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Distribution of the spectral slope in the NIR range of the Ryugu surface

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Abstract

The Near-Earth asteroid 162173 Ryugu is the target of the JAXA sample return Hayabusa2 mission, which arrived at the asteroid in June 2018 and will analyse the surface until December 2019. Reflectance spectra of the Ryugu surface, acquired by the NIRS3 spectrometer (Near-Infrared Spectrometer), revealed a dark object with a positive slope, ranging from 0.10 to 0.29. A detailed analysis about areas with different spectral slopes has been performed, with the aim to detect physical/chemical variations and better constrain the history of Ryugu.

1. Introduction

The JAXA/Haybusa2 spacecraft is studying the 162173 Ryugu asteroid since June 2018, obtaining reflectance spectra of the asteroid's surface by means of the NIRS3 spectrometer. The NIRS3 observations of 10, 11 and 19 July 2018, taken from an altitude of 20 km (Home Position) and 13 km, cover almost the entire asteroid surface, with a spatial resolution of 40 m and 20 m, respectively. A 2.7 μm band is present in NIRS3 spectra, related to the symmetric stretching of hydroxyl group (OH) [1]. The Ryugu surface is homogeneously dark with the moderate occurrence of hydrated minerals [1]. Areas with different spectral slope were analysed in this work, in order to reveal more detailed information about the physical properties and/or chemical composition of the Ryugu surface, in turn related to the processes experienced by Ryugu and the parent body from where it formed.

2. Procedure

The spectral slope, evaluated between 1.9 and 2.5 μm, was retrieved for each pixel of NIRS3 data (photometrically and thermally corrected), acquired on the 10 and 11 July 2018 and on the 19 July 2018. The values are included between 0.10 and 0.29 whereas the mean value (MS) of Ryugu surface is about 0.163. Different families of slope were defined in order to observe spectral variations: starting from the mean value of Ryugu's slope, 4 "bluer" families and 8 "redder" families were identified. All these families are characterized by positive spectral slope, but the "redder" families are those with a higher value than the MS and the "bluer" families have lower slope value than MS. The R1 family includes areas with a spectral slope between the MS and slope greater than the 10% of MS; the R2 family includes areas with spectral slope larger, between 10% and 20% of MS, and so on. The last "redder" family is R8, where the slope is between the 70% and 80% of MS. The "bluer" B1 family, contrarily to R1, is characterized by areas with a slope included between a value less than the 10% of MS and the MS; the B2 family shows value between a value less than the 10% and 20% of MS. The family B4 is the most "bluer" family, with value included between a value less than the 30% and the 40% of MS. In table 1, the slope families are summarized.

Family	Range of slope	Range of slope values
B1	-10%MS/MS	0.146-0.163
B2	-20%MS/-10%MS	0.130-0.146
B3	-30%MS/-20%MS	0.114-0.130
B4	-40%MS/-30%MS	0.103-0.114
R1	MS/+10%MS	0.163-0.179
R2	+10%MS/+20%MS	0.179-0.195
R3	+20%MS/+30%MS	0.195-0.211
R4	+30%MS/+40%MS	0.211-0.227
R5	+40%MS/+50%MS	0.227-0.243
R6	+50%MS/+60%MS	0.243-0.260
R7	+60%MS/+70%MS	0.260-0.276
R8	+70%MS/+80%MS	0.276-0.290

Table 1: Definition of Ryugu spectral slope.

3. Spectral analysis of families

The mean spectrum of R8 family (red) and B4 family (blue) are shown in Figure 1, compared with the mean spectrum of Ryugu surface (black). The mean value of spectral slope was estimated for each family, in addition to other parameters, such as the depth of 2.7 μm band, the reflectance value at 1.9 μm, temperature, latitude and longitude.

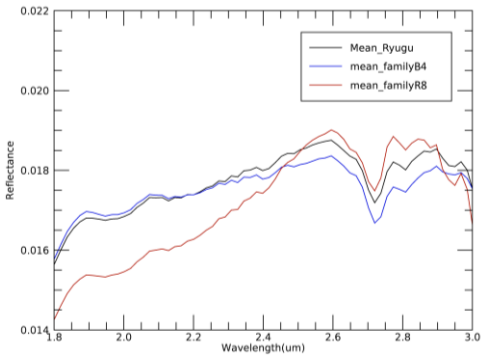

Figure 1: Mean spectrum of the R8 family (red) and of the B4 family (blue) compared with the Ryugu mean spectrum (black spectrum).

A dichotomy between northern and southern hemisphere emerges, revealing "bluer" areas in the northern hemisphere and "redder" areas in the southern one. In particular, "redder" areas are mainly related to impact features, such as crater floor, crater wall and crater rim. The R8 family is, nonetheless, localized in the Ejima saxum, which lies at 30 °S in latitude and at about 105°E in longitude.

Strong anti-correlations emerge between spectral slope and 2.7-μm band depth (Pearson coefficient is -0.84) and between spectral slope and reflectance at 1.9 μm (Pearson coefficient is -0.86). In Figure 2 is shown the scatterplot of slope vs reflectance at 1.9 μm for all families (green diamonds) and mean Ryugu (red diamond).

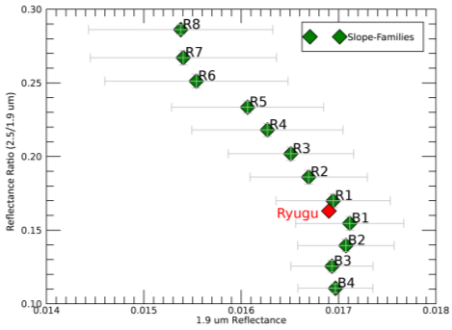

Figure 2: Scatterplot of slope (estimated between 1.9 and 2.5 μm) vs reflectance (at 1.9 μm) for "bluer" and "redder" families (green diamonds) and for mean Ryugu (red diamond).

Consequently, areas with higher slope values appear to be darker and with a weaker OH-band, whereas areas with flatter slope are brighter and richer in hydrated minerals.

Dark objects as Ryugu are supposed to become brighter and bluer with space weathering processes [2]: the Ryugu surface is bluer-sloped, mainly included in the B1 family, suggesting an altered surface as consequence of space weathering. Areas with "redder" slope could be probably composed by fresher material which experienced a dehydration as consequence of crater's formation.

References

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