NANOSIMS O & S-ISOTOPE ANALYSES OF COSMIC SYMPLECTITE IN THE PRIMITIVE CHONDRITE ACFER 094

L. G. Vacher[1], R. C. Ogliore[1], N. Liu[1] and J. B. Lewis[1], [1]Department of Physics, Washington University in St. Louis, St. Louis, MO, USA (lvacher@wustl.edu).

Introduction: Cosmic Symplectite (COS) are anomalous ^{17,18}O-rich magnetite-sulfide grains ($\Delta^{17}O$ = ~90‰) found in the ungrouped carbonaceous chondrite Acfer 094 [1, 2]. They are thought to have formed from sulfidation and oxidation of Fe,Ni metal by H_2S and isotopically heavy water vapor. This ^{17,18}O-rich water possibly originated from isotopic mass-independent fractionation (MIF) from CO photochemical self-shielding in the protoplanetary disk [3, 4].

Like for the O-isotopes, S-isotopes ($\Delta^{33}S$) may undergo MIF by UV photodissociation processes [5], but the magnitude of fractionation is smaller than for O-isotopes (only few per mil). Because COS has large O isotope MIF and contains ≈10 wt.% S [2], it is an important phase to investigate S-MIF in the early Solar System. Here we report petrographic and O-isotopic searches for COS in Acfer 094 and present preliminary results of S isotope measurements.

Methodology: COS candidates were identified from petrographic observations and SEM-EDS analyses using a Tescan Mira3 FEG-SEM (Fig. 1A). Oxygen isotope measurements on COS candidates were then performed with the Wash U NanoSIMS using a ~2 pA primary beam focused to ~100 nm. We acquired 10x10 µm scanning ion images of $^{16}O^-$, $^{17}O^-$, and $^{18}O^-$ using EMs. O isotope ratios of COS were normalized to their surrounding matrix, assumed to have the same composition as reported in [1]. 2σ errors were estimated to be ≈10‰ on $\delta^{18}O$, ≈23‰ on $\delta^{17}O$. Finally, we performed S-isotope (^{32}S, ^{33}S and ^{34}S) on these COS grains under similar analytical conditions as O isotopes. Because sulfide grains in CM-CI chondrites fall along a mass-dependent fractionation (MDF) line [6], we corrected the $\Delta^{33}S$ values of COS with micrometer sulfide grains located in the matrix that show reproductible $\Delta^{33}S$ values (σ ≈ 2‰), assumed to fall along a MDF line (i.e., $\Delta^{33}S_{sulfide}$ = 0‰). 2σ errors were estimated to be ≈5‰ on $\Delta^{33}S$.

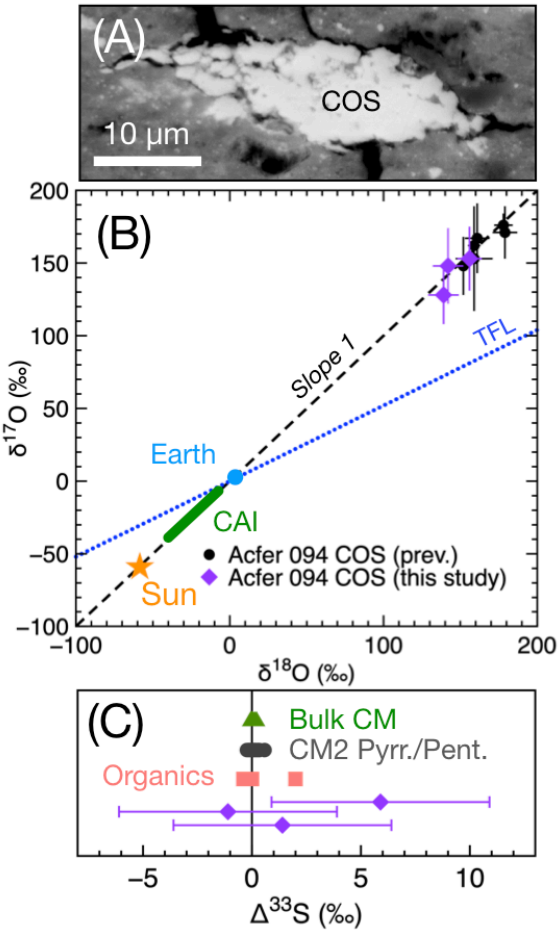

Fig. 1 – (A) BSE image of a COS grain in Acfer 094. (B) $\delta^{18}O$ vs $\delta^{17}O$ showing the O-isotopic composition of the COS from this study and from [1]. Other data from [8] and references therein. (C) $\Delta^{33}S$ plot showing $\Delta^{33}S$ measurements in COS (this study) and in chondrites (Bulk CM: [9]; CM2 Pyrrhotite/Pentlandite: [6]; Organics: [10]). Errors are given as 2σ.

Results and discussion: The O-isotopic compositions of the three COS candidates reveal that these grains have anomalous O-isotopic signature compared to their surrounding matrix ($\delta^{17}O \approx \delta^{18}O \approx$ 130-160‰; Fig. 1B), confirming their nature as cosmic symplectite [1, 7]. The S isotopic compositions of two COS grains are consistent with zero and one COS showed a hint of S-MIF anomaly at the 2σ level: $\Delta^{33}S_{COS} \approx 6 \pm 5$‰ (Fig. 1C). If the COS S-MIF can be confirmed with a higher precision measurement, then this result suggests that a MIF process, e.g. UV photodissociation, for both O & S were recorded for some COS grains. The analytical uncertainties of our S isotope measurements by NanoSIMS ion imaging are too high (and dominated by systematics) to detect small mass-independent fractionation as expected for S-isotopes (only S-MIF > 5‰ can be ruled out). Future S isotope analyses of a selection of identified COS using a Cameca ims 1280 are planned.

References: [1] Sakamoto N. et al. (2007) *Science* 317:231–233. [2] Abe K. et al. (2017). *Geochemical Journal* 51:3-15. [3] Yurimoto H. & Kuramoto K. (2004) *Science* 305:1763–1766. [4] Lyons J. R. & Young E. D. (2004) *Nature* 435:317–320. [5] Chakraborty S. et al. (2013) *PNAS* 110:17650–17655. [6] Bullock E. S. et al. (2010) *MAPS* 45:885–898. [7] Nittler L. et al. (2015) 46th *LPSC* Abstract #2097. [8] McKeegan K. D. et al. (2011) *Science* 332:1528-1532. [10] Cooper G. W. et al. (1997) *Science* 277:1072-1074.