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Visible-IR and Raman spectra of three Itokawa particles

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Abstract

The present study characterizes the mineralogy and the extent of space weathering of three particles collected by the Hayabusa mission at the surface of asteroid 25143 Itokawa.

1. Introduction & methods

Hayabusa-returned samples offer a unique perspective to understand the link between asteroids and cosmomaterials available in the laboratory, and to provide insights on the early stages of surface space weathering. In this work we characterize the mineralogy and the extent of space weathering of the three Itokawa particles RA-QD02-0163, RA-QD02-0174, and RB-QD02-0213 provided by JAXA to our consortium. We report here a series of results based on non-destructive analyses through visible near-infrared reflectance and Raman spectroscopy. Results were obtained on the raw particles, both in their original containers and deposited on diamond windows.

2. Results

Particle RA-QD02-0163 consists of a heterogeneous mixture of minerals: olivine (Fo76) dominates an assemblage of Ca-rich (En50, Wo50) and Ca-poor (En85) pyroxenes. The elemental compositions of silicates are consistent with those previously reported for distinct Hayabusa particles. Particles RA-QD-0174 and RB-QD02-0213 are solely composed of olivine, whose chemical composition is similar to that observed in RA-QD02-0163. It has been previously shown that the S-type asteroid 25143 Itokawa is a breccia of poorly equilibrated LL4 and highly equilibrated LL5 and LL6 materials [1].

The three particles studied here can be related to the least metamorphosed lithology (LL4) based on the high Fo content of the olivine. Neither carbonaceous matter nor hydrated minerals were detected through Raman on the three allocated particles.

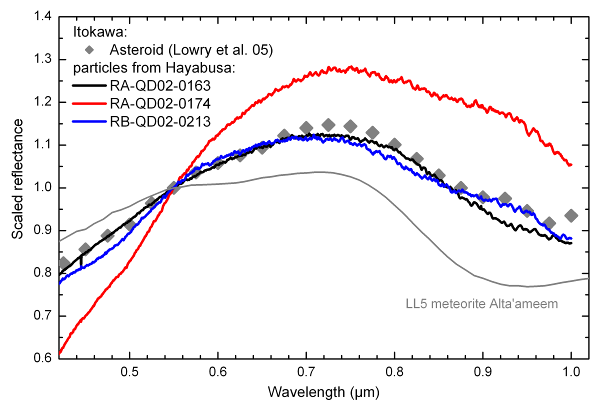

Figure 1: Comparison of the reflectance spectra of objects having experienced distinct extents of space weathering: our three Hayabusa particles [2], the laboratory spectrum of the Alta'ameem LL5 meteorite [3] and the ground-based spectra of asteroids Itokawa [4].

The NIR-VIS reflectance (incidence = 45°, light collection at e=0°) spectra of the three particles, in particular the 1-µm band, are consistent with the presence of both olivine and pyroxene detected via Raman. As shown in Figure 1, the spectra of particles RA-QD02-0163 and RB-QD02-0213 are also fully compatible with the ground-based observations of asteroid (25143) Itokawa in terms of both spectral features and slope. By contrast, particle RA-QD02-0174 has a similar 1-µm band depth but higher (redder) spectral slope than the surface of Itokawa.

This probably reveals a variable extent of space weathering among the regolith particles. RA-QD02-0174 may contain a higher amount of nanophase metallic iron and nanophase FeS. Such phases are produced by space weathering induced by solar wind, as previously detected on other Itokawa particles [5].

6. Summary and Conclusions

Identification of the minerals, characterization of their elemental compositions and measurements of their relative abundances were led through Raman spectroscopy in punctual and automatic mode. Reflectance spectra in the visible and near-IR wavelengths constrain the mineralogy of the grains and allow for direct comparison with the surface of Itokawa. The spectra reflect the extent of space weathering experienced by the three particles.

To go further in the characterization of space weathering and to better constrain the link between the spectral slope of reflectance spectra and the abundance of nanophase metallic iron, additional analytical techniques, such as STEM, need to be applied to image the Fe-rich nanoparticles.

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