Regional Magnetotelluric Studies across Mongolia: Report on New Measurements, New Models, and Implications for Intracontinental Deformation, Deep Mineral Systems, and Intraplate Volcanism

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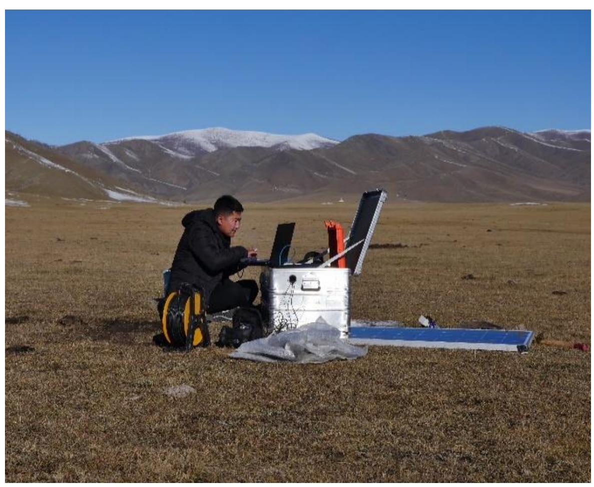

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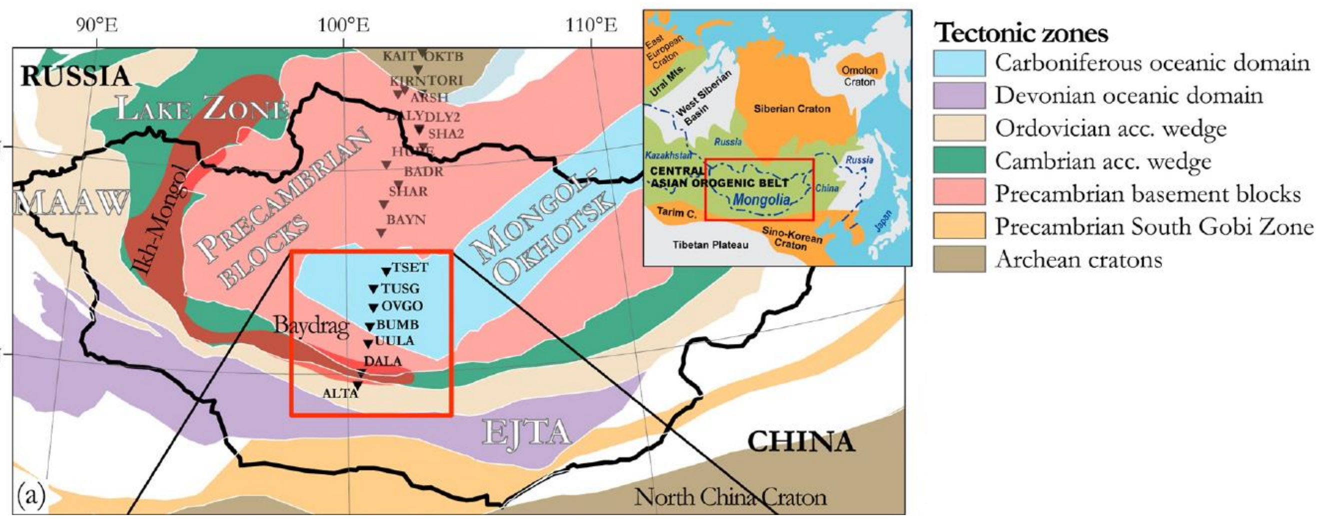
1. Introduction & Geotectonic Background

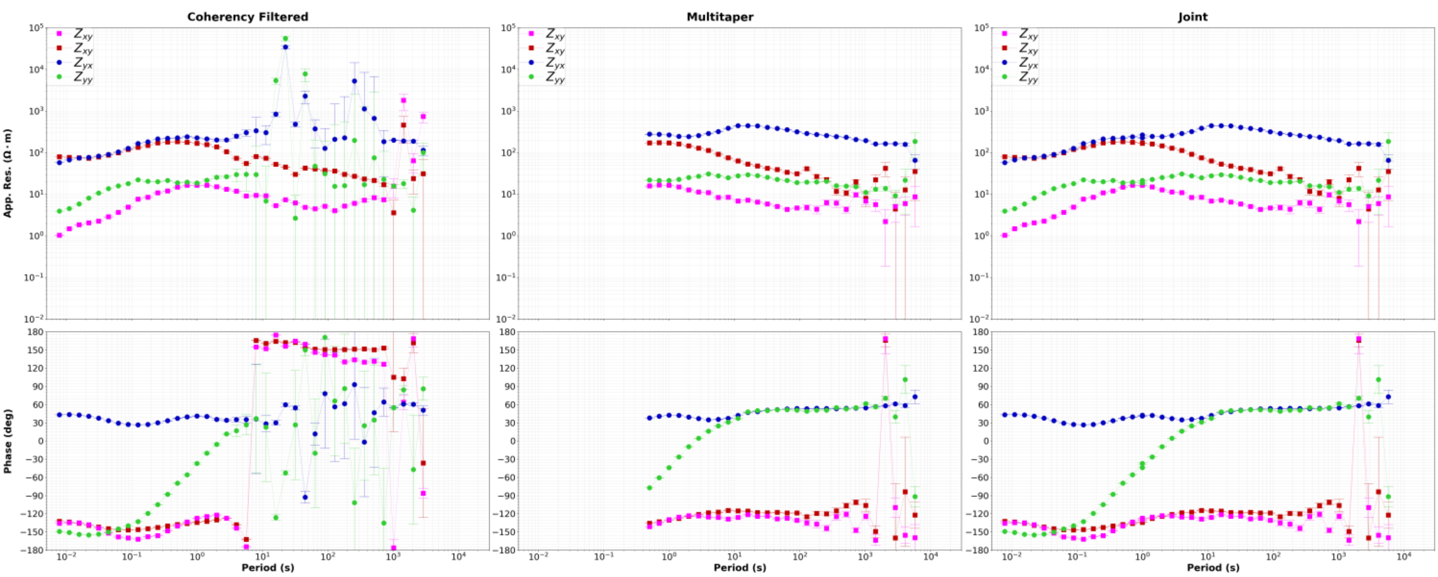
- Mongolia is an ideal natural laboratory for studying intracontinental deformation and volcanism since it is far from major tectonic boundaries.
- We are investigating the lithospheric properties and architecture beneath this region with magnetotelluric (MT) measurements and two- and three-dimensional models of electrical resistivity.
- We report on new measurements and models across Mongolia.



▲**Fig. 1**: Tectonics of Mongolia and the Central Asian Orogenic Belt, modified from Guy et al. (2024).

2. MT Data Acquisition and Processing

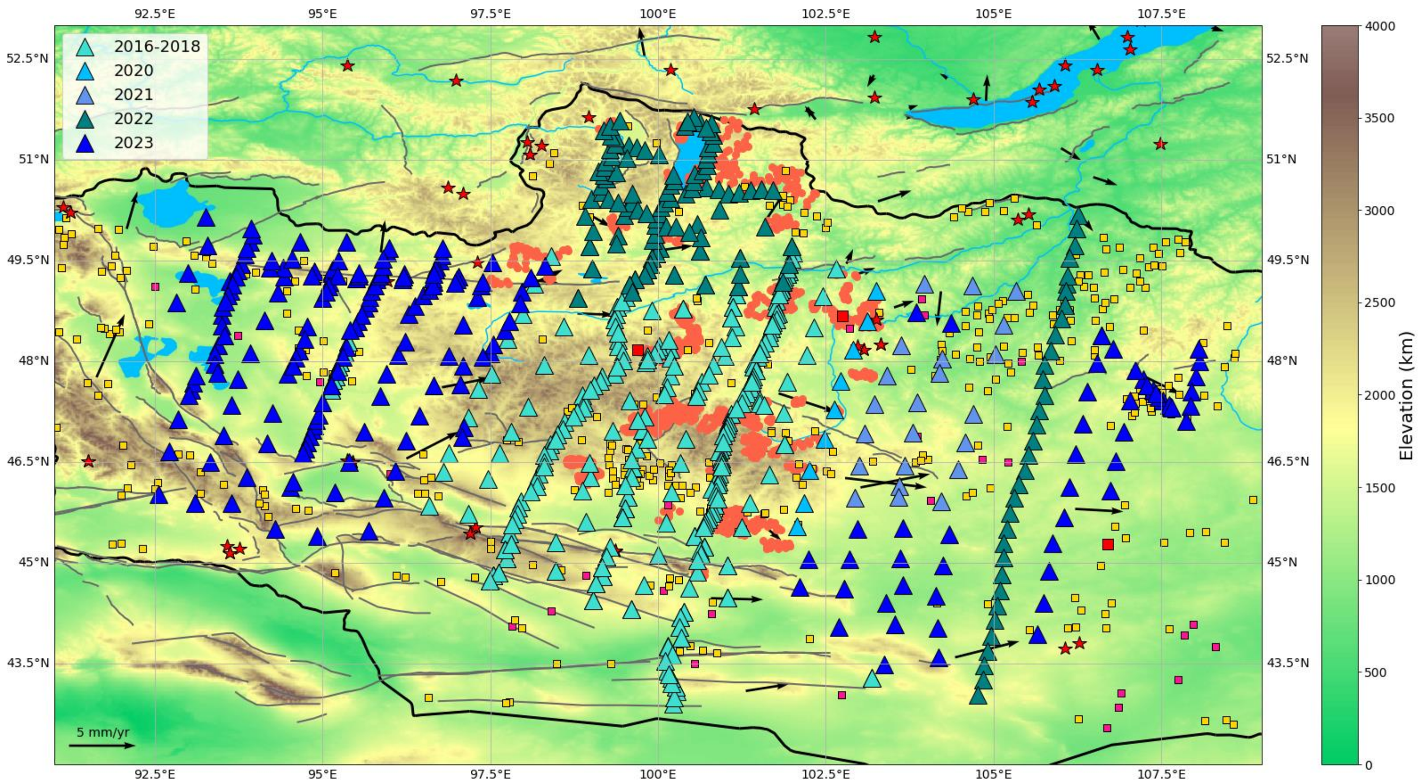
- 378 new BB MT sites installed to the east, west, and north of the Hangai Dome (collected in 2020-2023) complement 328 sites previously collected (2016-2018) across Central Mongolia (see Fig. 3; Comeau et al., 2018; Käufl et al, 2020).
- The data was processed using a robust processing scheme based on the M-estimator and a minimal covariance determinant method (Fig. 2; see also Rigaud et al., 2023).
- Responses were improved using a multi-taper processing approach at periods > 1 sec and a coherency threshold at periods < 1 sec (Fig. 2).



▲**Fig. 2**: Example of the MT processing scheme at measurement site -5650.

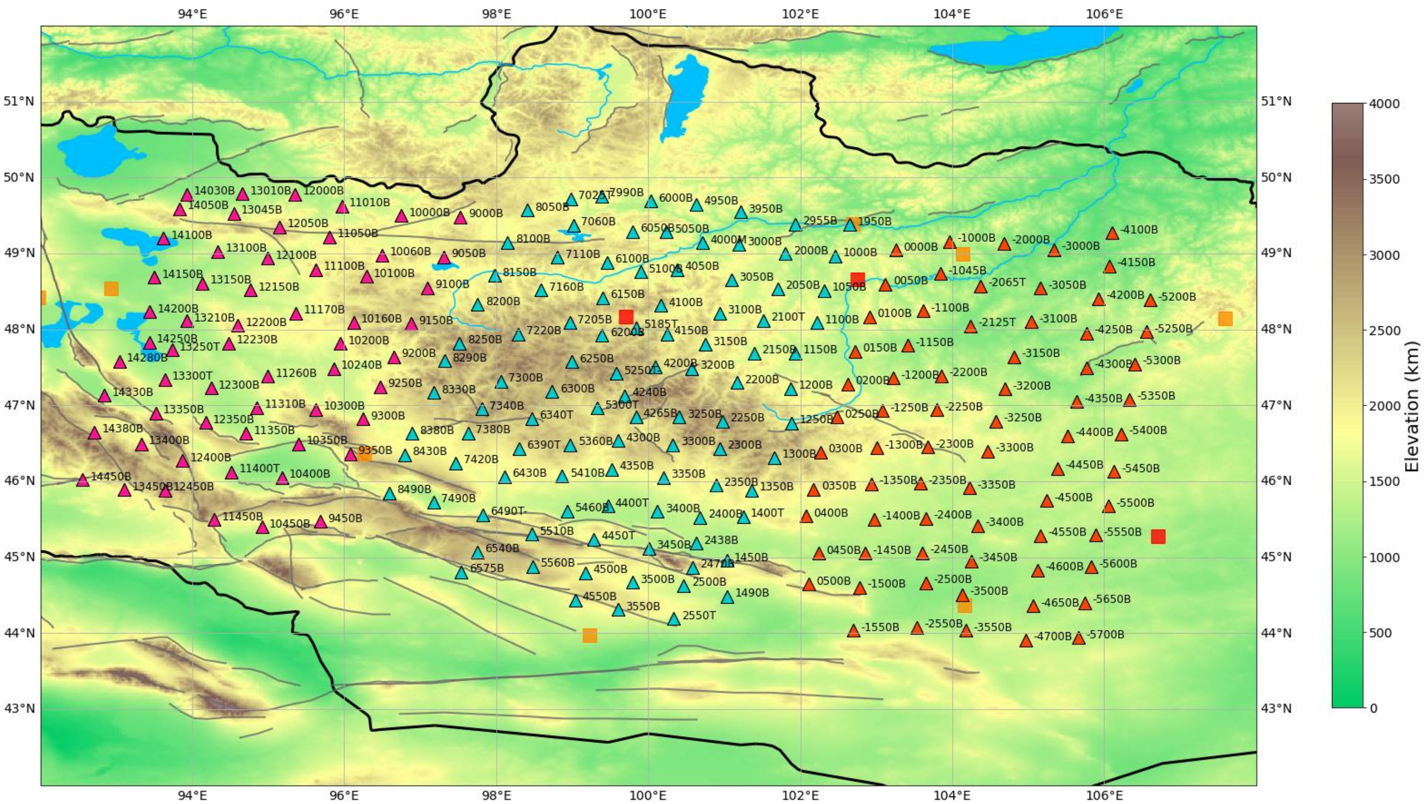
3. Methodology: 3-D Inversion

- We used 129 of the new measurements with 97 previously acquired measurements to generate a new regional 3-D resistivity model with average station spacing of 50 km.
- Inversion was performed using GEMMIE 3-D integral equation solver (Kruglyakov & Kuvshinov, 2022) following a two-stage cooling regularization approach. At first, we used a regularization parameter of 10 until convergence. Then, we smoothed the final model of this stage and used it as input model of the next stage with regularization parameter of 1.
- We inverted responses at 12 periods between 1 and 10000 sec.
- The starting model was obtained from the 1-D inversion of the averaged ssq impedances (cf. Käufl et al, 2020).
- The model comprised a volume of 1248x896x200 km^3 and was discretized in 312x224x24 cells. Inversion was performed using 624 cores.
- The final root mean square error (RMSE) was of 1.91, for a 5% error floor applied to the data.

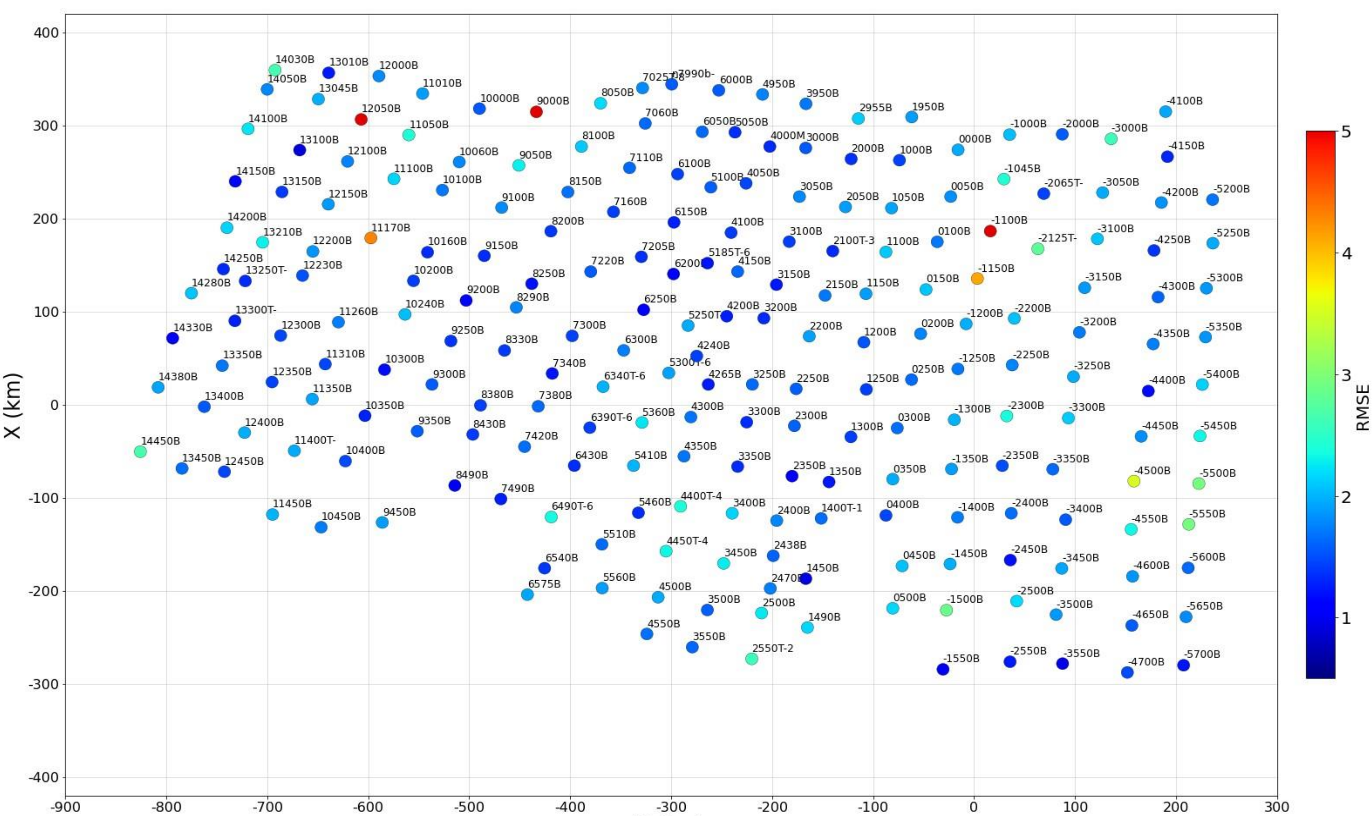


▲**Fig. 3**: MT measurements in Mongolia (2016-2023; triangles). Faults are grey lines; earthquake (magnitude 6-8.5) focal points are red stars; black arrows represent GPS-derived motion (Calais et al., 2002). Red marks Cenozoic basalts (Sahagian et al 2016); orange squares indicate gold occurrences and pink squares copper deposits (MRAM).

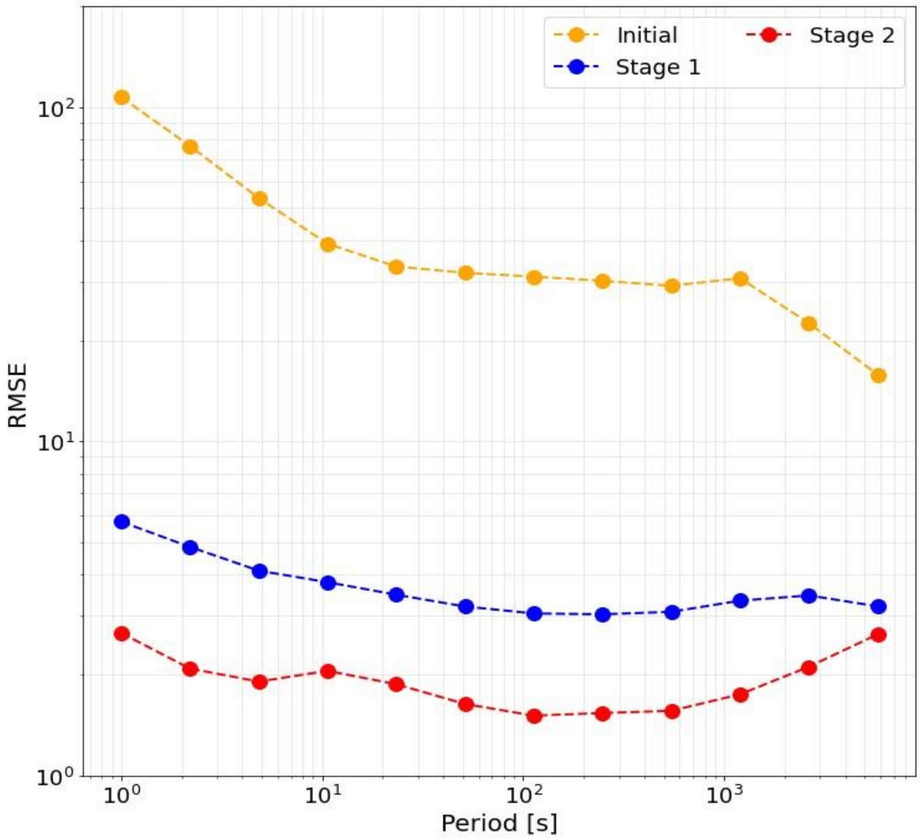
4. Results



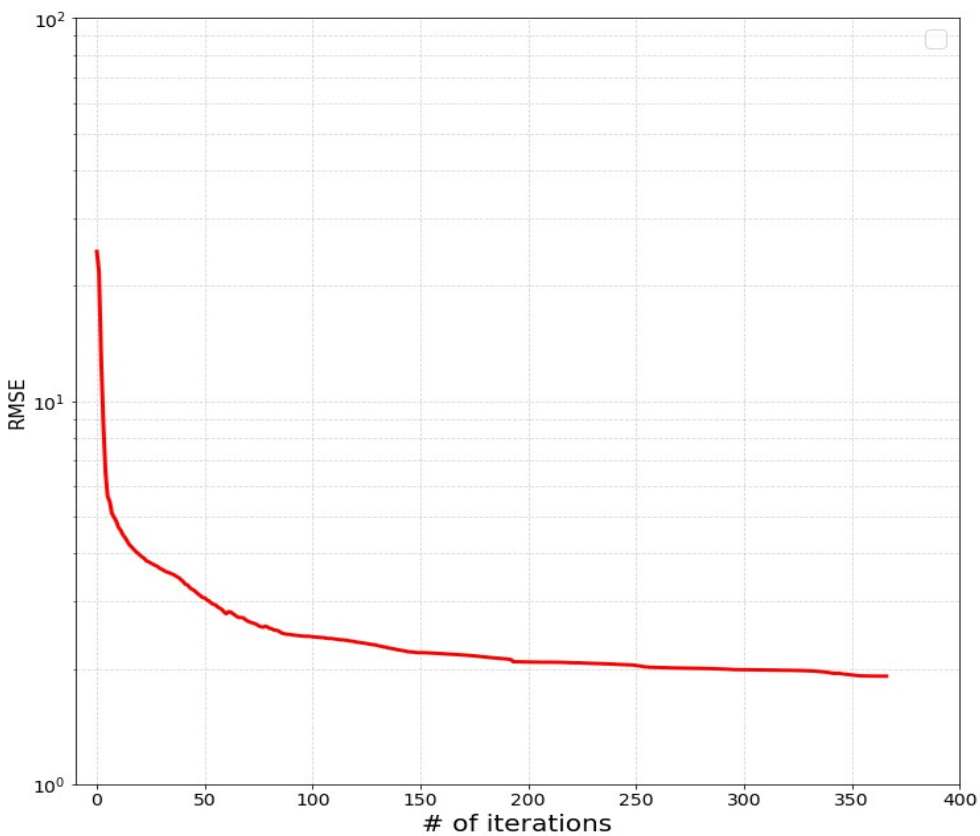
▲**Fig. 4**: MT stations used in the model.



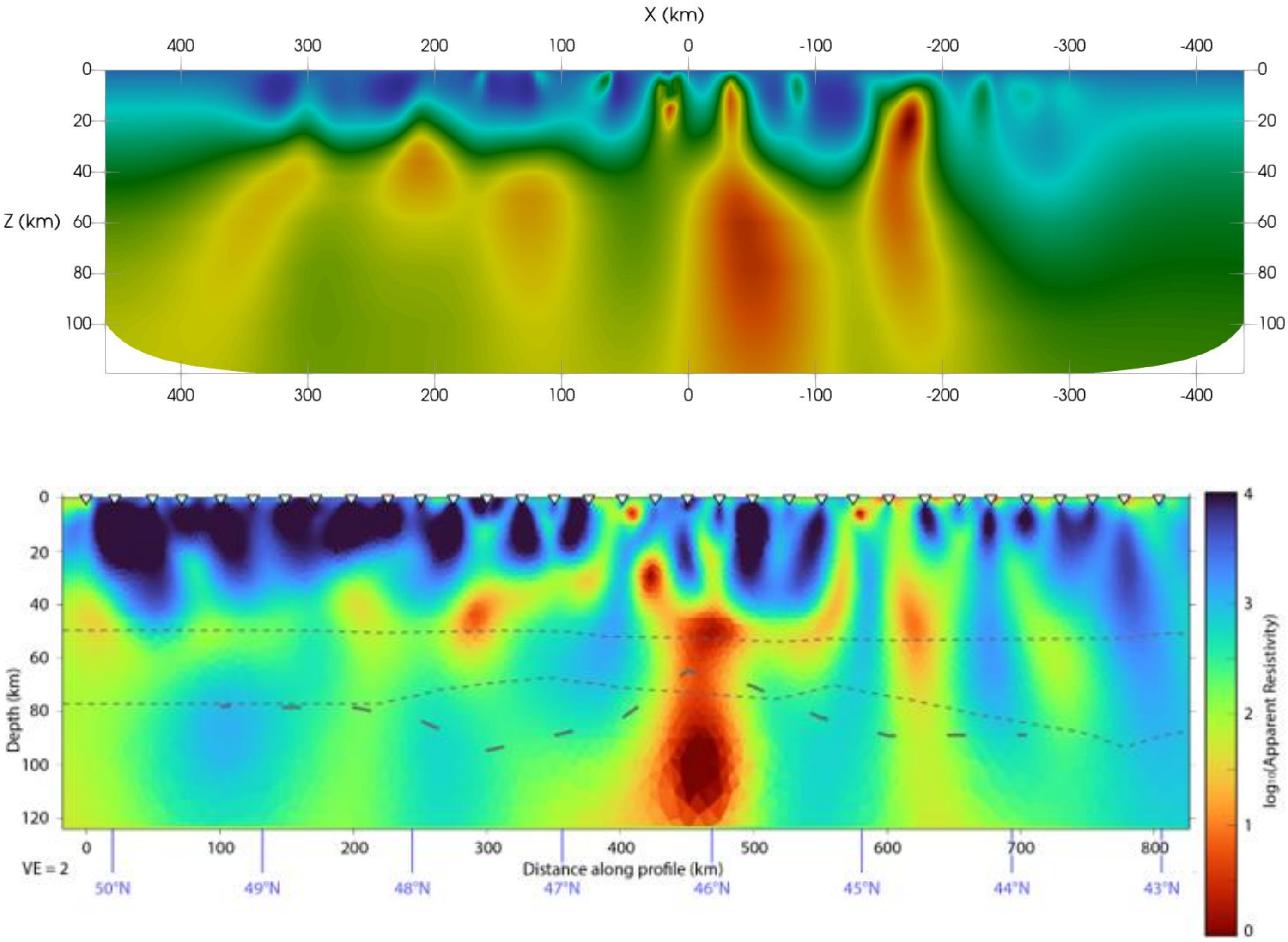
▲**Fig. 6**: Final RMSE values at each site.



▲ **Fig. 5**: RMSE vs. period for each stage.

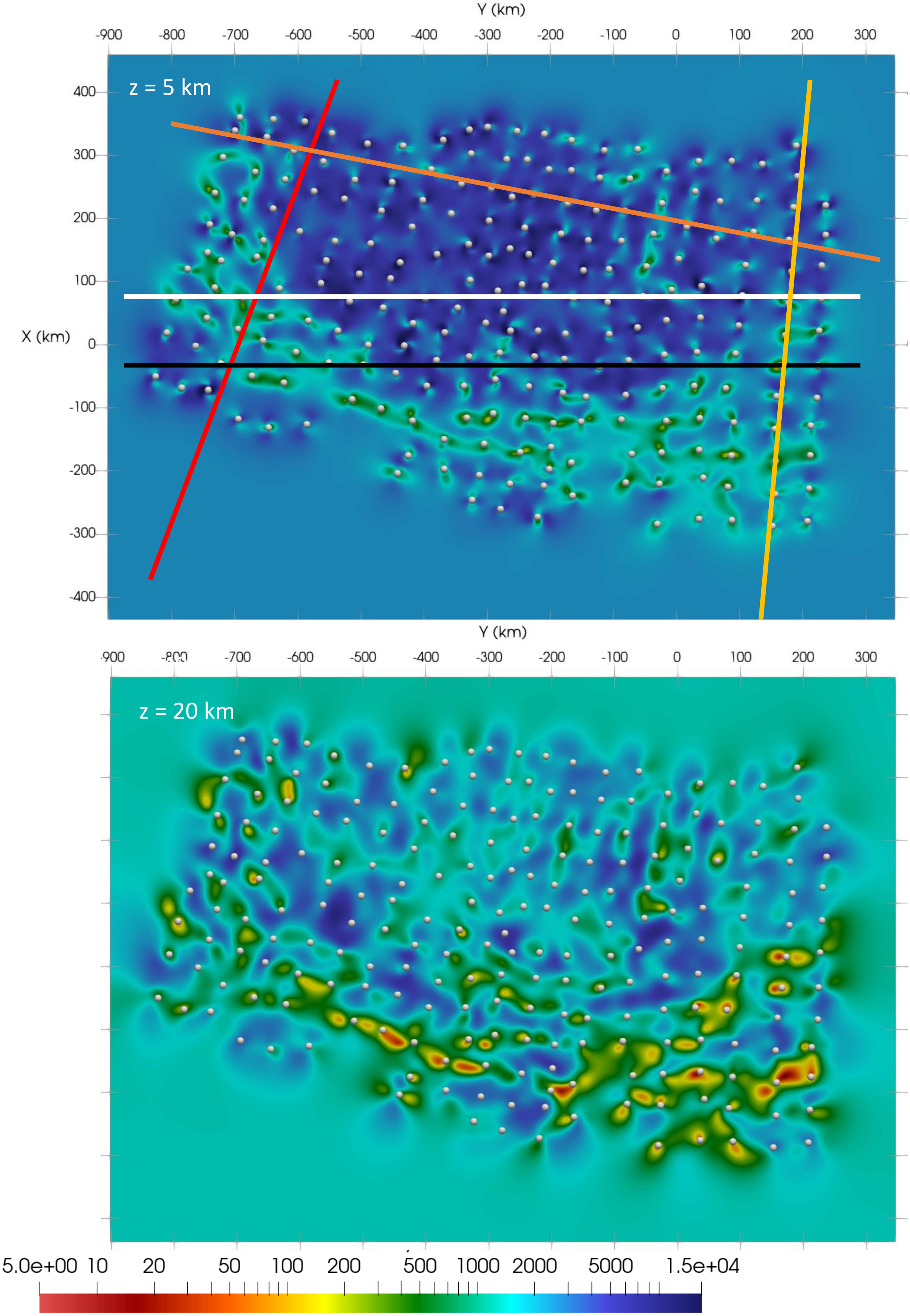


▲ **Fig. 7**: RMSE progression

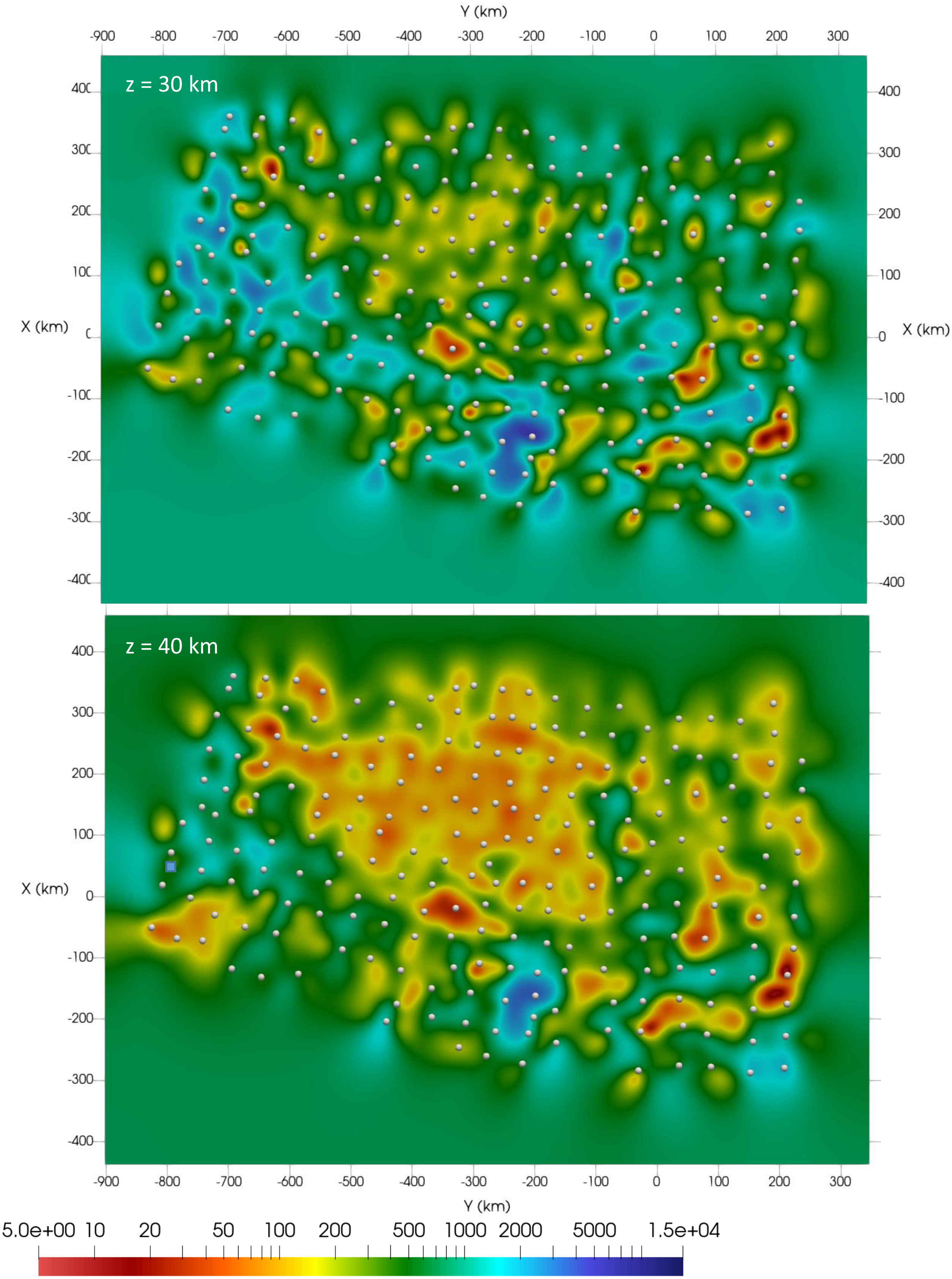


▲**Fig. 8**: Left: Vertical section of the 3-D regional model along the -4000 profile location (yellow line in Fig. 9). There is a vertical exaggeration of 2. Geographic north is directed towards the positive x-axis direction.

Right: A 2-D model obtained from the -4000 profile data by Comeau, Rigaud, et al. (2024, JGR). The red box highlights the location of the -4000 profile stations. A good correspondence between the regional and profile models model is observed.



▲**Fig. 9**: Horizontal slices of the 3-D model. White circles mark MT sites. Geographic north is directed towards the positive x-axis direction.



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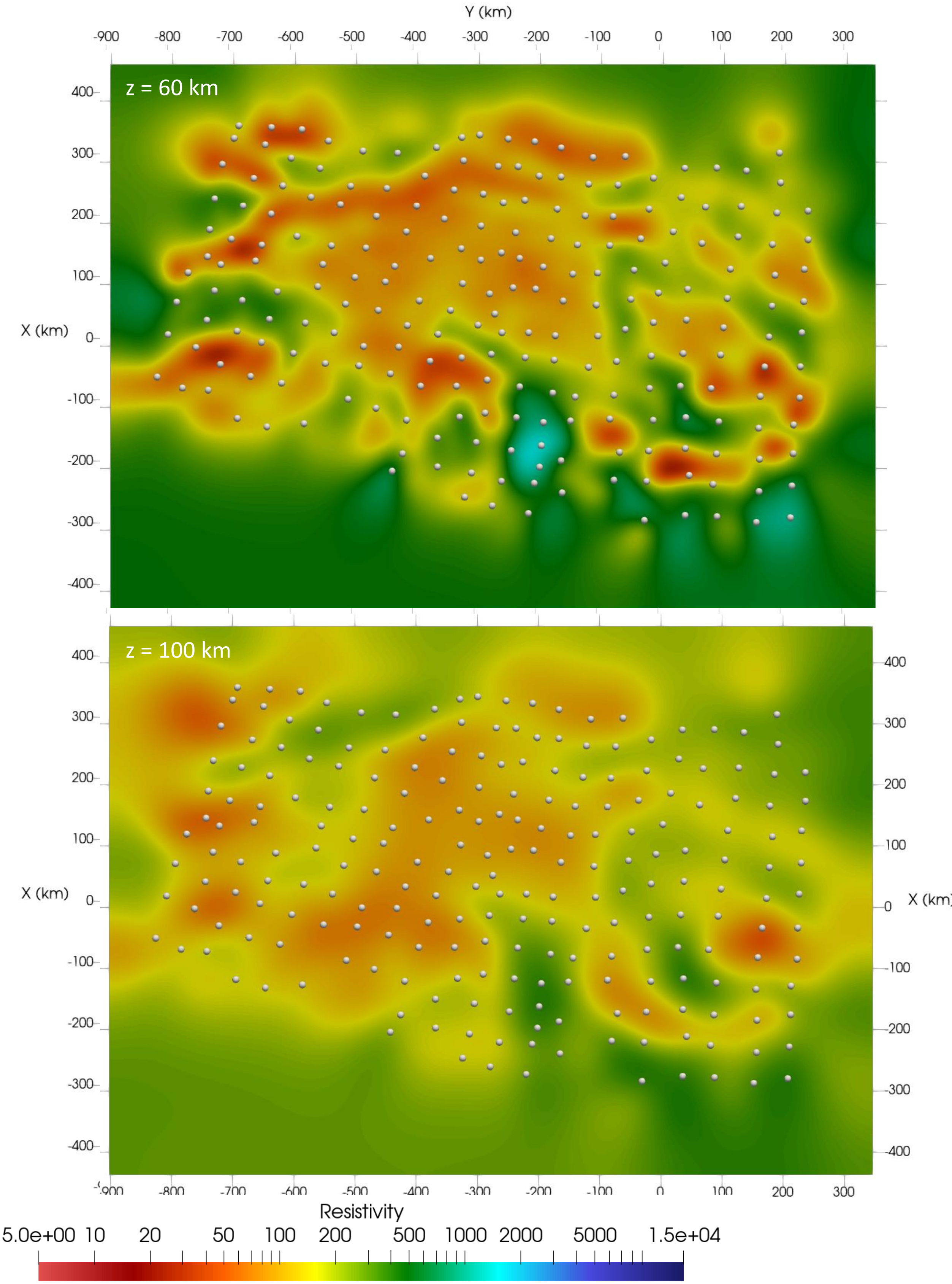

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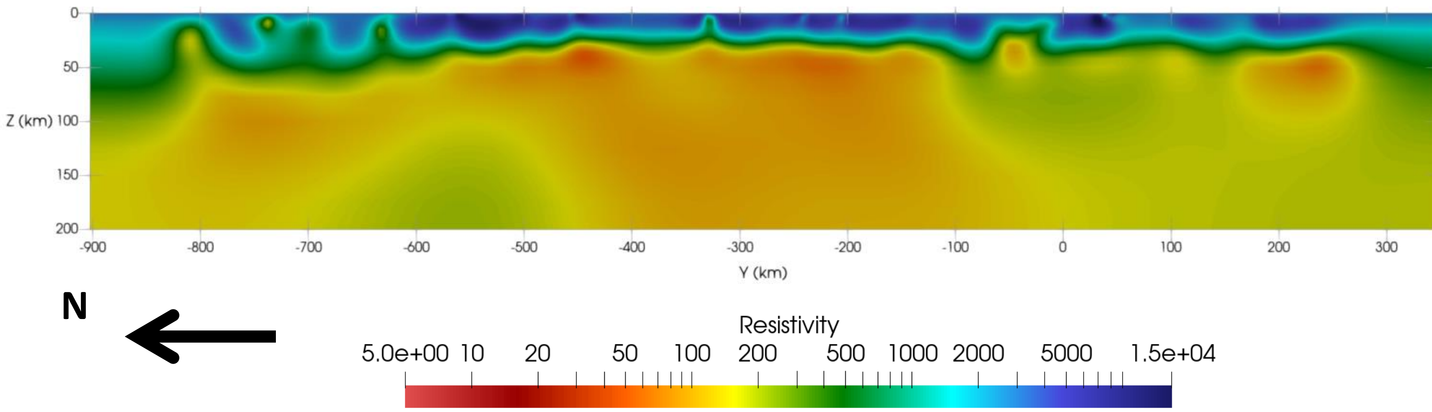
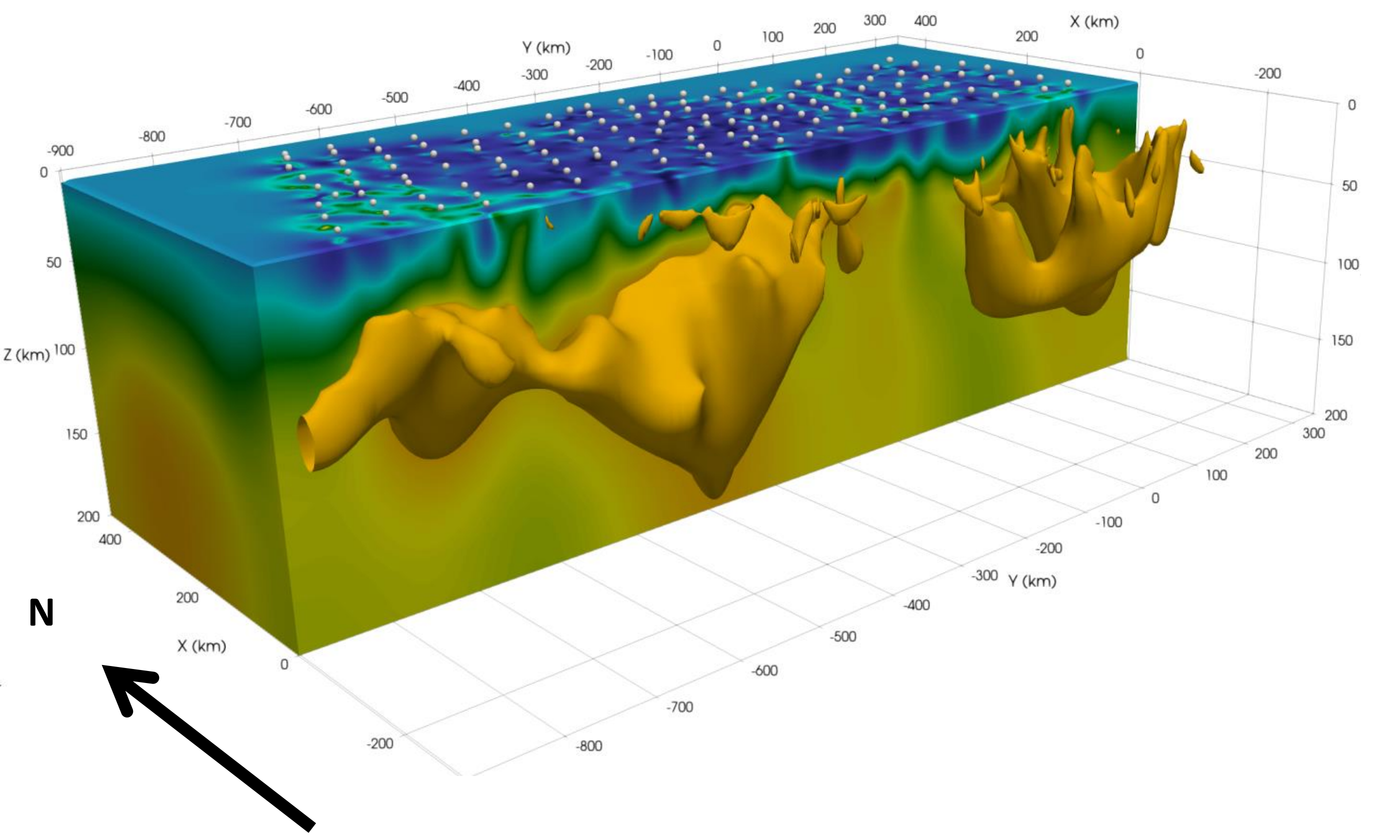
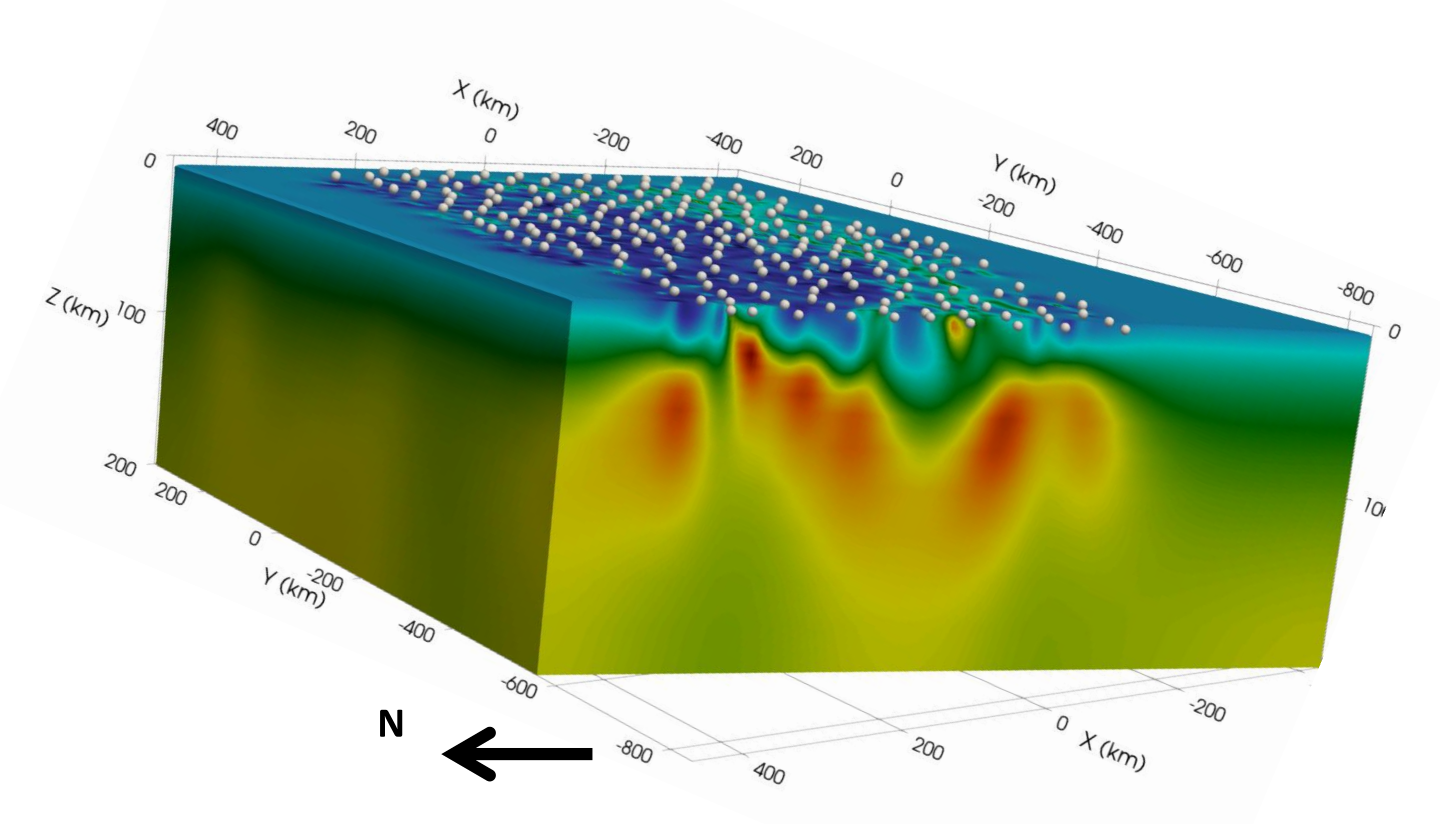


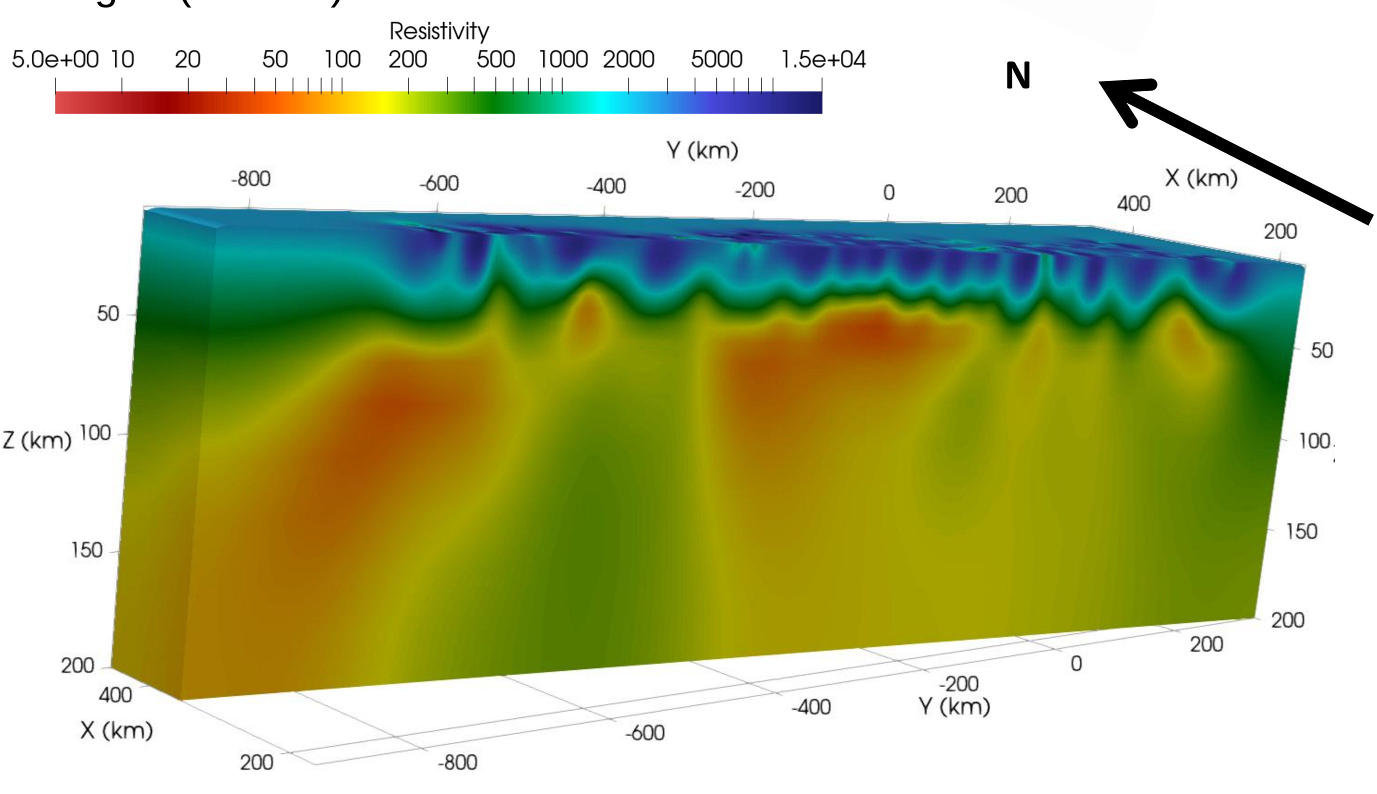
▲**Fig. 10**: View of the model (west-east) at x=100, along white line in Fig. 9.



◄**Fig. 11**: View of the model (west-east) at x=0, black line in Fig. 9 and isosurface of 85 ohm-m. White spheres mark MT sites.



▶**Fig. 12**: View of the model (north-south) along profile 13, red line in Fig. 9 (z=5 km).



◀**Fig. 13**: View of the model (west-east), along the orange line in Fig. 9 (z=5 km).

5. Conclusions & Outlook

- A clear north-south dichotomy is observed in the conductivity models. This matches the expected tectonic and geological structures (see Comeau et al. 2020).
- Some features observed underneath the Hangai Dome extend to the west and east.
- The new models have implications for intracontinental deformation, deep mineral systems, and intraplate volcanism (see Comeau et al., 2022; Stein et al., 2022; Comeau et al., 2021).
- The next step is to include higher frequency responses and measurements with finer spacing into the inversion process, producing a higher resolution model.

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