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# An ancient prebiotic chemistry in the parent bodies of carbonaceous chondrites?

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## Abstract

It is well known that some groups of carbonaceous chondrites (hereafter CCs) accreted with significant organic and water content. We are studying members of rare CC groups from the NASA Antarctic collection in order to get new clues on their astrobiological role. Some of these meteorites are very pristine, and particularly rich in minerals that make them excellent candidates to catalyze organics during aqueous alteration. We compile here recent evidence found in this regard.

## 1. Introduction

Current dynamic models involving the migration of giant planets at the period known as the Late Heavy Bombardment occurred between 3.9 and 3.8 Ga ago point towards a massive scattering of carbon- and water-rich bodies formed in the outer part of the Main Belt [1]. In such scenario a significant amount of such transitional bodies with forming materials similar to CCs, were scattered towards the near-Earth region. Such materials arrived massively to our planet and probably participated in Earth enrichment in organics and volatiles. In that late-accretion process, the amount of organics and water delivered to Earth by the gravitational scattering of minor bodies could have been very significant [2]. In order to gain insight on the nature and composition of such materials it seems important to study pristine meteorites. They are accretionary rocks that can be considered authentic sediments of the materials forming the protoplanetary disk. The different groups exhibit diverse components in very distinctive abundance ratios. Chondrules, refractory inclusions, and metal grains are among the most common ingredients. Despite of their primordial nature, some groups exhibit clear evidence of have being aqueously processed. Probably at early stages of parent body evolution the water was released and then soaked the forming materials. Chondrules are the most abundant, but vary in average size and proportions in each group. Primordial silicates forming the chondrules, like e.g. olivine and pyroxene, are typically transformed into clays under the action of water. Also metal grains present in the matrix of these meteorites were affected in minor or larger degree depending of the availability of water, but their presence has direct implications to reflectance.

## 2. Experimental setup

We have analyzed carbonaceous chondrites from the Antarctic meteorite collection of NASA. Here we compile a representative number of them to exemplify the use of a Smart Orbit Attenuated Total Reflectance (ATR) IR spectrometer. Small chips of each meteorite were grinded using an agate mortar. Powders were carefully located in between a diamond detector of the ATR spectrometer. It provides high resolution internal reflection spectra of meteorite powders following standard procedures [3].

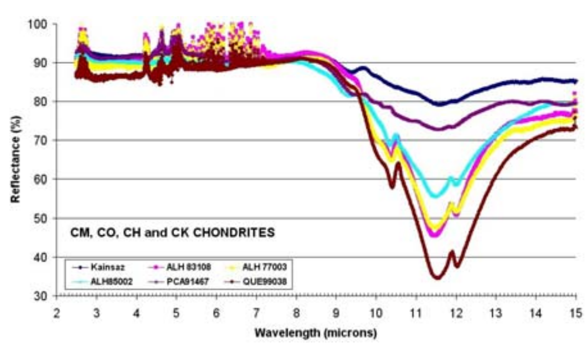


Figure 1: ATR IR spectra for selected members of different CC groups.

## 3. Discussion

CC meteorites are primitive asteroidal fragments that provide analytical clues on the role played by parent body processes such as aqueous alteration in chemical evolution. In this sense, IR ATR spectra are useful to provide a general assessment of the main mineral bands and organic features contained in grinded powders (see e.g. Fig. 1). More detailed analytical techniques found evidence for some members of CR, CM and CI carbonaceous chondrites groups that the organic matter present in their undifferentiated bodies experienced significant processing concomitant to the formation of clays and other minerals. Several lines of evidence exist for this, e.g., clays have been found to be associated with complex organics [4, 5]. Furthermore, analytical studies appear to correlate the abiotic chemistry of carbonaceous chondrites with extant biomolecules, e.g., L-chiral excesses found in some CC amino acids are similar to those observed in terrestrial living organisms [6-8]. We also note that the carbon-rich matrix of carbonaceous chondrites is a potential source of all biogenic elements, including phosphorus. Consequently, there is growing evidence pointing towards a prebiotic synthesis of complex organic species in water rich undifferentiated bodies. Interdisciplinary research is needed to significantly enrich our knowledge of this new Meteoritics' discipline.

## 4. Summary and Conclusions

IR ATR spectra of several CC groups are presented. Such spectra exhibit different degrees of water adsorption and organics abundance. A possibility is that such patterns could be consequence of different degrees of aqueous alteration. Future research will clarify the role of clay minerals in organic synthesis.


## Acknowledgements

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Table 1. Main distinctive features of organics in the IR spectra of CM carbonaceous chondrites.

| Mineral or feature | $\lambda$ ($cm^{-1}$) | $\lambda$($\mu m$) | Notes |
|---|---|---|---|
| CH stretch band | 3,000 | 3.3 | Organics |
| CC double bond stretch | 1,650 | 6.1 | Organics, distinctive in CMs. |
| $CH_2$ & $CH_3$ bend bands | 1,450 & 1,400 | 6.9 & 7.1 | Organics, distinctive in CMs |
| Al/Si-OH libration bands | 930-950 | 10.8-10.5 | Variable location |
| Peroxo groups (O-O) | ~865 | ~11.6 | Ubiquitous in CCs |