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The nature of seismicity in a complex volcanic rift setting

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Deciphering the nature of seismicity in regions of active magmatic and tectonic areas is critical when examining the interplay between faulting, magmatism and magmatic fluids. Here, we present a rich seismic data set from a 15-month temporary network from the Natron basin of the East African Rift System, which provides an ideal location to study these processes owing to its recent magmatic-tectonic activity and ongoing active carbonatite volcanism at Oldoinyo Lengai. We report seismicity, seismic swarms and their fault plane solutions which we use to constrain the complex volcanic plumbing system and long-term tectonic processes.

Between March 2019 and May 2020, we locate ~10 000 earthquakes with M_L -0.85 to 3.6. These are related to ongoing magmatic and volcanic activity in the region, as well as regional tectonic extension. We observe seismicity down to ~17 km depth north and south of Oldoinyo Lengai and shallow seismicity (3 - 10 km) beneath the inactive shield volcano Gelai, including two likely fluid driven swarms. The deepest seismicity (down to ~20 km) occurs above a previously imaged magma body below Naibor Soito volcanic field. These seismicity patterns reveal a detailed image of a complex volcanic plumbing system, supporting potential lateral and vertical connections between shallow- and deep-seated magmas, where fluid and melt transport to the surface is facilitated by intrusion of dikes and sills.

Focal mechanisms vary spatially and are a strong indicator for differences between magmatic and tectonic forces. T-axis trends reveal dominantly WNW-ESE extension near Gelai, while strike-slip mechanisms and a radial trend in P-axes are observed in the vicinity of Oldoinyo Lengai. These observations support local variations in the state of stress, resulting from a combination of volcanic edifice loading and magma-driven stress changes imposed on a regional extensional stress field. Our results indicate that the southern Natron basin is a segmented rift system, in which fluids preferentially percolate vertically and laterally in a region where strain transfers from a border fault to a developing magmatic rift segment.