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An experimental setup to evaluate metal-silicate diffusion of Fe isotopes in Pallasites

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Nucleosynthetic isotope variations in meteorites are used to identify genetic relationships between meteorite groups and planets (e.g. [1]). Pallasites consists of intermingled metal and olivine that is thought to represent mixing between core and mantle material. One proposed formation mechanism is the injection of impactor core material into the mantle of the target body (e.g. [2]). Iron isotope analysis of pallasites might provide a rare opportunity to trace the origin of both the metal and olivine since Fe is a major element in both these phases [3]. However, diffusion of Fe isotopes between metal and olivine might erase original differences. The extent to which diffusion may affect such signatures, as well as the rates of isotopic-specific interdiffusion, are not well understood [4].

To address this, we performed high-temperature experiments to study the isotopic exchange of Fe between metal and natural olivine. The setup mimics the petrogenetic conditions of pallasites, with peak temperatures akin to the Fe-Ni alloy liquidus (c. 1550 °C) followed by prolonged cooling at sub-solidus conditions. Samples consists of synthetic Fe-Ni metal mixtures doped in ^{57}Fe which are encapsulated in natural San Carlos Olivine. Both gas-mixing furnace and piston cylinder experiments are being considered. The sample is first heated above the metal liquidus but below the olivine solidus, then the temperature is lowered into solid state for both. The length of diffusion profiles are a function of run time, temperature, oxygen fugacity and metal composition [5, 6], independently adjusted for each run. After the experiments the mass-independent ε^{57}Fe composition of the olivine and metal run products will be measured. From this data we can quantitatively evaluate isotopic diffusion rates, with the goal to improve our understanding of mixing in the protoplanetary disk and the preservation of distinct nucleosynthetic signatures in pallasites.

[1] Rüfenacht et al. (2023) *GCA* 335, 110-125. [2] Walte et al. (2020) *EPSL* 546, 116419. [3] Chernonozhkin et al. (2017) *GCA* 217, 95-111. [4] Richter et al. (2009) *Chem Geo* 258, 1-2. [5] Donohue et al. (2018) *GCA* 222, 305-318. [6] Zhukova et al. (2014) *Contrib Mineral Petrol* 168, 1029.