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Heterogeneities of mechanical properties in potential geothermal reservoir rocks of the North German Basin

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Heterogeneous rock properties in terms of layering and complex infrastructure of fault zones are typical phenomena in sedimentary basins such as the North German Basin. To be able to model reservoir stimulation in layered stratifications and to better adapt the drilling strategy to the rock mechanical conditions it is important to have knowledge about the effects of heterogeneous rock properties on fracture propagation and fault zone infrastructure for typical sedimentary reservoir rocks in the North German Basin. Therefore we aim at quantifying these properties by performing structural geological field studies in outcrop analogues combined with laboratory analyses.

The field studies in Rotliegend sandstones (Lower Permian), the sandstones of the Middle Bunter (Lower Triassic) and the sandstones of the Upper Keuper (Upper Triassic) focus on 1) host rock fracture systems and 2) fault zone infrastructure. We analyse quantitatively the dimension, geometry, persistence and connectivity of fracture systems separately for host rocks and fault damage zones. The results show that in rocks with distinctive layering (sandstones and shales) natural fractures are often restricted to individual layers, that is, they are stratabound. The probability of fracture arrest seems to depend on the stiffness contrast between the two layers and on the thickness of the softer layer.

The field studies are complemented by systematic sampling to obtain mechanical property variations caused by the layering. For the samples we measure the parameters Young's modulus, compressive and tensile strengths, elastic strain energy, density and porosity. The results show that the mechanical properties vary considerably and many samples are clearly anisotropic. That is, samples taken perpendicular to layering commonly have higher strengths but lower stiffnesses than those taken parallel to layering.

We combine the results of laboratory analyses and field measurements to specify the mechanical heterogeneities of the sedimentary reservoir rocks of the North German Basin and of the mechanical units of fault zones therein. To estimate the in situ rock properties at different depths it is further important to understand how rocks from outcrops differ from rocks at depth (for example due to alteration and removal of the overburden load). To answer these questions we analyse samples from drill cores from depths relevant for the use as geothermal reservoirs which are stratigraphically and lithologically equivalent to those taken in outcrop analogues. The results from drill-core sample analyses are then compared with the results from the outcrop samples. Another approach is to analyse how rock mechanical properties correlate with petrographic properties (e.g., mineral content, cementation, fabric, porosity) to use this knowledge to extrapolate the data to depth. Altogether these results will be very useful to make better assumptions on natural reservoir permeabilities and to better adapt the drilling and reservoir stimulation strategy to the rock mechanical conditions.