SPECTRAL AND MINERALOGICAL ANALYSES OF AGUAS ZARCAS IN SEARCH OF ITS PARENT BODY

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Introduction: Aguas Zarcas is an intriguing carbonaceous chondrite that fell in Aguas Zarcas district, San Carlos, Alajulea, Costa Rica on 23 April 2019 [1]. This carbonaceous chondrite was found to be a breccia at al all scales with diverse lithologies (metal-rich, brecciated CM, and CI) [2]. Here we present spectroscopic and PSD-XRD analyses of a sample of Aguas Zarcas (donated to NASA JSC by Robert Ward) to better understand the origin and parent body for this meteorite. The spectral and mineralogical analyses are placed in the context of the published petrological and geochemical analyses of Aguas Zarcas, and its spectra are compared to a suite of spectra of asteroidal materials, including cabon-bearing asteroids, asteroid returned samples, and carbonaceous chondrites. The focus of this investigation will be on hydrated minerals and carbon-bearing materials, including organics and carbonates.

Methods: We ground a chip of Aguas Zarcas into a ~150 mg powder. Bidirectional reflectance spectra (incidence=15°, emission=45°, phase angle=60°) of Aguas Zarcas were collected at the Laboratory for Spectroscopy under Planetary Environmental Conditions (LabSPEC) at the Johns Hopkins University Applied Physics Laboratory (JHU APL). Spectra were recorded under vacuum- and thermally-desiccated conditions. Spectra were measured from ~0.8 to ~8 µm using a high-vacuum chamber system (10^{-6} to 10^{-7} Torr) with a Bruker Vertex 70 FTIR spectrometer and an external liquid-nitrogen cooled MCT detector. The same Aguas Zarcas powder analyzed using NIR spectroscopy was used for position-sensitive detector X-ray diffraction (PSD-XRD) measurements at Kingsborough Community College for further analysis.

Results and Discussion: Near-infrared reflectance spectra of Aguas Zarcas show signatures of absorption features (Figure 1, left) at ~0.7 µm due to an Fe^{2+}- Fe^{3+} charge transfer transition in oxidized iron in phyllosilicates (e.g., [3]), at ~2.78 µm attributed to ν_1 symmetric OH stretch in phyllosilicates (e.g., [4]), and at ~3.4-3.5 µm attributed to C-stretching of aliphatic organic compounds (e.g., [5]). The bulk mineralogy of Aguas Zarcas revealed by PSD-XRD analysis shows that this sample is dominated by cronstedtite (37%) and Mg/Fe serpentine (40%), with a derived PSF [total phyllosilicate / (total anhydrous silicate + total phyllosilicate)] of 0.81 (Figure 1, right) that is consistent with the CM2 chondrite lithology. The spectral and mineralogical analyses suggest that Aguas Zarcas is consistent with 'Group 2' studied by [4]. This group (e.g., the ungrouped Bells) is thought to have experienced a moderate degree of aqueous alteration with a 3-µm band (ν_1 symmetric HOH and ν_3 asymmetric OH stretch in phyllosilicates) center that varies from 2.76 to 2.80 µm. The studied sample of Aguas Zarcas is also consistent with the 'sharp' group of carbon-bearing asteroids (e.g., 121 Hermione), located in the 2.5 < a < 3.5 AU heliocentric region [6]. Future work will include spectral and mineralogical analyses of Aguas Zarcas samples that represent other lithologies (i.e., metal-rich, CI).

References: [1] Meteoritical Bulletin, no. 108 (2020) Meteorit. Planet. Sci. 55, 1146-1150. [2] Kerraouch, I. et al. (2021). *MAPS* 56, 277-310. [3] Vilas F. et al . (1989) *Science*, 246:790-792. [4] Takir D. et al. (2013) *MAPS*, 48, 1618-1637. [5] Clark R. N. et al. (2009) *Journal of Geophysical Research*,114: E03001. [6] Takir D. and Emery J. P. (2012). *Icarus* 219:641-654.

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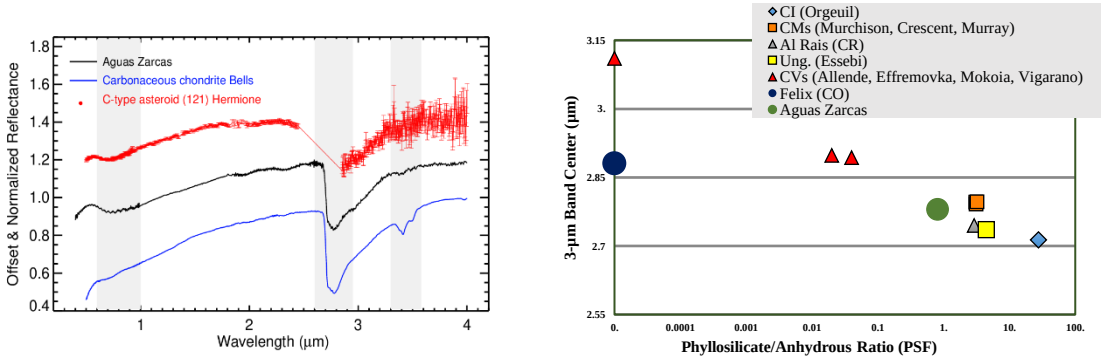

Figure 1: **(left)** NIR spectrum of Aguas Zarcas sample found to be consistent with spectra of Bells and the 'sharp' group of carbon-bearing asteroids. **(right)** Correlating spectral data with mineralogical data of Aguas Zarcas and other carbonaceous chondrites.