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 proto-solar 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, comets, as well as re-turned 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 the 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-group asteroids.

The study includes the examination of several prerain fragments. X-ray computed tomography (XCT) results show many 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 lithologies. We describe all fragments in detail and attempt a classification of each lithology in order to understand the 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 by the Bennu and Ryugu asteroids.

Spectroscopic observations of the Ryugu and Bennu asteroids 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 the Ryugu and Bennu asteroids. The presence of unique and rare lithologies in the Aguas Zarcas, different from the typical CM chondrite lithologies, suggests complex mixing of different materials in a highly dynamic environment.

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Acknowledgements: This work was partly funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Project-ID 263649064 – TRR 170 (subproject B05; AB); MZ was supported by NASA's Emerging Worlds and Hayabusa2 Participating Scientist Programs.