Hambleton - A New Sulphur Rich Pallasite

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Introduction

A 17.6kg single mass pallasite was found south of Hambleton, North Yorkshire, UK, by R and I Elliott, in 2005. It is composed of 60% vol olivine, 25% vol metal and 15% vol sulphide, Figure 1 shows an image of the mass on deposit with the Open University. It has suffered significant weathering which has penetrated for 4-5 cm towards the interior of the mass where the olivine-rich outer portion is brittle and prone to disintegration. It is however rich in troilite which makes this meteorite significant to our understanding of core formation. Here we present the results of an optical and analytical scanning electron microscope study.

Figure 1. Optical image of the 1.5kg sample as deposited at the OU, note the contrast between the bright metal areas and the dull orange coloured sulphide regions.

Observations

The olivine data shown in the table below was used to classify Hambleton as a main group pallasite. Olivine occurs as cm-sized sub-rounded crystals in a granular mosaic. Many contain sub-parallel sets of fractures, some of which are Annealed. Examples of this are shown in Figures 2 and 3, while others are filled with metal or sulphide.

Olivine composition:	Forsterite 88.0 WDXRD[1]
Oxygen isotopic ratios:	$\delta^{17}O$ = +1.383‰ $\delta^{18}O$ = +3.029‰ $\Delta^{17}O$ = -0.187‰ [ref2]

Table 1. Olivine data

Figure 2

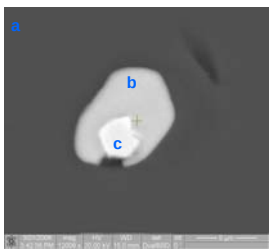

Figure 3.

BSD SEM images showing: (2) Annealed olivine crystal fracture with metal and sulphide particles along fracture line. (3) Metal particle remaining in annealed fracture line, letter points composed of (a) olivine, (b) troilite (c) kamacite.

Many metal areas are composed of plessitic kamacite rimmed with taenite as shown in Figures 4 and 5. The majority of metal has suffered terrestrial oxidation, especially low Ni phases such as kamacite, cloudy taenite or plessite. Troilte and schreibersite have also suffered terrestrial weathering, however the sulphide phase is generously distributed throughout this meteorite. In some areas there is a significant nickel enrichment of the FeS as Ni 60At%,Fe 20At%, S 20At%. This typically appears as growth of vein structures along boundaries that are shared with oxidised materials and is most probably weathering, an example of this is shown in Figure 6. Small angular olivine is predominantly found in the troilite. An example of this given in Figure 7. Some regions are entirely composed of large olivine crystals enclosed within troilite, such as the top edge of sample shown in Figure 1.

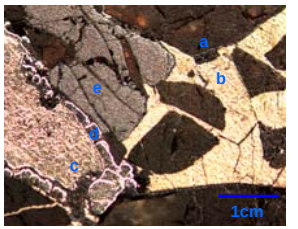

Figure 4
Optical image showing compositions: (a)olivine, (b)troilite, (c)plessitic kamacite (d)taenite rim, (e)chromite.

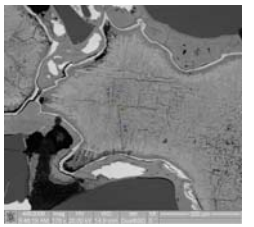

Figure 5
SEM BSD image of oxidised plessitic kamacite rimmed with taenite

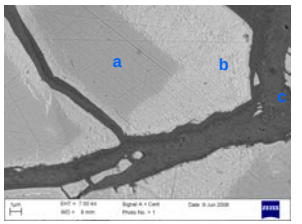

Figure 6
FEGSEM BSD image showing compositions: (a)Troilite, (b)Ni enriched FeS, (c) Iron oxide.[3]

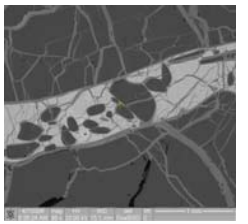

Figure 7
SEM BSD image of a vein of FeS enclosing small olivine fragments.

Discussion

Metal rich regions are consistent with the view of Scott[4] that pallasites formed by the injection of metallic liquid into dunite. Evolved metallic melts, related to IIIAB irons, should be sulphur-rich. Paucity of sulphide in pallasites led Ulff-Moller et al[5] to suggest that either FeS-rich liquid was lost or formed pallasites that are underrepresented in our samples, Hambleton could be such a pallasites.

Conclusion

Along with the Phillips County pallasite, Hambleton is a rare FeS-rich pallasite which is worthy of further research.

References

(1) WDXRD data gathered by A.G.Tindle, Open University, UK.
(2) O isotope data gathered by I.A.Franchi, Open University, UK.
(3) FEGSEM data gathered in collaboration with G.G.Imlach, Open University,UK.
(4) Scott E.R.D. 1977. *Geochimica et Cosmochimica Acta* 47: 693-710.
(5) Ülff-Moller et al. 1998.*Meteoritics & Planetary Science* 33: 221-227.

Acknowledgments:

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