A NanoSIMS study of micro-distribution of carbon isotope in ureilite meteorites

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Ureilites are ultramafic meteorite samples composed mainly of coarse-grained olivine and pyroxene with fine-grained carbonaceous interstitial materials (often referred to as C-matrix). They constitute the second largest group of achondritic meteorites, with paradoxical petrological characteristics and an enigmatic origin. Bulk C isotopic compositions of ureiltes suggest a large (>1000 km in diameter) and unique ureilite parent body (UPB) with a mantle that has two C-rich reservoirs of distinctive Fe/Mg ratios, C and O isotopic compositions. However, the O isotopic compositions of ureilites indicate the preservation of original geochemical signatures from the heterogeneous nebula that are inconsistent with planetary-scale igneous differentiation of a large parent body.

Carbon reduction (smelting) of olivine and pyroxene is ubiquitous in all ureilite samples. It is possbible that bulk data do not reflect the true micro-distribution nature of C isotope of ureilites. If the C-reduction process could fractionate C isotope, then the large variation of C isotopic compositions among different ureilite samples could be resulted from various degrees of C reduction. There would be no need to invoke two C-reservoirs for UPB. If no obvious C isotopic fractionation can be observed between the C-matrices and reduction rims in ureilites, then different C isotopic sources on UPB need to be considered.

Two repesentative ureilite samples (Kenna and Goalpara) have been investigated for this work. Several standards (graphite, charcoal, 1-Hydroxybenzotriazole, and the C905 organic carbon) are used to assess possible matrix effects for C isotope analysis with NanoSIMS. The overal analytical precision is ~±3‰ (2σ). Three amorphous graphite areas have $\delta^{13}C$ values between -11 to -14‰; whereas three euhedral graphites in olivine reduction rims show $\delta^{13}C$ values between -4 to -7‰. The distiguishable difference in the $\delta^{13}C$ vaules of graphites from the two distinctive occurrences suggests C reduction in individual ureilite can indeed fractioante C isotope. The large variarion in bulk C isotopic compositions of ureilites probably does not indicate two C-reservoirs on UPB.