

**PALLADIUM ISOTOPE COMPOSITION OF GROUP IVB IRONS: INITIAL RESULTS.** M. Humayun<sup>1</sup>, and S. Huang<sup>1</sup>, <sup>1</sup>National High Magnetic Field Laboratory & Department of Geological Sciences, Florida State University, 1800 E. Paul Dirac Drive, Tallahassee, FL 32310; [humayun@magnet.fsu.edu](mailto:humayun@magnet.fsu.edu), [huang@magnet.fsu.edu](mailto:huang@magnet.fsu.edu).

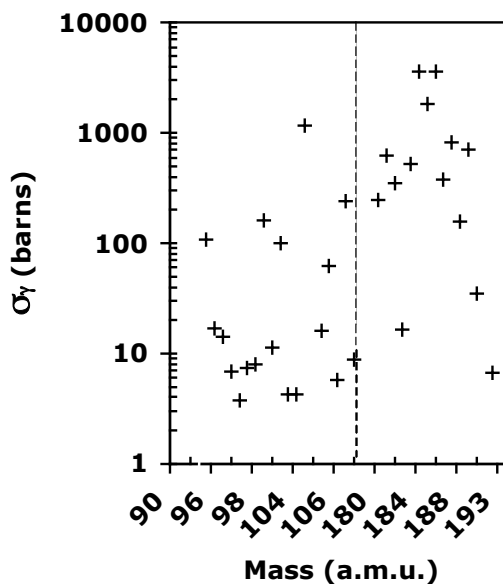
**Introduction:** Isotope studies of siderophile elements in iron meteorites provide important information on chronology and/or on the efficiency of mixing in the primordial solar nebula [e.g., 1-5]. The principal chronometers for iron meteorites:  $^{182}\text{Hf}$ - $^{182}\text{W}$ ,  $^{187}\text{Re}$ - $^{187}\text{Os}$  and  $^{190}\text{Pt}$ - $^{186}\text{Os}$  systematics, are affected by cosmic-ray neutron capture effects. The cosmogenic burn-out of  $^{182}\text{W}$  has been well-studied [e.g., 4, 6-7]. Corrections for cosmogenic effects are better corrected when neutron fluence is independently constrained, e.g., in stony meteorites, the neutron fluence can be constrained by using Cd, Sm and/or Gd isotopes as neutron fluence monitors [7, 8]. An equivalent neutron dosimeter for iron meteorites is lacking, thus far.

To better understand isotope compositions of iron meteorites, we have examined the neutron capture effects on the various siderophile elements to determine the efficacy with which each of their isotopes responds to neutron capture of thermal or epithermal neutrons. Below, we identify isotopes of Os and Pd as potentially useful in determining the neutron fluence. We have described new results for Os isotopes in a companion paper [9]. In this study, we present information on cosmogenic isotope effects expected in the siderophile elements, and report new determinations of the isotopic composition of Pd.

**Cosmogenic isotope effects:** Fig. 1 shows neutron capture cross sections for the isotopes of the Mo-Pd and W-Os mass regions. In the W-Os region, the isotopes with the largest cross sections are all isotopes of interest to Re-Os-Pt systematics or  $^{182}\text{Hf}$ - $^{182}\text{W}$  dating with cross sections decreasing in the order:  $^{186}\text{Os} > ^{185}\text{Re} > ^{187}\text{Os} > ^{189}\text{Os} > ^{182}\text{W}$ . In contrast to the W-Os region, the majority of isotopes in the Mo-Pd region have  $\sigma < 20$  barns, with only  $^{103}\text{Rh}$  having a cross section comparable to those of the W-Os region.

To attribute isotope anomalies to cosmogenic effects, highly precise isotope compositions with internal normalization is essential. This is restricted to poly-isotopic elements: Mo, Ru, Pd, W, Os or Pt. Since the isotopes of W and Os that have the largest epithermal neutron capture cross sections also have radiogenic contributions, we examined Pd instead as a possible neutron dosimeter. A previous study of Pd isotopes in iron meteorites had shown that Pd was free of endemic nuclear anomalies [2]. Neutron capture on  $^{103}\text{Rh}$  produces  $^{104}\text{Pd}$  as the stable product after beta decay of the intermediate  $^{104}\text{Rh}$  (half-life= 4 min). Thus, neutron capture in iron meteorites should produce excess  $^{104}\text{Pd}$ .

Correlated variations in Pd, W and Os isotopes were calculated by solving a set of simultaneous equations. For the estimated cosmogenic effect on  $^{182}\text{W}$  in Tlacotepec [4, 11], good agreement was found with  $^{189}\text{Os}$  anomalies in Tlacotepec [9]. The same calculations predicted an 8 epsilon unit effect in  $^{104}\text{Pd}$  for Tlacotepec. Accordingly, we initiated an experimental effort to determine Pd isotopes by MC-ICP-MS in Group IVB irons for which precise Os isotope compositions had been determined [9].

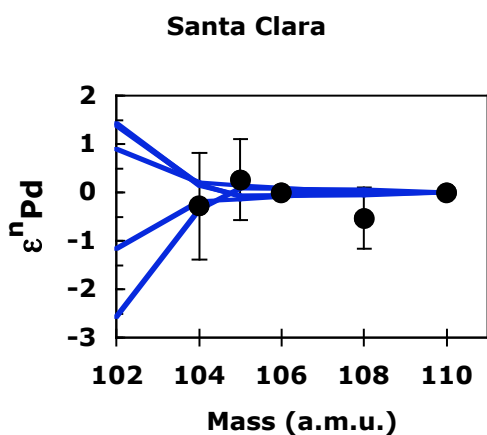


**Figure 1:** Epithermal neutron capture cross sections (barns) for siderophile elements in the Mo-Pd and W-Os mass regions [10].

**Analytical Methods:** Samples were processed for Os isotopes as described in a companion abstract [9]. After Os extraction, the residual aqua regia was dried down, and PGEs were group separated by cation exchange chromatography [12]. Palladium was then extracted by anion exchange chromatography using Bio-Rad AG1X8. Palladium has important interferences from Ru (102, 104) and Cd (mass: 106, 108, 110). Only  $^{105}\text{Pd}$  is free of isobaric interferences from adjacent elements. Cadmium was completely separated from Pd with  $^{111}\text{Cd}/^{106}\text{Pd} \leq 0.00004$  measured in samples and standards. But Ru/Pd separation, which is

critical for  $^{104}\text{Pd}$  analysis, proved to be difficult. Aliquots of the Pd were introduced into a ThermoFinnigan Neptune™ multicollector ICP-MS with an ESI Apex™ nebulizer at FSU. High-precision Pd isotopic data were collected using the MC-ICP-MS, normalized for mass fractionation to  $^{110}\text{Pd}/^{106}\text{Pd} = 0.42066$  [13] using the exponential law.

**Palladium isotopes in Group IVB irons:** Figs. 2 and 3 show our new Pd data for Santa Clara and Warburton Range. Kelly and Wasserburg [14] reported Pd by P-TIMS on Santa Clara relative to a laboratory standard, and found normal Pd isotope composition at the  $\pm 2\%$  level for all isotopes (except  $^{102}\text{Pd}$ ), which was reaffirmed at higher precision by Chen and Papanastassiou [2]. Mermelengas et al. [13] reported Pd data on Warburton Range and found no anomaly at the  $\pm 2\text{-}3\%$  level. We observe anomalies in Warburton Range in raw and fractionation corrected  $^{105}\text{Pd}/^{106}\text{Pd}$  and  $^{108}\text{Pd}/^{106}\text{Pd}$  which are free of Ru interferences.

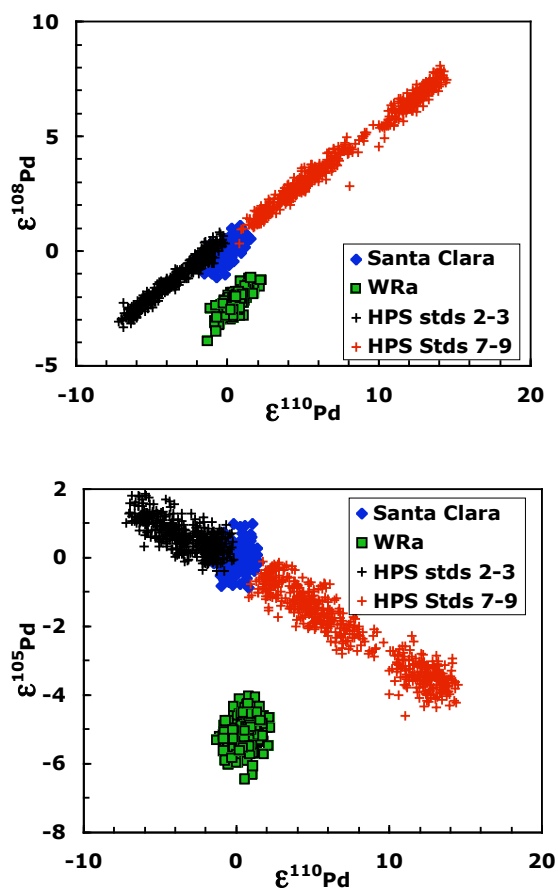


**Figure 2:** Palladium isotopic composition for Santa Clara ( $2\sigma$  errors) corrected for mass bias. Blue lines represent 5 runs of a pure Pd standard, interspersed with Santa Clara runs.

Papanastassiou and Chen [3] plotted their raw Ru isotope data for TIMS and MC-ICP-MS to avoid artifacts associated with fractionation laws. Fig. 3 shows raw Pd isotopic data obtained on Santa Clara and Warburton Range. It can be clearly seen that Santa Clara data plot along the mass fractionation trend of the HPS Pd standard run before and after the samples. However, Warburton Range is clearly anomalous and showed no hint of Cd interferences. The origin of this anomaly and why it is limited to Warburton Range is unclear, at present. A replicate analysis is required to confirm whether these anomalies exist.

#### References:

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**Figure 3:** Raw Pd isotopic data for masses 105-110 represented in epsilon notation normalized to the average of Santa Clara values. WRa= Warburton Range.