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Electrical conductivity models of the Gross Schönebeck geothermal reservoir obtained from magnetotellurics

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The EU funded project I-GET is aimed at developing an innovative strategy for a geophysical exploration of (geothermal) deep water systems. The strategy is to integrate all the available knowledge, from rock physics to seismic and magnetotelluric (MT) data processing and modelling. For geothermal exploitation, the detection of permeable zones and fluid bearing fractures is crucial. The magnetotelluric (MT) method is a natural-source electromagnetic method capable of imaging the subsurface electrical conductivity down to depths of several kilometers. Since electrical conductivity depends strongly on the presence of fluids, the magnetotelluric method is a very promising exploration technique for geothermal reservoirs.

The 4-4.5 km deep siliciclastic reservoir of Groß Schönebeck (50 km north of Berlin/Germany) is part of the South Permian Basin system and as such it is representative for large sedimentary basins which exist all over Europe. The Groß Schönebeck test site consist of a well doublet made up of the wells GrSk 3/90 and GrSk 4/05. It is currently used as an in situ geothermal laboratory. The main objective of the geophysical site characterization experiments is to develop high resolution electrical conductivity images together with seismic tomographic models for a joint interpretation.

In this work we present results of the two MT experiments carried out in the study area. MT data was collected along a 40 km-long NNE-SSW trending profile centered around the well doublet (profile S) and a second 20 km-long profile of the same orientation located 5 km to the east of the long profile (profile W). Profile S consists of 55 stations with a site spacing of 400 m in the central part (close to the borehole) of the profile, increasing to 800 m towards the profile ends. Profile W consists of 18 stations with a site spacing of 1 km. The period range of the observations was 0,001 to 1000 s. At all sites, we recorded horizontal electric and magnetic field components and the vertical magnetic field.

The models obtained from 2D inversion show a prominent shallow conductive layer along the entire profile. Comparison with sedimentary boundaries in the overburden rock of evaporitic strata obtained from 2D seismic and well data for gas exploration, shows a good correlation of the resistivity model with the structures related to salt tectonics. The high conductivity anomalies coincide with the structural lows above the thick evaporitic rocks, probably due to sedimentation of more porous materials or fluid accumulation. Two deeper conductors located at a depth of 4-5 km could be related to a highly fracture anhydrite zone within the residual brittle evaporitic rocks after salt movement or to higher formation temperatures below the salt lows. We assume that the formation of the current salt morphology with its thickness variations of 0-1500 m has a considerable impact on the resistivity of both overburden and reservoir rocks.