

Mapping the Distribution of Water in Carbonaceous Chondrites

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Motivation: Carbonaceous chondrites (CCs) record the different types of alteration (aqueous vs. thermal metamorphism vs. impact) these materials have experienced and their locations (nebular vs. parent body). Understanding alteration also drives petrologic classification approaches. Abundant mineralogical evidence for the aqueous alteration of chondritic materials early in solar system history is present across nearly all major chondrite groups in the form of hydrated or other secondary phases. Nominally anhydrous phases typically are associated with a lack of aqueous alteration or with thermal metamorphism. Unfortunately, the distribution, speciation, and abundance of water have proven notoriously difficult to measure and integrate into meteorite studies because water is not measured directly by techniques such as mass spectroscopy of bulk materials or electron microprobe and X-ray mapping of thin sections; rather, its presence is inferred from major element chemical data and it is generally assumed to be present in the nominally hydrous phases as water and/or (oxy-)hydroxyl. However, nominally anhydrous phases can host small amounts of OH⁻ and H₂O, and knowledge of the distribution and speciation of water among meteoritic components could contribute greatly to understanding meteorites' alteration histories. Fortunately, infrared (IR) spectroscopy is sensitive to the presence and speciation of water through vibrational modes in the ~3- μ m region; combined with diagnostic fundamental absorptions in the ~6 – 25 μ m region, these features indicate mineralogy and solid solution composition. Used at microscopic scales (25-300 μ m) to map thin sections, IR spectroscopy can provide valuable information about the spatial distribution and speciation of water in petrologic context, e.g., between clasts, as well as in discrete components such as matrix, chondrules, and dark inclusions. Finally, IR spectroscopy is a commonly used remote sensing tool, and individual phase spectra are important for the correct interpretation of such data.

Preliminary Analysis: Our IR reflectance micro-spectroscopy of 25 meteorites representing virtually all CC groups reveals differences in the spatial distribution of water across meteorites representing petrologic types 1 – 6 [1]. Our examination of individual map spectra has enabled us to identify OH⁻ and H₂O, as well as the host phases. We are now in the process of evaluating whether spectral feature strength and band area can be used to determine the quantitative abundance of water using methods developed by [2-4] for transmission and reflectance spectra of powders.

References: [1] Hamilton, V. E. et al. (2016) *LPS XLVII* 1793–1794. [2] Milliken, R. E. and Mustard, J. F. (2005) *JGR 110*, doi: 10.1029/2005JE002534. [3] Osawa, T. et al. (2005) *MAPS 40*, 71-86. [4] Beck, P. et al. (2010) *GCA 74*, 4881-4892.

ANTARCTIC MICROMETEORITES vs. CARBONACEOUS CHONDRITES: the organic point of view

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Introduction: Primitive small bodies of the Solar System might be much more diverse than revealed by the few chondrite groups we have in hands. The present work is focused on CONCORDIA Antarctic micrometeorites (AMMs) [1] in comparison to primitive carbonaceous chondrites (CCs): one of the objectives is to constrain the nature and diversity of the parent body(ies) sampled by AMMs in comparison to CCs. We are based on combined Raman at 514 nm (to characterize the structure of polyaromatic organic matter (OM)) and InfraRed (IR) (functional analysis of OM and bulk mineralogy) spectroscopies.

Samples and experiments: 10 fine-grained (Fgs), 1 scoriaceous (Sc) and 1 intermediate particle (Fg-Sc) are considered here. Fgs did not experienced significant heating through atmospheric entry, in contrast to Sc and Fg-Sc that are partially melted [2, 3]. For measurements, each AMM was pressed on a diamond or on a germanium window. To remove adsorbed terrestrial water, IR spectra were acquired under heated (T=80°C) vacuum (P=10⁻⁶ mbar) [4].

Results: Raman spectra of the considered AMMs attest the presence of polyaromatic organic matter, whose structure reflects the thermal history of the samples: a range of atmospheric flash heating and absence of significant thermal metamorphism on their respective parent body(ies). Five (out of 10) Fg-AMMs have mostly escaped flash heating: (i) their Raman spectral parameters are indicative of comparable or even lower structural order than in CCs [3,5]; (ii) they are systematically enriched in organics in comparison to CCs and other AMMs; (iii) they have the lowest CH₂/CH₃ among the considered AMMs, slightly higher than in CCs; and (iv) they are hydrated, in contrast to other AMMs. Last, recent NanoSIMS measurements reveal bulk ¹⁵N-enrichments higher in these Fg-AMMs than in the other ones.

Discussion: Raman and IR spectroscopy allows for the identification of AMMs the least modified by their atmospheric entry. The poorly structured OM, hydration signatures, high organic abundance and ¹⁵N-enrichments are interpreted as primordial signatures and point to the sampling of parent bodies distinct from CCs. This confirms that studying AMMs in laboratory offer the opportunity to get a more complete sampling of small primitive bodies than chondrites. These results will be complemented with 244-nm Raman measurements, to seek other chemical groups (e.g. –CN) and further insights into the polyaromatic structure.

References: [1] Duprat et al. (2007) *Advances in Space Research* **39**, 605 [2] Genge et al. (2008) *MAPS 43*, 497 [3] Dobrica et al. (2011) *MAPS 46*, 1363 [4] Beck et al. (2010) *GCA 74*, 4881 [5] Quirico et al. (2014) *GCA 136*, 80