

## IRON ISOTOPE COMPOSITIONS OF ACHONDRITIC METEORITES

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**Introduction:** Mass dependent fractionation of iron isotopes relative to bulk chondrites has been reported for a variety of planetary materials [1-7]. However, the cause of this fractionation is debated. While some have argued for iron isotope fractionation primarily occurring during core formation processes and subsequent partial melting [8], others associate it with volatile depletion processes during accretion [9]. With the goal of better understanding the cause of iron isotope fractionation during differentiation processes in particular, we have begun an investigation of a variety of achondrites, including ungrouped ones. We recently reported the iron isotope compositions of several achondrites, based on which we concluded that magmatic redox and structural controls may at least partly control the degree of fractionation recorded in these samples [10]. Here, we report the iron isotope compositions of three ungrouped achondrites, North West Africa (NWA) 8777, NWA 10503, NWA 7325, an angrite NWA 4590 and mineral separates from the Norton County and Bishopville aubrites.

**Analytical Method:** All mineral separation, sample preparation and column chemistry were carried out under clean laboratory conditions in the Isotope Cosmochemistry and Geochronology Laboratory (ICGL) at Arizona State University (ASU). Metal nodules from the two aubrites were separated (6 from Norton County and 1 from Bishopville) using a hand magnet while pyroxenes were hand picked under the microscope. The 6 metal nodules from Norton County (NC1-6) were cut in half; one half was mounted in epoxy and then characterized as described in [11]. The other half of each Norton County metal nodule and the Bishopville metal nodule were ultrasonicated in MilliQ water, and then dissolved in 6N HCl. The hand-picked pyroxene fractions from these aubrites were further crushed, sieved and clean crystals from 140 mesh size fraction were picked under the microscope. Pyroxene separates were dissolved in 3:1 HNO<sub>3</sub>:HF mixture and digested in a Parr vessel. For the bulk achondrites, a clean interior piece of each meteorite (~100-200 mg) was ultrasonicated in MilliQ water and dried, crushed and homogenized to a powder. A ~50 mg aliquot of each homogenized powder was digested in a 3:1 HNO<sub>3</sub>:HF mixture, followed by digestion in a Parr vessel. Iron was purified using standard anion exchange column chemistry technique [12]. Iron isotopes were measured on a Thermo Neptune MC-ICPMS in medium-resolution mode and instrument mass bias was corrected using both Cu-doping and sample-standard bracketing (using IRMM-014 as the standard). The accuracy and precision of our analyses were assessed using repeated analyses of BCR-2, TAG and ICP-B terrestrial rock standards during each analytical session.

**Result and Discussion:** The ungrouped achondrites, NWA 8777 and NWA 10503, have iron isotope compositions ( $\delta^{56}\text{Fe} = +0.02 \pm 0.05\%$  and  $0.00 \pm 0.06\%$ , respectively; errors are  $\pm 2\text{SD}$ ) similar, within uncertainties, to brachinites and brachinite-like achondrites [13]. NWA 8777 resembles some brachinites in its oxygen isotope composition but differs in its lack of olivine and clinopyroxene, and the presence of very calcic plagioclase [14]. NWA 10503, despite similarities in texture, has an oxygen isotopic composition distinct from those of any brachinites [15]. The ungrouped achondrite NWA 7325, a reduced Fe-poor cumulate olivine gabbro, has very light iron isotope composition ( $\delta^{56}\text{Fe} = -0.47 \pm 0.03\%$ , 2SD), lighter than the reduced, Fe-poor aubrites ( $\delta^{56}\text{Fe} = -0.17 \pm 0.19\%$ ; [16]). The NWA 4590 angrite has an iron isotope composition ( $\delta^{56}\text{Fe} = +0.12 \pm 0.10\%$ ) that is consistent with that of other angrites [10,17]. Four of the 6 metal nodules from Norton County (NC2,3,4,6) and the nodule from Bishopville have an average iron isotope composition ( $\delta^{56}\text{Fe} = +0.12 \pm 0.03\%$ , 2SD) that is similar to those of magnetic separates from the enstatite chondrites [16]. However, two of the Norton County metal nodules (NC1 and NC5) have distinct iron isotope compositions ( $\delta^{56}\text{Fe} = +0.02 \pm 0.06\%$  and  $+0.34 \pm 0.03\%$ , respectively). Interestingly, these 2 NC nodules are quite distinct from the other four in having low Si contents [11]. As suggested by [11], this implies that metal nodules in aubrites have distinct origins; unlike NC2,3,4,6, the NC 1 and NC5 metal nodules in Norton County were not formed simply through igneous processes on the aubrite parent body.

**References:** [1] Zhu X.K. et al. (2001) *Nature* 412:311-313. [2] Poitrasson F. et al. (2005) *Earth & Planetary Science Letters* 234:151-164. [3] Weyer S. et al. 2005. *Earth & Planetary Science Letters* 240:251-264. [4] Schoenberg R. and von Blanckenburg F. (2006) *Earth & Planetary Science Letters* 252:342-359. [5] Weyer S. et al. 2007. *Earth & Planetary Science Letters* 256:638-646. [6] Craddock P. R. et al. (2013) *Earth & Planetary Science Letters* 365:63-76. [7] Poitrasson F. et al. 2013. *Contributions to Mineralogy & Petrology* 165:1243-1258. [8] Elardo S. M. and Shahar A. (2017) *Nature Geoscience* 10:317-321 [9] Liu J. et al. (2017) *Nature Communications* 8:pp14377. [10] Dybal E.M.K. (2016) 79<sup>th</sup> Annual Meeting of the Meteoritical Society, Abstract #6535. [11] Garvie, L.A.J. et al. (2017) 80<sup>th</sup> Annual Meeting of Meteoritical Society Abstract#6384. [12] Arnold G. L. et al. 2004. *Analytical Chemistry* 76:322-327. [13] Wang K. (2014) *Earth and Planetary Science Letters* 392:124-132. [14] Irving A. J. et al. (2015) *Meteoritical Bulletin* No. 104. [15] Irving A. J. et al. (2016) *Meteoritical Bulletin* No. 105. [16] Wang K. (2014) *Geochimica et Cosmochimica Acta* 142:149-165. [17] Wang K. (2012) *Geochimica et Cosmochimica Acta* 89:31-45.