Groundwater Flow in the Fractured System Surrounding a Nuclear Waste Repository

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Abstract

To assess the safety deep geological repositories for nuclear waste, it is important to have a clear understanding of groundwater flow at the interface between the storage vault and the fractured rock. Traditional approaches for modelling groundwater often consider both the geological and engineered structures as porous media domains. However, there are cases where radionuclide transport in groundwater is controlled by discrete fractures.COMSOL Multiphysics® comes with predefined physics interfaces that can model coupled groundwater flow and mass transport through porous media and/or discrete fractures. These interfaces are available in the Subsurface Flow module.

This work evaluates the influence of fractures in granitic rock on the flow and transport of radionuclides in a storage vault and its environs. The host-rock is impervious granitic rock crossed by several fractures of high permeability. Most groundwater is channeled through these fractures. Therefore, it is appropriate to represent the host-rock considering only the fracture network.
A discrete fracture network (DFN) based on geological data [1] was imported from file to COMSOL Multiphysics® using a COMSOL utility app. The DFN (.fab) file contains information of the vertex coordinates, transmissivity, aperture and storativity of each fracture. As a result of the import, a geometry consisting of of 7,250 discrete fractures could be generated and meshed in the COMSOL model (Figure 1). We present a model that couples the groundwater flow in the host-rock through the fractures (Fracture Flow interface) with the groundwater flow in a rock vault for nuclear waste disposal (Darcy's Law interface). In a similar way, we couple the transport of diluted species in the fractures (Transport in Fractures interface) with the transport of species in the waste vault (Transport of Diluted Species in Porous Media"). The coupling between the flow or the transport in both media (porous and fractured) is carried out using source/sink terms applied at the edges where both domains are in contact. This approach ensures a better control of the fluxes at the interface compared with other methods.

We analyze the radionuclide mass transport in the rock vault considering the effect of flow, diffusion, sorption and radioactive decay. In addition, we investigate the flow entering the rock vault and its relationship with the fractures orientation.

References

[1] Joyce S, Simpson T, Hartley L, Applegate D, Hoek J, Jackson P, Roberts D, Swan, D, Gylling B, Marsic N, Rhén I, 2010. Groundwater flow modelling of periods with temperate climate conditions - Laxemar. SKB R-09-24, Svensk Kärnbränslehantering AB.

Figures used in the abstract

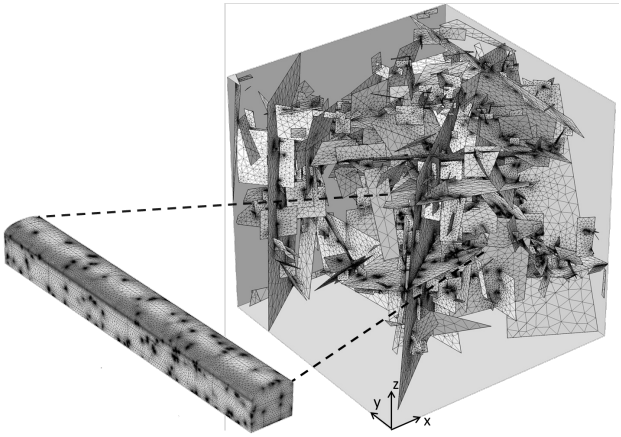

Figure 1: Finite element mesh showing the discrete fracture network (DFN) formed by 7,250 fractures and a schematic rock vault for nuclear waste disposal at the center of the model.