Thèse

Native hydrogen and mineral resources associated to geothermal exploitation in granitic plutons:

case study of the Upper Rhine Graben. Experimental and modelling approaches

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Descriptif du contexte scientifique et du sujet (maximum 2 pages).

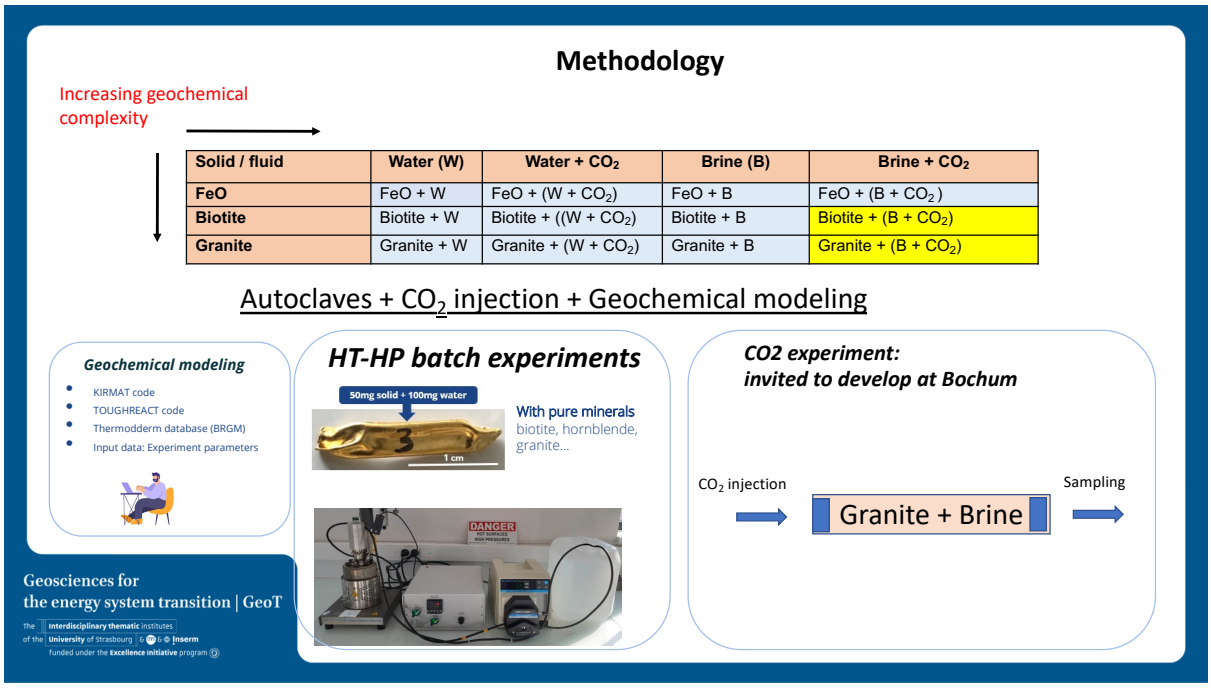
In the current world scenario of energy transition, new CO_2-free energy sources are necessary. Hydrogen gas (H_2) will play an important role as either an energy vector or a zero-carbon source of energy. Moreover, this transition also relays in some critical mineral resources (such as Li for batteries and transition metals necessary for electronic components) that are also present in geothermal brines. Previous research, in particular from ITES, indicate that Upper Rhine Graben is a favorable environment for natural H_2 generation as well as exploitation of trace elements like Li from the geothermal brines (Fritz et al. 2010; Lucas et al., 2020; Murray et al. 2020). Native H_2 is produced by oxidation of iron in Fe^{2+}-rich minerals like biotite and hornblende, which are also amongst the minerals showing the highest concentrations of trace elements with economic interest (Sanjuan et al. 2022). Therefore, a deeply understanding of the hot water-rock interactions processes within the granitic and sedimentary rocks is needed. In particular, it is important to understand the conditions that lead and even enhance the production of native H_2 as well as the understanding of the physico-chemical conditions that lead to the non-stoechiometric release of trace element (Lemarchand et al. 2022).

From previous research, our hypothesis is that H_2 production can be enhanced by increasing CO_2 pressure (Murray et al., 2020). Batch experiments at HT-HP recently performed at ISTO (Orleans) demonstrated that H_2 can be generated by hydrothermal alteration of the Soultz-sous- Forêts granitic reservoir under anoxic conditions. However, the impact of CO_2 as an H_2 enhancing factor remains to be tested. The main objective is to perform CO_2 injection experiments at HT-HP at increasing CO_2 pressures to test the stimulation of ferrous minerals oxidation and H_2 generation. Since the injection of CO2 directly modifies the fluid pH and, therefore, the rate of mineral dissolution as well as the nature and amount of secondary phases, it may also impact the release of trace elements that can be monitored and modeled with thermodynamic approaches.

Methodology
The hydro-thermal context of the Upper Rhine Graben will be used as case study for this thesis. It is representative of multiple hydro-thermal sites in continental Europe and in the world. The processes occurring at their geothermal reservoirs can be used as analog for better understanding other worldwide geologic basements in which granitic and metamorphic rocks are present.

To increase in complexity, we will work on pure FeO, standard biotite minerals and the granite from Soultz-sous-forêts that will be reacting with pure water, and brines with addition of CO2 (see illustration below).

We will develop the HT experimental facility at ITES and perform laboratory work and geochemical modeling to simulate water-rock-gas reactions leading to abiotic H_2 and Li generation. A collaboration with Dr. Thomas Reinsch will allow to develop the experiments of CO_2 injection at his laboratory: Fraunhofer Institution for Energy Infrastructures and Geothermal Systems IEG (Bochum, Germany).



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