

**$^{187}\text{Re}$ - $^{187}\text{Os}$  ISOTOPIC AND HIGHLY SIDEROPHILE ELEMENT SYSTEMATICS OF GROUP IVB IRONS, AND UNGROUPED IRONS CHINGA, TISHOMINGO AND WILLOW GROVE.** J. Honesto<sup>1</sup>, W.F. McDonough<sup>1</sup>, R.J. Walker<sup>1</sup>, C.M. Corrigan<sup>2</sup>, T.J. McCoy<sup>3</sup>, N.L. Chabot<sup>2</sup> and R.D. Ash<sup>1</sup>. <sup>1</sup>Department of Geology, Univ. MD, College Park, MD 20742 (jhonesto@geol.umd.edu), <sup>2</sup>Applied Physics Lab, Johns Hopkins Univ., Laurel, MD 20723-6099, <sup>3</sup>Dept. of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, DC, 20560-0119

**Introduction:** Last year we presented  $^{187}\text{Re}$ - $^{187}\text{Os}$  isotopic and high-precision highly siderophile element (HSE) data for some group IVB irons [1]. Here we present data for most remaining IVB irons, as well as data for Chinga (previously termed both ungrouped and also as an anomalous IVB iron), and two ungrouped, high-Ni irons Tishomingo and Willow Grove, for which genetic links to IVB have been previously proposed [2,3]. The objectives of this work are twofold, first to use the isotopic systematics to examine the timing of HSE closure, and second to use the HSE data to consider liquid-crystal fractionation, or other models that may relate these irons. Ultimately, we plan to test models that are viable from the standpoint of other diagnostic elements.

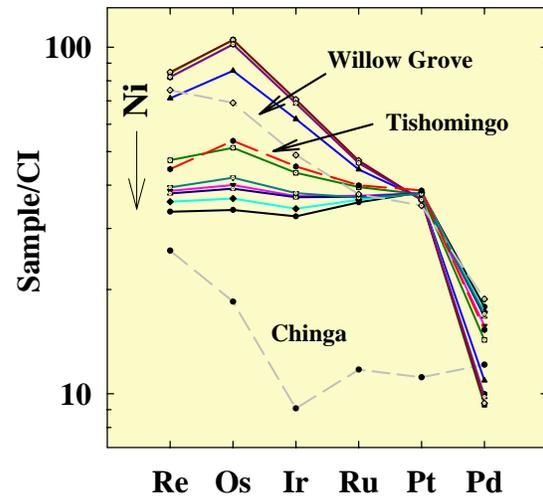
**Analytical Methods:** Chemical separation techniques used were similar to previous studies [4]. Osmium measurements were accomplished via negative thermal ionization mass spectrometry (*Sector 54*). The isotope dilution measurements of all other elements were done via static multi-collector ICP-MS (*Nu Instruments*) using Faraday buckets. Fractionation was monitored and corrected by interspersal of samples with standards. Concentration data for these elements are  $\pm 0.5\%$  or better.

**Results:** A  $^{187}\text{Re}$ - $^{187}\text{Os}$  isochron regression for eleven IVB irons (and eight duplicate analyses) gives an age of  $4575 \pm 56$  Ma (MSWD=2.5) and an initial  $^{187}\text{Os}/^{188}\text{Os} = 0.09536 \pm 0.00036$ . Precision is limited by the minimal range in  $^{187}\text{Re}/^{188}\text{Os}$  from 0.322 to 0.398. Nonetheless, this age is similar to Re-Os ages of other iron groups and implies early crystallization [5,6]. Tishomingo and Chinga are co-isochronous with the IVB iron, Willow Grove plots significantly below the IVB isochron.

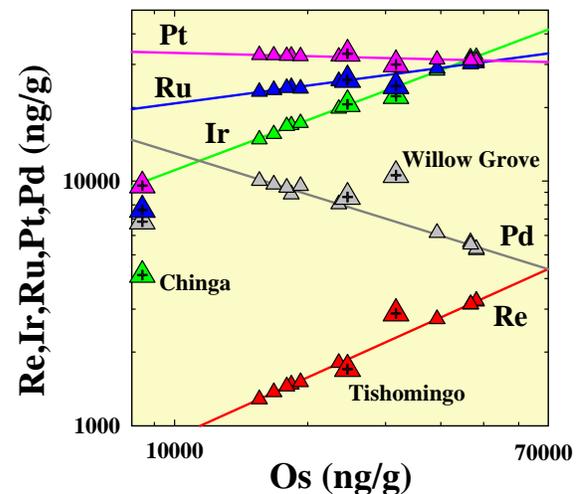
Data for all eleven irons are consistent with closed-system behavior subsequent to crystallization. There is a regular drop in abundances of Re, Os, Ir, and Ru progressing from lowest Ni to highest Ni irons. Palladium abundances increase regularly with increasing Ni for the IVBs.

**Discussion:** Chondrite normalized HSE patterns for the IVB irons form a continuous trend consistent with Re, Os, Ir, and Ru behaving as compatible elements during metal crystallization (Fig. 1). A remarkable lack of variation in Pt concentrations (<5%) requires a solid metal-liquid metal bulk distribution

coefficient of ~unity throughout the presumed crystal-



**Fig. 1.** CI chondrite normalized abundances of HSE for IVB irons, and ungrouped Chinga, Tishomingo and Willow Grove. For the IVB irons, Ni contents increase downward. Willow Grove and Tishomingo have much higher Ni contents than the IVB irons.



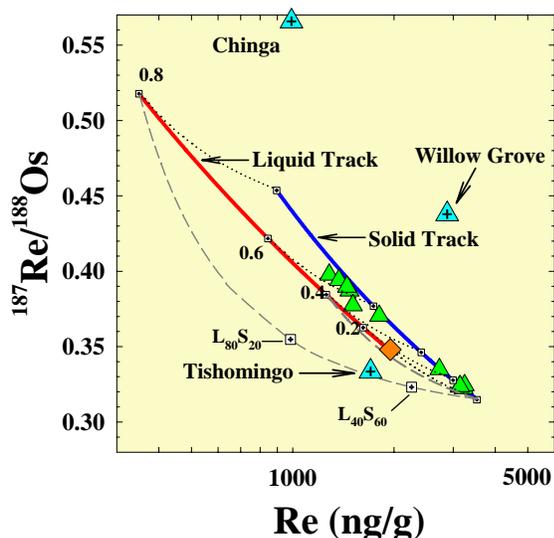
**Fig. 2.** Logarithmic plot of Os versus other HSE concentrations. All *bona fide* IVB irons plot along well-correlated linear trends (all  $r^2 > 0.98$ ). Data for Tishomingo are good, but not perfect fits to the

trends, whereas some data for Chinga and Willow Grove plot far off the IVB trends.

liquid fractionation sequence. Palladium is the only element that behaves incompatibly among the IVB group measured.

Logarithmic plots of Os vs. Re, Ir, Ru, Pt and Pd for all IVB irons give highly correlated linear trends (Fig. 2). Slopes of these lines can be used to estimate the relative solid metal-liquid metal partitioning behavior of these elements. The linearity requires that the relative D values did not change significantly during the crystallization sequence.

For modeling Re-Os, we consider 0 to 80% fractional crystallization with S and P concentrations (wt %) increasing from 0.25 to 3.8 and 0.09 to 1.1, respectively. By using the Jones and Malvin [7] parameterization for Ir,  $D_{Os}$  and  $D_{Re}$  can be calculated from the logarithmic diagram and were determined to increase from 2.00 to 2.93 and 1.81 to 2.57, respectively. On the plot of Re vs.  $^{187}Re/^{188}Os$  this model can account for all IVB compositions as primary solids, or mixtures of solids and equilibrium liquids (Fig. 3). However, this model requires a bulk core with very high HSE concentrations (Re = 1950 ng/g), and exceptionally low, fractionated  $^{187}Re/^{188}Os$  (0.348). Processes leading to formation of a core with such highly fractionated (non-chondritic) Re/Os are difficult to envision.



**Fig. 3.** Fractional crystallization model showing hypothetical liquid and solid tracks using parameters discussed in the text. Open squares along the liquid track correspond to the 20% fractions of liquid. Open squares labeled  $L_jS_j$  refer to mixtures of  $i$  proportion of liquid and  $j$  proportion of solid. Orange diamond is initial melt.

It is difficult to relate two of the three ungrouped irons to IVB. Chinga has little in common with the HSE characteristics of IVB irons and plots well to the right of the solid track in Fig. 3. Willow Grove has HSE characteristics that are more consistent with IVB, but would still be difficult to account for with any simple crystal-liquid fractionation model we can envision. It is also difficult to link the HSE characteristics of Willow Grove and Tishomingo. Willow Grove and Tishomingo share a myriad of properties, such as structure, high Ni, and similar siderophile element abundances. Both meteorites have been previously linked to one another [8], so the fact that they may not be related from a HSE perspective is somewhat surprising.

The relationship between Tishomingo and IVB remains deliciously ambiguous, at least with respect to HSE. The HSE pattern for this iron is quite similar to the IVB Santa Clara. If related to IVB, the high Ni content for Tishomingo could have been achieved via extensive crystal-liquid fractionation, or oxidative loss of Fe, however attempts to model the former have been unsuccessful thus far. Neither process could likely result in a HSE pattern so similar to Santa Clara. Conversely, if Tishomingo is unrelated to IVB, it is difficult to envision a process that would generate such a similar pattern shape, and absolute abundances of HSE compared to IVB. This is especially true for Pt, for which all IVB and Tishomingo fall within a very narrow range of concentrations.

**References:** [1] J. Honesto *et al.* (2005) *LPSC* 36 [2] K.L. Rasmussen *et al.* (1984) *GCA* 48, 805-813 [3] C.M. Corrigan *et al.* (2005) *LPSC* 36 [4] D.L. Cook *et al.* (2004) *GCA* 68, 1413-1431 [5] M.I. Smoliar *et al.* (1996) *Science* 271, 1099-1102 [6] J.J. Shen *et al.* (1996) *GCA* 60, 2887-2900 [7] J.H. Jones and D.J. Malvin (1990) *Metall. Trans.* 21B, 697-706 [8] W.D. Birch *et al.* (2001) *Meteoritics* 36, A247-A254

This work was supported by NASA grants NNG04GG17G (WFM), NNG04GK52G (RJW), and NAG5-13464 (TJM).