Rock-water interactions in the Opalinus Clay, based on research in the international Mont Terri Rock Laboratory.

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Over the past ten years, the 12 Mont Terri partner organisations ANDRA, BGR, CRIEPI, ENRESA, GRS, HSK, IRSN, JAEA, NAGRA, OBAYASHI, SCK·CEN and FOWG (now SWISSTOPO) have jointly carried out and financed a research programme in the generic Mont Terri Rock Laboratory. The experiments can be assigned to process and mechanism understanding in undisturbed Opalinus Clay and experiments related to excavation-induced perturbations. Methodologies and tools for measuring hydraulic, geochemical and rock mechanical proprieties have been developed.

The pore structure of the undisturbed matrix, the geometry of tectonic faults and the fracture network of the excavation damaged zone are presented, together with relevant hydraulic parameters such as effective porosity, hydraulic conductivity and fracture transmissivity. Special emphasis was placed on small-scale mapping of tectonic faults and artificial fractures, the latter being formed during tunnel construction. Various methods were developed for porewater sampling and characterisation, such as drillcore squeezing, aqueous leachates on crushed clays and diffusive equilibration (Pearson et al. 2003). In contrast with these laboratory methods, in-situ sampling techniques for porewater and dissolved gases were developed and applied successfully in the Rock Laboratory. Finally, the results of diffusion experiments carried out in the matrix and in a tectonic fault zone of the Opalinus Clay are presented. The resulting parameters are compared with those obtained from laboratory experiments.

Rock-water interaction processes are different in the undisturbed matrix, tectonic faults and the excavation damaged zone. Porewater of marine origin remains stagnant in the matrix pores and tectonic faults, provided that no large hydraulic gradients are applied. In this case, molecular diffusion and sorption of solutes on clay mineral surfaces are the key transport processes and advection can be ignored.

A different situation exists in the excavation damaged zone: advection-dispersion may occur when fluids are injected, followed by a distinct reduction in transmissivity (sealing). The underlying processes are swelling of fracture walls and locally also pyrite oxidation. The swelling of the fracture walls results firstly in the desegregation of the fabric, then the formation of new cracks (Figure 1) and finally swelling of the latter. Similar fabric desegregations and fracture sealings were also observed within the framework of cyclic deformations measured on tunnel walls: low relative humidity in winter is correlated with shrinkage, while wet air in summer leads to swelling. In terms of rock-water interaction, this can be interpreted as repulsion between clay particles due to osmotic transport of water molecules into the interparticle spaces by the lowered chemical potential (concept of disjoining pressure, Horseman et al.

1995). This net repulsion is manifested in the swelling of clays and in the development of swelling pressures when volume change is constrained.

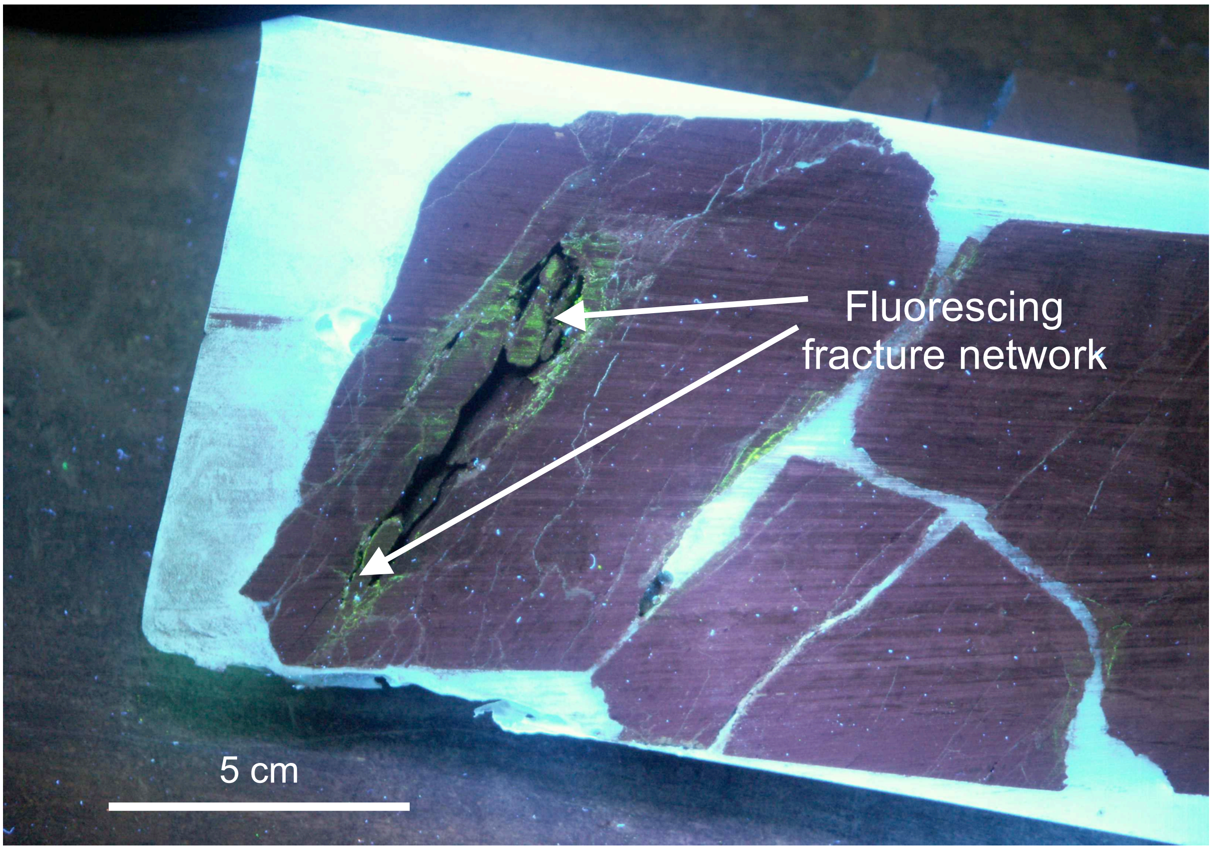

Figure 1. Section of a drillcore from the excavation damaged zone (EDZ) under ultraviolet light. Before drilling, fluorescent-doped synthetic porewater was injected into the EDZ fracture network at the drift bottom. The very fine fluorescing fractures are the result of disjoining pressures exerted by thin interparticle water films.

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