THE INTERNATIONAL CONFERENCE ON THE 120TH ANNIVERSARY OF THE BULNAY EARTHQUAKE: ADVANCES IN ASTRONOMY AND GEOPHYSICS

Magnetotelluric investigation to understand the formation of the Ulaanbaatar region and to evaluate geothermal potential.

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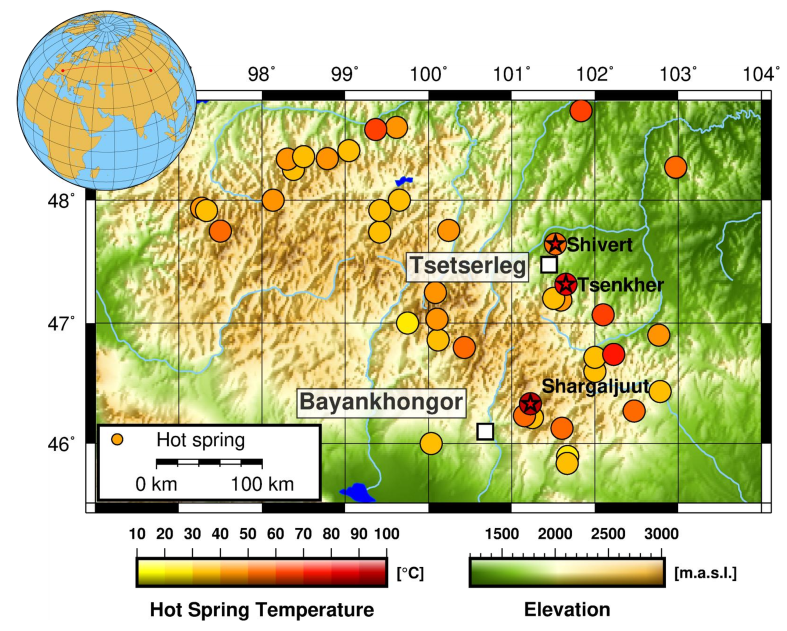
Motivation

- In Mongolia, all energy comes from burning coal
- Air pollution levels are >100 times higher than recommended by WHO.
- Initiatives to raise awareness, hardly any solutions

Numerous hot springs with T>90°C in Mongolia indicate the existence of a valuable untapped geothermal energy resource.



- The Ulaanbaatar area was chosen as a pilot site for magnetotelluric studies to explore the formation of a non-volcanic and a blind geothermal system.
- Heat flow and temperature gradient in the study area: 35-60 mW/m², 25-40°C/km (Tseesuren, 2001)
- T-gradient agreement with thermal properties for partially saturated granite 30-50 °C/km plus relict volcanic heat (Cho et al. 2010)
- pH of springs around UB ~7 suggests granite/hot water interaction at ~80-120°C

Geological setting and MT exploration

The electrical conductivity of the subsurface points to fluid pathways and aquifers. MT can help to image of deep fluid circulation and mechanisms that lead to hot spring formation.

Favourable geological setting for deep fluid circulation

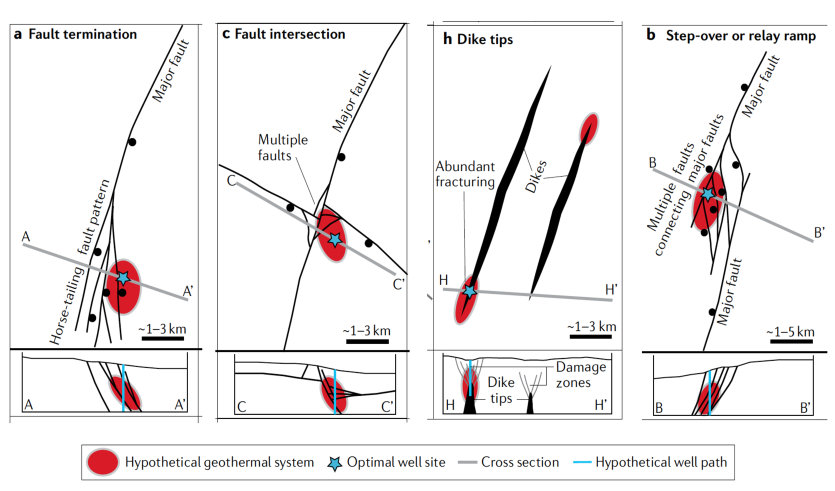
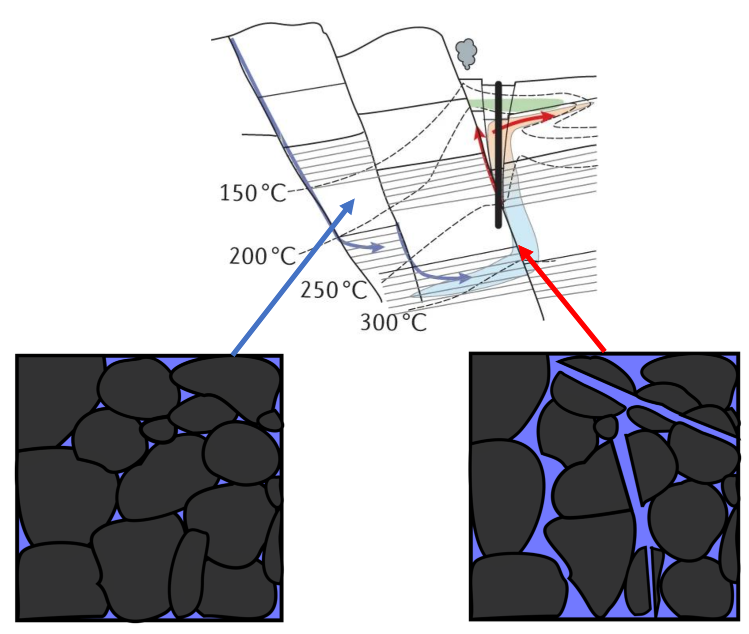


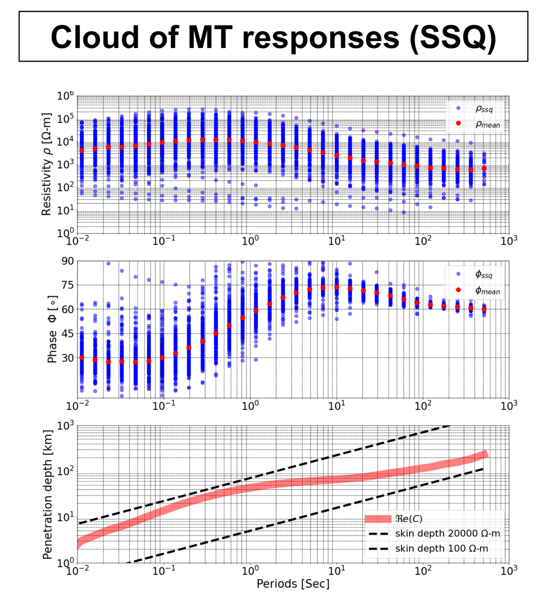
Figure modified from Jolie et al. (2021)



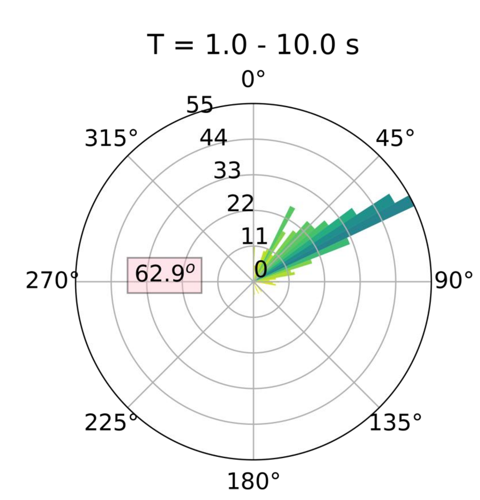
MT survey and data

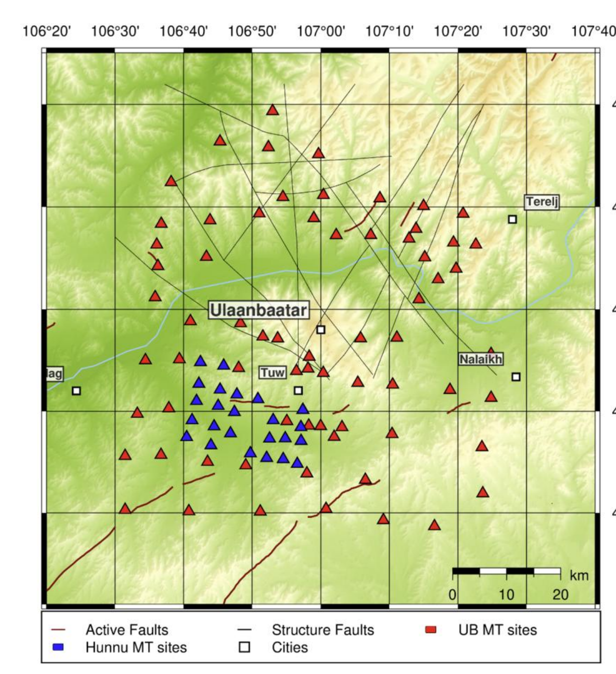
During the summer of 2025, we conducted MT measurements in the Ulaanbaatar area. A total of 94 MT stations were used for the inversion.

Cloud of MT responses (SSQ)



Strike direction



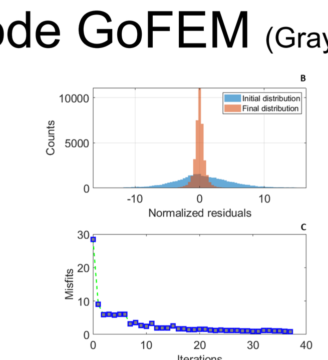


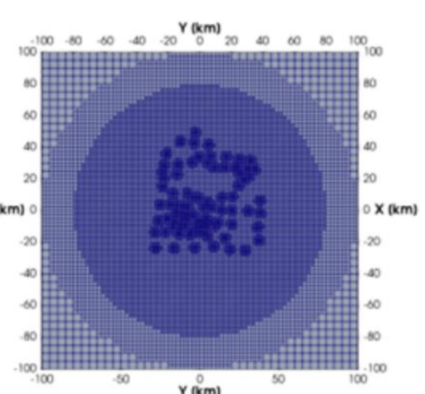
Distribution of MT sites and tectonic formation of the region

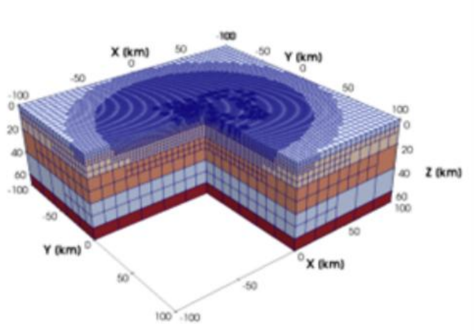
Inversion

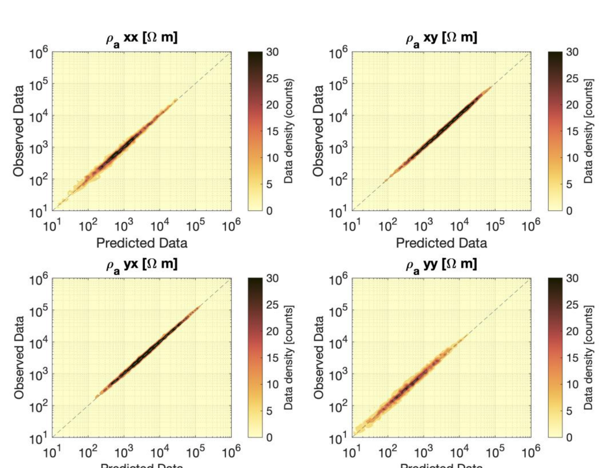
For inverting the MT data we used the finite element code GoFEM (Grayver, 2015)

1. Mesh refinements around area of interest and receivers
2. Mesh is adapted to topography
3. 3-layered 1-D starting model derived from SSQ-average
4. Row-wise error-floor of 5% assigned to impedances
5. RMS decreases from 28.3 to 0.97 within 36 iterations

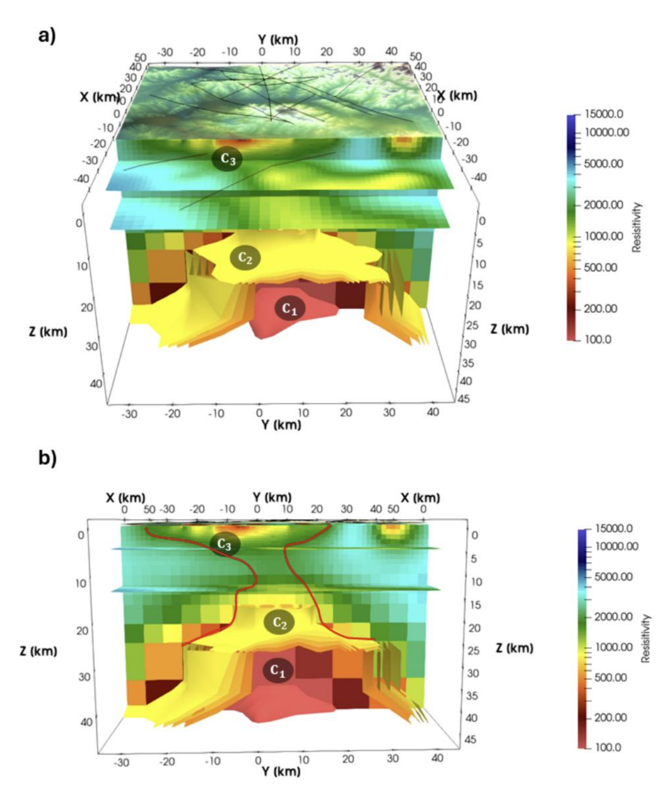








3-D electrical conductivity model



C2-C3

- Fault/fracture zone within resistive granitic basement **R**
- Fluid circulation zone and permeable drainage zone allowing transport of heated fluid to the surface.

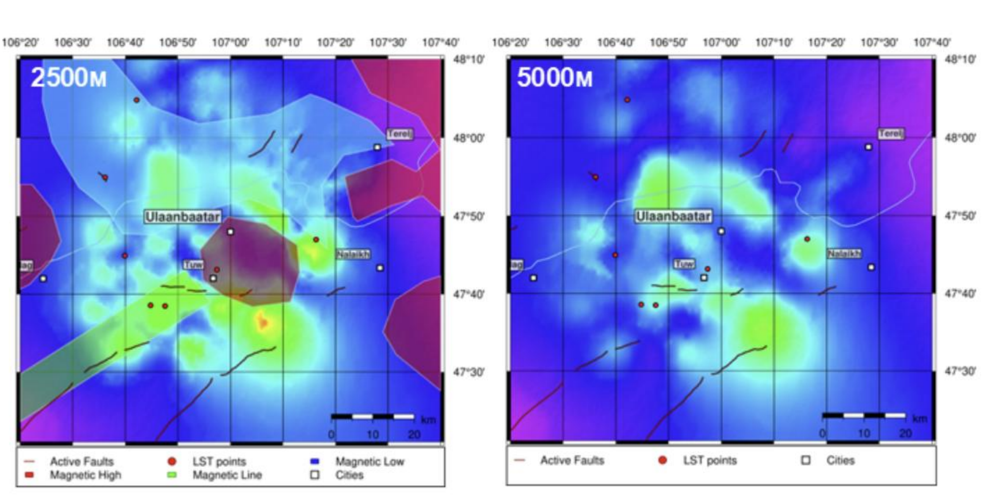
C1

- Rising from 20km depth. Extreme conductivities suggest a zone of mineralisation and relict volcanic activity.

Interpretation of the Ulaanbaatar MT model

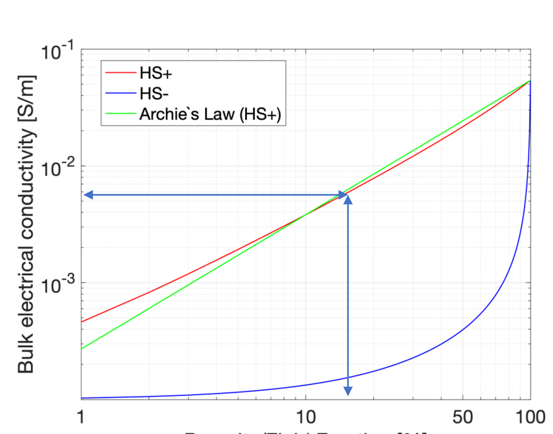
Characterization of conductor C2

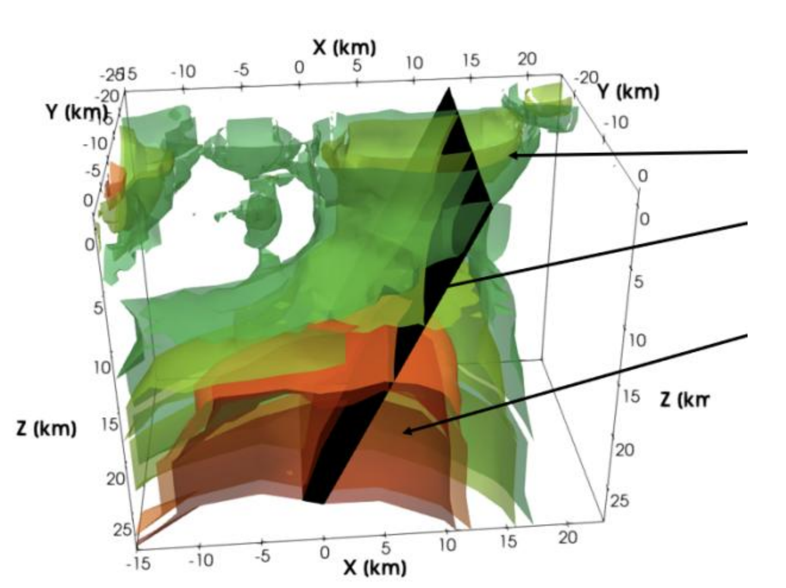
- Fault-controlled deep fluid circulation down to 3 km below surface.
- High elevation recharge area.



Porosity estimation

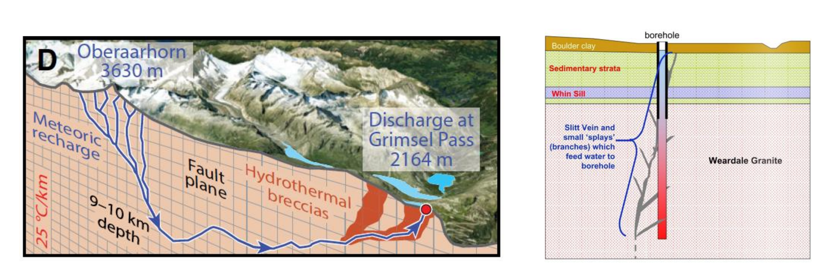
- Electrical conductivity of hot spring water: 0.02 S/m
- Mixing laws suggest porosities in fault of up to ~10%





Geological analogies

- Topography driven deep fluid circulation and thermal springs in Grimsel, Switzerland (Wanner et al, 2018)
- Hyper-permeable granite zones encountered in geothermal wells in the Eastgate Geothermal Borehole, Weardale, UK (Manning and Younger, 2010)



Summary

- MT allows to map and identify pathways of deep fluid circulation that form the basis of intermediate temperature geothermal systems.
- Potential hot water is sourced by meteoric fluids that circulate along permeable fault zone down to 3-4 km depth (reservoir ~90°C with 20-30°C/km).
- Taping this resource by drilling into the fault zone could provide energy for heating in Ulaanbaatar and dramatically reduce air pollution.