

## Magnetotelluric imaging of the magmatic roots of Kīlauea volcano

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### SUMMARY

Kīlauea volcano, in Hawaii, USA, is one of the most active volcanoes on Earth, erupting frequently from vents at its summit and along the southwest and east rift zones (SWRZ, ERZ) - an area of more than 2000 km<sup>2</sup>. Volcano-tectonic linkages were highlighted by a 2018 eruption, when fissure eruptions along the lower ERZ, 40 km away from the summit, were accompanied by collapse of the summit crater and slip on a décollement that facilitates escape of the volcano's south flank. Seismicity and deformation provide some constraints on Kīlauea's complex magmatic system, but geophysical imaging remains sparse.

Magnetotelluric (MT) data have been collected at Kīlauea for several decades yet past studies have been hindered by limited survey aperture and poor data quality. From 2022-2023 we collected wideband MT data (full impedance plus vertical magnetic transfer functions) at more than 125 wideband stations spanning the entire volcanic system with a nominal station spacing of 3 km. Several strategies were employed to collect quality data despite the challenging environment (e.g., low signal levels, high contact resistances, non-inductive electric field signals). These include long recording times, large station arrays, use of a distant remote station, and targeting Kīpukas ('islands' surrounded by fresh lava) for data collection. Long-period MT data have additionally been collected to image through the crustal column, while recently collected airborne electromagnetic data aid in constraining the hydrologic system, faults, and seawater intrusion from the surface to 500 m depth.

The MT responses are dominated by the conductive ocean and saltwater intrusion beneath the island, requiring the incorporation of detailed bathymetry as prior information during inversion. Three-dimensional inversion of the data reveals shallow magma storage within a pair of stacked reservoirs at 1 and 3 km depth beneath the summit, as well as shallow magmatic connections extending 10 km from the summit along both the SWRZ and ERZ. At greater depths, linear resistors mark sheeted-dike complexes aligned with the rift zones. These features merge at depth into a 500 km<sup>2</sup> resistive zone extending from 4-10+ km depth, coincident with a high density and velocity zone interpreted as the intrusive/cumulate core of the volcano. Notably, no conductive connection is imaged between the summit and vents from the 2018 eruption, consistent with episodic transport of melt from the summit via dikes that cool below the solidus within a few years of emplacement. Taken together, the MT model suggest Kīlauea's magmatic system is driven by flux to the summit reservoirs and that melt moves rapidly through the rift zones with melt storage confined to small pockets at 1-2 km depth.

**Keywords:** magnetotellurics, volcanic systems, Kīlauea

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