

## Spectroscopic investigations of IOM: Insights into aqueous alteration on CM parent body.

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**Introduction:** Primitive chondrites such as carbonaceous chondrites contain upto 5wt% of carbon in organic and inorganic phases. In general the insoluble organic matter (IOM) accounts for 60-70% of the total organic carbon and the remaining is attributed to soluble organic matter (SOM). Throughout their lifetimes, meteorite parent bodies go through various transformations, for instance, due to radiogenic heating, impact shocks and electromagnetic induction which act as triggers for various parent body processes like aqueous alteration and thermal alteration. The influence of water and related activity on the organics encased in meteorites makes their origin inextricably linked. Various scenarios like episodic alteration [1], closed system, open system for aqueous alterations [2]–[4]. A recent study suggests that CC parent body has experienced fluid flow up until 100,000 years ago [5] and the recent fluid transport would influence all mobile species like organics, alkali etc. Given the large number of parameters to be considered, the effects of aqueous alteration on organics are not distinctly understood.

In this study, we have performed a multitechnique study of IOM extracted from 18 carbonaceous (CI, CM, CR) meteorite samples with an aim to understand the aqueous alteration processes using FTIR, Raman and XANES analyses. FTIR, Raman and XANES study combined present a great advantage as all three are non-destructive techniques and these techniques combined provide complimentary information regarding the structure and composition of the samples.

**Results and Discussions:** We have estimated the aqueous alteration temperature and peak metamorphic temperatures which range from 12–66°C for the suite of sample studied here. The elemental and functional group data extracted from XANES and FTIR analysis are represented in figure 1. The aromatic/aliphatic and CH<sub>2</sub>/CH<sub>3</sub> increase with alteration which could indicate aromatization process (figure 1) [6]. Generally, the C XANES spectra for the bulk IOM show typical features like aromatic, ketone and carboxyl for all carbonaceous chondrites analyzed but there is an increased heterogeneity of abundances with increasing degree of alteration (figure 1) [7]–[9]. Furthermore, it is observed in figure 1 that with increase in alteration, i.e., increased phyllosilicate abundance, N/C decreases which could indicate the loss of polar components [10]. In organic chemistry when energy is provided, materials become insoluble (hydrophobic) in nature thus it implies that higher the aqueous alteration lower would be the N/C ratio. This could imply a conversion of SOM to IOM through aqueous alteration. We propose a state of chemical equilibrium that is reached between IOM and SOM during aqueous alteration where IOM could have evolved from SOM modification and organo-mineral interactions. We also observe that temperature was not the driving parameter for the extent of alteration.

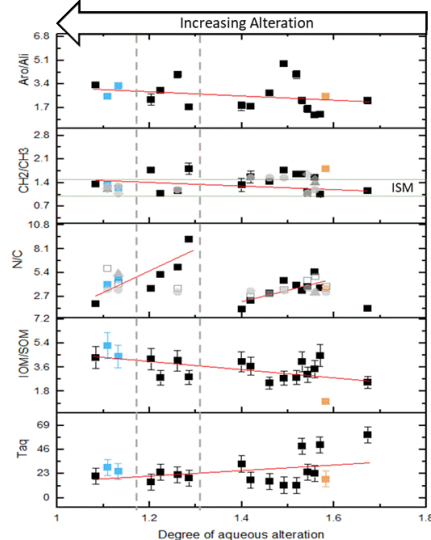


Figure 1: Comparison of elemental and functional group ratios with degree of aqueous alteration. All errors are 1 sigma. Here  $T_{aq}$  is the aqueous alteration temperature calculated based on FTIR data (section 3.1 equation 1). The ratio of abundance of insoluble and soluble organic matter is represented as IOM/SOM.  $CH_2/CH_3$  and Aro/Al represent the aromatic to aliphatic ratio obtained from FTIR spectra. The blue and orange squares represent the CIs and CR in our study respectively. The light gray symbols are literature values.

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