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Possible Hydrated Minerals on Pole Regions of (162173) Ryugu by ONC-T Observations.

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Abstract

C-type asteroids are one of the possible carriers of water to the Earth. To discuss the possibility of this scenario, it is important to find indications of hydrated minerals on C-type asteroids in-situ. First reports of remote-sensing observations by ONC-T and NIRS3 indicated that the asteroid (162173) Ryugu is a moderately dehydrated asteroid, which suggests Ryugu does not possess a large amount of hydrated minerals on its surface [1,2]. However, we have continued the intensive investigations of the 0.7-μm band absorption by ONC-T, the telescopic optical navigation camera [3], and found a slightly deeper 0.7-μm band absorption in the pole regions, suggesting the possibility of more hydrated minerals in pole regions. This suggests a scenario of dehydration or space weathering by solar irradiation in the past. Thus, Ryugu might possess more hydrated minerals than it appears. This also leads to possible connections between Ryugu and Bennu.

1. Introduction

The Japanese spacecraft Hayabusa2 started its investigation of the C-type asteroid Ryugu on June 2018. Hayabusa2 is equipped with a multiband camera, ONC-T. ONC-T has 7 color filters; ul: 0.40 μm, b: 0.48 μm, v: 0.55 μm, Na: 0.59 μm, w: 0.70 μm, x: 0.86 μm, p: 0.95 μm. Using those filters we can measure spatial variations in spectral slope, or band absorptions, which are important indices for surface processes, such as space weathering, aqueous alteration, and heating. Aqueous alteration and dehydration processes are especially indicated by a 0.7-μm band absorption, which is attributed to an Fe^{2+} to Fe^{3+} charge-transfer transition in oxidized iron in phyllosilicates [4]. ONC-T is capable of measuring this absorption feature by observing in the v (0.55 μm)-, w (0.70 μm)-, and x (0.86 μm)-bands with SNR~2 [3]. In this study, we measured 0.7-μm band absorption based on the images obtained from an altitude of ~5 km at phase angles between 15 – 18 degree.

2. Data reduction

A series of pole region observations were conducted at an altitude of ~5 km (spatial resolution of 0.5 m/pixel) on 28 February to 1 March on 2019. Because the observations were conducted after the first touch-down, we needed to carefully investigate the degradation of the optical system of the ONC-T due to dust from the touch-down operation settling on the camera optics. Based on the flat-field lamp observation and the 20-km altitude observations of Ryugu, the degradation of absolute sensitivity of ONC-T was estimated to be 3 to 5%. However, the change in relative sensitivities normalized by v-band was measured to be within 0.5%. Furthermore the flatness of sensitivity over the image did not change very much, even there are several darkened spots possibly caused by dusts on the lens. Thus, the effect on the measurement of the 0.7-μm band absorption is very small. Radiance factors (I/F) were calculated using the calibration described in [3]. Note that we used the updated flat-fields [5] to reduce the fringe pattern in the original flat-fields. Moreover, we also implemented the radiator stray-light reduction described in [3]. We measured the degree of the 0.7-μm band absorption using the relationship

$$d_{0.7} = 1 - \frac{3.1R_w}{1.6R_v + 1.5R_x} \quad (1)$$

where R_v, R_w, and R_x indicate the radiance factor at v-, w-, and x-bands, respectively. After conducting the calculation on a pixel-by-pixel resolution, we took the median value of 8 x 8 pixel boxes in order to reduce statistical noise. We also measured the b-to-x spectral slope using the same methods as [1].

3. Results

Figure 1 shows the 0.7-µm band absorption and b-to-x spectral slope on both the north and south poles. The pole regions have bluer spectra, i.e., negative spectral slope, than other low latitudinal regions. At the same time, some of the bluer regions are showing a deeper absorption at 0.7 µm. Specifically, some boulders on the north pole and the Otohime boulder on the south pole exhibit stronger absorption compared with adjacent regions. Although there are still random noise and shadows to be carefully removed, the relative positiveness of the absorption on the polar boulders is considered real. This 0.7-µm band absorption may indicate the presence of more hydrated minerals at the pole regions.

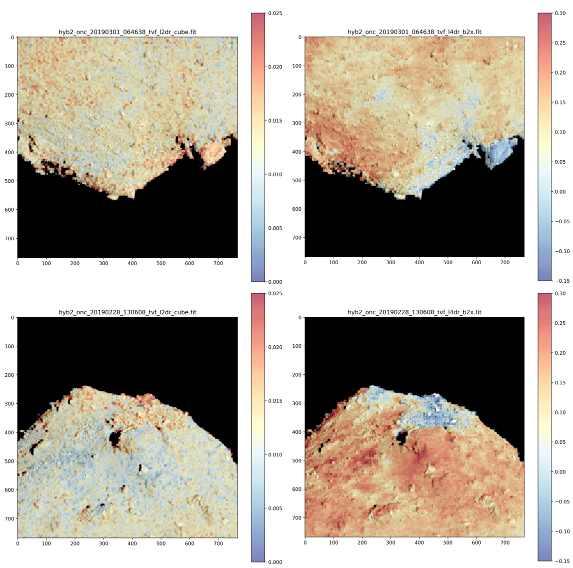

Figure 1. The 0.7-µm band absorption maps (left) and b-to-x spectral slope maps (right) for the north pole (top) and the south pole (bottom).

4. Discussions

Discovering a slightly deeper 0.7-µm band absorption in the pole regions can be related to solar irradiation of the surface. Calculations of the solar photon flux to the entire surface of Ryugu shows that the irradiation rate of the pole regions is ~5 times less than that of the equatorial ridge in the asteroid's current orbit and pole position. Thus, 0.7-µm band absorption could be weaken and the spectral slope could become redder due to the heat and/or solar wind from the Sun. If this is the case, there would be more hydrated material inside of Ryugu than how it appears on the surface. Moreover, the bluer regions are spectrally similar in the visible to the near-earth asteroid Bennu which is the target asteroid for OSIRIS-REx [6]. More hydration and blueness of the spectra for less irradiated boulders suggest that Ryugu and Bennu could be siblings that had different orbital histories or different creation time. Future NIRS3 observations may provide a stronger constraint to distinguish between these scenarios.

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References

[1] Sugita, S. et al.: The geomorphology, color, and thermal properties of Ryugu: Implications for parent-body processes, Science Vol. 364, eaaw0422, 2019.

[2] Kitazato, K. et al.:The surface composition of asteroid 162173 Ryugu from Hayabusa2 near-infrared spectroscopy, Science Vol. 364, pp. 272-275, 2019.

[3] Tatsumi, E. et al.: Updated inflight calibration of Hayaubsa2's optical navigation camera (ONC) for scientific observations during the cruise phase, Icarus Vol. 325, pp. 153-195, 2019.

[4] Vilas, F. and Gaffey, M.J.: Phyllosilicate Absorption Features in Main-Belt and Outer-Belt Asteroid Reflectance Spectra, Science Vol. 246, pp. 790-792, 1989.

[5] Tatsumi, E. et al.: Updated flat-fields of ONC-T/Hayabusa2 based close encounter with Ryugu, 50th Lunar and Planetary Science Conference, #1745, 2019.

[6] Lauretta, D. et al.: The unexpected surface of asteroid (101955) Bennu, Nature Vol. 568, pp. 55-60, 2019.