ORIGIN OF CARBON IN UREILITE METEORITES: A STEP COMBUSTION STUDY OF FRAGMENTS OF ALMAHATA SITTA

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Introduction: Carbon (in the form of diamond and graphite) is a significant component (up to 7 wt%) within ureilite meteorites [1], and is extremely important in understanding the formation history of their precursor asteroidal parent body. We have characterised the carbon and nitrogen abundances and isotopic compositions in 5 fragments of Almahata Sitta, a recent polymict ureilite meteorite fall in Sudan [2]. These samples were collected soon after they fell, so they may be considered to be amongst the freshest ureilite samples available and have avoided many of the terrestrial contamination problems often associated with light element isotope analyses.

Method and results: We analysed the bulk rocks for carbon and nitrogen isotopes simultaneously using a combination of stepped combustion and mass spectrometry using the Finesse instrument at the Open University. The samples contain 1.2-2.3 wt% carbon; most show the main carbon release at temperatures between 600 and 700 °C with different fragments yielding $\delta^{13}C$ values ranging from -7.3 to +0.5 ‰. They also contained a small amount (<2% of total carbon) of a low temperature (≤500 °C) contaminant with a $\delta^{13}C$ value of ca -25 ‰. Our results are similar to literature data for unbrecciated ureilites [3]. Bulk nitrogen contents range from 9.4 to 27.1 ppm, with major releases mostly occurring at temperatures between 600 and 750 °C. The $\delta^{15}N$ values associated with the largest release of N range from -53 to -94 ‰. These are within the range reported for unbrecciated ureilite samples [3]and are similar to those of diamond separates and acid leached material from ureilites [4, 5].

Interpretation: When we compare our C and N isotopic results results with those for step-combustion analyses of carbonaceous chondrites, the only overlap is with CO chondrites, which contain very little carbon. This implies that, despite oxygen isotope similarities with carbonaceous chondrites, either there is a mechanism that acted to concentrate carbon and nitrogen which did not result in isotope fractionation, or that the parent body of ureilite meteorites could not have formed from a known carbonaceous chondrite precursor. Our evidence suggests that carbon in the Solar Nebula was heterogeneous in its $\delta^{13}C$ and $\delta^{15}N$ isotope ratios and that ureilites were derived from an as-yet unrecognized source.

References: [1] Grady M & Wright I 2003 Sp. Sci. Rev. 106: 231-248; [2] Jenniskens P. et al. 2009 Nature 458: 485-488; [3] Grady M et al 1985 GCA 49, 903-915; [4] FisenkoA V et al 2004 Solar Syst. Res. 38, 383-393; [5] Russell S et al 1993. 24th LPSC Abstract.