Imperial College London

Natural Environment Research Council

2024_34_ESE_MPa: Teleseismic full-waveform imaging of active volcanoes with massive arrays of seismic nodes

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Background:

Seismic tomography is widely used to constraint the depth of magma storage at active volcanoes. However, traditional travel-time tomography methods struggle to image low-velocity zones because of wavefront healing and cannot provide robust constraints on the physical properties of magma reservoirs. Full waveform inversion (FWI) can overcome these limitations but has so far mostly been limited to active source data, which are very expensive to collect and are often not an option for land volcanoes.

Full waveform inversion can also be applied to teleseismic data, using the waves from distant earthquakes to illuminate the subsurface structure beneath a recording array. This is a new technique that has seen only limited use so far but is very promising for volcano imaging. Teleseismic full waveform inversion (TSFWI) could also be used to image geothermal fields, ore deposits, or other interesting industrial targets at a lower cost and lower environmental impact that traditional active-source techniques. TSFWI has been shown to work at the lithospheric scale, but its applicability to imaging crustal structures remains to be tested. Key to its success is the use of closely spaced receivers with a broad signal bandwidth, which have recently become easier to achieve thanks to the widespread adoption of massive arrays of seismic nodes.

Project:

The student will develop a workflow for TSFWI using an open-source software package (AxiSEM/SpecFEM3D). The work will consist of investigating the feasibility of combining TSFWI with dense arrays of nodes for imaging active volcanoes. The aim is to develop a method that can detect magma reservoirs and constrain the magma storage conditions and thus inform on the likelihood and size of future eruptions. The method can also be applied to understanding the mineral systems associated with large magmatic intrusions. The student will develop optimal inversion strategies and acquisition parameters for future experiments and test the method on a dataset from Mount St. Helens. The project will run in partnership with SmartSolo, a company that is a market leader in low-cost geophone nodes and will provide expertise on seismic nodes instrumentation and field acquisition.

Training and skills development:

We are looking for geologists, geophysicists, physicists, computer scientists, applied mathematicians, and others with a numerical background and an interest in exploring the Earth. The student will be trained in the use of waveform modelling and geophysical inversion. This project represents an opportunity to gain hands-on experience in advanced seismic imaging techniques and to develop programming, scripting and computing skills. The student will work in a vibrant research environment, with opportunities to interact with industry partners and international collaborators