

Micro-mineralogical characterization of two Ryugu particles by advanced FIB-SEM, TEM and electron diffraction

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Volatile-rich C-type asteroids are planetary bodies with primitive composition that are thought to represent the parent-bodies of carbonaceous chondrites [1], which in turn are the probable source of the volatile species delivered to the Earth during its accretion history [2]. The C-type asteroid (162173) Ryugu has been recently sampled by the JAXA/Hayabusa2 mission [3], providing samples of inestimable scientific value. However, given the rubble-pile nature of the asteroid, these samples are often fragile, porous and made of a heterogeneous material consisting of micrometric to nanometric minerals and amorphous phases. These features represent an analytical challenge that requires innovative instrumentation and techniques. In this work, we show the application of different techniques involving scanning electron microscope (SEM), focused ion beam (FIB) and transmission electron microscope (TEM) to two grains (A0198 and C0091) in order to achieve a petrographic and mineralogical characterization of the asteroid Ryugu and expand to our comprehension about planetary phenomena that affect the C-type asteroids.

SEM images show textures that suggest aqueous alteration and different cycles of hydration-dehydration, e.g. fibrous phases, phyllosilicate flakes, sulfide dissolution, veining, framboidal magnetite and structures similar to mud cracks. More in-depth TEM observations, obtained crossing chemical analyses by energy-dispersive X-ray spectroscopy (EDS) and structural analyses by three-dimensional electron diffraction (3DED) [4], show amorphous carbonaceous matter, Fe-Mg silicates (both anhydrous and hydrate, e.g. olivine and phyllosilicates), Fe-oxides (magnetite and/or maghemite), Fe-sulfides (pyrrhotite and a single grain of troilite), pentlandite, Zn-sulfide (possibly wurtzite), Cr-oxide (possibly eskolaite), manganochromite, Mn-bearing dolomite, apatite, Ca-Na-Mg-phosphates (possibly merrillite), unidentified Fe-Ni-phosphides and a fibrous Fe-S-O phase (possibly tochilinite).

This research highlighted the analytical potential of using sophisticated techniques to analyse challenging samples of scientific value and the importance of developing innovative analytical protocols from the sample preparation to the data collection and processing.

References:

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