



Synthesis of quenchable high-pressure form of magnetite (h-Fe₃O₄) with composition $^{[4]}(\text{Fe}_{0.73}^{2+} \text{Mg}_{0.26})^{[6]}(\text{Fe}_{0.71}^{3+} \text{Cr}_{0.14} \text{Al}_{0.10} \text{Si}_{0.04})_2 \text{O}_4$

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Cubic inverse-spinel magnetite transforms under pressure to orthorhombic normal-spinel magnetite, h-Fe₃O₄ (e.g. Fei et al. 1999; Bengtson et al. 2013). The pressure at which the transition takes place is still controversial. The high-pressure form is reported to be not quenchable to ambient conditions. We report the synthesis of h-magnetite which incorporates considerable amounts of additional cations (Cr, Mg, Al, Si) and is quenchable to ambient conditions. Two experiments were performed at 18 GPa and 1800 °C in a multi-anvil press. The run products were investigated by electron microprobe, transmission electron microscopy and electron diffraction tomography. We observed the formation of h-magnetite in both experiments. In experiment MA-367 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 as starting material, with Si and Mg in excess. The Fe-oxide phase forms elongated aggregates 10–30 μm in length, mutually intergrown with majorite, the latter being the main phase of the run products coexisting with small amounts of stishovite. The formula for h-magnetite in run MA-367 was calculated as $^{[4]}(\text{Fe}_{0.73}^{2+} \text{Mg}_{0.26})^{[6]}(\text{Fe}_{0.71}^{3+} \text{Cr}_{0.14} \text{Al}_{0.10} \text{Si}_{0.04})_2 \text{O}_4$. In the second experiment (MA-376) we used an oxide mixture corresponding to the composition of h-magnetite obtained in MA-367. In this experiment the main phase was h-magnetite with composition $^{[4]}(\text{Fe}_{0.98}^{2+})^{[6]}(\text{Fe}_{0.68}^{3+} \text{Cr}_{0.17} \text{Al}_{0.13} \text{Si}_{0.02})_2 \text{O}_4$ coexisting with very small amounts of wadsleyite. Interestingly no magnesium was incorporated into the Fe-oxide in this experiment compared to MA-367 and no iron was found in the coexisting wadsleyite. For the first time it was possible to perform electron diffraction on recovered h-magnetite of both experiments and we observed that -at least in our case- the h-magnetite structure can better be described in space group *Amam* than in space group *Bbmm* as previously proposed. The substitution of Fe by Cr, Mg, Al and Si, all smaller in atomic size, may have favored the survival of the high pressure form to ambient conditions. We prove that the h-magnetite phase is also stable in chemical systems more complex than the simple Fe-O. Based on our results obtained at 18 GPa and 1800 °C in a system that is closely related to Fe-enriched oceanic lithospheric material, we suggest that h-magnetite may be present in environments connected to deeply subducted slabs. The strong enrichment of Cr in this oxide phase implies that coexisting silicates may be depleted in Cr compared to Fe₃O₄-free assemblages. This would significantly affect the chemical signature of melts produced in the deep mantle.

References:

- Fei et al. (1999) *American Mineralogist*, 84, 203 – 206
Bengtson et al. (2013) *Physical Review B* 87, 155141