EXPERIMENTAL CONSTRAINTS ON THE ^{205}Pb-^{205}Tl CHRONOLOGY OF IRON METEORITES. J.H. Jones, SN2, NASA Johnson Space Center, Houston, TX 77058.

Chen and Wasserburg [1] have presented evidence for ^{205}Tl anomalies in two iron meteorites, Bogou (IA) and Nantan (IIICD). The results were difficult to interpret in any standard geochemical manner because, while Bogou sulfide appeared to have a negative ^{205}Tl anomaly, analysis of Nantan sulfide yielded a positive ^{205}Tl anomaly. In both meteorites the metallic phase contained "normal" Tl isotopic abundances. Unfortunately, these observations were compromised by the possibility that Tl isotopic fractionation had occurred prior to analysis. Because Tl has only two stable isotopes, the possibility of isotopic fractionation is difficult to evaluate. However, the total range of Tl isotopic variation observed in Nantan (2.3902/2.3770 = 1.0056) slightly exceeds the theoretical limit for the amount of possible fractionation in a single-stage diffusive process (1.0049). Thus, if the isotopic anomalies reported by [1] are due to isotopic fractionation rather than to decay of ^{205}Pb, then fractionation must have been extreme.

Taking seriously the possibility that the range of $^{205}Tl/^{203}Tl$ ratios reported by [1] may reflect the decay of ^{205}Pb, experiments have been performed to measure the partition coefficients of Pb and Tl between S-rich metallic liquid and phases important in the petrogenesis of iron meteorites -- (Fe,Ni) metal, troilite and schreibersite. Pb partitioning data between metal, troilite and metallic liquid have already been reported by Jones and Hart [2] and Jones et al. [3]. In both these earlier cases, Pb was found to be very incompatible in the solid phases. The results here indicate that Tl is also very incompatible in metal and troilite. Both Pb and Tl appear to be somewhat more compatible in schreibersite but still have very small D values. Thus, the host phases of Pb and Tl in iron meteorites cannot be confidently predicted on the basis of these experiments.

Experimental. Experimental charges consisted of Fe and Ni metal powders (Æsar) and natural pyrite ± elemental P (Aldrich). Charges were spiked at the 1-2 wt.% level with either natural galena (PbS) or Tl_2O_3 (Æsar). Charges were then placed in alumina crucibles and sealed under vacuum in fused silica tubing [4]. Charges were suspended in air within a Deltech furnace at ~950°C for approximately one week, quenched in water, mounted in epoxy and polished. Experimental charges contained either (metal + sulfide liquid ± troilite) or (schreibersite + troilite + sulfide liquid), depending on whether P was added initially. The polished thick sections were analyzed using a Cameca automated electron microprobe. Standards for Pb and Tl were PbS and Tl_2S. The synthetic carlinite (Tl_2S) standard was obtained from F.W. Dickson (U. Nevada-Reno) and assumed to be stoichiometric. Matrix corrections were made using standard ZAF procedures.

Results. A summary of partition coefficients is given in Table 1. In many cases electron microprobe analysis permits only upper limits, because of the incompatible nature of Pb and Tl. Even in the cases where partition coefficient values are quoted, errors are often large. Both Pb and Tl are very incompatible in all solid phases that have been investigated. Taking the data in Table 1 at face value, the $({}^{Pb}D/{}^{Tl}D)_{schreibersite} = 8$ and the predicted $(Pb/Tl)_{schreibersite}/(Pb/Tl)_{metal}$ ratio for iron meteorites is <160. No meaningful value for the corresponding troilite-metal (Pb/Tl) ratio may be calculated.

Discussion. Earlier we speculated [3] that the Pb measured in the "metal" and "sulfide" phases of iron meteorites by Chen and Wasserburg [5] might actually be contained in minor or trace phases rather than the metal and sulfide themselves. This alternative was presented because experiments had shown Pb to be extremely incompatible in troilite and metal. The new results presented here reinforce and broaden that original concern. Pb is also very incompatible in schreibersite and, on the basis of electron probe data only, Tl appears similarly incompatible. Qualitatively at least, the measured incompatibility is consistent with the large ionic radii of Pb^{2+} and Tl^{3+} (1.18 and 0.88 Å, respectively) compared to the ionic radius of Fe^{2+} (0.61 Å), the major cation in both troilite and schreibersite. Quite possibly both Pb and Tl in iron meteorites are concentrated in phases other than the major metals and sulfides.

This hypothesis provides a sensible explanation for the apparently conflicting Tl partitioning observed by Chen and Wasserburg [1] in Bogou and Nantan. In Bogou ${}^{Tl}D_{metal/sulfide} = 0.31$, while in Nantan ${}^{Tl}D_{metal/sulfide} = 1.9$. Although no reversal is seen in Pb partitioning, the ${}^{Pb}D_{metal/sulfide}$ observed in Bogou is ~200 while the same ratio in Nantan is ~10. Thus, significant fractions of the Pb and Tl analyzed by [1] may not have resided in either metal or troilite prior to dissolution. Variation in the abundance of this unknown phase(s) may then be reflected in apparent changes in sulfide/metal partitioning. Additionally, it may also be that the Pb- and Tl-bearing phases in Bogou are more closely equilibrated than those in Nantan.

It is likely that the host phases of Pb and Tl will be difficult to characterize. However, as a speculation, it is conceivable that schreibersite is an important reservoir for Pb in iron meteorites. Although the measured (schreibersite/liquid) partition coefficient is low, the (schreibersite/metal) and the (schreibersite/troilite) partition coefficients could be respectable and would be predicted to increase with decreasing temperature. Therefore, it is possible that at subsolidus conditions, where no liquid exists, Pb may prefer schreibersite to the other major mineral phases. It is also possible that the Pb/Tl ratio could be quite high in schreibersite, although the same argument that was made for Pb could equally well apply to Tl, within the uncertainties of the data.

Summary. Regardless of the validity of these speculations, to the extent that Pb is chalcophile [6], a significant portion of a planetoid's Pb budget should reside in its core. If the major mineral phases of the solidified core exclude Pb efficiently, then there must be a mineral phase which is enriched in Pb. Discovery and analysis of this phase could possibly aid in better determination of the initial Pb isotopic composition of the solar system and in the search for ${}^{205}Tl$ anomalies.

Table 1
Summary of Pb and Tl Partition Coefficients

Element	Solid metal/Liquid metal	Troilite/Liquid metal	Schreibersite/Liquid metal
Pb	~0.0002*	0.006±0.0012*	0.024±0.013
Tl	~<0.004	~<0.01	0.003±0.002

*From Jones and Hart [2] and Jones et al. [3].

References: [1] Chen J.H. and Wasserburg G.J. (1987) *Lunar and Planetary Science XVIII*. pp. 165-166. [2] Jones J.H. and Hart S.R. (1984) *Meteoritics* **19**, 248. [3] Jones J.H. et al. (1986) *Lunar and Planetary Science XVII*. pp. 400-401. [4] Jones J.H. and Drake M.J. (1983) *Geochim. Cosmochim. Acta* **47**, 1199-1209. [5] Chen J.H. and Wasserburg G.J. (1983) *Geochim. Cosmochim. Acta* **47**, 1725-1737. [6] Jones J.H. and Drake M.J. (1986) *Nature* **322**, 221-228.