Equilibrium Metal-silicate Fe Isotope Fractionation and the Implications for Planetary Differentiation. M. K. Jordan[1] and E. D. Young[1], [1]Department of Earth, Planetary, and Space Sciences, University of California, Los Angeles, USA, mkjordan@ucla.edu, eyoung@epss.ucla.edu.

Variations in Fe isotope composition are observed among different planetary bodies. The Earth and Moon are isotopically heavy in $^{57}Fe/^{54}Fe$ relative to chondrites, HED meteorites (Vesta), and Mars [1]. Several mechanisms have been suggested to account for these variations. Magmatic iron meteorites exhibit an enrichment in $^{57}Fe/^{54}Fe$ relative to chondrites of ~0.2‰ [2]. This is suggestive of heavy Fe partitioning into the cores of differentiated bodies. We aim to determine if core formation is accompanied by an isotopic signature which can explain the variation of Fe isotopes observed in the Solar System. Measurements of Fe isotope fractionations between metallic and silicate phases in meteorites, and measurements in the laboratory, have yielded contradictory results for equilibrium Fe fractionation [2, 3, 5, 6, 7, 8, 9]. Here, we determine the equilibrium metal-silicate Fe isotope fractionation using aubrites Norton County and Mount Egerton.

Norton County and Mount Egerton consist primarily of nearly FeO-free enstatite. The metallic phase is primarily kamacite [10, 11]. Agreement between previously measured metal-silicate Si fractionation for these meteorites, Si isotope temperatures calibrated in the laboratory, and previous Si-concentration thermometry suggests that these rocks are in isotopic equilibrium at a temperature of 1130 K and 1200 K ± 80 K, respectively [3, 4, 12].

Ion-exchange chromatography was used to separate Fe. Data were collected on a ThermoFinnigan Neptune™ MC-ICP-MS run in wet plasma mode (mass resolving power >9000). Data are reported as per mil deviations from the standard IRMM-14.

The calculated isotopic fractionation $\Delta^{57}Fe_{metal\text{-}silicate}$ is 0.08‰ ± 0.039 (2 SE) for Norton County and 0.09‰ ± 0.019 (2 SE) for Mount Egerton, indicating that the heavy isotopes of Fe partition into the metallic phase. We use the equilibration temperatures for these rocks in conjunction with the equilibrium Fe isotope fractionation between metal and silicate to establish a temperature calibration since isotope fractionation varies as $1/T^2$ (Figure 1). Experimental results are plotted for comparison as well as the fractionation between metal and troilite measured by Wang et al. [13] Metal-silicate and metal-troilite fractionation should be very similar [14, 15]

Using our calibration and mass balance, we determine the $\delta^{57}Fe$ of the BSE to be approximately 0.002‰ below chondritic $\delta^{57}Fe$. This value is below our current level of detection. As a result, equilibrium Fe fractionation during core formation is probably not responsible for the heavy Fe isotope compositions observed in the Moon and Earth relative to chondrites. The calibration should prove more useful for smaller bodies that formed under lower pressure and temperature conditions [16]. One potential application is Vesta for which we predict a metal-silicate fractionation of ~0.035 ‰. This number is at our current level of precision and still difficult to measure. Our results thus far suggest that the 0.2 ‰ higher $^{57}Fe/^{54}Fe$ of iron meteorites cannot be explained as the result of silicate-metal partitioning of chondritic-like bodies.

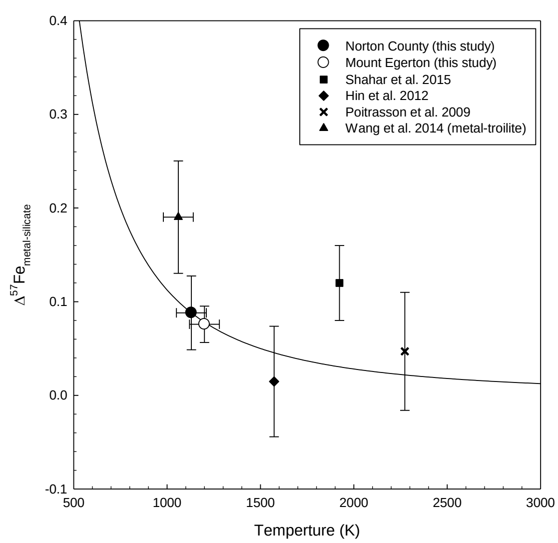

Figure 1: Temperature calibration determined from measured metal-silicate fractionation of Norton County and Mount Egerton. Experimental and natural sample results for metal-silicate fractionation plotted.

References: [1] Poitrasson F. et al. (2004) *EPSL, 223*, 253-266. [2] Poitrasson, F. et al. (2005) *EPSL, 234*, 151-164. [3] Shahar A. et al. (2011) *GCA, 75*, 7688-7697. [4] Ziegler K. et al. (2010) *EPSL, 295,* 487-496. [5] Zhu X. K. et al. (2002) *EPSL, 200,* 47-62. [6] Weyer S. et al. (2005) *EPSL, 240,* 251-265. [7] Shahar et al (2012) *LPS XLIII,* Abstract #2049. [8] Shahar et al. (2013*) LPS XLIV,* Abstract #2351. [9] Hin R. C. et al. (2012) *GCA, 77*, 164-181. [10] Watters T. R. and Prinz M. (1979) *LPS X,* 1073-1093. [11] Casanova I. et al. (1993) *GCA, 57,* 675-682. [12] Wasson J. T. et al. (1994) *Meteoritics, 29,* 658-662. [13] Wang K. et al. (2014) *GCA, 142,* 149-165. [14] Polyakov V.B. et al. (2007) *GCA, 71*, 3833-3846. [15] Polyakov, V.B. and Mineev S.D. (2000) GCA, 64, 849-865. [16] Zhou Q. et al. (2013) *GCA, 110*, 152-175.