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Trace Element Distributions in Main Group Pallasites

D. Johnson (1), N. W. Rogers (2) and M. M.Grady (1,3)
(1) Planetary and Space Sciences Research Institute, The Open University, Walton Hall, Milton Keynes, MK76AA, UK (D.Johnson@open.ac.uk). (2) Department of Earth and Environmental Sciences, The Open University, Walton Hall, Milton Keynes, MK76AA, UK. (3) Department of Mineralogy, The Natural History Museum, London, SW7 5BD, UK.

Abstract

Pallasites are frequently considered to have formed at core mantle boundaries within small asteroid bodies. This study employs LA-ICPMS, EMPA, SEM and optical microscopy to characterise a selection of main group pallasites, and the trace element abundances of kamacite to provide evidence of the relationship between members of the main group pallasites.

1. Introduction

Pallasites are an enigmatic group of stony-iron meteorites, the origins of which have been greatly debated. Previous formation models proposed 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 from the IIIAB irons [6]. This study provides trace element results from the pallasite Hambleton (see Figure 1) and compares them to a selection of main group pallasites as evidence of potential formation mechanisms.

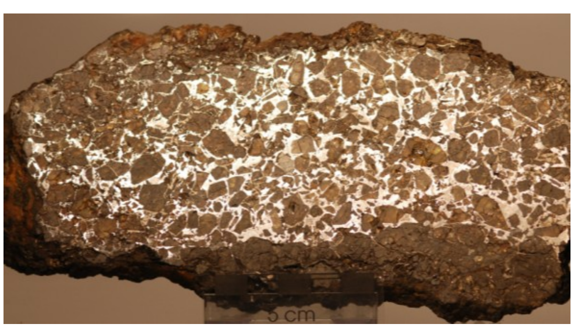

Figure 1. Slice of Hambleton a Main Group pallasite.

2. Methods and Discussion

We characterized 1 inch polished blocks of Hambleton, Brahin, Seymchan, Brenham, Fukang, Imilac, using an optical microscope and electron microscopy with an FEI Quanta 200. Major element compositions were measured using EMPA with a Cameca SX100 at 15kV and a probe current of 20nA. A range of trace level elements were measured in selected locations of kamacite grains and large olivine crystals with an Agilent 7500s LA-ICPMS with a New Wave 213 system at the Open University, UK. 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 std (P, V, Mo) were used as standards for kamacite and NIST std No. 612 (Li, Mg, Si, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Zn, Ga, In, Sn) for olivine analysis. Cobalt data measured by EMPA were used as an internal standard for metal analyses, with ablation spot sizes between 50-80 µm in diameter (Figure 2). Backscattered electron images and x-ray spectra were used to examine metal areas to ensure the metal grains for analysis were composed of kamacite only, areas of plessite and taenite were observed but selectively avoided as the analytical error associated with measuring such small scale intergrowths and thin rims was considered to be large in both LA-ICP-MS and EMPA hence unreliable for quantitative analysis.

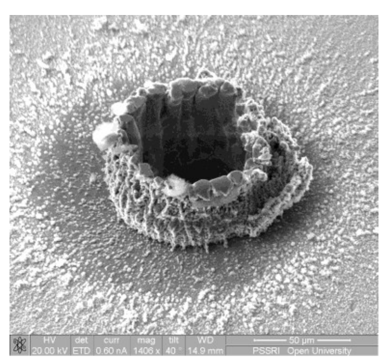

Figure 2. Laser ablation pit in Brenham kamacite.

3. Summary and Conclusions

Hambleton kamacite analyses of multiple grains appears to support a fractional crystallisation process, with approximate linear trends between trace elements, such as that shown in Figure 3.

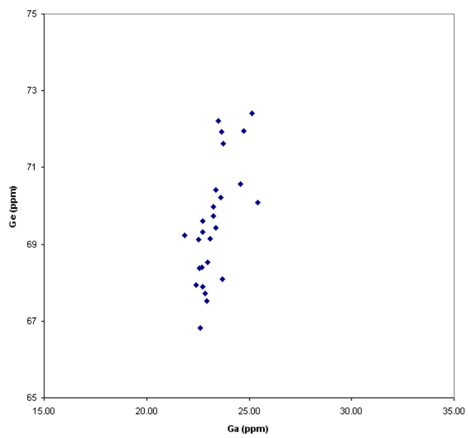

Figure 3. Ge Vs Ga plot for Hambleton kamacite data.

All data recorded were considered to be in the normal range for the main group pallasites examined except Seymchan which is known to have metal chemistry similar to the IIE irons. Linear relationships between elements (such as Rh vs Ga; Figure 4) are apparent within groups of individual samples, which may be indicative of common parent body processing.

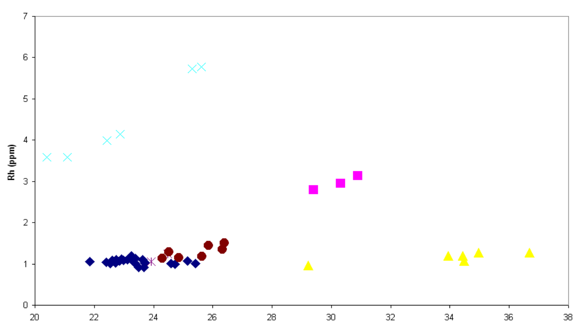

Figure 4. Rh Vs Ga (ppm) plot for Main Group Pallasites. Symbol key: Brenham = cross, Seymchan= square, Hambleton= diamond, Imilac= circle, Brahin= star, Fukang= triangle.

Acknowledgements

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