow chamber [1] and that Santorini remains one of the most hazardous volcanoes in Europe. A suite of seismic data was acquired across this volcano in an international experiment in 2015, with scientists from Imperial College, Greece and the US. Results from the seismic traveltime inversion confirmed that magma is present at 4 km depth beneath the volcano [2].

Objectives: This project aims to combine geophysical observations, rock physics and numerical modelling to understand the deep structure of Santorini and other arc volcanoes and the detailed distribution of magma in the crust. This will allow to better understand whether the magmatic system is close to an eruptible state and to estimate the size of potential future eruptions.

Methods: The student will apply geophysical inversion to obtain high resolution models of multiple physical properties such as seismic velocities, density, anisotropy, and attenuation. Techniques to be applied include full wavefield tomography (FWI)[3] and joint inversion [4]: FWI involves finding a velocity model that is able to match the full seismic wavefield wiggle-for-wiggle. The principal advantage of FWI is that the recovered velocity models have a high spatial resolution. The student will develop new strategies to invert the imaged physical properties for melt content and melt distribution using inverse theory, machine learning and rock physics.

Student profile: We are looking for geologists, geophysicists, physicists, computer scientists, applied mathematicians, and others with a numerical background and an interest in imaging the Earth. Some previous experience with active source seismic data and/or numerical modelling would be an advantage. The student will work in a vibrant research environment, have opportunities to undertake internships with industrial sponsors (should they wish to do so), and travel abroad to attend international meetings, visit collaborators and exotic field areas.

Multi-disciplinarity: This project applies techniques borrowed from exploration seismology and materials science to advance our understanding of active volcanoes.

Critical skills: The research will involve software development and data analysis using local and national HPC resources and will help the student develop highly sought-after skills including software development, numeracy, data management and machine learning.

References:

[1] Nomikou, P., et al. (2014), The emergence and growth of a submarine volcano: The Kameni islands, Santorini (Greece), doi:10.1016/j.grj.2014.02.002.

[2] McVey, B. et al., (2019), Magma accumulation beneath Santorini volcano from P-wave tomography, doi:10.1130/G47127.

[3] Morgan J. et al. (2016), Next-generation seismic experiments – II: wide-angle, multi-azimuth, 3-D, full-waveform inversion of sparse field data, doi:10.1093/gji/ggv513.

[4] Paulatto, M. et al. (2020), Vertically extensive magma reservoir revealed from joint inversion and quantitative interpretation of seismic and gravity data, doi:10.1029/2019JB018476.