

# THE DISTRIBUTION OF MAJOR CARBONACEOUS COMPONENTS IN CHONDRITIC MATERIALS.

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**Introduction:** Carbonate materials comprise the second most abundant class (~3 vol%) of carbon-bearing phases in CM chondrites after organic matter, followed by other C-bearing phases such as diamond, silicon carbide, and graphite [1, 2]. Understanding the abundances of carbonates and the associated organic matter provides critical insight into the genesis of major carbonaceous components in chondritic materials, which were likely also the feedstock for chondrules.

With the use of Raman spectroscopy we present a study of the structure of the organic matter (OM) in the matrix and carbonate phases in five CM chondrites: Jbilet Winselwan, Murchison, Nogoya, Santa Cruz, and Wisconsin Range (WIS) 91600. We determined the degree of maturation of the OM in these meteorites and the formation conditions of the carbonates.

**Methods:** We identified carbonates in each sample with an optical microscope. The samples were then analyzed using a Jobin-Yvon Horiba LabRam HR Raman microprobe with a 40× objective. The excitation source was a 514.53 nm laser provided by a Modu-Laser Stellar Pro-L, 100 Mw solid-state laser. The peak position and full width half-maximum of each Raman band were determined by peak fitting to Lorentzian profiles and linear baseline correction.

**Results and Discussion:** Our observations indicate that the five CM2 samples have all experienced typical levels of aqueous processing, as evidenced by the presence of considerable amounts of Ca carbonates. A detailed description of the carbonate peak assignments is provided in [3, 4].

The organic compositions of the analyzed carbonates in the CM2 samples show notable variations. All the analyzed calcite grains observed in Murchison samples lacked typical Raman OM features. Calcite grains in Nogoya were also barren of organics, but the dolomite grain contains OM showing a degree of maturation that is distinctive from the organics observed in Nogoya matrix. Jbilet and Santa Cruz are hosts to a mixture of carbonate grains, with and without organics. Calcite in WIS 91600 also contains organics. Our Raman observations suggest that carbonates in the CM2s were produced under diverse chemical conditions, perhaps with an evolving fluid composition, or different sources of fluid. This is supported by the view that different carbonates might not have formed under equilibrium conditions from the same fluid [5].

Differences in the nature of carbonate phases in different CMs were also noted in previous studies based on isotopic and petrologic observations [6-8]. Carbonates that show typical Raman OM features are comparable to the type 2 carbonate described in literature of which the  $\delta^{18}\text{O}$  value  $\approx 19\%$ . This type of carbonate was reported to occur as pseudomorphs replacing chondrule silicates in some CM2s [9], and was identified in all CM chondrites investigated in this study except for Murchison. Carbonate grains which lack typical Raman OM features might be comparable to type 1 carbonate ( $\delta^{18}\text{O}$  value  $\approx 34\%$ ).

The matrix OM of the CM meteorite samples in this study has a lower structural order than the carbonate organics, which indicates variation in their organic components. Since different types of organic precursors should mature in a distinctive manner and thus should lead to discontinuities in the graphitization process [10], the maturity trend observed for the organics in matrix and carbonate suggests that they are likely derived from a similar source of precursors and/or exhibit a generic relationship.

**Summary:** The carbonate OM shows an apparently higher degree of maturation compared to meteorite matrix OM, indicating that the carbonate OM contains different organic components than the matrix OM. We propose that the initial aqueous activity that formed the first generation of carbonate could have involved highly oxidized fluids that led to the oxidation of OM and thus the production of the OM-barren carbonate. The aqueous activity ceased upon the termination of the heating event. A later short-term heating event recreated a favorable condition for the second generation of carbonate to precipitate, and at places they replaced chondrule silicates. The associated aqueous event could also have synthesized other organic materials observed in carbonaceous chondrites [11, 12]. Therefore carbonate and more evolved OM could coexist.

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