

# Hydrothermal transformation of hematite by molecular hydrogen: A multitude of parallel reactions

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The reduction of hematite by molecular hydrogen has been studied in a multitude of systems, for reactions in melts, under aqueous hydrothermal conditions, near-surface conditions in groundwater and during gaseous conversion of iron oxides in steel production. The description of the identified reactions and processes involved differs depending on the system investigated. Even whether the transformation of hematite to magnetite (or vice versa) is a redox process or could be occurring as a “non-redox transformation<sup>1</sup>” is controversial.

In the context of subsurface storage of hydrogen as energy carrier of surplus renewable energy we investigated the reactions of isolated hematite with molecular hydrogen in an aqueous solution. The hydrothermal type experiments were conducted in gold capsules or flexible Dickson-type gold-titanium cells at temperatures of 80-200°C and pressures of 200 bar with partial pressures of H<sub>2</sub> up to 100 bar for durations of days to weeks. Whereas gas phase analyses documented the extent of oxidation of molecular hydrogen, the microscopic analyses of the solids and Raman mapping on the surfaces of the grains after experiments documented a multitude of reactions occurring during the experiment: Besides smooth pristine hematite areas on the grains there are others dominated by dissolution features as etch pits. In addition, secondary micrometer-sized hummocks of hematite have been precipitating on the hematite surface. Throughout the grains, cracks developed in the hematite, possible due to lattice strain in the reordering of the hematite to magnetite lattice. At the cracks and extending onto the surfaces of the grains distinct domains of magnetite are visible, documenting the transformation of hematite to magnetite. These findings are interpreted in a network of parallel reactions of dissolution-reprecipitation of hematite, possible solid-state-transformation of hematite to magnetite and dissolution of hematite – or better – release of oxygen and iron into the aqueous solution. These findings will be presented and the implications for different systems, e.g. the subsurface storage of H<sub>2</sub> in porous rocks with hematite in sandstone reservoirs will be discussed.

<sup>1</sup> Otake et al. (2007). Experimental evidence for non-redox transformations between magnetite and hematite under H<sub>2</sub>-rich hydrothermal conditions. *Earth and Planetary Science Letters*, 257, 60-70.