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Title : Cometary dust and origin of the matter in the protoplanetary disk

Keywords : micrometeorites ; organic matter ; protoplanetary disk ; cometary dust

Abstract:The objective of this thesis is the analysis of extraterrestrial dust collected in Antarctica: chondritic Antarctic micrometeorites (AMMs) and ultracarbonaceous micrometeorites (UCAMMs). Models predict that 80% of the dust that falls to Earth is of cometary origin. AMMs share many characteristics with the cometary dust reported by the Stardust space mission, and the characteristics of UCAMMs suggest formation at very low temperatures, far from the early sun. Micrometeorites therefore offer an opportunity to understand the mechanisms of cometary dust formation. UCAMMs are mostly composed of an organic matrix containing small mineralogical assemblages. The large amount of organic matter (OM) present in UCAMMs allows its analysis without using the classical extraction methods used to extract insoluble organic matter (IOM) from meteorites. Analyses of the AMMs by Raman and infrared microspectroscopy indicate a polyaromatic OM with a high degree of disorder, with characteristics close to those of the cometary grains reported by the Stardust mission. The variability of the OM spectral parameters is however more important for hydrated chondritic AMMs than for those without phyllosilicates. The mid- and far-infrared spectra show that the non-hydrated AMMs contain pyroxene and olivine silicates and that the aqueous phases of the hydrated AMMs are mainly phyllosilicates. Infrared and Raman analyses of the UCAMMs show a relatively large amount of nitrogen in the organic matter, and the occasional presence of nitrile groups. Spatially resolved X-ray transmission microscopy (STXM-XANES) analyses of the OM show the presence of 3 organic phases of distinct compositions within the UCAMM OM. The nitrogen present in the UCAMMs is carried by only one of these three phases, which has N/C atomic ratios up to 0.2. The inorganic phases contained in the UCAMMs were analysed by transmission electron microscopy. They exist as isolated phases, or as small mineral assemblages in the organic matrix, or as aggregates of different minerals, often cemented by a silicon-rich matrix. A mineral with a texture similar to that of a phyllosilicate was observed in one of the UCAMMs analysed. The similarity between the organic matter of UCAMMs and that of cometary particles suggests that these objects were formed in the outer regions of the protoplanetary disk. The joint presence of high-temperature-forming minerals and hydrated minerals within this organic matter implies a transport mechanism from the inner to the outer regions of the protoplanetary disk. The observation of a potential phyllosilicate in UCAMMs also raises the question of the possibility of aqueous alteration directly on cometary surfaces. However, the presence of hydrated phases within cometary material could also result from the accretion of already altered grains on a previous parent body. Micrometeorites in general thus offer a unique tool for the study of the asteroid-comet continuum highlighted since the return of the Stardust mission samples, and for a better understanding of the relationships between the different objects of the young solar system and the space weathering mechanisms they have undergone.