Paleohydrogeological Reactive Transport Model of the Olkiluoto Site (Finland)

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Abstract

The safety assessment of the deep geological repository for nuclear waste of Olkiluoto (Finland) requires the evaluation of the influence of the progressive land uplift (caused by ice withdrawal) in groundwater dynamics and chemistry (Figure 1). With this objective in mind, we have developed a three dimensional reactive transport of the Olkiluoto. The model simulates the four most relevant deformation zones of the WCA (Well Characterized Area). These zones are represented as two-dimensional planes in a three-dimensional domain (Figure 2). In the past (i.e. more than 2000 years ago), the groundwater flux through these zones was mainly driven by differences in water density. At present, however, the hydraulic gradient is the main controlling factor. This evolution in groundwater patterns has been successfully reproduced by the model, which has been coupled to an existing hydrogeological model (Löfman and Karvonen, 2012). Solute transport processes consider the influence of matrix diffusion. Also, the chemical interaction of the meteoric water with fracture filling materials has been simulated (Figure 3). More specifically, the main geochemical processes considered are: mineral dissolution and precipitation (in equilibrium or kinetic) and cation exchange. The Paleohydrogelogical Reactive Transport (PRT) simulations, which lasted 2000 years (from 0AD to present), aimed at capturing the mutual interplay of different processes (i.e. land uplift, intrusion of meteoric water, weathering, mixing of waters etc.). All the work has been carried out with the interface COMSOL Multiphysics®-Phreeqc (iCP) (Nardi et al., 2014) developed by Amphos 21.

Reference

1. Löfman, J. & Karvonen, T. 2012. Simulations of Hydrogeological Evolution at Olkiluoto. Posiva Oy, Eurajoki, Finland. Working Report 2012-35.
2. Nardi, A.et al. (2014). Interface COMSOL-PHREEQC (iCP), an efficient numerical framework for the solution of coupled multiphysics and geochemistry. Computers & Geosciences. http://dx.doi.org/10.1016/j.cageo.2014.04.011
3. Parkhurst, D. L., & C. A. J. Appelo (1999), User's guide to PHREEQC (version 2)—A computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations, U.S. Geol. Surv. Water Resour. Invest.,Rep. 99-4259.

Figures used in the abstract

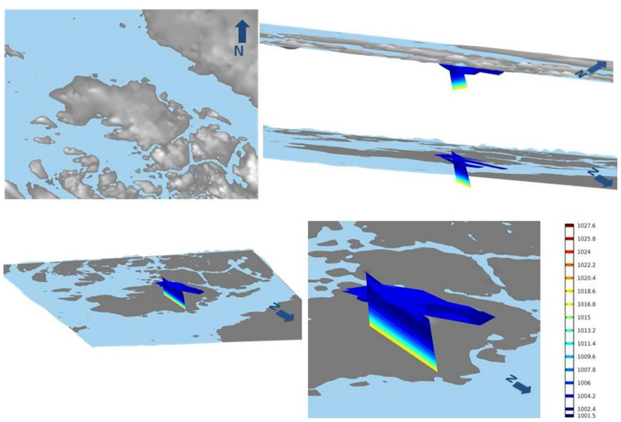

Figure 1: Detail of the study area (Olkiluoto Island) and the related simulated fractur system.

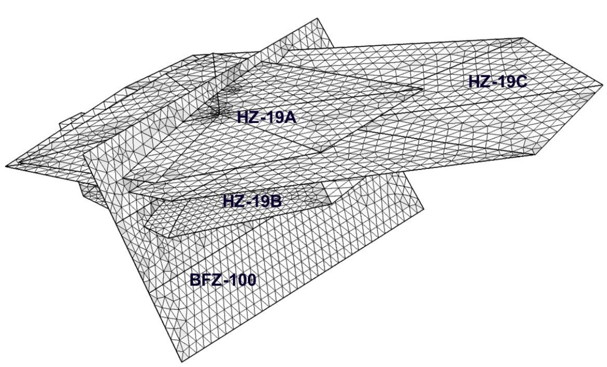

Figure 2: Detail of the finite element numerical mesh used in COMSOL to discretize the different hydrogeological zones.

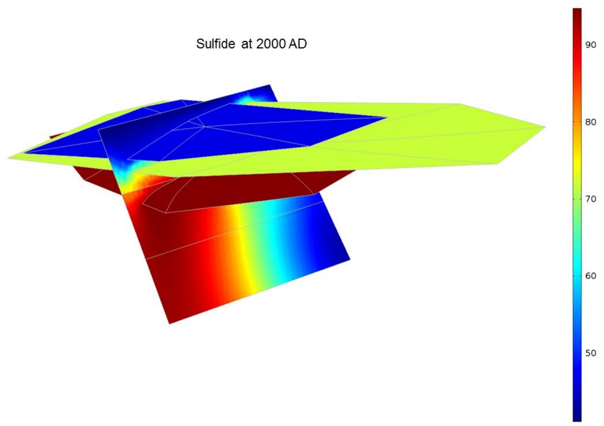

Figure 3: Detail of sulphide concentration in depth for 2000 AD (present).