An experimental approach to high-temperature iron isotope fractionation

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There is considerable variation in $^{57}$Fe/$^{54}$Fe among igneous minerals but the cause is uncertain. A central problem in interpreting natural iron isotope data is that equilibrium fractionation factors among coexisting minerals are poorly known. We performed experiments to establish the iron isotope equilibrium partitioning between fayalite and magnetite at a range of temperatures. These minerals are surrogates for mantle spinel and olivine. Experiments were performed in a piston cylinder apparatus at 1 GPa and at 600, 700, and 800 °C. Starting synthetic magnetite was spiked with $^{54}$Fe to track the approach to equilibrium (e.g., Matsuhisa et al., 1978). The experiments were conducted with added quartz to ensure that oxygen fugacity was fixed at the quartz-fayalite-magnetite equilibrium.

The results show that there is a resolvable fractionation between the fayalite and magnetite and that it decreases with increasing temperature: at 600°C $\Delta_{\text{mgt-fa}} = 0.45$‰, at 700°C $\Delta_{\text{mgt-fa}} = 0.31$‰, and at 800°C $\Delta_{\text{mgt-fa}} = 0.28$‰ +/- 0.017‰. The figure below shows our data compared with the predicted fractionation factors (Polyakov and Mineev, 2000). At higher temperatures the theory and experiments are in fair agreement, but as temperature decreases there is a more substantial difference. This study has experimentally determined for the first time inter-mineral $^{57}$Fe/$^{54}$Fe equilibrium fractionation at high temperature. The results show that the magnitudes of these fractionations are large and require consideration when interpreting iron isotope ratios observed in natural igneous samples.

References