Copper Isotope Fractionation During Solid-Liquid Metal Equilibrium

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Having experienced rapid developments in the past 15 years, the non-tranditional isotope systems show great potential in tracing the formation and evolution processes of planetary bodies. However, despite an explosive increase in the amount of isotopic data for terrestrial, lunar and meteoritic samples, our understanding of the mechanisms causing isotopic fractionation remains far behind.

Studies of Cu isotopes for terrestrial rocks found that the δ^{65}Cu of mid-ocean ridge basalts, ocean island basalts, komatiites, and peridotites all fall into a narrow range. On the other hand, degrees of Cu isotopic fractionation in iron meteorite samples have been found to be considerably higher. Among the major magmatic iron meteorites, for example, δ^{65}Cu varies from -1.49 to 0.04 ‰ for IIAB, -0.49 to 0.99 ‰ for IIIAB, -1.83 to -0.35 ‰ for IVA, and -5.84 to -0.24 ‰ for IVB. Because iron meteorites are thought to be from early Solar System planetesimals, understanding the processes that caused their Cu isotopic variations might shed light on the origin and evolution of their parent bodies.

In this study, solid/liquid equilibrium experiments were conducted to understand the effect of planetesimal core crystallization on Cu isotope fractionation in iron meteorites. Metal and sulfide powders with mostly Fe, Ni and FeS were mixed and doped with ~2 wt% Cu as the starting powder. The starting powder was sealed in evacuated silica tubes and heated to between 1260–1425 ºC in a 1 atm furnace for 1 to 6 days for each experiment. The liquid and solid metal of each experiment was sampled using a micromill and Cu was purified from the matrix by eluting 8M HCl through AG1-X8 resin. The purified Cu cut from the column was measured using a Nu Plasma II under low-resolution mode. The instrument mass fractionation was corrected using the sample-standard bracketing method.

Our preliminary results of two time-series experiments with ~25 wt% S at 1260 ºC for 25 and 66 hours indicate negaligible Cu isotope fractionation between the liquid and solid metal. These results and those of future analyses may help narrow down the causes of Cu isotope fractionation in iron meteorites and help track the processes their parent bodies experienced.