Creating a generic model of a high level waste (HLW) repository in crystalline rock and determining hydraulic parameters to investigate minimum requirements to the host rock for a safe storage location according to national German law

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Nuclear power generation became popular in the 1950s in industrialised countries as an alternative to fossil energy sources to provide large amounts of low cost, low carbon energy. Currently 6% of the world’s energy supply is produced in 451 nuclear reactors across 30 countries. However, nuclear power generation has a serious disadvantage and hidden cost: the accumulation and disposal of spent fuel or high level nuclear waste (HLW) - notably highly radioactive nuclear fission products and the absence of suitable long-term storage solutions, threatening livestock and the environment. Sustainable disposal of HLW holds many challenges: fluid and heat transfer may induce strongly coupled undesirable thermal, hydrological, mechanical and chemical processes.

A crystalline rock repository construction license has been accomplished by Finland in 2015 for the first long-term HLW repository worldwide. In Germany, a consortium of federal offices is exploring the opportunity of establishing a long-term underground repository in crystalline rock for HLW as an alternative to potential repositories in salt rock and mudrock.

The aim of this research is to de-risk hypothetical storage solutions for long-term HLW repositories in Germany in crystalline rock. As no geological site must be alluded to for legal reasons during the repository site investigation process at the time being, flow is modelled for a generic fractured rock site based on academic studies of crystalline rock. An inverse problem approach is applied to investigate hydraulic site requirements for the long-term storage of HLW and provide footing for the analysis of coupled thermal, hydrological, mechanical and chemical processes.

This work demonstrates progress towards finding a long-term storage solution for HLW in Germany through evaluating hydrological processes in a generic crystalline rock site. Through Oda analysis and simulating steady-state flow and particle tracking in a synthetic discrete fracture network (DFN), degrees of fracture connectivity and hydraulic conductivity of fractures have been identified for the hydraulic (boundary) conditions in a repository in crystalline rock.

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