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Numerical assessment of the barrier integrity from a generic nuclear waste repository in crystalline rock

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Safe deep geological disposal of heat generating nuclear waste requires a detailed assessment of the geotechnical integrity of potential host rocks. In Germany, several repository systems are under discussion, in which clay stone, salt or crystalline rock could serve as host rock. This contribution proposes a modelling concept for the numerical analysis of the thermal, hydraulic and mechanical (THM) coupled processes used for the barrier integrity assessment of a nuclear waste repository in crystalline rock. In particular, focusing on repository systems where the Containment Providing Rock Zone (CRZ) represents the essential barrier. This implies that understanding the potential changes in the geological barrier caused by the disposal of the waste is fundamental in order to avoid the creation of preferential flow paths for the disposed waste into the biosphere. Furthermore, in Germany, the host rocks must comply with the safety requirements stipulated by the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection in 2020.

Crystalline rock, in contrast to clay stone and salt rock, is usually characterised by fractures and other types of discontinuities. Therefore, it cannot be assumed that a single sufficiently large unfractured area can be found in which all of the nuclear waste could be emplaced. In consequence, multiple smaller CRZs, each providing undisturbed rock, have to be defined. Moreover, the fracture network is expected to influence the hydraulic behaviour of the system. Thus, an adequate representation of the fracture network is required in order to capture its relevant properties, which will ultimately define the hydraulic boundary conditions surrounding the CRZs.

The proposed modelling concept is applied to a generic geological model reflecting a realistic geological situation. A Discrete Fracture Network (DFN) model is used to determine the hydraulic properties that are then upscaled and mapped into a continuum Finite Element (FE) model. The preliminary numerical results (e.g. stresses and pore fluid pressures) from the parameterized continuum model are used to exemplary assess the barrier integrity using criteria which take into account the dilatancy strength and fluid pressure.