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The post-spinel transition in Fe_3O_4-Fe_2SiO_4 and Fe_3O_4- $FeCr_2O_4$ solid solutions

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Minerals with spinel structure are important phases in the Earth´s mantle. Both magnetite (mt, Fe_3O_4) and chromite (chr, $FeCr_2O_4$) are known to transform to denser orthorhombic post-spinel phases at pressures$\geq$10 GPa and $\geq$12.5 GPa, respectively (Schollenbruch et al. 2009a; Chen et al. 2003). On the other hand, Fe_2SiO_4 decomposes to its constituent oxides, FeO and SiO_2 at high P and no post-spinel polymorph appears to be stable (e.g. Ito & Takahashi 1989). An important question is how spinel solid solutions behave at high pressures and temperatures since such compositions are arguably more petrologically relevant. In addition, since h-Fe_3O_4 is apparently not quenchable, it is difficult to investigate its structure. In contrast, two high-P polymorphs of $FeCr_2O_4$-rich compositions have been found in a meteorite (Chen et al. 2003), suggesting that the addition of Cr might allow us to recover the post-spinel phase of Fe_3O_4-bearing compositions from experiments.

Building on recent results for the Fe_3O_4 end member (Schollenbruch et al. 2009a, 2009b), we have begun a study of the high-pressure behaviour of solid solutions along the Fe_3O_4 -Fe2SiO4 and Fe_3O_4- $FeCr_2O_4$ joins. Multianvil experiments were performed at 10 and 13 GPa and 1200-1300°C on pre-synthesised spinels with compositions 85mt-15 Fe_2SiO_4, 50mt-50chr and 80mt-20chr. For the Si-bearing experiments, stishovite was present in the run products. This occurrence, along with observed twinning in the Fe-oxide phase (Schollenbruch et al. 2009a) allows us to conclude that the original spinel had transformed to a high-P polymorph at a pressure and that Si is essentially excluded from this new structure. However, the powder XRD data from the run products could not be indexed either to magnetite (spinel structure) or to any other expected phase, including the known post-spinel structures. Interestingly, these are the same reflections reported by Koch et al. (2004) for an unidentified phase in their high-P ($>$ 9 GPa) syntheses in the system Fe_3O_4-Fe_2SiO_4-Mg_2SiO_4.

In the Cr-bearing experiments, the 80mt-20chr composition produced a single phase, while the 50mt-50chr composition yielded several phases. In all samples, the same set of diffraction peaks found in the Si-bearing experiments were present even though microprobe analysis revealed that all phases present contained significant Cr. A first look at the 80mt-20chr sample with TEM suggests a hexagonal structure, however, it is inconsistent with an eskolaite-hematite solid solution. Positive identification of this phase awaits further analysis. In addition to this "mystery" phase, the 50mt-50chr samples either contained a spinel or an eskolaite-hematite solid solution. Thus, Si- and Cr-bearing spinels have also been demonstrated to undergo a phase transition at essentially the same pressure as that observed for the magnetite end member (Schollenbruch et al. 2009b), however, the resulting phase appears to be different.

References

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