ZEDEX - A STUDY OF DAMAGE AND DISTURBANCE FROM TUNNEL EXCAVATION BY BLASTING AND TUNNEL BORING

Simon Emsley, 011e Olsson, Leif Stenberg, Hans-Joachim Alheid, Stephen Falls

1 Golder Associates, Maidenhead, United Kingdom
2 Swedish Nuclear Fuel and Waste Management Co., Figeholm, Sweden
3 Federal Institute for Geosciences and Natural Resources, Hannover, Germany
4 Queens University, Kingston, Ontario, Canada

December 1997
ABSTRACT

The ZEDEX project was undertaken as a joint project by ANDRA, UK Nirex and SKB with significant contributions from BMBF and Nagra. The objectives of the project were to understand the mechanical behaviour of the Excavation Disturbed Zone (EDZ) with respect to its origin, character, magnitude of property change, extent and its dependence on excavation method. Supporting studies to increase understanding of the hydraulic significance of the EDZ and to test equipment and methodology for quantifying the EDZ were also performed. In the ZEDEX project excavation with "normal" smooth blasting, blasting with low-shock explosives and tunnel boring (TBM) was studied. The drifts are located in the Aspo Hard Rock Laboratory at a depth of 420 metres, the profiles are circular and 5 metres in diameter.

The results from the ZEDEX Project have shown that there is a damaged zone, close to the drift wall dominated by changes in rock properties which are mainly irreversible and that there is a disturbed zone beyond the damaged zone that is dominated by changes in stress state and hydraulic head and where changes in rock properties are small and mainly reversible. The changes in rock properties and rock stress with distance from the rock wall of the excavation is gradational and there is hence no distinct boundary between the two zones.

The damaged zone caused by the excavation methods applied has been identified by several measurement techniques. Monitoring of Acoustic Emission (AE) events is the most sensitive method which indicates minor damage due to crack opening and slip. For the Drill&Blast (D&B) drift significant AE-activity was observed up to 1 metre from the drift wall while the corresponding extent for the TBM drift is a few tens of centimetres. Changes in seismic velocity indicate a larger increase in crack density. The dye penetration tests performed in the slots cut from the drift has shown the extent of macro fracturing, which in the floor of the D&B drift has extended to about 50 centimetres. The hydraulic measurements performed in the damaged zone showed little if any change in permeability of the rock matrix.

The disturbed zone is characterised by elastic displacements and no induced fracturing. There are only very few AE-events observed in the disturbed zone and these have been found to correspond to slip on existing fractures. The AE-event density in the disturbed zone is also similar for both the TBM and D&B drifts. The hydraulic tests performed before and after excavation have not revealed any significant changes in hydraulic properties due to excavation.

The results from ZEDEX indicate that the role of the EDZ as a preferential pathway to radionuclide transport is limited to the damaged zone. The extent of the damaged zone can be limited through application of
appropriate excavation methods. By limiting the extent of the damaged zone it should also be feasible to block pathways in the damaged zone by plugs placed at strategic locations.