The Afar Rift Consortium

University of Bristol
University of Oxford
University of Cambridge
British Geological Survey
University of Rochester
University of Auckland, NZ

- Opportunistic programme following start of dyking in the Dabbahu magmatic segment
- First such episode in the satellite era
- NERC 'Urgency' grant got equipment in the field within 2 weeks
- Afar Rift Consortium conceived soon after

Programme structure

- Themed around 5 inter-disciplinary working groups

A: **where** melt forms and ponds in the crust and mantle and how this correlates with zones of lithospheric stretching

B: **what** the composition of magma is and how it evolves

C: **when** previous eruptions have occurred and the time scale of magma evolution

D: **how** magma moves through the crust and mantle (kinematics)

E: **why** magma moves through the crust and mantle (dynamics)

Where …

- Seismic tomography & receiver functions
- Magnetotellurics
- Links to petrology, remote sensing, seismicity, gravity, shear-wave splitting, …

What …

- … is down there?
- Nature and relationships of magma, magma genesis and magmatism
- Modern petrology and geochemistry
- Inferences on volcanic processes and eruption mechanisms
- Relationships with all other groups e.g. physical properties of magma, modelling thermal evolution

When …

- Eruptive history of Dabbahu magmatic segment and the timescales over which magmas evolved
- Isotopic chronometers
- Combine with other information to get time-stratigraphic framework to constrain rates of magma emplacement and eruption

How …

- … does melt move through the crust and lithosphere?
- … does the brittle crust respond?
- inSAR
- GPS
- LiDAR topography
- Seismicity
- Shear-wave splitting

Why?

- Physical mechanisms responsible for lithospheric extension, magma movement, crustal segmentation and growth
- Integration of *geophysical*, *geochemical* and *geological* techniques
- Numerical and analogue modelling

also

- Advanced remote sensing to map lithology at multiple scales
- LiDAR and hyperspectral imaging
- Mapping of faults, features of flows
- Palaeomagnetic sampling
- Satellite data on eruptions (gases, temperatures, extrusive mapping)
- Updated geological map with GIS

- 6 year programme, coming to an end
- 3 main field seasons, many other visits to service and move equipment
- Shared resources, data with other groups (US, French)
- Interested in future collaboration
- 7 PhD students, ~4 Post-Docs
- Several *AAU* Project Partners had research periods in UK Universities

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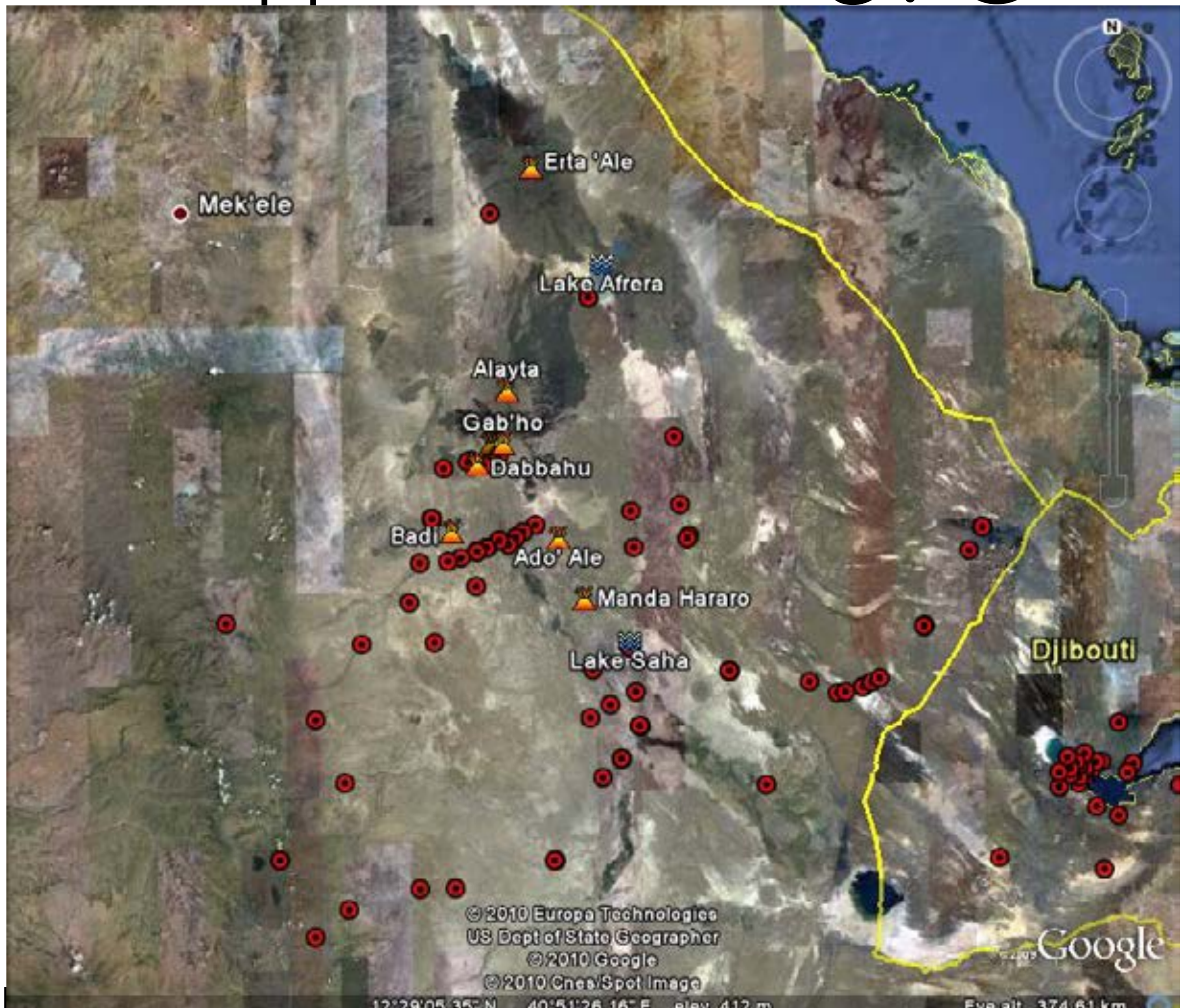
GPS

Where our equipment is



Main GPS stations within Afar

Map of Afar

GPS stations

Seismic stations

MT sites

Gravity sites

Volcanology sampling sites

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Seismic stations

Where our equipment is

Map of Afar

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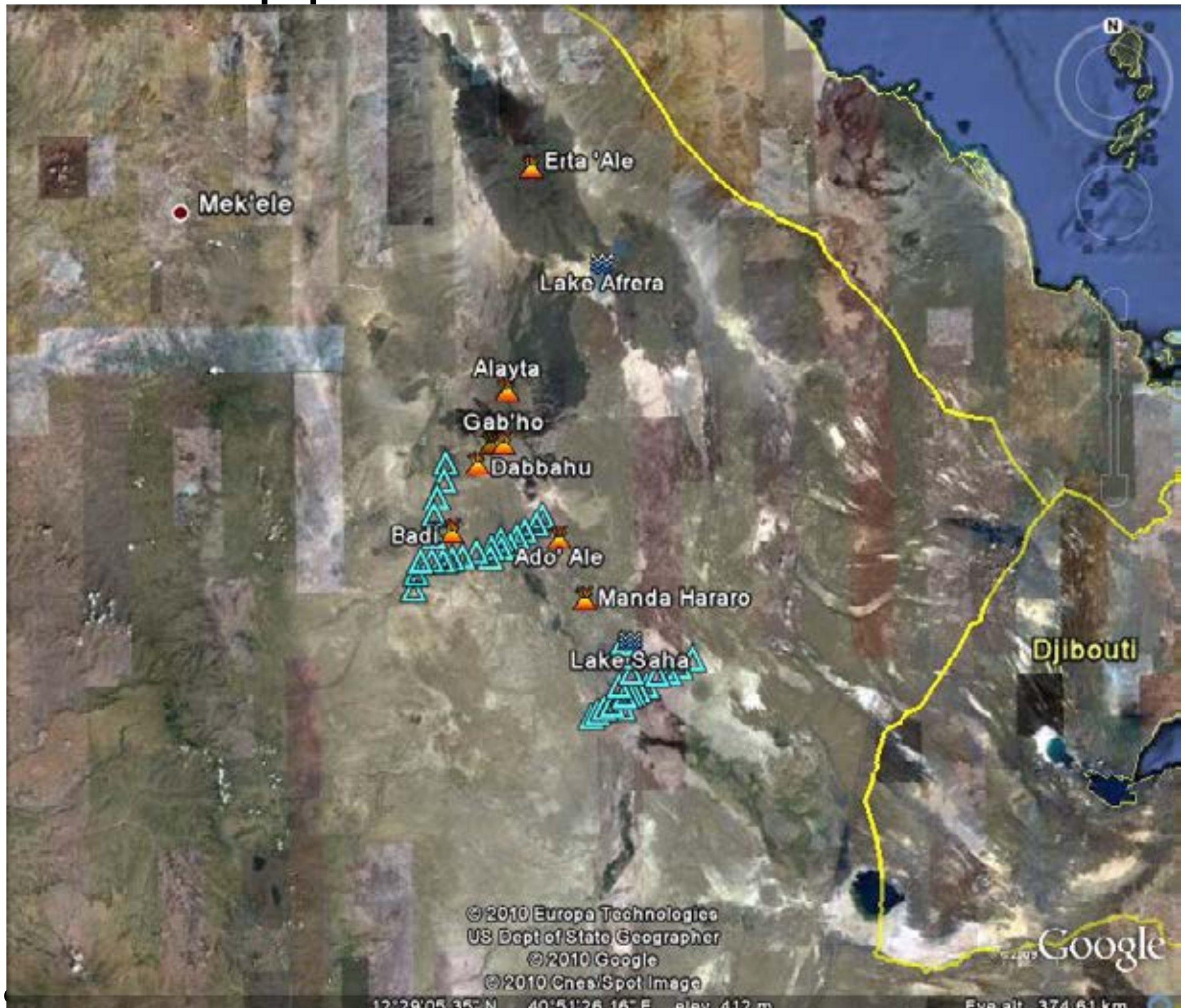
Magnetotelluric sites

Where our equipment is



Sites where MT equipment has been installed

Map of Afar | GPS stations | Seismic stations | MT sites | Gravity sites | Volcanology sampling sites

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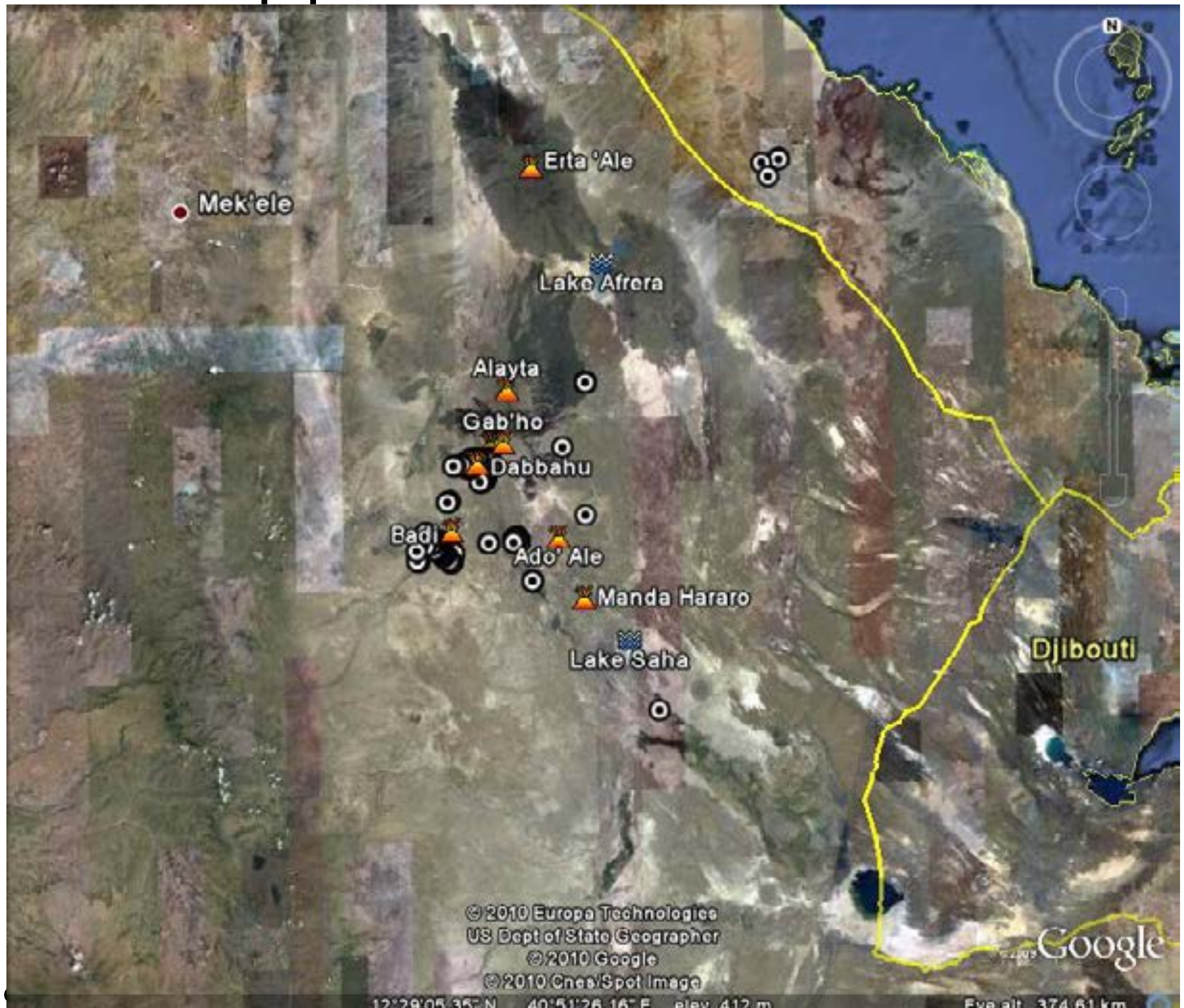
Volcanology sampling

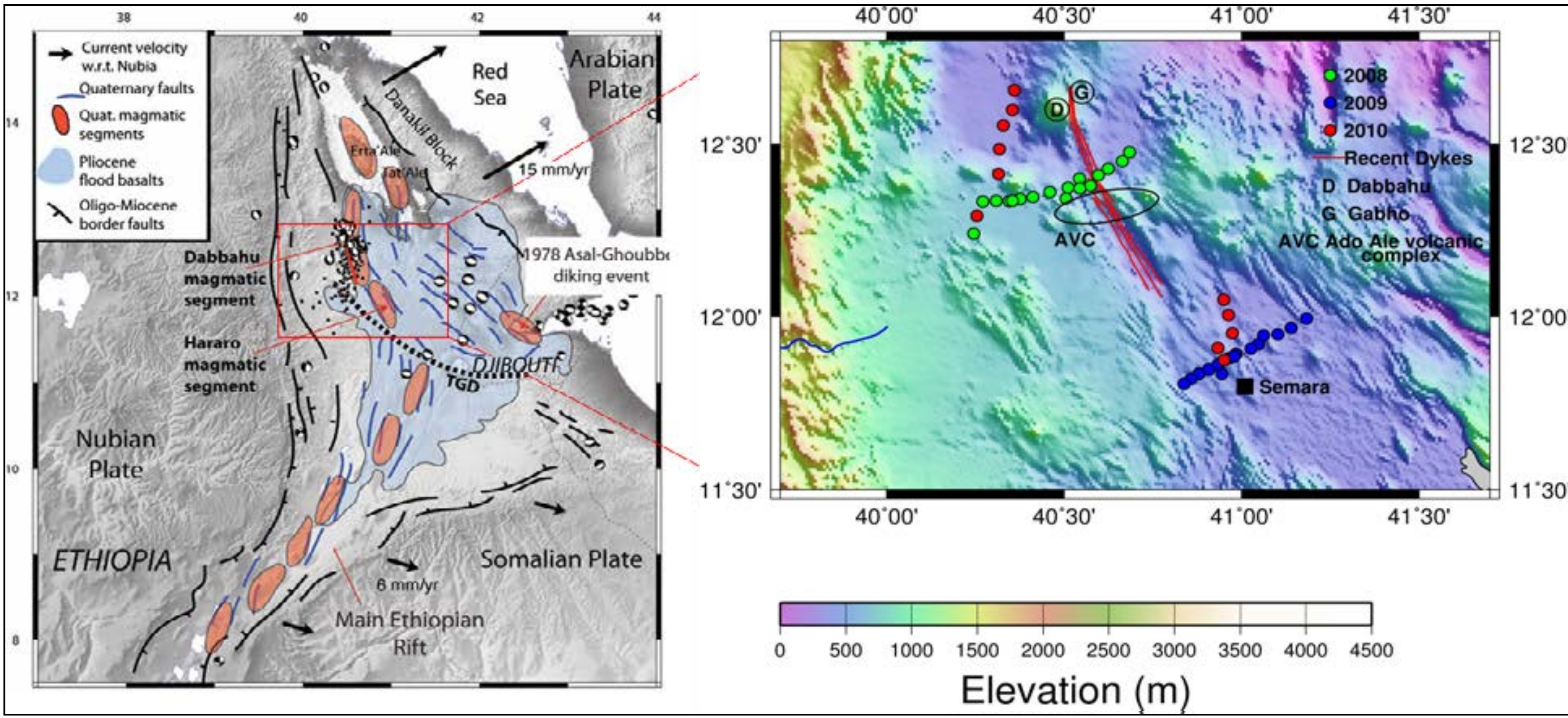
Where our equipment is



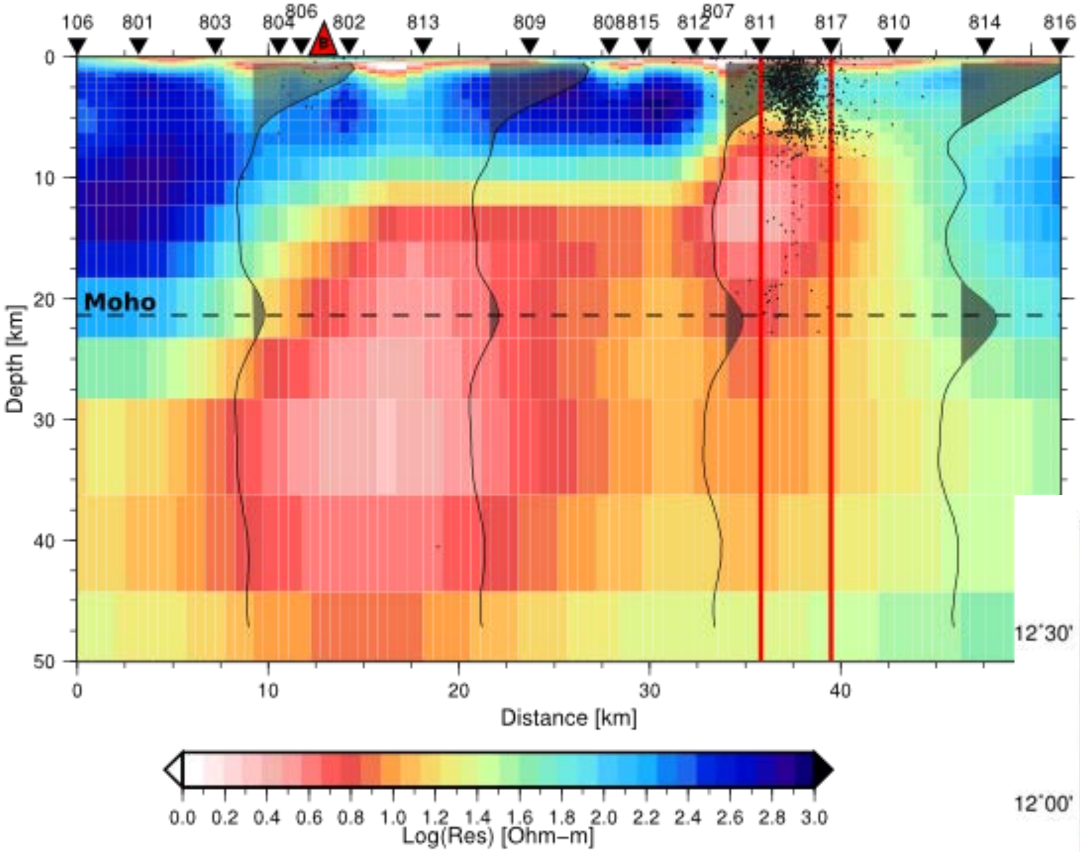
Sites from where volcanic rocks have been collected

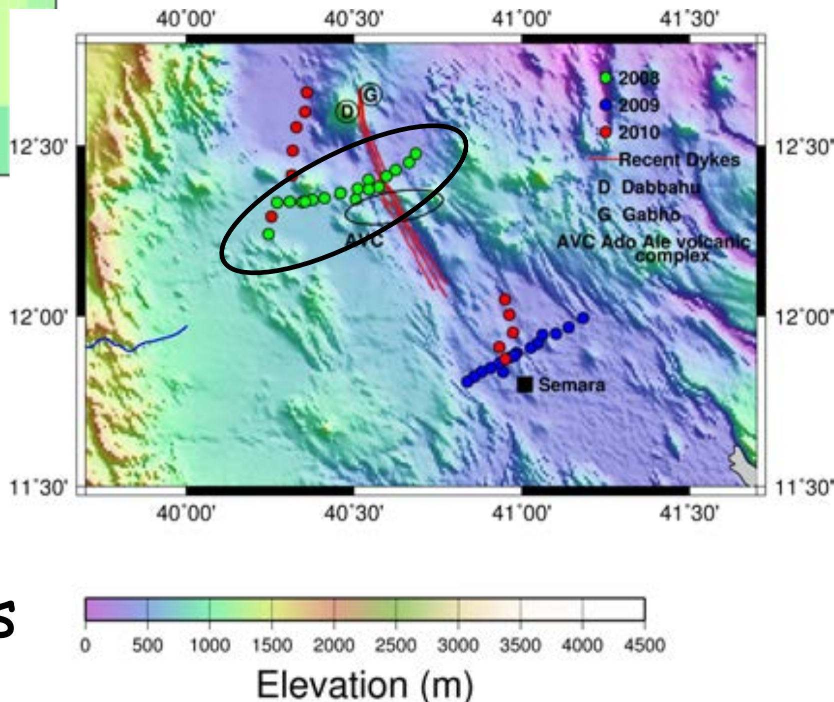
Map of Afar | GPS stations | Seismic stations | MT sites | Gravity sites | Volcanology sampling sites

MT site distribution



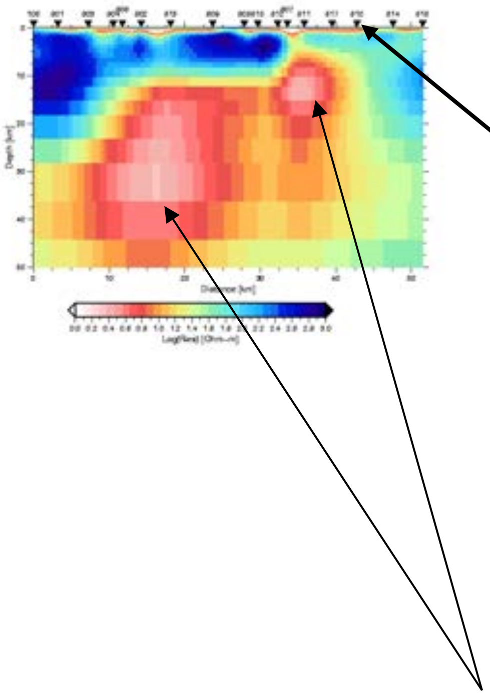
Profile across active segment





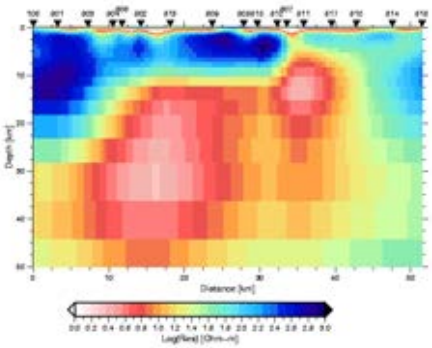
Best-fitting 2D model of resistivity parameterised in blocks

Joint interpretation



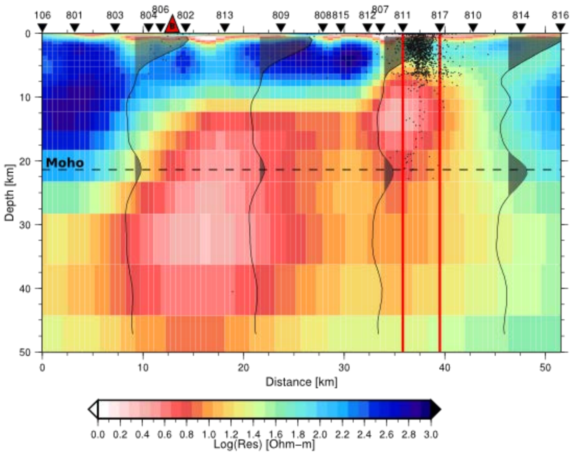
- Shallow conductor – saline fluids in sediments and faulted and fractured basalt
- Evidence from geochemistry (and economic salt production from Danakil depression)
- Deeper conductors – partial melt/ magma
- How much?
- Use petrology to constrain composition (Si, Na, H_2O, T)

Joint interpretation



- High conductivities imply well-connected melt
- Infer melt fraction from bulk and melt conductivity using HS^+ or parallel pathways models
- Parallel pathways consistent with OMP seismic anisotropy
- Minimum melt amount for given bulk conductivity – 12%
- ~200 km^3 melt beneath profile

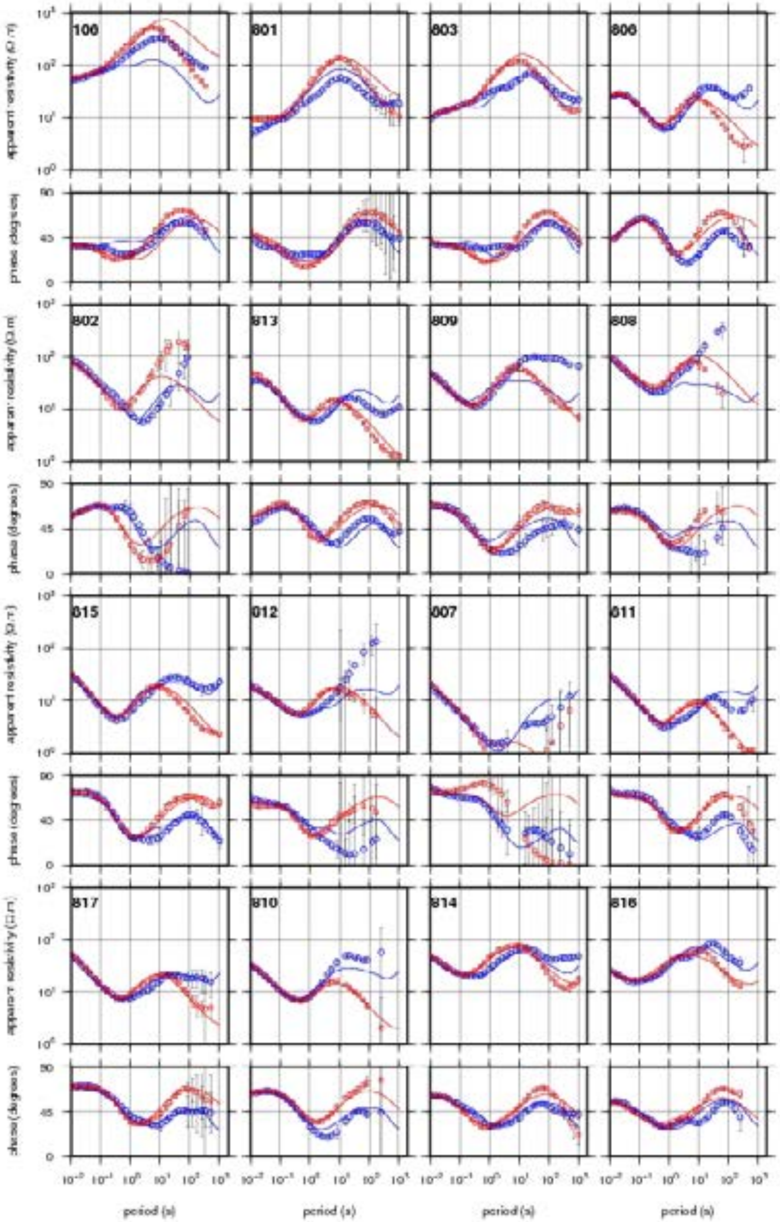
Joint interpretation



- Seismic evidence for melt in crust and upper mantle
  - Receiver functions
  - Surface waves
  - Anisotropy
  - Pn study
  - Tomography from seismicity data

Data and model fits

W



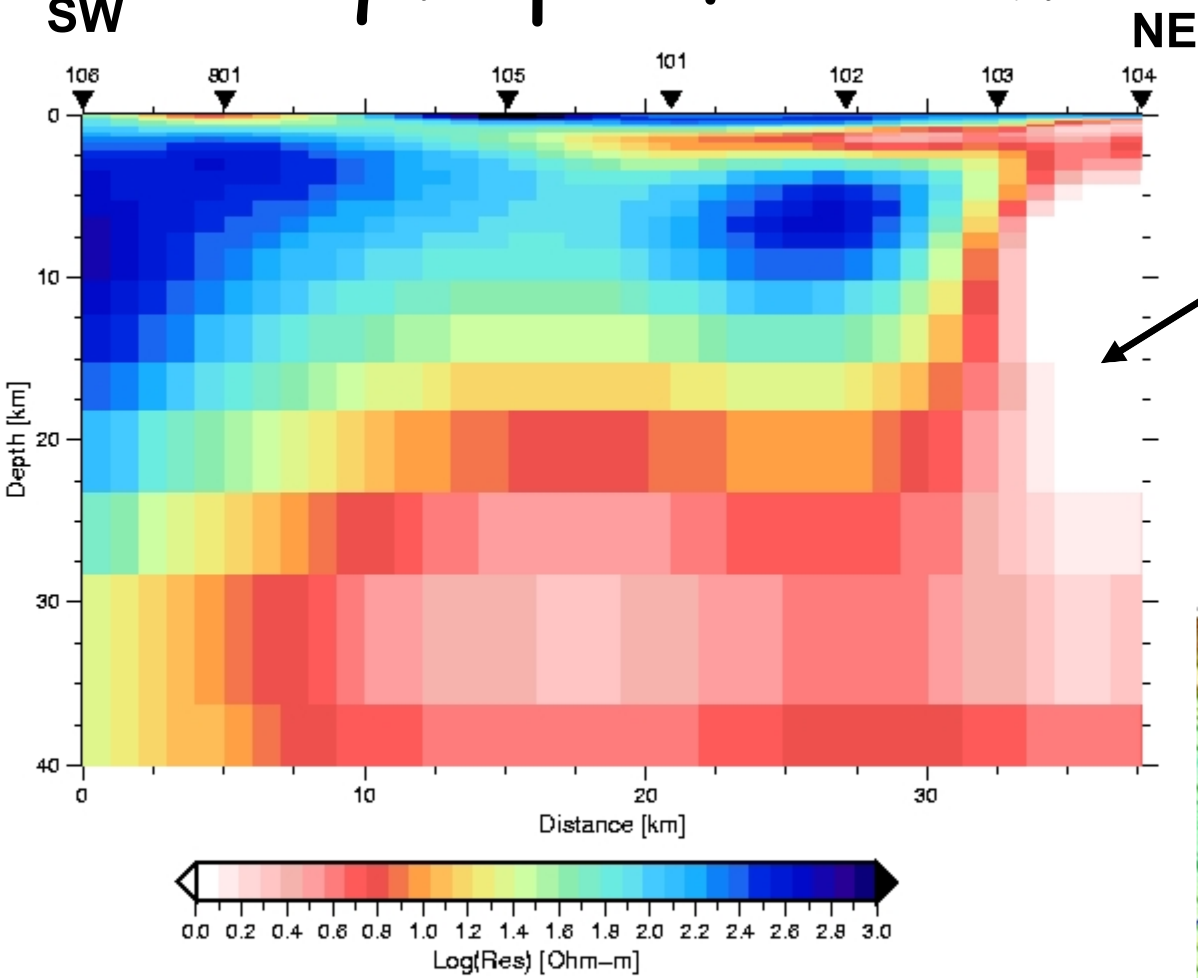
E

Two quantities deduced from the data, in two orthogonal directions (plotted red and blue)

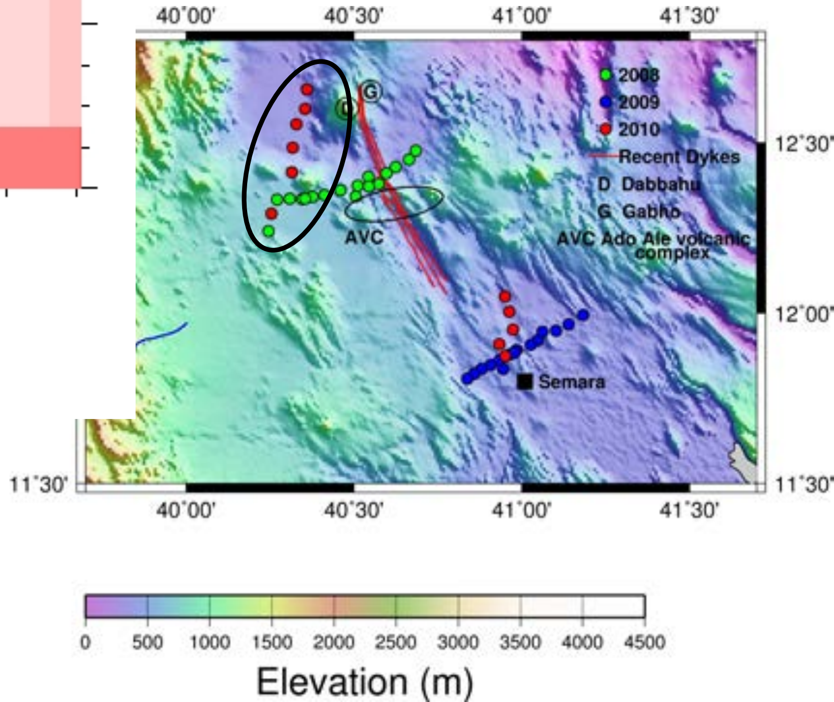
Points are data, solid curves model predictions

Data plotted horizontally as a function of period – depth proxy

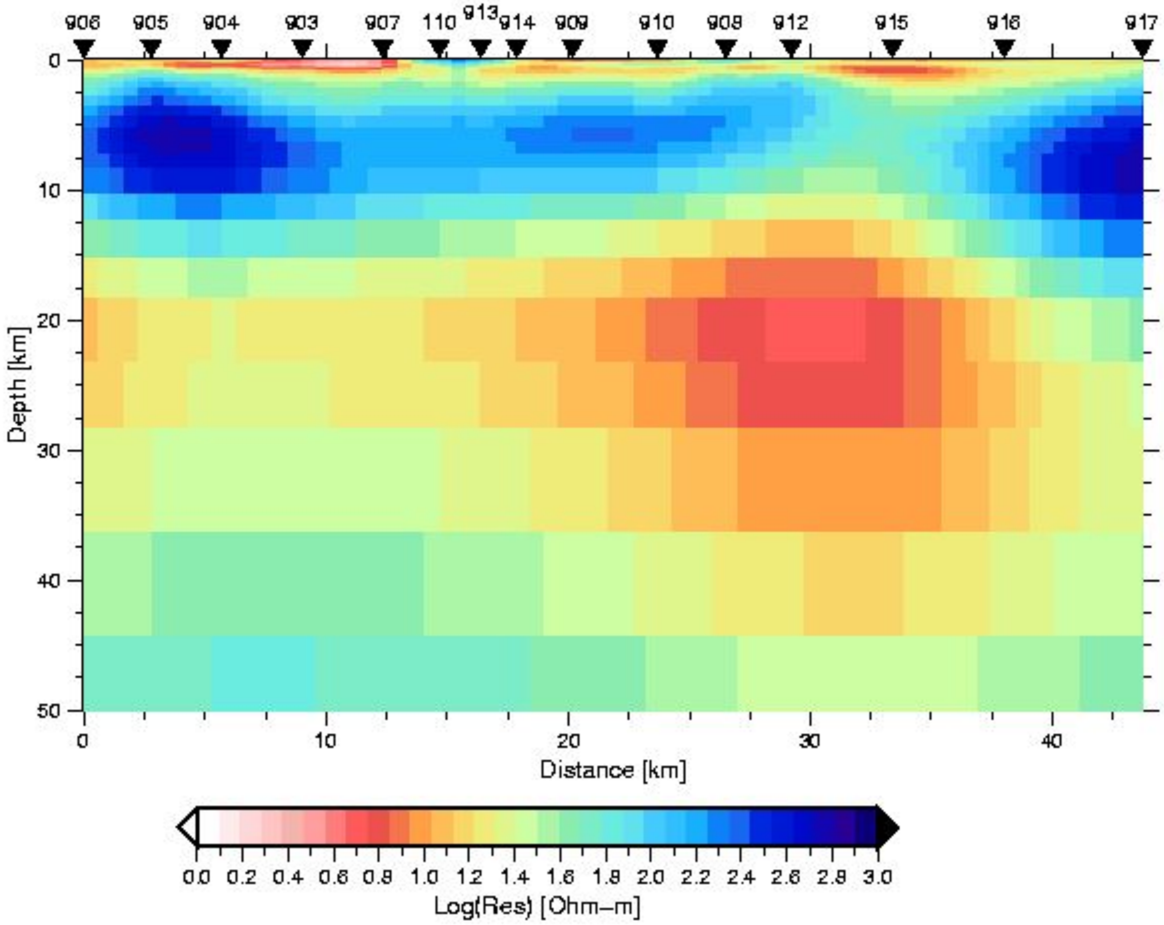
Oblique profile towards Dabbahu

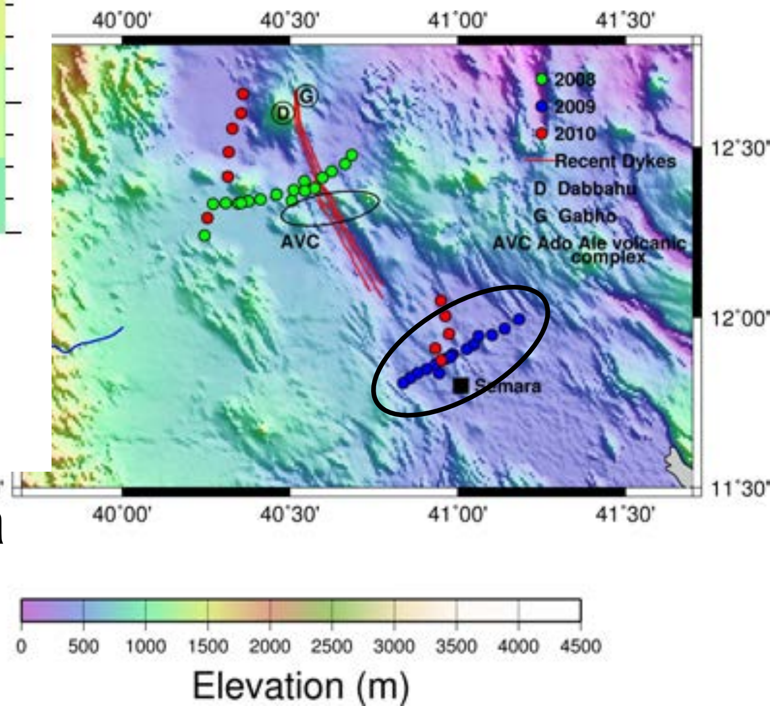


Large volumes of melt in crust and mantle



Comparison with inactive segment





Higher resistivities ⇒ much less magma
No evidence for sub-crustal magma chamber