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Geophysical imaging of transcrustal magma storage and transport beneath volcanoes in the Main Ethiopian Rift

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The Main Ethiopian Rift (MER) is the most active part of the greater East African Rift System and an ideal place to study rift related volcanism. In the Ethiopian rift valley volcanism is concentrated along rift aligned magmatically active zones. Here we present results from a multi-disciplinary study of two of the major volcanic complexes in the MER, namely Tulu Moye and Aluto. Both study areas consist of clusters of silicic eruptive centers and are characterized by surface deformation with cycles of uplift and setting. Magnetotelluric (MT) surveys have been performed at both, Tulu Moye and Aluto, for geothermal exploration purposes and more than 400 stations have been measured. We derived 3-D electrical conductivity models by inversion of MT phase tensors. The subsurface models reveal the existence of two-stage transcrustal magmatic systems beneath the investigated areas. Here, melt propagates along major rift faults from a lower crustal magmatic reservoir into upper crustal partial melt zones that drive convective hydrothermal reservoirs. Melt under Aluto is stored at upper crustal depths in form of a highly crystalline mush. Tulu Moye, however, is characterized by a rhyolitic partial melt zone with up to 30% melt situated beneath young lava flows that outpoured through rift faults and fissures between one and two centuries ago. Observations of low-frequency earthquakes during a contemporaneous deployment of seismic stations confirm the location of the partial melt reservoir and show that it must contain a high hydrous-fluid content. Volcano-tectonic seismicity reveals hydrothermal fluids, probably sourced from the high-temperature region, are channeled along pre-existing caldera structures. Surface deformation observations do not correlate with the observed magmatic system and therefore are probably caused by changes in the hydrothermal system.