FTIR SPECTROSCOPY AND X-CT CHARACTERIZATION OF THE NEW CM AGUAS ZARCAS.

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Introduction: The Aguas Zarcas (AZ) meteorite fell in Costa Rica in 2019. Thanks to a rapid recovery, hundreds of fragments were collected before local rainfall. AZ shows significant petrographic diversity with five different lithologies [1]: a brecciated CM lithology; a C1/2 lithology; a C1 lithology and two distinct metal-rich lithologies. Their intricacy at millimetric scale as well as the presence of unique and rare lithologies in AZ indicate a complex history in a ″highly dynamic environment" [1]. Thus, the history of AZ could be comparable to that of the rubble-pile asteroids Ryugu and Bennu, which are interpreted as second-generation parent bodies, formed by disruption and re-accretion of larger asteroids [2]. This makes the AZ meteorite a high priority sample for further investigation.

Material and methods: Here, we report results of a campaign of measurements on three fragments coming from Aguas Zarcas CM chondrule-rich lithology. We have first examined the 3D morphological structure of a large fragment (1.2 * 0.9 * 0.4 mm sized) thanks to X-ray Computed Tomography (X-CT) analyses performed at the ANATOMIX line of synchrotron SOLEIL (France), with a pixel size of 0.325 µm. The mineral/organic composition of this large fragment and of two smaller fragments was studied using FTIR hyperspectral imaging. Data were collected using an Agilent Cary 670/620 micro-spectrometer combined with a 128x128 pixels FPA detector, available at the SMIS beamline of SOLEIL. Using the Globar source, we collected spectra in the 850-3950 cm^{-1} spectral range. Analyses in reflection were performed on the larger sample using a 15x objective (pixel size of 5.5 µm). The spatial resolution was diffraction-limited for the whole investigated spectral range. Measurements in transmission mode were performed on one of the two small grains crushed between diamond windows (200µm * 200µm * 11 µm sized) using a 25x objective with an additional 5x magnification (pixel size of 0.66 µm). The second small grain (20x15x30µm µm) was mounted on a tungsten needle to perform FTIR micro-tomography [3], in order to select regions of interest, and then was sliced in thin sections using a FIB for further high-resolution analyses [4]. IR measurements in reflection at different angles were also performed on this small grain with a pixel size of 3.3 µm.

Results and discussion: The morphological characterization by X-CT reveals that AZ has a porosity of 4.5 +/- 0.5 vol% and heterogeneous distribution of pores. The value of porosity is low compared to what is expected for CM chondrites [5]. This mismatch could be explained by the small sample volumes investigated, unaffected by larger scale pores (e.g. cracks and fractures). However, our analysis provides a study of chondrule porosity, revealing values of 6.3 vol% +/- 1 vol%. Several explanations about the origin of this relatively large porosity are considered: porosity produced by temperature variation during the chondrule formation, due to shocks or produced by dissolution during aqueous alteration. We estimated a petrologic type for that specific CM lithology using two independent techniques (FTIR and XCT), and obtained in both cases a type CM2.5 for this carbonaceous chondrite, in agreement with previous estimation [1,6]. By comparing the Si-O 10-µm signature of the AZ average FTIR spectra with several other CMs, we managed to place AZ in the context of aqueous alteration of CMs parent bodies. Finally, by exploring the µm-scale 3D distributions of organic and mineral compounds, we observed a correlation between the abundance of organic matter and hydrated minerals, suggesting that aqueous alteration in AZ parent body played a major role in the evolution of the organic matter, in agreement with previous studies on other CM chondrites [7,8,9].

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