Hydrogen-bearing iron peroxide in Earth's lowermost mantle

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How water cycles through the Earth's interior, presumably is of fundamental importance for understanding the evolution of our planet. The presence of even trace amounts of water (or hydrogen) can dramatically affect many physical and chemical properties of Earth materials, such as phase stability conditions, viscosity, thermal conductivity, etc. Here, we report that the reaction between water and iron to form a pyrite-structured hydrogen-bearing iron peroxide, FeO2Hx (with x = 0 to 1), under the pressure-temperature conditions relevant to the Earth's deep lower mantle. Combined with theoretical calculations and high-pressure experiments using laser-heated diamond anvil cells coupled with a suite of in-situ and characterization techniques (e.g. nuclear resonant inelastic X-ray scattering spectroscopy, X-ray absorption spectroscopy, and X-ray diffraction), we find that this extremely oxygen-rich form of iron peroxide has properties consistent with ultralow velocity zones that are seismically observed at the core-mantle boundary. This phase may also have implications for deep volatile cycling and mantle redox.