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Impact of initial air and subsequent H₂ gas migration in a radioactive waste repository

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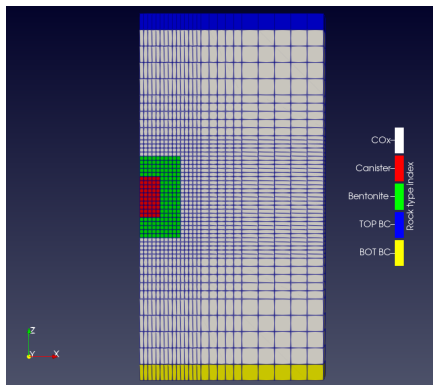
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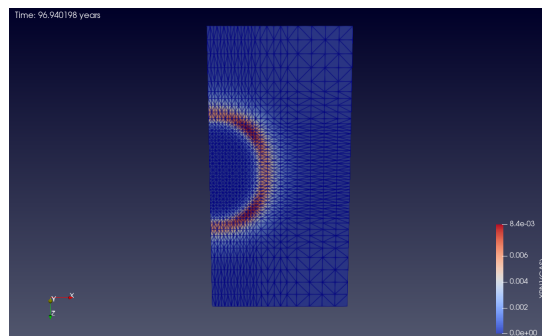
In a geological repository for high-level radioactive waste, corrosion of steel and water radiolysis leads to generation and accumulation of hydrogen gas which may significantly affect long-term safety of the repository. Numerical modeling can be used to predict the hydraulic and hydromechanical evolution of such a disposal facility and to estimate the influence of excavation and generated gas on host clay rock and sealings. While several modelling teams have studied gas migration [1], very few have considered the initial presence of air and its impact on later hydrogen migration. Note that, during excavation, the CO₂ around the tunnels is disturbed, which creates an Excavation Disturbed Zone (EDZ), both hydraulically (rock desaturation) and mechanically (fracturing, redistribution of stresses, natural convergence).

In our study, we have compared results obtained from TOUGH [2] modules (Equations Of States): EOS5 for modeling two-phase flow with only water and hydrogen, and EOS7R for modeling a more complex multi-component two-phase system with water, brine, air, and two radionuclides able to volatilize and dissolve. This EOS7R model is tuned to attribute non-radioactive hydrogen gas properties to the 1st radionuclide (brine and the 2nd radionuclide are turned off). The van Genuchten (1980) relative permeability and capillary pressure functions are used.

The model is then run at the scale of a waste cell: Figure 1a. One challenge is to estimate the peak gas pressure around the cell and check whether it exceeds lithostatic pressure at depth 630m. If that is achieved, the mechanical stability of the engineered system and natural barriers may be affected. The results indicate that hydrogen gas plume migration is impeded by the bentonite seal around the canister. However, the migration of dissolved H₂ away from the container is less impeded, as indicated by Figure 1b. In future, this model will be extended to take into account hydromechanical coupling.



(a) Preliminary axi-symmetric model of CIGEO waste cell: Finite Volumes mesh



(b) EOS7R TOUGH2 simulation: H₂ Mass Fraction XH₂GAS in the Gas mixture ($t = 97$ years)

References

- [1] Talandier, Jean. *Couplex-Gaz Benchmark: Synthesis of results for case 1*. (Workshop Couplex-Gaz, 4 avril 2007).
- [2] Pruess, Karsten, Curtis M. Oldenburg, and G. J. Moridis. *TOUGH2 user's guide version 2. No. LBNL-43134*. Lawrence Berkeley National Lab.(LBNL), Berkeley, CA (United States), 1999.