RHENIUM ISOTOPIC COMPOSITIONS OF IRON METEORITES: INITIAL RESULTS. L. Hu[1], M. Humayun[1] and N. Wittig[1], [1]National High Magnetic Field Laboratory & Department of Earth, Ocean and Atmospheric Science, Florida State University, 1800 E. Paul Dirac Drive, Tallahassee, FL 32310, USA (lihaihu@magnet.fsu.edu, humayun@magnet.fsu.edu, wittig@magnet.fsu.edu).

Introduction: Several processes can contribute isotopic variability in refractory elements including nucleosynthetic anomalies, and cosmogenic isotope anomalies. Recent work on Mo [1-3], Ru [4], W [5] and Os [6-7] isotope anomalies in meteorites, particularly iron meteorites, has focused new interest on other elements. Rhenium isotope abundances are controlled by both s-process and r-process nucleosynthesis, and occur near the prominent r-process peak at Os-Ir-Pt-Au. Natural rhenium has two isotopes, stable isotope ^{185}Re and radioactive ^{187}Re (^{187}Re -> ^{187}Os with a half-life of 42.3 Ga). Gramlich et al. [8] reported 1.6740(11) as the reference value of ^{187}Re/^{185}Re of natural Re standard SRM 989 by using gravimetric calibrations for the mass fractionation. Subsequently, the Re isotopic composition was measured by Secondary Ion Mass Spectrometry (SIMS, ±6 ‰ precision, 2σ [9]), Resonance Ionization Mass Spectrometry (RIMS, ±5‰ precision, 2σ [10]) and Negative Thermal Ionization Mass Spectrometry (NTIMS, ±0.3 ‰ precision, 2σ [11]; ±0.9 ‰ [12]). Since Re has only two isotopes, the instrumental mass fractionation can not be corrected for by SIMS, RIMS or NTIMS. Therefore, the precision of Re isotopic composition is restricted to permil level. Limited by the precision, the variation of Re isotopic composition in nature has not been well studied.

Recent advances in MC-ICP-MS allow the determination of Re isotope composition using W as an internal standard [13]. Tungsten and Re have similar first ionization potentials and do not isobarically interfere, so that tungsten can be used for external mass fractionation correction of rhenium. This simultaneous internal correction can give sub-permil level precision for the measurement of Re isotopic composition, which provides the opportunity to study the variation of Re isotopic composition in meteorites.

Cosmic rays can alter the Re isotopic composition of iron meteorites with long exposure histories. Cosmogenic effects have been reported for IVB irons in W [5] and Os [7]. In this study, we measured Re isotopic composition of seven iron meteorites by using Neptune MC-ICP-MS with internal mass fractionation correction.

Analytical methodology: Four IVB iron meteorites were dissolved in aqua regia by using Carius tube technique [7]. Osmium was extracted into CCl_4 by solvent extraction. Samples were dried down and dissolved in inverse aqua regia several times to evaporate Os away. Samples were then taken up in 0.1N HCl and loaded on 4mL anion resin (AG1-X8 100-200 mesh). Re was recovered by using 4N HNO_3 and was purified by another anion exchange procedure using fresh resin to avoid eluting Os trapped on the prior column. The two-column separation resulted in ^{190}Os/^{185}Re > 0.004, and residual W from the irons was < 0.1%, except for Tlacotepec (<2 %). The solutions containing Re were dried down and taken up in 2% HNO3 with trace HF. These solutions were spiked with SRM 3163 W standard for mass spectrometric analysis (Re concentration ~ 20ppb and W concentration ~ 35ppb).

All isotope ratios were measured with a Thermo Neptune Multicollector ICP-MS at the Plasma Analytical Facility at the NHMFL. An ESI™ SIS glass spray chamber was used for sample introduction. Isotopes 180, 182, 183, 184, 185, 186, 187, 190 were simultaneously measured in L3, L2, L1, C, H1, H2, H3 and H4 faraday cups, respectively. ^{184}W and ^{186}W have interferences from ^{184}Os and ^{186}Os. ^{187}Re has an interference from ^{187}Os. Os interferences were corrected by subtracting the amount of ^{184}Os, ^{186}Os and ^{187}Os corresponding to the ^{190}Os signal. We obtained ~2V signal for a 100 ppb W solution and collected 60 ratios for each analysis. Instrumental mass fractionation was corrected by means of combining standard-bracketing and external W correction by normalizing to ^{186}W/^{183}W = 1.98594 [V] using the exponential law. Re isotopic composition is reported as δ^{187}Re, relative to the average value of a laboratory reagent (Specpure™) acquired from Alfa Aesar. Three standards were measured between each sample for sample-standard bracketing. External standard reproducibility was 0.05 ‰ (2SD). A Re wire was dissolved to obtain a pure Re internal standard. The isotopic composition of this solution was found to differ by -0.3 ‰ from other laboratory reagents. This solution was also run as an internal control.

Results and Discussion: A set of four high-purity Re solutions obtained from commercial sources were analyzed for Re isotopic composition (Figure 1). One of these solutions, derived from a Re wire dissolved in-house, was isotopically fractionated by -0.3 ‰. the other Re sources cannot be isotopically distinguished at the highest levels of precision attained.

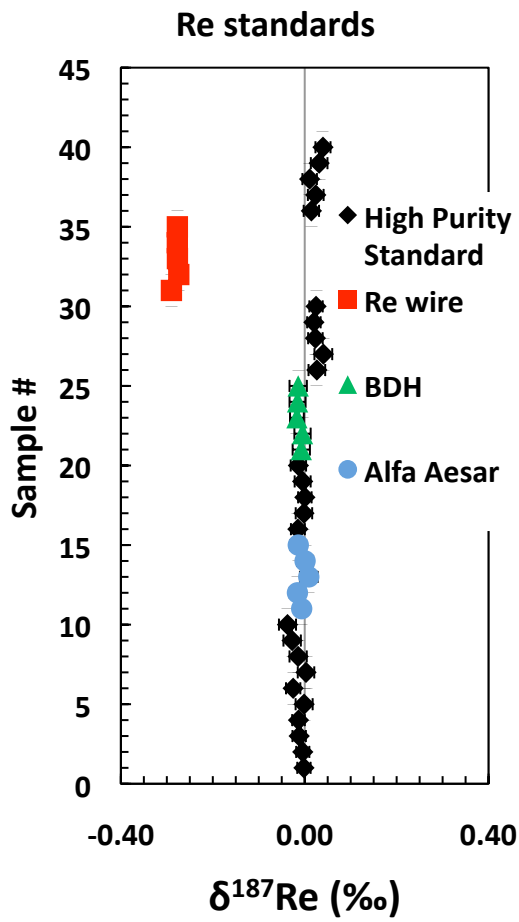

Figure 1. Isotopic composition of Re relative to Alfa Aesar laboratory reagent (in-house standard) for several laboratory Re reagents, all of high-purity.

Results for multiple runs of the Alfa Aesar standard solution, the Re wire solution, and from four IVB irons are shown in Figure 2. Consistent corrections for the mass fractionation were obtained with $^{186}W/^{182}W$ and $^{186}W/^{183}W$. The maximum Os correction was for Hoba, which was shifted by 0.2‰. Since the correction yielded a resolvable positive anomaly in $\delta^{187}Re$, this analysis will need to be replicated. The other three irons yield a $\delta^{187}Re$ unresolvable from the laboratory standard. Thus, the Re isotopic composition of iron meteorites is identical to the terrestrial value. The effects of cosmogenic irradiation are too small to be perceptible. The largest cosmogenic effects for W and Os are in Tlacotepec [5, 7]. However, Tlacotepec shows no deviation in its Re isotope composition (Figure 2).

Conclusions: The isotopic composition of natural Re from 4 Group IVB iron meteorites is unresolvable from the terrestrial Re isotope composition, with the exception of the Hoba analysis. Because the Hoba analysis was slightly contaminated by Os, and had to be corrected, this analysis will need to be repeated. The isotopic composition of a series of other iron meteorites will be performed. Our data is important confirmation that Re isotope composition of Gramlich et al. [8] can be applied to Re-Os chronology of iron meteorites.

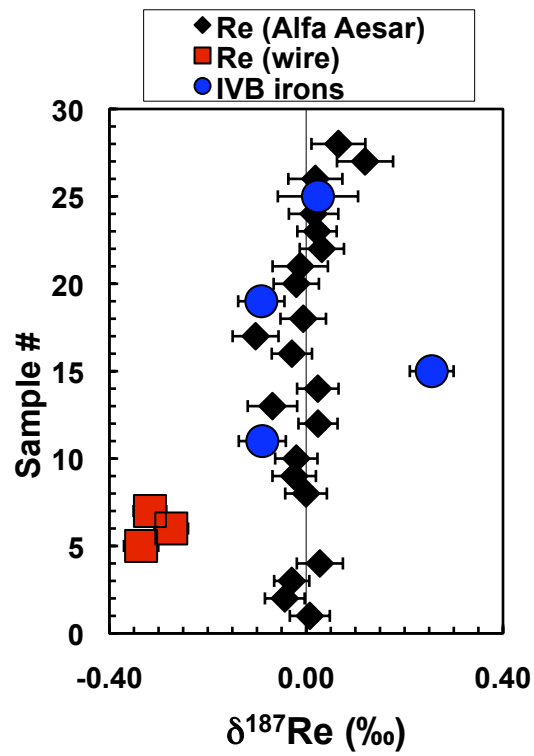

Figure 2. $\delta^{187}Re$ values for the four iron meteorites (blue circles), Re wire (red squares), and Alfa Aesar in-house Re standard solution (black diamonds). The irons are (from the bottom up): Tlacotepec (USNM 872), Hoba (USNM 6506), Weaver Mountains (ASU #313.2), and Kokomo (Harvard 269b). The error bars of a single measurement correspond to 2 standard deviations of the in-run precision.

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