The Aguas Zarcas breccia - similarities to surface features of C-type asteroids Ryugu and Bennu

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Knowledge of the materials originally present in the protosolar nebula is one of the most significant constraints for models of the formation of our solar system. The physicochemical properties of these original materials can be determined through two different and complementary approaches: (a) astronomical observations of nascent stellar systems and the dense clouds from which they originated and (b) laboratory studies of available astromaterials such as meteorites, interplanetary dust particles, comet coma grains, including returned mission samples (e.g., from Hayabusa -1 -2; OSIRIS-Rex). Laboratory study of these extraterrestrial materials provides valuable information about the first solid materials of the early solar system and their evolution. Here, we present petrographic and mineralogical characteristics of work on the polymict carbonaceous breccia Aguas Zarcas [1].

On April 23, 2019, at 21:07 local time, a meteorite fall occurred in Aguas Zarcas, San Carlos County, Alajuela province, Costa Rica. The rapid recovery of this brecciated carbonaceous chondrite after its fall provides an opportunity to investigate a freshly fallen, relatively uncontaminated, and highly-brecciated meteorite to compare with samples returned by the Hayabusa2 and OSIRIS-REx spacecraft from C-complex asteroids.

This study includes the examination of several pre-rain fragments. X-ray computed tomography (XCT) results show numerous different lithologies [1]. In this study, we describe the petrography and mineralogy of five different lithologies of the Aguas Zarcas meteorite. We also present data on the bulk oxygen isotopes of some of these lithologies. We describe all fragments in detail and attempt a classification of each lithology in order to better understand tfhe origin and formation history of the Aguas Zarcas parent body.

Our results show that some lithologies of Aguas Zarcas are similar to those in CM chondrites, but others are unique. The different lithologies [1] also represent different degrees of hydration and heating, which are good analogues for the types of material returned from asteroids Bennu and Ryugu.

Spectroscopic observations of Ryugu and Bennus compared to laboratory measurements of meteorites suggest that the asteroids have some similarities to heated CM, heated CI, or CI chondrites [2-5]. Both asteroids are thought to be composed of materials altered by aqueous alteration (e.g., [5]) and formed by reaccretion after destruction by impacts and brecciation (e.g., [6-7]). Considering the different lithologies in Aguas Zarcas [2] and other CM chondrites [8-9], these types of carbonaceous chondrites can be considered good analogues for samples from Ryugu and Bennu. The presence of unique and rare lithologies in Aguas Zarcas, different from typical CM chondrite lithologies, requires complex mixing of different materials in a highly dynamic environment.

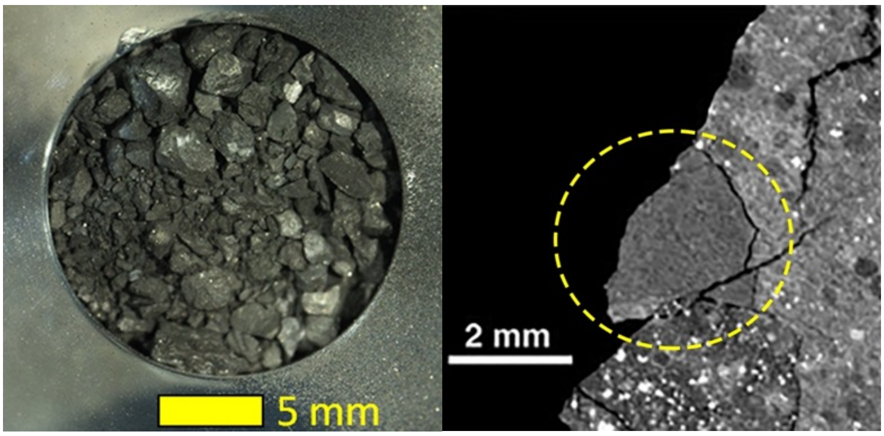

Fig.1: Left image: sample catcher chamber A from Hayabusa2, captured by an optical microscope, shows many particles larger than 1 mm (Photo by JAXA Dec. 24, 2021). The right image: XCT image of a sample of Aguas Zarcas, showing a dark homogeneous C1-clast (marked by a circle) (Kerraouch et al., 2021; 2022). Both materials exhibit a mixture of different lithologies resulting from impact fragmentation, mixing, and reaccretion during the evolution of their parent bodies.

References [1] Kerraouch et al., 2021. Meteoritics & Planet. Sci. 56, 277-310; [2] Kitazato et al., 2019. Science 364, 272–275; [3] Matsuoka et al., 2015. Icarus 254. 135–143; [4] Hanna et al., 2019. LPI abstract #2029; [5] Hamilton et al., 2019. Nature Astronomy. 3.332–340; [6] McCoy et al., 2019. Metsoc54 abstract #6428; [7] Michel et al., 2020. Nature 11, 2655; [8] Kerraouch et al., 2019. Chemie der Erde 79, 125518; [9] Lentfort et al., 2020. Meteoritics & Planetary Sci. 56, 127-147.