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Deep Geothermal Energy for Lower Saxony (North Germany) – Combined Investigations of Geothermal Reservoir Characteristics

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In Germany, successful deep geothermal projects are mainly situated in Southern Germany in the Molassebecken, furthermore in the Upper Rhine Graben and, to a minor extend, in the North German Basin. Mostly they are hydrothermal projects with the aim of heat production. In a few cases, they are also constructed for the generation of electricity.
In the North German Basin temperature gradients are moderate. Therefore, deep drilling of several thousand meters is necessary to reach temperatures high enough for electricity production. However, the porosity of the sedimentary rocks is not sufficient for hydrothermal projects, so that natural fracture zones have to be used or the rocks must be hydraulically stimulated.
In order to make deep geothermal projects in Lower Saxony (Northern Germany) economically more attractive, the interdisciplinary research program "Geothermal Energy and High-Performance Drilling" (gebo) was initiated in 2009. It comprises four focus areas: Geosystem, Drilling Technology, Materials and Technical System and aims at improving exploration of the geothermal reservoir, reducing costs of drilling and optimizing exploitation.
Here we want to give an overview of results of the focus area "Geosystem" which investigates geological, geophysical, geochemical and modeling aspects of the geothermal reservoir.
Geological and rock mechanical investigations in quarrys and core samples give a comprehensive overview on rock properties and fracture zone characteristics in sandstones and carbonates. We also show that it is possible to transfer results of rock property measurements from quarry samples to core samples or to in situ conditions by use of empirical relations.
Geophysical prospecting methods were tested near the surface in a North German Graben system. We aim at transferring the results to the prospection of deep situated fracture zones. The comparison of P- and S-wave measurements shows that we can get hints on a possible fluid content of the fracture zone. The assumed elastic rock properties can be evaluated by FD modeling. Geoelectric and electromagnetic investigations of the fracture zone were carried out to investigate their potential to give hints on minerals, brines or hydrothermal fluids within the fracture zone. Measurements of the Spectral Induced Polarization show that anisotropy of phase angles may not be neglected, because otherwise data may be misinterpreted and structural models become unnecessarily complicated.
A crucial aspect for the performance of a Geothermal plant is the mineral contents of the formation water. Scalings and corrosion can severely disturb the operation and the properties of the reservoir. Therefore, North German formation waters were analysed and categorized and a thermodynamic database was developed. It allows hydrogeochemical modeling of geothermally used waters and of hydrogeochemically and technically induced processes under North German conditions.
Hydromechanical modeling showed that differences of elastic rock properties between neighboring layers does not strongly influence propagation paths of fractures, whereas they significantly influence fracture aperture. On the other hand, differences of mechanical rock properties significantly influence propagation paths of fractures. Existing fractures are also affected by the induced fracture – after stimulation, they propagate further in the direction of maximum shear stress. Furthermore, rock deformation during the production phase depends strongly on the contrast of hydraulic conductivity between highly permeable fracture core and low permeable rock matrix.
The projects within gebo-Geosystem are well interconnected. Both the focus area "Geosystem" as well as the whole collaborative research program "gebo" offer different approaches that lead to an improvement of geothermal exploration and exploitation as well as a better understanding of the processes within geothermal reservoirs.

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