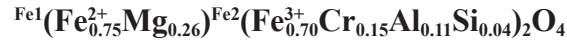


Synthesis of a quenchable high-pressure form of magnetite (h-Fe₃O₄) with composition



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ABSTRACT

We report the synthesis of h-magnetite, ideally h-Fe₃O₄ with considerable amounts of substitutional cations (Cr, Mg, Al, Si) and quenchable to ambient conditions. Two types of experiments were performed at 18 GPa and 1800 °C in a multi-anvil press. In one, we used an oxide mixture with a majoritic stoichiometry Mg_{1.8}Fe_{1.2}(Al_{1.4}Cr_{0.2}Si_{0.2}Mg_{0.2})Si₃O₁₂, with Si and Mg in excess as starting material (MA-367, MA-380). In the second type of experiment (MA-376), we started from an oxide mixture on the composition of the Fe-oxide phase obtained in MA-367. The Fe-oxide phases of both experiments were investigated by electron microprobe and transmission electron microscopy including electron diffraction tomography. Our investigations show that the Fe-oxide phases crystallize in the structure-type of h-magnetite. However, electron diffraction data show that keeping the cell setting from literature, this phase crystallizes in space group *Amam* and not in space group *Bbmm* as previously proposed. In the experiment MA-367, the Fe-oxide phase are mutually intergrown with majorite, the major phase of the run products. The formula for h-magnetite in this run was calculated as $\text{Fe}^{\text{I}}(\text{Fe}_{0.75}^{2+}\text{Mg}_{0.26})\text{Fe}^{\text{II}}(\text{Fe}_{0.70}^{3+}\text{Cr}_{0.15}\text{Al}_{0.11}\text{Si}_{0.04})_2\text{O}_4$. In the experiment on the bulk composition of the Fe-oxide, the main phase was h-magnetite with composition $\text{Fe}^{\text{I}}(\text{Fe}_{1.02}^{2+})\text{Fe}^{\text{II}}(\text{Fe}_{0.65}^{3+}\text{Cr}_{0.19}\text{Al}_{0.13}\text{Si}_{0.03})_2\text{O}_4$ and traces of nearly pure end-member wadsleyite and stishovite. Our results indicate that the substitution of 20 to 30% of Fe (0.7 to 0.9 atoms per formula unit) by smaller cations favored the preservation of the high-pressure form to ambient conditions. We prove that the h-magnetite-type oxide is also stable in chemical systems more complex than Fe-O. Based on our results, which were obtained at 18 GPa and 1800 °C in a system (MA-367) that is closely related to Fe-enriched oceanic lithospheric material, we suggest that a Fe₃O₄-rich phase may be present in environments connected to deeply subducted slabs and possibly associated with deep carbonatitic melting. Our observations show that Cr strongly partitions in the oxide phase such that the coexisting silicates are depleted in Cr compared to Fe₃O₄-free assemblages. This may significantly affect the chemical signature of melts produced in the deep mantle.

Keywords: Fe-oxide, h-Fe₃O₄, high pressure, electron transmission microscopy, electron diffraction tomography, electron energy-loss spectroscopy, electron microprobe analyses, crystal chemistry