**Magnetite exsolution in ilmenite derived from sub-solidus re-equilibration of Fe-Ti oxides**

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Ilm-Hem$_{ss}$ plays an important role in the acquisition of natural remanent magnetization (NRM) in different types of rocks. As temperature decreases, Ilm-Hem$_{ss}$ commonly separates into hematite-rich and ilmenite-rich end-member phases due to a miscibility gap at 600–700 °C. However, an enigmatic intergrowth, magnetite lamellae and ilmenite host, occurs in the Fe-Ti oxide gabbro from the Xinjie layered intrusion, SW China. Raman spectra and micro-XRD analyses confirmed that the exsolved phase in ilmenite is magnetite. The exsolved magnetite lamellae in the ilmenite contain nearly pure Fe$_3$O$_4$ with ~1 wt% TiO$_2$ and exhibit an crystallographic orientations, $\{111\}_{Mag} // (0001)_{Irm}$ and $<110>_{Mag} // <10-10>_{Irm}$ with the host ilmenite.

Titanomagnetite makes up 40-50% and ilmenite makes up 20-30% of the samples in this study, the titanomagnetite is thus the dominant phase in the samples. Therefore, the Fe$^{3+}$ in the magnetite lamellae are probably derived from adjacent titanomagnetite by sub-solidus inter-oxide cation re-equilibration of Fe$^{2+}$ + Ti$^{4+}$ = 2Fe$^{3+}$ on cooling. This study indicates that both magnetite (Fe$^{2+}$Fe$^{3+}$O$_4$) and hematite (Fe$^{3+}$O$_3$) can exsolve from host ilmenite when the Ilm-Hem$_{ss}$ precursor experienced different sub-solidus re-equilibration.

Detailed characterization for the micro-intergrowth in host ilmenite and intracrystalline exsolved phases is crucial for reconstructing the composition of Ilm-Hem$_{ss}$ precursor and explaining unusual strong NRM in some natural ilmenite.