A POSSIBLE RECORD OF AN ACTIVE ASTEROID: DISCOVERY OF A COMPACT LITHOLOGY IN THE AGUAS ZARCAS CM CHONDRITE

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Introduction: We present a study of the Aguas Zarcas (hereafter AZ) carbonaceous chondrite, a 2019 fall from Costa Rica and the largest recovered CM chondrite since Murchison. We found a previously unreported compact lithology component embedded in the AZ regolith breccia that may record frequent particle ejection and redeposition events similar to those observed by NASA's OSIRIS-REx mission on Bennu [1].

Methods: 79 g of fragments separated from a large hand sample of AZ donated by Terry Boudreaux (FMHN ME 6112; 1.894 kg) were immersed in ultrapure water for freeze-thaw disintegration using alternating cycles of liquid nitrogen and 50 °C water. Over 10 sub-cm-sized fragments (3.2 wt%) survived 112 cycles showing no sign of break-down (hereafter compact AZ), while the remainder of the rock disaggregated into powder within 50 cycles. We scanned 11 compact fragments and 3 randomly selected AZ fragments with X-ray computed microtomography (μCT) at the University of Chicago and the University of Texas High-Resolution X-ray Computed Tomography Facility (UTCT). We prepared two polished sections of the regular lithology and one from a relatively large compact AZ fragment. We analyzed the polished sections with scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS) at the University of Chicago. We also μCT-scanned Murchison and Allende samples at UTCT as references. All samples are loans from the Field Museum of Natural History's meteorite collecton.

Results and conclusions: Through μCT and SEM analysis, we found that the compact fragments exhibit flattened chondrules and inclusions with a strong preferred orientation along with fractures in the surrounding matrix that are parallel and subparallel to the direction of chondrule flattening. Other AZ lithologies do not show this texture. Using the empirical relationship between the mean aspect ratio of chondrules and shock pressure from [2], we estimate that the deformation in compact AZ occurred at a high pressure of 15–20 GPa. The chondrule flattening and observed fractures require that compact AZ must have undergone at least one hypervelocity impact. The coexistence of regular and shock-produced compact lithologies within a large hand-sample of AZ requires mass transport and mixing on the parent body. We compared the size distribution of the compact AZ fragments with that of ejected fragments from Bennu [3] and found that compact AZ rocks have a size typical of Bennu ejecta. The size similarity indicates that a series of ejection and reaccretion of sub-cm-sized fragments produced by ejection events can also account for the mass transport and mixing on the AZ parent body. Our findings also suggest that compact rock fragments may exist in other CM chondrite breccias where their main lithologies only preserve weak shocks. Our hypothesis can be tested by surveying other CM chondrite breccias and the future sample from Bennu for compact lithologies with μCT.

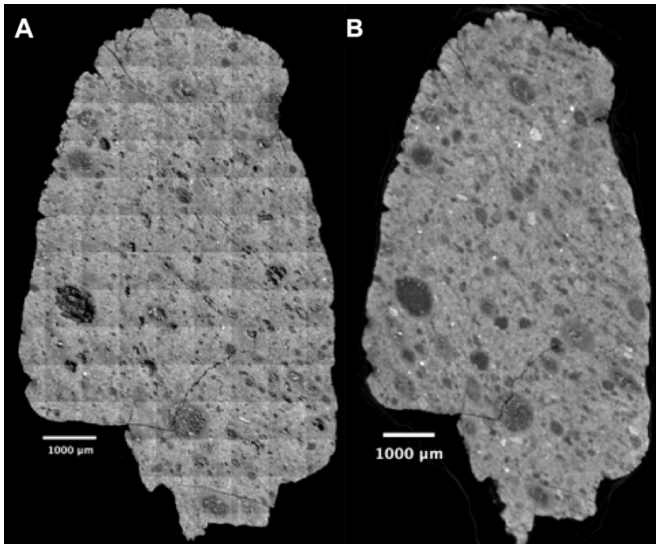

Fig. 1. (A) BSE image of one compact fragments, cross-sectioned parallel to the long axis of the flattened chondrules. (B) μCT image of approximately same section, showing the same relative greyscales as in the BSE data. Dark-toned objects in both panels are Mg-rich chondrules.

References: [1] Lauretta et al. (2019) *Science* 366, #eaay3544 (10 pp). [2] Tomeoka K. et al. (1999) *GCA* 63, 3683-3703. [3] Chesley S. R. et al. (2020) *JGR Planets* 125, #e2019JE006363 (33 pp).