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Geothermal potential of the German Buntsandstein: The effect of layering on fracture permeability

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Worldwide there is a high potential for generating renewable, geothermal energy. The principle of this technique is that heat is extracted from depths of 3-5 km by injection and extraction of water. The most important parameter for the economic use of geothermal energy is the high permeability of the reservoir. The hydraulic properties of a geothermal reservoir are influenced considerably by numerous fracture parameters; the fracture aperture and the connectivity of the fracture system being the most important. If there is no interconnected fracture system in a geothermal reservoir, the percolation threshold will not reached. We analyse fracture systems in outcrops of rocks comparable to potential reservoir rocks and consider the fracture parameters to estimate the permeability in potential geothermal reservoirs.

In the North German Sedimentary Basin there is a high potential for the exploration of geothermal energy, e.g., in the Buntsandstein Formation (lower Triassic). The Buntsandstein comprises of alluvial fans, fluviatile and playa deposits and represents the main subsidence episode of the North German Basin. The Middle Buntsandstein can be divided into four units, each represents a fining-upward cycle and consists of a coarse sandstone at the base overlain by alternating siltstone and shale layers.

Field analysis in the Buntsandstein of several hundreds joints indicate that most became arrested or offset at layer contacts. Fractures that are restricted to single layers (stratabound) are common in layered rocks. The most important factor contributing to fracture arrest in the Buntsandstein are material contrasts (particularly changes in Young's modulus), caused by alternating sandstone, siltstone and shale layers. In reservoirs where most fractures are stratabound, interconnected fracture systems are less likely to form than in reservoirs with mainly non-stratabound fractures. Therefore

the percolation threshold, necessary for fracture permeability, may not be reached in the Buntsandstein. However, there are some fractures that are more continuous and propagate through many layers (non-stratabound).

To understand fracture propagation, sufficient knowledge of the stress distribution in alternating layers with different material properties (mechanically-layered rocks) is necessary. This study focuses on field observations to obtain further information about fracture systems (dimension, orientation, aperture, arrest behaviour, etc.) in typical lithological profiles of the Middle Buntsandstein. In addition, we run numerical models of fracture systems in mechanically-layered rocks which focus on the local stress fields effecting fracture propagation. This investigation may help to minimise the risk and thereby increase the economic potential of geothermal energy.