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Possible preservation of amino acids in calcium carbonates

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Many organic molecules are present in interstellar clouds and might be carried to the early Earth by comets and meteorites during the heavy bombardment phase in the first few hundred million years of the solar system. It has been suggested that extraterrestrial organic material may thus represent an important part of the organic material available for the origin of life. To address the issue of the origin of life and its homochirality on Earth, presence and chirality of the extraterrestrial organic molecules have to be determined.

Search for organics on Mars failed to detect organics at the ppb levels for complex organics. Since the meteorites and interplanetary dust should carry organics to Mars, their absence in the Martian soil suggests that they are being actively destroyed by chemicals such as H2O2 and/ or UV radiations. Future exploration missions should seek for well preserved samples. Preservation on Earth is strongly linked to interactions between mineral surfaces and organics. Regarding the most common mineral on Earth and in meteorites, involved in the search for origin of life, we focused our studies on the interactions between calcium carbonates (CaCO3) and organics such as amino acids.

Influence of type, concentration and chirality of amino acids during nucleation and crystal growth of calcium carbonates has been studied by X-ray diffraction and Scanning Electron Microscopy. During the precipitation of calcium carbonates at low temperatures (25°C to 80°C), the presence of amino acids in solution has induced the crystal growth of three polytypes and their correlated polymorphs. If the calcite is the most common and stable calcium carbonate,in our experiments it has often been associated with thermodynamically unstable polymorphs vaterite (frequent) and aragonite (rare).

Water and acid treatments have been conducted to discriminate free, adsorbed and linked molecules in the synthesized carbonates. Oxidative attacks of the resulting samples have then been conducted by H2O2 treatments to estimate preservation of amino acids depending on the ratio of calcite, vaterite or aragonite in carbonates. Behaviour of the different polymorphs in such oxidizing conditions has been determined. Quantification and enantiomeric excess of amino acids in oxidized calcium carbonate samples has been performed by Gas Chromatography coupled to mass spectrometry.

Main results of the study consisted in the preservation of amino acids which is clearly enhanced by the presence of carbonates.