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Organics in Ryugu, Orgueil and other chondrites analyzed in situ by STXM and TEM

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The Ryugu asteroid was visited by the Hayabusa II mission and brought back to earth precious samples of a hydrated and carbon-rich object that shares strong similarities with CI chondrites. It is one of the most pristine extraterrestrial object in our collection and has been preserved from long term atmospheric weathering on earth [1, 2].

Here, we investigate organic matter (OM) and compare it to Orgueil and other carbonaceous chondrites. Using scanning transmission X-ray microscopy (STXM) at the carbon edge coupled with transmission electron microscopy (imaging + EDXS), we reveal the molecular nature of the OM and its diversity, as well as the spatial relationship of OM with surrounding phyllosilicates. The goals are to understand the nature of the OM at the time of its accretion within asteroids, as well as the role of aqueous alteration on their subsequent modification.

We mapped 2 FIB sections of Ryugu and 2 FIB sections of Orgueil. As in other carbonaceous chondrites, we found individual organic particles with a more intense absorption of the aromatic and olefinic groups, as well as diffuse organic matter, which is intimately embedded within phyllosilicates and contains a higher fraction of aliphatic groups, as well as an ubiquitous carbonate group absorption.

However, a advanced analysis based on pixel/pixel normalization and spectral quantification reveals meaningful differences between Ryugu and Orgueil : the diffuse OM in Ryugu is more aromatic-rich and less aliphatic-rich than in Orgueil. The molecular heterogeneity within each FIB sections also appears lower in Ryugu than in Orgueil.

These results will be compared to other ongoing works on Ryugu organics [3] and placed in the context of previous works on other carbonaceous chondrites [4]. We will discuss whether these differences are due to secondary terrestrial weathering of Orgueil or if they are indicative of an OM that was processed in different conditions, either prior to accretion or during parent body alteration.

[1] Nakamura et al. (2022), Science
[2] Noguchi et al. (2023), Nature Astronomy
[3] Yabuta H. et al. (2023), Science.
[4] Le Guillou et al. (2014), GCA