Organic material and gases in the early Solar System: the meteorite record.

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The Solar System formed from a dusty molecular cloud. During its first ages, the condensation of materials resulted in the formation of solids that hereafter accreted to form planet embryos. These solids were combination of icy bodies, organic grains and silicate particles and have recorded the signature of the sources of the solar system components and the processes occurring during the birth of the Solar System. In the most primitive chondrites and comets, these primitive materials have been preserved from the planets differentiation processes that occurred on Earth, for instance. Because these objects have undergone few modifications on their respective parent bodies during the 4.5 billion years of the Solar System, they can deliver to laboratories components that witnessed the origin of the protosolar nebula. This talk will focus on organic matter, water and noble gases contained in carbonaceous chondrites and comets, in relation with opened questions that could be assessed by laboratory experiments.

Although chondrites contain presolar grains, characterised by isotopic compositions that can only be explained by nuclear processes in supernovae or evolved stars, most of their components are formed during the early stages of the Solar System (in the so called protosolar nebula). Isotopic compositions are often used to characterize the conditions that prevailed in the protosolar nebula. For instance, D/H ratio in meteorites and extraterrestrial particles may answer questions like the origin of water in the inner solar system or the synthesis and evolution of organic compounds in the Solar System. Water, for instance, is 5 times more enriched in D than the protosolar molecular hydrogen. Organics in meteorites are even more enriched, with D/H ratios ranging from 10 to 20 times the protosolar D/H. Ion/molecule reactions are usually suggested to account for these D enrichments, but the exact location of these reactions remains unclear. Another striking observation is the heterogeneous distribution of D between and within meteorite samples, likely reflecting large scale heterogeneity in the protosolar nebula and important mixing processes during the accretion of meteorites parent bodies.

The molecular study of organic matter during the last 4 decades has revealed crucial characteristics of chondritic organic compounds. This allows us to compare the organic matter in meteorites and comets with organic matter detected in the interstellar medium and in molecular clouds. This may fill the gap between the understanding of interstellar reactions and the extraterrestrial organic compounds brought to laboratories by meteorites and comets. It may also reveal the processes that formed the organic compounds available in the Solar System before life started on Earth. Because their carrier phases were isolated in the same way as organic matter, noble gases history seems likely related to organics origin in meteorites. Among all the questions around the noble gases content and properties, the processes that trapped them in meteorites remain unconstrained. Laboratory experiments are required to better understand how meteorites have acquired their noble gases content, and by extension, its organic matter and water.