

Goethite behavior at Earth's lower mantle conditions

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Water and water-bearing species have a strong impact on numerous processes in Earth's interiors. Presence of water affects chemical and physical properties of mantle minerals, changes melting temperatures, sound velocities and viscosity of materials, and causing different global phenomena such as, for example, arc volcanism and plate tectonics. Thereby, the deep Earth's regions enriched with water are crucial for understanding our planet's geodynamics and geochemistry. Still, mechanisms of water circulation between geospheres remain poorly understood. Recent studies suggest that goethite present in Banded Iron Formations (BIFs) may transfer some quantities of water to the deep Earth interiors with subducting slabs. It was reported that goethite remains stable in the sinking slab until it reaches the base of a lower mantle. By the meaning of in situ powder XRD it was revealed that at pressures corresponding to the depths ~1500-1800 km and moderately high temperatures goethite undergoes a phase transition to form a novel stable pyrite-type phase FeO_2H_x with $0 \leq x \leq 1$ (named as Py-phase). Thus, goethite and its HP pyrite-type form became a candidate for water and/or hydrogen transfer and storage to the lower mantle and the core-mantle boundary. Using laser-heating in diamond anvil cells we performed a series of experiments on an investigation of goethite (as a starting material) stability at P-T conditions covering possible range in subducting slabs. By the meaning of sensitive in situ single-crystal XRD in DACs we registered decomposition of goethite and formation of known (such as ϵ - Fe_2O_3 , η - Fe_2O_3 , a high-pressure orthorhombic form of Fe_3O_4 , Fe_5O_7) and novel iron-oxygen compounds. Results of structure solution and refinement established these compounds to be orthorhombic Fe_7O_{10} and hexagonal non-stoichiometric phase $\text{Fe}_{6.31}\text{O}_9$. Our results suggest that FeOOH cannot transport water into the deep of Earth's mantle.

Keywords: Goethite, Diamond anvil cell, High Pressure, Single-crystal XRD, Subducting slabs