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The lithospheric structure of west-central Mongolia from electrical resistivity models

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Universität Münster, Germany

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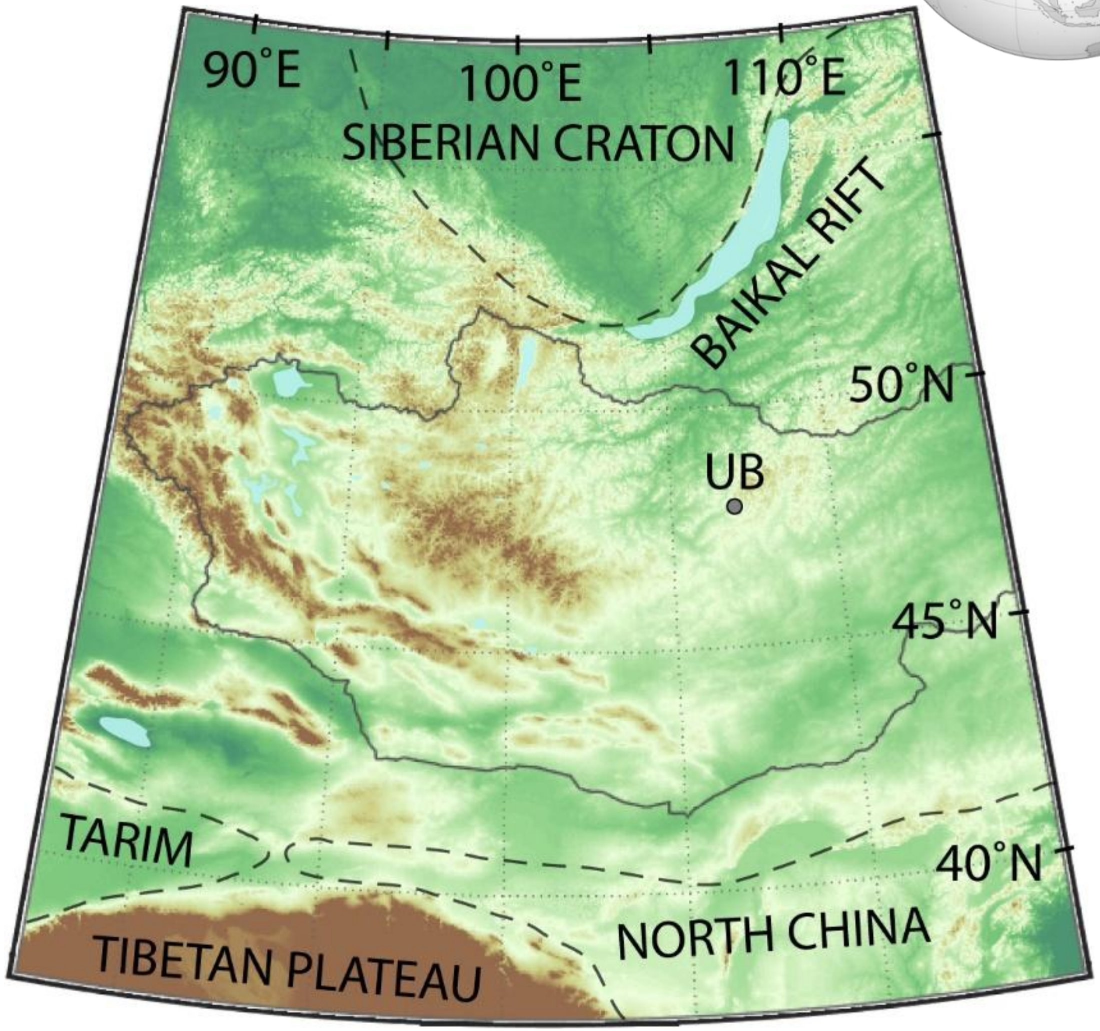
[2]ETH, Zürich, Switzerland
[3]Mongolian Academy of Science, Ulaanbaatar, Mongolia

European Geosciences Union

Westfälische Wilhelms-Universität Münster

Mongolia

- Unique position between Tibet and Siberian craton



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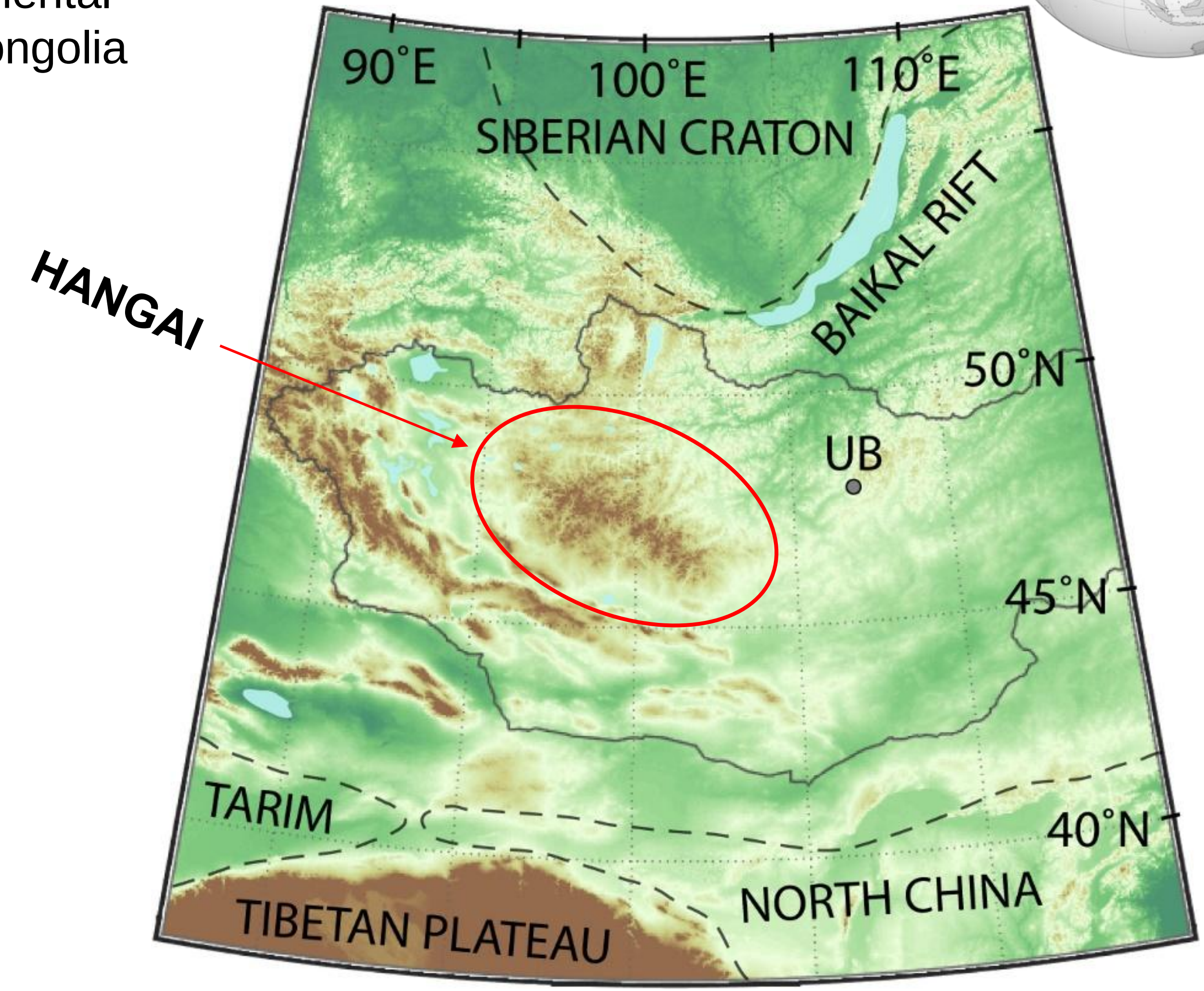

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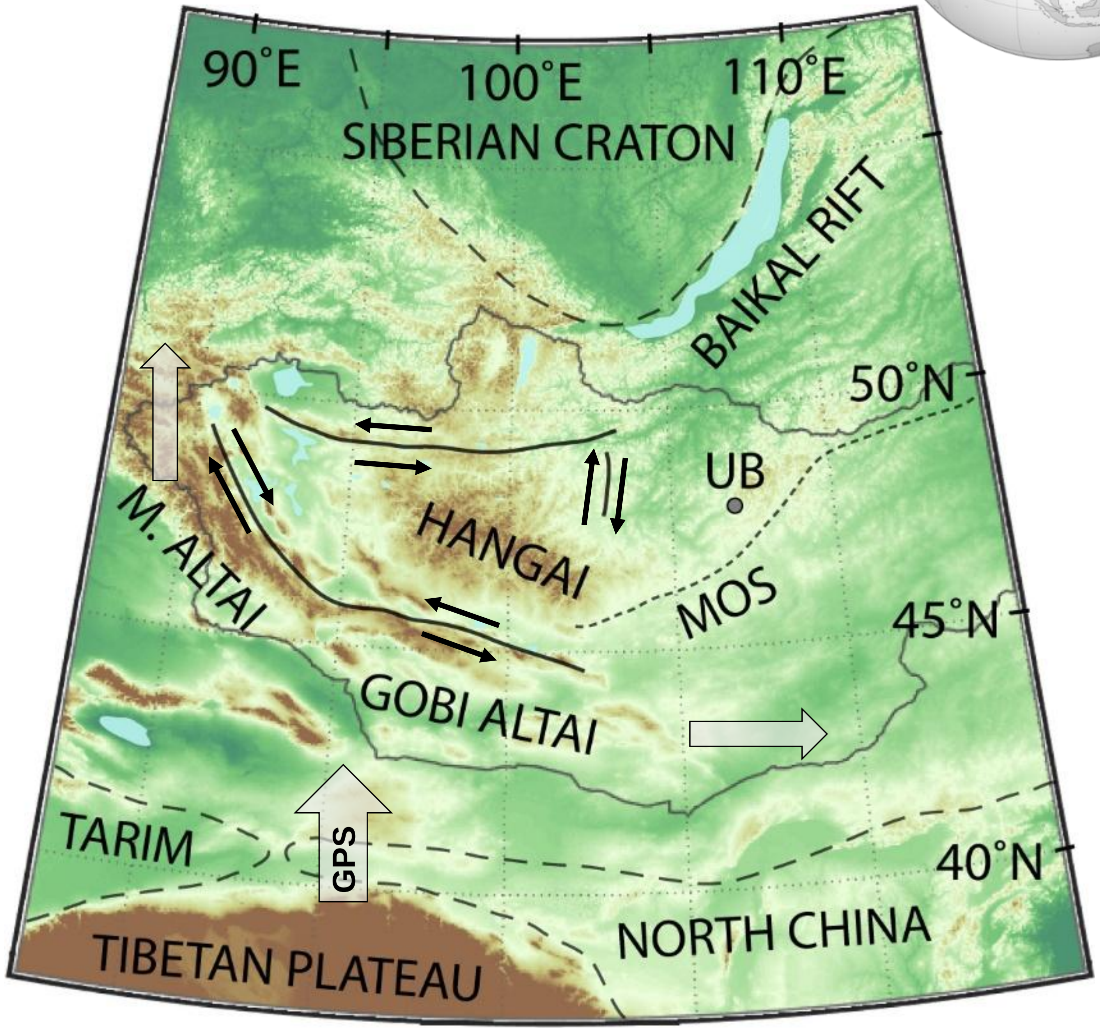
- Compression accommodated along major bounding faults

- Little deformation within rigid Hangai block
(pre-Cambrian micro-continent ?)



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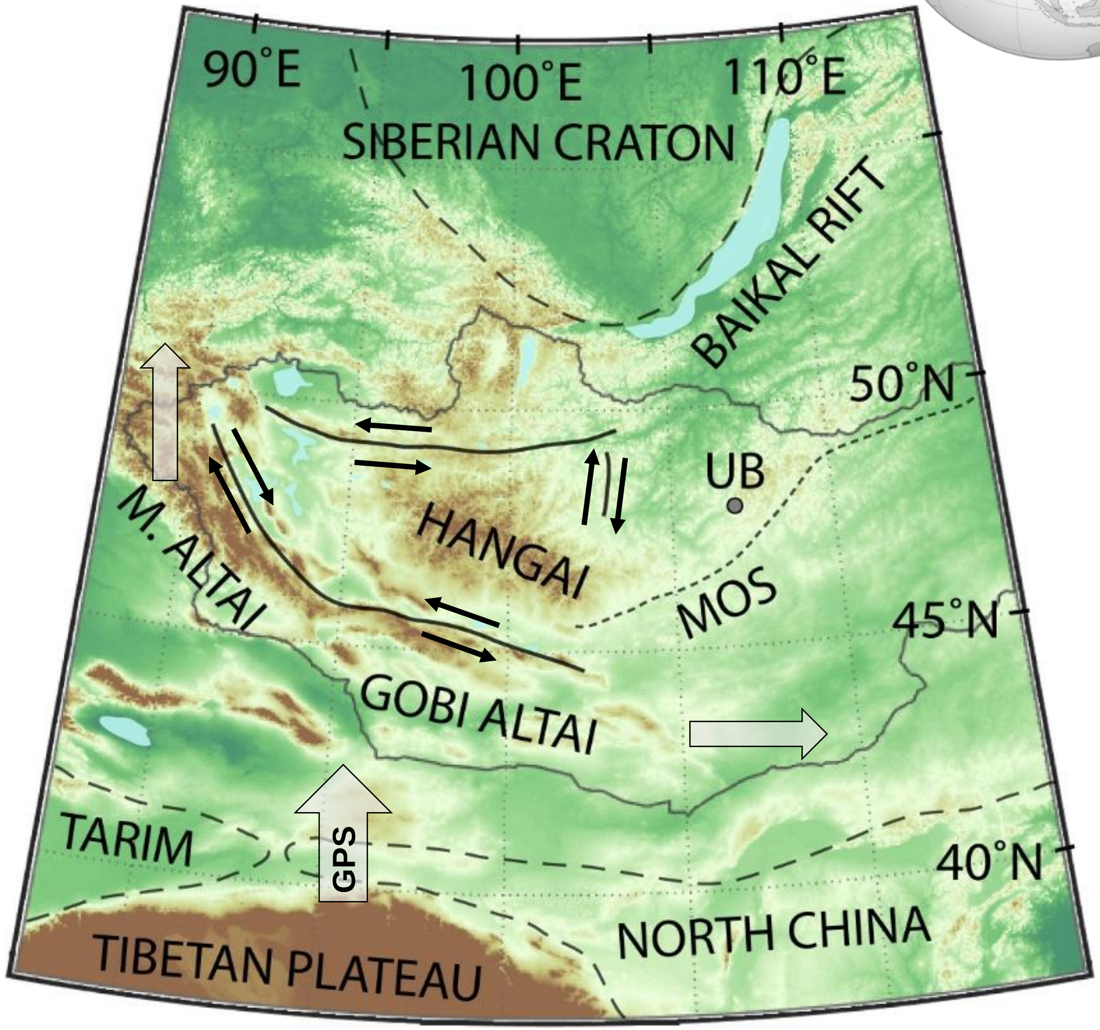

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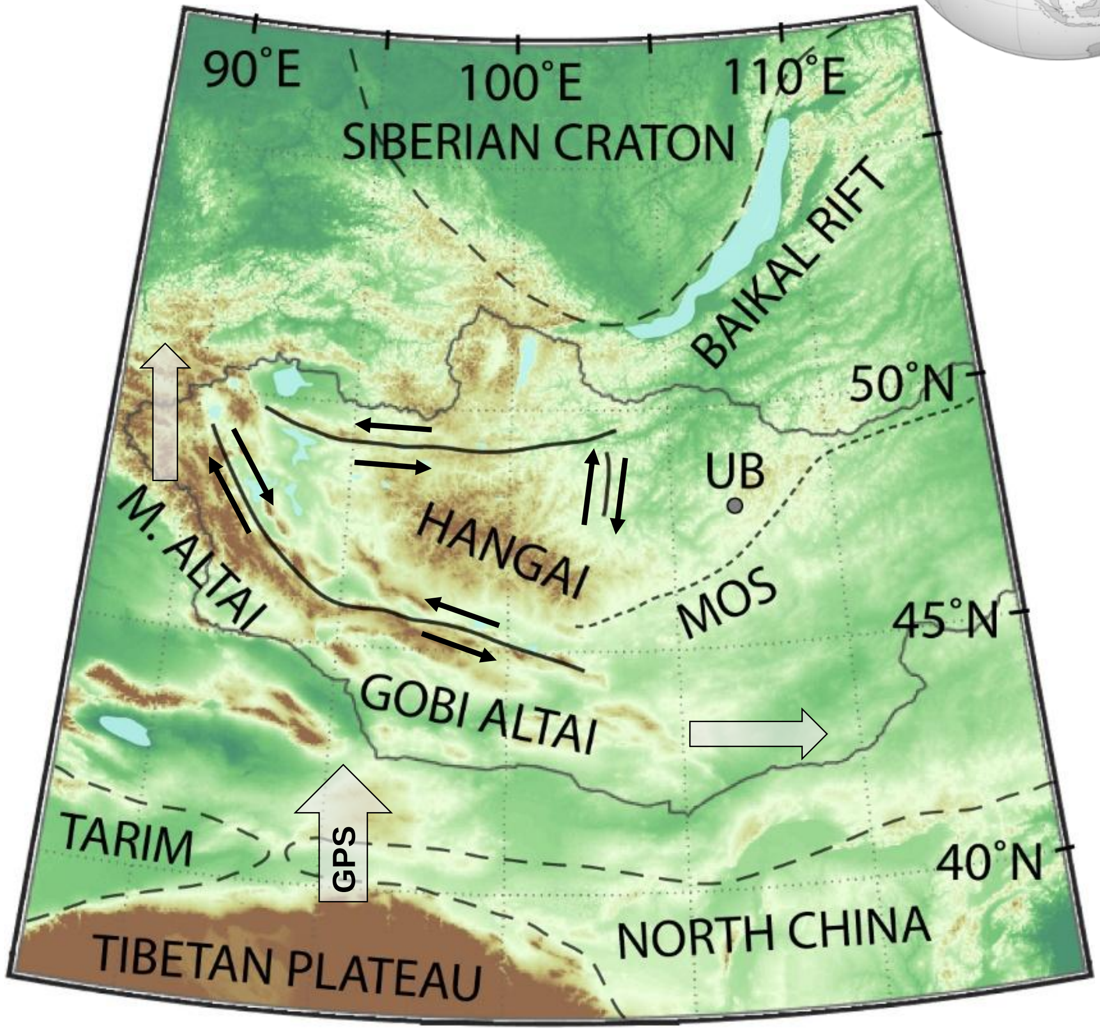
- Structure and history of region is an open question



Geophysical and Geochemical data

- What do we know ?
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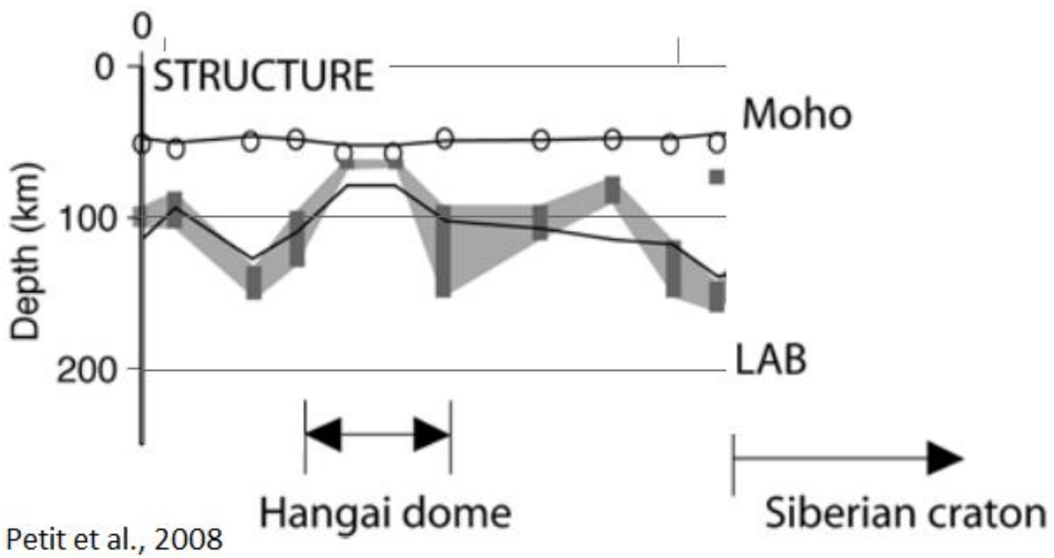
- Thick crust (45 - 55 km)



Petit et al., 2008

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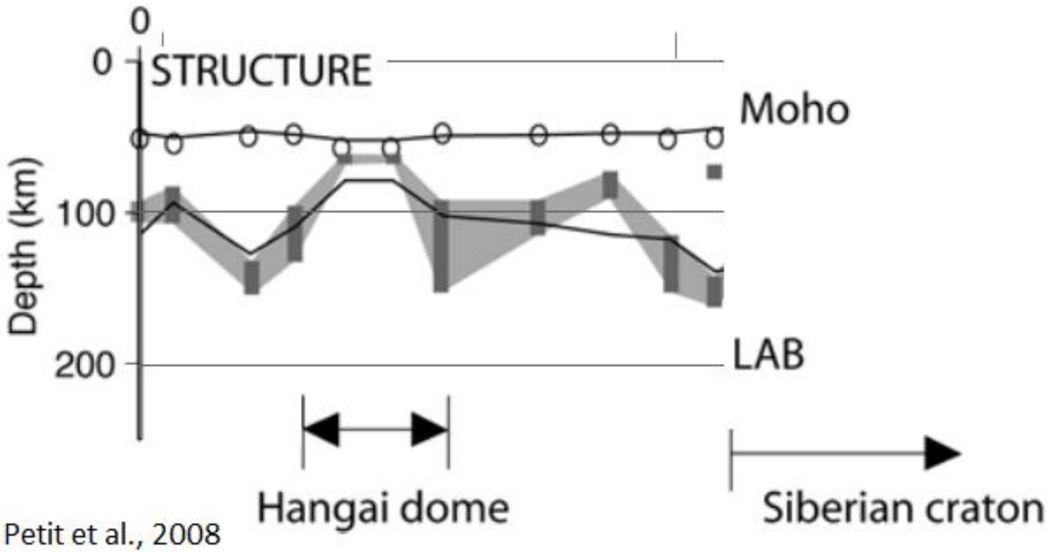


Petit et al., 2008

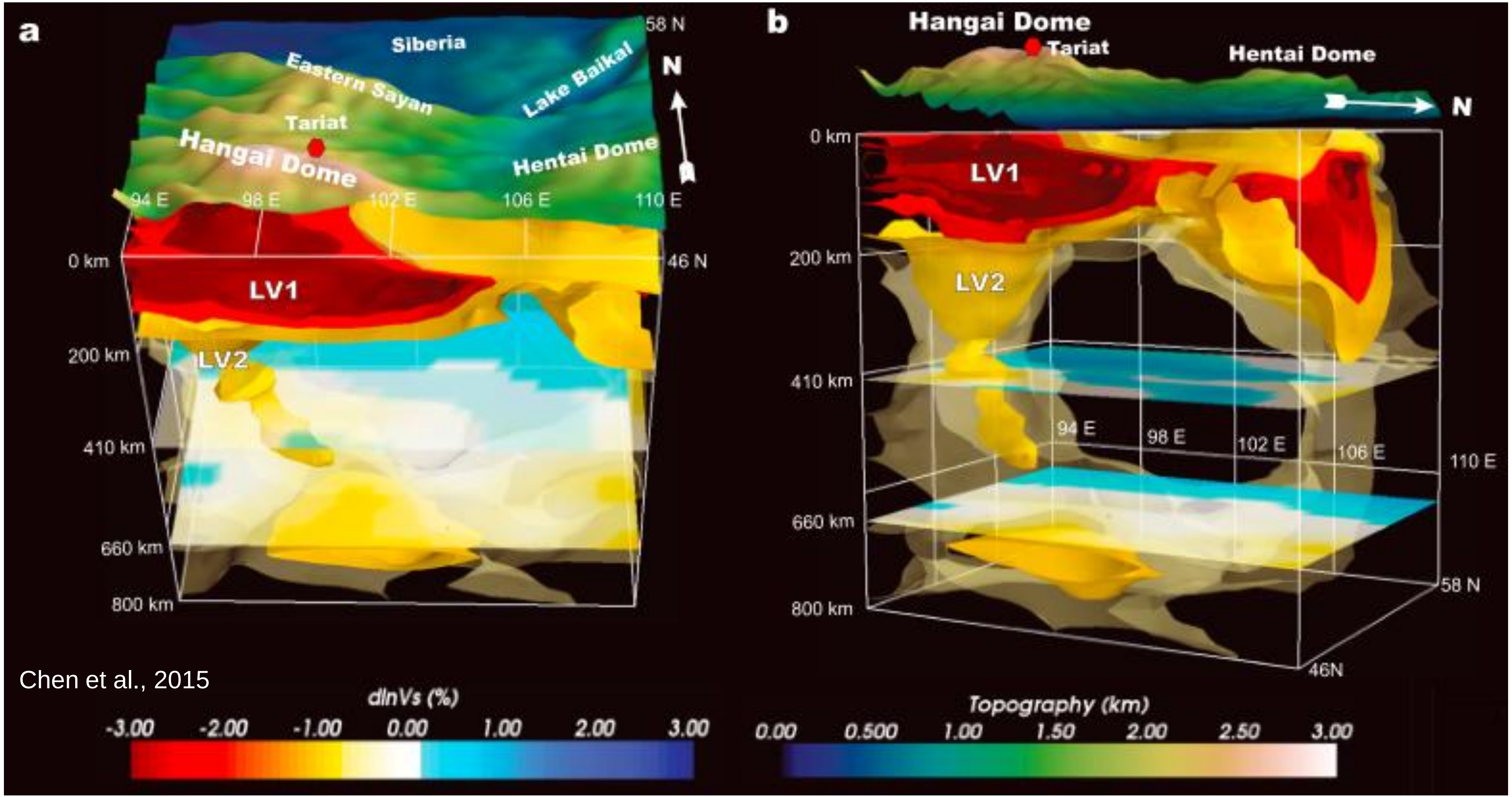
- Lavas originated from single source at 70 - 120 km depth
- Fast ascent through the crust

Ilmenite megacryst 1 cm in size.

Models for plateau growth and volcanism

Models for plateau growth and volcanism - Seismic

- Plume-like structure beneath central Mongolia ?



Chen et al., 2015

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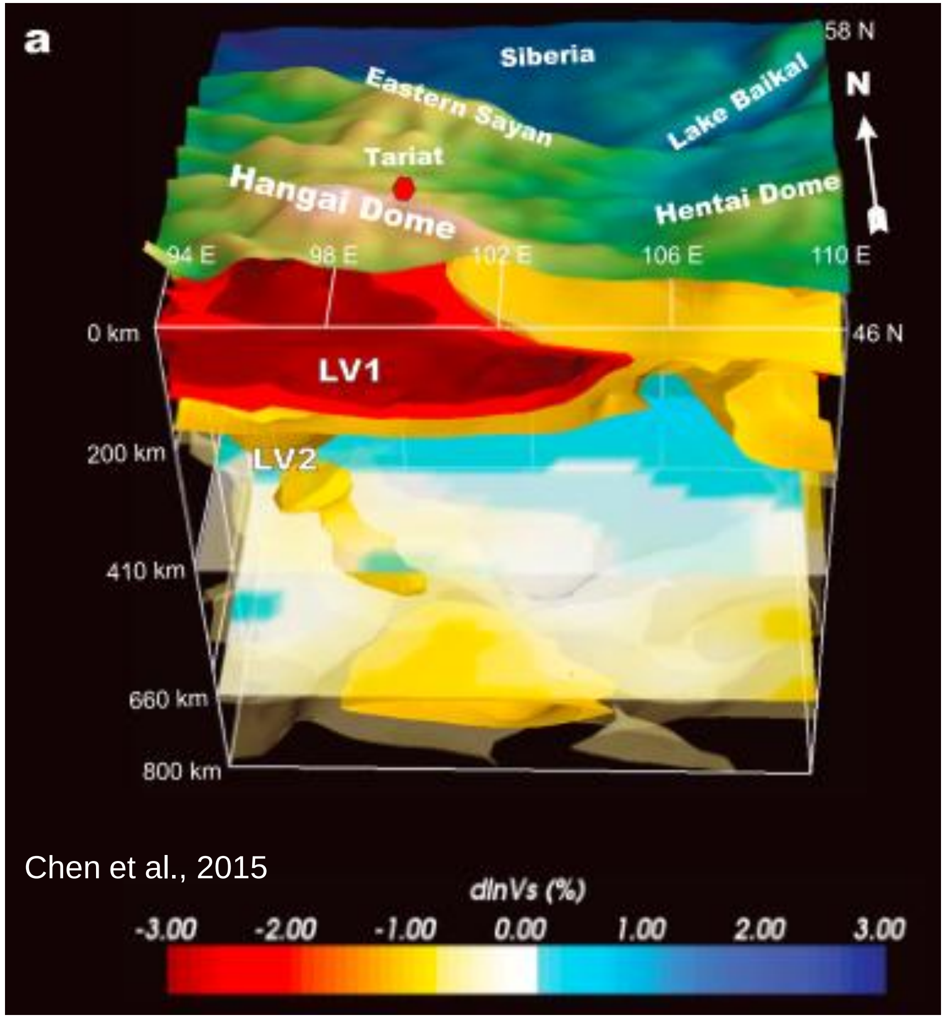

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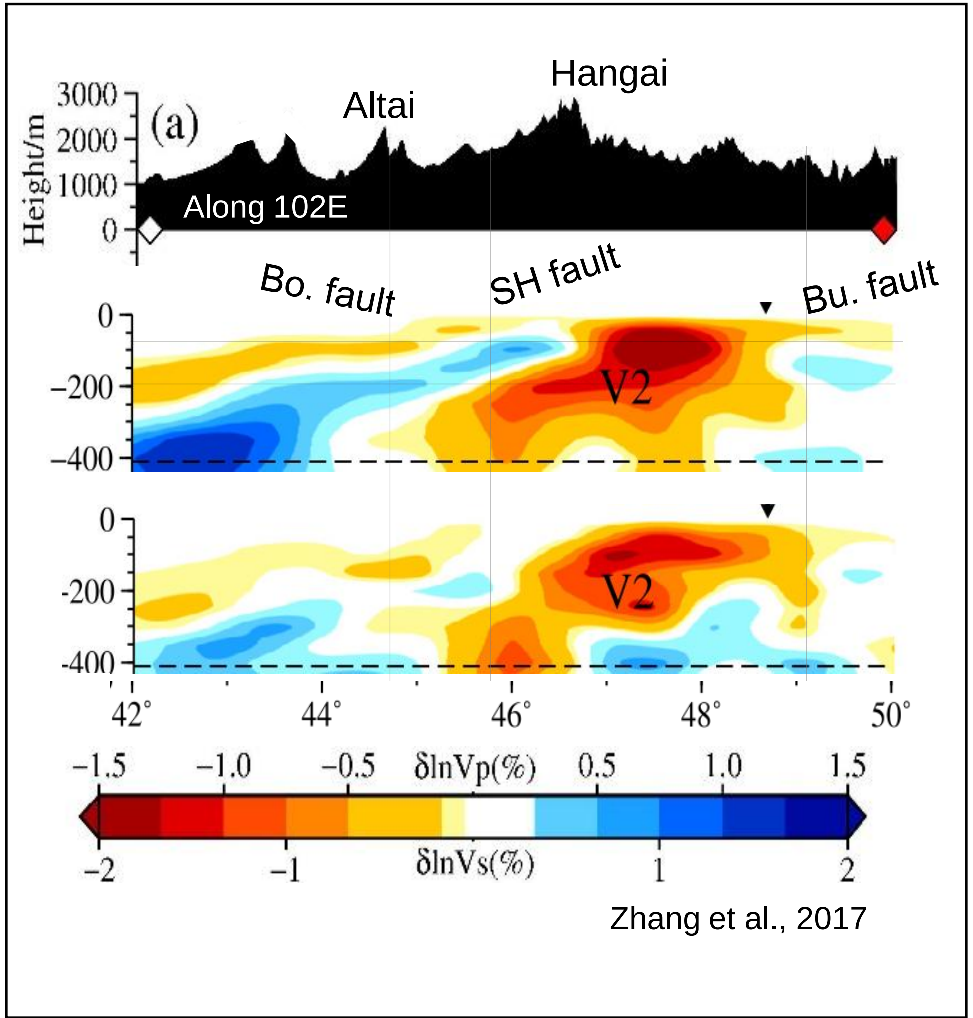
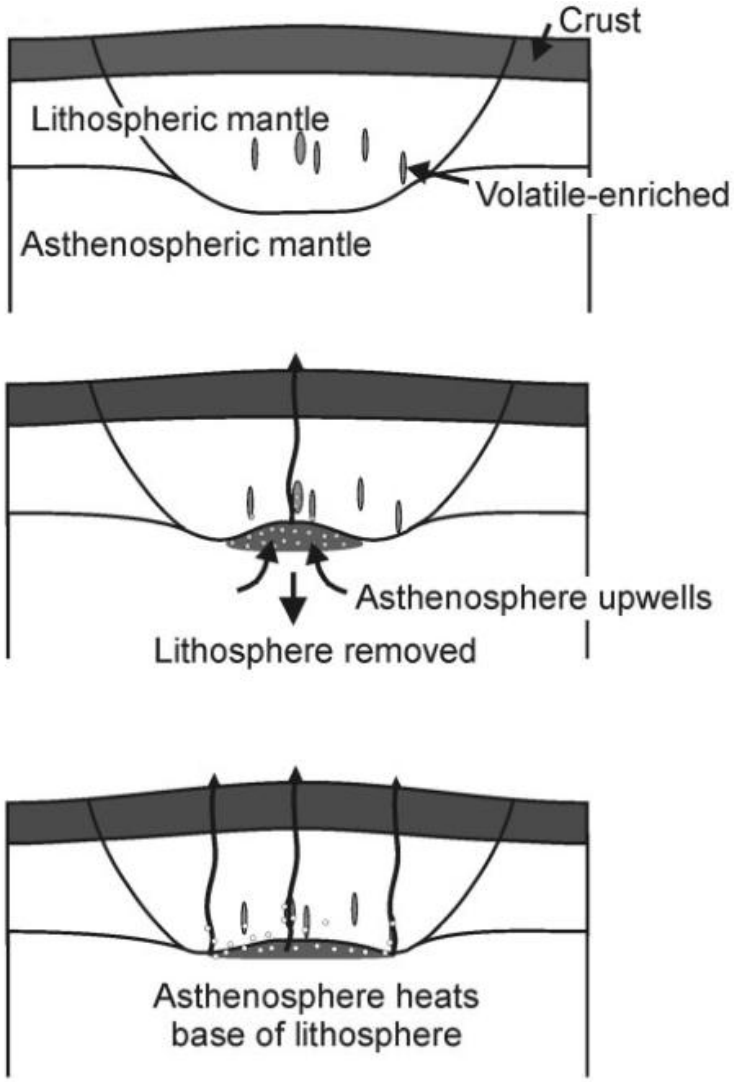


Zhang et al., 2017

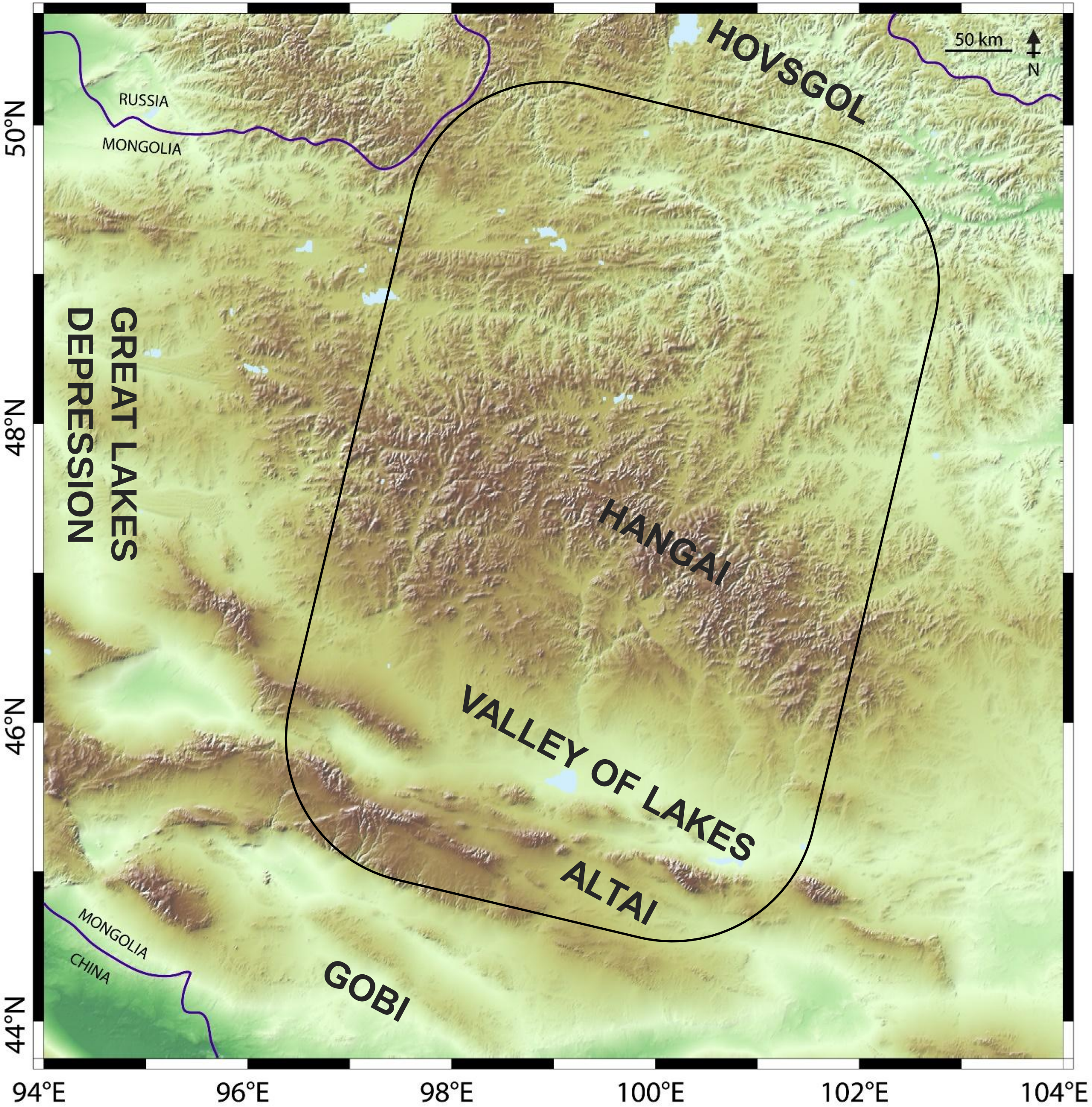
Models for plateau growth and volcanism
- Petrology

- Asthenospheric upwelling can explain sporadic volcanism



Hunt et al., 2012

Magnetotelluric Array: west-central Mongolia



Extensive magnetotelluric survey across west-central Mongolia carried out in 2016 & 2017

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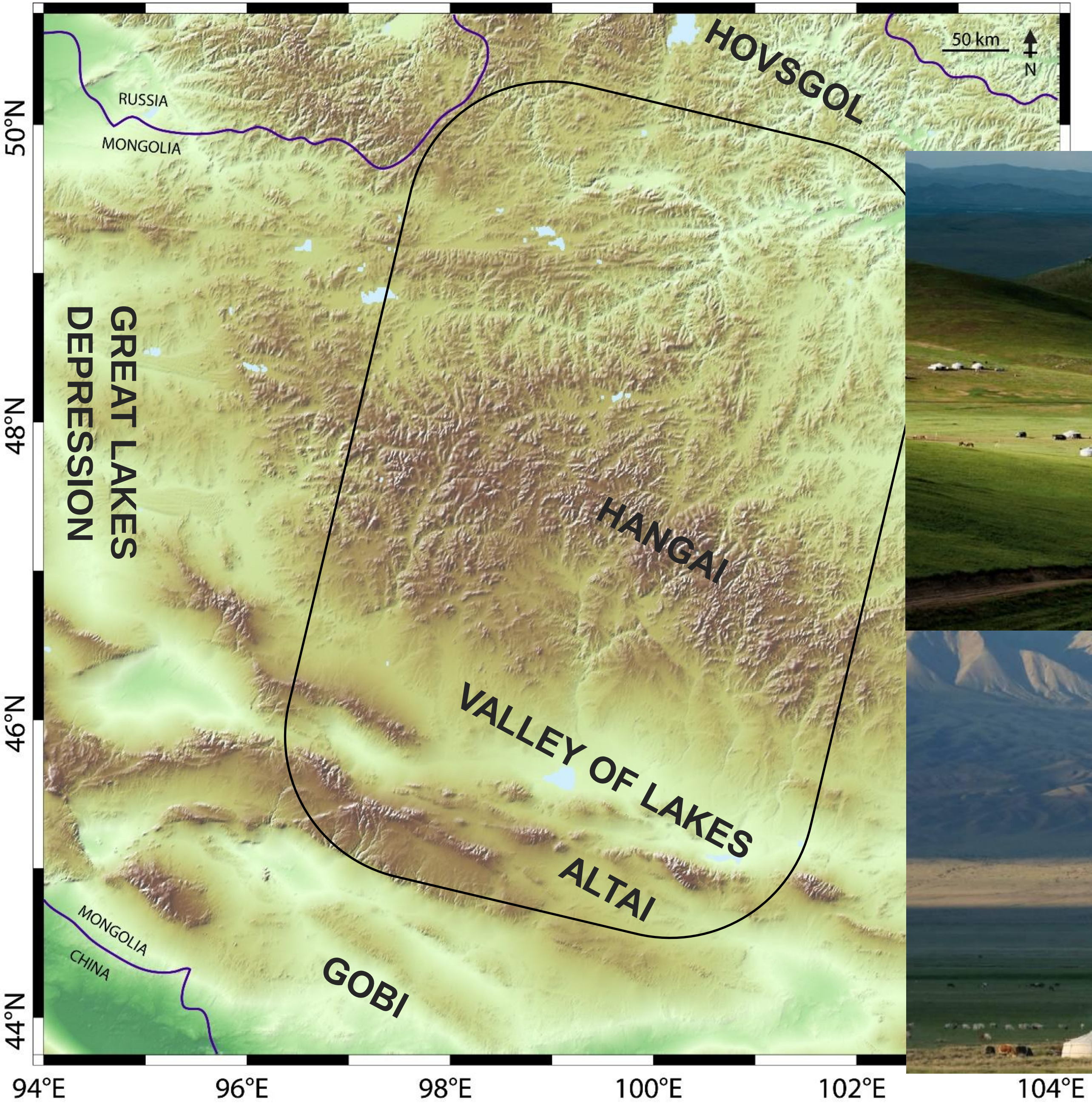

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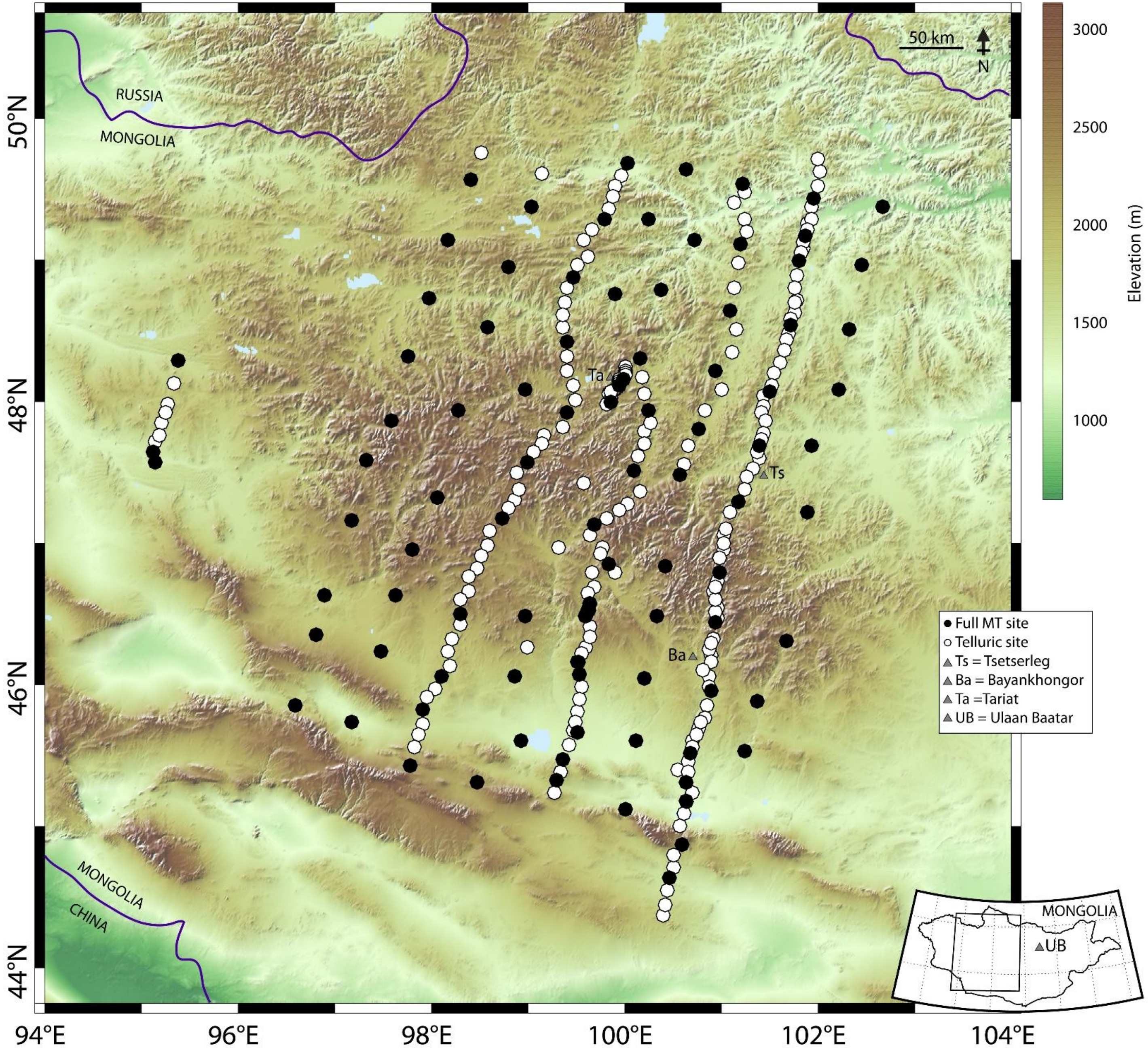

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- Combined MT sites (broadband/long-period) and telluric-only sites (fast and efficient)

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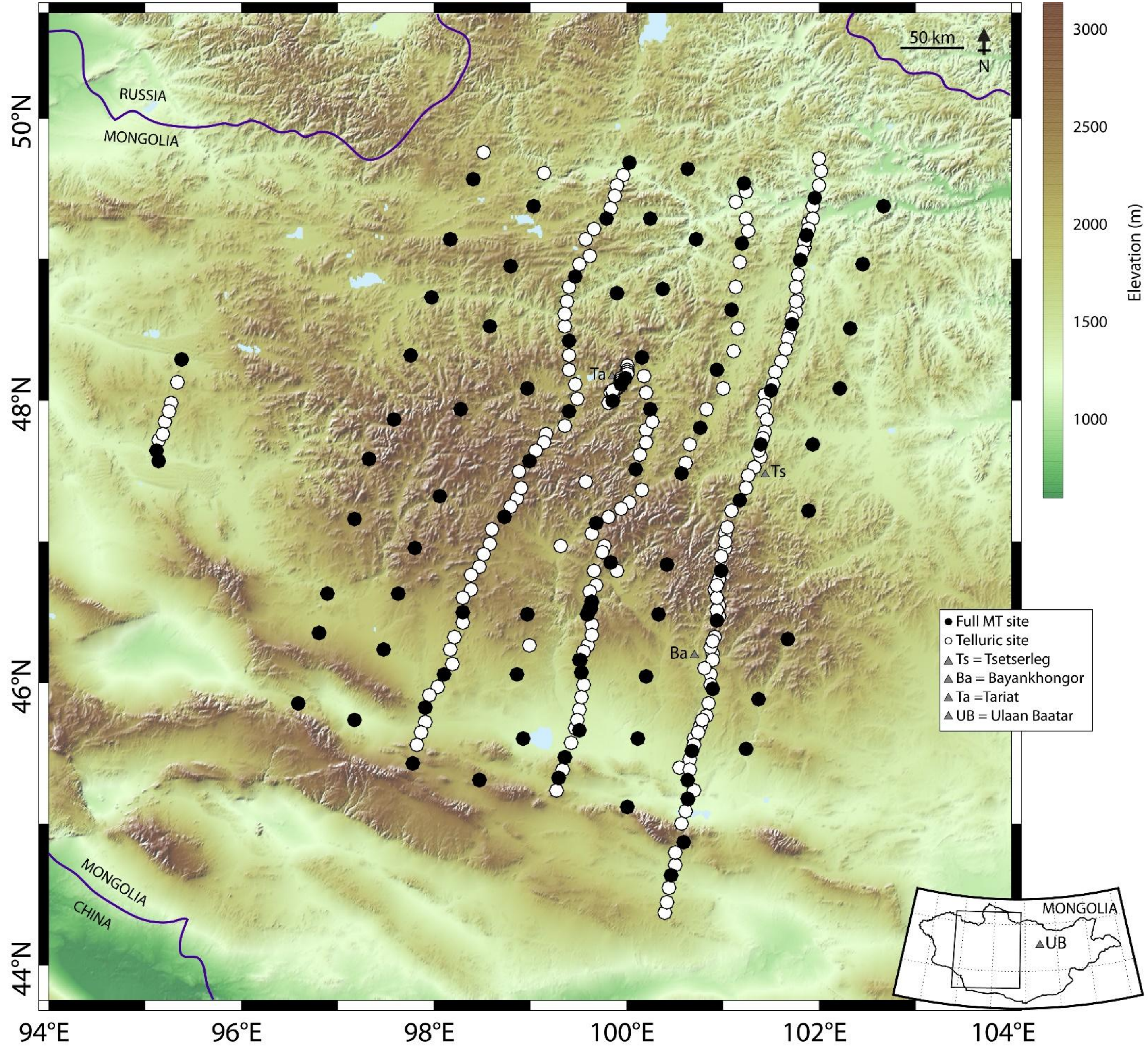

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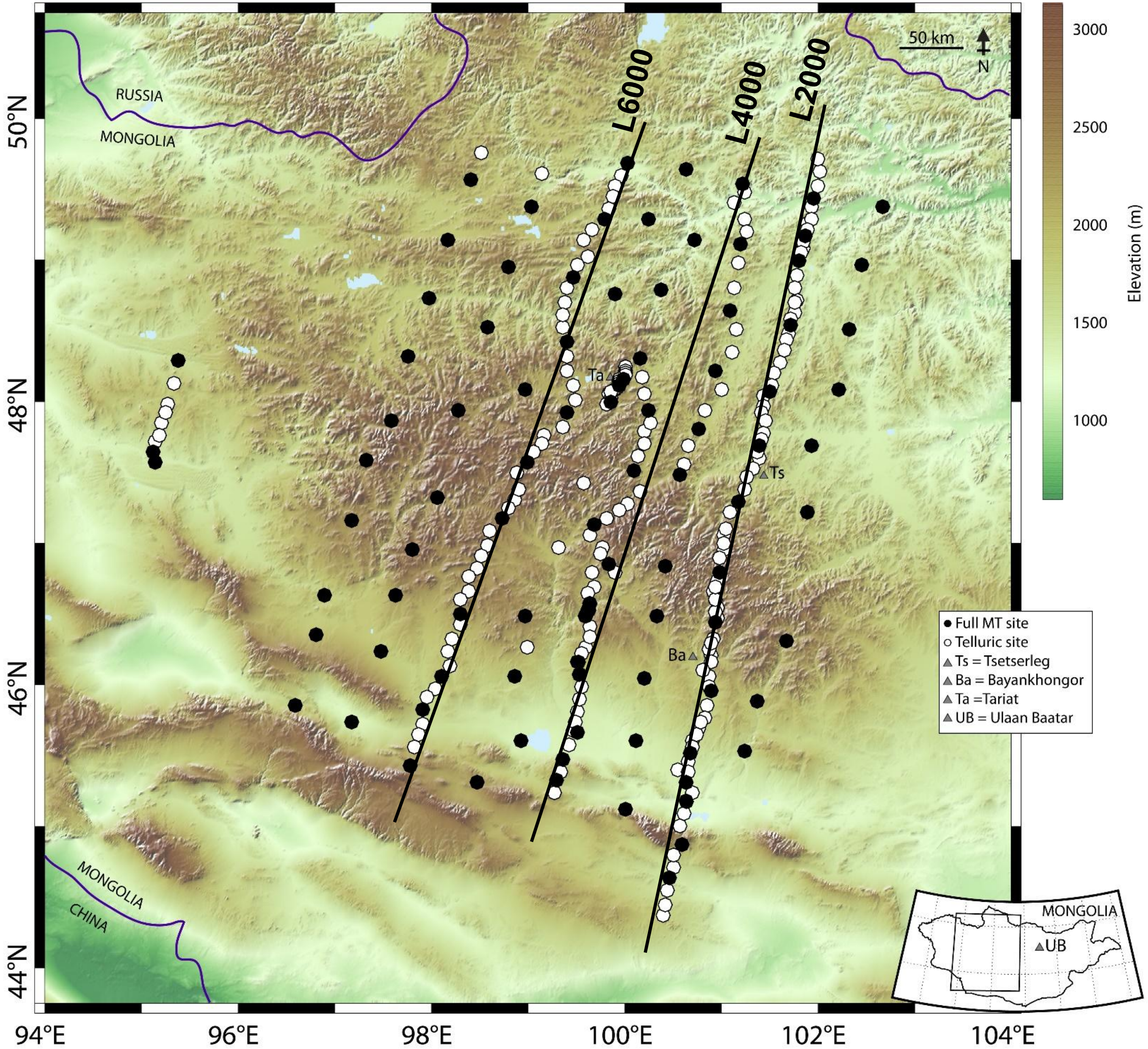

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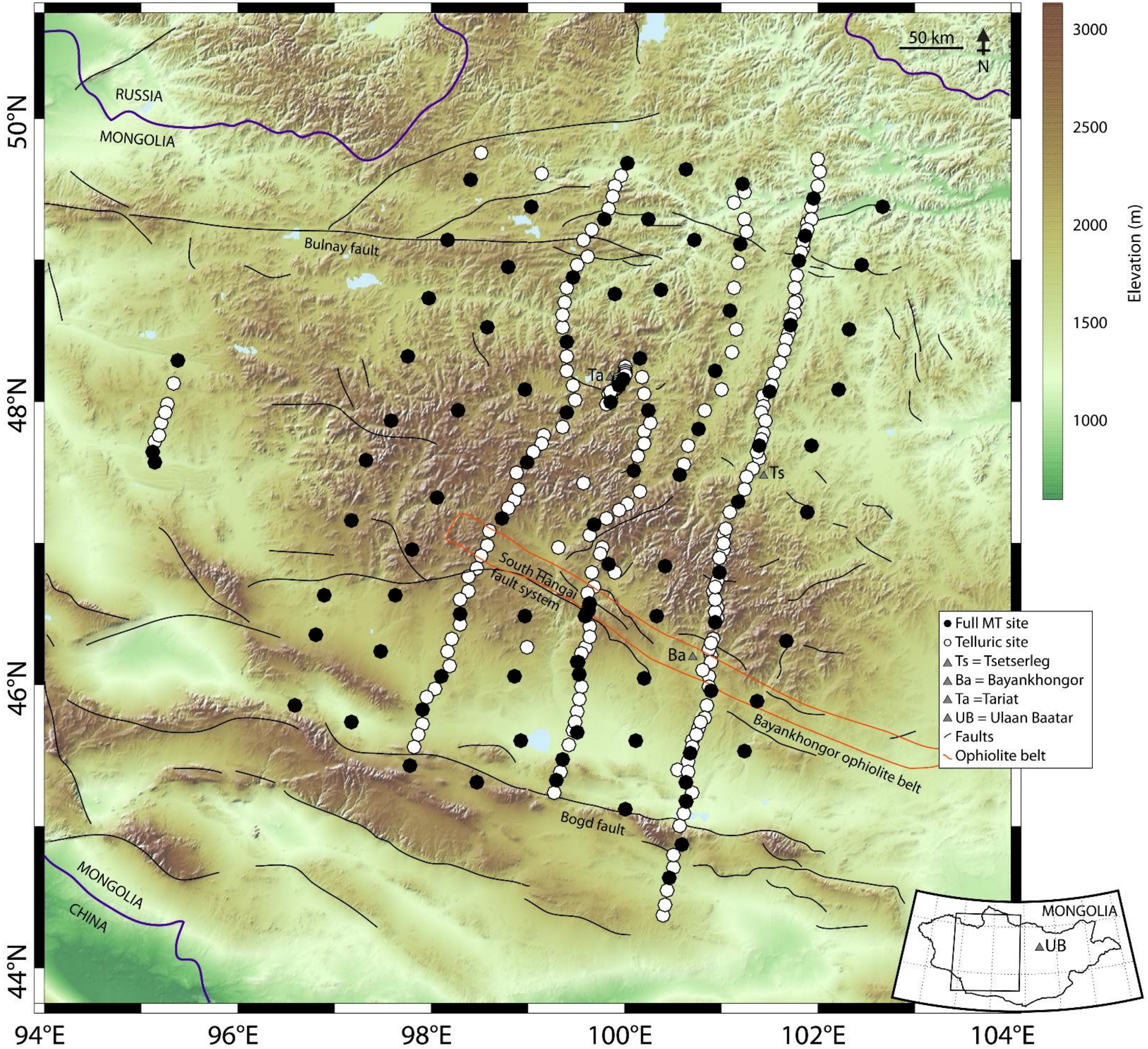
- 3-D MT array (~50 km spacing)
- Dense 2-D profiles (5-10 km)

Magnetotelluric Array



- Array crosses Hangai Dome, bounding faults Bulnay & Bogd, and reaches Altai

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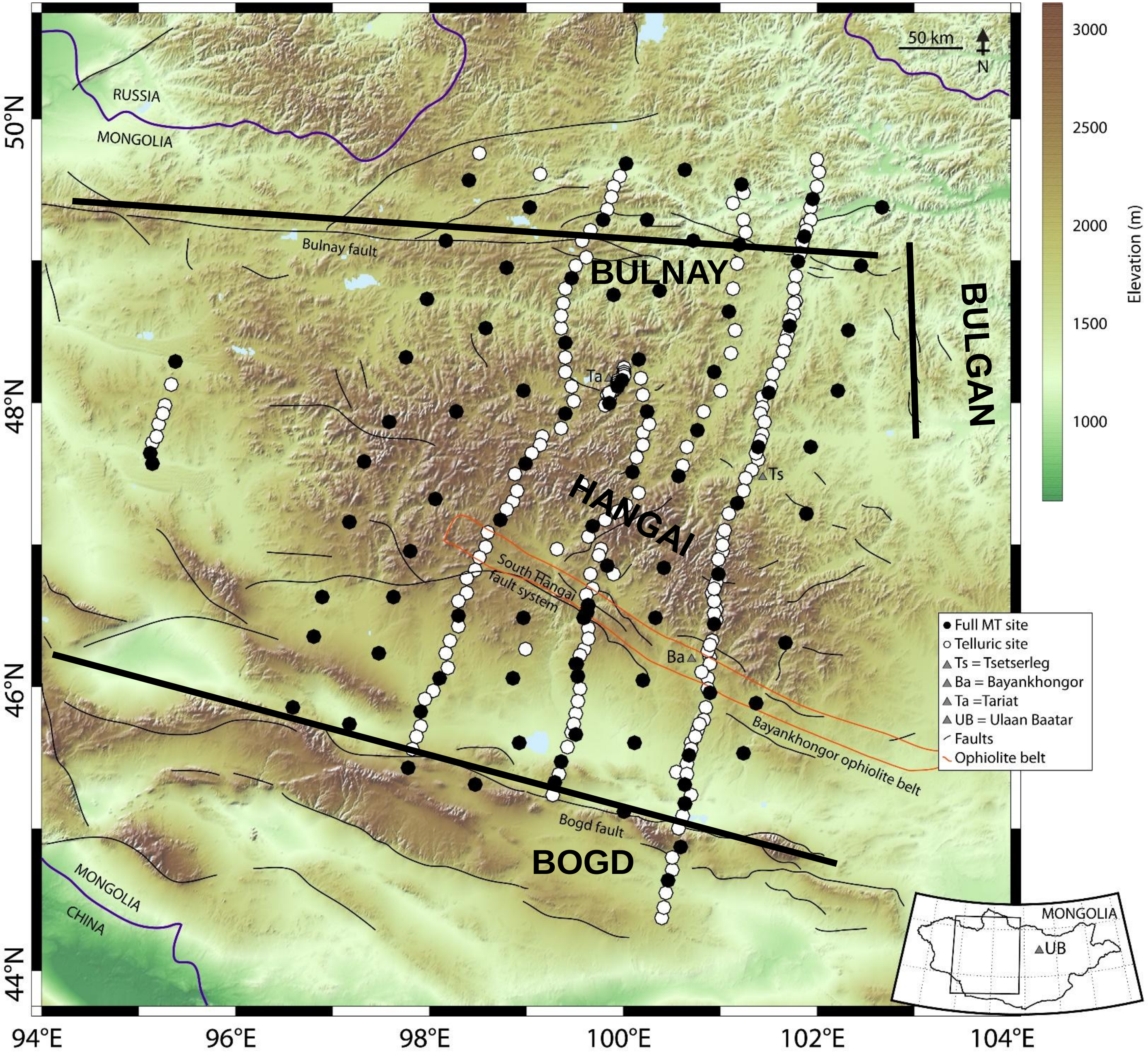

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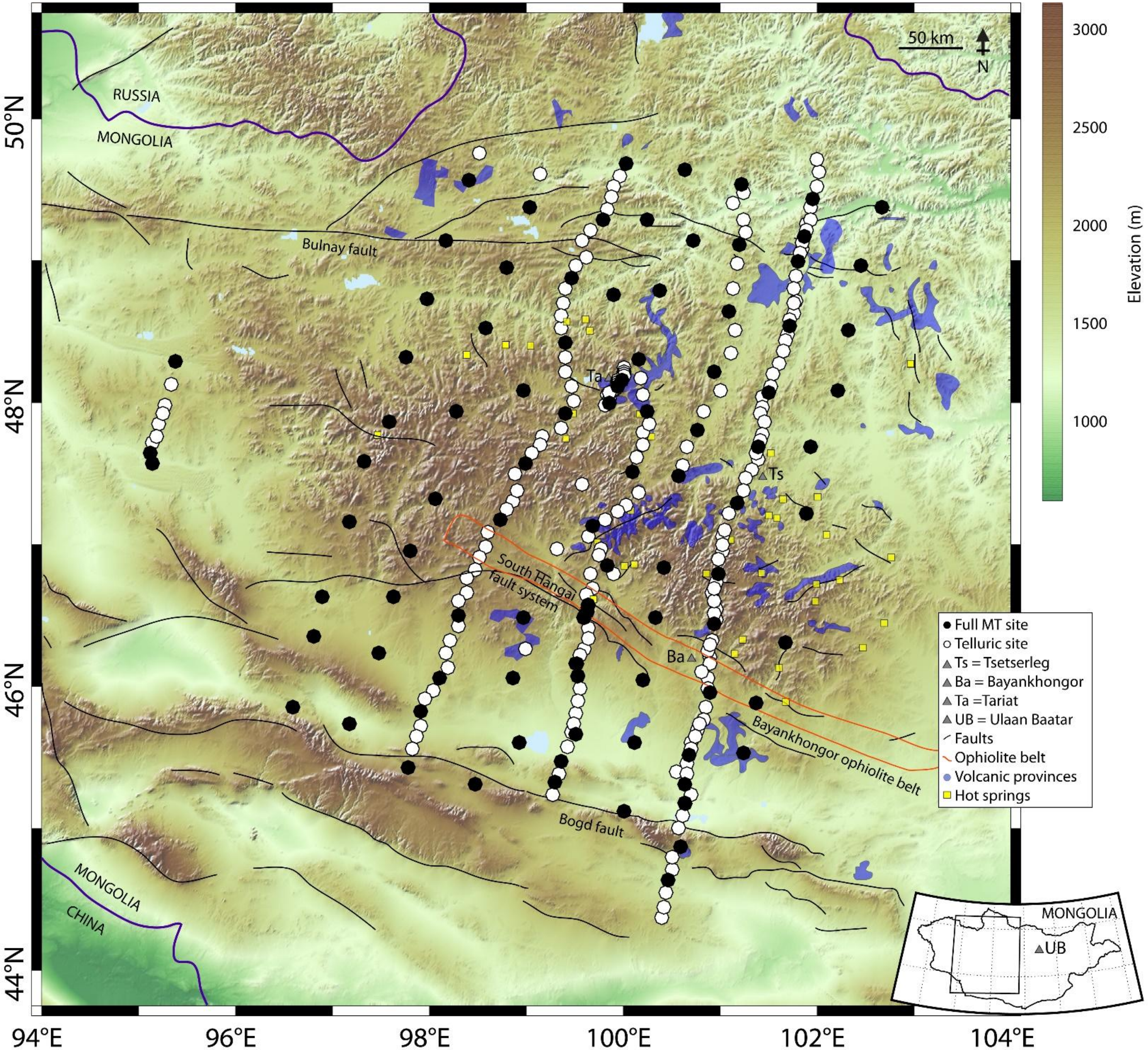
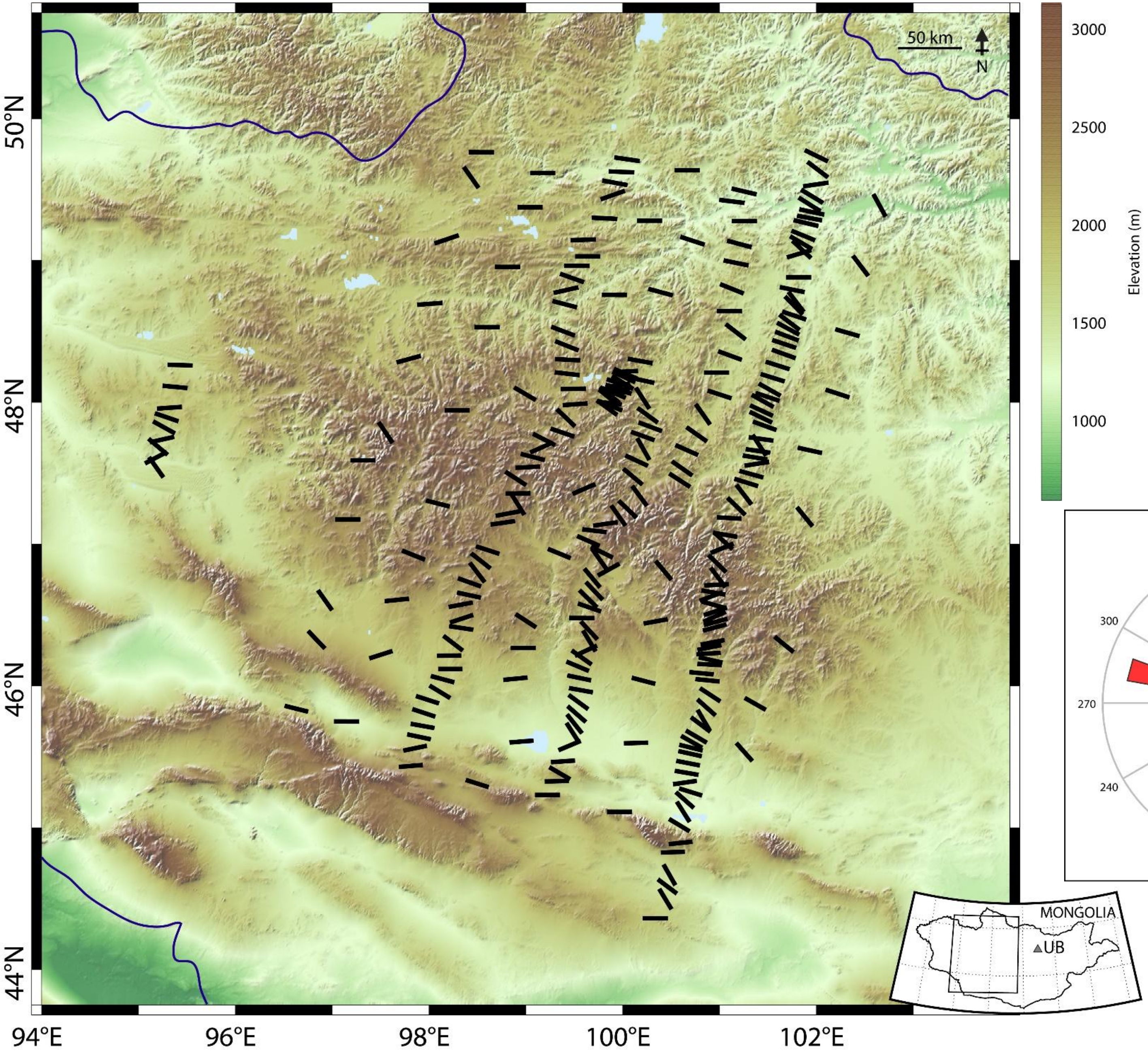
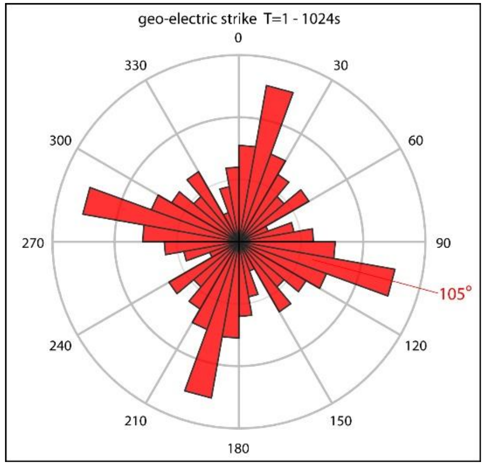


- Array crosses Hangai Dome, bounding faults Bolnay & Bogd, and reaches Altai
- Central Hangai has youngest volcanism and high concentration of hydrothermal systems

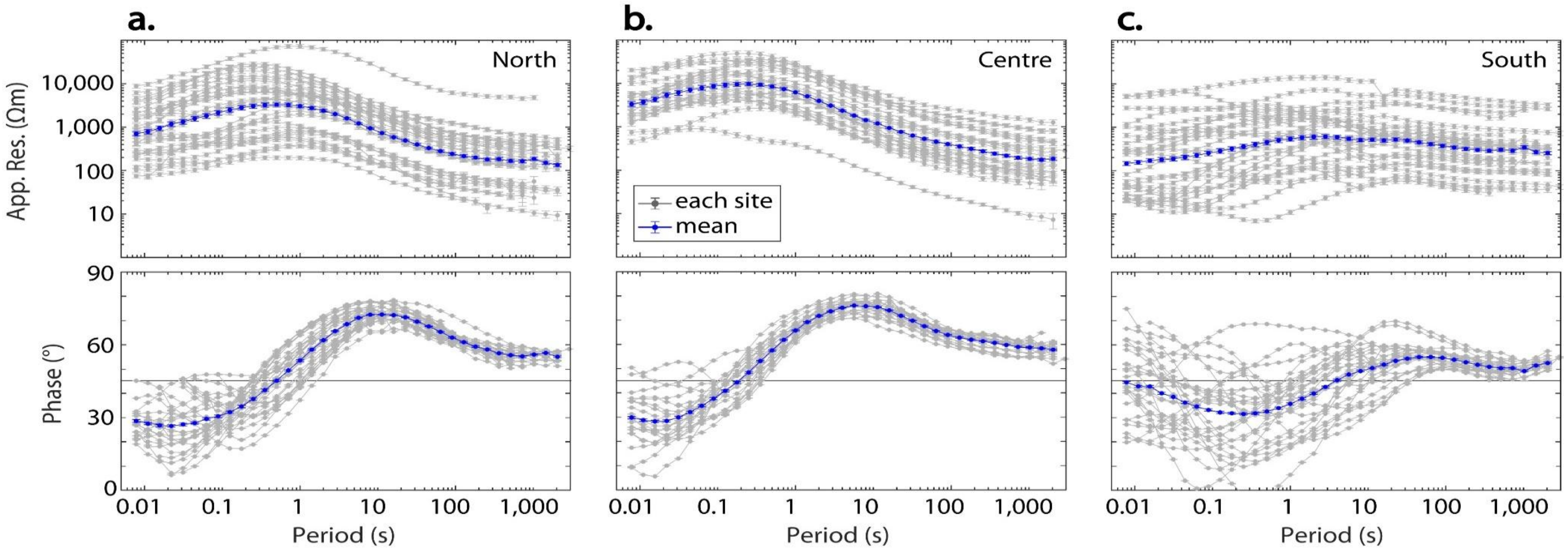
Magnetotelluric Array – Geo-electric Strike



- •Strike direction is consistent across array (>1s)
- •Consistent with trend of faults and mountain ranges
- •Local, small-scale 3-D features

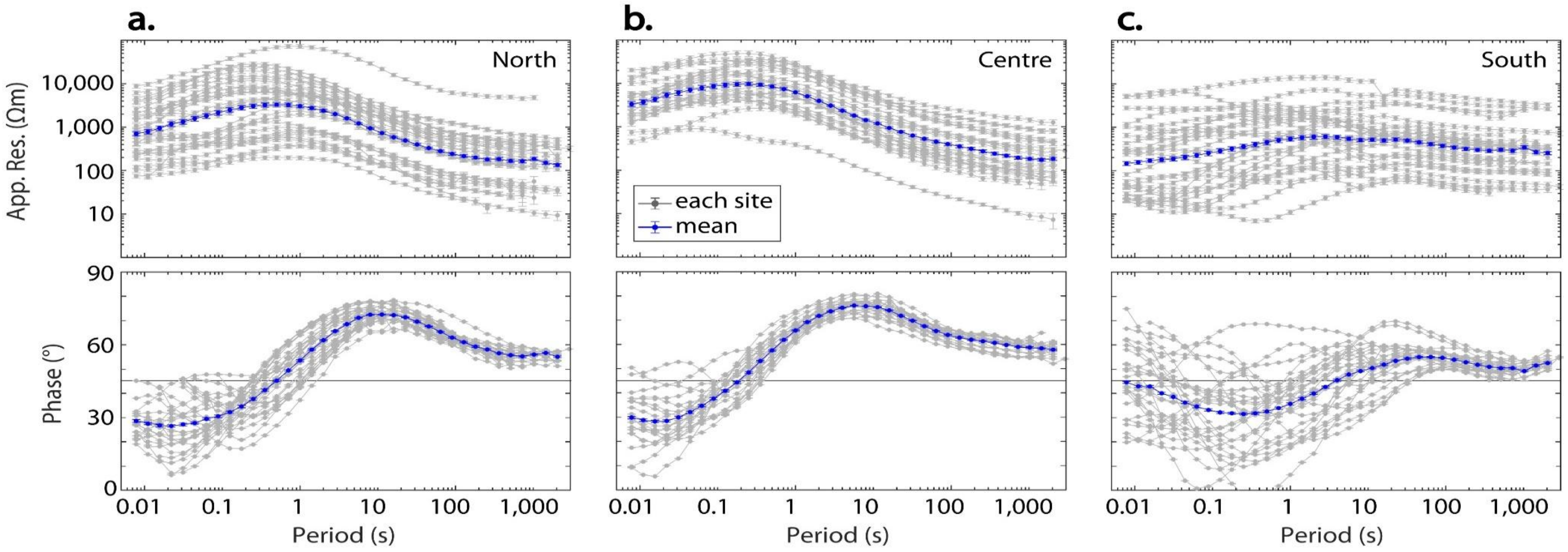


MT data & 1-D model

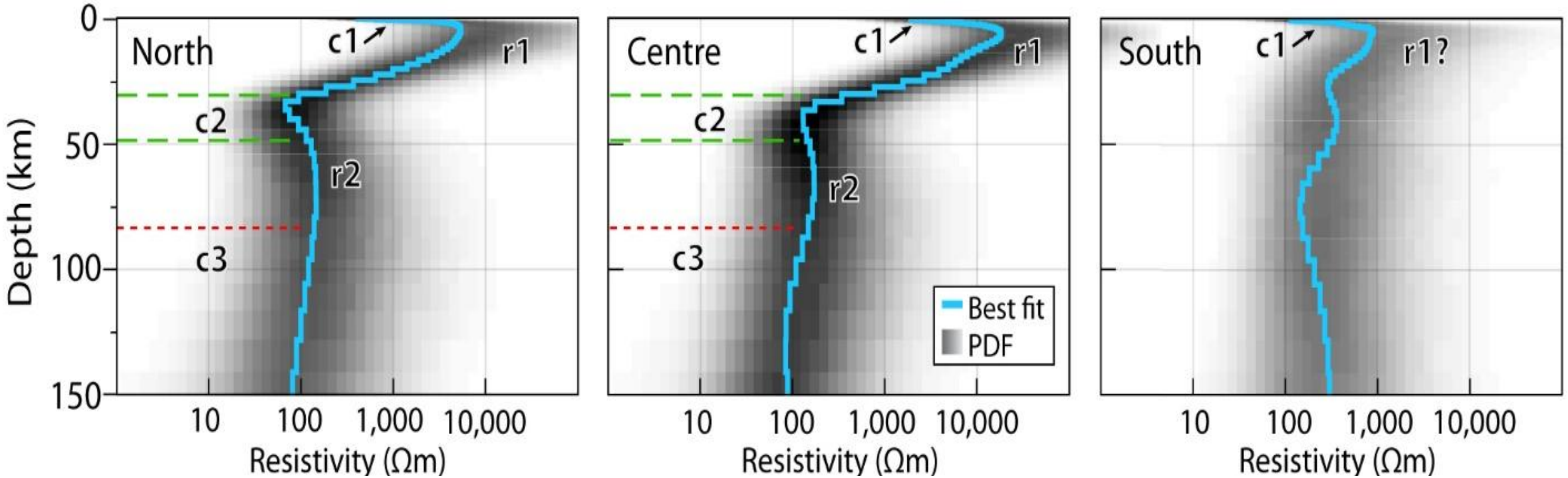


1. MT data curves for all MT sites and their geometric mean (using ssq; Rung-Arunwan et al., 2016).

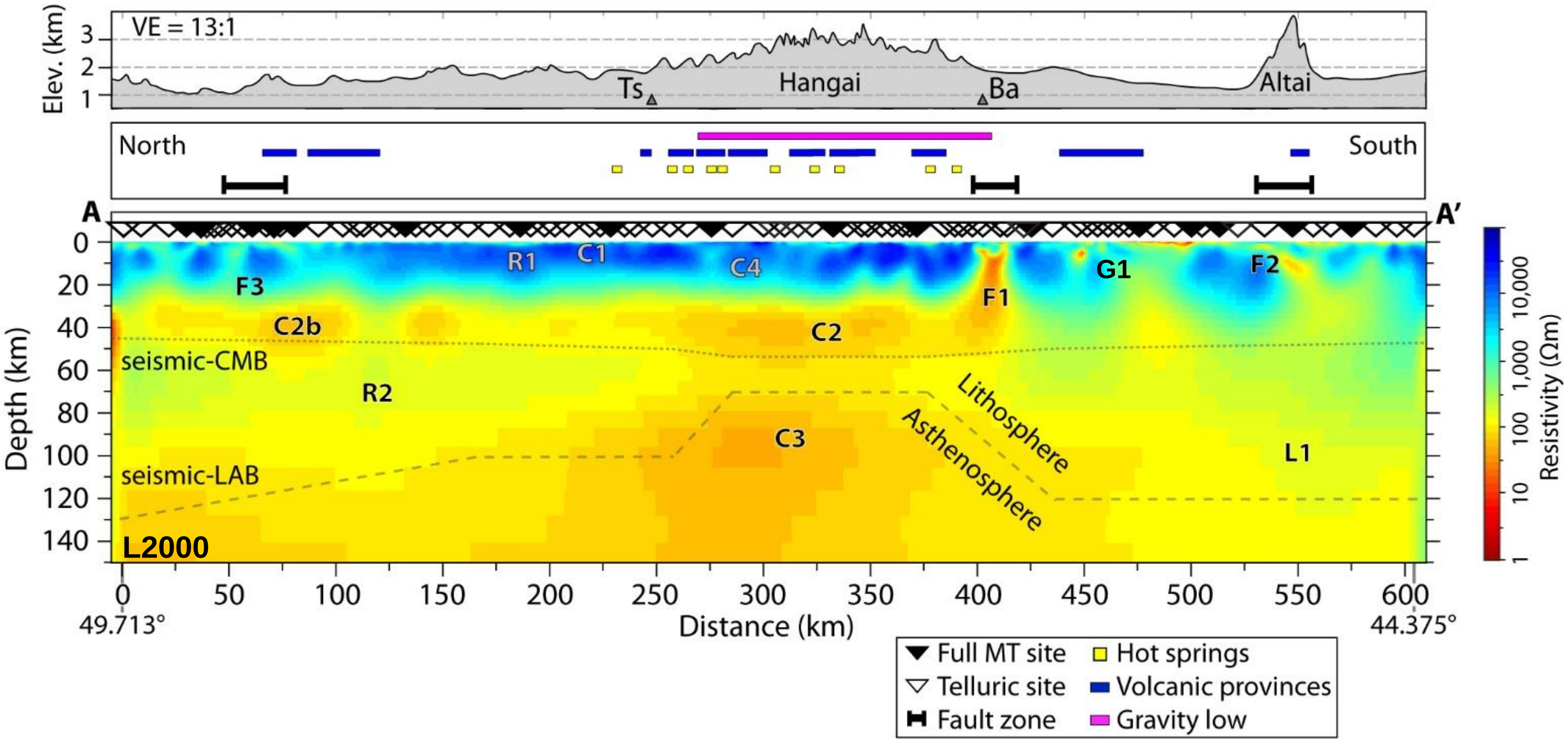
MT data & 1-D model



1. MT data curves for all MT sites and their geometric mean (using ssq; Rung-Arunwan et al., 2016).
2. 1-D probabilistic inversion quantifies the uncertainty (algorithm of Grayver & Kuvshinov, 2016).



2-D resistivity model: Line-2000

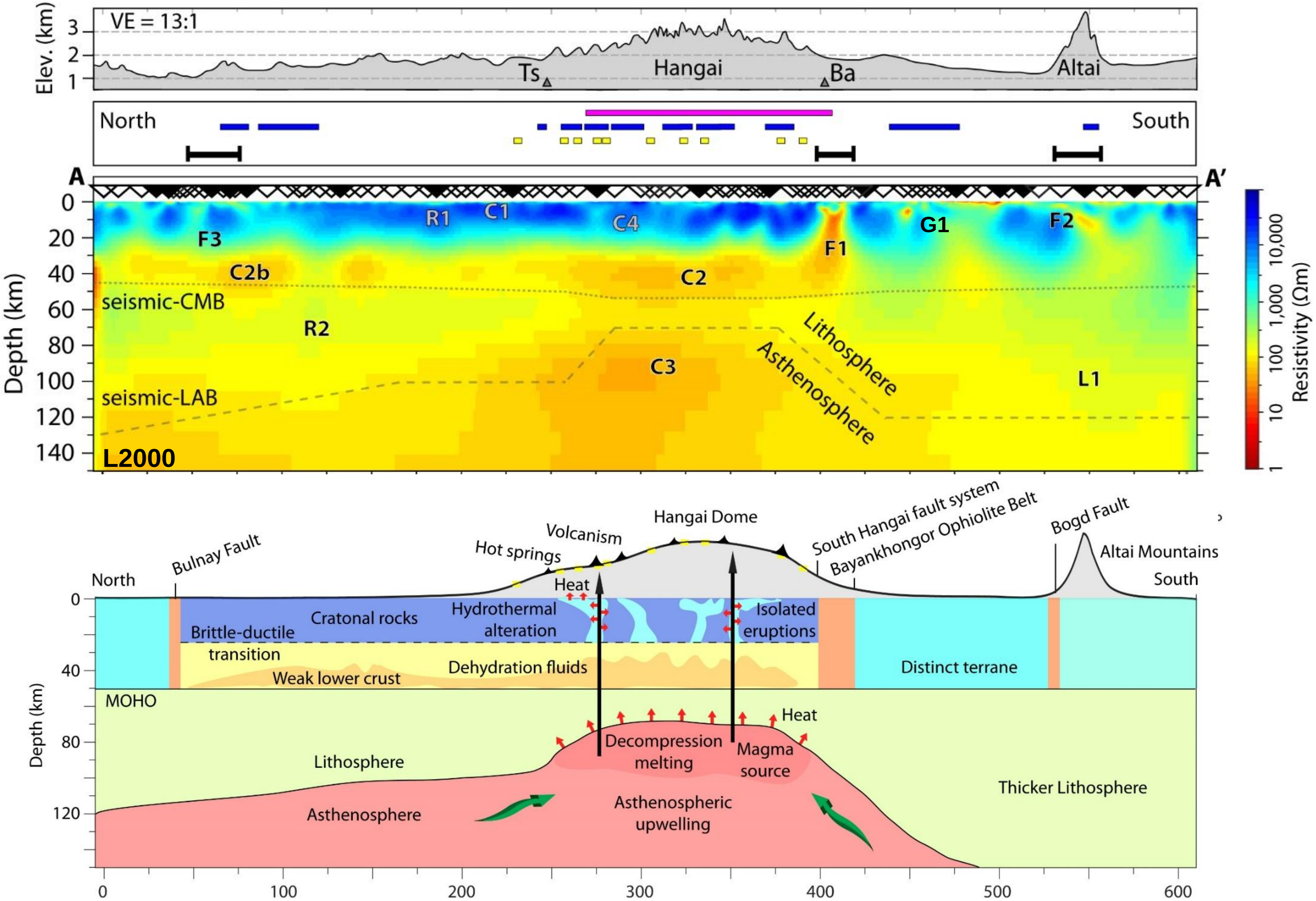


Resistivity model obtained from the 2-D inversion of magnetotelluric (MT) data at 89 sites along line-2000, using the EMILIA algorithm of Kalscheuer et al. (2010).

Evidence for fluid and melt generation in response to an asthenospheric upwelling beneath the Hangai Dome, Mongolia.

M.J. Comeau, et al., Earth and Planetary Science Letters, 2018

2-D resistivity model & interpretation



2-D resistivity models: Lines-2/4/6000

What do other lines show ?
Are there east-west variations ?

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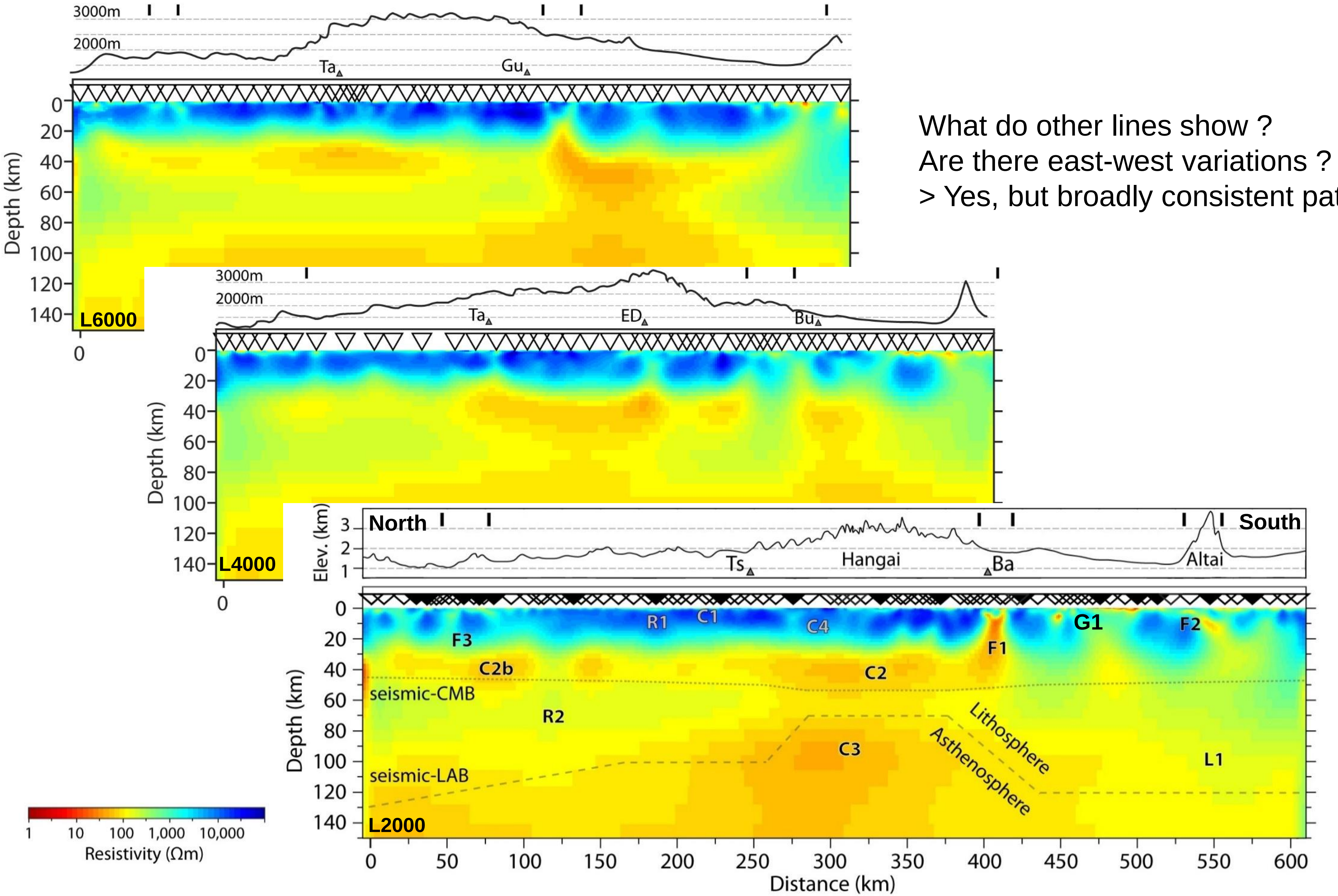

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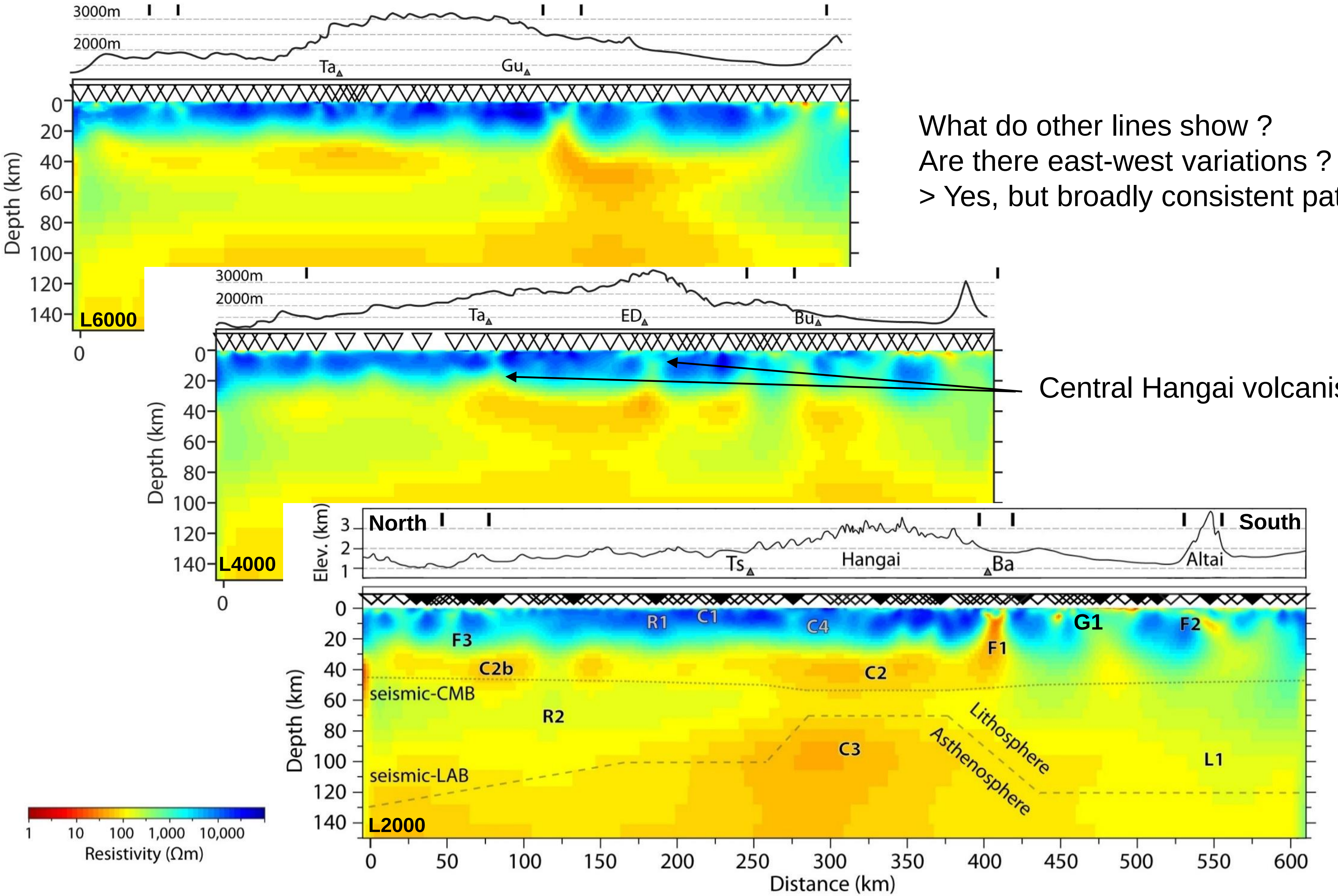

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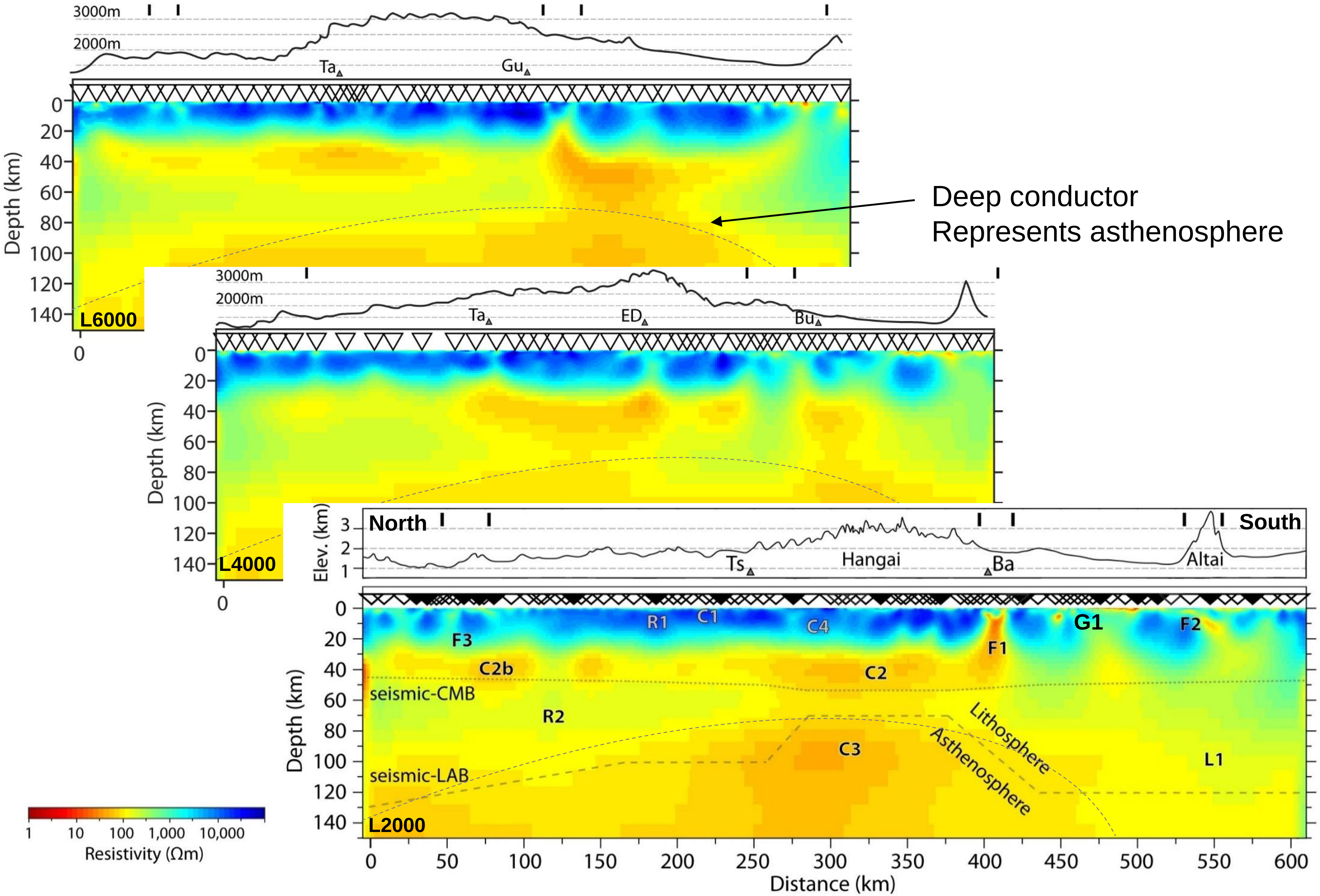
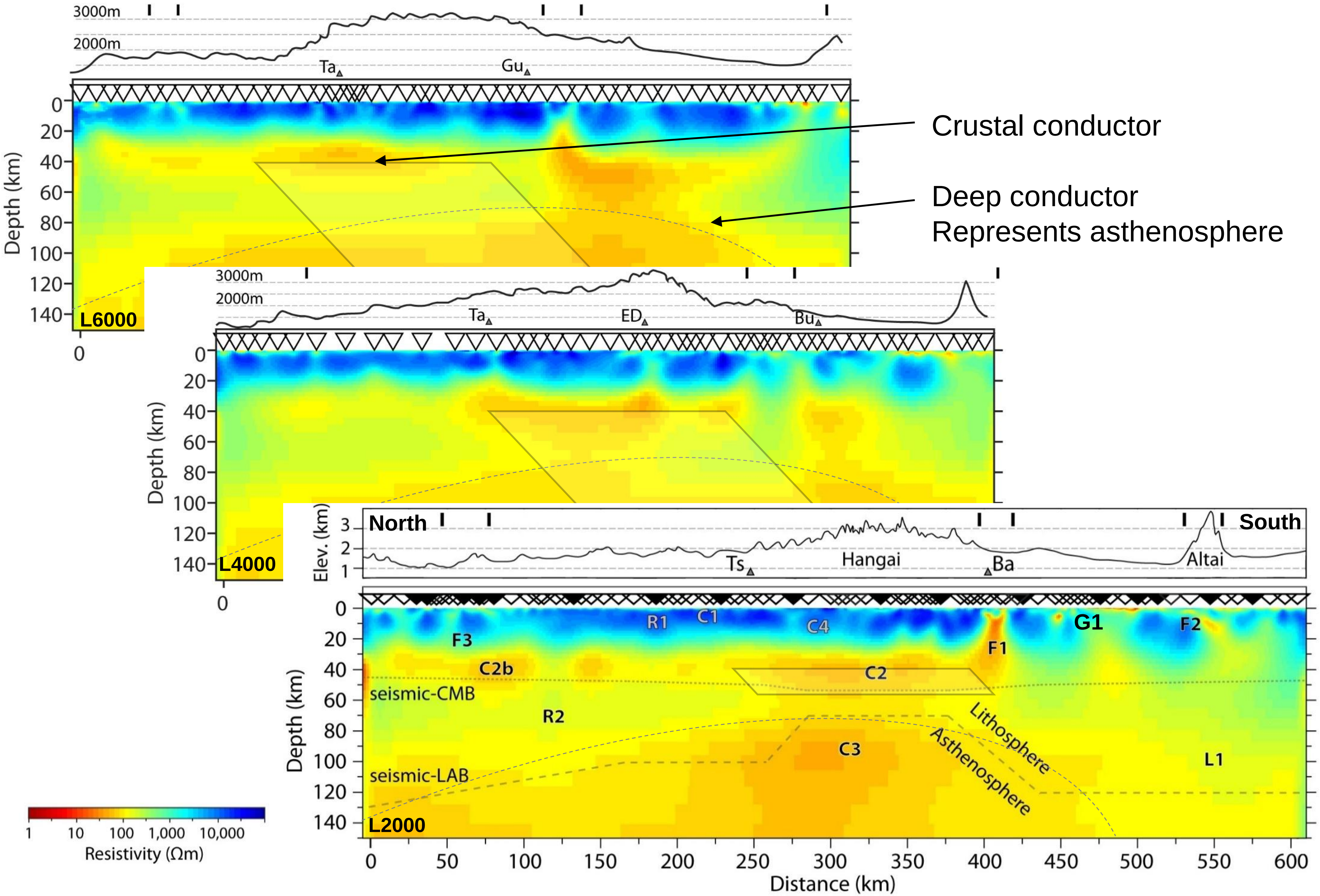


Deep conductor
Represents asthenosphere

2-D resistivity models: Lines-2/4/6000



Crustal conductor

Deep conductor
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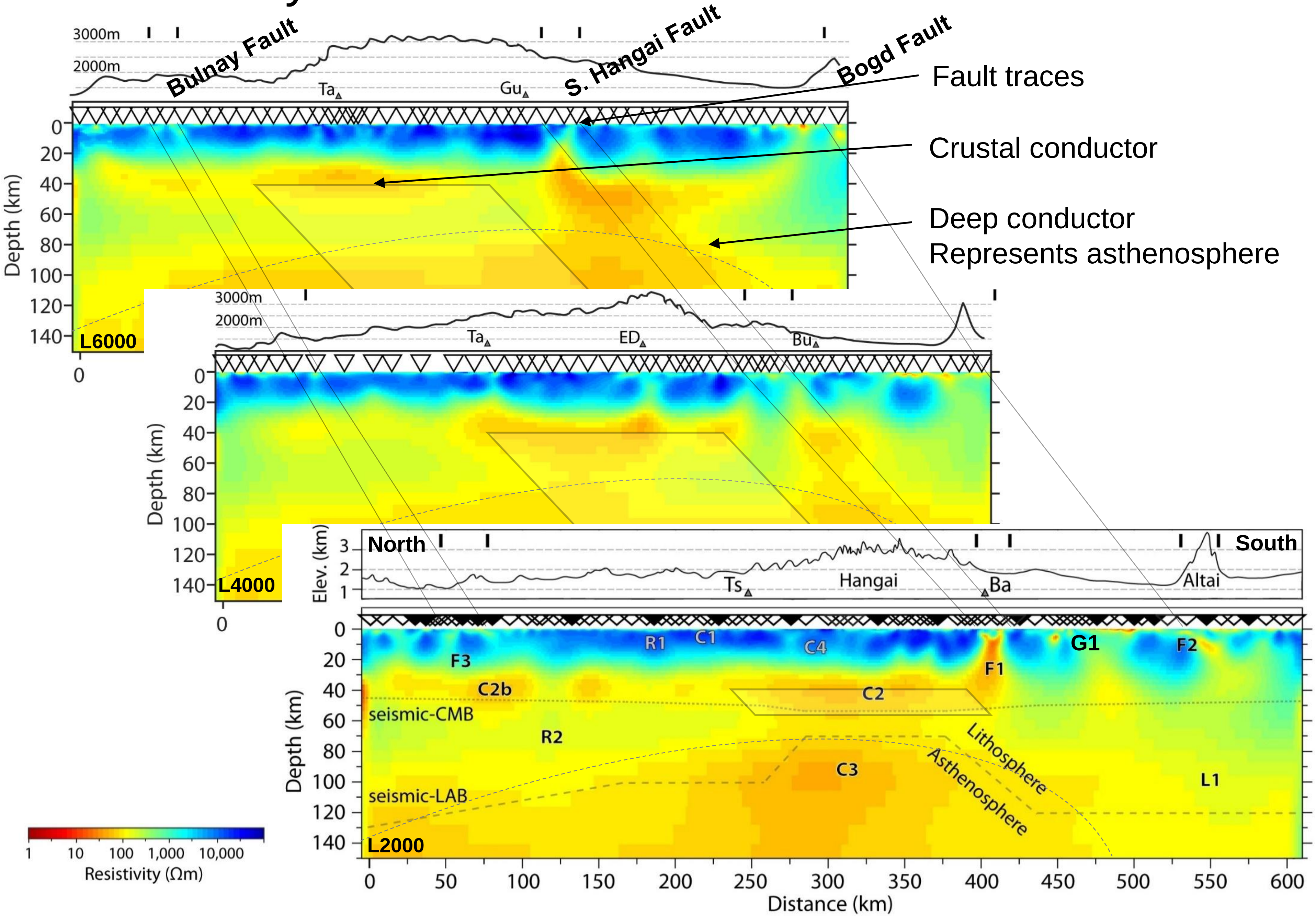
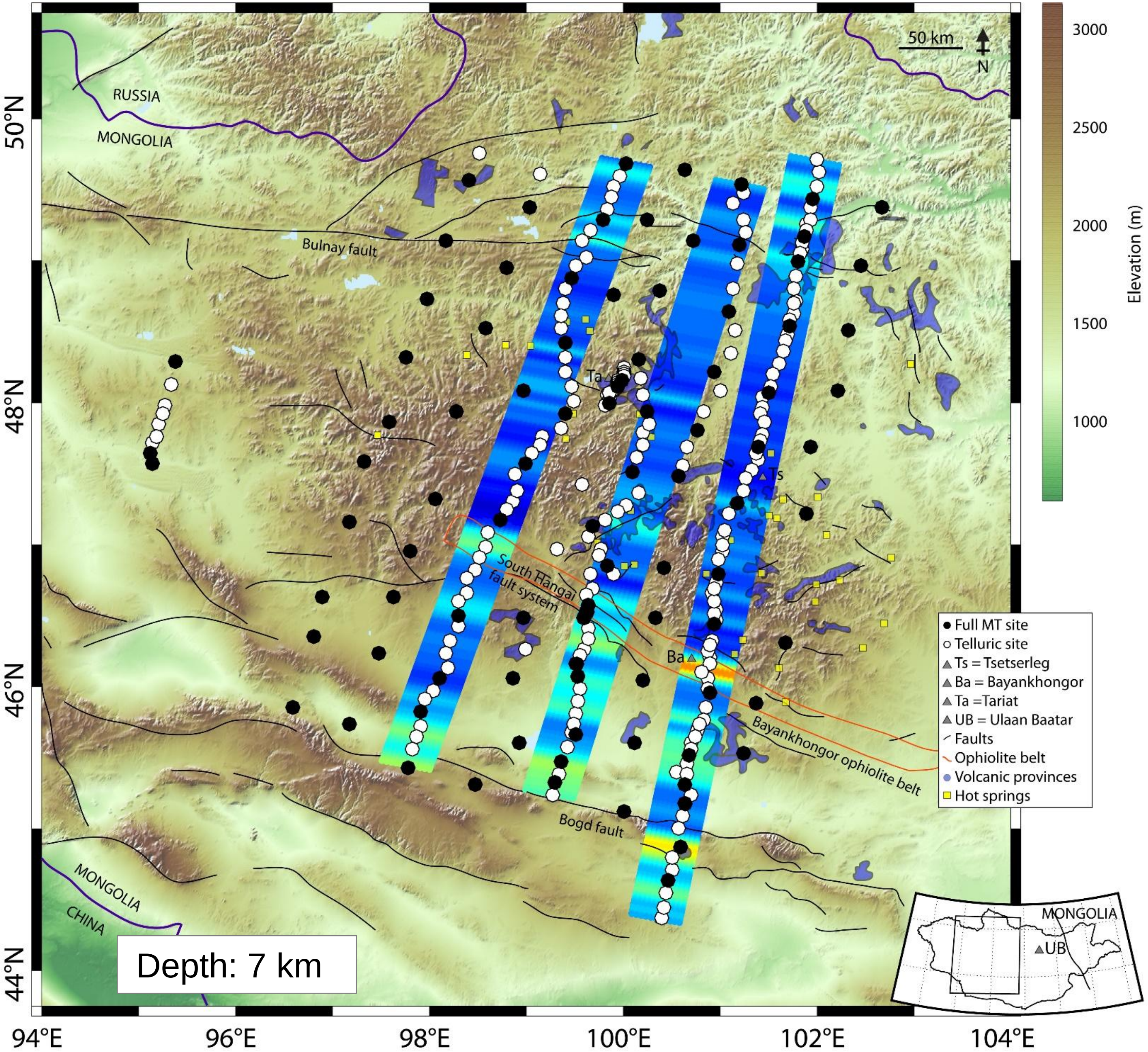


Resistivity map view



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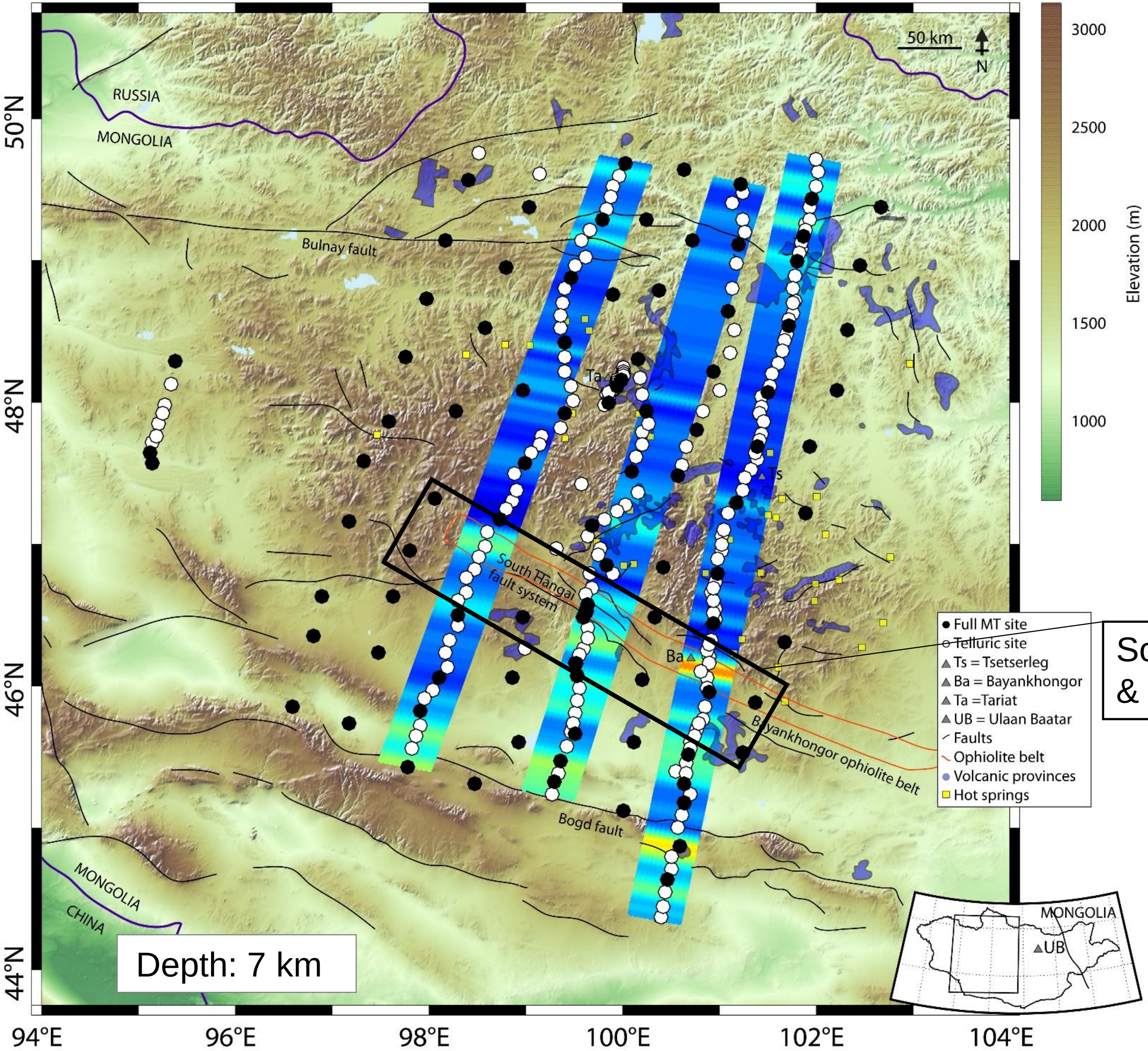
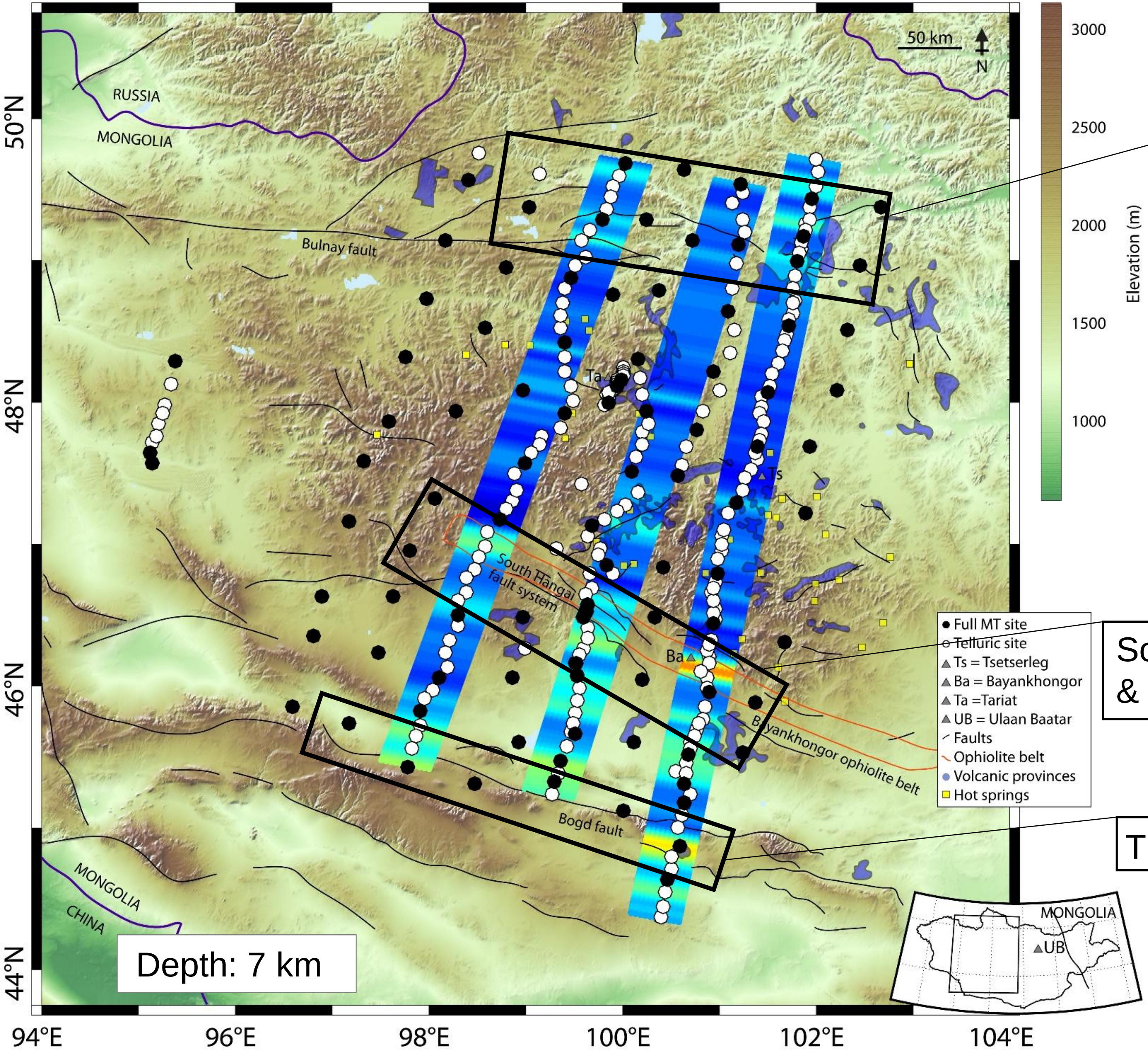


South Hangai fault system
& mineralized ophiolite belt

Resistivity map view



Bolnay Fault

South Hangai fault system & mineralized ophiolite belt

The Altai & Bogd fault

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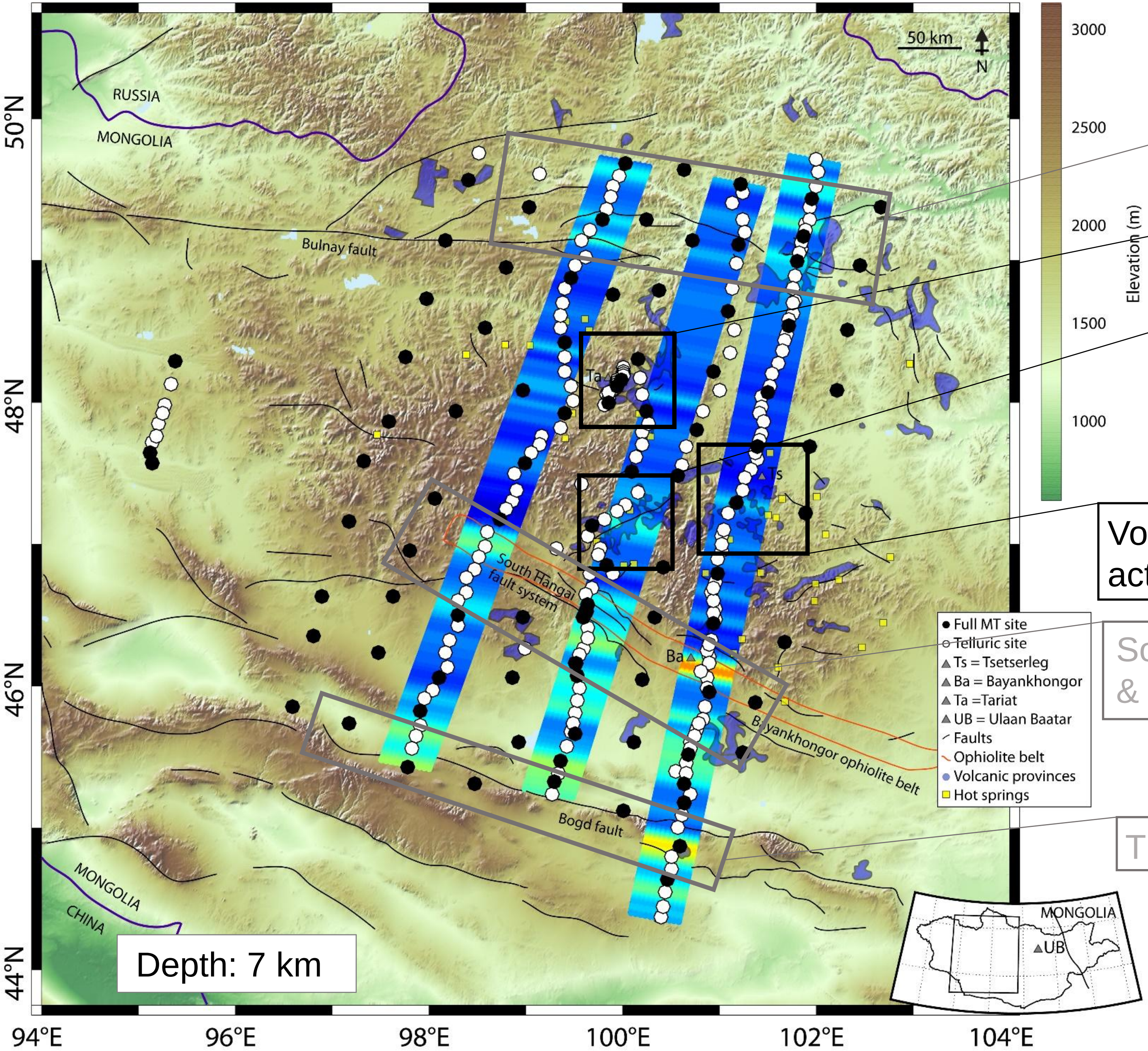


Depth: 7 km

Bolnay Fault

Volcanism at Tariat

Volcanism at Chuluut

Volcanism & hydrothermal activity in Tsetserleg

South Hangai fault system & mineralized ophiolite belt

The Altai & Bogd fault

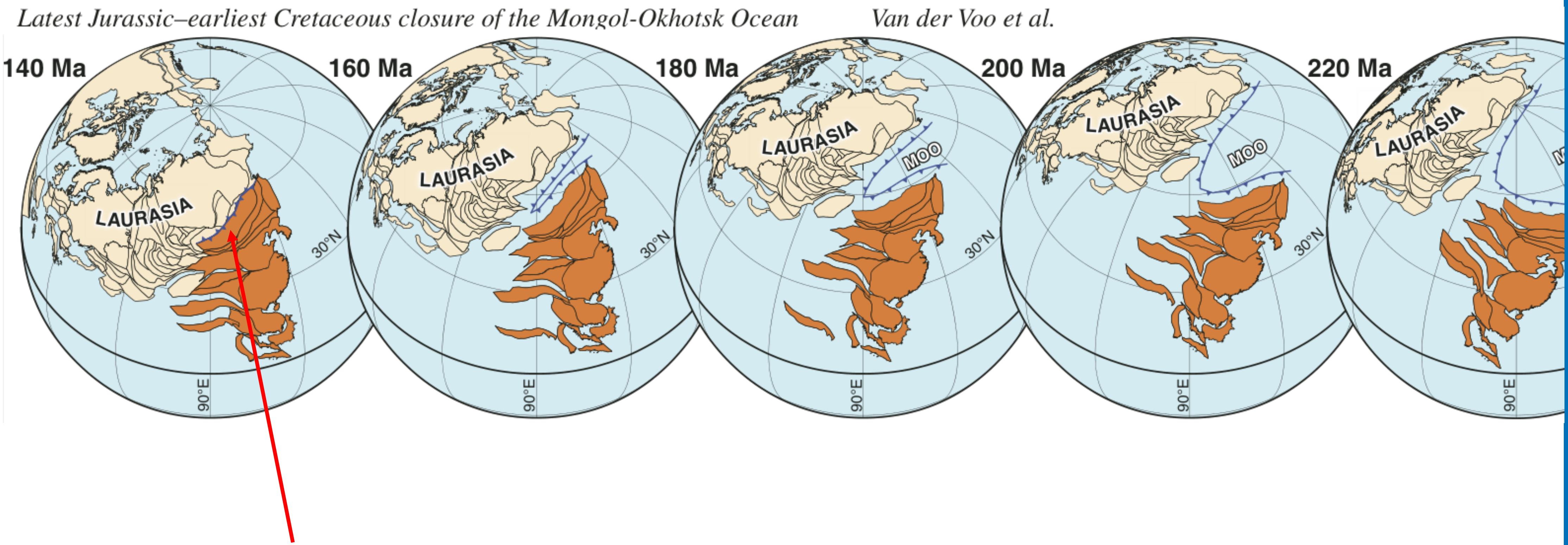
South Hangai fault system & ophiolite belt

The South Hangai fault system and the Bayankhongor ophiolite belt is a very important zone of mineralization

How did it form ?

South Hangai fault system & ophiolite belt

Mongol-Okhotsk Ocean closure created a major suture zone across Mongolia



MOO suture zone

South Hangai fault system & ophiolite belt

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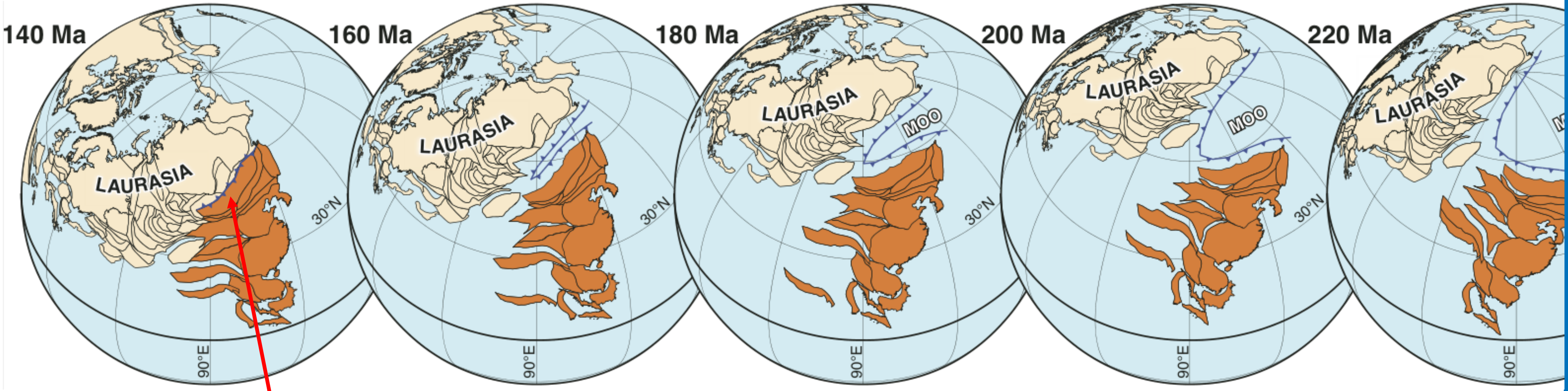
Latest Jurassic–earliest Cretaceous closure of the Mongol-Okhotsk Ocean *Van der Voo et al.*



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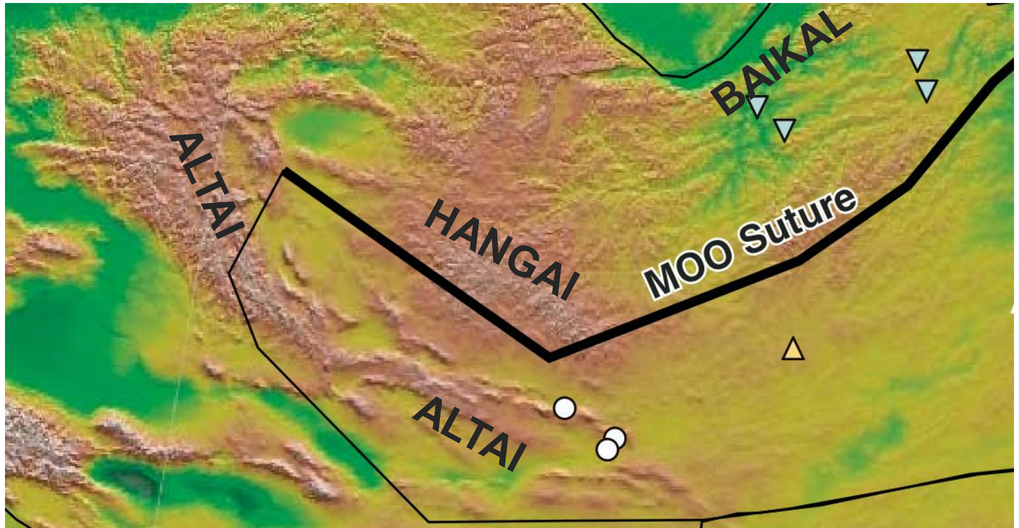
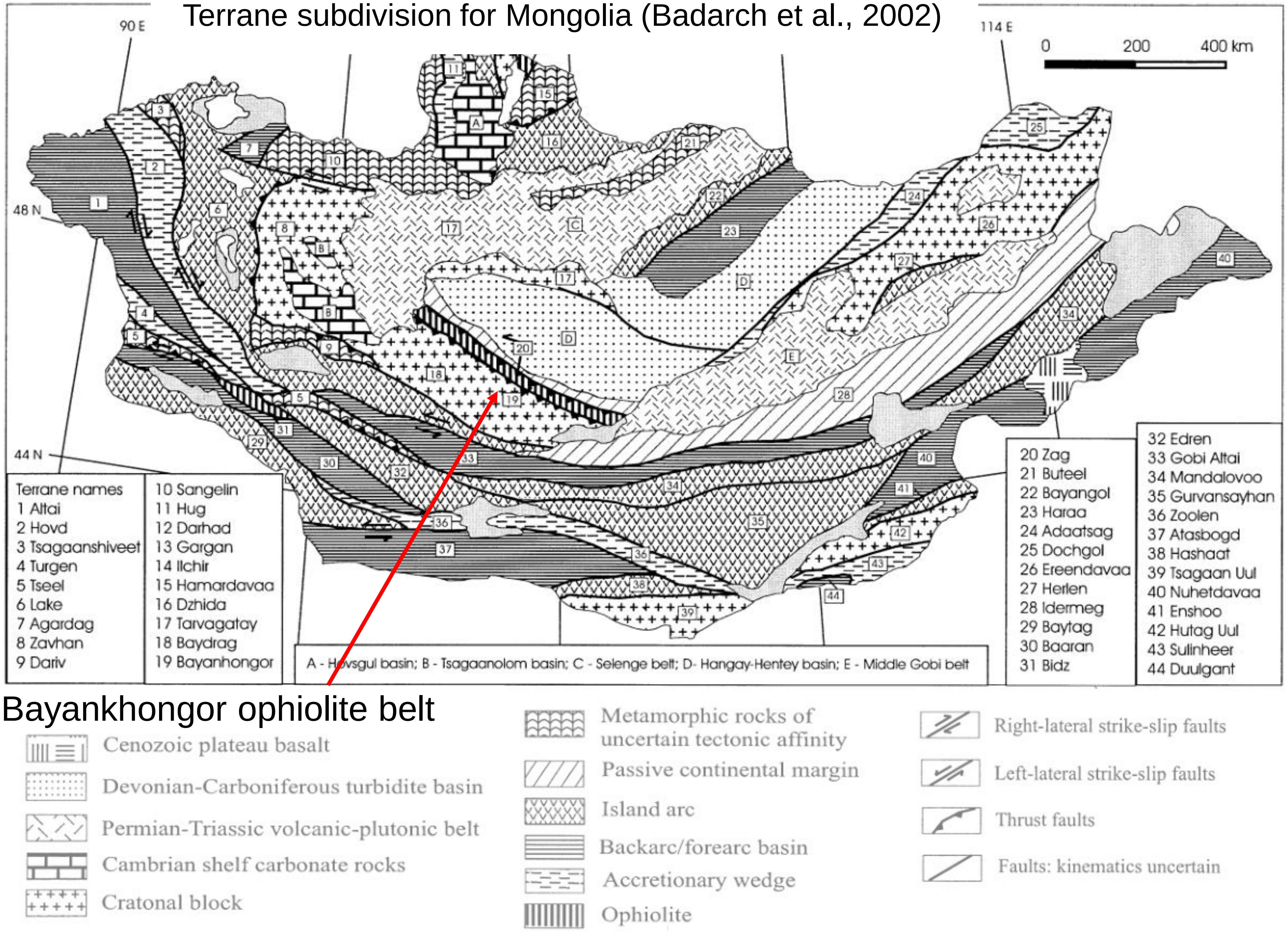


Ophiolite belt emplaced along suture from uplifted oceanic crust

Terrane subdivision

Terrane subdivision for Mongolia (Badarch et al., 2002)



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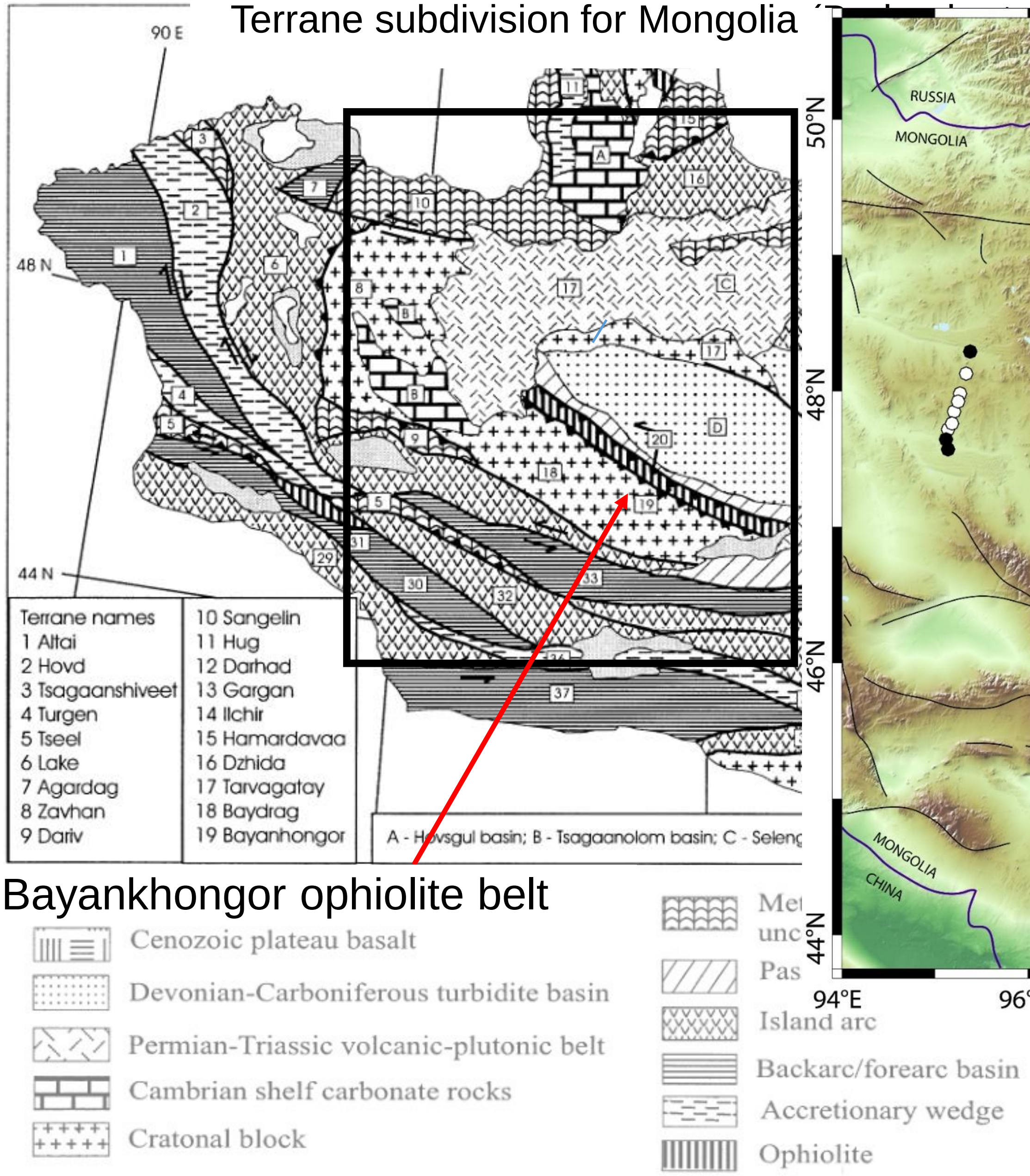
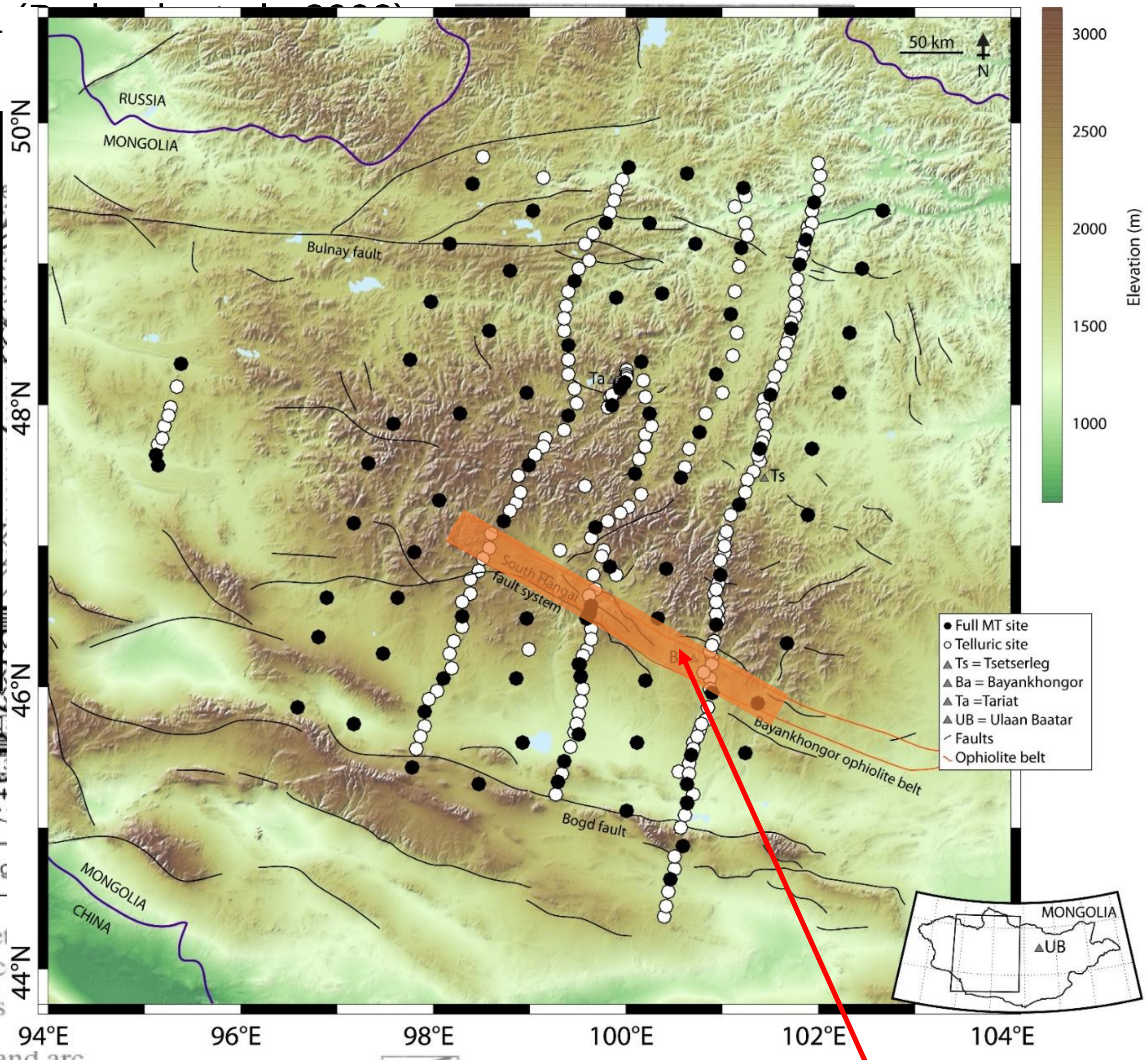
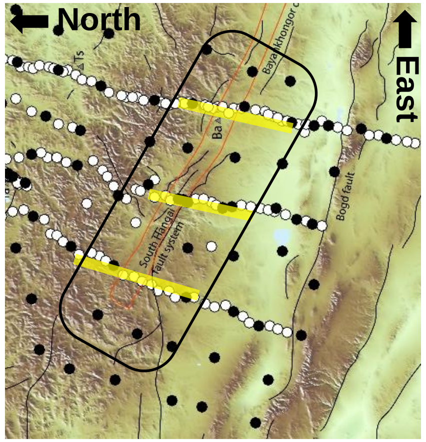


Bayankhongor ophiolite belt



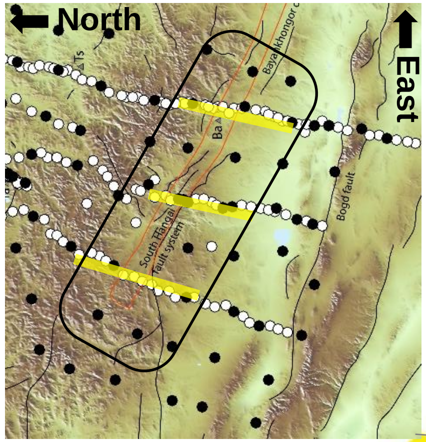
Ophiolite belt

South Hangai mineralized zone: 3-D models



The South Hangai fault system is a very important zone of mineralization

South Hangai mineralized zone: 3-D models



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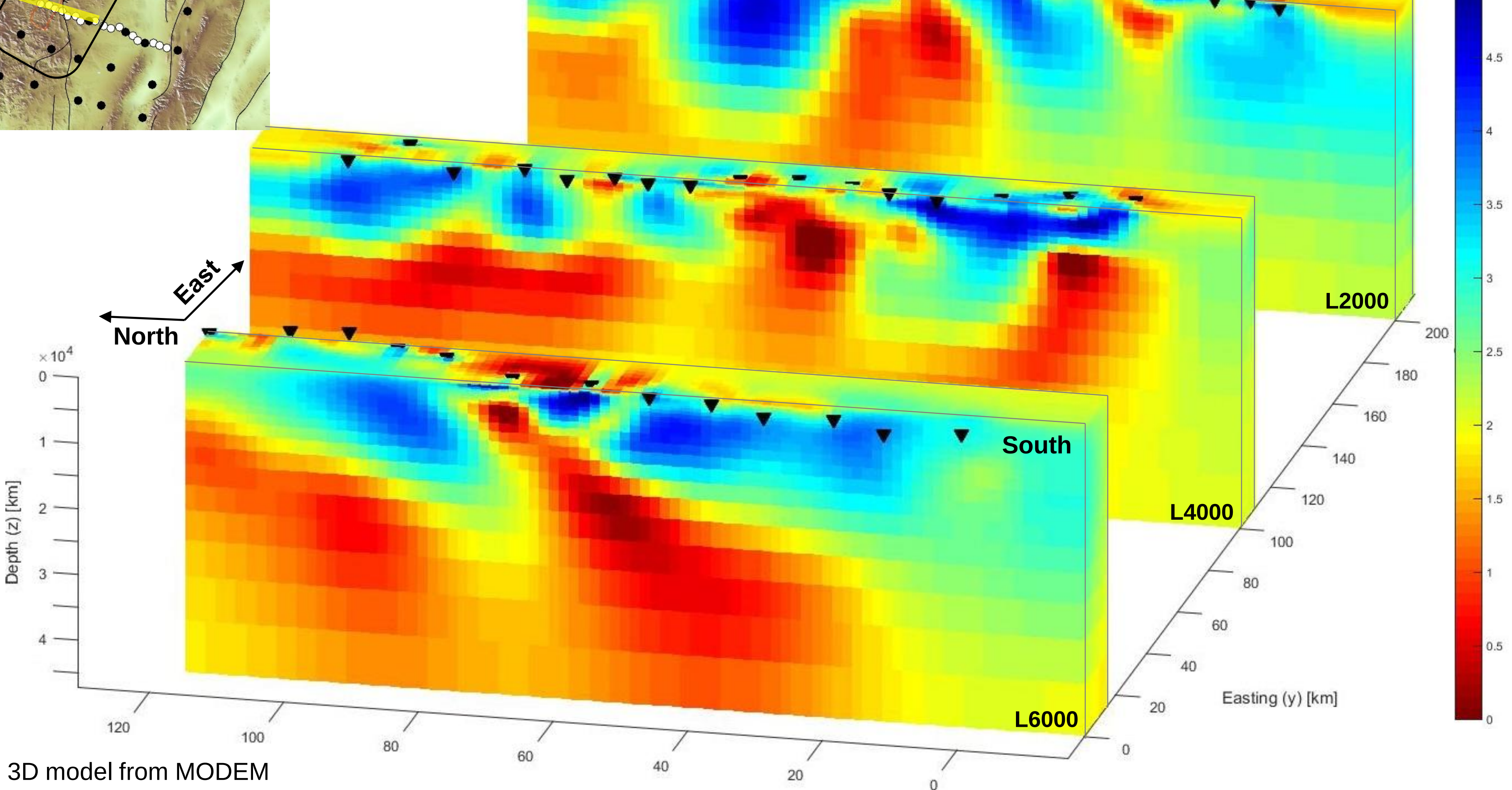

3D model from MODEM

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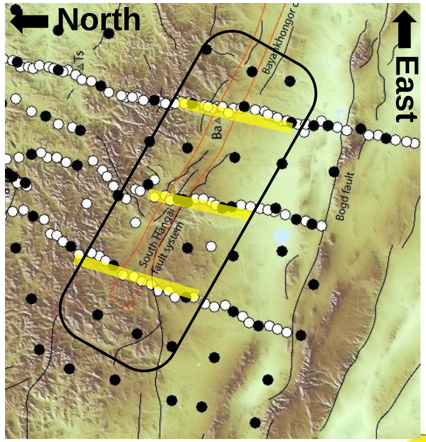

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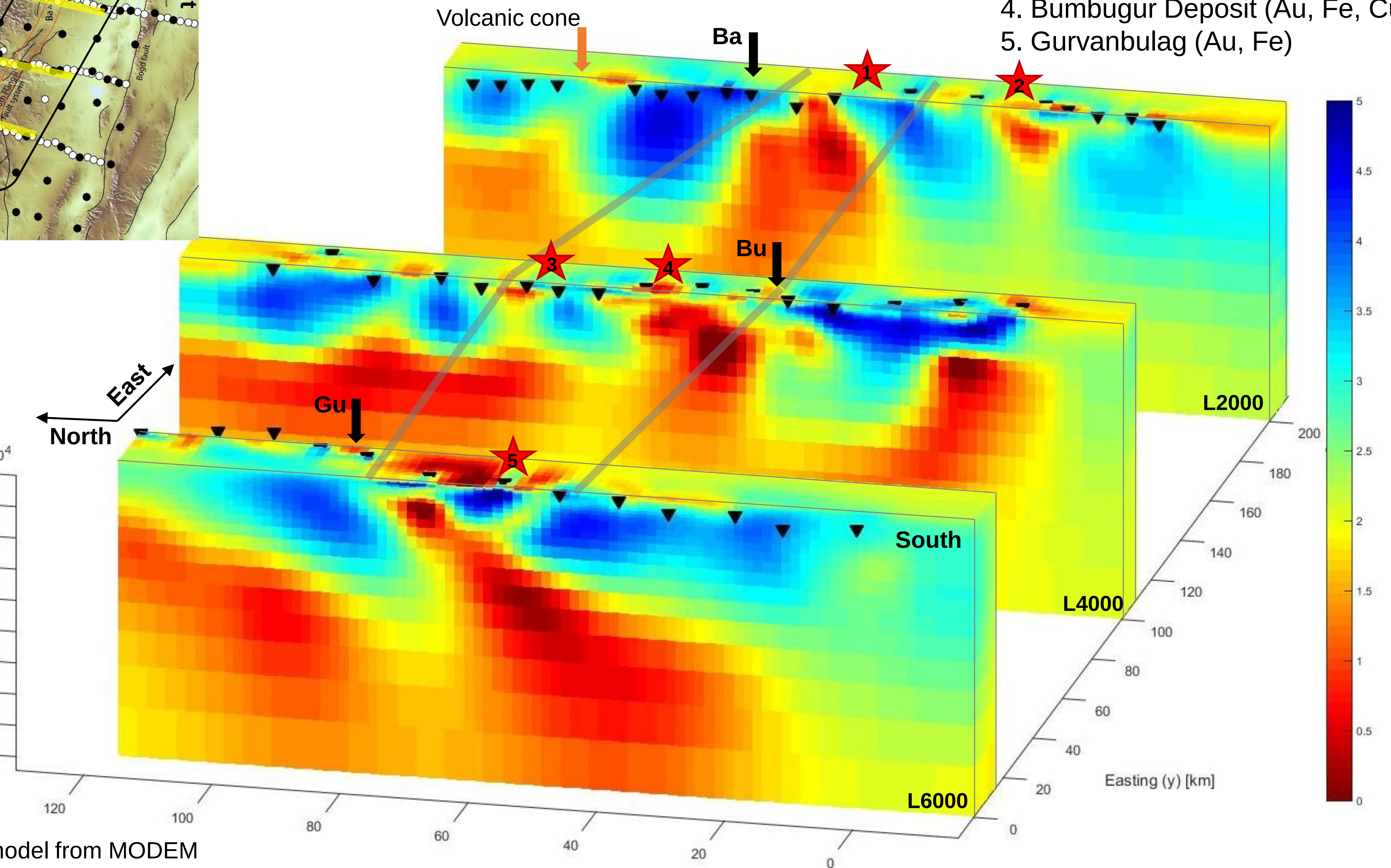
1. Bayankhongor Mineral Belt (Fe, Cu)
2. Tsagaan Tsahi Uul Deposit (Au)
3. Duck Canyon (Au)
4. Bumbugur Deposit (Au, Fe, Cu)
5. Gurvanbulag (Au, Fe)



3D model from MODEM

Central Hangai Volcanism

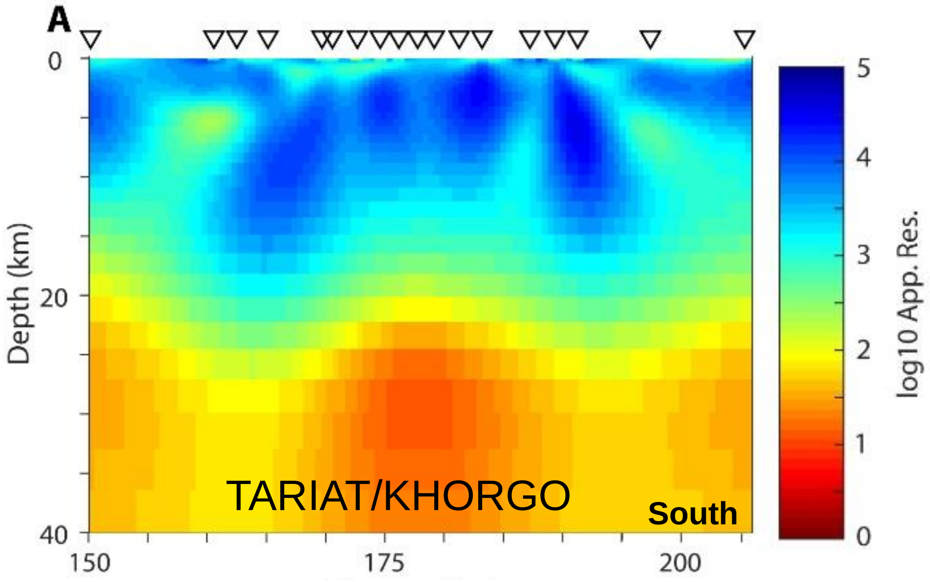
Central Hangai Volcanism

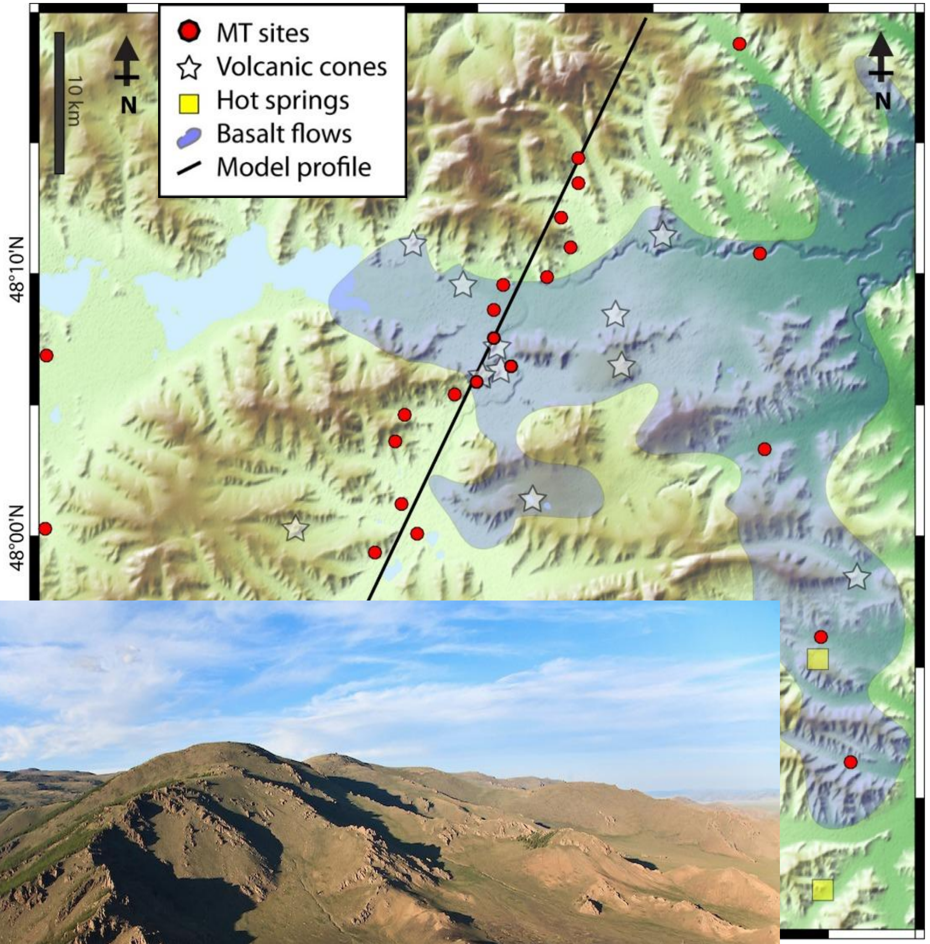
Chuluut canyon

Numerous small volcanic cones
Calderas ~300m wide & ~100m deep
Lava flows 40-200m thick
Chuluut active 6Ma to 300ka
(produced ~486 km3)
Khorgo active 1Ma to 3ka
(produced ~27 km3)

Khorgo

Central Hangai Volcanism





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2D model using EMILIA algorithm of Kalscheuer et al. (2010).

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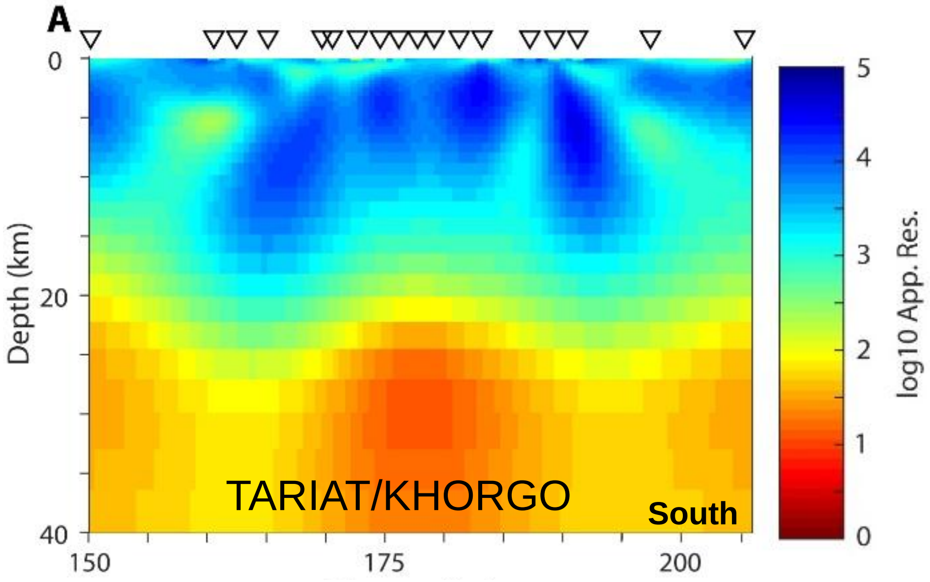

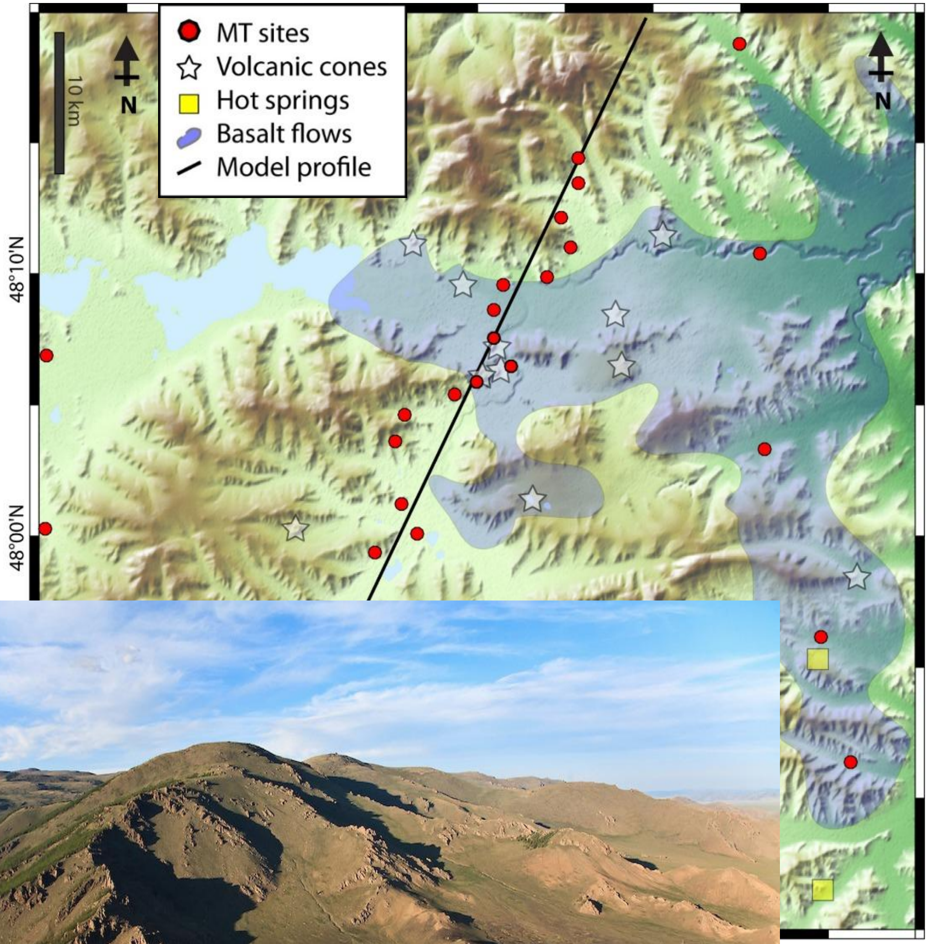

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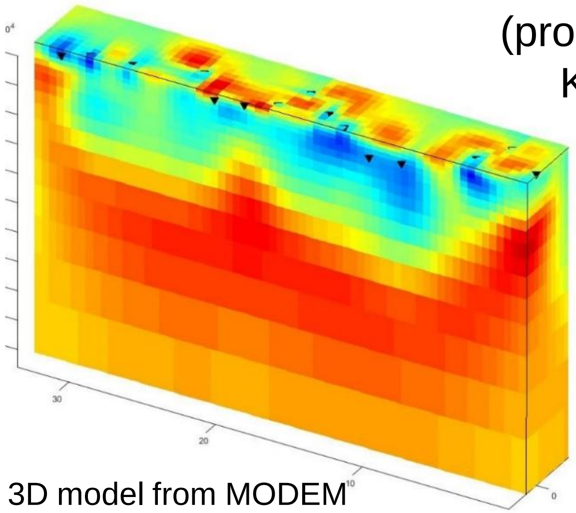

3D model from MODEM

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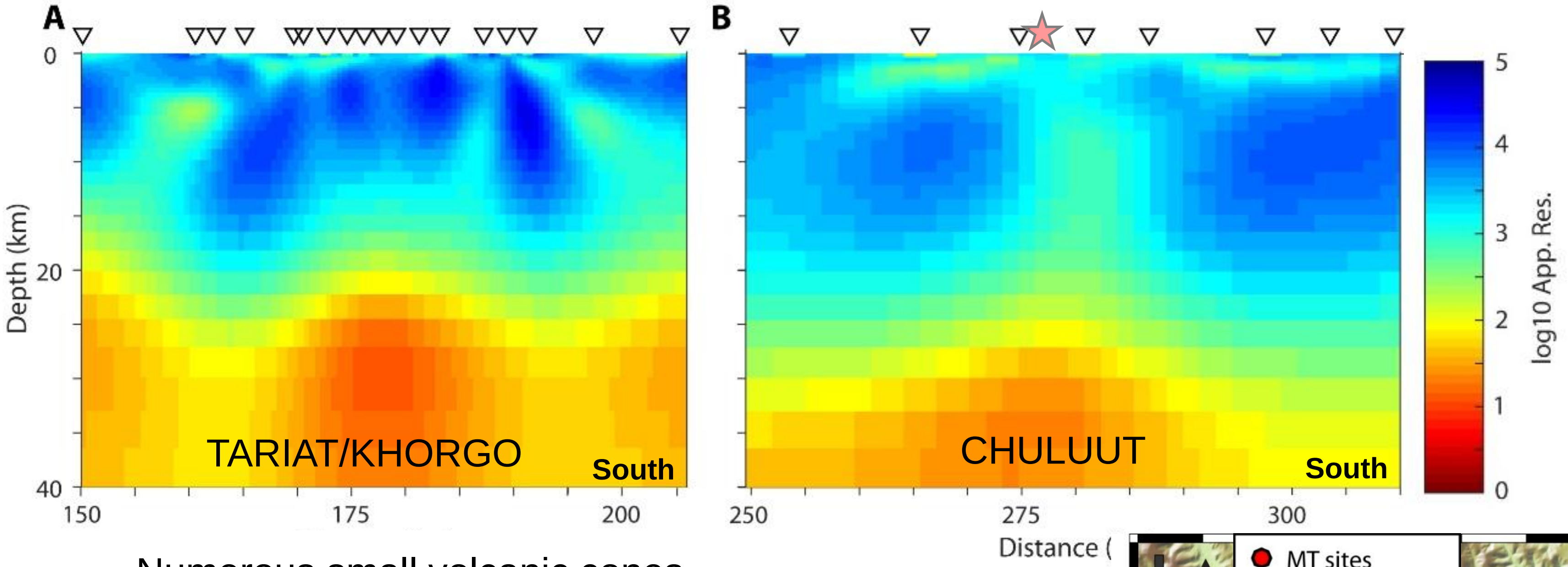

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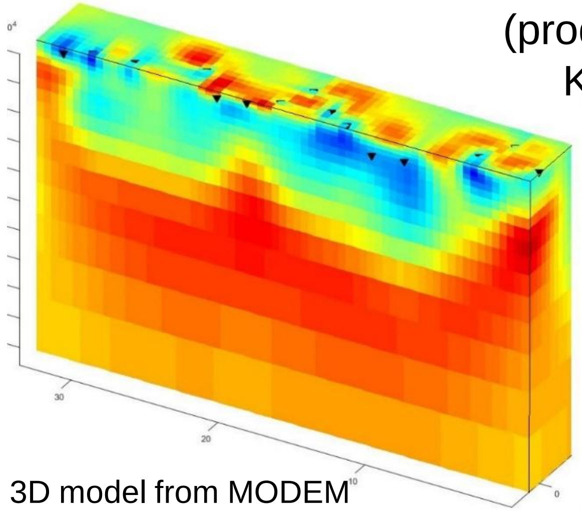
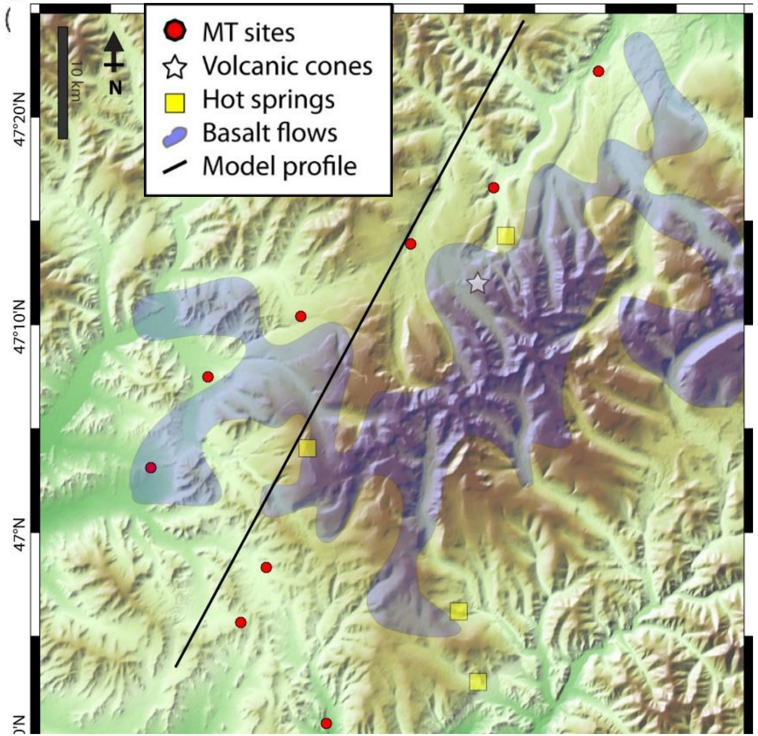
Khorgo active 1Ma to 3ka

(produced ~27 km3)



3D model from MODEM



Conclusions

1. Resistivity models give new insights into the structure of the Hangai region and constrain its development

2. We find a weak lower crust (fluids ?), and that the South Hangai fault zone is a major terrane boundary where lithosphere thickens

3. We modeled past signatures of intraplate volcanism and mineralization zones

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Future work

1. What initiated process remains speculative; needs further modelling
2. Future work will continue on full dataset, including 3-D inversion, for both large-scale features and small-scale features (volcanism, mineralization, etc)
3. MT data can provide constraints on viscosity & mechanical strength, required for accurate modeling of rheology & lithosphere dynamics

Thank You