

D. Johnson¹, N.W.Rogers², M.M. Grady^{1,3}

¹PSSRI, Open University, Walton Hall, Milton Keynes, MK7 6AA, UK; E-mail: D.Johnson@open.ac.uk, ²Department of Earth and Environmental Sciences, Open University, Walton Hall, Milton Keynes, MK76AA, UK. ³Department of Mineralogy, The Natural History Museum, London, SW7 5BD, UK.

Introduction: The origins and evolution of Pallasites have been greatly debated. Proposed formation models include core-mantle boundary regions, crystallised impact materials(1), dendritic core growth(2), crystallised material close to the surface of an asteroid subject to external heating(3). Others have suggested links between Pallasites, IIIAB Irons and HEDs, based on oxygen isotope analysis (4), although high resolution isotopic analysis has revealed different oxygen isotope values for these groups(5) in addition to different cooling rates with IIIAB irons(6). This study provides trace element data from a selection of Main Group Pallasites as evidence of potential formation mechanisms.

If examined carefully an individual pallasite can often show considerable variation in bulk composition. Many have areas rich in metals mixed with olivine fragments but also have other regions poor in metal and rich in olivine and Troilite veins, see Figures 1-3. How such diverse samples can form has been the subject of much debate.

Material and Methods:

We characterized polished 1 inch blocks of Hambleton, Brahin, Seymchan, Brenham, Fukang, Imilac, using optical microscopy and electron microscopy, major element compositions were measured using EMPA. Cobalt data measured by EMPA was used as an internal standard for ICPMS analysis. A range of trace level elements were measured in selected kamacite grains using a New Wave 213 laser ablation system with an Agilent ICPMS at the Open University, UK, with ablation spot sizes between 50-80 micrometer diameters. The iron meteorites Hoba and North Chile-Filomena (Co, Ni, Ru, Rh, Pd, Re, Os, Ir, Pt, Ga, Ge, Au) (7, 8) and NIST steel (P, V, Mo) were used as standards for Kamacite. Data reduction was performed using GLITTER software, metal grain errors displayed in Figures 5-7 are $\pm \sigma$. When ICPMS analysis was complete the ablation pits were imaged with SEM to confirm the laser hit the target site, Figure 4.



Figure 1. Metal rich example of Main Group pallasite Brahin, scale bar 1cm

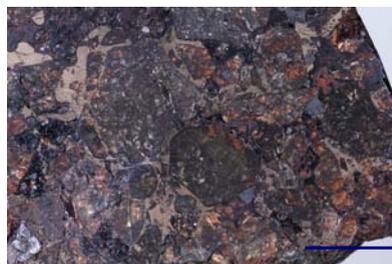


Figure 2. Olivine and Troilite rich area of Brahin, scale bar 1cm.



Figure 3. Example of Main Group pallasite Hambleton, displaying areas rich in metal and others rich in olivine.

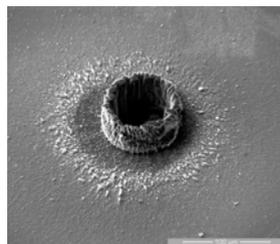


Figure 4. ablation crater on kamacite

Results and Discussion: Hambleton analysis of multiple Kamacite grains shows inter-grain variation trends as shown in Figures 5-7. This can be explained by mixing of the residual melt with pre-existing metal crystals this would have taken place at the same time as the olivine metal mixing event. All data recorded was considered to be in the normal range for the main group pallasites examined except Seymchan which is known to have metal chemistry in coincidence with the IIE irons. Linear trends of data points appear to exist with different samples displayed on certain elements plots such as Pd vs Ga and Rh vs Ga see Figures 8-11 which may be indicative of common parent body processing.

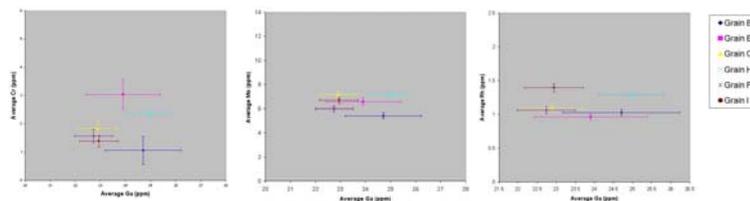


Figure 5. Hambleton metal grains Cr vs Ga data.

Figure 6. Hambleton metal grains Mo vs Ga data.

Figure 7. Hambleton metal grains Mo vs Ga data.

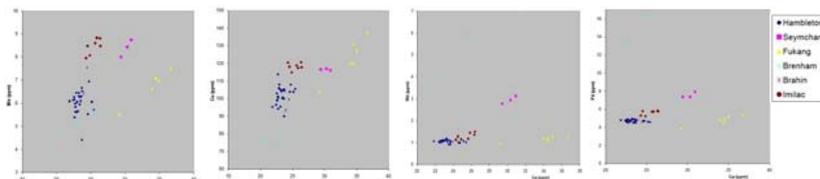


Figure 8. Pallasite comparison plots of Mo vs Ga

Figure 9. Pallasite comparison plots of Cu vs Ga

Figure 10. Pallasite comparison plots of Pd vs Ga

Figure 11. Pallasite comparison plots Rh vs Ga

Conclusions:

Trace element compositions show the existence of different groups, these could have been established by either (a) mixing of additional materials, (b) differing crystallisation histories of separate parts of a large heterogeneous body. We hope to investigate the trace element content of discrete components within pallasites, specifically the sulphides in order to determine whether there is any mineralogical or volatility related effect controlling the element distribution profiles.

References: [1] Malvin D.J. et al. *Meteoritics*, 20, 259, 1985. [2] Haack H and Scott E.R.D., *Geochimica Cosmochimica Acta*, 57, 3457, 1993. [3] Mittlefehldt D.W., *EPSL*, 51, 29, 1980. [4] Clayton R.N. and Mayeda T.K., *Geochimica Cosmochimica Acta*, 60, 1999, 1996. [5] Greenwood et al., *Science*, 313, 1763, 2006. [6] Yang J, Goldstein J.I., Scott ERD, *Geochimica Cosmochimica Acta*, 74, 4471, 2010. [7] Campell A.J. and Humayun M, *Analytical Chemistry*, 71, 939, 1999. [8] Campell et al., *Geochimica Cosmochimica Acta*, 66, 647, 2002.

Acknowledgements: The authors wish to thank the STFC and NERC for support and funding. The Natural History Museum, London is also thanked for loan of Imilac sample, NHM:1927,88. Figures 1,2 photography © A. Tindle, Open University, UK.