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Elucidation of chemical processes in carbonaceous chondrites during aqueous alteration using X-ray microscopy

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Carbonaceous chondrites contain a variety of organic materials such as amino acids and aromatic compounds. How these substances are synthesized is an important question that will lead to the elucidation of the origin of life. The organic matter in carbonaceous chondrites has been investigated by various methods. However, it is not clear how organic matter distributes in the meteorite. The Aguas Zarcas meteorite, a CM chondrite that fell in Costa Rica in 2019 and is rich in organic matter with less alteration by the terrestrial environment, was selected as a sample. To clarify meteorite's mineral-organic interactions, we prepared ultrathin meteorite slices and investigated the spatial distribution of chemical species of several elements in the meteorite slices using scanning transmission X-ray microscopy (STXM; KEK-PF BL-19A) with synchrotron radiation. The same samples were also used for TEM observations to identify the mineral phases.

As a result of the experiment, in the layered silicate phase of the Aguas Zarcas meteorite, carbonate and aliphatic carbon were found to be concentrated in the same region (Fig.1). In this phase, from TEM analysis and STXM analysis of iron and magnesium, there is a structure that appears to be in the process of changing from a divalent iron-rich cronstedtite to a trivalent iron-rich serpentine. It is possible that the iron in the cronstedtite changed from divalent to trivalent through reactions such as the Fischer-Tropsch type process, which reduced carbonate to produce aliphatic carbon.

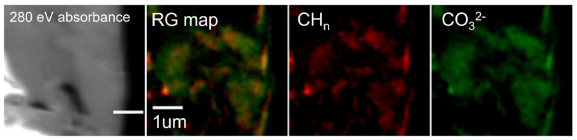

Fig. 1 Coexistence of aliphatic carbons and carbonic acids