The surface evolution of Ryugu (Noguchi et al. 2022)

Airless surfaces of small bodies gradually alter in composition, structure, and optical properties through a collective process referred to as space weathering. Solar wind irradiation and high-velocity micrometeoroid bombardment are the main causes of space weathering. Thus far, space weathering of carbonaceous bodies has been poorly understood. The Ryugu samples show surface modifications of the phyllosilicate-rich matrix in ~6% of the fine grains from the first touch-down site and ~7% from the second touch-down site. Several distinct surface modifications are observed in scanning electron microscope (SEM) and (scanning) transmission electron microscope (STEM) analyses, including smooth layers, frothy layers, melt splashes, and their combinations (Fig. 3).

The smooth layers are continuous smooth sheets with completely amorphous structures. The iron is more reduced in the smooth layers than in the matrix. Ion irradiation experiments simulating solar wind exposure produced surface structures similar to those of the smooth layers. Solar wind irradiation therefore likely played a key role in forming the smooth layers. The frothy layers are composed of silicate glass containing abundant vesicles and submicroscopic iron sulfides. The internal structure suggests the melting of silicate and Fe–Ni sulfides and their immiscible separation, indicating that these structures formed by heating through micrometeorite bombardments. The depletion of structural –OH has been identified in both layers, suggesting that structural –OH in phyllosilicates is removed through dehydroxylation as space weathering proceeds. Approximately 40% of C-type asteroids do not show the 2.7-µm band features in their reflectance spectra; this is related to water absorption. Based on the analysis of the Ryugu samples, the absence of the 2.7-µm absorption band can be partly explained by surface dehydration resulting from space weathering, suggesting that asteroids showing apparently dry surfaces may have water-rich regions in their interiors.

REFERENCES