Unconventional decomposition of FeOOH and its role in the Earth hydrogen cycle

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The Earth's geochemistry can be regarded as a ternary system of oxygen, its most abundant element by atomic fraction, iron, its major redox ingredient, and hydrogen, its most mobile element responsible for electron transfer. The mineral goethite (α-FeOOH), exists ubiquitously as "rust" in the nature, and also concentrates by large quantity in bog iron ore. It has been used as a copious, renewable resource of iron ever since the "iron age".

Here we conduct x-ray diffraction experiment with laser heating and first-principles simulation up to deep lower mantle (DLM) conditions. Our work is attempting to anticipate the fate of FeOOH within the cold subduction slabs. We observed a previously unknown Fe-O phase that holds an excessive amount of oxygen and it involves reactions that have major impacts to our understandings of the Earth. The reaction involves the decomposition of FeOOH that releases hydrogen that would diffuse, infiltrate or react to form hydrocarbon or other volatiles. The new iron oxide phase is left in DLM and cumulates through plate tectonics. Such process provides an alternative interpretation to the origin of seismic and geochemical anomalies in the DLM.