The Control of Pyrrhotite on the Fe Isotope Composition of Magmatic Systems: Implications for the Formation of Magmatic Ni-Cu Deposits and Layered Intrusions

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We present the first systematic characterization of the Fe isotope composition of magmatic pyrrhotite for the application of Fe isotopes to the origin and evolution of magmatic sulfide deposits. Although fractionation is small at high temperature, Fe isotopes provide information about redox, temperature, fluid exsolution, fractional crystallization, and inter-mineral diffusion at magmatic or sub-solidus conditions. Iron isotopes have also proven to be useful tracers of crustal contamination in bulk magmatic sulfide, thus far when paired with S isotopes. Relative and specific Fe isotope values exist for major Fe-bearing igneous minerals (e.g., magnetite, olivine, pyroxene), however, there is a paucity of data for sulfides. Recent studies indicate that pyrrhotite will strongly influence the Fe isotope systematics of magmatic systems, without published $\delta^{56}Fe$ values ($^{56}Fe/^{54}Fe$ in the sample relative to IRMM-14) for natural pyrrhotite. To provide this fundamental information, we report the first dataset for magmatic pyrrhotite from nine deposits of various origin and age (Komatiite-related, astrobleme, anorthosite-related, convergent margin, layered intrusion, flood basalt-related; 2720 to 93 Ma). The $\delta^{56}Fe$ of pyrrhotite samples (n=17) ranges from -0.55±0.04‰ to +0.05±0.03‰, and reflects the composition of the sulfide, variable degrees of assimilation, and crystallization history of each deposit. Only the impact-related Sudbury deposit shows especially light $\delta^{56}Fe$ values for pyrrhotite (-0.89±0.04‰; -0.62±0.04‰; n=2). A fractional crystallization model incorporating these new data and published fractionation factors after [1] confirms the potentially strong influence of pyrrhotite on the Fe isotope systematics of a magmatic system. A global dataset of individual sulfide minerals will aid in more accurately tracing the processes at play in the formation and evolution of deposits containing magmatic sulfide.

[1] Bilenker *et al.* (2017) *G-Cubed*, **18**, 956-972.