Diffusive fractionation of Fe and Ni isotopes in iron-nickel alloys

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Iron-nickel alloys are the main component of iron meteorites, as well as important features in many chondrites. Chemical zoning and isotopic fractionation has been observed in metal found in both types of meteorites. Understanding the processes that contribute to this zoning and fractionation is important to model the formation and evolution of these planetary building blocks. The process of diffusion can create chemical signatures in Earth and planetary materials that help constrain an objects thermal history. Diffusion can also lead to the fractionation of stable isotopes within a material that can be described by the expression $D_1/D_2 = (m_2/m_1)^\beta$ where D_1/D_2 and m_2/m_1 refer to the ratios of diffusion coefficients and masses of isotopes 1 and 2, and β is an empirical factor observed to be 0.5 for self diffusion in an ideal gas.

Experiments were performed to determine the diffusive fractionation of Fe and Ni isotopes within Fe-Ni alloys pertinent to metal phases in meteorites. Iron-nickel inter-diffusion experiments were conducted as diffusion couples in a piston-cylinder apparatus at 1GPa and 1200° C-1400° C for durations between 24 and ~260 hours. Concentration profiles were measured using the Cameca SX 100 electron microprobe at RPI and Fe-Ni interdiffusion coefficients were extracted from these profiles. Iron and nickel isotope profiles were measured using the Cameca ims 1280 ion microprobe at the University of Hawaii. Multi-spot profiles parallel to the microprobe path were measured and referenced to the isotopic composition of the starting materials. A series of iron-nickel alloys were synthesized and used to determine matrix effects. Preliminary results indicate that β is approximately 0.4 for Fe and 0.25 for Ni at the conditions studied.