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Evolution of 10–20 year old Excavation Damaged Zones at the Mont Terri Underground Rock Laboratory and implications for self-sealing

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In this work, we characterize changes in 10–20 year old Excavation Damaged Zones (EDZs) at the Mont Terri Underground Rock Laboratory (URL) in St. Ursanne, Switzerland. Opalinus Clay has been chosen as a potential host rock for Switzerland's high- and low-level nuclear waste. Hence, evaluating its integrity with regards to changes in EDZ extent over time is critical in assessing the safety performance of a repository. Changes in the EDZ can originate from self-sealing processes, which result in closure of fractures over time and lead to decreased permeability in EDZs and a higher degree of repository safety. Our experiment sites at the Mont Terri URL are the galleries 08 and 98, excavated in 2008 and 1998 by a road header in the direction perpendicular to bedding strike.

We completed seven, 27–35 m long seismic refraction profiles along the two galleries. The four profiles in gallery 08 have previously been tested shortly after excavation and results from this previous investigation were re-processed. Two profiles in gallery 98 were carried out at the lower sidewalls and one line was completed in the crown. Borehole investigations focused on the drilling, mapping, and geophysical (electrical resistivity tomography, seismic interval velocity, and seismic cross-hole surveys) and optical televiewer (OPTV) logging of ten short (4.5–6.0 m), horizontal boreholes. These boreholes extended at least 1 m beyond the expected EDZ depth in each gallery.

We found that EDZ extents, given as the radial distance from the tunnel wall, measured by absolute p-wave velocities (vp) decreased by 0–1.0 m from 2008 to 2018, with an average decrease of 0.5 m, along the seismic refraction lines in gallery 08. Most, but not all, areas experienced increases in vp from 2008 to 2018. Increases in vp demonstrate a return towards intact seismic properties and might indicate sealing has occurred in these areas. However, important localized areas of vp decreases also occurred, with one profile in gallery 08 showing a vp decrease in the direction perpendicular to bedding in almost 80% of the investigated rock volume. In gallery 98, vp values are generally higher than in gallery 08 in both the bedding-perpendicular and bedding-parallel directions and EDZ depths based upon absolute vp values range from 1.0 m to greater than 3.5 m in the direction parallel to bedding and 2.5–3.0 m perpendicular to bedding. OPTV and rock core structural analyses showed EDZ fractures in the first 2.2 m of the boreholes in gallery 08, and the first 0.7 m of the boreholes in gallery 98. The inferred frequency of EDZ fractures varies from 0 to 9 fractures/m, indicating a very heterogeneous EDZ distribution for both galleries, which is in disagreement with our refraction results.

Laboratory tests on selected drill core fracture samples are planned to investigate the exact sealing processes which might have occurred over the 10–20 year period since excavation.