GAUSSIAN DECONVOLUTION OF THE 2.7-MICRON BAND OF HAYABUSA2/NIRS3 SPECTRUM OF ASTEROID RYUGU – POSSIBLY A HEAVILY SPACE-WEATHERED CM CHONDRITE BODY.

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Introduction: Last year we developed a method to remove the effect of adsorbed telluric water from the 3-µm absorption band of carbonaceous chondrite (CC) samples [1] based on a heating experiment in vacuum similar to [2]. In this study, our method has been applied to a larger number of CC samples and a spectrum of asteroid 162173 Ryugu obtained recently by the Near-InfraRed Spectrometer (NIRS3) onboard JAXA Hayabusa2 spacecraft in order to derive its surface composition, specifically the CC counterpart.

Experimental: In addition to one CI1, two CM2, one CR2, and Tagish Lake samples studied last time [1], reflectance spectra (2.5-4 µm) of Kaidun and 14 CM chondrite powder samples were taken from the RELAB database [3]. Also, newly measured were spectra of MET 00639 (shocked CM2) powder and MIL 13005 (CM1/2) chip samples, Y-793595 (CM2) pellet sample irradiated with pulse laser, and Murchison (CM2) pellet sample irradiated with UV light [4] using the bidirectional spectrometer, ASD Fieldspec3 spectrometer, and Thermo Nexus 870 FT-IR spectrometer with PIKE AutoDiffuse biconical reflectance accessory at RELAB. NIRS3 data of Ryugu obtained on November 14, 2018 were thermally corrected and calibrated [5] into 2,650 reflectance spectra, which were averaged for analysis in this study.

Method: In the same manner as in [1], natural log reflectance spectra of all meteorite samples were deconvolved into 8-9 Gaussians (2 for hydroxyl, 4 for adsorbed water, and 2-3 for organics) and a linear continuum background in wavenumber over the wavelength range of 2.68-3.8 µm. All the bands except the first two absorption bands near 2.72 and 2.76 µm in wavelength due to the structural hydroxyl group were removed from each natural log reflectance spectrum, and those two bands and the continuum background were converted back to a reflectance spectrum. Then, the model dry-state spectrum was resampled into a simulated NIRS3 spectrum, which was deconvolved again into two Gaussians and a continuum background. Actual Ryugu average spectrum on November 14, 2018 was also deconvolved in the same manner.

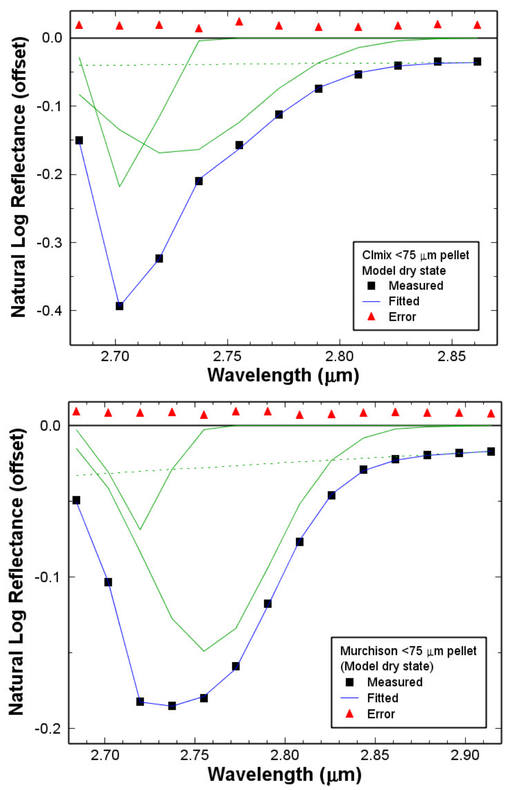

Fig. 1. Examples of Gaussian deconvolution of simulated NIRS3 spectra of CC (CI1 and CM2) samples.

Results: Shown in Fig. 1 are examples of Gaussian deconvolution of model dry-state reflectance spectra of CI and CM chondrite samples. In spite of much lower wavelength resolution of NIRS3 than in the laboratory, their differences in band peak wavelength positions and relative band strength are clearly distinguished.

Surprisingly, as shown in Fig. 2, deconvolving the Ryugu spectrum took five Gaussians instead of two for a reasonable quality fit. Corresponding to the CC deconvolution results, the 2.72 and 2.76 µm absorption bands are called as Band 1 and Band 2 below.

Their obtained band center and width values of Bands 1 and 2 are plotted in Figs. 3 and 4, and their centers and relative strengths are plotted in Fig. 4. In terms of the band center values, Bells (anomalous CM) and Cold Bekkeveld (CM2) are the closest to Ryugu.

Summary: Based on Band 1 and 2 center values, Ryugu is most likely made of a CM chondrite material, which must be heavily space-weathered based on its darkness and flat spectrum and band width and strength shifts from CMs. Among the normal CMs showing 0.7-µm band, Cold Bokkevelt may be the most similar to Ryugu. The fact that Ryugu shows absorption bands beyond 2.8 µm may suggest the presence of adsorbed water or unknown modes of hydroxyl absorption.

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References: [1] Hiroi T. et al. (2018) *LPS XLIX*, Abstract #1056. [2] Takir D. et al. (2013) *Meteoritics Planet. Sci. 48*, 1618. [3] RELAB database: www.planetary.brown.edu/relab/. [4] Kaiden H. et al. (2018) *Symp. Polar Sci. 9th*, Abstract #106. [5] Matsuoka M. et al. (2017) *Earth, Planets & Space 69*, 120.

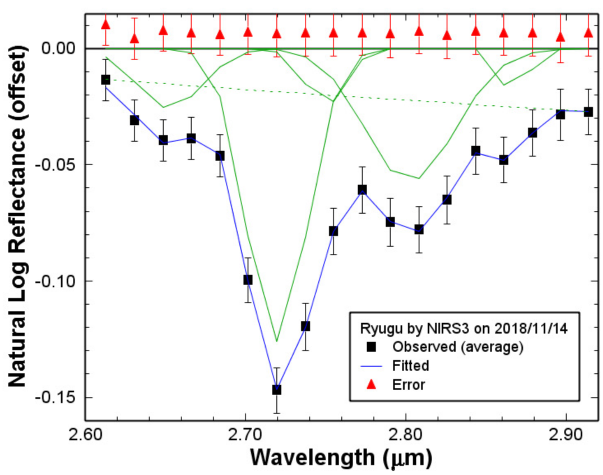

Fig. 2. Gaussian deconvolution of average NIRS3 spectrum of asteroid Ryugu on November 14, 2018.

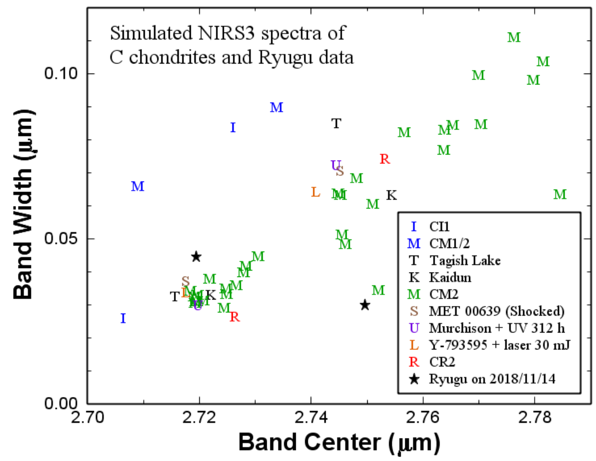

Fig. 3. The center and width values of Band 1 and Band 2 of CC samples and average Ryugu.

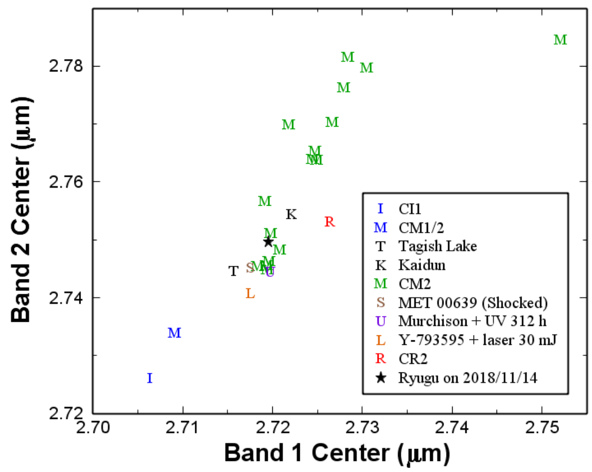

Fig. 4. Band 1 center vs. Band 2 center values of CC samples and average Ryugu.

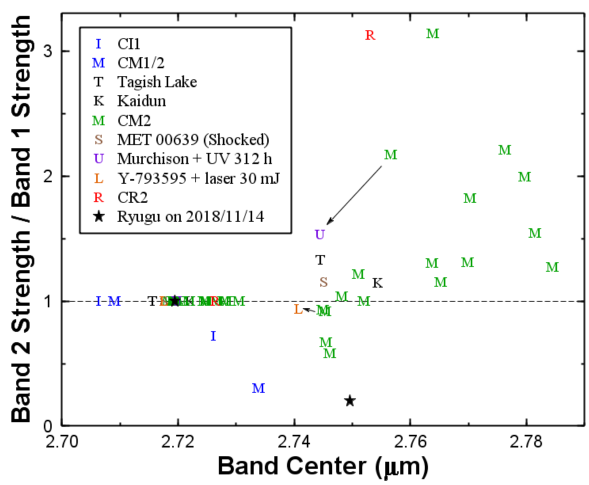

Fig. 5. The center and relative strength values of Band 1 and Band 2 of CC samples and average Ryugu.