**Introduction:** Pallasites are of great interest to meteoriticists because they may represent samples of the interfaces between core and mantle materials in asteroids. Further, certain pallasites may be genetically related to the group IIIAB irons, based on similar $\Delta^{17}$O values [1], potentially permitting the study of core-mantle evolution within a single body. To better understand the origin and evolution of pallasites we have examined $^{187}$Re-$^{187}$Os, $^{190}$Pt-$^{186}$Os and highly siderophile element (HSE; Re,Os,Ir,Ru,Pt,Pd measured here) abundances in a variety of pallasite metals, including those from the Main Group (PMG), including four with anomalous metal (PMG-am), as defined by Wasson and Choi [2]. We have also analyzed Cold Bay to complement our previous data for the Eagle Station grouplet (PES).

The objectives of this work are to use the isotope systems to examine closure ages for HSE migration, and consider processes that may relate the metal phases via modeling of the high-precision HSE isotope dilution data. Ultimately, models that are viable from a HSE standpoint will be considered with respect to other diagnostic elements.

**Analytical Methods:** Chemical separation techniques used were similar to previous studies [e.g. 3]. Blanks for Re, Pt, Os, Pd, Ru, and Ir averaged 2, 300, 2, 30, 50 and 1 pg, respectively. Osmium measurements were accomplished via negative thermal ionization mass spectrometry (Sector 54). The isotope dilution measurements of all other elements were done via static multi-collector ICP-MS (Nu Plasma) using faraday buckets. Fractionation was monitored and corrected via interspersal of samples with standards. All concentration data are $\pm 0.5\%$ or better.

**Results:** Concentrations of Ir and Os measured here are generally similar to those reported previously for pallasites [e.g. 1-2,4]. As has been previously noted, the ranges of concentrations within the PMG of Ir and Os are large (Fig. 1a-b), though they range considerably less than for the group IIAB and IIIAB irons. Platinum and Pd abundances vary much less over the range of Ni or Au contents represented by the PMG. The $^{187}$Re/$^{188}$Os ratios for PMG vary from 0.310 to 1.029.

**Discussion:** A $^{187}$Re-$^{187}$Os isochron regression for the 12 PMG examined yields an age of 4548 ± 87 Ma and initial $^{187}$Os/$^{188}$Os = 0.9515±0.00091. There is substantially more variance of data about this isochron than for any of the IIAB, IIIAB, IVA, IVB iron groups analyzed previously [3,5-6]. The observation that some pallasites plot well to the right of the isochron (not shown) suggests substantial open-system behavior of Re and/or Os well after initial crystallization. This may have important bearing on the interpretation of other HSE abundances. One previous study of Re-Os isotopes in pallasites also reported modest non-isochronous behavior [4].

Compared to chondrites, most of the PMG examined here are relatively depleted in Re, Os and Ir, but with much less fractionated Ru, Pt and Pd. As...
with magmatic iron groups, in general Re, Os, Ir, Ru and Pt appear to have behaved as compatible elements during metal crystallization (Figs. 1a-b; 2). Palladium concentrations vary remarkably little and, if all PMG can be related by some form of crystal-liquid fractionation, must have evolved with a solid metal-liquid metal D value of nearly 1. The four PMG-am examined here (Brenham, Krasnojarsk, Huckitta, and Pavlodar) have highly diverse patterns, with Pavlodar having nearly chondritic relative abundances of HSE, except for apparent Pd depletion. Log plots of Os concentration versus other HSE are much more poorly defined than for magmatic iron groups [e.g. 3], particularly for Ru, Pt and Pd (Fig. 2). This indicates either more complex evolution than for magmatic irons, or that there were considerable relative differences in D values between these elements during the evolution of pallasite metal.

Fig. 2. Log-log concentration diagram for HSE versus Os. Circles with crosses are PMG-am.

Several potential models to explain Re vs. $^{187}$Re/$^{188}$Os characteristics of group IIIAB irons were proposed by Cook et al. [3]. One of these models is reproduced in Fig. 3 with the addition of the PMG and PMG-am data. For this model, an initial Re concentration of 470ng/g and a chondritic $^{187}$Re/$^{188}$Os of 0.40 were assumed. Bulk D values for Re were varied as per the parameterization of Jones and Malvin [7], assuming $D_{Re}$ and $D_{Os}$ varying from 13.0 to 14.5 and 14.9 to 16.6, respectively, for 0 to 50% fractional crystallization. This model can account for most IIIAB compositions as primary solids, mixtures of solids and equilibrium liquids (samples that plot to the left of the liquid track in Fig. 3). When considering only Re-Os, most of the pallasites could have formed via mixtures of early formed solids and evolved liquids. For this model, Pavlovár has a composition very similar to that of the bulk core. Pallasites Finnmarken and Marjalahti have lower $^{187}$Re/$^{188}$Os than the first solids generated by this model. They can be accounted for as mixtures of early formed solids and later stage liquids assuming either a bulk core with sub-chondritic Re/Os, or larger D values (implying higher S+P than used in the existing model).

Fig. 3. Fractional crystallization model for IIIAB irons from Cook et al. [3]. The blue curve represents the track for solids, the red represents the track for equilibrium liquids. Data for some pallasites overlap with the IIIAB envelope.


This work was supported by NASA grants NNG04GK52G (RJW), and NAG5-13464 (TJM).