IRON ISOTOPE COSMOCHEMISTRY: HIGH-PRECISION ISOTOPE RATIO MEASUREMENT USING MC-ICPMS. X. K. Zhu, Y. Guo, R. K. O'Nions, A. Galy, E. D. Young and R. D. Ash, Dept. of Earth Sciences, Univ. of Oxford, Parks Road, OX1 3PR, UK. E-mail: xiangz@earth.ox.ac.uk

Introduction: The investigation of natural variations in stable isotope abundances in meteoritic material has provided profound insights into our understanding of early solar system evolution. Fe, as one of the most abundant elements is the solid materials of the solar system, and as an element which is relatively volatile and exists in multiple oxidation states, is a particularly interesting target for isotopic investigation [1, 2]. Here we report the results of high precision Fe isotope measurements of meteorites, using plasma source mass spectrometry (MC-ICPMS).

Samples and Techniques: A wide variety of meteorite types have been sampled. These include chondrites, achondrites, pallasites, and iron meteorites. Fe-isotope measurements were performed on chondrules, metal-and silicate-fractions, matrices or bulk samples. All samples were purified by ion exchange separation following complete digestions. Fe-isotope analyses were performed on a Nu Instruments MC-ICPMS, using a standard-sample bracketing method. Measured $^{56}Fe/^{54}Fe$ and $^{57}Fe/^{54}Fe$ ratios are expressed in terms of $\varepsilon^{56}Fe$ and $\varepsilon^{57}Fe$ units that are deviations in parts per 10^4 from the Fe isotope reference material IRMM-14.

Iron-Isotope Distribution: The analyzed meteoritic materials show overall variations in $^{56}Fe/^{54}Fe$ and $^{57}Fe/^{54}Fe$ ratios of ~18 and 27 ε-units, respectively, with $\varepsilon^{57}Fe$ varying from –8.8 to 18.2. These variations are about 40 to 50 times the external analytical errors at 2σ level. In more detail, the unequilibrated chondritic materials show the largest variation, whereas achondrites and pallasites display much smaller variations with $-3 \leq \varepsilon^{57}Fe \leq 2.5$, and iron meteorites are particularly homogeneous with $\varepsilon^{57}Fe$ varying from 0.6 to 2.0.

Homogeneity of the Early Solar Nebula. When plotted in a three-isotope diagram all of the data fall on the terrestrial mass fractionation line. This observation is entirely consistent with theoretical expectations if the iron isotope compositions in all analysed meteoritic materials and terrestrial samples evolved from a single isotopically uniform reservoir in a mass dependent manner. As the samples analysed are ultimately derived from different parent bodies, the iron isotope homogenisation cannot be attributed to processes occurring within the parent bodies themselves. Thus the observation of this single mass fractionation line shows that iron isotopes in the solar nebula were homogenised before both planetesimal accretion and chondrule formation.

Metal phase segregation and iron isotope fractionation. Iron metal segregation from silicates is a fundamental process during solar nebular evolution and planet formation. A question arises as to whether this process can induce significant mass fractionation for Fe isotopes. To investigate this issue, we have separated the metal phase from bulk samples of different types of meteorites. Fe metal and olivine were analysed for pallasites. Strongly magnetic and non-magnetic phases were measured for the stony meteorites. The results show that the Fe isotope compositions of the metal phases are systematically heavier than those of the corresponding silicates or silicate-rich potions of the meteorite samples, with difference between each pairs varies from 2.3 to 19.1 ε-units in $^{57}Fe/^{54}Fe$ ratios.

Iron Depletion and Chondrule Formation. A prominent feature of chondrules is their iron depletion relative to the matrix. The iron isotope results obtained here place constraints on the mechanism of Fe depletion and chondrule formation. For the unequilibrated chondrites Allende and Chainpur, the $\varepsilon^{56}Fe$ and $\varepsilon^{57}Fe$ values obtained from chondrules, matrices, and bulk samples show a positive correlation with Fe/Al ratio. This demonstrates that Fe depletion in these chondrules can not be explained by volatilization during, but must have resulted predominantly from metal-silicate fractionation during chondrule formation.

References:

[1] Alexander C. M. O'D and Wang J. (2001) *Meteoritics & Planet. Sci*., 36, 419-428. [2] Zhu X. K. et al. (2001) *Nature,* in press.