

SEARCH FOR FLUID INCLUSIONS IN A CARBONACEOUS CHONDRITE USING A NEW X-RAY MICRO-TOMOGRAPHY TECHNIQUE COMBAINED WITH FIB SAMPLING.

A. Tsuchiyama¹, A. Miyake¹, M. E. Zolensky², K. Uesugi³, T. Nakano⁴, A. Takeuchi³, Y. Suzuki³ and K. Yoshida¹. ¹Graduate School of Science, Kyoto University. E-mail: atsuchi@kueps.kyoto-u.ac.jp. ²NASA, JSC. ³JASRI, SPring-8. ⁴AIST, GSJ.

Introduction: Early solar system aqueous fluids are preserved in some H chondrites as aqueous fluid inclusions in halite (e.g., [1]). Although potential fluid inclusions are also expected in carbonaceous chondrites [2], they have not been surely confirmed. In order to search for these fluid inclusions, we have developed a new X-ray micro-tomography technique combined with FIB sampling and applied this technique to a carbonaceous chondrite.

Experimental: A polished thin section of Sutter's Mill meteorite (CM) was observed with an optical microscope and FE-SEM (JEOL 7001F) for choosing mineral grains of carbonates (mainly calcite) and sulfides (FeS and ZnS) 20-50 μm in typical size, which may have aqueous fluid inclusions. Then, a "house" similar to a cube with a roof (20-30 μm in size) is sampled from the mineral grain by using FIB (FEI Quanta 200 3DS). Then, the house was attached to a thin W-needle by FIB and imaged by a SR-based imaging microtomography system with a Fresnel zone plate at beamline BL47XU, SPring-8, Japan. One sample was imaged at two X-ray energies, 7 and 8 keV, to identify mineral phases (dual-energy microtomography: [3]). The size of voxel (pixel in 3D) was 50-80 nm, which gave the effective spatial resolution of ~ 200 nm. A terrestrial quartz sample with an aqueous fluid inclusion with a bubble was also examined as a test sample by the same method.

Results and discussion: A fluid inclusion of 5-8 μm in quartz was clearly identified in a CT image. A bubble of ~ 4 μm was also identified as refraction contrast although the X-ray absorption difference between fluid and bubble is small. Volumes of the fluid and bubble were obtained from the 3D CT images.

Fourteen grains of calcite, two grains of iron sulfide and one grain of (Zn,Fe)S were examined. Ten calcite, one iron sulfide and one (Zn,Fe)S grains have inclusions >1 μm in size (the maximum: ~ 5 μm). The shapes are spherical or irregular. Tiny inclusions (<1 μm) are also present in all the grains examined. These results show that mineral grains have more inclusions than expected from 2D observations.

The X-ray absorption of the inclusions shows that they are not solid inclusions. No bubbles were observed inside, indicating that we cannot determine whether they are really aqueous fluids or merely voids. One calcite grain has an inclusion ~ 2 μm in size, which seems to have a bubble and a tiny solid daughter crystal inside (three-phase inclusion). As we know the exact 3D position of the inclusion, we will analyze the inclusion by SIMS after freezing the sample as has been done for a halite sample [3]. The present technique is useful for finding small inclusions not only in carbonaceous chondrites but also for terrestrial materials.

References: [1] Zolensky et al. 1999. *Science*, 285:1377-1379. [2] Zolensky et al. (2004) *MAPS*, 39:A118. [3] Tsuchiyama et al. 2013. *GCA*, 116:5-16. [4] Yurimoto et al. 2010. *MAPS*, 45:A5178.