Imaging magma storage in the Main Ethiopian Rift with 3-D Magnetotellurics

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Main Ethiopian Rift (MER)

MER is located at transition between continental rifting and seafloor spreading in Afar.

Volcanism is greatly variable: silicic calderas, basaltic monogenetic vents etc. (Fontijn et al. 2018)

Magma storage and supply is debated.

Number of active volcanoes – geothermal energy is of great interest, but also large hazard for population.

Rooney et al. (2007)
Imaging magmatic processes with magnetotellurics (MT)

MT images the bulk electrical conductivity/resistivity of the Earth -> highly sensitive to presence of magma/fluid

Electrical conductivity can be interpreted in terms of temperature, pressure, water and melt content using petrological models and lab experiments

Whaler&Hautot (2006) EAGLE profile in the northern main Ethiopian rift, deeper conductor related to magmatic segment

After Guo et al. (2016)
MT data collected within RiftVolc:

14 Long period MT + Broadband stations, 45 Broadband stations in array in Western part of MER, mixed data quality (high population density) + 2 Sites from Reykjavik Geothermal’s Tulu Moye prospect ★

-> roughly 6 parallel profiles

Crossing Central volcano Aluto (silicic caldera with active hydrothermal system), focus of many more detailed studies
A new full 3-D inversion model of electrical resistivity in the MER

Inversion parameters and details:

- ModEM (Egbert & Kelbert 2012)
- Starting model is homogeneous half space with 25 Ωm (average of all apparent resistivity curves)
- Covariance set to 0.4 (after testing)
- Start with full impedance data (>1s), then all impedance data plus LMT tipper (BB tipper is very small and noisy)
- RMS of preferred model is 2.7
3-D inversion model of CMER
3-D inversion model of CMER – some details

- No big conductor at 5km under central volcano
- Large deeper conductor in the northern part with connection to Tulu Moye hydrothermal prospect deep reservoir at ~5km
- Large zone of higher conductivity in the lower crust in the Western part of the rift
- Asymmetric shoulders
Structural interpretation of melt storage in the MER supported by MT model

Chambers et al. (2019), 3-D slow shear wave velocity anomaly roughly 200-km by 100-km wide positioned 20km beneath the MER axis

Iddon (2019), model of melt storage in the MER
Summary
- Broadband and long period MT data from an array in the CMER yield new 3-D model of electrical conductivity of the crust (<40km)
- Electrical conductivity observed/modelled can constraint water and partial melt content of current storage conditions
- Magma is stored below the rift centre and off-axis
- Zone of higher conductivity in the lower crust coincides with low shear-wave velocity

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