EPSC Abstracts
Vol. 13, EPSC-DPS2019-337-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Statistical analysis of spectrophotometry and spectra of (162173) Ryugu

M.A. Barucci(1), P.H. Hasselmann(1), M. Fulchignoni(1), R. Honda(2), Y. Yokota(3, 2), S. Sugita(4, 14), K. Kitazato(5), J.D.P. Deshapriya(1), D. Perna(6, 1), E. Tatsumi(4), D. Dominique(17), T. Morota(7), S. Kameda(8), T. Iwata(3, 17), M. Abe(3, 17), M. Ohtake(3, 17), S. Matsuura(9), M. Matsuoka(3), T. Hiroi(10), T. Nakamura(11), T. Kouyama(12), H. Suzuki(13), M. Yamada(14), N. Sakatani(3), C. Honda(5), K. Ogawa(15), M. Hayakawa(3), K. Yoshioka(4), Y. Cho(4), H. Sawada(3), D. Takir(16), F. Vilas(17), N. Hirata(5), N. Hirata(15), Y. Yamamo(3), S. Tanaka(3), M. Yoshikawa(3, 18), S. Watanabe(7, 3), and Y. Tsuda(3, 18)

(1) LESIA, Observatoire de Paris, PSL Research University, CNRS, Univ. Paris Diderot, Sorbonne Paris Cité, UPMC Univ. Paris 06, Sorbonne Universités, 92195 Meudon, France (antonella.barucci@obspm.fr) (2) Kochi University, Kochi 780-8520, Japan, (3) ISAS, JAXA, Sagamihara 252-5210, Japan, (4) The University of Tokyo, Tokyo 113-0033, Japan ; (5) The University of Aizu, Aizu-Wakamatsu 965-8580, Japan, (6) INAF, Osservatorio Astronomico di Roma, Monte Porzio Catone 00078, Italy, (7) Nagoya University, Nagoya 464-8601, Japan, (8) Rikkyo University, Tokyo 171-8501, Japan, (9) Kwansei Gakuin University, Hyogo 662-8501, Japan, (10) Brown University, Providence, RI 02912, USA, 11 Tohoku University, Sendai 980-8578, Japan, (12) AIST, Tokyo 135-0064, Japan, (13) Meiji University, Kawasaki 214-8571, Japan,(14) Chiba Institute of Technology, Narashino 275-0016, Japan, (15) Kobe University, Kobe 657-8501, Japan, (16) Jacobs/NASA Johnson Space Center, Houston, TX 77058, USA, (17) Planetary Science Institute, Tucson, AZ 85710, USA, (18) SOKENDAI (The Graduate University for Advanced Studies), Hayama 240-0193, Japan.

Abstract

We studied the visible and near-infrared spectral behaviour of the Ryugu surface using the G-mode multivariate statistical method, aiming to distinguish spectral homogeneous groups in order to individuate heterogeneities and to constrain the surface composition variation.

1. Introduction

From late June 2018, the JAXA asteroid sample return mission Hayabusa2 acquired a huge quantity of resolved images and spectra of the surface of the asteroid (162173) Ryugu [1]. Two instruments, the optical navigation camera (ONC) and the near-infrared spectrometer (NIRS3) are devoted to investigate the surface composition variations mapping the complete surface of Ryugu. The asteroid shows a surface rich in geological structures. The ONC images revealed a large quantity of morphological features, impact craters, and an abundance of boulders with the largest one, Otohime Saxum, of about 160m [2]. The telescopic camera ONC-T obtained spectrophotometric data by imaging Ryugu with seven broad band filters spanning from 0.40 to 0.95 μm at different surface resolutions.

The near-infrared spectrometer NIRS3 acquired reflectance spectra in the wavelength from 1.8 to 3.2 μm range operating in scanning mode [3]. The spectral data show a weak positive spectral slope in the first part of the spectra and a clear weak narrow absorption band at 2.72 μm, detected across the whole observed surface. No meteoritic samples seem to have reflectance spectra to match perfectly those of the Ryugu's surface obtained at the same wavelengths. The absorption band indicates the presence of hydroxyl OH-bearing minerals all over the surface, associated to Mg-rich phyllosilicates [3]. Possible similarities have been found with the spectra of thermally-metamorphosed CI chondrites and shocked CM chondrites.

The spectral and spectrophotometric data show almost homogeneous surface with small variations. A detailed analysis has been conducted to study more in depth any possible small surface compositional variation and to support the landing and sampling sites selection.

2. Method

In order to determine and interpret the difference in the asteroid surface spectral behaviour, we apply the G-mode multivariate statistical analysis [4, 5] to a set of pixels containing the information of i) the visible ONC spectrophotometry and ii) the NIRS3 spectral data. This method allows the user to obtain an automatic statistical clustering of a sample containing N objects (in this case the pixels) described by M variables (the normalized reflectance of each filter

for the ONC data and those of a selected set of wavelengths for the NIRS3 data) in terms of homogeneous groups without any priori criteria and taking into account the instrumental errors in measuring each variable.

We used the normalized reflectance measured in the seven band filters with their calibration and errors. The data have been co-registered and photometrically corrected as described by [2, 6]. For the NIRS3 data, we used the spectra (thermally and photometrically corrected as described by [3] collected on July 11 and July 19 which allowed to obtain near-global coverage at a spatial resolution of 40m/px and 20m/px, respectively.

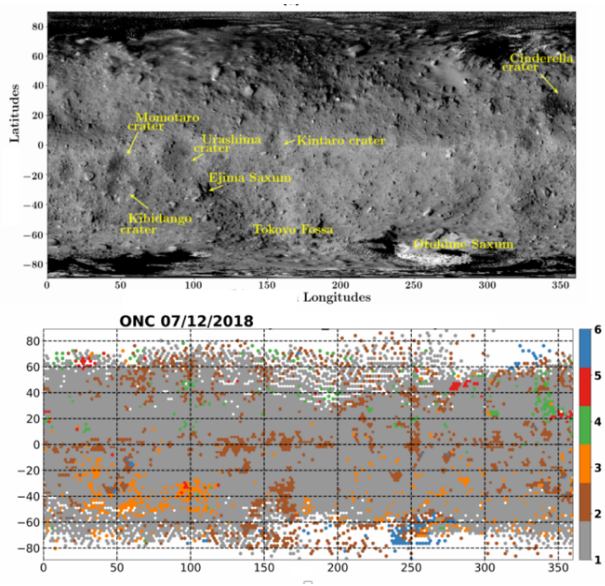

Figure 1: Distribution of several groups obtained by multivariate statistical analysis compared to the geological map obtained by Sugita et al. (2019).

3. Results

The analysis of both ONC and NIRS3 data allows us to highlight small spectral variation on the Ryugu surface. At 3σ confidence level only two groups are evident with both instruments, confirming a very homogeneous surface with slightly different small areas including about 3% of the analyzed data. Decreasing the confidence level, small groups are detected showing a clear dichotomy between the East and West hemispheres and between North and South hemispheres. From the ONC data, which has much complete coverage and high spatial resolution, some young surfaces are well highlighted in the equatorial ridge and particularly in specific areas (Fig. 1). Hayabusa2 is still working and more detailed data both with ONC and NIRS3 instruments will be available.

4. Conclusions

Ryugu is a very dark asteroid with very small variations in albedo and spectral (visible and near infrared) properties. It is very likely that it comes from the reaggregation of a fragmented parent body with some slightly fresh material on its surface. The similarity of the Ryugu's spectra with those of thermally-metamorphosed CI chondrites and shocked CM, and the found dichotomy (East-West and North-South hemispheres) with the small differences on the spectra could be associated to some material of the parent body less thermally altered.

Acknowledgements

We thank the Haybusa2 JAXA teams for their efforts in making the mission successful. Hayabusa2 was developed and built under the leadership of JAXA, with contributions from the DLR and the CNES, and in collaboration with NASA, Nagoya University, University of Tokyo, National Astronomical Observatory of Japan, Aizu University, Kobe University, and other universities, institutes, and companies in Japan. This study was supported by JSPS International Planetary Network. MAB, PH, JDPD and MF acknowledge funding support from CNES. DP has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie actions (grant agreement n. 664931).

References

[1] Watanabe, S., Hairabayashi, M., Hirata, N. et al., Science, 364, 268, 2019.

[2] Sugita, S., Honda, R., Morota , R., et al., Science, 364, 252, 2019.

[3] Kitazato, K., Milliken, R., Iwata, T. et al. Science, 364, 272, 2019.

[4] Barucci, M.A., Capria, M.T., Coradini, A. et al. Icarus 72, 304, 1987.

[5] Barucci, M.A., Belskaya, I., Fulchignoni, M.et al. AJ 130, 1291, 2005.

[6] Honda, R. Yokota, Y, Tatsumi, E. et al. , LPSC #50, 2901, 2019.