PhD position at Ecole des Ponts ParisTech

Impact of chemical transients on swelling and self-sealing of damaged clay rock.

The long-term disposal site Cigéo in France would be a multi-barrier system composed of the geological barrier (COx), the so-called Engineered Barrier and of waste packages. The perturbation due to the excavation of disposal galleries, access shaft and ramps is known to generate an Excavation Damaged Zone (EDZ) in the surrounding rock, which can act as preferential pathways for the migration of pollutants. However, several studies have shown that the EDZ is able to recover its initial properties over time by self-sealing, owing to progressive re-saturation by underground water seepage. As the Cigéo project progresses towards its potential industrialization, new questions arise concerning the Chemical, Hydraulic and Mechanical (CHM) alterability of the multi-barrier system, and particularly of the clayey geomaterials involved. Indeed, the massive concrete components used to support bentonite seals together with the concrete liners will release quantities of dissolved alkalis ions (NaOH, KOH). On the short term, when clays are partially water-saturated, self-sealing of the host rock has been demonstrated under a circumneutral pH (7-8.5) of the pore water. However, the pH of the under-ground water, initially at 7.5 is expected to increase up to 13.5. Highly alkaline plumes may limit self-sealing of the COx during and after resaturation and have a great impact on permeability allowing the contaminant to use preferential pathways. To our knowledge, this scenario has not been assessed yet. These processes may change the porewater chemistry, which could alter the pore network of clay-based materials and have also a great impact on the self-sealing and transport properties of the EDZ. In 2020, a research program was lunched to investigate the effect of concentrated saline and alkaline solutions on the mechanical and transport properties of a damaged clay host rock (OPAlinus clay). Particular attention was paid to the effect of osmotic suction and pH on the liquid retention properties, volume change and microstructure evolution (poral space and mineralogy) behavior which are crucial for the interpretation of the self-sealing behavior. These results allowed to provide first insight into the effect of alkaline plumes on the damaged host rock behavior, however, several aspects would value additional investigations to increase our understanding, especially on the role of the observed microstructural and retention properties changes on the self-sealing and permeability of the damaged material. The aim of this work is to determine the chemical, mechanical and hydro-dynamical perturbations caused by high pH alkaline plumes on the self-sealing behavior and permeability of the damaged geological barrier. Laboratory sealing experiments will be carried out on cracked samples from the COx and/or Opalinus claystones under relevant repository conditions. The fractured samples will be flown through with alkaline plumes together with a reference pore water solution for comparison. Permeability tests will be lunched using a new developed cell. At the microscopic scale, the self-sealing process will be monitored through X Ray micro-CT using a new CT transparent cell. Regular micro-CT scans will be taken upon sample exposure to the alkaline solution at different pH. Initial and post-mortem analyses will be performed to determine microstructural changes (by mercury intrusion porosimetry, nitrogen adsorption, etc.).

- Funding: Institute for radiation protection and nuclear safety
- Supervision: Yu Jun Cui and Nadia Mokni
- Candidate profile: MSc degree in civil engineering or geotechnical Engineering

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