Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.16740

Reassessing the role of magnetite during natural hydrogen generation

ISABELLE MARTINEZ[1], UGO GEYMOND[1], THÉO BRIOLET[2], VALENTINE COMBAUDON[3], OLIVIER SISSMANN[4], MATHIEU DUTTINE[5] AND ISABELLE MORETTI[6]

[1]Institut de Physique du Globe de Paris
[2]IFP energies nouvelles
[3]Université de Pau et des Pays de l'Adour, E2S UPPA, CNRS, TotalEnergies, LFCR, Pau
[4]IFP Energies Nouvelles
[5]Université de Bordeaux
[6]Université de Pau et des Pays de l'Adour

Presenting Author: martinez@ipgp.fr

Interactions between water and ferrous rocks are known to generate natural H_2 in oceanic and continental domains via the oxidation of iron. Such generation has been mainly investigated through the alteration of Fe^{2+}-silicate, and additionally some Fe^{2+}-carbonates. So far magnetite (α-Fe_3O_4) has never been considered as a potential source mineral for natural H_2since it is considered as a by-product of every known chemical reaction leading to the formation of H_2, despite it bears 1/3 of Fe^{2+}. This iron oxide is rather seen as a good catalyst for the formation of H_2. Recently, hydrogen emissions were observed in the surroundings of Banded Iron Formations (BIF) that are constituted, among other minerals, by magnetite. Thus, this work is an attempt to constrain the true potential of magnetite, by the mean of batch reactor experiments and additional thermodynamic calculations. It explores theoretical and practical reactivities of magnetite during water-rock interactions, focusing on low temperatures (T < 200°C). For the purpose of experiments, gold capsules filled with magnetite powders were run at 80°C and 200°C. Gas products were analyzed using gas chromatography (GC) while solid products were characterized by X-ray diffraction (XRD), Mössbauer spectroscopy and scanning electron microscopy (SEM). After experimental alteration, high amounts of H_2 were quantified while mineralogical transition were observed by SEM. It showed self-reorganization of the primary iron oxide resulting in sharp-edge and better crystalized secondary minerals. In parallel, XRD analyses showed tiny changes between the patterns of initial powder and solid products of reaction. Finally, Mössbauer spectroscopy revealed that the starting magnetite was partly converted to maghemite (γ-Fe_2O_3), a metastable Fe-oxide only containing Fe^{3+}. Major implications arise from these results. Concerning H_2exploration, this work provide evidence that natural hydrogen can be generated at near-ambient temperature. It also infers that magnetite-rich lithologies such as BIF should be targeted while looking for H_2 source rocks. In addition, these outcomes could be of major interest for mining compagnies as it provides key elements to understand the formation of BIF-hosted iron ores.