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Natural hydrogen generation in granitic geothermal reservoirs

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Non-ultramafic basements in deep continental hydro-thermal systems are potential zones for natural H_2 generation. In particular, the generation of H_2 from granitic rocks [1,2] could represent a process of global magnitude because they are major components of the continental crust. Our research is focused on the hydro-thermal context of the Upper Rhine Graben (URG). In this continental environment, geothermal brines of up to 200 °C circulate through granitic reservoirs at > 2000 m depth. In previous research, we performed geochemical modeling and experimental work to simulate the hydrothermal alteration of the granitic geothermal reservoir at the Soultz-sous-Forêts geothermal site [1]. The results provided indications for H_2 generation by the alteration of ferrous iron present in some minerals of the granite such as biotite (1).

$Fe^{2+} + H_2O \rightarrow Fe^{3+} + OH^- + 1/2H_2$ (1)

To better understand the H_2 generation process in the granitic geothermal reservoirs of the URG, a new set of water-rock-gas interaction experiments and geochemical modeling are being developed. For that, batch reactions using specimens of Fe^{2+}-rich biotite, amphibole, and magnetite (present in the URG granites) are performed to simulate the hydrothermal alteration at different temperatures of the reservoirs (130 to 200 °C). In addition, some experiments simulate the presence of CO_2 to address its effects on the Fe^{2+}/Fe^{3+} redox equilibrium. The geochemical simulations performed in parallel, provide a better understanding of the mineral evolution during the reactions.

This research will improve the understanding of abiotic H_2 generation in deep granitic environments, which had received less attention in comparison to the serpentinization of ultramafic rocks. In the context of the energy transition, the generation of H_2 in geothermal sites could be seen as an additional decarbonized source of energy together with the current production of electricity, heat, and critical elements.

[1] Murray, et al., (2020), Applied Geochemistry 119, 104631.

[2] Truche, et al., (2021), Geochimica et Cosmochimica Acta 308, 42–59.