ORGANIC AGGREGATES WITH δD AND $\delta^{15}N$ ANOMALIES IN THE ZAG CLAST REVEALED BY STXM AND NANOSIMS.

Y. Kebukawa[1], M. Ito[2], M. E. Zolensky[3], Z. Rahman[4], A. L. D. Kilcoyne[5], A. Nakato[6], Y. Takeichi[7], H. Suga[8], C. Miyamoto[9], K. Mase[7], Y. Takahashi[9], Q. Chan[3] and M. Fries[3]. [1]Faculty of Engineering, Yokohama National University (kebukawa@ynu.ac.jp), [2]Kochi Institute for Core Sample Research, JAMSTEC, [3]ARES, NASA Johnson Space Center, [4]Jacobs, NASA Johnson Space Center, [5]Advanced Light Source, Lawrence Berkeley National Laboratory, [6]Graduate School of Science, Kyoto University, [7]Institute of Materials Structure Science, High-Energy Accelerator Research Organization (KEK), [8]Department of Earth and Planetary Systems Science, Hiroshima University, [9]Department of Earth and Planetary Science, The University of Tokyo.

Introduction: Xenolithic clasts are often found in a wide variety of meteorite groups [e.g., 1]. Some ordinary chondrite clasts are interesting since these clasts might have originated from Ceres which shares crossing orbits with a possible ordinary chondrite parent body, Hebe [2]. The Zag meteorite contains a dark clast dominated by saponite, serpentine, carbonates, sulfides, magnetite, minor olivine and pyroxene, which is consistent with formation on a large, carbonaceous, aqueously active body, e.g., Ceres [3]. Abundant large C-rich grains up to 20 µm were found in the Zag clast as well [3]. Such large C-rich grains are unique among any other meteorites in our knowledge, and will provide important clues to decipher the origin of the clast and accretion history.

Methods: C-rich grains were selected in the Zag dark clast using SEM and approximately 100 nm-thick sections were prepared using a focused ion beam (FIB) at NASA-JSC. The sections were analyzed using the scanning transmission X-ray microscope (STXM) on beamline 5.3.2.2 at Advanced Light Source, LBNL, and BL-13A at the Photon Factory, KEK. Subsequently, the FIB section was analyzed for H, C and N isotopic compositions using a CAMECA NanoSIMS 50L ion microprobe at Kochi Institute for Core Sample Research, JAMSTEC.

Results and Discussion: The FIB section showed a large C-rich area over 10 µm width that corresponded to the C-rich grain (Fig. 1b). Carbon X-ray absorption near edge structure (XANES) of the C-rich grain showed a peak at 284.8 eV that is assigned to sp^2 carbon (C=C) (Fig. 1c,d in Red). The surrounded matrix area showed a peak at 290.3 eV that is assigned to carbonates with smaller 284.8 eV peak. The C-XANES of the C-rich grain had no other functional groups (e.g., C=O) that are characteristic of primitive chondritic insoluble organic matter (IOM) (e.g., Murchison), nor 1s-σ* exciton at 291.7 eV of graphene structures that is characteristic of thermally metamorphosed meteorites (e.g., Allende IOM) [4]. No specific nitrogen features were observed in N-XANES. XANES results indicate that the C-rich grain may consist of a hydrogenated amorphous carbon-like structure.

The C-rich grain had large δD and $\delta^{15}N$ anomaly, δD = 2,370 ± 74 ‰ and $\delta^{15}N$ = 696 ± 100 ‰ in average. $\delta^{13}C$ was −43 ± 20 ‰ that was broadly consistent with the values of CRs and Bells within the analytical error [5]. Two hot spots were observed; one is D- and ^{15}N-rich (δD = 4,200 ± 550 ‰ and $\delta^{15}N$ = 3,413 ± 1,070 ‰), and the other is D-rich (δD = 4,500 ± 900 ‰) with normal to moderate enrichment in ^{15}N (724 ± 780 ‰) (Fig. 1e,f). The origin of the C-rich grain and isotope anomaly is puzzling since no molecular heterogeneity was observed between the hot spots and the average area. Some "aromatic" globules in chondrites reported by [6] show C-XANES spectra similar to the C-rich grains in the Zag clast. In their study however, no clear correlation between molecular structure and $\delta^{15}N$ was observed; aromatic globules have similar or higher $\delta^{15}N$ values than IOM-like globules [6]. If the C-rich grain is an assemblage of organic matter with different origins (with different δD and $\delta^{15}N$ values), isotope heterogeneity might have survived the structural homogenization that possibly occurred during subsequent aqueous processing.

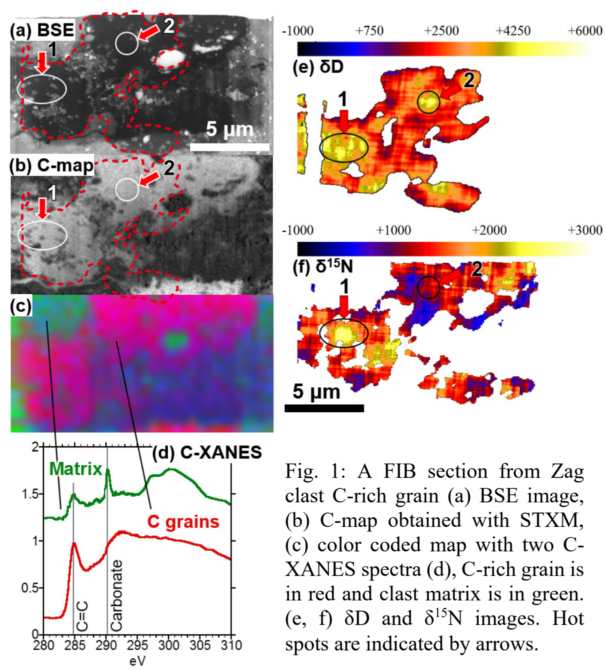

Fig. 1: A FIB section from Zag clast C-rich grain (a) BSE image, (b) C-map obtained with STXM, (c) color coded map with two C-XANES spectra (d), C-rich grain is in red and clast matrix is in green. (e, f) δD and $\delta^{15}N$ images. Hot spots are indicated by arrows.

References: [1] Rubin A. E. et al. 2002. *Meteoritics & Planetary Science* 37:125–141. [2] Fries M. et al. 2013. Abstract #5266. 76th Annual Meeting of The Meteoritical Society. [3] Zolensky M. E. et al. 2015. Abstract #5270. 78th Annual Meeting of The Meteoritical Society. [4] Cody G. D. et al. 2008. *Meteoritics & Planetary Science* 43:353–365. [5] Alexander C. M. O'D. et al. 2007. *Geochimica et Cosmochimica Acta* 71:4380–4403. [6] De Gregorio B. T. et al. 2013. *Meteoritics & Planetary Science* 48:904–928.