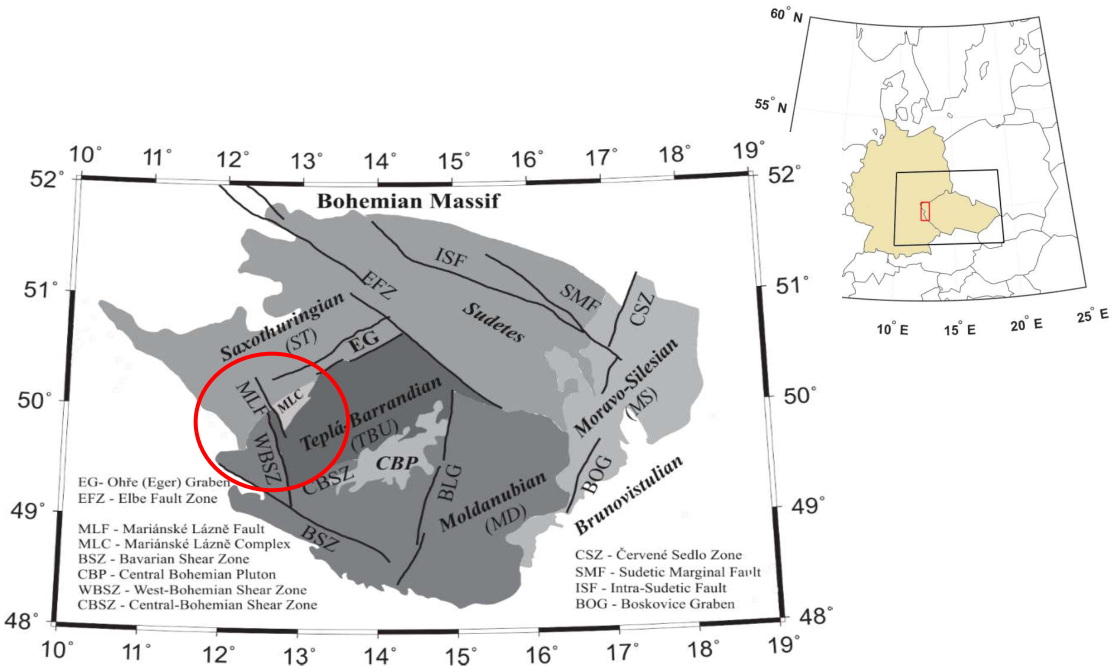
Magnetotelluric measurements in West Bohemia to image the local and regional subsurface electrical conductivity structure beneath the Mýtina and Neualbenreuth Maar

Platz, A., Weckmann, U., Pek, J., Kováčiková, S., Klanica, R. & Willkommen, G.

Motivation/Introduction Measurements Processing 2D-Analysis Outlook



Simplified tectonic map of the Bohemian Massif showing the major units and faults, modified after Plomerová et al. (2016). The area of interest is indicated by the red ellipse.

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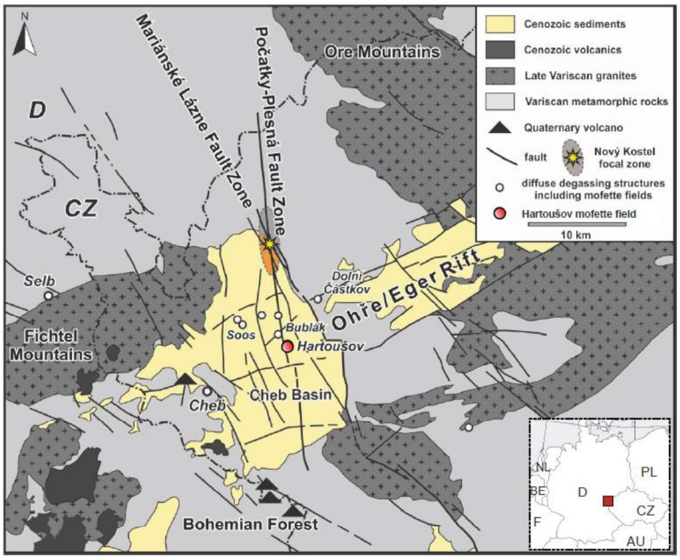

Geological sketch map of the western Bohemia area near the German-Czech border from Nickschick et al. (2019). The entire region is characterised by ongoing magmatic processes in the intra-continental lithospheric mantle. Phenomena - like Cenozoic volcanism represented e.g. by Quaternary volcanoes, massive degassing of CO_2 in the form of mineral springs and mofettes as well as the occurrence of repeated earthquake swarms - make the Eger Rift a unique target area for European intra-continental geoscientific research.

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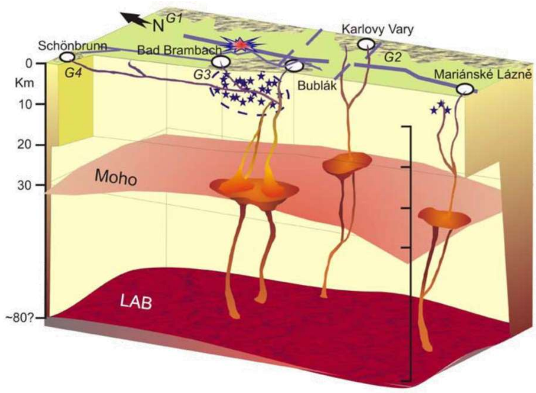
Key questions of the ICDP project

- Correlation between mofette degassing, gas composition and swarm and microbial activity
- Fault-valving mechanisms and their relevance for seismic hazard, degassing and the deep biosphere
- Triggering mechanism of fluid-induced earthquake swarms
- **Pathways for fluids from the upper mantle to the surface**



Cartoon illustrating the geodynamic situation in the area of interest (Bräuer et al., 2008)

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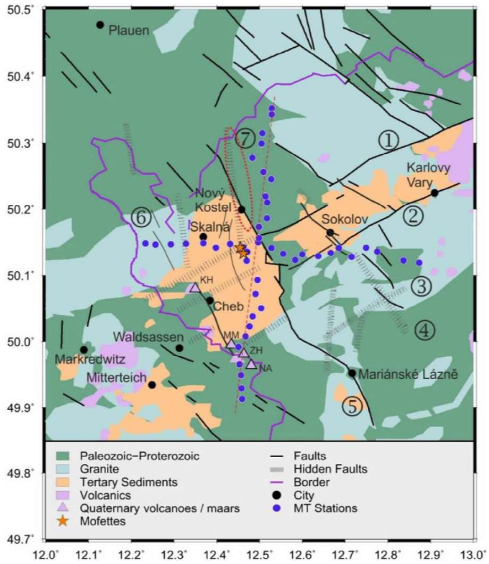
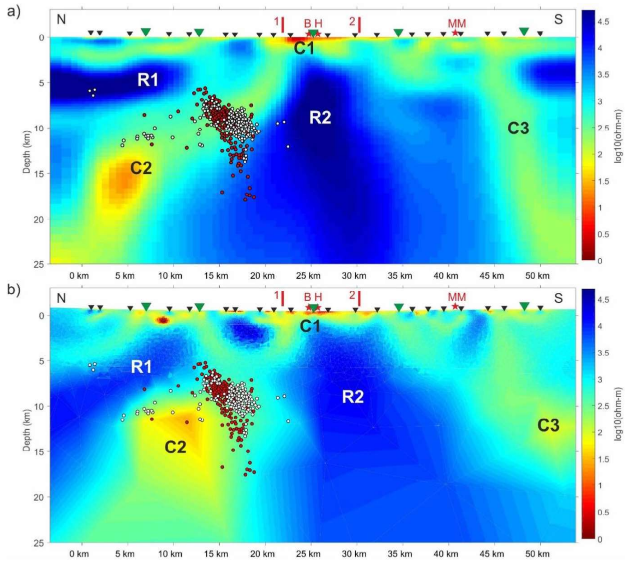
Previous results (EMERES, 2015)





Electrical resistivity models obtained from a) finite differences and b) finite elements inversion (Muñoz et al., 2018) revealing a conductive channel at the earthquake swarm region that extend from the lower crust to the surface forming a pathway for fluids into the region of the mofettes. A second conductive channel (C3) is present in the south of the model. Due to the given station setup, the resulting 2D inversion allows ambiguous interpretations of this feature.

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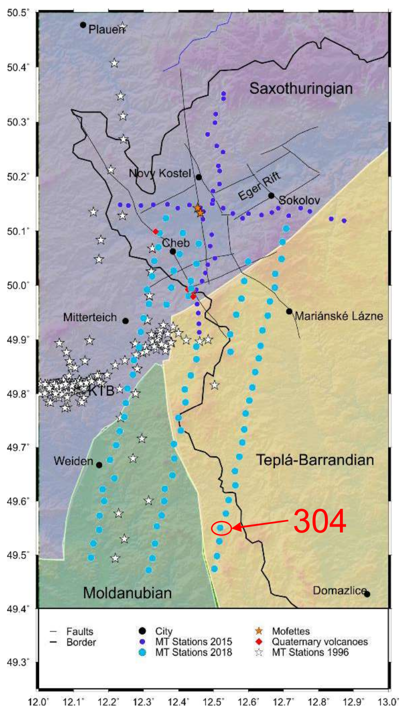

- 3D inversion is required to distinguish between the different explanations for the conductor C3 in Muñoz et al. (2018)
- ➢ another MT field experiment was conducted at the end of 2018
- 83 broad-band 5-component MT stations
- Period range: 10^{-4}-10^{3}s
- Relatively high noise level
- Good record of noise sources and broken instruments
- Reference station: Wittstock (~10^{-3}-10^{3}s) & local station 304 (only for the last two weeks)

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Processing strategy

- EMERALD processing code (Ritter et al., 1998; Weckmann et al., 2005; Krings, 2007; Platz & Weckmann, 2019)
- Different processing approaches:
  - Single-site processing
  - Remote reference processing with Wittstock (distance ~350km, only for $T > {}^{1}/_{512}\,s$)
  - „Local" remote reference processing with station 304 (distance ~3-65km)
  - Pseudo-remote processing (only for a few stations with problems in the magnetic channels)
- Application of notch and delay line filter for e.g. 50Hz and 16.7Hz
- Tests with different data selection criteria:
  - Coherence threshold
  - Magnetic polarisation direction criterion (Platz & Weckmann, 2019)
  - Mahalanobis distance criterion (Platz & Weckmann, 2019)

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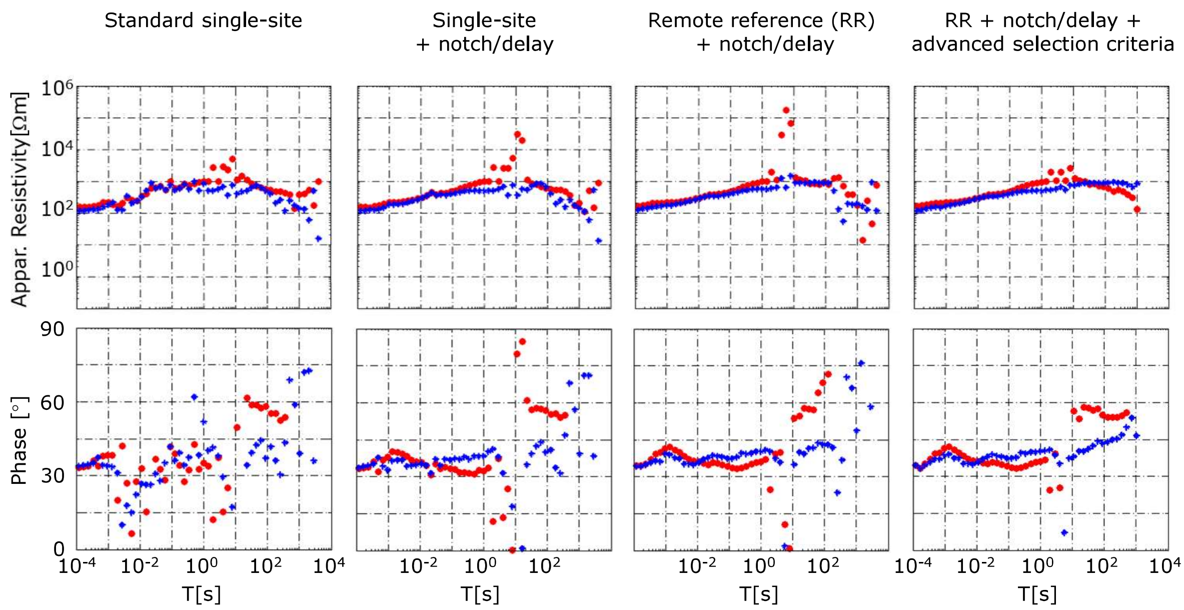
Exemplary processing results



A coherence threshold is applied for all shown processing results.

• Zxy
• Zyx

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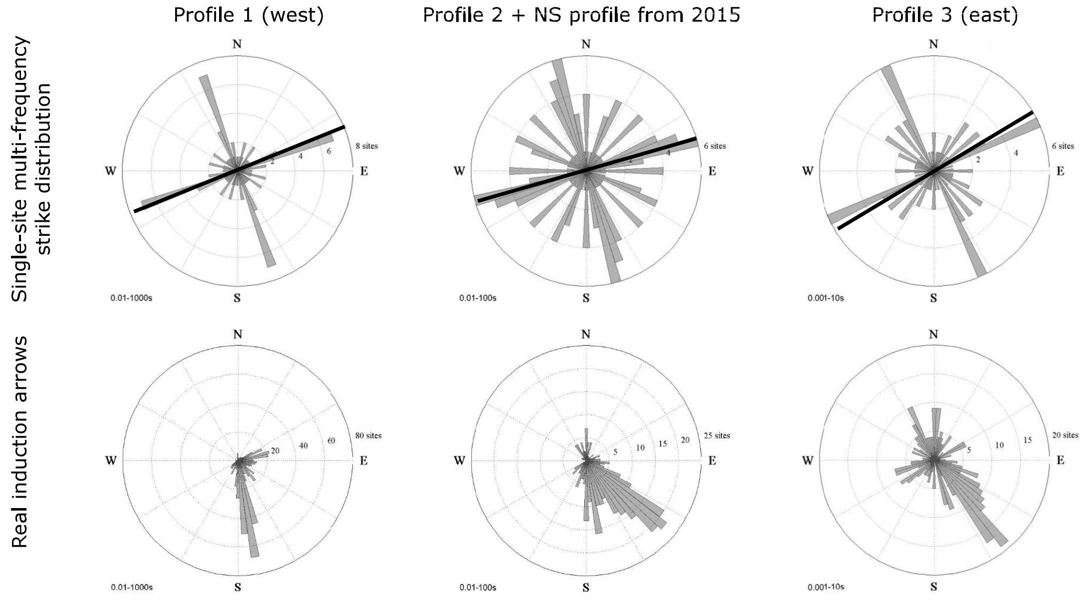
Strike analysis after Becken & Burkhardt (2004)



Multi-site multi-frequency strike

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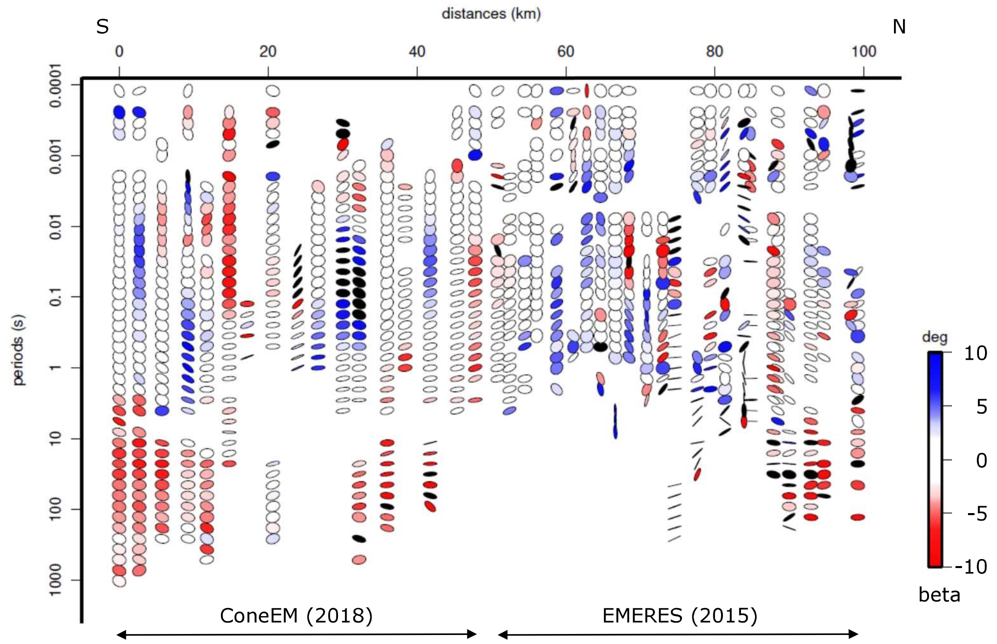
Phase tensors of profile 2



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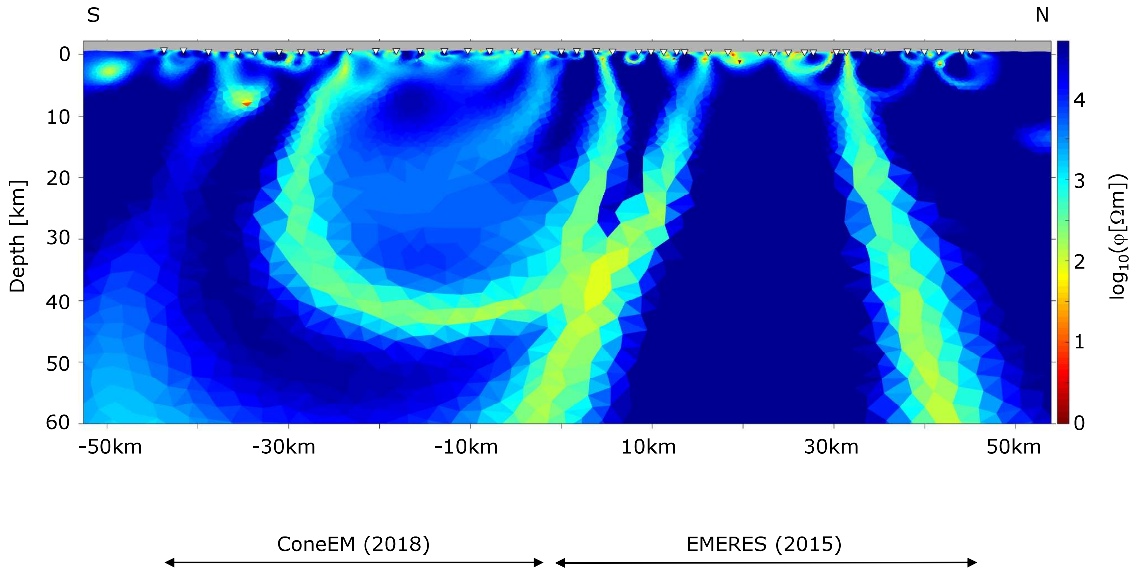
Preliminary model of profile 2 using Z



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Starting model: 500Ωm homogeneous half-space; ~40,000 free parameters

Error settings: $\rho_{a,TE}$=100%, $\rho_{a,TM}$=20%, ϕ=3°

RMS: 20.5 → **1.66** after 100 iterations

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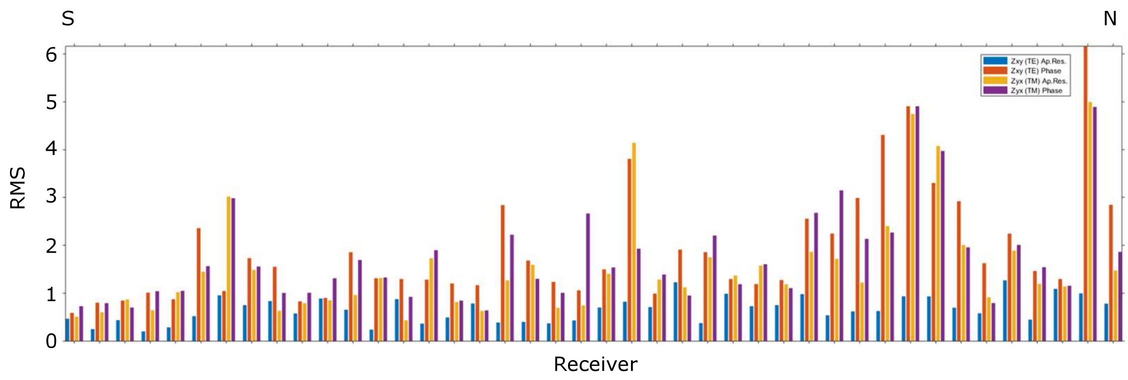
Data fit



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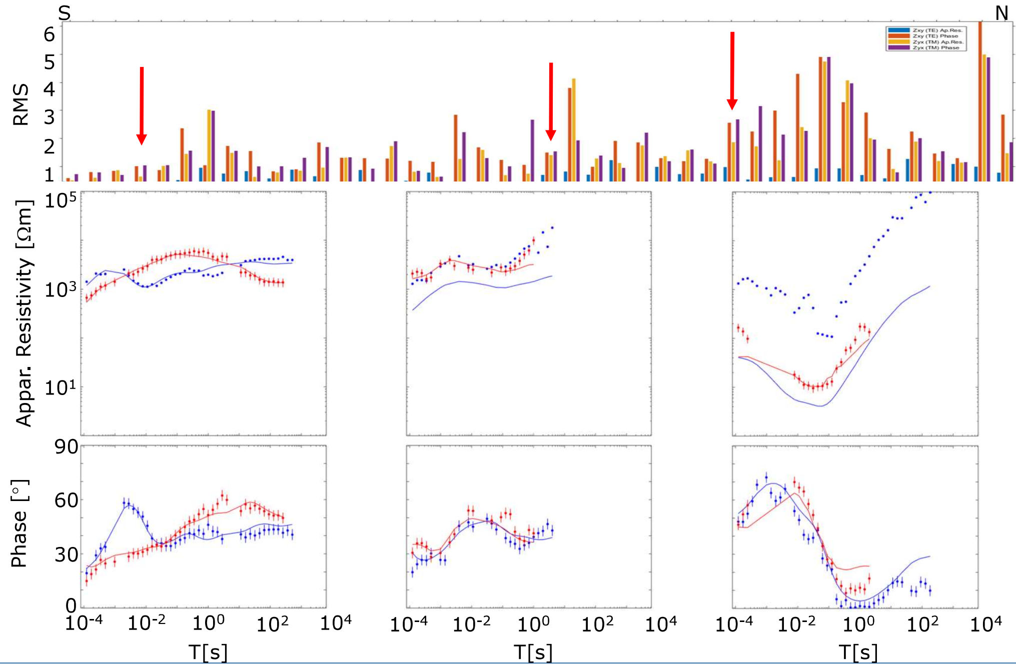
Data fit



• TM
• TE

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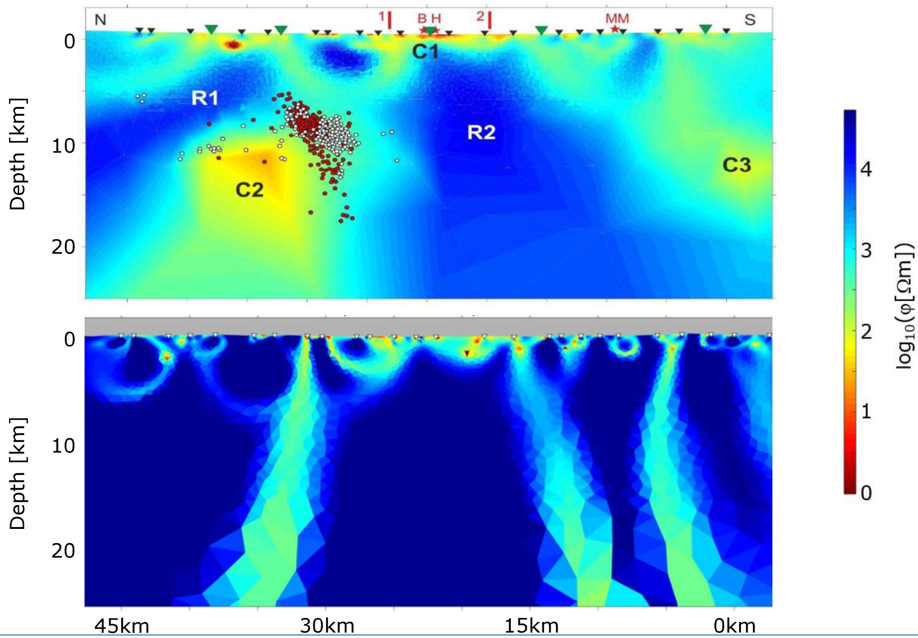
Comparison with previous result



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Next steps

- 2D inversions of all three profiles with Mare2DEM and several parameter tests
- 3D inversion with ModEM
- Interpretation of the final model in combination with other geoscientific data

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References

- Bräuer, K., Kämpf, H., Niedermann, S., Strauch, G. & Tesar, J. 2008. Natural laboratory NW Bohemia: Comprehensive fluid studies between 1992 and 2005 used to trace geodynamic processes. *Geochem. Geophys. Geosyst.*, **9**, 1-30
- Muñoz, G., Weckmann, U., Pek, J., Kováciková, S., & Klanica, R. 2018. Regional two-dimensional magnetotelluric profile in West Bohemia / Vogtland reveals deep conductive channel into the earthquake swarm region. *Tectonophysics,* **727**, 1-11
- Nickschick, T., Flechsig, C., Mrlina, J., Oppermann, F., Löbig, F., and Günther, T. 2019. Large-scale electrical resistivity tomography in the Cheb Basin (Eger Rift) at an ICDP monitoring drill site to image fluid-related structures, *Solid Earth Discuss.*, https://doi.org/10.5194/se-2019-38, in review
- Platz, A. & Weckmann, U. 2019. An automated new pre-selection tool for noisy Magnetotelluric data using the Mahalanobis distance and magnetic field constraints. *Geophysical Journal International,* **218**, 1853-1872
- Plomerová, J., Munzarová, H., Vecsey, L., Kissling, E., Achauer, U., & Babuška, V. 2016. Cenozoic volcanism in the Bohemian Massif in the context of P- and S-velocity high-resolution teleseismic tomography of the upper mantle. *Geochem. Geophys. Geosyst.*, **17**, 3326–3349

Acknowledgement

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