Metal Alloys in Disposal Drifts: Modelling the Coupled Hydrogen Generation and Migration in the Callovo-Oxfordian Clay

AF-Colenco Ltd

J. Croisé[1], G. Mayer[1], J. Talandier[2], J. Wendling[2]

Using an approach based on the anaerobic corrosion of metal alloys

$$Metal + x\ H_2O \rightarrow Metal(OH)_x + \frac{x}{2} H_2$$

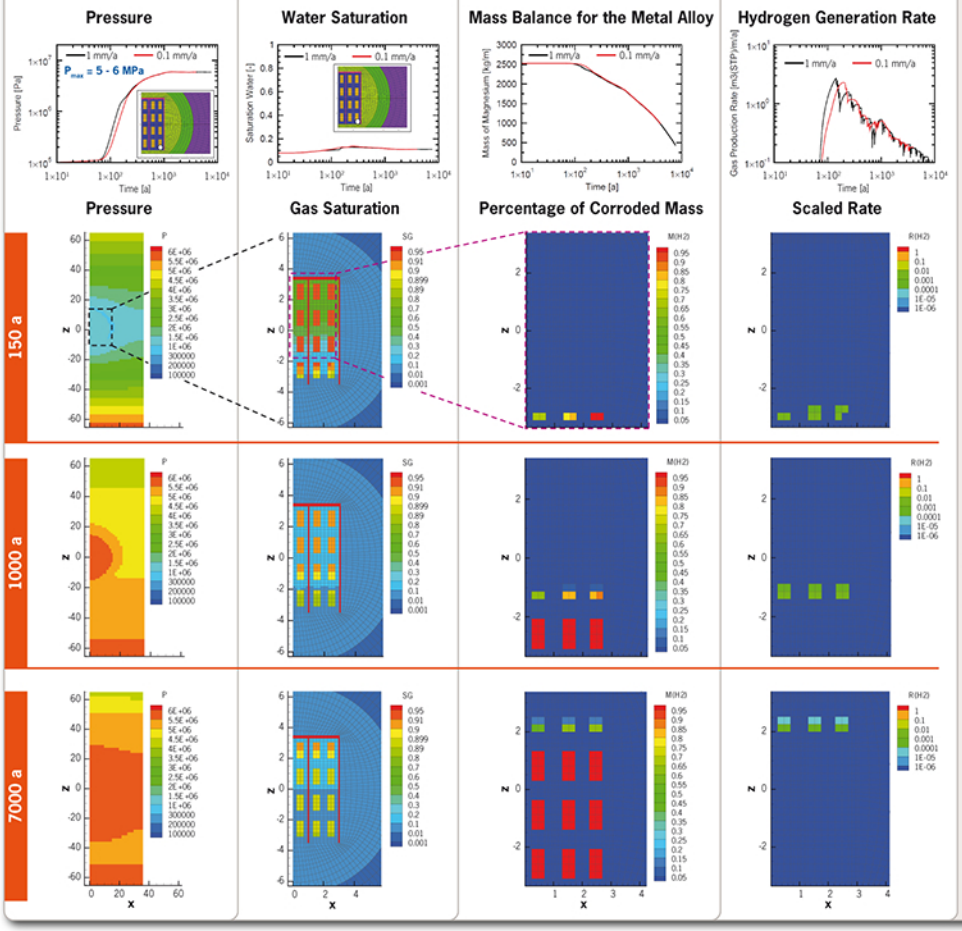
is a highly active process for Mg and Al alloys

- Maximum corrosion rate at full water saturation = corrosion rate [mm/a] × metal surface area available for corrosion [m²]
- Water consumption according to stoechiometry
- Hydrogen gas generation rate proportional to water saturation
- Hydrogen generation ceases when all available metal has been corroded
- Computation of the coupled flow and transport of water and hydrogen in a two-phase gas-water system "Repository + Callovo-Oxfordian clay"

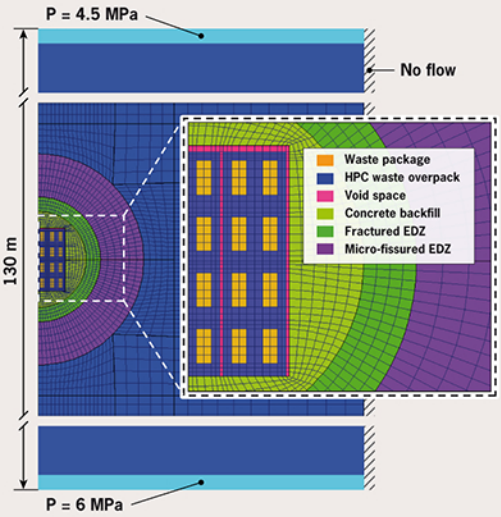
...we found:

- The hydrogen gas generation rate depends on the water becoming available through the Callovo-Oxfordian clay.
- The water consumption has a major impact on the evolution over time of the gas generation rate in the emplacement drift with the intermediate-level, long-lived MAVL wastes which bear metal alloys.
- The simulated pressure build-up inside the emplacement drift is much lower than the build-up expected for the assumed case with the maximum corrosion rate at full water saturation.
- Sensitivity runs show that the time at which the waste packages are assumed to become permeable to water (due to corrosion) strongly influences the evolution of the gas generation, resaturation and pressure build-up in the drift.
- The integration of the saturation-dependent model into TOUGH2, including water consumption, was successful.

These are the results from the simulation with TOUGH2-EOS5

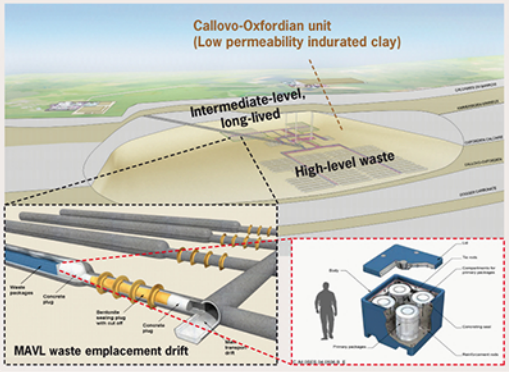


... with a 2D model configuration



... and certain assumptions

- The emplacement drift is constructed instantaneously.
- The waste packages are leaky at the time of emplacement in the drift.
- The drift is ventilated at 50% r.h. for 50 years.
- Corrosion/hydrogen generation starts when the water saturation inside the waste exceeds 0.1.
- Two simulation cases with different assumed corrosion rates: 1 mm/a and 0.1 mm/a.

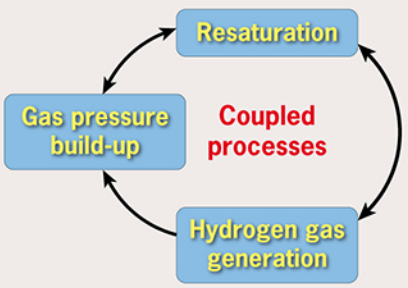


Background

The **resaturation** of the MAVL waste emplacement drifts in the post-closure phase is the key element for the anaerobic corrosion of metal alloys.

Magnesium and aluminium alloys have high corrosion rates and, therefore, high **hydrogen gas generation** rates, if there is sufficient water supply.

Attention: **Gas pressure build-up** is strongly overestimated, if the coupling of these processes is neglected.



[1] AF-Colenco Ltd, Groundwater Protection and Waste Disposal, Täfernstr. 26, CH-5404 Baden, Switzerland, E-mail: jean.croise@afconsult.com
[2] ANDRA, 1/7 Rue Jean Monnet, Parc de la Croix-Blanche, F-92298 Châtenay-Malabry, France

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Reference: Croisé J., Mayer G., Talandier J., Wendling J., 2010: Corrosion of magnesium alloys in disposal drifts of a deep geological repository: Modelling of the hydrogen generation and the water consumption. Submitted for publication in Transport in Porous Media, special issue TOUGH2 Symposium 2009