CHARACTERIZATION OF THE DISTRIBUTION OF SIDEROPHILE AND HIGHLY SIDEROPHILE ELEMENTS IN THE MILTON AND EAGLE STATION PALLASITES. J. T. Hillebrand, W. F. McDonough, R. J. Walker, and P. M. Piccoli, Department of Geology, University of Maryland, College Park, MD 20742.

Introduction: Pallasite meteorites may provide important information regarding the partitioning of siderophile and highly siderophile elements (HSE) between metal and silicate phases in magmatic systems. This information may in turn be used to predict the abundances of these elements present in the silicate portions of planetesimals and asteroids that segregated metallic cores.

Because of the tendency of siderophile elements and HSE to strongly partition into metal relative to silicates, studies examining concentrations in coexisting natural systems have been rare. In most instances, concentrations of the elements of interest in the silicate phases have been too low for *in situ* analysis. Experiments on synthetic materials doped with high abundances of siderophile elements and/or HSE, however, have been plentiful [e.g. 1-3]. Most such studies have indicated bulk metal-silicate partition coefficients for low pressure systems of $\geq 10^2$ for siderophile elements and $\geq 10^4$ for siderophile elements [2]. Results of such studies have been highly debated because some HSE occur as microscopic nuggests in silicates, leading to ambiguities in the interpretation of partitioning characteristics. Recent studies have concentrated on HSE less prone to forming nuggets, e.g. Pt and Pd, and reported that the $D^{Metal/Silicate}$ of some HSE, such as Pt and Pd, can exceed 10^6, even at high pressures [3].

Here, we examine the partitioning characterisitics of several siderophile elements and HSE in the Eagle Station and Milton pallasites to determine if the $D^{Metal/Silicate}$ in natural systems are comparable to the range of values determined for synthetic systems. Eagle Station and Milton are particularly appropriate for this type of study because previous studies have shown that bulk samples of these meteorites have much higher abundances of siderophile elements and HSE than bulk samples of main group pallasites or mesosiderites [4-5]. Thus, the expectation that initiated this study was that the abundances of at least some elements of interest present in the silicate phases may be at levels sufficiently high to be determined via *in situ* spot analysis using laser ablation ICP-MS.

Samples: Eagle Station station is genetically grouped with two other pallasites, Itzawisis and Cold Bay, to form the Eagle Station grouplet [e.g. 4]. These three meteorites share common O isotopic compositions. Milton is not presently known to be genetically linked to any other pallasite [5].

Analytical Methods: Samples of the Eagle Station and Milton pallasites were prepared for analysis by polishing using a 3 step procedure including 600 grit sanding paper, 0.3-micron aluminum polishing compound, followed by a 0.1-micron aluminum polishing compound to achieve a smooth, pit free surface. Polished samples were carbon coated and analyzed using a JEOL *JXA-8900* Electron Microanalyzer for major and minor elements in the metal phases (Fe, Ni, Co, Cu, and Cr) and olivine (Mg, Fe, Ca, Mn, Ni, Cr and Si). The following conditions were employed: accelerating voltage of 15 keV, 10 nA sample current, and a 5 υm diameter beam. Peak and background intensities were measured for all elements, and raw intensities were compared to intensities from natural standards, and corrected using a CIT-ZAF algorithm.

Trace element analyses were conducted using a laser ablation ICP-MS system consisting of a 213 nm Nd:YAG laser coupled to an *Element 2*, magnetic sector ICP-MS. We used a small volume, in-house developed ablation cell for these measurements; it was continuously flushed with He (~1.2 mL/min) and Ar (~0.6 mL/min) in a chamber before it entered the plasma. Laser spot sizes and laser repetition rate were set to optimize maximum signal intensity to ~10^6 cps. Time-resolved spectra included the acquisition of ~20 seconds of gas background followed by 40 to 80 seconds of signal. Analyses of unknowns were evaluated using a range of standard materials (i.e., NIST glasses and metals, Hoba and Filomena meteorites, and an in-house PGE-bearing sulfide standard).

Siderophile and highly siderophile element concentrations were determined for sampling sites that were first examined via electron probe microanalysis. To minimize contamination during ablation, the olivine crystals in each pallasite were analyzed prior to the metals. Initial analyses of the Eagle Station and Milton pallasites were be optimize operational parameters for further, more sensitive measurements.

Results: Major, minor and trace element variations in olivines for both pallasites are relatively minor (Table 1), a feature consistent with previous studies [e.g. 5]. Milton metal is also generally homogeneous, whereas metal compositions vary considerably in Eagle Station. Concentrations of minor and trace elements for metal and silicate are provided in Table 1. Of note, concentrations of W, Rh, Pd, Re and Au are significantly above detection limits in both Eagle Station and Milton, although signals for Re, Au (for both ES and Milton), and Rh and Pd (for ES) were $<2\sigma$ above background. In general, concentrations range from approximately 0.5 to 11 ppb. Concentrations in metals for most of these elements are in the range of 1-10 ppm. Calculated $D^{Metal/Silicate}$ values are highly variable (Table 2). For those elements for which silicate signals were low, minimum partition coefficients are cited.

Discussion: Metal/silicate partition coefficients for siderophile and HSE in Eagle Station and Milton pallasites, are broadly similar to those determined for synthetic materials. In general, however, calculated partition coefficients for these elements in Milton are considerably lower than for ES. For example, the D for W (~100) for Milton is much lower compared to 8000 for Eagle Station. The reason for the differences is presently unknown, although the presence of small metal or sulfide inclusions will be further explored.

Although initial results indicate that siderophile element and HSE concentrations variations in single olivine crystals are minor, further analyses will be conducted to assess the magnitude of any zoning.

At face value, the results for Milton suggest that some silicates in contact with metal in planetary bodies may retain relatively high concentrations of siderophile elements and HSE. Nonetheless, the relative abundances of the HSE are highly fractionated from chondritic.

Conclusions: It is now possible to directly measure the concentrations of some siderophile and HSE elements in the silicate phases of some pallasite meteorites. Metal-silicate partition coefficients obtained from Eagle Station and Milton are broady similar to values determined for synthetic systems, but differences in the values between the two meteorites are not currently explained.

References: [1] Kimura K. *et al*. (1974) *GCA* 38, 683-701. [2] Borisov A. & Palme H. (1997) *GCA* 58, 705-716. [3] Holzheid A. *et al*. (2000) *Nature* 406, 396-400. [4] Jones R. (2003) *LPSC XXXIV*, 1683. [5] Wasson J.T. and Choi B.-G. (2003) *GCA* 67, 3079-3096.

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Table 1. Concentration data for olivines and metal.

(ppm)	Eagle Station		Milton	
Olivines	average	±	average	±
Sc	2.9	0.4	4.0	0.4
V	9.9	0.5	17	1
Cr	156	34	574	133
Mn	1470	10	1230	10
Fe %	14.4	0.22	11.8	0.17
Co	20	1	31	5
Ni	49	1	84	21
Rh*	*0.2*	*0.1*	1.5	0.8
Pd*	*0.6*	*0.4*	5.8	0.9
W*	6	4	11	5
Re*	*0.5*	*0.3*	*1.6*	*0.5*
Au*	*3.3*	*1.3*	*1.5*	*0.9*
Metals	average	±	average	±
Fe %	80.5	4.7	82.5	0.3
Co	6660	668	8790	38
Ni %	17.6	4.9	16.5	0.5
Cu	80	4	256	20
Ga	--	--	33	10
Ge	129	132	55	9
As	75	44	7.2	1.5
Mo	--	--	14	2
Ru	2.3	1.4	31	5
Rh	2.4	1.3	5	1
Pd	3.5	0.5	5.2	0.1
W	46	53	1.2	0.1
Re	0.5	--	5.1	0.6
Os	18	13	51	3
Ir	14	11	45	2
Pt	1.6	1.9	33	1

* data reported in ppb (ng/g)

- data in italics are for signals that are $<2\sigma$ above background.

Table 2. Metal/Olivine D-values

	Eagle Station	Milton
Fe	5.6	7.0
Co	330	280
Ni	3600	1960
Rh	>10,000	3200
Pd	>5500	1000
W	8000	110
Re	>1000	>3000