

### TRACE ELEMENT COMPOSITIONS OF PALLASITE OLIVINE GRAINS AND PALLASITE ORIGIN

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Pallasites are mixtures of metal with magnesian olivine. Most have similar metal compositions and olivine oxygen isotopic compositions; these are the main-group pallasites (PMG) [1,2]. The Eagle Station grouplet of pallasites (PES) have distinctive metal and olivine compositions and oxygen isotopic compositions [1,2]. Pallasites are thought to have formed at the core-mantle boundary of their parent asteroids by mixing molten metal with solid olivine of either cumulatic or restitic origin [1,3].

We have continued our investigation of pallasite olivines [*e.g.* 4] by doing *in situ* trace element analyses in order to further constrain their origin. We determined Al, P, Ca, Ga and first row transition element contents of olivine grains from suite of PMG and PES by LA-ICP-MS at JSC. Included in the PMG suite are some that have anomalous metal compositions (PMG-am) and atypically ferroan olivines (PMG-as; nomenclature after [1]).

Our EMPA work has shown that there are unanticipated variations in olivine Fe/Mn, even within those PMG that have uniform Fe/Mg. Manganese is homologous with Fe<sup>2+</sup>, and thus can be used the same way to investigate magmatic fractionation processes. It has an advantage for pallasite studies in that it is unaffected by redox exchange with the metal. PMG can be divided into three clusters on the basis of Mn/Mg; low, medium and high (clever, no?) that can be thought of as less, typically and more fractionated in an igneous sense. The majority of PMG have medium Mn/Mg ratios. PMG-am occur in all three clusters; there does not seem to be any relationship between putative olivine igneous fractionation and metal composition. The PMG-as and one PMG-am make up the high Mn/Mg cluster; no PMG are in this cluster.

The high Mn/Mg cluster ought to be the most fractionated (equivalent to the most Fe-rich in igneous suites), yet they have among the lowest contents of incompatible lithophile elements Al and Ti and the two PMG-as in this cluster also have low Ca and Sc contents. This is inconsistent with simple igneous fractionation on a single, initially homogeneous parent asteroid. For Al and Ti, the low and high Mn/Mg clusters have generally uniform contents, while the medium cluster has wide ranges. This is also true of analyses of duplicate grains from the medium cluster pallasites which can have very different Al and Ti contents. Those from the low and high clusters do not. These observations suggest that pallasite olivines are not cumulates, but rather are restites from high degrees of melting [4].

The moderately siderophile elements P and Ga show wide ranges in the high Mn/Mg cluster, but very uniform compositions in the medium cluster, opposite the case for Al and Ti. There is no correlation of P or Ga and Fe/Mn as might be expected if redox processes controlled the contents of moderately siderophile elements in the olivines [*c.f.* 5]. The lack of correlation of P could reflect equilibration with phosphates [6], although there is no correlation of Ca with P as might be expected.

**References:** [1] Wasson & Choi (2003) GCA 67, 3079. [2] Clayton & Mayeda (1996) GCA 60, 1999. [3] Mittlefehldt et al. (1998) Reviews in Mineralogy 36, chp. 4. [4] Mittlefehldt & Rumble (2006) MAPS 41, A75. [5] Righter et al. (1990) GCA 54, 1803. [6] Buseck & Holdsworth (1977) Min. Mag. 41, 91.