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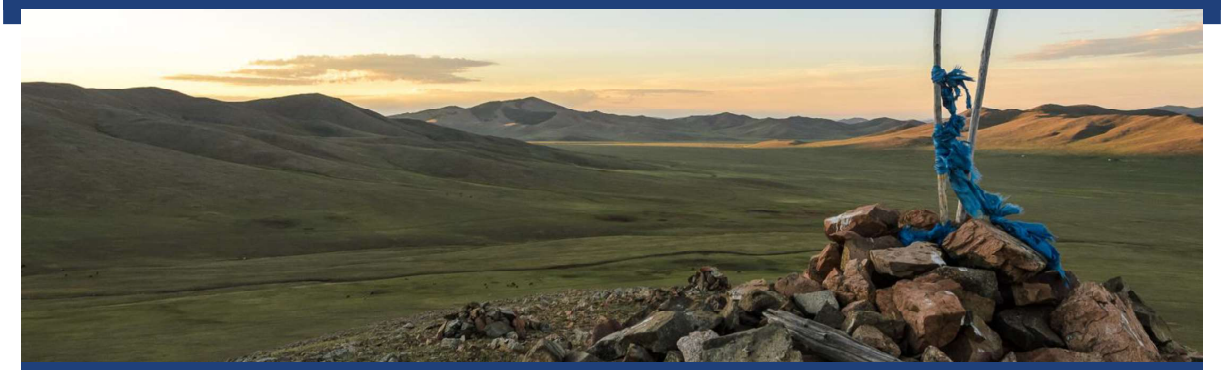

Intra-continental uplift and volcanism in the Hangai Mountains (Mongolia)

Insights from a multiscale magnetotelluric 3-D inversion

Johannes S. Käufl[1], Alexander V. Grayver[1], Matthew J. Comeau[2], Alexey V. Kuvshinov[1], Michael Becken[2], Erdenechimeg Batmagnai[1], Jochen Kamm[3], Sodnomsambu Demberel[4]

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

EMTF Kolloquium, Haltern am See, 24.9.2019

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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 Käufl, 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/

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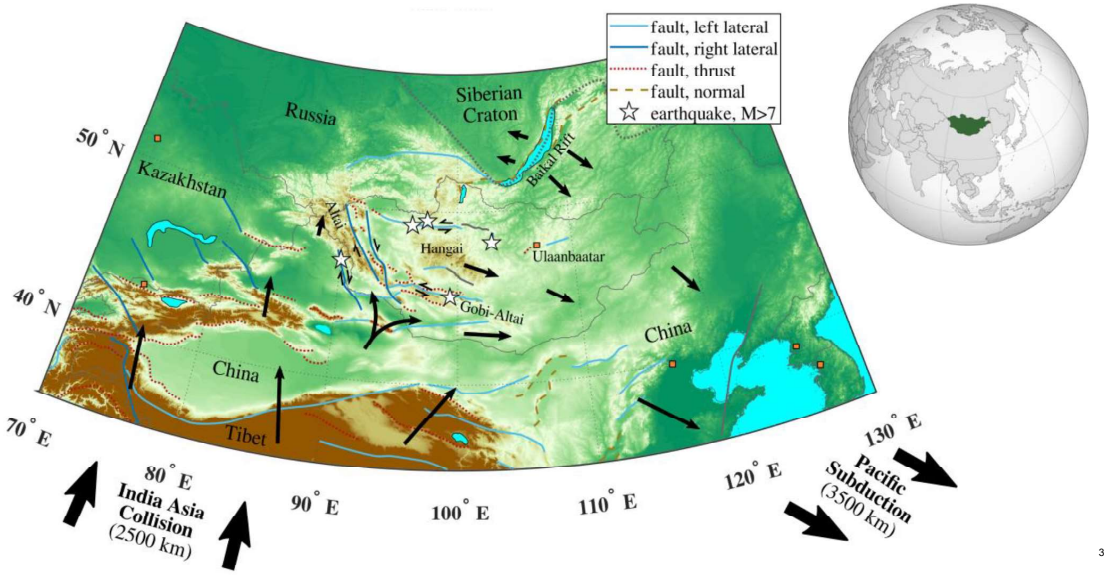
Geodynamics of western Mongolia



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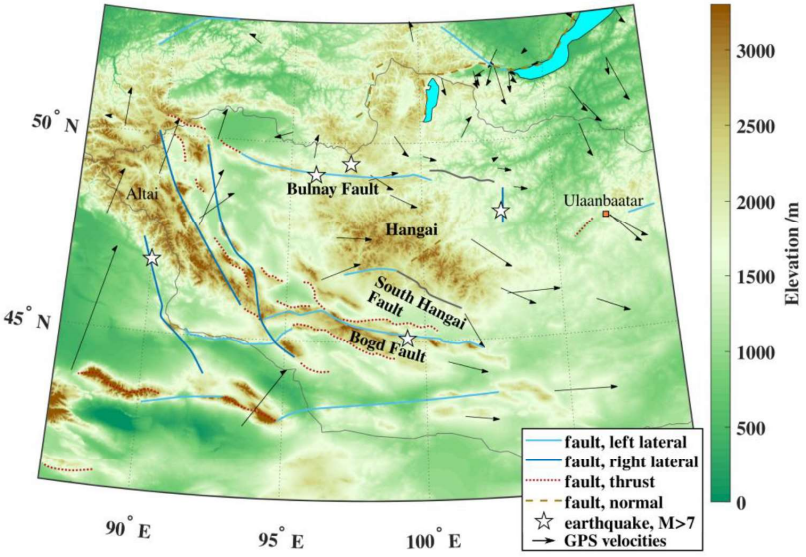
Hangai Mountains

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



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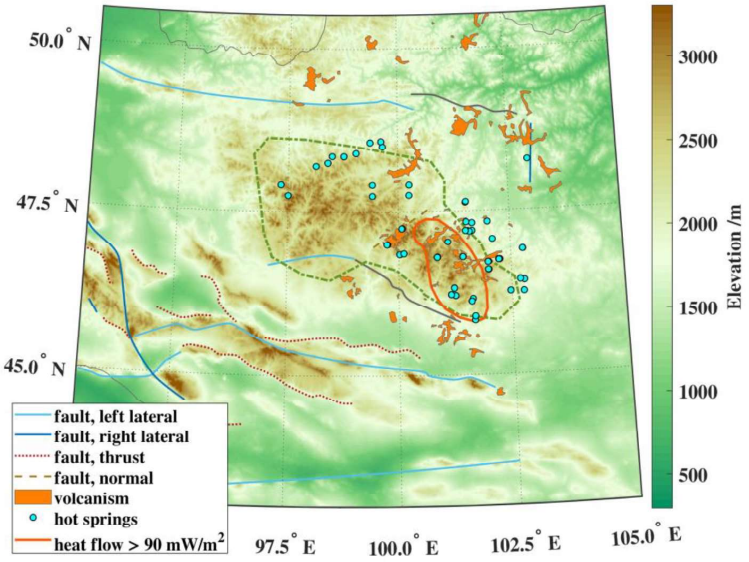
Cenozoic volcanism in the Hangai

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



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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 resisitivity:
  - Presence of melt / partial melt fraction
  - Fluid content
  - Composition
  - Temperature

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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
  - Surace fault traces, volcanic provinces, geothermal systems (< 10 km)

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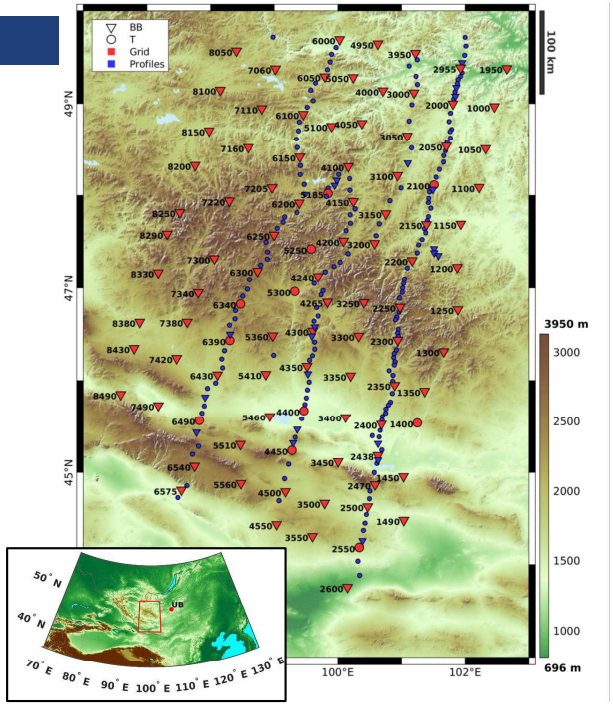
Data acquisition

- 272 locations on a 650x400 km^2
- grid with ~50 km spacing
- 4 profiles with 5-10 km spacing
- Instruments partly provided by GIPP



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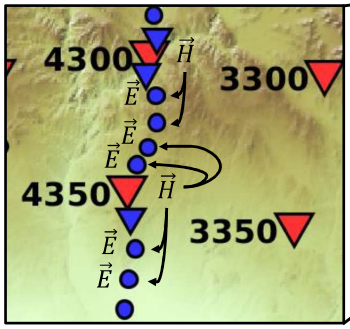
Inter-site transfer functions

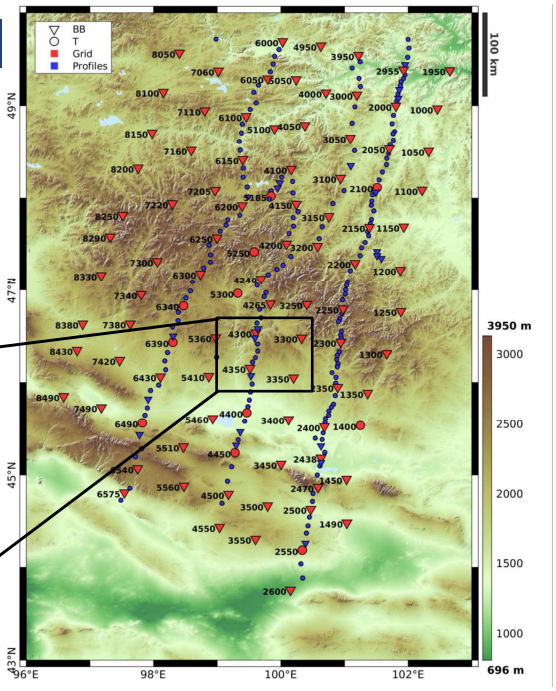
- Single-site impedance:

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

- Inter-site impedance:

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





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Magnetotelluric 3-D Inversion

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

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Magnetotelluric 3-D Inversion

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

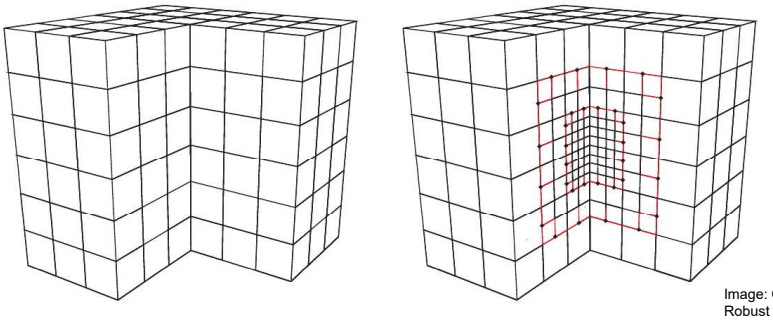

Image: Grayver & Bürg (2014)
Robust and scalable 3-D geoelectromagnetic modelling approach using the finite element method

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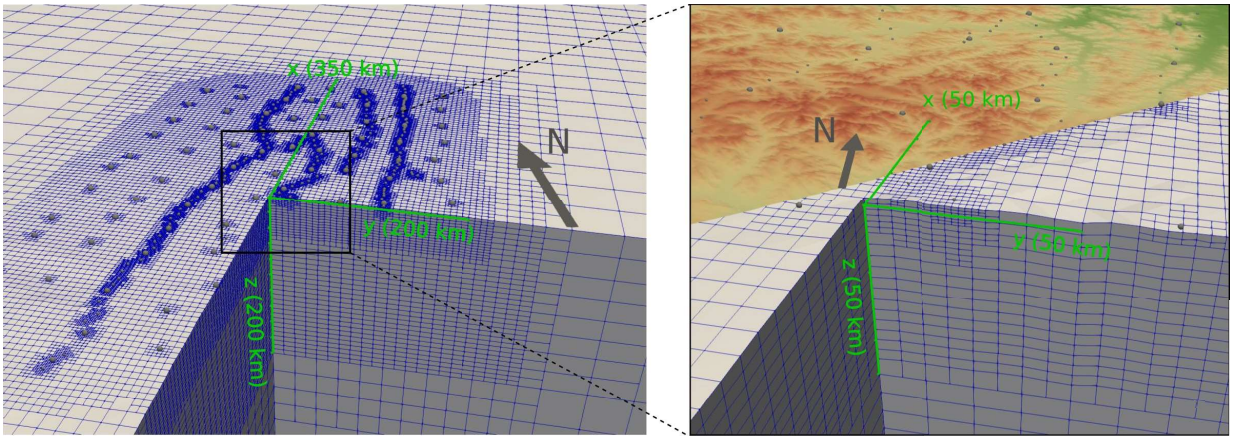
Inversion Mesh

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



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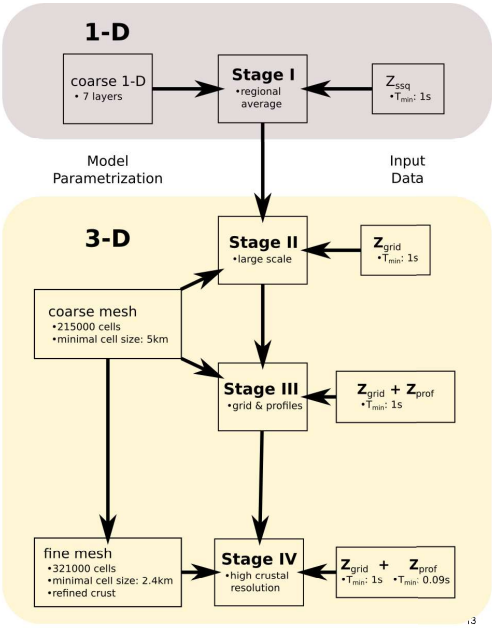
Inversion Process



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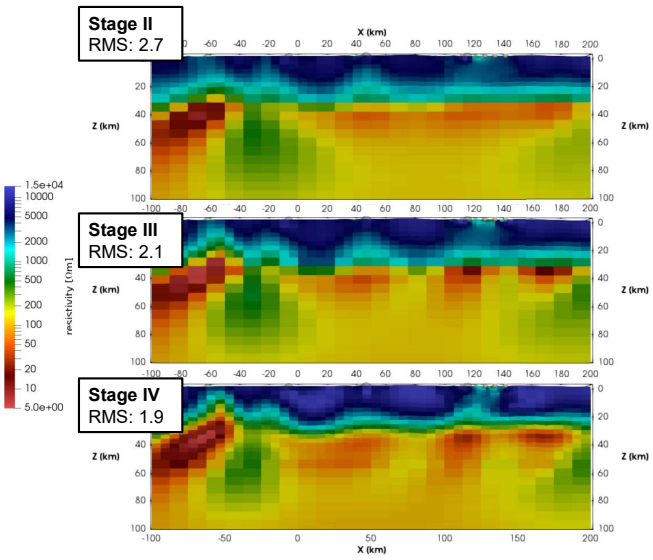

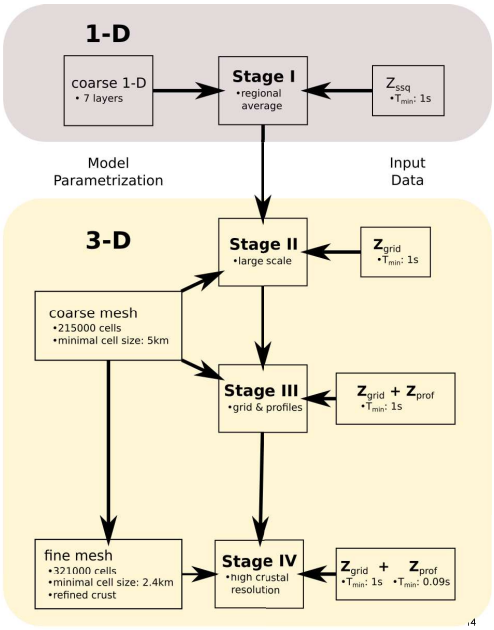

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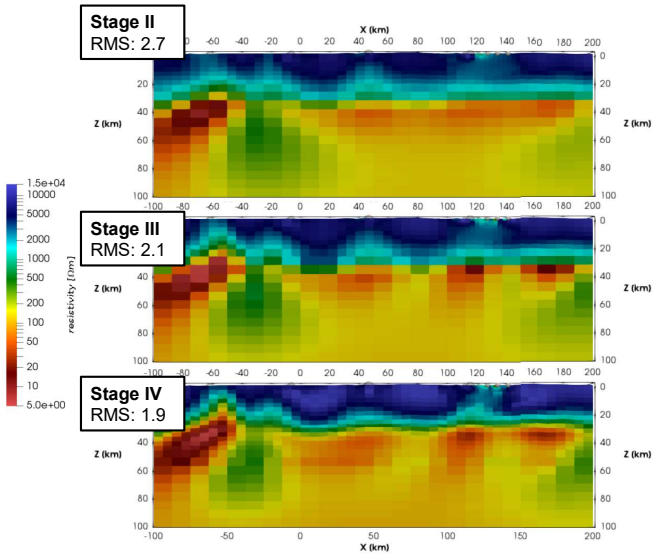
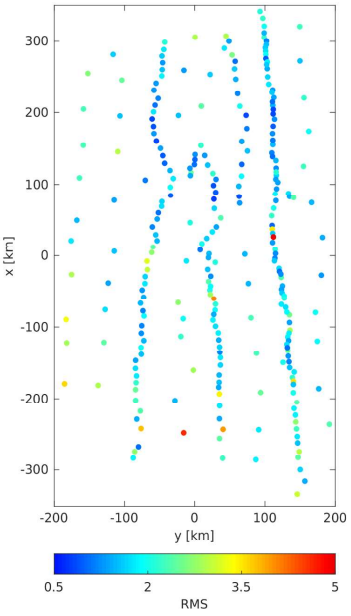
Inversion Process





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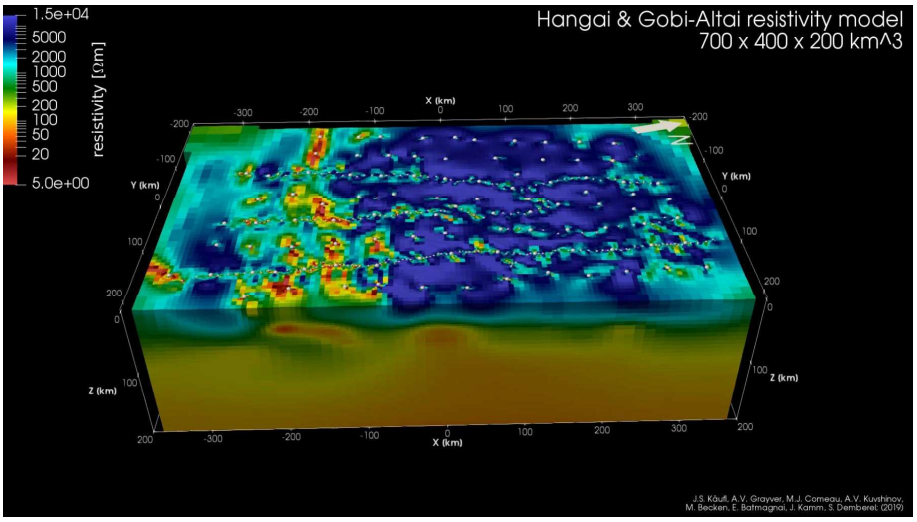
Animation of the final model:

https://osf.io/d9btv/



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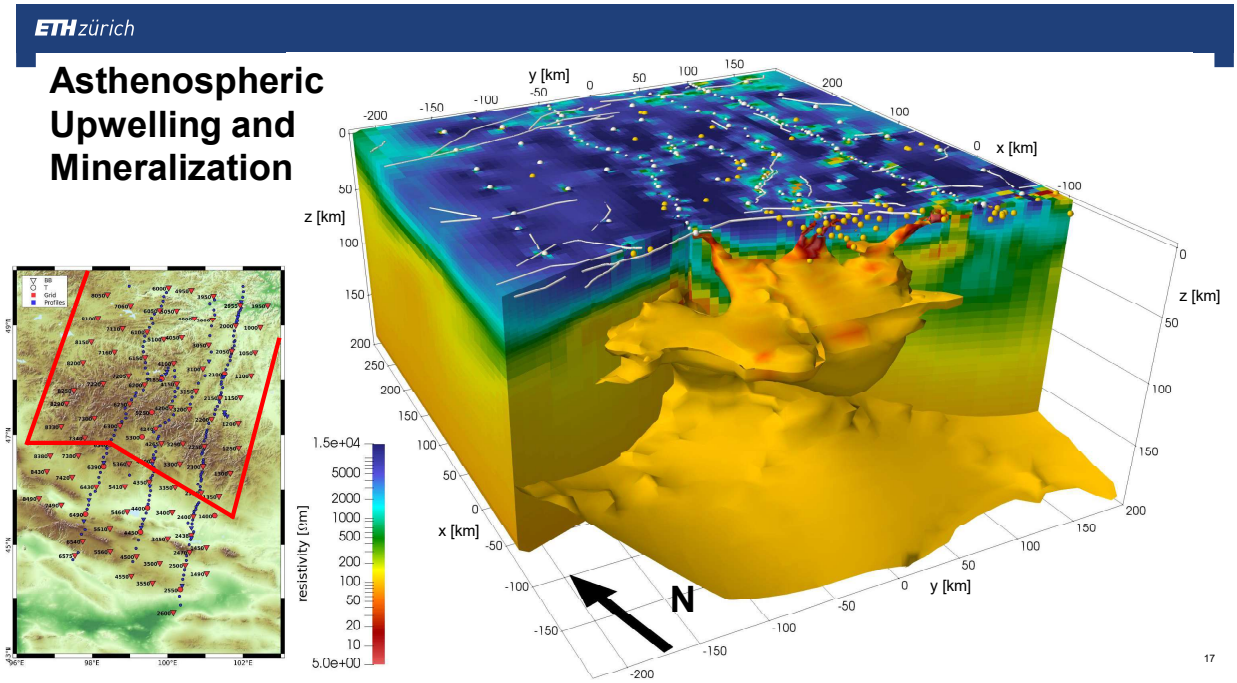
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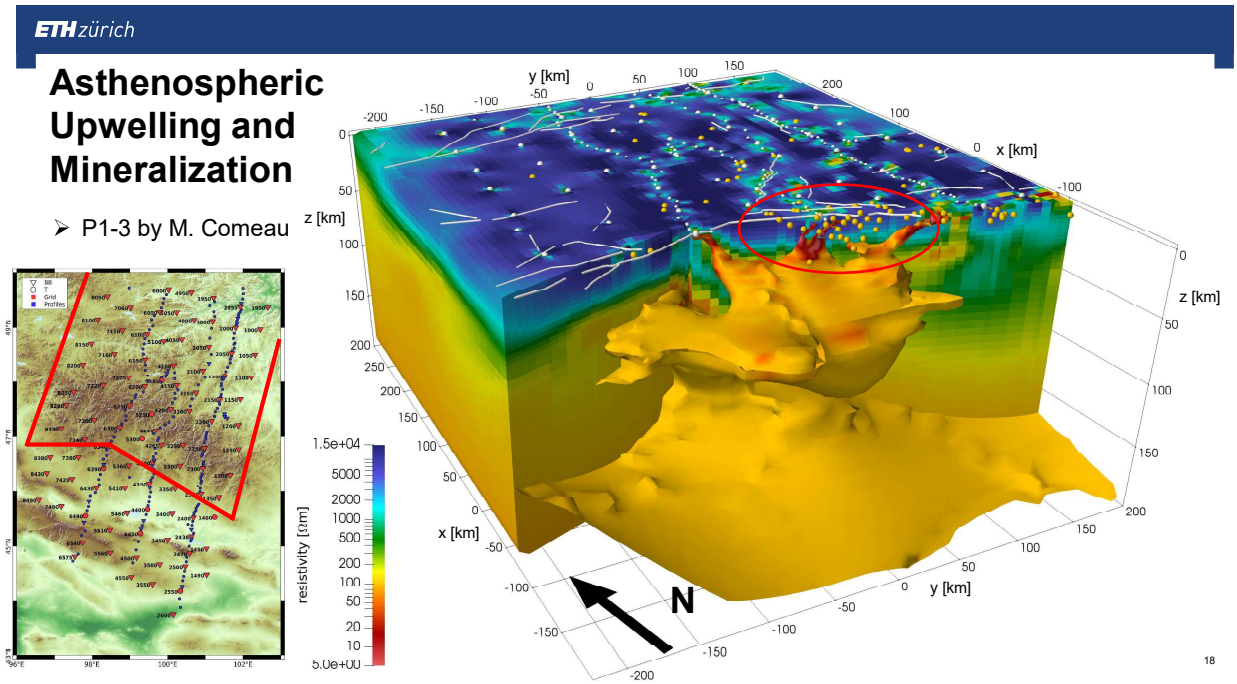
Asthenospheric Upwelling and Mineralization
y [km]
x [km]
z [km]
resistivity [Ωm]
1.5e+04
5000
2000
1000
500
200
100
50
20
10
5.0e+00
N
17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Asthenospheric Upwelling and Mineralization
➢ P1-3 by M. Comeau
y [km]
x [km]
z [km]
resistivity [Ωm]
1.5e+04
5000
2000
1000
500
200
100
50
20
10
5.0e+00
N
18

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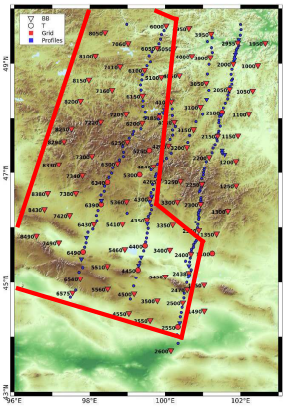
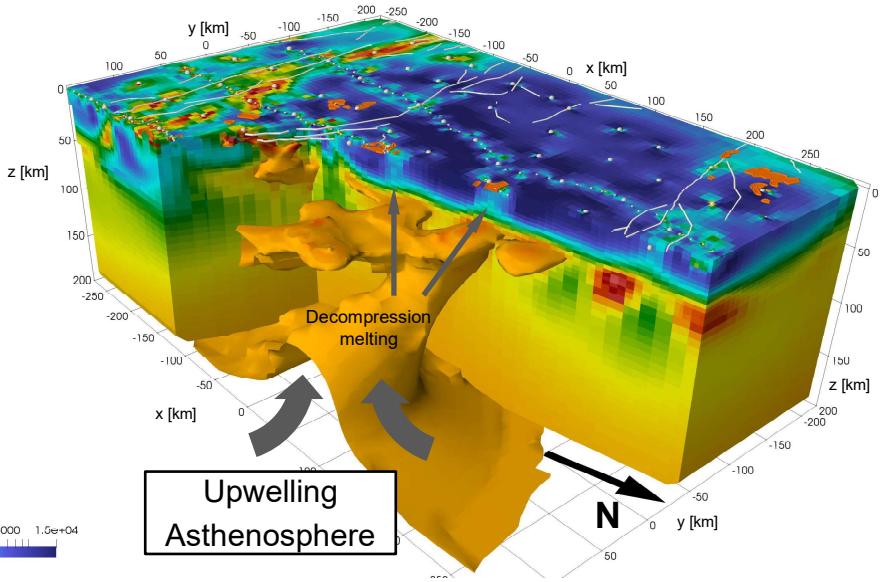
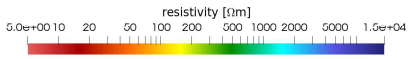
Asthenospheric Upwelling and Volcanism







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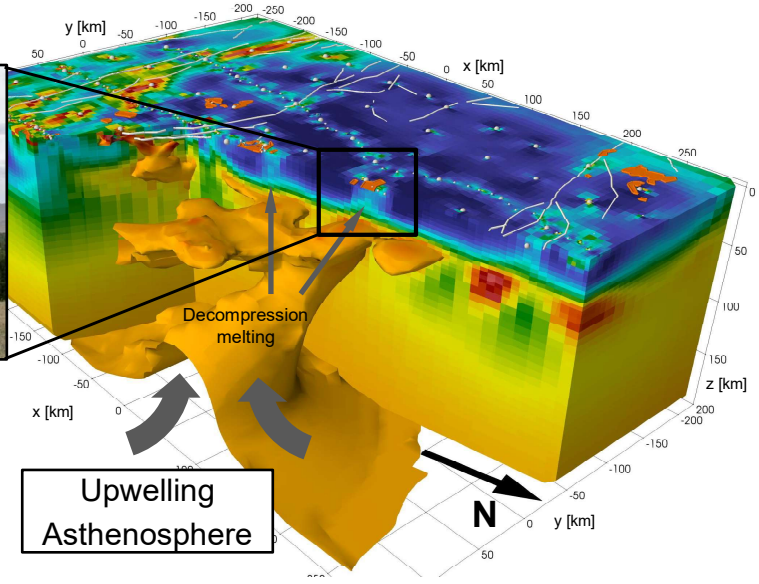
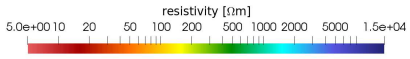
Asthenospheric Upwelling and Volcanism

Tariat Volcanic Field & Khorgo Volcano





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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

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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

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