An infrared look at Ryugu returned samples in the meteorite/asteroid perspective

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Laboratory analyses of materials originating from asteroids give us the opportunity to directly study the components that formed in the protoplanetary disk. However, collections of extraterrestrial materials available on Earth have strong biases, and the link between laboratory samples and their asteroidal parent bodies is often ambiguous. Furthermore, many classes of small bodies are likely absent from our collections [1]. Some of these limitations are overcome by sample return missions, such as Hayabusa2/JAXA that targeted and sampled the small and dark near-Earth asteroid Ryugu [2]. Ryugu has retained valuable information on the formation and evolution of planetesimals at different epochs of our Solar System history [3].

Samples originating from asteroids can be analyzed thanks to modern analytical techniques [4]. Among them, infrared spectroscopy is important for comparing lab measurements to remote sensing observations of small bodies. In addition, mid- and far-infrared (MIR, FIR) reflectance spectra of asteroids and meteorites contain fundamental vibrational bands which are diagnostic of their mineral and organic compositions. Infrared spectra of Ryugu were measured by NIRS3 on board Hayabusa2 in the near-IR range [5], however the MIR-FIR range was not available. The return of Ryugu samples collected by Hayabusa2 provide an excellent opportunity to measure the MIR-FIR spectra of Ryugu materials and to compare them with similar observations of meteorites and asteroid, in particular the remote sensing MIR-FIR spectra of B-type asteroid Bennu acquired by the OSIRIS-REx mission [6].

In this study we report IR reflectance measurements of two mm-sized Ryugu stones (A0026 and C0002), acquired at the SMIS beamline of synchrotron SOLEIL (France) and at Tohoku University (Japan), and we compare them with meteorite spectra acquired with similar setups, and with the available remote sensing spectra of different asteroids.

Generally speaking, the MIR and FIR reflectance spectra of the two Ryugu stones show similitudes with spectra of CI meteorites, both in terms of overall spectral shape and in terms of peak position of the main reststrahlen silicate features, although some differences are observed probably due to a different history of alteration (both in space and on Earth). The IR spectra of Ryugu samples are clearly different from those of CM meteorites and other ungrouped primitive meteorites. They also differ from the remote sensing spectrum of asteroid Bennu. Overall, the results indicate that Ryugu has both a mineral composition and a history of aqueous alteration that are more similar to those of CI chondrites than to those of CM chondrites and of asteroid Bennu. These observations confirm that Ryugu and Bennu, two small near-Earth asteroids that are so similar in many ways (size, morphology, density, etc.), have distinct IR spectra also in the mid-IR and far-IR, in agreement to what was previously shown in the near-IR range from orbital data [5,6].

Finally, the presence of different lithologies in C0002 [3] allows to trace the early evolution of Ryugu materials and the corresponding IR spectral variations. The parameters extracted from the micro-IR spectra of different clasts in C0002 draw an alteration pattern which is different from that of CM meteorites [7,8], and which helps to reconsider the general asteroid-meteorite connection in a different perspective.

References

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