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Discontinuity and matrix characterization of potential hydraulic conductivity in the Devonian limestone from the Rhenohercynian Massif in western Germany

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Within the last decade, conceptual models for deep geothermal applications in carbonate horizons in Bavaria (Germany) have been developed and implemented. Most of those horizons are located at depth of 4000 m to 6000 m. Recent studies noted that rock formations for geothermal applications are karstified carbonates from the Late Jurassic reef facies. In North Rhine-Westphalia carbonates from late Devonian and early Carboniferous are exposed but, so far, quantification of the in-situ hydraulic conductivity of these limestones is still lacking. Consequently, local geological surface measurements and laboratory tests have to be conducted in order to estimate the deep geothermal potential in western Germany. Three, representative open-pit mines were chosen for field surveys and to collect sample material for laboratory investigations. Those quarries are located in the east of the Rhenohercynian Massif in western Germany and are part of the Remscheid-Altena Anticline. During field surveys, discontinuities at various spacial scales were recorded which were cross-cutting an installed tape line at the outcrop wall. The so-called scanline survey method was used, that is, by counting all discontinuities along a fixed horizontal line at several locations in each quarry. In addition, the discontinuities were characterized by trace length, true spacing, roughness, aperture widths, and filling materials. Almost 800 discontinuities were recorded by this method. Joint orientation analysis indicated two dominant strike orientations in NNW-SSE and NE-SW. Discontinuity trace lengths and true discontinuity spacing results were used to describe potential settings for deep geothermal applications in the Rhine-Ruhr area. At the laboratory scale, basic physical properties, such as porosities, dynamic elastic moduli, and permeability, were determined on representative samples to compare these properties with the ones of recent studies on the Bavarian carbonates. Our results indicate that higher permeability can be expected for karstified formations related to the reef facies. Furthermore, the results of our structural joint-analysis provide a good basis for 3D subsurface modeling and numerical modeling of subsurface fluid flow.