Imperial College London

Natural Environment Research Council

2021_34: Monitoring seismicity at volcanoes with geothermal prospects in Ethiopia

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Earthquakes occur at active volcanoes due to rock fracturing during the migration of magma and hydrothermal fluids, and in response to changes in the stress field caused by inflating or deflating magma/fluid reservoirs. Micro-seismicity in volcanically-active regions is thus a powerful tool to understand the behaviour of fluid pathways, and magma-fault interactions.

Within the seismically and volcanically active East African Rift, geothermal energy exploration is being earmarked by the Ethiopian government as a solution to unreliable electricity supply issues. Extensive geoscientific research in central/northern Ethiopia over the past two decades has shown that magma intrusions and fracture systems are abundant and geothermal exploration viable, but primarily in a relatively narrow (~20km-wide) rift-axial zone. In particular, recordings from networks of seismograph stations have identified earthquake swarms that accompany melt intrusion episodes. However, similar studies are lacking in densely-populated southern Ethiopia, where investment in geothermal energy is planned. It is thus unclear whether or not, and precisely where, further geothermal investment would be worthwhile.

We have begun collecting new data from Lake Abaya volcanic field via establishment of a new seismograph network, in collaboration with Addis Ababa University and Reykjavík Geothermal LTD. We seek an enthusiastic applicant, interested in seismology and tectonics, to explore this growing dataset. This project, which will include opportunities to conduct fieldwork in Ethiopia, will establish a local earthquake catalogue for the Abaya region. 3D visualization and statistical analysis of hypocentres will help elucidate how seismicity varies spatially and temporally. Earthquake source mechanisms will be computed with both moment tensor inversion of full earthquake waveforms, and first motion polarity analyses. Moment tensors and local earthquake shear-wave splitting will be analysed for the state of stress. The student will also analyse legacy data from seismic networks on other volcanic systems of geothermal interest. Improved understanding of magmatic and fault relationships in the Abaya prospect will aid to definitively identify regions of out-flow (recharge zones) and up-flow regions. Critical to Ethiopia's ongoing geothermal development efforts is to avoid striking cold wells that cannot be used to generate electricity.

Wider implications: Most volcanism studies have been performed on subduction zones, but ~10% of volcanoes lie in continental rifts. Despite on-going scientific debate regarding the influence of rift dynamics on volcanism, and a large exposed population, East African Rift volcanoes are under-studied. This project will improve our understanding of the magmatic processes responsible for continental breakup. By elucidating the magma plumbing systems beneath prospective geothermal power stations, it will also aid Ethiopian sustainable energy development.