PALLASITE OLIVINE-METAL EQUILIBRIUM: INSIGHTS FROM NEW PARTITION COEFFICIENTS

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Introduction: Pallasites are stony-iron meteorites comprising olivine and FeNi-metal in roughly equal proportions, with minor amounts of accessory minerals (e.g., chromite, troilite, schreibersite). Chemical zonation between olivine cores and rims has been used to infer widely variable post-mixing cooling rates. These inferences are based on some assumptions regarding element behavior, such as olivine-metal partitioning. There is limited information about minor- and trace-element partitioning between olivine and metal in systems relevant to pallasites. We have previously presented partitioning behavior from an experimental study of pallasite analogues [1]. Here, these new results are applied to refine our understanding the thermal history of pallasite meteorites.

Experimental: The determination of metal-olivine partition coefficients ($D_i = M_{\text{metal}} / M_{\text{olivine}}$ where M = element wt%) for Cr, Mn, Co, and Ni were described in [1]. Briefly, synthetic olivine crystals were mixed with metal and heated to 900°C, 1300°C, and 1550°C for 1530 to 350 hr at fO_2 of IW-1. Three metal compositions were used (FeNi, FeCo, and FeNiCo) to ascertain the effects of composition on partitioning. The Fe abundance affects the partitioning behavior of minor elements, and this was taken into account by normalizing D_i by the ratio of Fe in olivine to that in the metal. This correction factor allows us to calculate pallasite-specific D_i.

Pallasite compositions: We evaluated five main group pallasites (PMG) and Eagle Station, for which literature olivine and metal compositions for Fe, Cr, Mn, Co, and Ni are available. Hsu [2] gives multiple profiles for Cr, Mn, and Ni, and Tomiyama et al. [3] report olivine core and rim Cr and Co compositions for Albin (pallasite), Esquel, Imilac, Springwater, and Eagle Station. Brenham comes from McKibbin et al. [4]. Metal data are limited [5–8], and we did not find any reports of Mn in metal for Springwater, Brenham, or Imilac. Further, chromite inclusions likely compromised Cr-in-metal analyses for Springwater and Imilac [7]. Here, we use the lowest Cr values from duplicate analyses for Imilac and Springwater metal [7], which are similar to average Cr of multiple PMGs (~12 ppm [9]).

Discussion: Using pallasite-specific D_i, we calculate the compositions of olivine (M_{olivine}) that would be in equilibrium with pallasite metal. If pallasite olivine equilibrated with metal, olivine compositions on Fig. 1 should indicate the temperature of equilibration. The cores of many olivines appear to have equilibrated with metal at high temperature (1300 to 1550°C). However, the ubiquitous decrease in Cr abundance toward olivine rims contradicts the expected behavior during cooling if only metal and olivine we present. Nucleation of chromite at lower temperatures (≤~1000°C) would decrease the amount of chromium available to olivine and metal, reducing the Cr content of olivine rims. In contrast, Mn and Co, which are not strongly zoned in pallasite olivines, remained in equilibrium with metal alone between ~1550°C and ~1300°C. By modeling temperatures of equilibration and nucleating phases, we are able to better understand the thermal and chemical evolution of pallasite parent bodies.

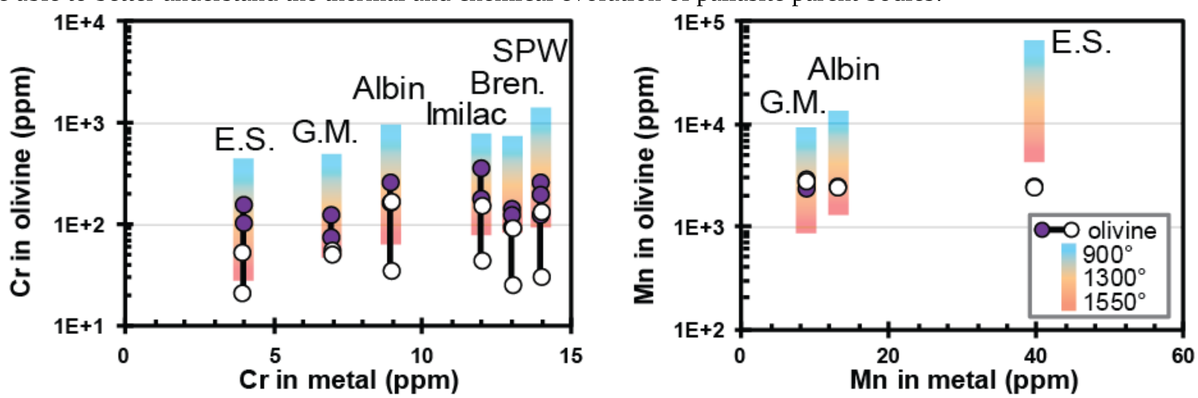

Fig. 1. Core (filled) and rim (open) compositions of olivines from pallasites and calculated compositions for olivine in equilibrium with FeNi-metal matrix at varying temperature. Abbreviations: Bren, Brenham; ES, Eagle Station; GM, Glorieta Mountain; SPW, Springwater. Sources for data are noted in text.

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Supported by the NASA Cosmochemistry program (NNX08AG58G & NNX14AI19G to GRH).