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Numerical modeling of a granodioritic MD-BTES test-site

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Geothermal energy and thermal energy storages can significantly reduce the consumption of fossil energy resources by storing large amounts of heat in the subsurface, which is especially valuable when dealing with fluctuating renewable energy sources. Crystalline rocks with low hydraulic conductivity are a suitable target for such storage systems due to reduced convective heat losses. In the frame of the research project SKEWS (Seasonal Crystalline Borehole Thermal Energy Storage), a medium deep borehole thermal energy storage demonstrator with four 750 m deep borehole heat exchangers will be built at the Technical University of Darmstadt, Germany. In the preparation phase of this project, an extensive geophysical, petrophysical and structural dataset is gathered for the characterization of the project site's subsurface.

This multi-disciplinary dataset is used for the creation of a first-order finite element method (FEM) model of the storage reservoir for thermo-hydraulic modelling. The input data includes a large petrophysical dataset for crystalline rocks and a stress-dependent Discrete Fracture Network (DFN) for the hydraulic characterization of the fractured granodioritic basement rock. For numerical analysis of the storage operation cycles, a novel co-simulation approach, using the FEM suite FEFLOW and the Modelica library MoSDH, is used to consider the interconnection between the subsurface heat-exchangers and the surface heating grid. This approach allows for detailed FEM modelling of the subsurface, while being able to take the complexity of the surface heating network into account at the same time. The model will be updated continuously by additional data during the building process of the pilot and the following experiments, to generate a highly detailed and validated numerical model of a heat storage system in a granodioritic reservoir. Ultimately, the presented workflow can serve for the accurate prediction of the performance of upscaled systems and therefore support a well-founded design process of this novel storage technology.