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Can weathering of Banded Iron Formations generate natural hydrogen? Constraints from thermodynamic modeling and experiments

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Interactions between water and ferrous rocks are known to generate H_2 in oceanic as well as in continental domain via the generic equation: $2FeO + H_2O$ â‡” $Fe_2O_3 + H_2$ [(a)]. H_2 generation has been mainly investigated through serpentinization of ultrabasic rocks but other iron rich lithologies might also be able to generate H_2 during water-rock interactions. The potential of Banded Iron Formations (BIF) as H_2 producers has thus been recently investigated [1]. This work focused on Western Australia and South Africa, since these regions are endowed with very large BIF-hosted iron resource with already proven H_2 emissions. A spatial correlation was established between BIF-hosted iron mines and Sub-Circular Depressions (SCD), inferring H_2 seepages related to BIF. Furthermore, mineral replacement due to BIF weathering was observed in natural samples from Western Australia, from Fe^{2+} silicate such as riebeckite (a Fe-Na rich amphibole), to Fe^{3+} oxi-hydroxides such as goethite, hence inferring H_2 generation is possible via BIF alteration through the generic equation (a).

In the present work, two other approaches are used to test this assumption and further investigate H_2 production during water-BIF interactions: (1) thermodynamic modeling and (2) analog modeling through experimental alteration of synthetic samples. Based on mineralogical compositions of natural fresh BIF from Western Australia [2], thermodynamic modeling is used to constrain the optimum physico-chemical conditions, as well as the best BIF mineralogy, in order to generate H_2 during water-BIF interactions.

In addition, batch reactor experiments are conducted at low temperature (below 100°C) to reproduce water-BIF interactions. Synthetic samples of Fe^{2+} oxides (magnetite), Fe-silicates (riebeckite) and Fe-carbonates (siderite) are reacted separately to evaluate their H_2 production potential. Results are then compared to other common H_2-producing minerals studied in literature such as olivine. The synthetic minerals are finally tested together as a mineral assemblage to evaluate potential catalytic effects, notably magnetite which is already suspected to accelerate H_2 generation during serpentinization [3].

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