Stimulated Geological Hydrogen: multiphase reactive transport modeling of a pilot site

Keywords
Stimulated geological hydrogen, pilot site modeling, multiphase reactive transport

Thesis description

Vema is developing **Stimulated Geological Hydrogen (SGH)** technology, which has the potential to produce safe, low-cost, and clean hydrogen. This technology leverages natural and spontaneous geochemical reactions that generate hydrogen underground. A brine-based solution containing catalysts is injected into a shallow geological formation, where it reacts with iron-bearing minerals to produce hydrogen. The hydrogen is then extracted through pumping and can be used to generate electricity, industrial heat, and green chemicals (notably ammonia and methanol) or serve as a fuel. The use of non-toxic catalysts enables predictable, industrial-scale, and stable production while reducing costs.

The production potential is immense, and preliminary techno-economic analyses suggest that this technology could supply all the hydrogen needed—not only to replace current production methods but also to shift some fossil fuel applications—for thousands of years. However, hydrogen production depends on factors such as mineralogical composition, reservoir temperature and pressure, and the injected solution.

The objective of this thesis is to gain a deeper understanding of the **physicochemical processes** involved, including heat transfer, and to develop a realistic **reservoir-scale model** to optimize SGH technology. This research aims to unlock thousands of years' worth of **decarbonized hydrogen** for the energy transition. The modeling will be conducted using the **HYTEC** multiphase reactive transport code, developed by the Geosciences Center at Mines Paris PSL.

Objectives

1. **Literature review** on olivine serpentinization and hydrogen production.
2. **Sensitivity analysis** of thermodynamic parameters, mineralogy, injected solution, etc.
3. **Technology optimization**, leveraging data from a **Vema pilot site planned for 2026** in the United States. The thesis work will contribute to the site's design, while pilot data will refine and optimize the numerical model.

References

- Osselin, F., et al. (2022). *Reactive transport experiments of coupled carbonation and serpentinization in a natural serpentinite: Implications for hydrogen production and carbon geological storage.* Geochimica et Cosmochimica Acta, 318, 165–189. DOI:10.1016/j.gca.2021.11.039
- Osselin, F., et al. (2022). *Orange hydrogen is the new green.* Nature Geoscience, 15(10), 765–769. DOI:10.1038/s41561-022-01043-9
- Sin, I., et al. (2017). *Integrating a compressible multicomponent two-phase flow into an existing reactive transport simulator.* Advances in Water Resources, 100, 62–77. DOI:10.1016/j.advwatres.2016.11.014

Research impact and dissemination

- Development of a **multiphase reactive transport model** to optimize **stimulated geological hydrogen** production.
- **Publications** in reactive transport and geoscience journals, with participation in national and international conferences.

Supervision

- **PhD advisor:** Vincent LAGNEAU (Geosciences Center, Mines Paris PSL)
- **Co-supervisors:** Florian OSSELIN (Vema), Irina SIN, Jérôme CORVISIER (Geosciences Center, Mines Paris PSL)

Required skills

- Strong motivation for the project
- Master's degree or engineering background in **geochemistry, reservoir engineering, or environmental sciences**
- Strong interest in **physicochemical modeling**
- Proficiency in **English**
- Interest in **industrial research**

Funding & logistics

- **CIFRE contract**
- Required travel: regular trips to Orléans, conferences, and a mission to the U.S. pilot site

Contacts

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