

ETH zürich



Intra-continental uplift and volcanism in the Hangai Mountains (Mongolia) Insights from a multiscale magnetotelluric 3-D inversion

Johannes S. Käüfl¹, Alexander V. Grayver¹, Matthew J. Comeau², Alexey V. Kuvshinov¹, Michael Becken², Erdenechimeg Batmagnai¹, Jochen Kamm³, Sodnomsambu Demberel⁴

¹Institute of Geophysics, ETH Zürich, Switzerland; ²Institut für Geophysik, WWU Münster, Germany; ³Geological Survey of Finland, Espoo, Finland; ⁴Institut of Astronomy & Geophysics, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia

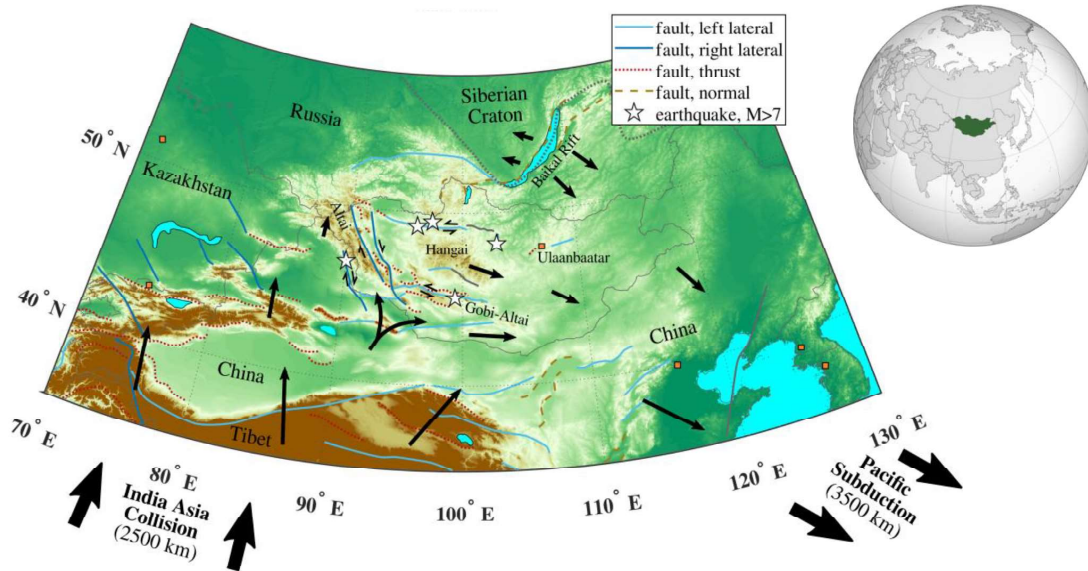
EMTF Kolloquium, Haltern am See, 24.9.2019

ETH zürich

See the following preprint for more information:

- **Magnetotelluric multiscale 3-D inversion reveals crustal and upper mantle structure beneath the Hangai and Gobi-Altai region in Mongolia**
- Johannes Käüfl, Alexander V. Grayver, Matthew J. Comeau, Alexey V. Kuvshinov, Michael Becken, Jochen Kamm, Erdenechimeg Batmagnai, Sodnomsambu Demberel
- **DOI:** 10.31223/osf.io/5zd3n
- <https://eartharxiv.org/5zd3n/>

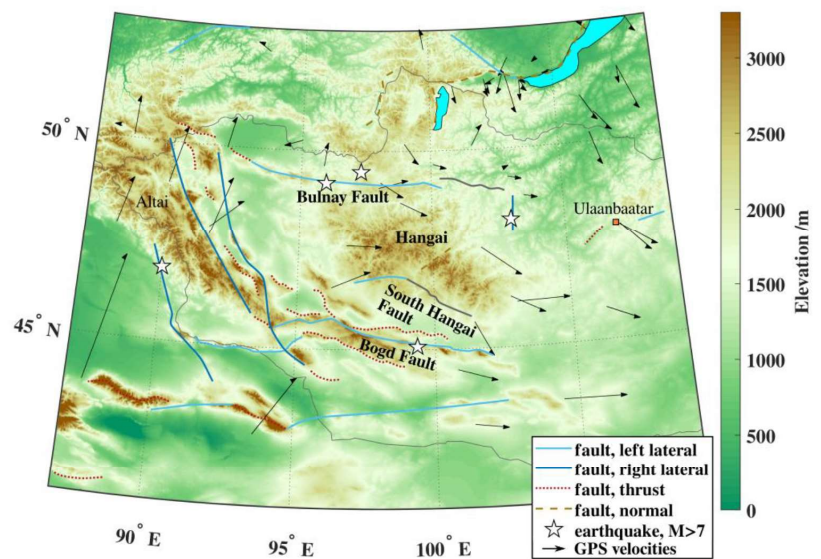
Geodynamics of western Mongolia



3

Hangai Mountains

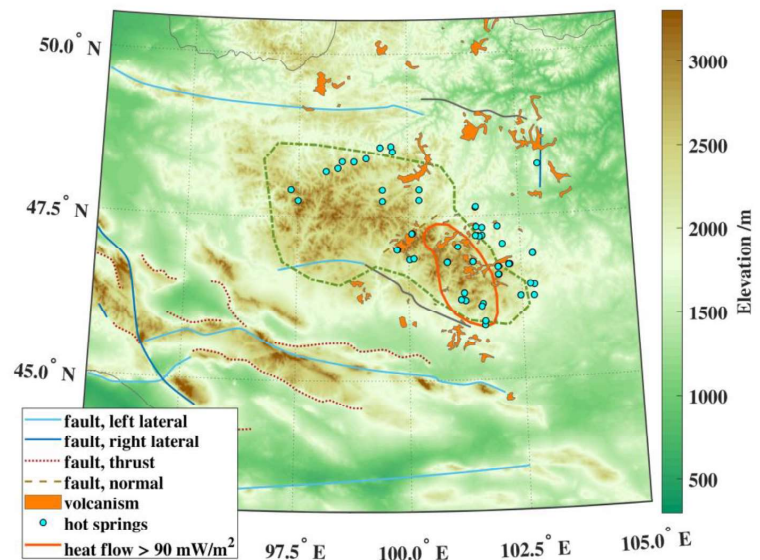
- Bogd and Bulnay Faults accommodate deformation
- Large Earthquakes M>8 in the last century
- Mineralization zone along the South Hangai Fault



4

Cenozoic volcanism in the Hangai

- Young volcanism (~5 ka to 33 Ma)
- Hot springs
- Shallow lithosphere-asthenosphere boundary
- Evidence for the presence of melt below the Hangai Dome



The Hangai Magnetotelluric experiment

- Obtain the first 3-D el. resistivity model of the region
- Understand the Hangai Mountains uplift
- Study intra-continental volcanism
- Electrical resistivity:
 - Presence of melt / partial melt fraction
 - Fluid content
 - Composition
 - Temperature



The Hangai Magnetotelluric experiment

- Obtain the first 3-D resistivity model of the region
- Understand the Hangai Mountains uplift
- Study intra-continental volcanism

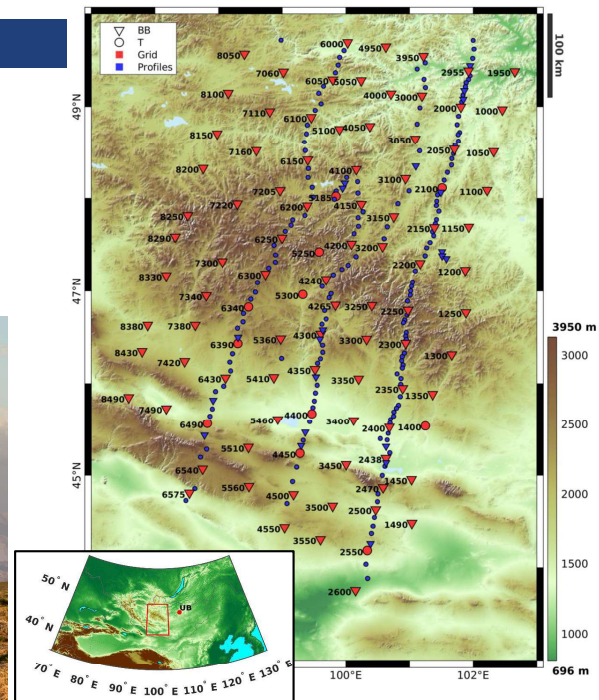
How to bridge the different scales in a single model?

- Large scale geodynamic and tectonic processes
 - Lithospheric & Asthenospheric structure (>100 km)
- Intermediate Scale
 - Crustal structure and geol. terrane boundaries (10 - 100 km)
- Local features and surface observables
 - Surface fault traces, volcanic provinces, geothermal systems (< 10 km)

7

Data acquisition

- 272 locations on a 650x400 km²
- grid with ~50 km spacing
- 4 profiles with 5-10 km spacing
- Instruments partly provided by GIPP



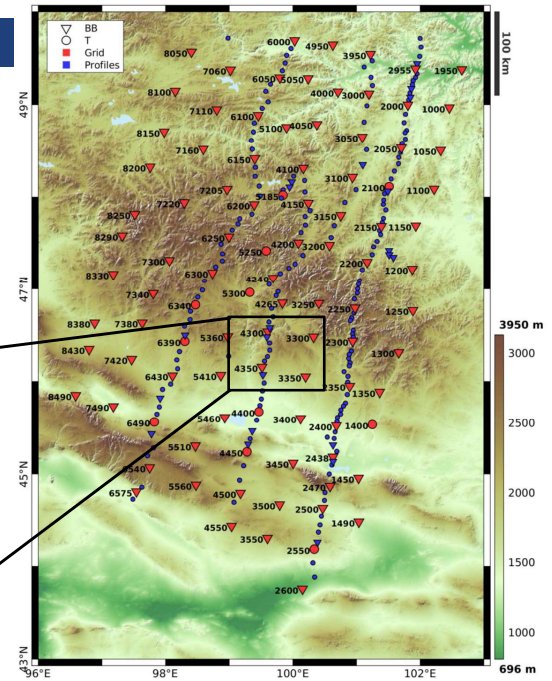
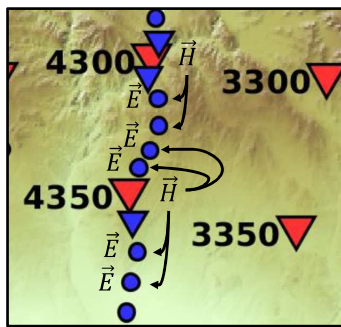
Inter-site transfer functions

- Single-site impedance:

$$\vec{E}_H(\vec{r}, \omega) = Z(\vec{r}, \omega) \vec{H}_H(\vec{r}, \omega)$$

- Inter-site impedance:

$$\vec{E}_H(\vec{r}, \omega) = \tilde{Z}(\vec{r}, \vec{r}_b, \omega) \vec{H}_H(\vec{r}_b, \omega)$$



Magnetotelluric 3-D Inversion

- 3-D finite element forward modelling and inversion code: GoFEM (Grayver, 2015)

Magnetotelluric 3-D Inversion

- 3-D finite element forward modelling and inversion code: GoFEM (Grayver, 2015)
- Locally refined unstructured meshes

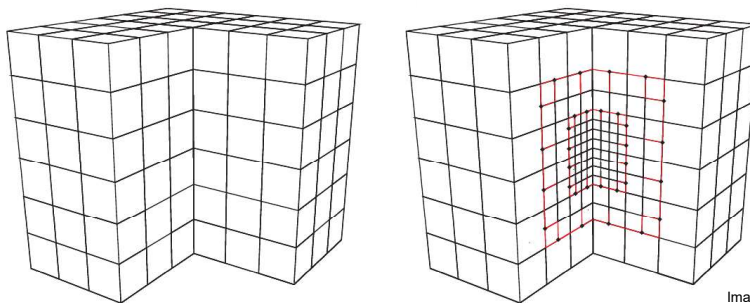
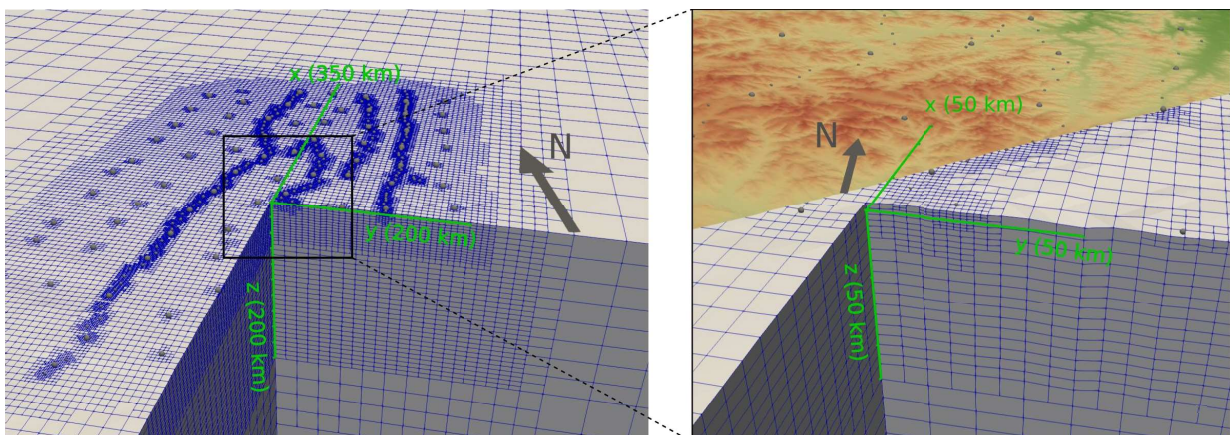


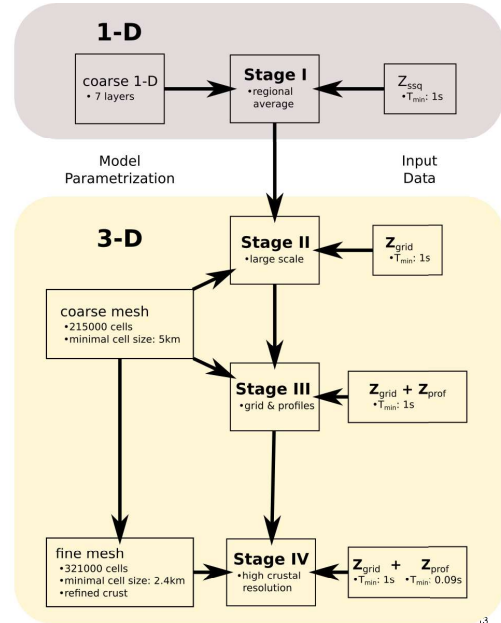
Image: Grayver & Bürg (2014)
Robust and scalable 3-D geoelectromagnetic modelling approach using the finite element method

Inversion Mesh

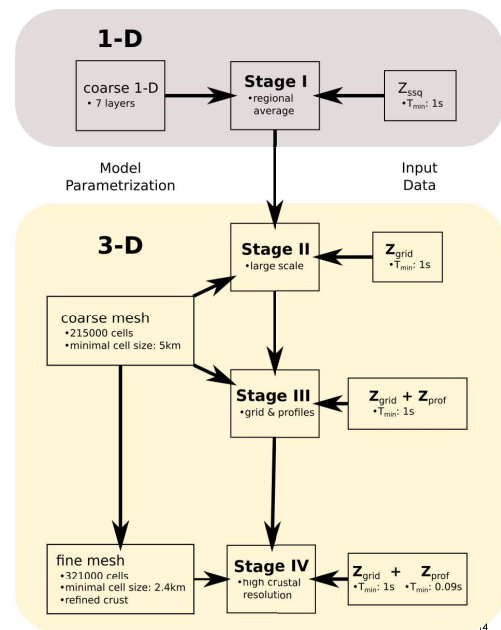
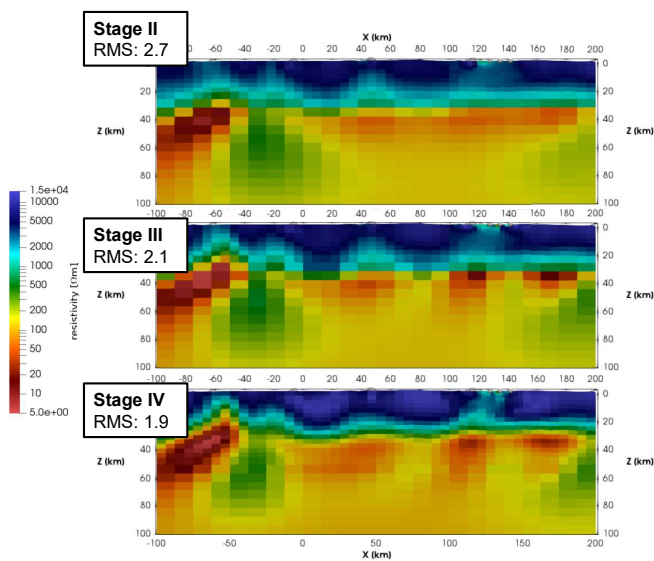
- Nested multi-scale hexahedral mesh with 321000 cells
- Cellsizes: 2.4 km to 350 km



Inversion Process

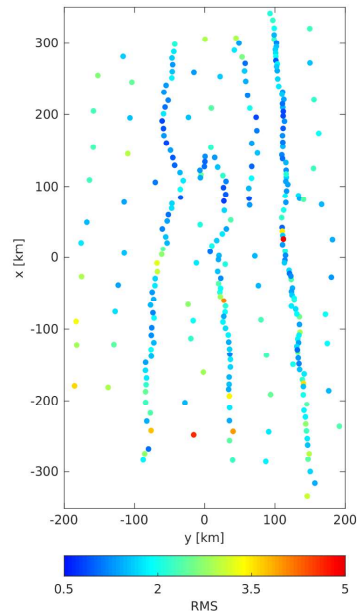
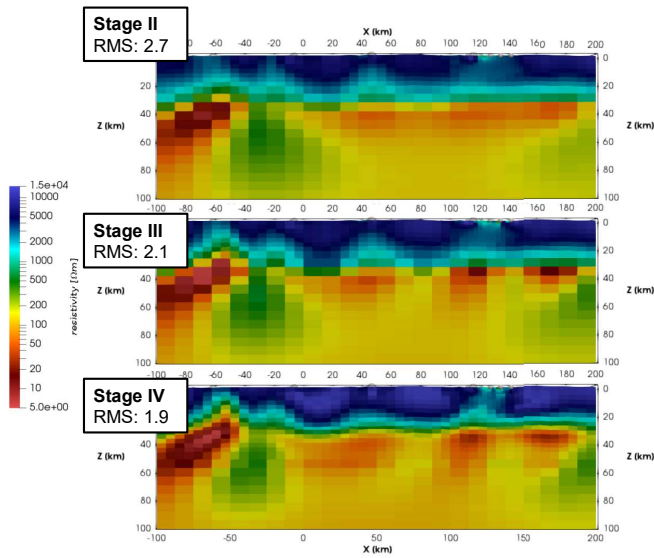


Inversion Process





Inversion Process

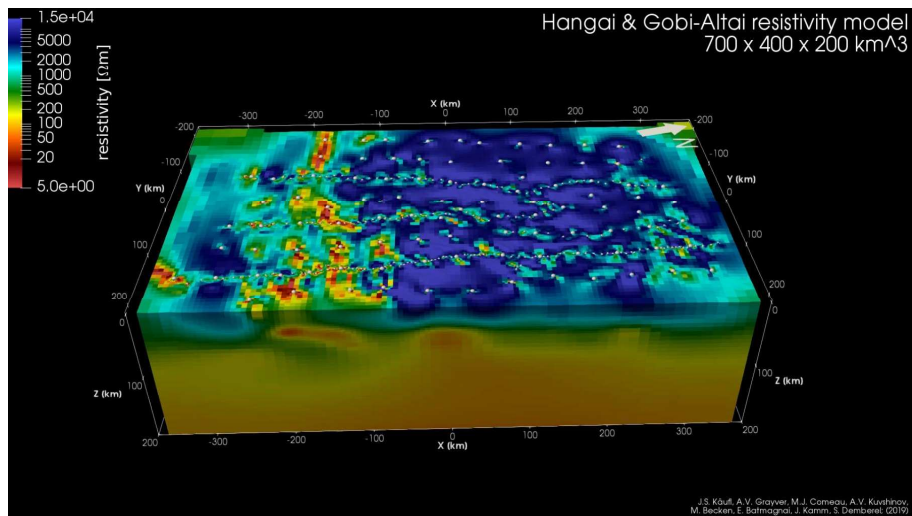


15



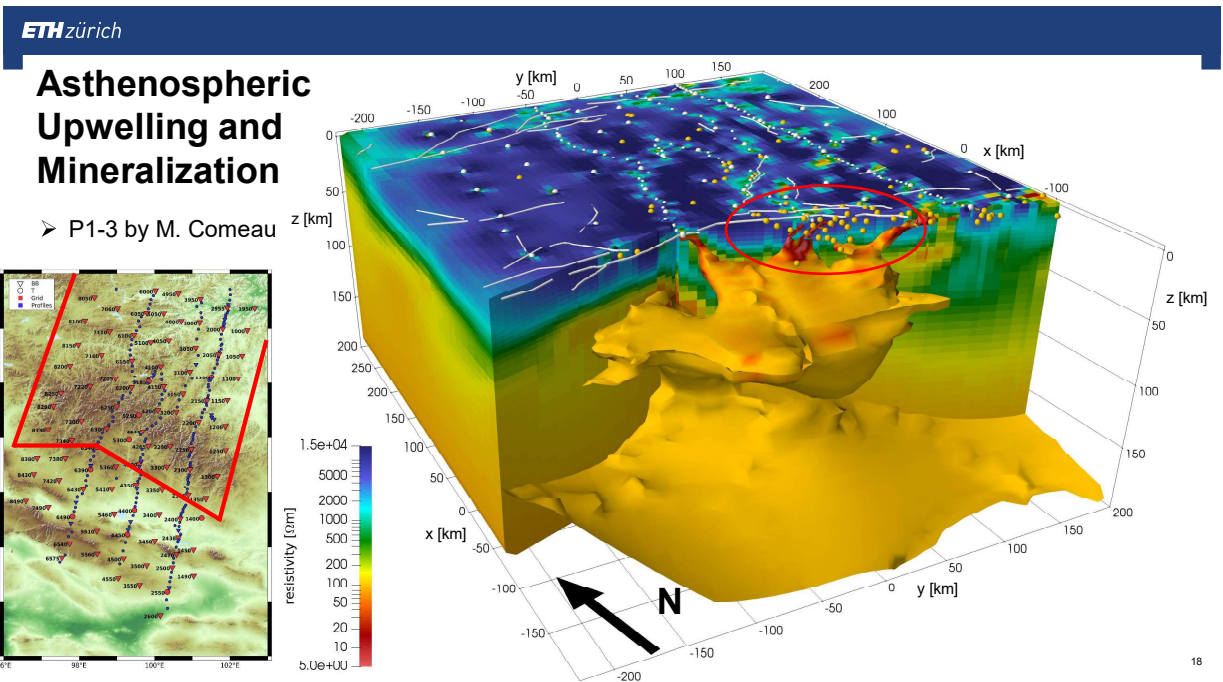
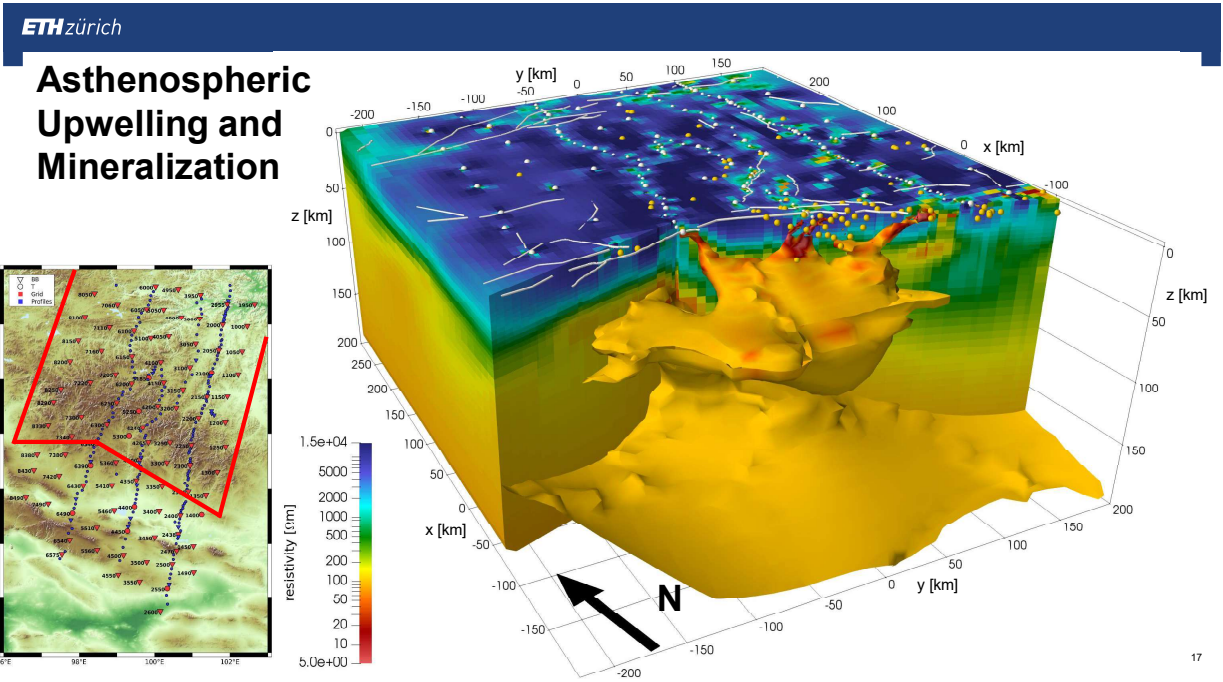
Animation of the final model:

<https://osf.io/d9btv/>

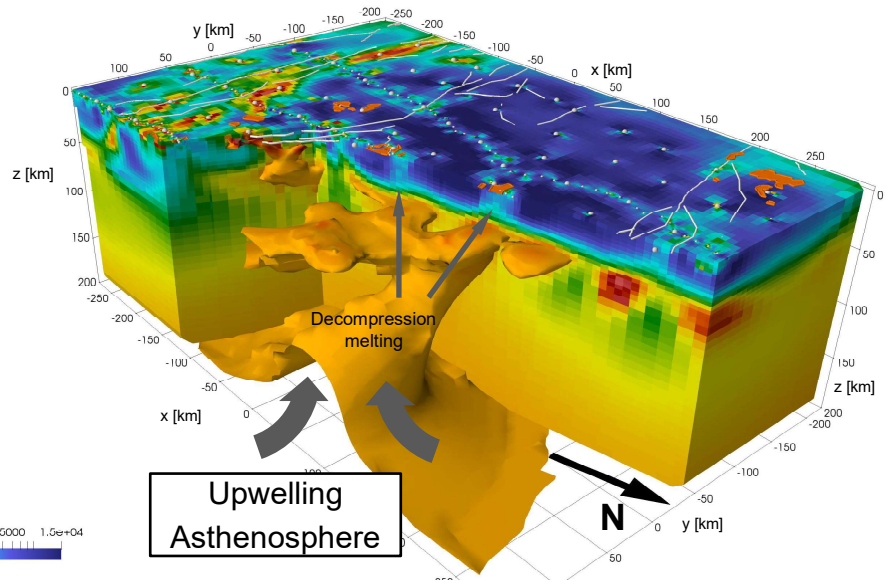
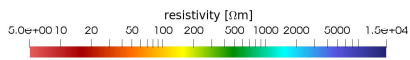
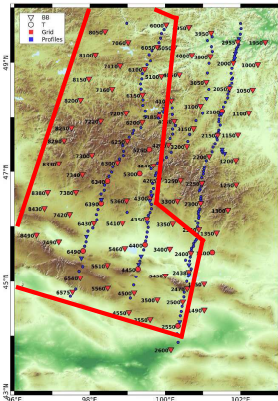


J.S. Käuffl, A.V. Grayver, M.J. Comeau, A.V. Kuvshinov, M. Becken, E. Balmagnat, J. Kamin, S. Demberel (2019)

16



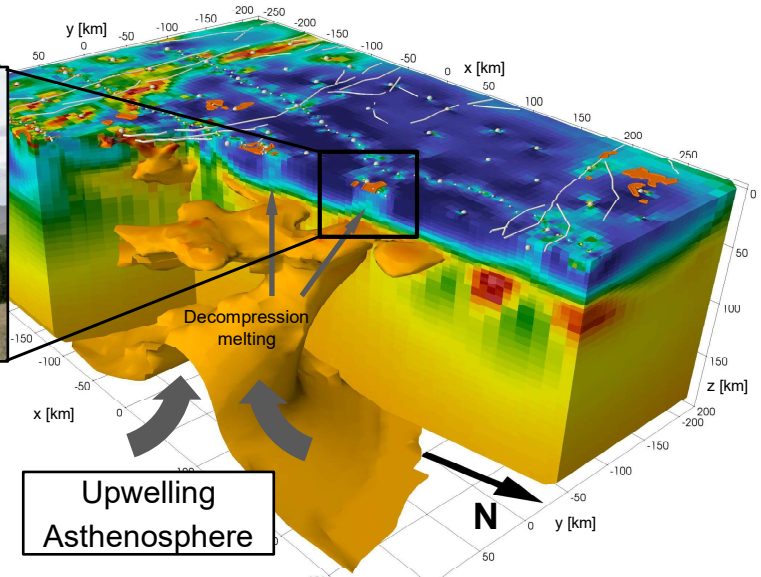
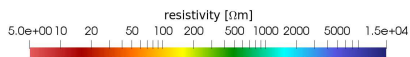
Asthenospheric Upwelling and Volcanism



Asthenospheric Upwelling and Volcanism



Tariat Volcanic Field & Khorgo Volcano



Conclusions

- First 3-D resistivity model of the Hangai and Gobi-Altai region
 - Complex resistivity structure, from small crustal features to large regional structures
 - Heterogeneously conductive lower crust below the Hangai dome
 - **subsequent talk by Matthew**
 - Asthenospheric upwelling in the eastern and southern Hangai, linked to volcanism and mineralization
- Remaining questions (WIP):
 - Link between uplift and upwelling?
 - Driving force behind the asthenospheric upwelling?
- Outlook
 - Joint inversion of MT and global induction methods
 - EM-constrained geodynamic modelling
 - Integrated interpretation with seismology

21

Field Crew:



Batbileg Tegshjargal, Bayrjarga Bizya, Dominic Harpering, Dorian Sörgel, Eldev-Ochir Bold, Friedemann Samrock, Gantsogt Sukhbaatar, Jörg Schmalzl, Nasan-Ochir Tumen, Neeraj Sudhir, Nomuun Narantsogt, Phillip Kotowski, Robin Mann, Sandra Grazioli, Sukhbaatar Usnikh, Tsagaansukh Halzaa, Tserendug Shoovdor, Zagdsuren Shatar

22