Paper Number: 1053

Controlling Hydraulic Conditions of the Excavation-Damaged Zone at the Äspö Hard Rock Laboratory, Sweden

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The excavation damaged zone (EDZ) due to blasting is considered to be of importance in the context of safety assessment analysis of an underground nuclear waste repository. Especially, induced hydraulic features in the surroundings of the waste canisters are in focus in terms of potentially increased groundwater flows and radionuclide migration risks, see e.g. Swedish Nuclear Fuel and Waste Management Co, SKB [1]. An experiment was set up by SKB at 410 m depth at the Äspö Hard Rock Laboratory (HRL), Sweden, in order to propose requirements needed to execute tunnelling with a drill-and-blast method so that the EDZ is minimized. The project elaborated a characterization strategy to confirm the initial state regarding the extent of excavation-induced fractures. Furthermore, a method for characterization of the hydraulic properties of the EDZ was developed. A methodology for application in a tunnel environment was demonstrated, see Ericsson et al., [2].

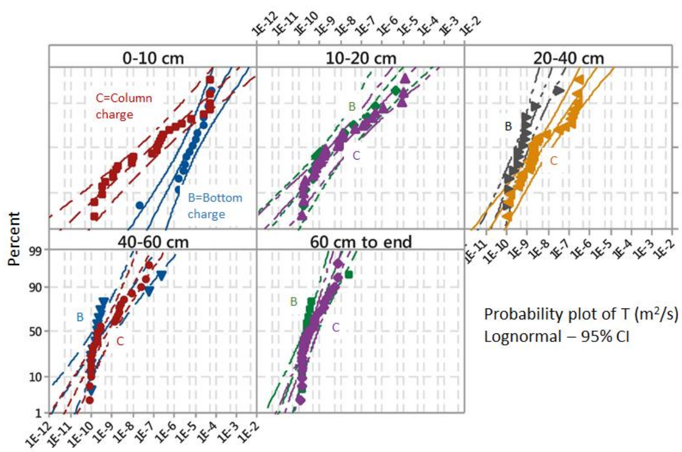

Fig. 1: T-values in Bottom and Column charge areas

The hydraulic testing focused on transmissivity and flow connectivity at water saturated conditions. In the development of an appropriate hydraulic test method, several aspects had to be considered, e.g. choice of test location, equipment robustness, equipment mobility, measurement resolution, initial and boundary conditions, confinement, hydro-mechanical couplings and test durations. For the evaluation and interpretation of tests, it was also essential to consider heterogeneity, anisotropy (hydraulic and structural), spatial variability and scale dependence. In total 210 injection tests were performed and evaluated according to steady-state and transient conditions.

The main findings of the hydrogeology part of the project was: 1) Conductive conditions due to blasting effects and rock stress redistribution should be considered as superimposed on natural conditions and may increase hydraulic properties in the repository tunnel floors. 2) Blast damages in the tunnel floor exhibit a zonation with respect to the bottom charge and the column charge, see Figure 1. The depth of the excavation-induced fractures beneath the floor was interpreted to be on average 0.3 m for the column charge used vs. 0.5 m for the bottom charge (primer). 3) The connectivity of the most transmissive fractures was short and normally connected to the tunnel floor. The longest connectivity observed in this project was approximately 7 m, and it was usually less than 3 m. 4) Measurement of hydraulic properties should focus on obtaining data on transmissivities or specific capacities using a specified test section length and injection duration time.

References:

[1] SKB (2011). Long term safety for the final repository for spent nuclear fuel at Forsmark. Main report of the SR-Site project. Updated 2012-12. SKB TR-11-01. Svensk Kärnbränslehantering AB.

[2] Ericsson L O et al. (2015). A demonstration project on controlling and verifying the excavation-damaged zone – Experience from the Äspö Hard Rock Laboratory. SKB Report R-14-30, Stockholm, Sweden.