Numerical and experimental approaches on the behavior of salt caverns during storage of hydrogen and other gases

PhD opportunity at the École des Mines de Paris – Centre des Géosciences - Fontainebleau

Subject:
The intermittency problem that usually characterizes renewable energy led to vast storage techniques in the last few decades. Hydrogen/energy storage in solution-mined caverns is one of the suggested solutions. In this context, a precise prediction of the cavern thermodynamic state is needed. Besides, such a thermodynamic response requires to be fully coupled with the thermo-hydro-mechanical behavior of the rock mass surrounding the cavern.

Most of the recent available researches with regard to gas storage in salt caverns depend on numerical tools that assume a uniform cavern thermodynamic state, thus they ignore the spatial variations of the cavern thermodynamic variables as well as the flow nature (laminar/turbulent). These numerical approaches allow for low cost and fast simulations, however, a question arises about their validity during fast circulation.

This proposed PhD thesis is dedicated to investigate the integrity of salt cavern mechanical and thermodynamic behavior during fast and slow cycling while addressing the entire complexity of the Computational Fluid Dynamics (CFD) problem, i.e. full discretization of the cavern, gas cavern velocity and thermodynamic variables spatial variations, nature of flow, and the 3D thermo-hydro-mechanical behavior of salt. Moreover, the problem of H_2 storage in salt caverns is particular from other gases. This is attributed to the large mobility of hydrogen induced by its very small molecular length, and its potential reactivity with other chemical species that can be present in the storage environment. We aspire that this PhD thesis would shed a light on the phenomenon of hydrogen seepage into the salt rock during fast and slow cycling.

The centre of geosciences and the centre of thermodynamics and processes (CTP) of Mines ParisTech, associated with academic and industrial partners, are involved in a scientific research that includes the development of a laboratory model that is intended to be used to investigate the thermodynamic aspects of underground caverns during gas storage. This laboratory model will help understand the spatial distribution of the thermodynamic variables of caverns during fast and slow cycling. With properly controlling its boundary conditions, it is supposed to reproduce a similar thermodynamic response to real underground caverns. We wish to use this model to study other important phenomena that take place in caverns during cycling, i.e. the presence of water vapor due to brine evaporation, and hydrogen solubility in brine.

If you got to this point reading and "almost" understanding all of the above Chinese, you're good, do not hesitate to apply, you'll do it!

Required skills:
Interested applicants need to have good scientific backgrounds in thermodynamics and mechanics of solids. Numerical expertise in the finite element method is needed as well. Other skills may be learnt during the PhD course. Applicants who appreciate laboratory work are strongly recommended to apply. The outcome of this PhD work will be utilized in finalizing industrial projects, therefore chosen applicant will have direct contact with our industrial partners which will promote a certain future work in prestigious companies. The École des Mines de Paris is a prestigious school of engineering and ranked second in France.

Interested applicants should send their CVs along with a brief motivation letter to Murad ABUAISHA:
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