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Multiscale 3D stress field modelling for the URL 'Reiche Zeche' using a discontinuum model approach

Sebastian Rehde and Prof. Dr.-Ing. habil. Heinz Konietzky
Technische Universität Bergakademie Freiberg, Geotechnik, Felsmechanik, Freiberg, Germany (sebastian.rehde@ifgt.tu-freiberg.de)

Underneath the small town of Freiberg, Saxony, stretches the ore mine complex 'Reiche Zeche'. The underground laboratory (URL) inside the mine was inaugurated in 1919 and is an internationally acknowledged institution for experimental work of variable scales and subjects. Our work is part of the Stimtec project, which aims on improving planning and conducting hydraulic stimulation in anisotropic, crystalline rocks. The project comprises numerical modelling and field work inside the URL. Prior to the numerical analysis, we implemented a tool to perform a slip tendency analysis of faults that were mapped along the tunnel walls at the project site. It allows to assess the slip tendency of arbitrarily oriented faults and stress fields. The tool is used for preselection of stimulation intervals, enabling identification of faults which are likely to be reactivated by hydraulic stimulation.
We perform the stress field modelling using a multiscale numerical model approach. Therefore, we set up three different sized models deriving from a large scale 3D geomodel. The geomodel contains the topography, drifts and 47 fault structures taken from mine maps. The project site and measurement points are positioned in the center of the model. From the large scale geomodel, we developed a simplified numerical model geometry with 12 major faults, disregarding the galleries. We use the distinct element code 3DEC for discontinuous numerical modelling of the stress field. This allows to take into account discrete displacements along the faults. Far field stress is taken from previous investigations and literature as boundary and initial conditions. The resulting stress field provides the stress tensors for calculating the corresponding forces for each gridpoint at the model boundaries of the small scale model. The small scale numerical model is smaller by a factor of 10, including two major fault segments, the galleries and mapped local faults. Hydraulic fracturing stress measurements taken during the field tests indicate that the stress field is strongly distorted in the vicinity of the tunnels and excavations along the ore veins. Hence, we developed a third model approach, a 2.5D slice model, to investigate the influence of the assumed excavation damage zones.
With this work, we provide an approach to predict the stress field inside the complex, anisotropic rock volume. Within the framework of the Stimtec project, we developed a workflow for planning hydraulic stimulation tests and 3D geological models for a diverse set of further appliations in the URL 'Reiche Zeche'.