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Centre de Géosciences – PhD position announcement

Multi-scale approach for the mechanical behavior of rock salt: application to salt cavern abandonment

1. Context

The framework of this PhD topic is the time-dependent mechanical behavior of rock salt and the need to develop constitutive models that have good predictive capabilities in the mid to long-term. Rock salt has very interesting properties for underground storage and disposal, and salt caverns have been used for decades to store hydrocarbons and other substances (compressed air, hydrogen, chemical wastes, etc.). As part of the energy transition to low-carbon sources, underground storage will play a very important role, and hundreds of new salt caverns will be created in Europe in the coming years. Studies of the feasibility and long-term stability of these facilities need to be based on constitutive laws that can be extrapolated over long periods of time. However, the development of such laws is still a major challenge.

2. Research project outline

At present, the behavior of salt caverns in standard engineering practice is simulated using phenomenological constitutive laws, based on the results of short-term laboratory tests. In order to reduce the uncertainties associated with long-term extrapolation, both during cavern operation (*e.g.*, estimates of cavern volume) and during cavern abandonment (*e.g.*, monitoring of cavern pressure and volume, brine management, operations at the well head), this PhD thesis aims to improve the predictive capabilities of constitutive laws by enriching macroscopic models with physical considerations observed at the microscopic scale. To this end, laboratory tests on centimetric-scale samples will be combined with analyses on a millimetric/microscopic scale. The results of the study will be integrated into constitutive laws, which will be implemented in dedicated FEM software to simulate several storage scenarios, as well as the abandonment phase of salt caverns.

3. References

- Azabou, M., Rouabhi, A., Blanco-Martín, L., Hadj-Hassen, F., Karimi-Jafari, M., Hévin, G. (2021). Rock salt behavior: From laboratory experiments to pertinent long-term predictions. International Journal of Rock Mechanics and Mining Sciences, 142 , 104588. doi:10.1016/j.ijrmms.2020.104588.
- Azabou, M. (2021). Modélisation et prédiction du comportement macroscopique du sel gemme dans le contexte du stockage souterrain. PhD thesis, Ecole des Mines de Paris.

4. Keywords

Rock salt; multi-scale approach; laboratory experiments; numerical modeling; underground energy storage

5. Prerequisite skills and knowledge

Rock mechanics and continuum solid mechanics

Modeling experience (FEM, FDM)

Programming

Basic knowledge on petrophysics and petrology

Fluent in English and ideally French (oral, spoken, written)

Eager to work in a multidisciplinary, international environment

Eager to design and analyze tests on rock salt specimens (at different scales)

6. **Applications should be sent to laura.blanco_martin@minesparis.psl.eu before July 20 2023 and include:**
    a. CV
    b. Motivation letter
    c. MSc and BSc transcripts
    d. Proof of English proficiency (not mandatory but highly appreciated)
    e. Names and contact information of three references

The successful candidate is expected to join our team between October-December 2023