Melt distribution between the crust and mantle beneath the Dabbahu-Manda Hararo rift segment, Afar, from 3D magnetotelluric imaging

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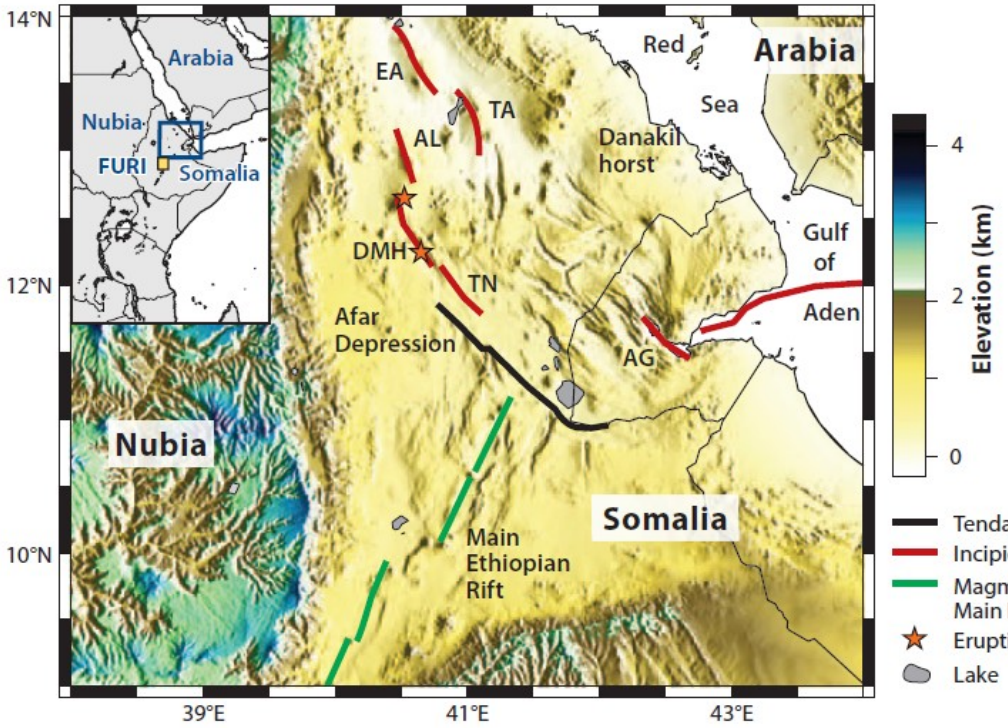
The magnetotelluric data set

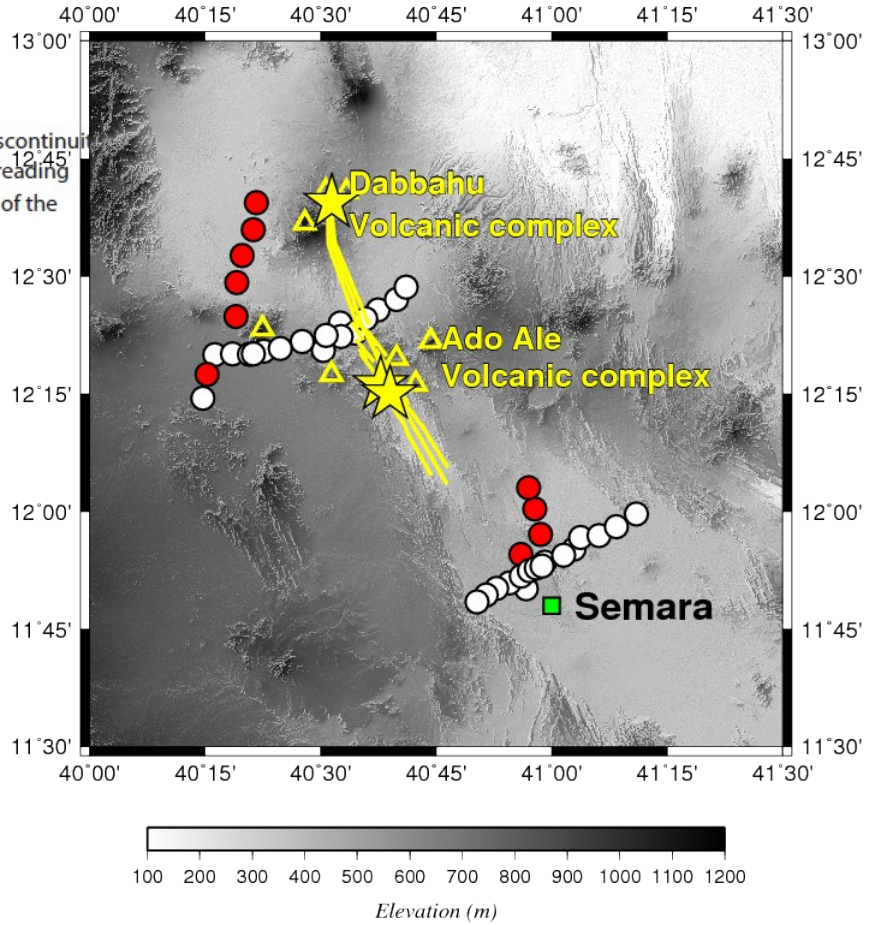


(Ebinger et al., 2010)

2008-2009 MT sites

2010 MT sites (for 3D)

The Dabbahu-Manda-Hararo magmatic segment



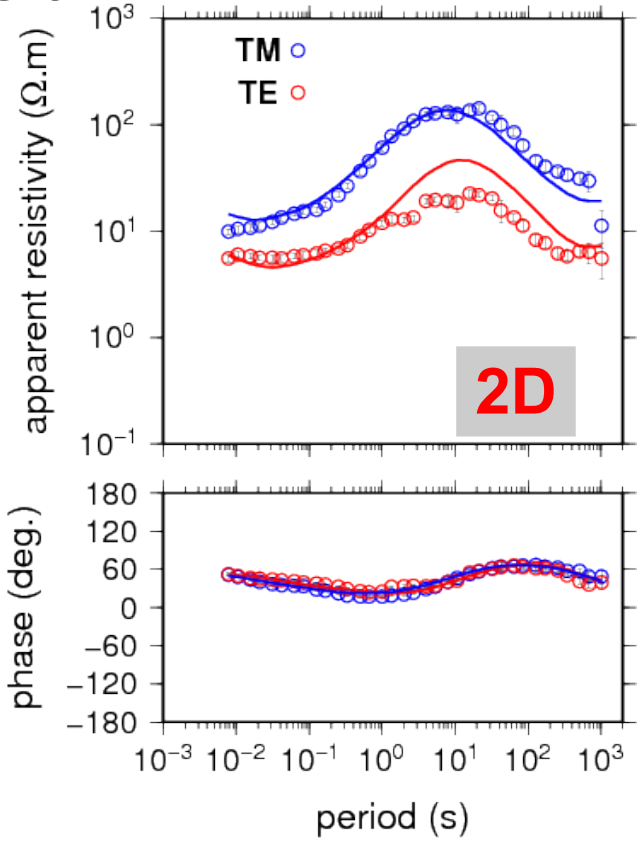
3D MT inversion: Methodology

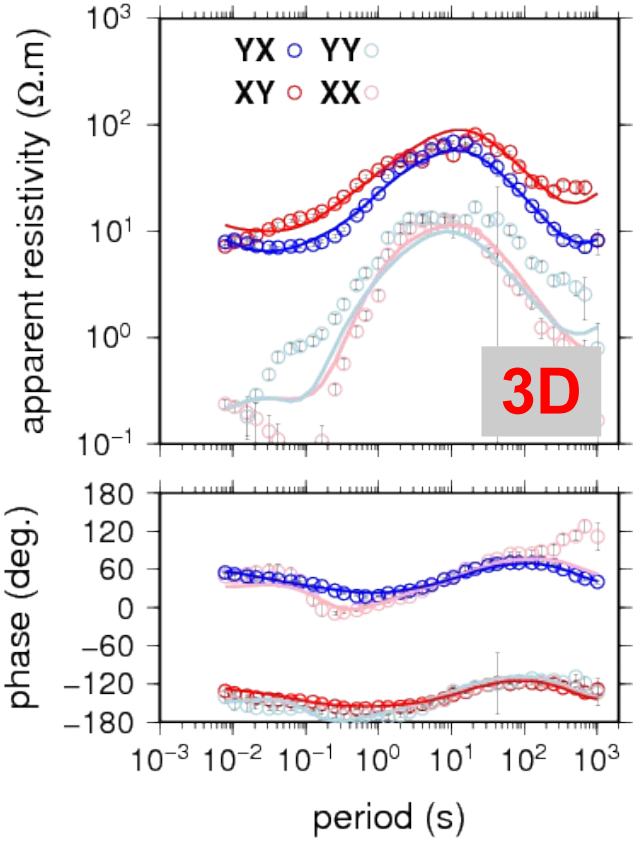
MT measures a 4 complex components tensor. The method, based on induced EM fields is very sensitive to 3-D structures.

With a 3D interpretation

- No a priori assumption on the geological structures

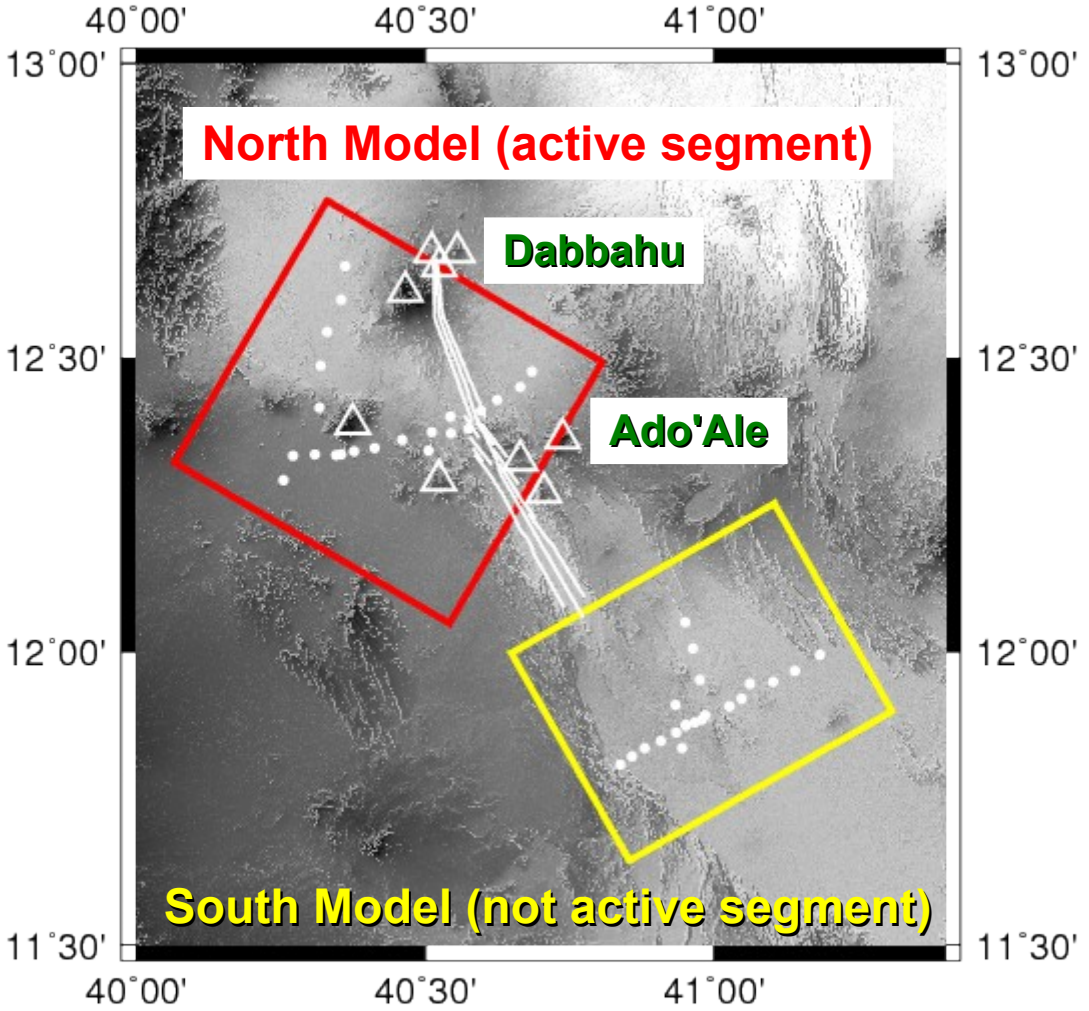
- All data collected are used in the inversion (number x2 compared to 2D inversion





3D MT inversion: Methodology

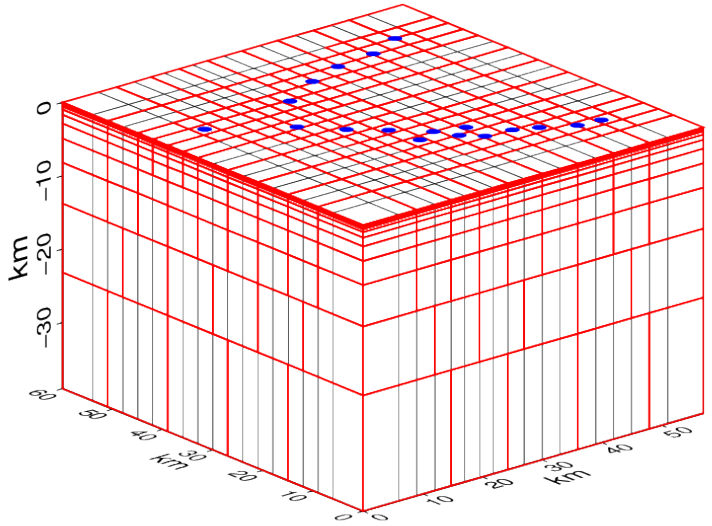
We applied our full 3D MT inversion code to perform the inversion of 2 data sets independently (Hautot and Tarits, 2009)



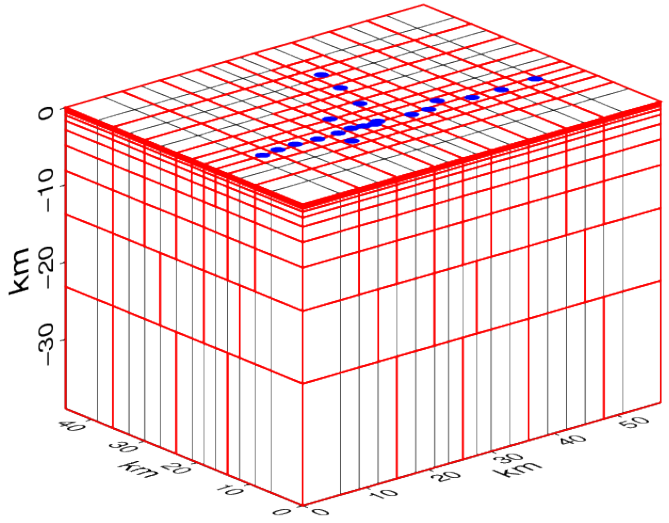
3D MT inversion: Methodology

The 2 starting models are uniform half-space (25 ohm-m)

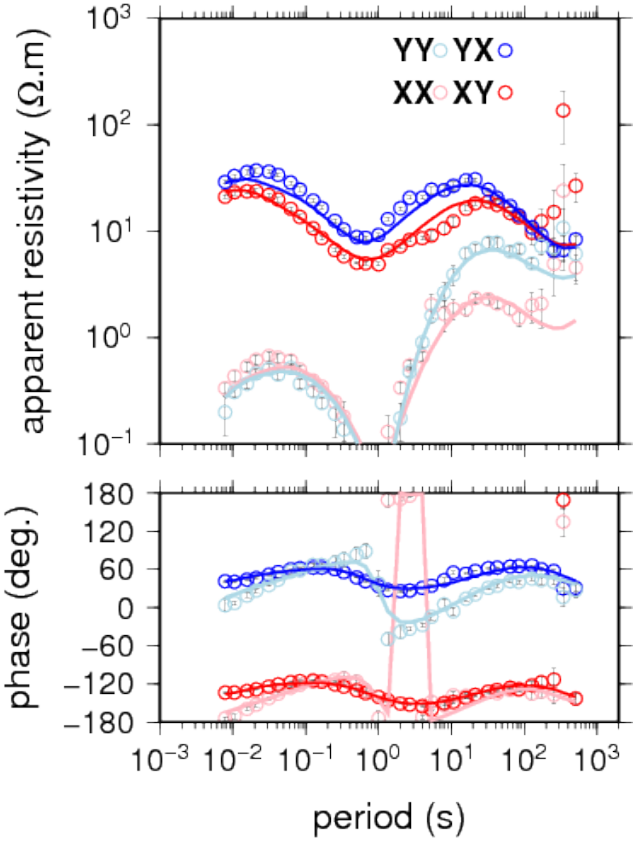
Dabbahu (north)



Hararo (south)

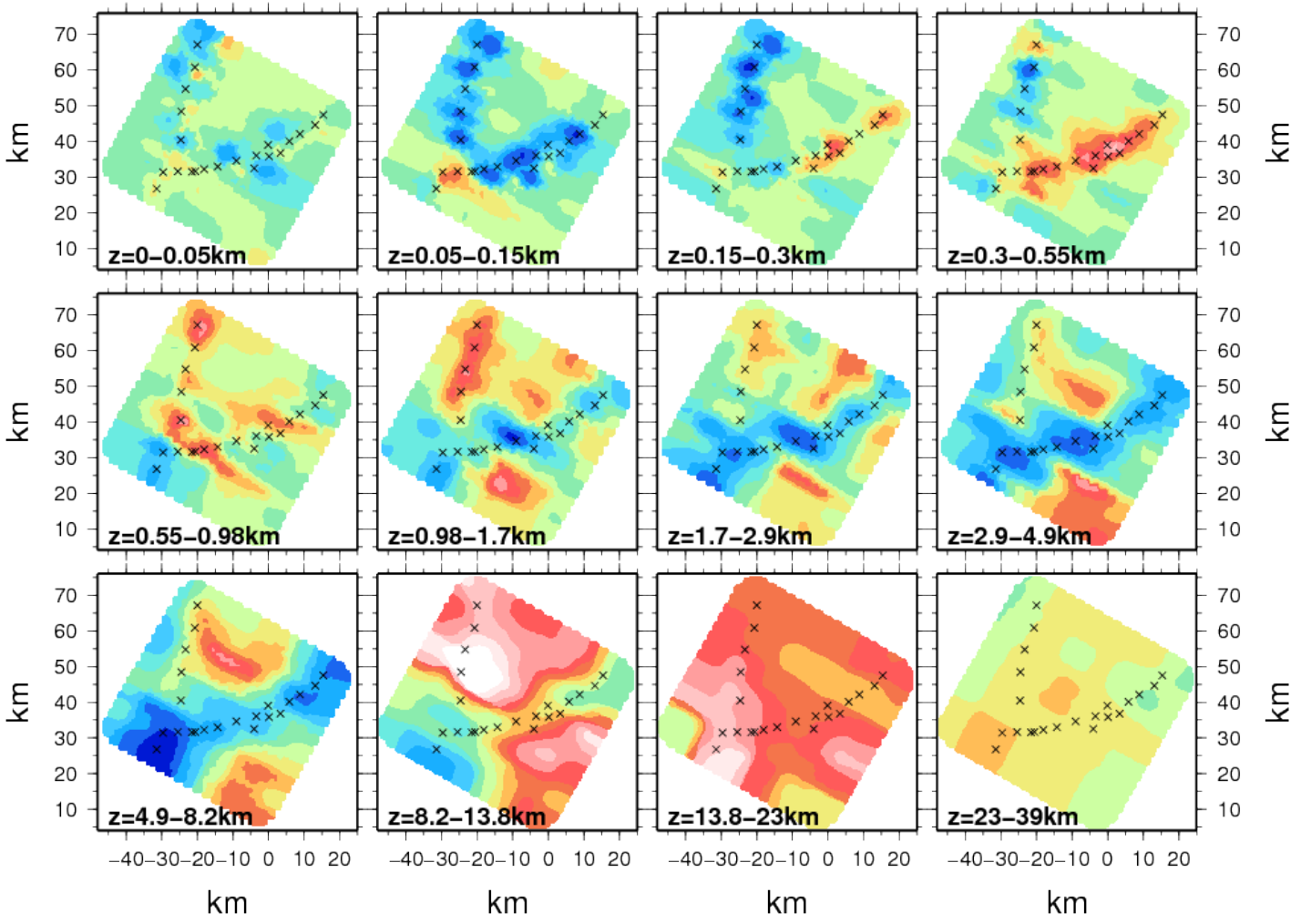


Full 3D inversion: resistivity distribution in the 3D grid that fits all data



Results

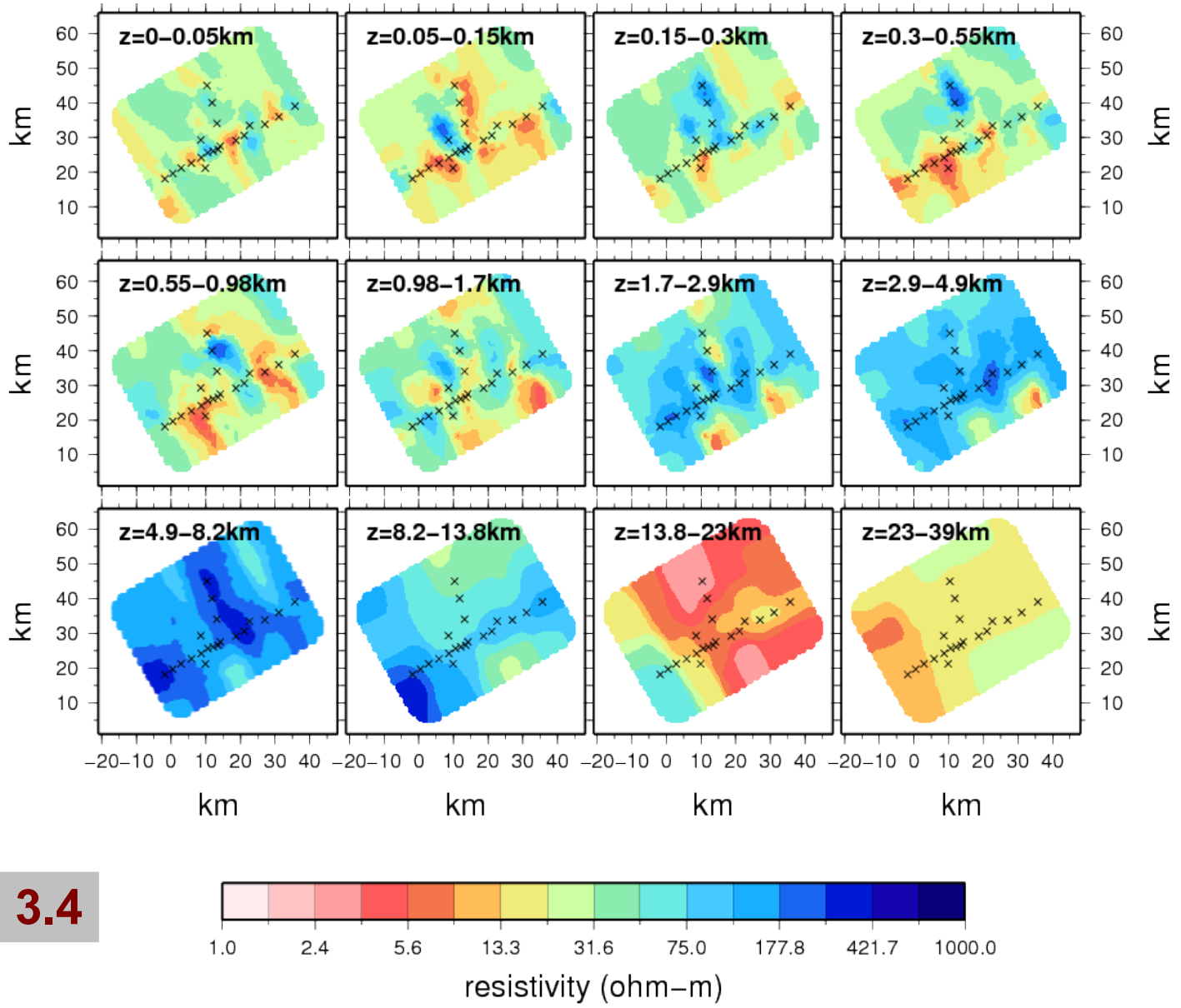
Dabbahu (North, active segment)



rms error = 4.1

Results

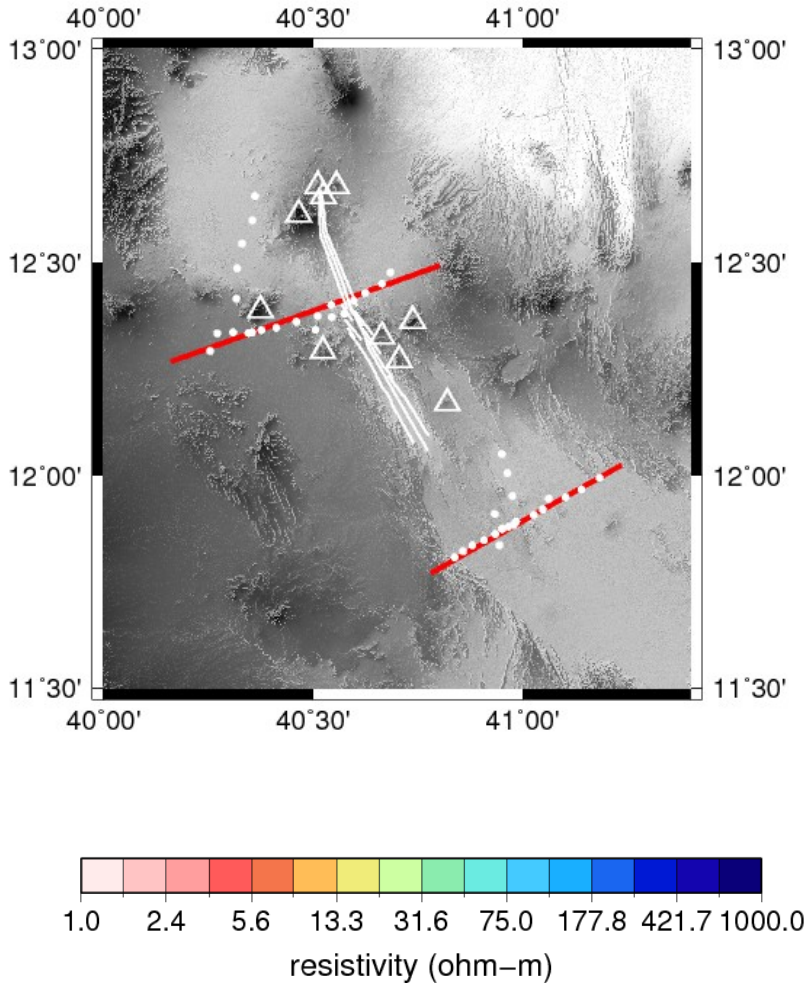
Hararo (South, currently not active segment)

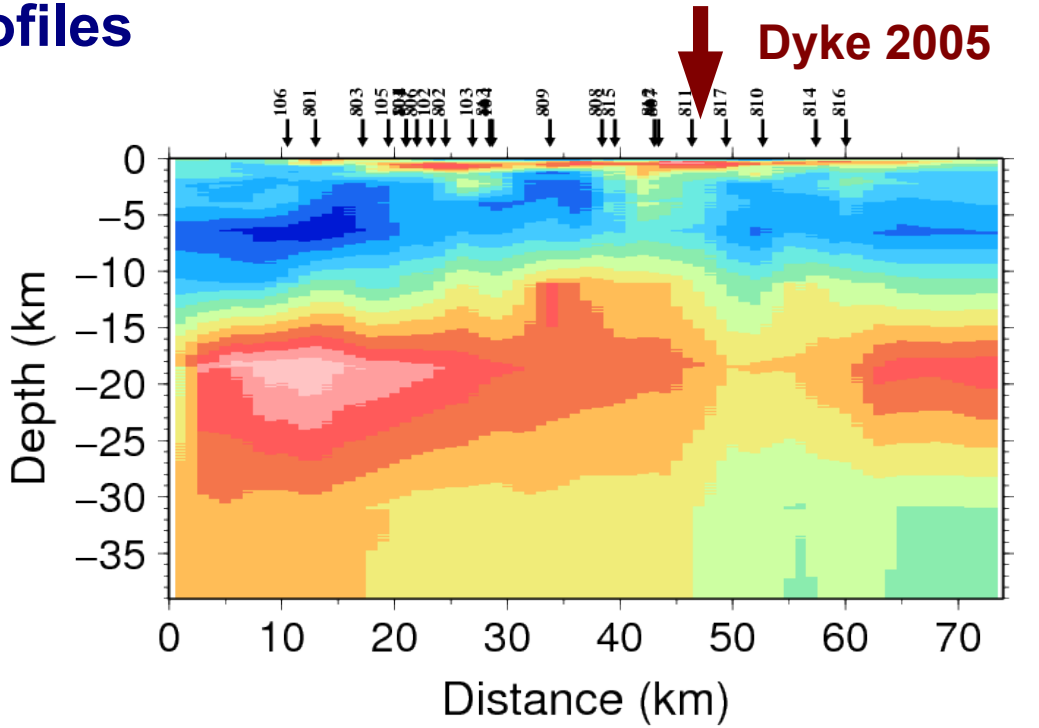


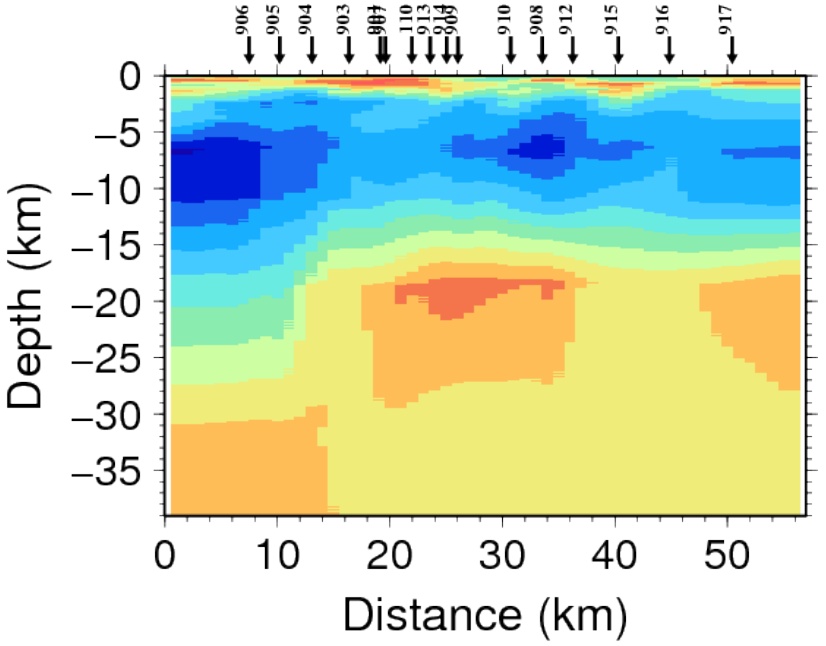
rms error = 3.4

Results

Vertical cross-sections along profiles

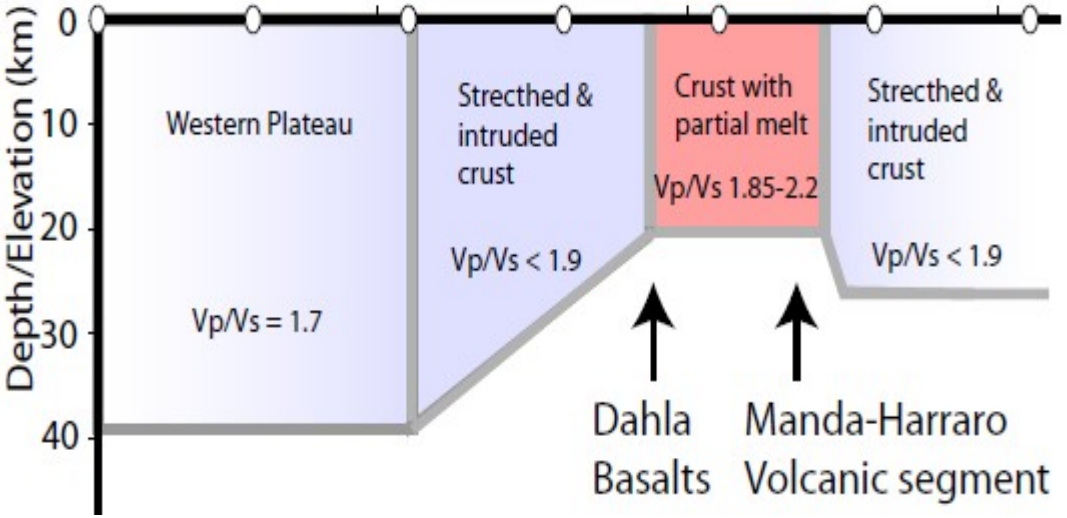


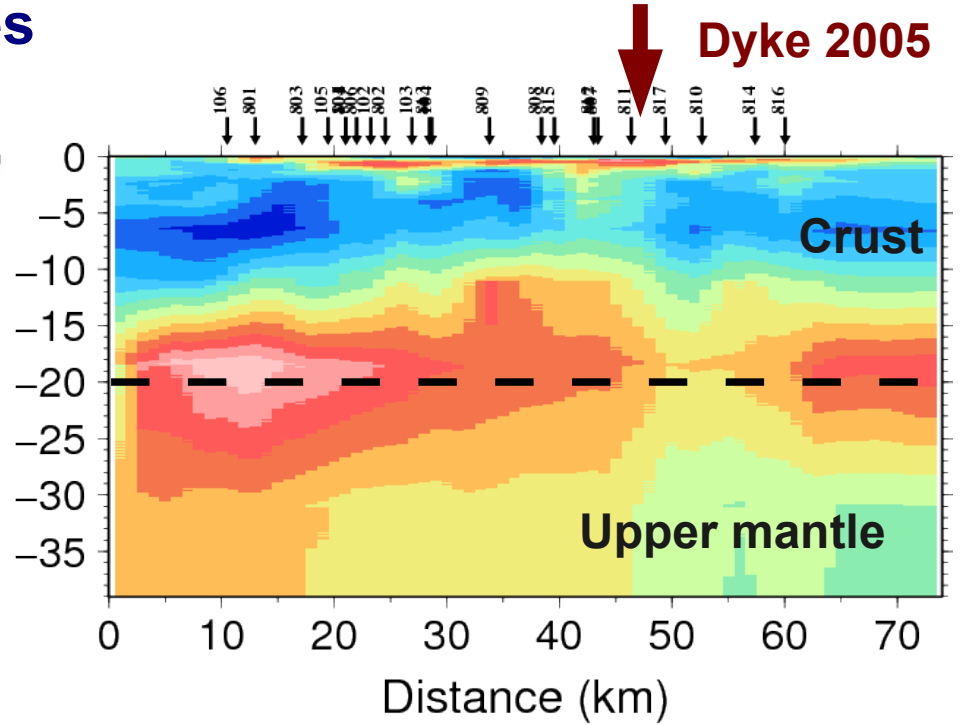




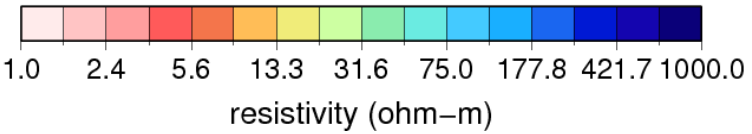
Results

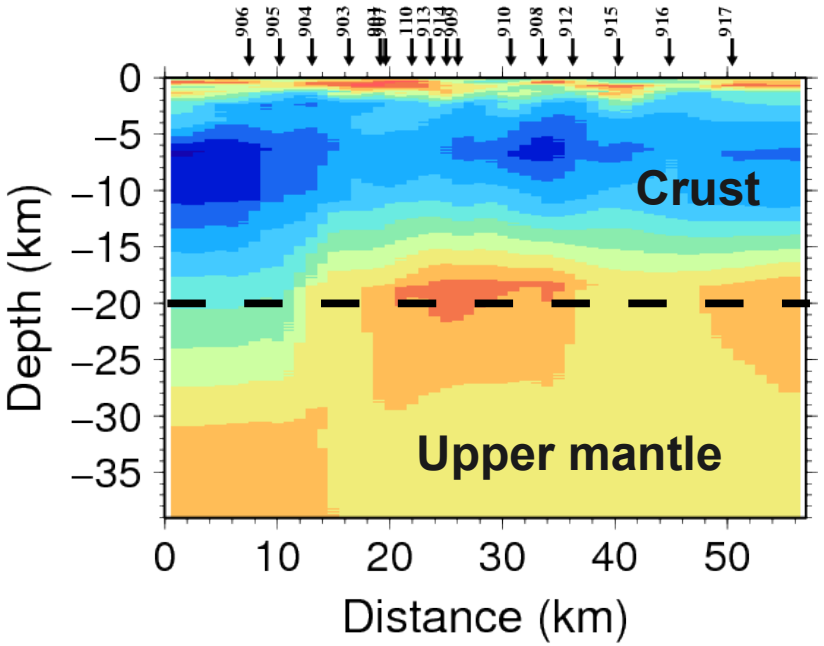
Vertical cross-sections along profiles





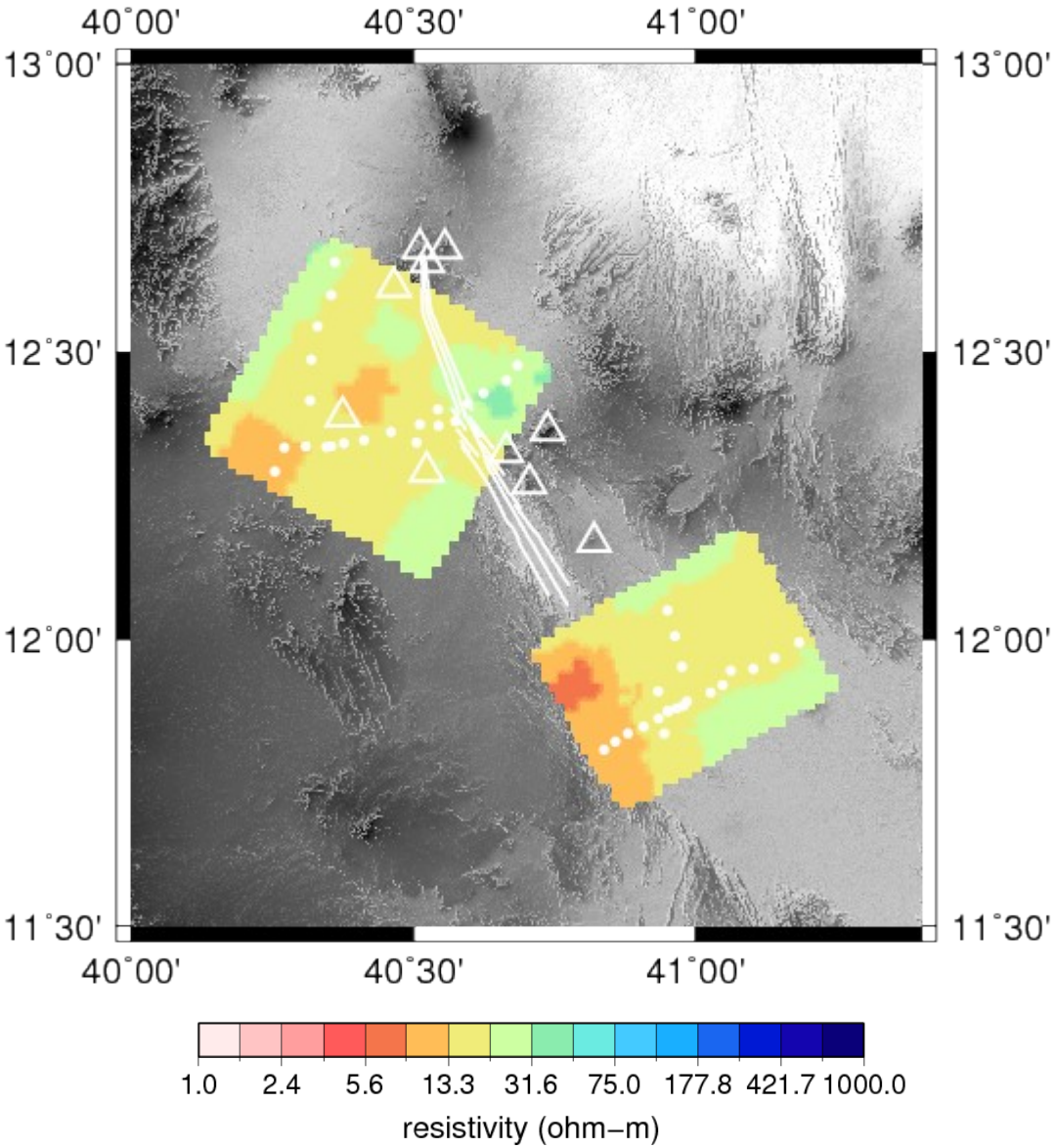
Receiver function analysis (Hammond et al., 2011)





Results

Resistivity maps: Upper Mantle (> 20 km depth)

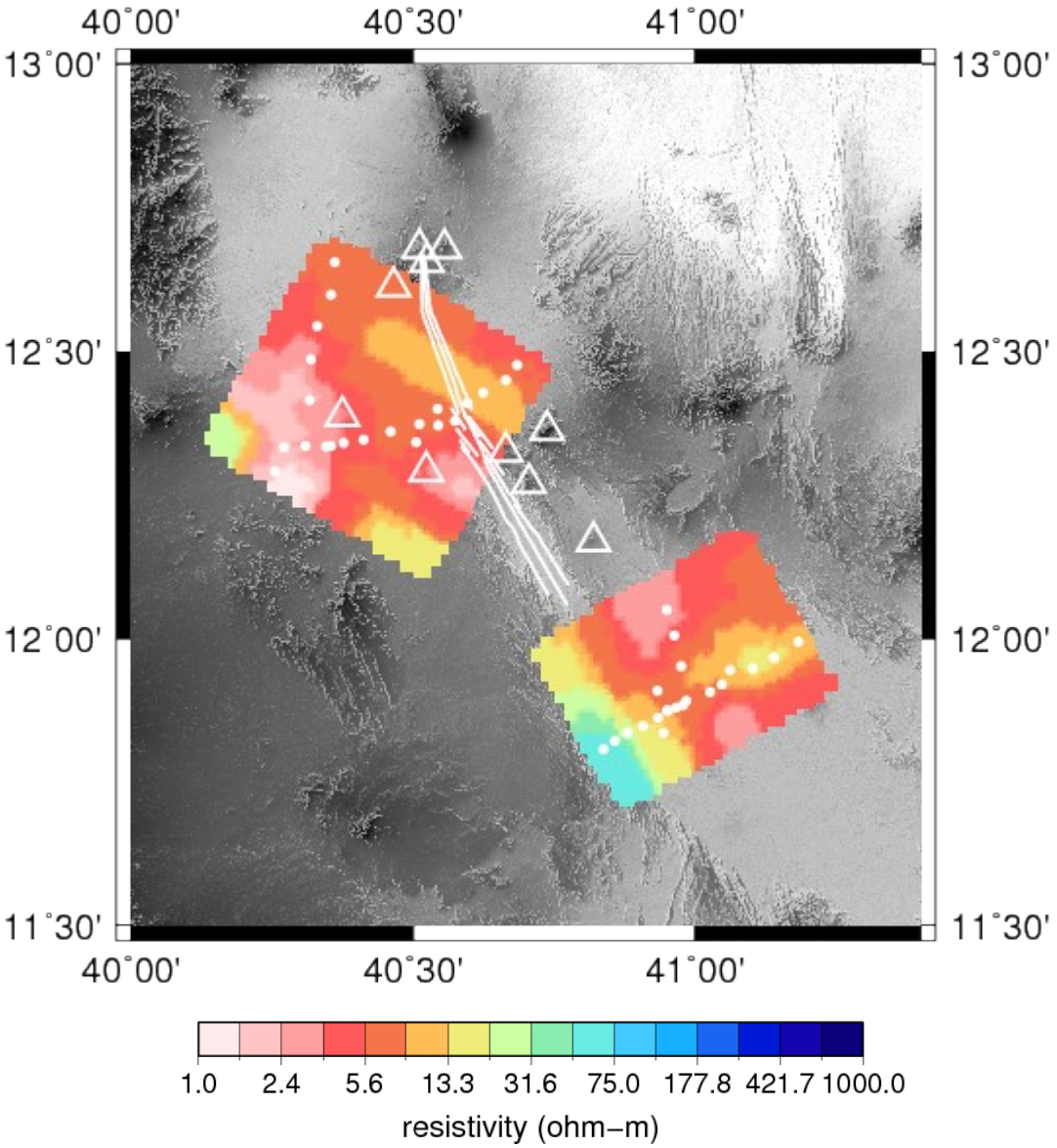


No significant difference between Dabbahu (North) and Hararo (South) regions

Average resistivity of 15-20 ohm-m
Low value
Implies the presence of melt/liquid in the mantle

Results

Resistivity maps: Lower Crust (15-20 km depth)



Independent inversion of the Dabbahu (North) and Hararo (South) data set:

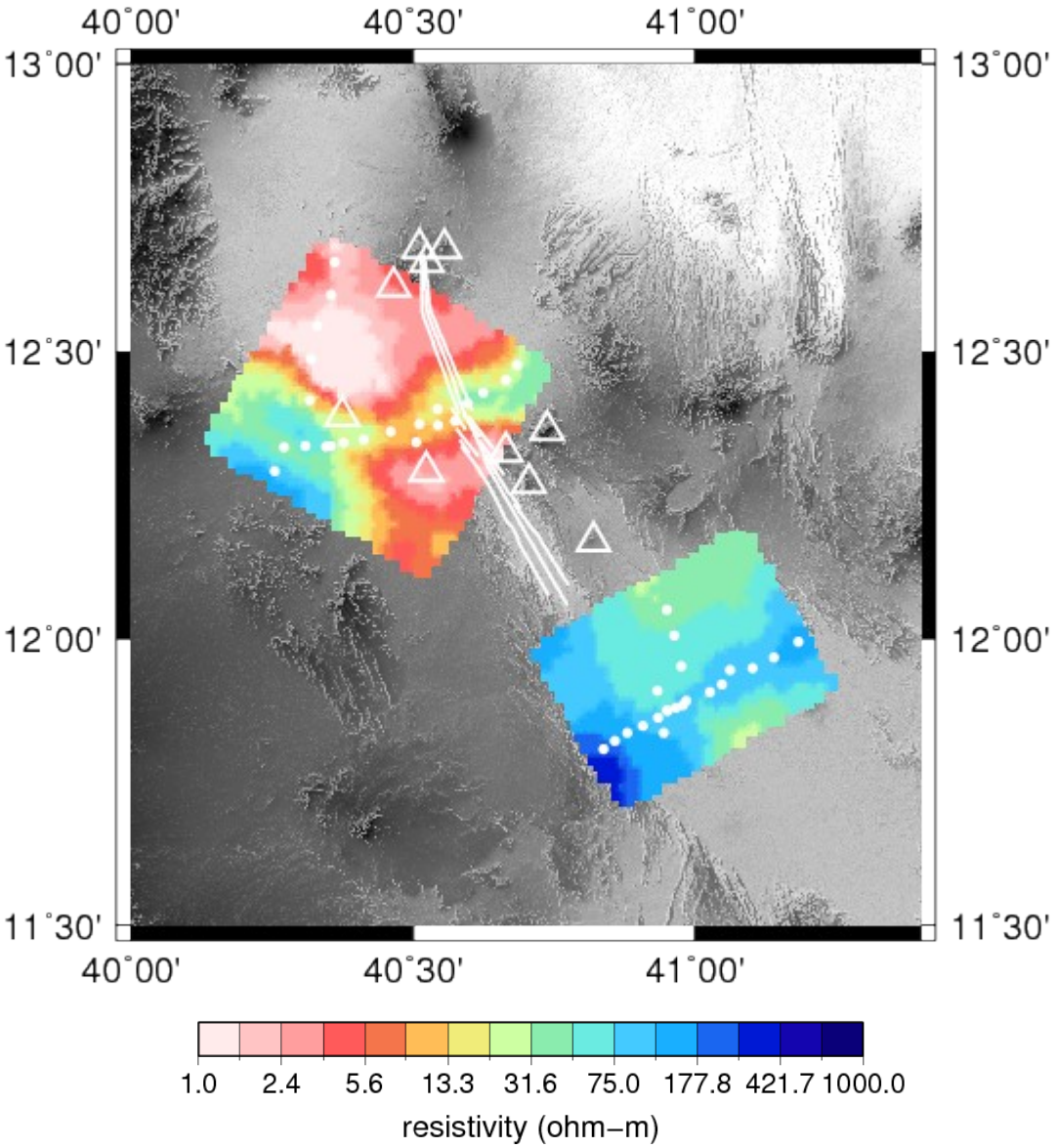
- Similar resistivity structures

- Continuity of the structures from North to South

Large conductive bodies: Suggest large distribution of partial melt

Results

Resistivity maps: Mid Crust (8-15 km depth)



Conductive bodies to the North: Mid crustal magma chambers beneath Ado'Ale and Dabbahu Volcanic complex?

No melt storage beneath Hararo region

Results

Resistivity maps: Upper Crust (3-5 km depth)

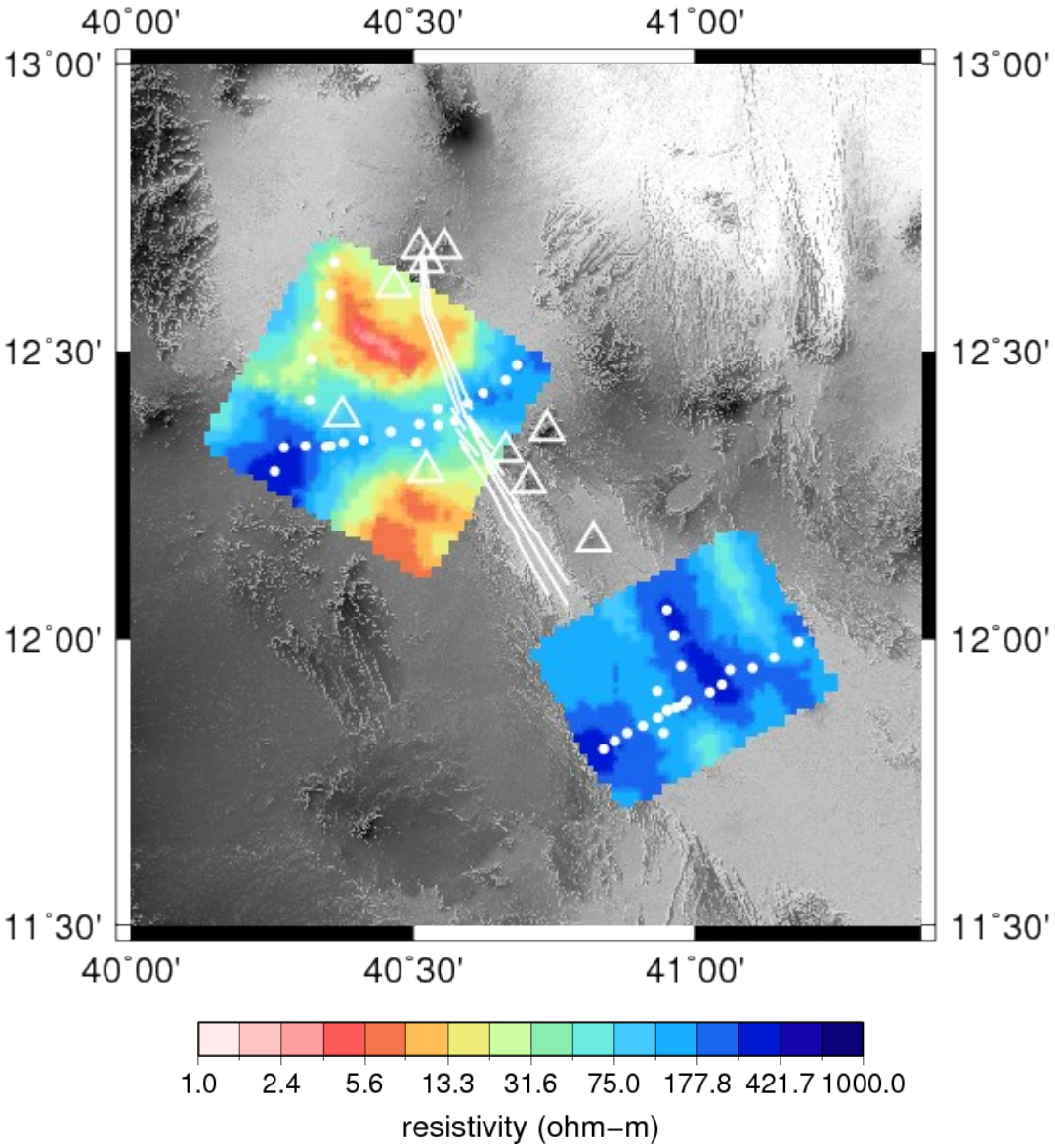
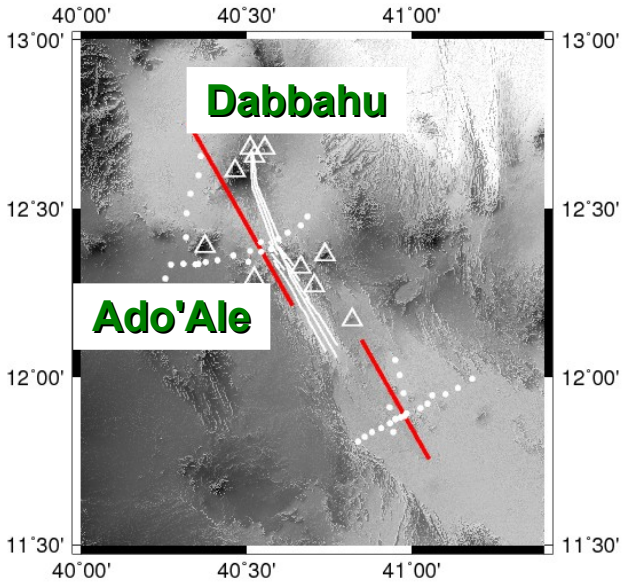


Image of the top of the mid crustal magma chambers to the North beneath Ado'Ale and Dabbahu Volcanic complex

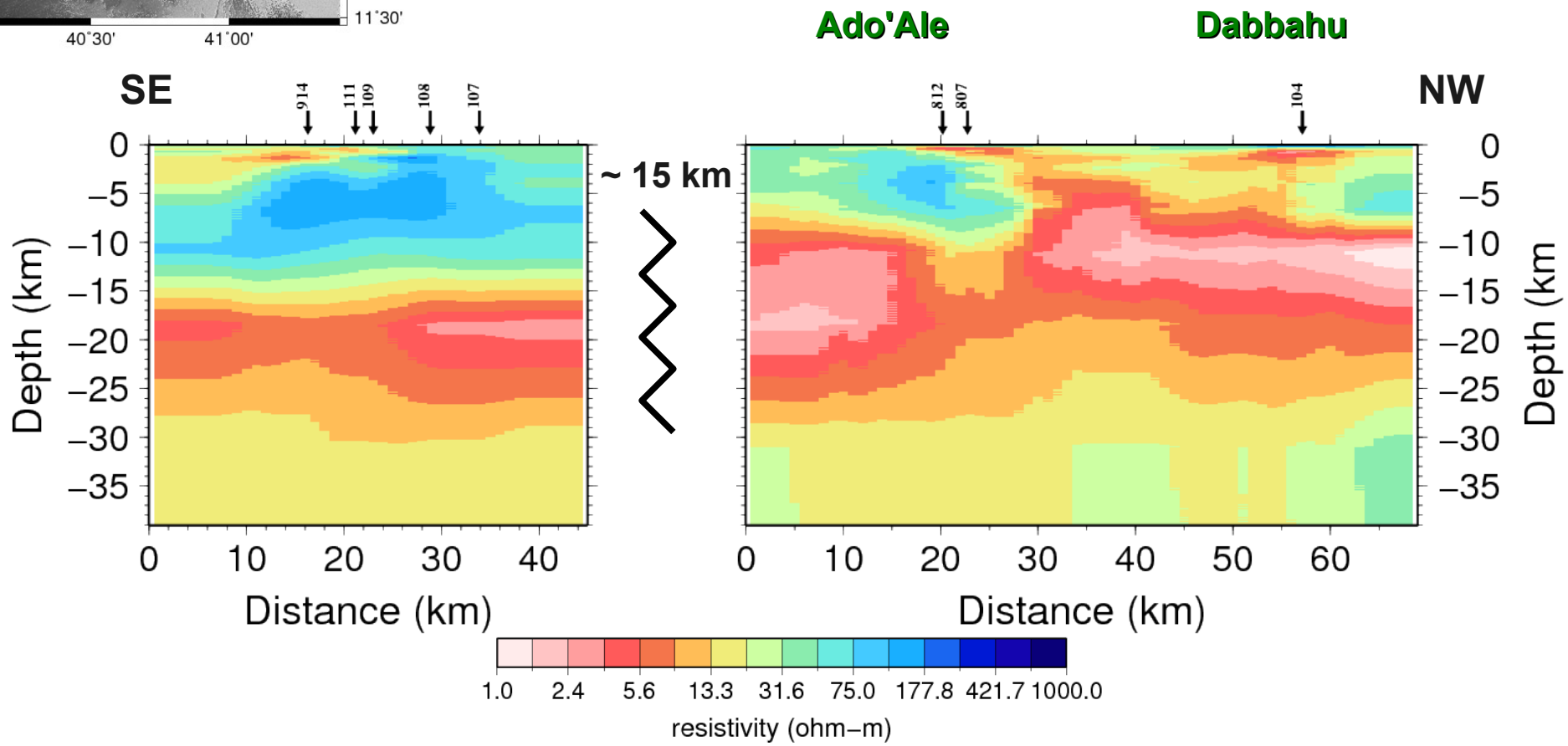
Poor coverage of MT sites at shallow depth: Geometry not fully constrained.

Discussion

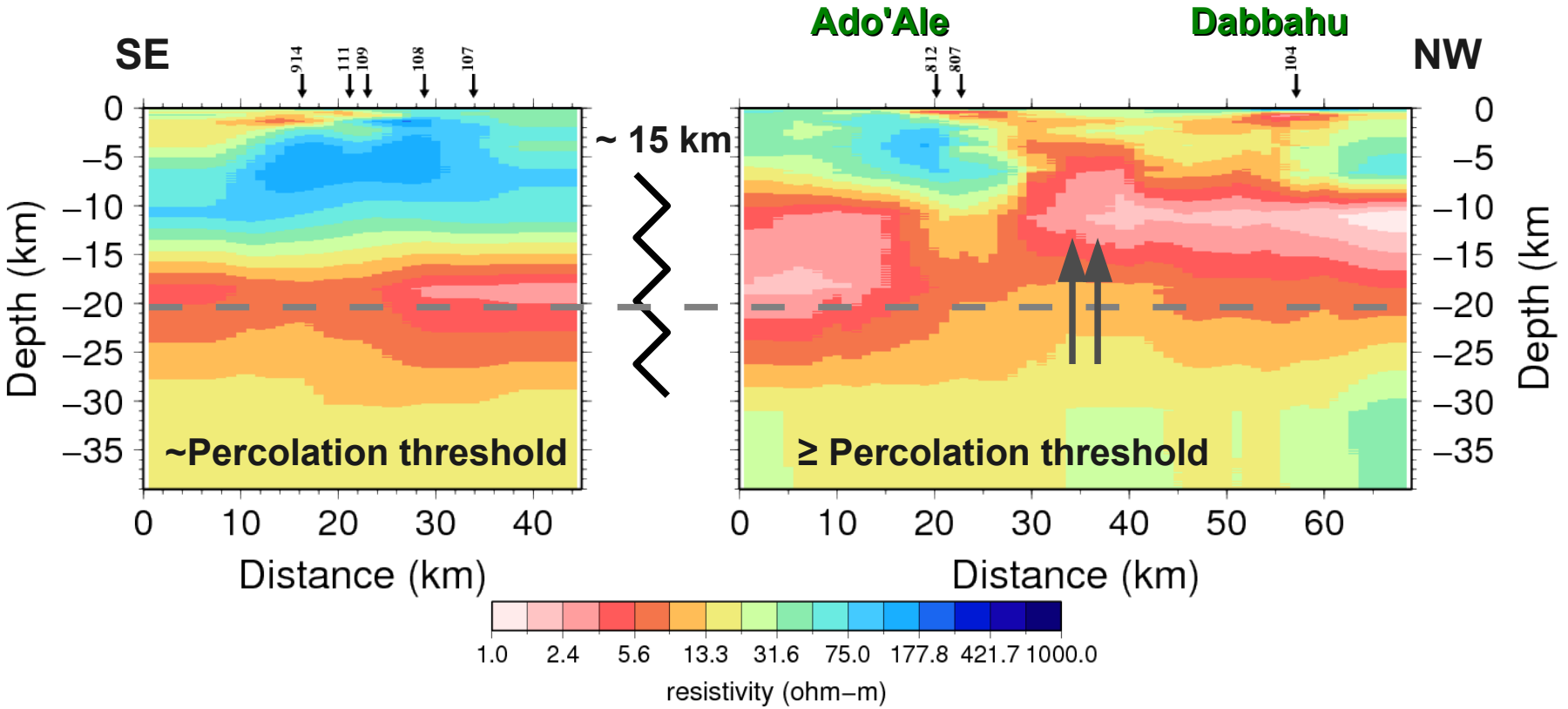


Vertical sections along the rift zone

Resistivity structures differ from SE to NW only at crustal depths



Discussion



Resistivity of liquids in the mantle ~0.2-1 ohm-m (Alkali-hydrous - basaltic melt, Gaillard et al., 2008). Percolation threshold =1 %

Mantle resistivity from model ~20 ohm-m

1% melt: melt resistivity should be ~0.2 ohm-m
(with a dry mantle resistivity @1200-1300 C: ~1000 ohm-m)

If melt resistivity ~1 ohm-m, then the % melt should be ~5-10 %: would percolate in the SE

Summary

- The 3D resistivity inversion of the MT data sets provide the image of the crust-upper mantle structure beneath an active and inactive magmatic segment

- The structure of the crust beneath the Dabbahu region (active) confirms results from other studies with 2 magma sources at crustal depth. MT constrain their depth and geometry.

- From the lower most part of the crust to the mantle, the resistivity structures are similar. Low resistivity suggest highly conductive phase, probably melt (deep source).

- Results suggest that the nature of the liquid and percolation threshold could be discussed from these data and compared with results from geochemistry and other field studies.