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Phase relations of $MgFe_2O_4$ at conditions of the deep upper mantle and transition zone

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Abstract

Phase relations of magnesioferrite ($MgFe_2O_4$) have been studied between 8 and 18 GPa and 1000–1600 °C using multi-anvil experiments. At 8–10 GPa and 900–1200 °C, $MgFe_2O_4$ breaks down to Fe_2O_3+MgO. At higher temperatures, a new phase appears along with Fe_2O_3. Although this new phase is unquenchable, EPMA and TEM data point to a composition with $Mg_5Fe_2O_8$ or $Mg_4Fe_2O_7$ stoichiometry. Depending on pressure and temperature, other stoichiometries also appear to be stable together with Fe_2O_3. In terms of pressure, the stability field of the unquenchable phases + hematite widens with increasing temperature to 3 ± 1 GPa at ~1400 °C, and then narrows to ~1 GPa at 1600 °C. The recoverable assemblage of $Mg_2Fe_2O_5$+Fe_2O_3 becomes stable between 11–13 GPa. The $Mg_2Fe_2O_5$+Fe_2O_3 assemblage is stable up to at least 18 GPa at 1300 °C without any evidence of a hp-$MgFe_2O_4$ phase. In addition, hematite plays an important role in the phase relations of $MgFe_2O_4$ by being present over a wide range in pressure and temperature together with a Mg-rich Fe-oxide. Interestingly, hematite incorporates variable amounts of Mg whereby its concentration appears to be a function of temperature. This experimental study has implications for interpreting inclusions in natural diamonds where magnesioferrite occurs by placing a maximum pressure stability on the formation of this phase. Through these inclusions, it also provides constraints on diamond formation and their subsequent evolution prior to eruption. For example, the occasional observation of nano-sized magnesioferrite within (Mg,Fe)O inclusions must have either formed from a high-pressure precursor phase with a different stoichiometry at transition zone or upper lower mantle conditions, or it exsolved directly from the host (Mg,Fe)O under upper mantle conditions (i.e., <9–10 GPa). Since several studies report various non-silicate inclusions with simple oxide compositions, including magnesioferrite, magnetite, or ferropericlase, such inclusions provide evidence for variable redox conditions at the time of entrapment.

Keywords: Magnesioferrite, $MgFe_2O_4$, $Mg_2Fe_2O_5$, deep upper mantle, transition zone, high pressure