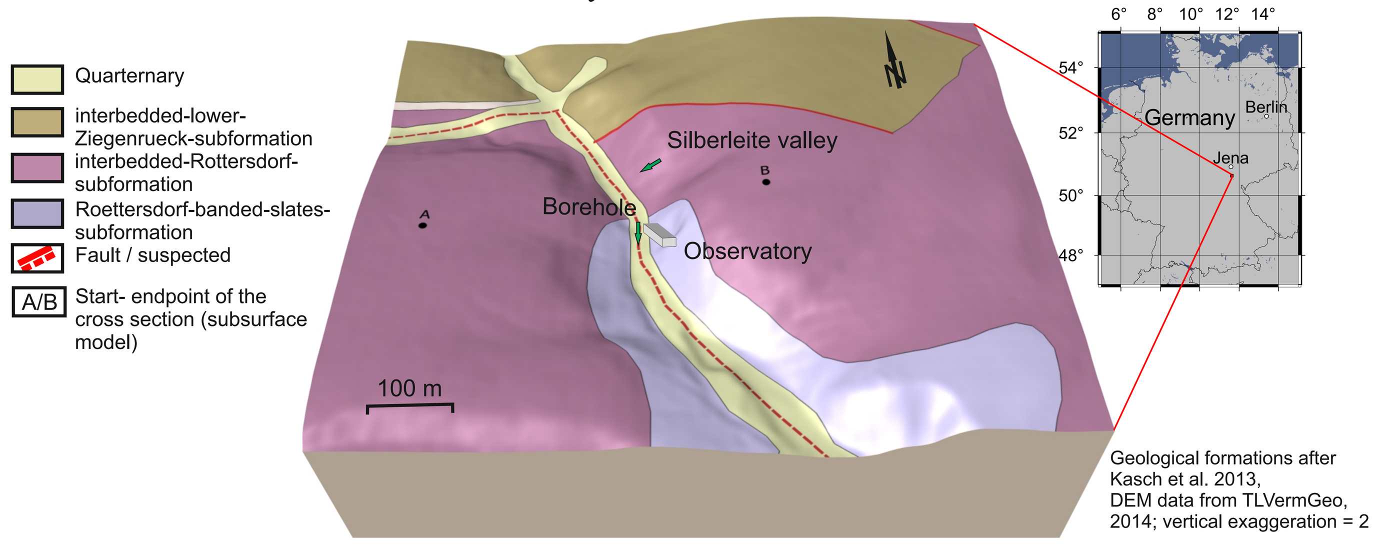
Identification of a fault zone beneath Moxa observatory (Central Germany): evidence from combining logging, rock physical measurements, and geophysical profiling

Valentin Kasburg[1], Todor Valchev, Andreas Goepel, Cornelius O. Schwarze & Nina Kukowski
Friedrich-Schiller-Universität Jena, Institut für Geowissenschaften, AG Allgemeine Geophysik
[1]valentin.kasburg@uni-jena.de

FRIEDRICH-SCHILLER-UNIVERSITÄT JENA

Geological setting

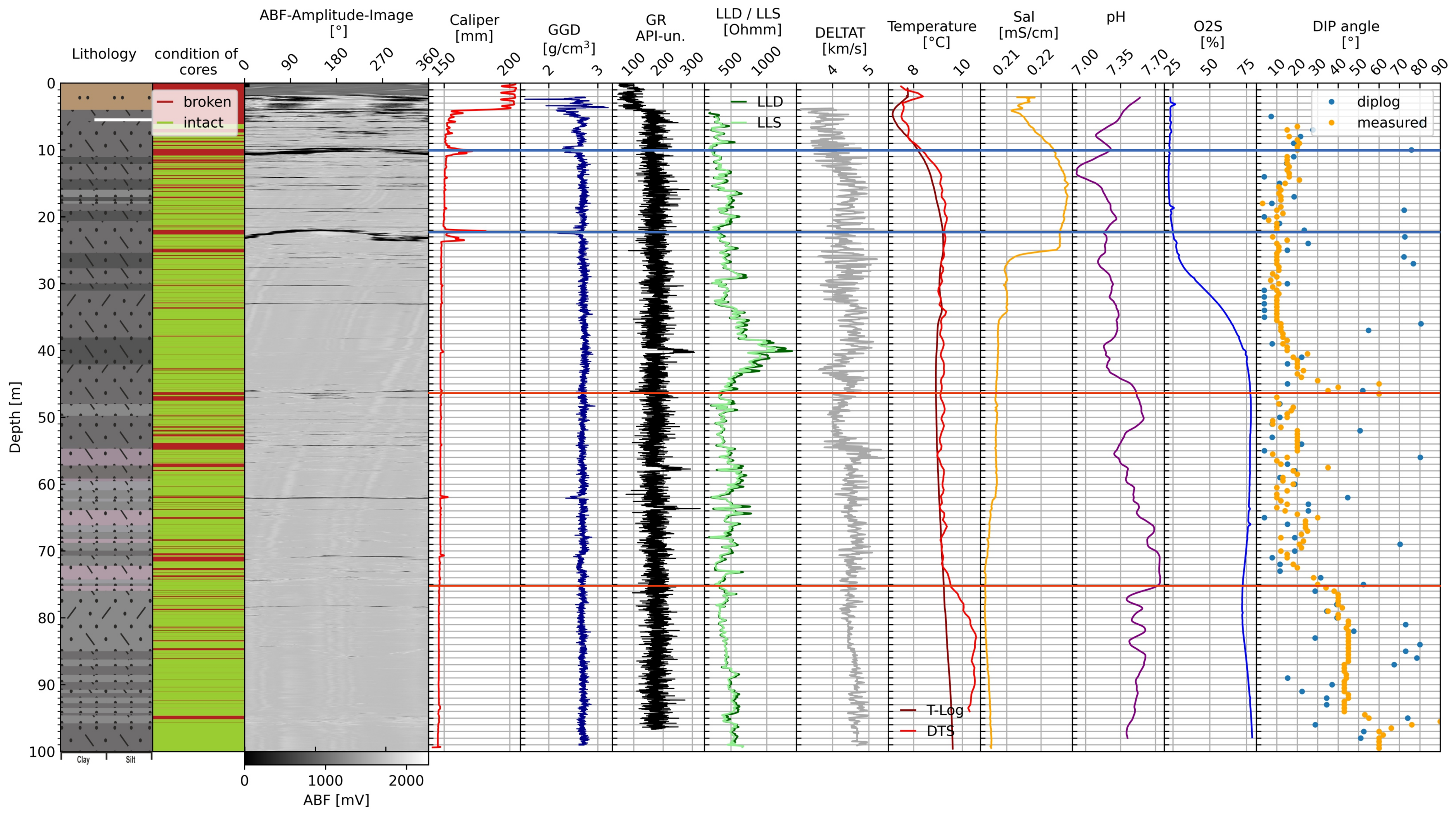
Moxa Geodynamic Observatory is located about 30 km south of Jena in the Thuringian Slate Mountains (Paleozoic Saxo-Thuringian). Folding in the surrounding of the observatory shows SW-NE striking and SE vergence (Franke, 1984). The predominantly fine clastic lithologies are of Lower Carboniferous age. Kasch (2006) carried out a detailed mapping around the observatory and suspected a fault in the valley of the Silberleite creek, where the observatory is located.



To better characterize the subsurface and understand the underground structures, a 99.6 m deep borehole was drilled in 2013, core material was collected and borehole geophysical measurements were carried out. The borehole was developed and a temperature measurement system was installed.

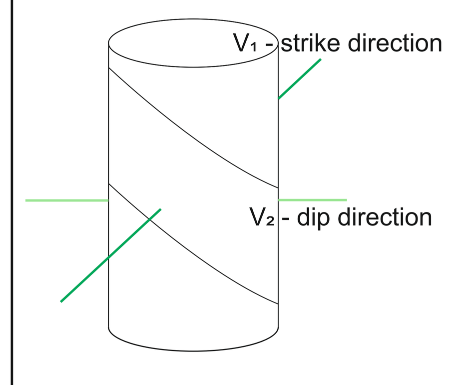
Borehole measurements

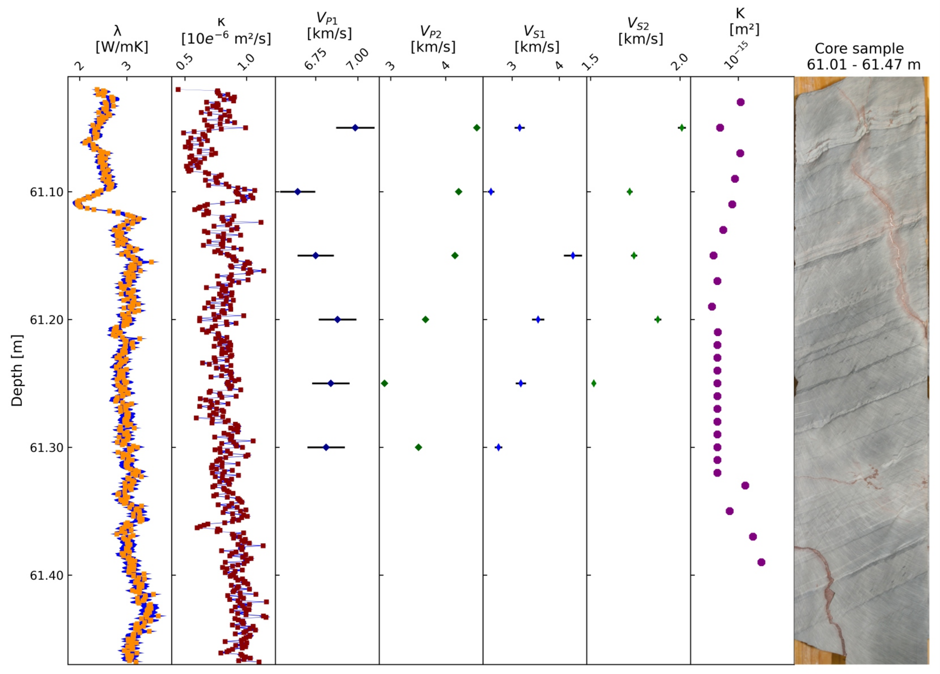
The borehole measurements were taken directly after drilling and may have been influenced by the drilling fluid taken from Silberleite creek. Measured temperatures from the log in comparison with the temperatures measured three years later via the distributed temperature sensing (DTS) glass fiber show no influence of the drilling fluid down to a depth of 73 m. From there the trend of pH changes and a local minimum of oxygen saturation is evident. Two major aquifers can be identified in conjunction with the weathered and strongly broken cores at 10 – 11 m and 22 – 23 m. Calculated dipping shows similar dip angles of the layering measured at the cores. Higher dip values fit well with the dipping of fractures measured by Kasch (2006) at surrounding outcrops.

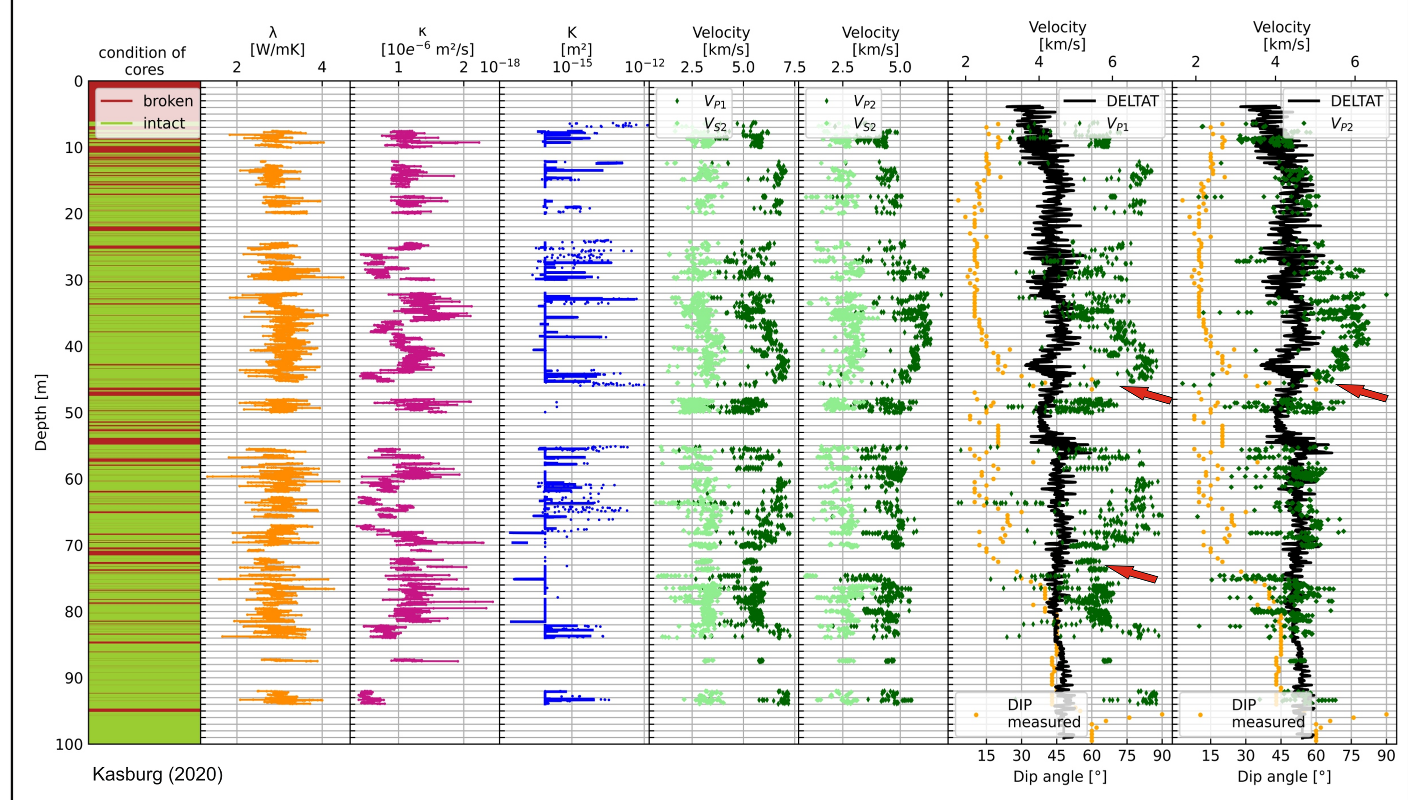


Petrophysical measurements

Thermal conductivity, thermal diffusivity, permeability and sonic velocities have been determined on the cores (Iwakiri (2015), Schwarze (2015), Kasburg (2020)). While the thermal conductivity is relatively constant, the thermal diffusivity shows small variations. Permeability is highly variable, which can be related to the width of the fractures and degree of refilling with secondary minerals. Sonic velocities have been measured in the xy-plane. Above the two identified faults the velocities in strike direction decrease. For the velocities in the dip direction, this only applies to the cores above 46.5 m.

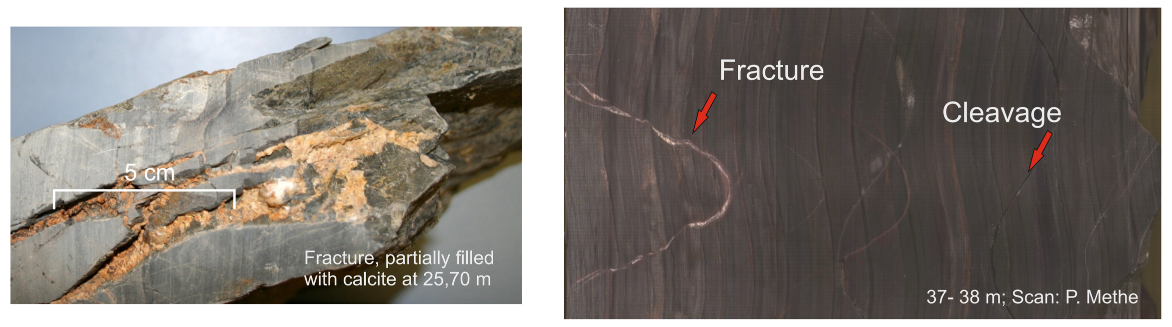


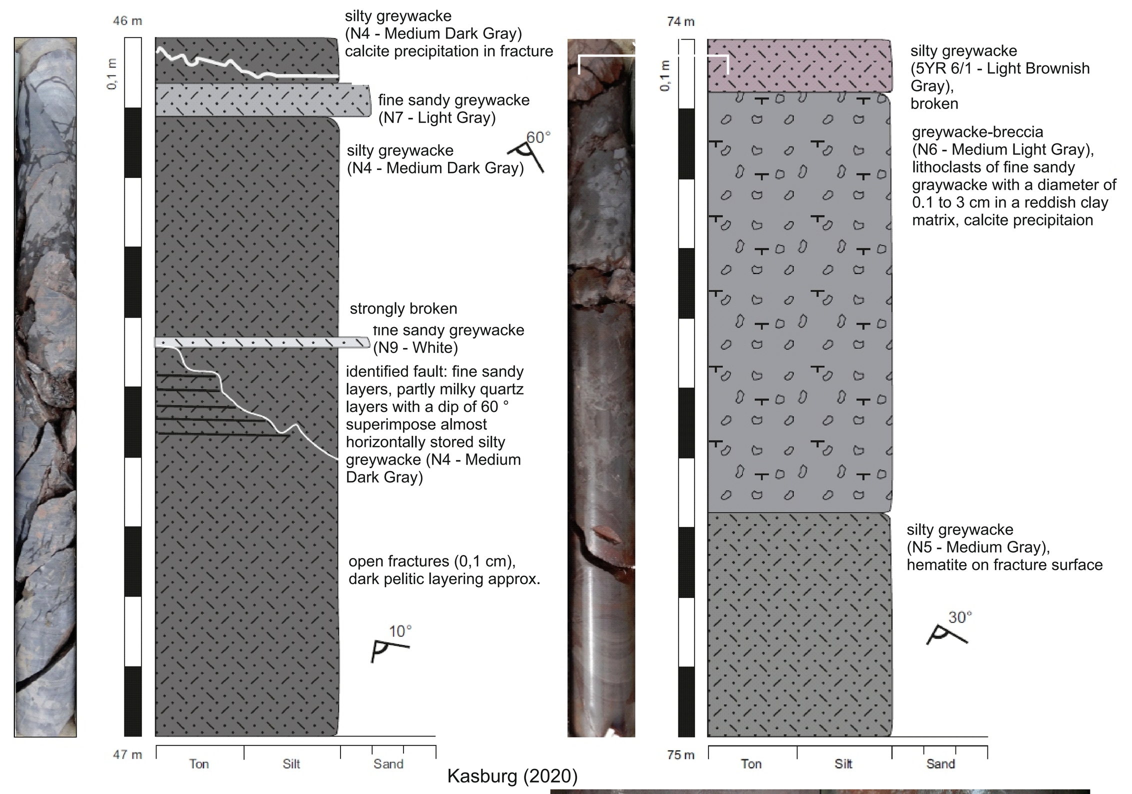


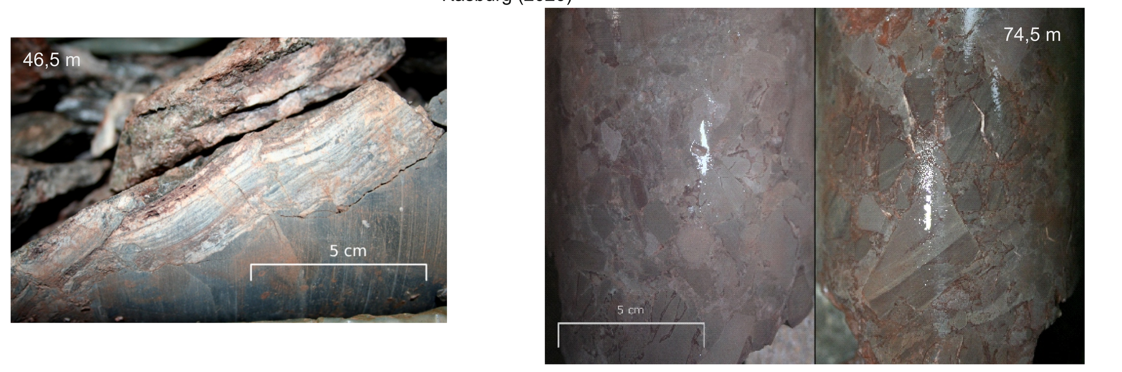


Core sample information

The cores consist of silty graywackes corresponding to a sequence of the upper three layers of the Bouma sequence. The dip of the layers was measured with a spacing of 0.5 m on the cores. Fractures with several secondary minerals occure with a spacing of approximately 60 cm. At 46.5 m depth 6 cm thick quartz layers overlaid by 4 cm fault gouch were found. At 74.5 m depth a 60 cm thick fault breccia was identified.

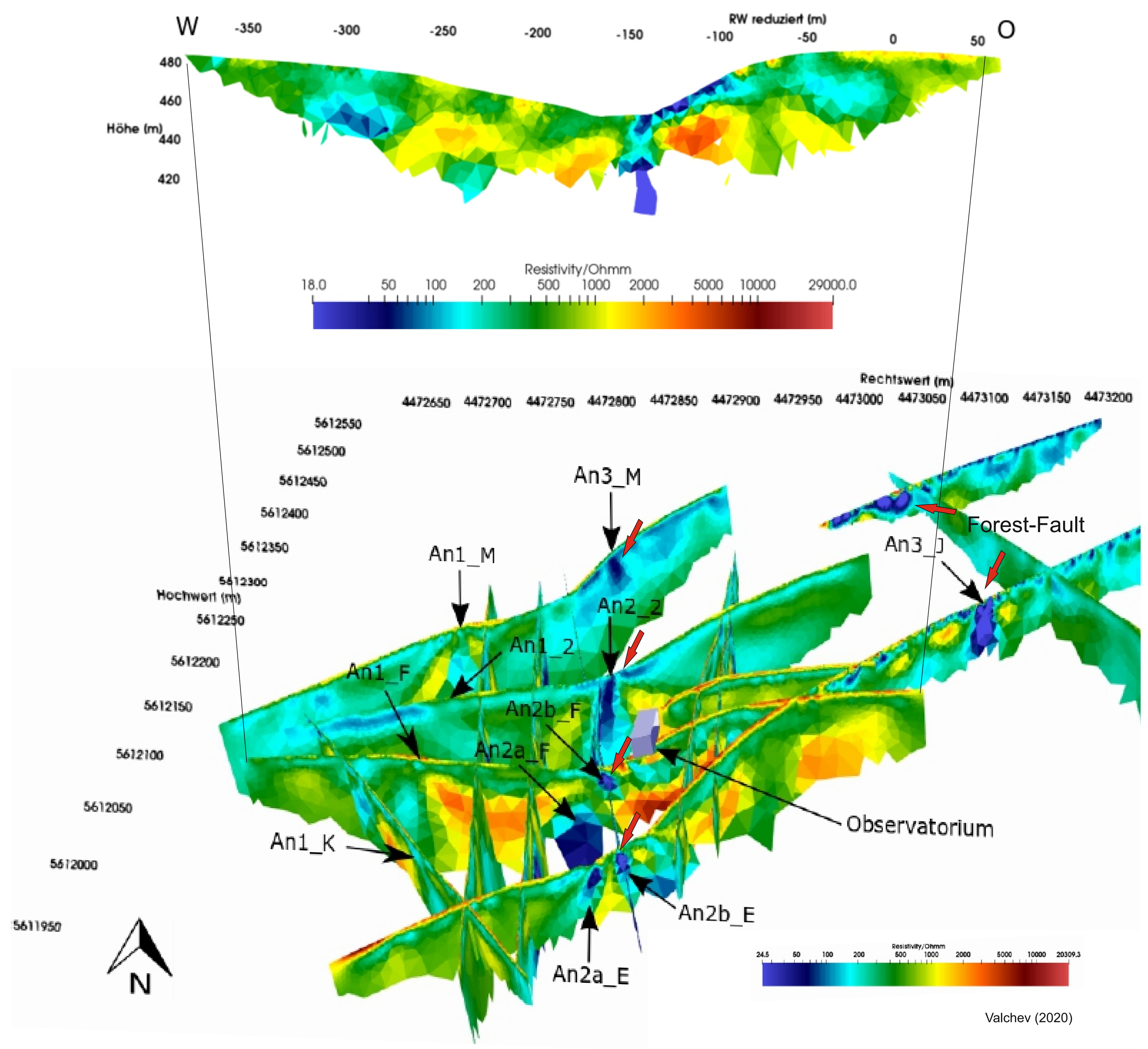






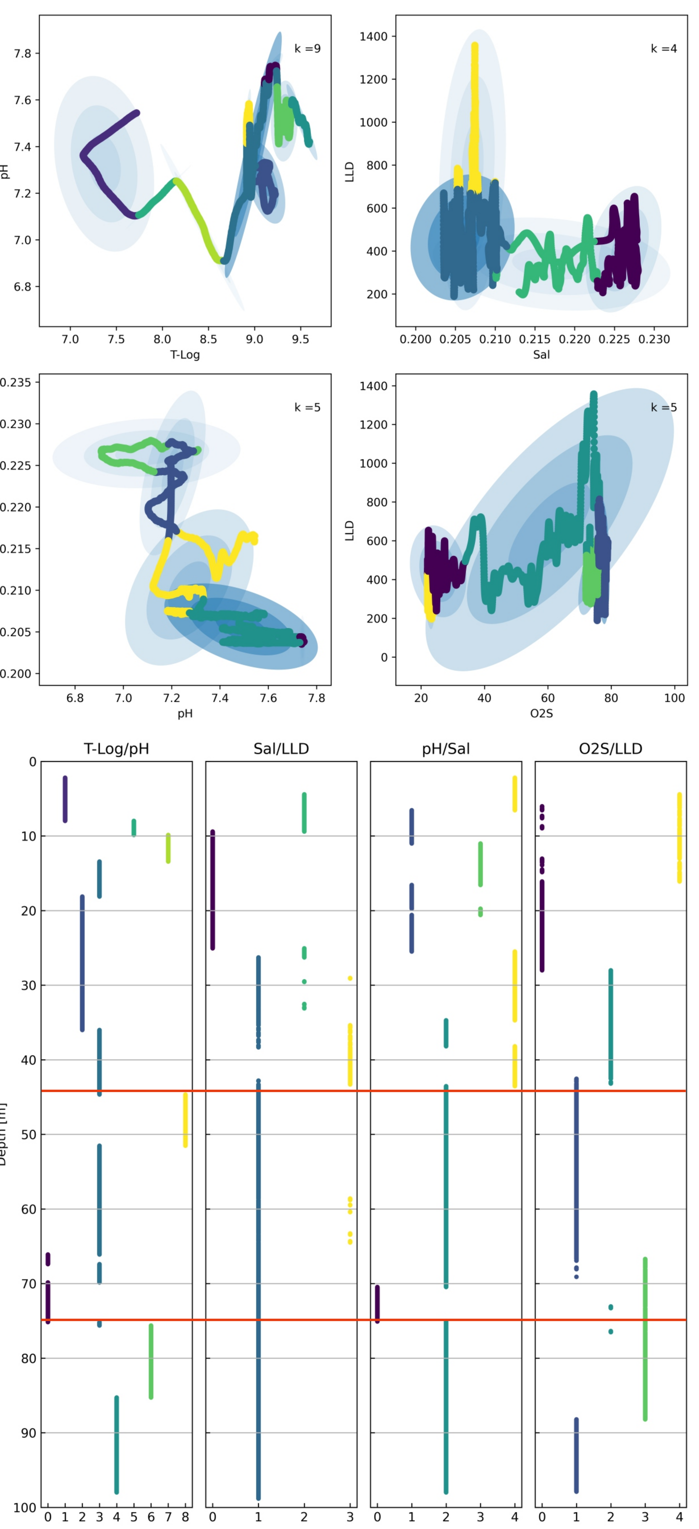
Surface geophysical surveys

Using geoelectrical resistivity tomography (ERT) for resistivity profile measurements Valchev (2020) was able to demonstrate a low resistivity anomaly in the in the valley of the Silberleite where the observatory is located. Low resistivity anomalies also occur in profiles crossing the "Forest"-fault northeast of the observatory.



Cluster Analysis

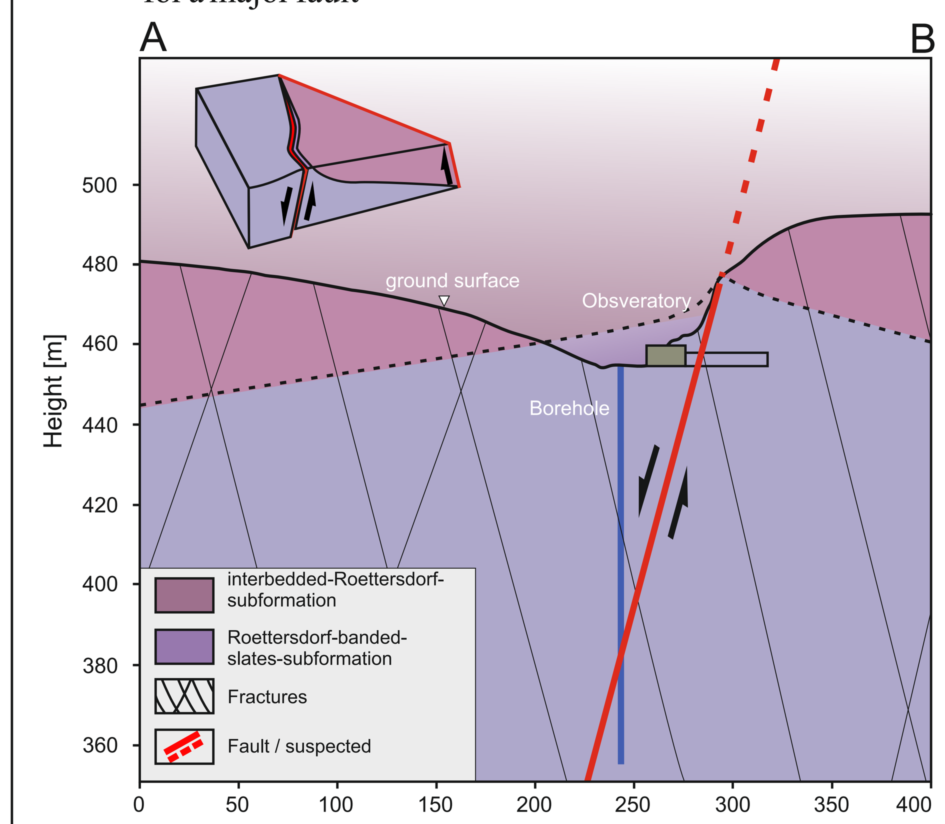
Cluster analysis was performed for Gaussian mixed models using the expectation maximization algorithm. In the depth representation of selected measurements, class changes in the encountered fault zones and aquifers become visible.



Conclusions

The combined evaluation of logging, rock physical measurements and geophysical profiling allows a better understanding of the subsurface structure:

- major horizontal aquifers are at depths of 3 – 6 m, 10 – 11 m and 22 – 23 m
- approx. 75 ° dipping fractures occur frequently and serve as minor aquifers with variable permeability
- several faults were identified in the cores, but only sections at 46.5 m and 74.5 m are relevant for a major fault



Due to the greater thickness of the fault breccia and the deviating temperatures of the DTS measurement in the same depth it can be considered as the main fault. During construction in 1964, the entrance to the gallery had to be shifted backwards by several meters because increased moisture was encountered there along with a fracture and unstable lithology. We interpret this as fault breccia and relate it to the faulted zone observed in the drill core.

Acknowledgements

Thanks to the Honours Program of the FSU Jena, in the framework of which this poster was created.

References

Franke, W., 1984: Variszischer Deckenbau im Raume der Münchberger Gneismasse - abgeleitet aus der Fazies, Deckenbauinformation und Metamorphose im umgebenden Paläozoikum. Geotektonische Forschungen, W. Zeil, V. 68, E. Schweizerbart'sche Verlagsbuchhandlung.

Iwakiri, S., 2015: Gesteinsphysikalische Untersuchungen an Kernmaterialien aus der Bohrung Moxa 1/2013. Bachelors Thesis, FSU Jena.

Kasch, N., 2006: Diplomkartierung & Diplomarbeit - Strukturgeologische Betrachtungen im nordwestlichen Teilabschnitt des Ziegenrück-Synklinoriums bei Moxa. Diploma Thesis, FSU Jena.

Kasburg, V., 2020: Kernbohrung Moxa - Bericht zur Untersuchung des Bohrkerns unter Einbeziehung der bohrlochgeophysikalischen, geologischen, als auch der im Labor erhobenen petrophysikalischen Daten. Research report, FSU Jena.

Kasch, N., Naujoks, M., Kley, J. and Jahr, T. (2013). Combined geological and gravimetric mapping and modelling for an improved understanding of observed high-resolution gravity variations: A case study for the Global Geodynamics Project (GGP) station Moxa, Germany. International Journal of Earth Sciences. 102. 10.1007/s00531-012-0859-z.

Schwarze, C. 2015: Bestimmung der thermischen Gesteinseigenschaften imUntergrund durch Labor- und Feldversuche an den Bohrungen KB-Moxa 1/13 und FB-Moxa 1/13. Diploma Thesis, FSU Jena.

Valchev, T. 2020: Aquisition und Inversion 2D/3D-geoelektrischer Daten: Ableitung eines tektonischen Untergrundmodells des Geodynamischen Observatoriums Moxa. Masters Thesis, FSU Jena.