THE MULTIPLE ORIGINS OF INSOLUBLE ORGANIC MATTER FROM PRIMITIVE CHONDRITES

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Introduction: Insoluble Organic Matter (IOM) is a polyaromatic solid recovered in chondrites and dusts of presumably cometary origin. It bears D and ^{15}N isotopic anomalies whose interpretation has been a long standing and still unclosed debate: so far, the place and process of formation of this compound remains unclear [1]. Here we questioned the origin of the chemical and structural variations of IOMs observed from one chondrite to another, and that has been interpreted either by the action of post-accretional processes and/or the accretion of different organic precursors [2,3]. For this purpose, we selected a comprehensive series of 28 chondrites that sample the common chemical classes of primitive chondrites and that experienced varying degrees of post-accretional processes. The structure and composition of these IOMs have been characterized by Raman and IR microscopies, the latter allowing a link towards astronomical and spacecraft observations, in particular the VIRTIS instrument onboard the ROSETTA mission.

Samples and Experimental Techniques: We studied 28 chondrites belonging to the CI, CM and CR classes, as well as the ungrouped C2 Tagish Lake, Essebi, Bells and Acfer094. IOMs were extracted with a home-made reactor allowing to execute acid demineralization on ~ µg particules within only 36 hours. IR measurements were performed with a BRUKER HYPERION microscope. Raman measurements were performed with different instruments employing 514 and 532 nm excitation wavelengths. A particular attention was devoted to measurements reproducibility, as IOM is critically sensitive to laser irradiation (heating, annealing, photoblanking).

Results and Discussion: The measurements reveal large chemical and structural variations among the chondrites studied. Four groups are distinguished. The first (I) contains the CM Murchison, CI and CR chondrites. All these objects have high alkyl abundances and low CH_2/CH_3 ratio, and similar polyaromatic structures according to Raman spectroscopy (RS). The larger CH_2/CH_3 and H/C ratio in CR than in CI chondrites, as well as the carbon isotopic composition [1] reveal that CR and CI chondrites did not accreted similar organic precusors, evidencing a *protosolar disk chemical heterogeneity*. Moreover, the lack of any correlation between the alkyl abundance or the CH_2/CH_3 ratio with the petrologic type unambiguously evidences that *aqueous alteration had no major effect on IOM* composition *and structure*.

The second group (II) gathers objects whose IOMs have composition and structure different than in group I. The low alkyl and carbonyl abundances, the high CH_2/CH_3 ratio, as well as the peculiar polyaromatic structure as determined from RS evidence the action of thermal processing. Indeed, the objects in group II experienced short duration parent body thermal processing, presumably induced by shocks. *In this regard, the sole parent-body process that modifies composition and structure of IOM in type 2 chondrite is thermal heating.* Note that the ungrouped Tagish Lake and the CM2.1 QUE93005 are two thermally processed chondrites.

A third group (III) gathers CM chondrites whose IOMs have a polyaromatic structure similar to that in group I, but a higher CH_2/CH_3 ratio. This could point to a low intensity thermal processing and/or to chemical differences in the accreted organic precursors. The fourth group (IV) gathers objects whose IOM history remains obscure. This is the case of the ungrouped Essebi, Bells and Acfer 094. At last, the enigmatic CR *GRA95229, which releases ammonia under 300 °C hydrothermal conditions* [4], *has a very peculiar polyaromatic structure*. Surprisingly, we did not notice significant differences in its chemical composition as deduced by IR microscopy.

Conclusion: The compositional and structural variations of IOM in types 1 and 2 chondrites are accounted for by presolar disk chemical heterogeneity and parent-body thermal processing. In contrast, aqueous alteration had no or a negligeable effect. Unravelling both effects appear difficult in certain chondrites, like the CM Nogoya, Murray, Mighei, the CR GRA95229 and the ungrouped C2 Essebi, Bells and Acfer094. Finally, our set of data will be a useful proxy for understanding the origin of OM in stratospheric IDPs and Antarctic micrometeorites, and investigating the asteroid-comet continuum.

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