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Feiite: Synthesis, stability, and implications for its formation conditions in nature

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Abstract

Feiite (Fe_3TiO_5) is a high-pressure Fe-Ti oxide mineral recently discovered in martian meteorite Shergotty. Feiite is isostructural with Fe_4O_5, a high-pressure iron oxide stable at pressures >10 GPa. The stability of feiite has yet to be studied, as it has not previously been synthesized in the laboratory. To determine the minimum pressure at which feiite can be synthesized, we have conducted multi-anvil experiments at 1200 °C and at pressures ranging from 7 to 12 GPa. Major element compositions and XRD patterns indicate that we successfully synthesized feiite with an orthorhombic unit cell (*Cmcm* structure) in experiments conducted at pressures 8 GPa or greater. Relative to $A_2B_2O_5$ phases with similar structure, feiite can be synthesized at lower pressures. The coexistence of feiite and liuite ($FeTiO_3$-perovskite) in Shergotty indicates that the upper pressure limit of feiite stability is above 15 GPa. To investigate the effect of oxygen fugacity on the composition and stability of feiite, we conducted an additional series of experiments at 1200 °C and 10 GPa pressure in which we varied the Fe^{3+}/Fe_{total} ratio of the experimental starting materials. In doing so, we identified a minimum Fe^{3+} content necessary to stabilize the feiite structure (Fe^{3+}/Fe_{total} = 0.26 at 10 GPa and 1200 °C). The importance of Fe^{3+} for feiite stability suggests this phase would not form in lunar or HED meteorites, where iron-titanium oxides contain little to no ferric iron. Though our experimental results can only place a lower limit on the shock pressures experienced in Shergotty, the determined pressure stability indicates feiite could also be present in diamond-bearing terrestrial rocks sourced from the upper mantle or transition zone. Additionally, the presence of feiite would be an indicator of source Fe^{3+}/ Fe_{total}.

Keywords: Feiite, iron titanium oxide, iron oxide, Shergotty, multi-anvil, high pressure