American Mineralogist, Volume 111, pages 118–127, 2026

Iron isotope fractionation between solid and liquid metal in the Fe-P±Ni system: Experimental constraints and implications for meteorites

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Abstract

Iron meteorites record a range of Fe isotope compositions that hold valuable information regarding the evolution of their parent bodies. Interpreting this isotopic variability, however, requires experimental constraints on the equilibrium isotope fractionation between phases. It is thought that the cores of many iron meteorite parent bodies experienced fractional crystallization, during which crystallization of solid iron-nickel occurs from an increasingly non-metal-rich liquid alloy. Phosphorus is one component of this alloy, and this study provides the first constraints on Fe-isotope fractionation between solid and liquid alloys in the Fe-Ni-P system. Experiments comprising Fe and P show a clear enrichment in the light isotopes of Fe in the liquid phase, which increases with the amount of phosphorus. Nickel-bearing samples are offset from the trend defined by Ni-free experiments, which is accounted for by the change in the solid alloy phase from a body-centered cubic to face-centered cubic structure upon the addition of Ni. The increasing light isotope enrichment of the liquid with increasing P content suggests interstitial solution of P, which is known to lengthen Fe-Fe bonds in Fe-P liquids (Waseda and Shiraishi 1977). Results suggest a negligible effect of P on Fe isotope fractionation during planetesimal core crystallization. Iron isotopes may, however, prove useful for identifying the petrogenesis of schreibersite in pallasites and iron meteorites.

Keywords: Iron isotope, meteorite, experimental petrology, alloy, schreibersite