ESTIMATING THE CARBON CONTENTS AND DISTINGUISHING THE TYPES OF CARBONACEOUS CHONDRITES BY SPECTRAL INSTRUMENTS ONBOARD HAYABUSA2 SPACECRAFT. T. Hiroi[1,2], H. Kaiden[2], N. Imae[2], A. Yamaguchi[2], H. Kojima[2], S. Sasaki[3], M. Matsuoka[4], T. Nakamura[4], Carlé M. Pieters[1], [1]Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, RI 02912, USA (takahiro_hiroi@brown.edu), [2]Antarctic Meteorite Laboratory, National Institute of Polar Research, Tachikawa, Tokyo 190-8518, Japan, [3]Department of Earth and Space Sciences, Osaka University, Toyonaka, Osaka 560-0043, Japan, [4]Department of Earth and Planetary Materials Sciences, Tohoku University, Sendai, Miyagi 980-8578, Japan.

Introduction: Hayabusa2 spacecraft has two onboard instruments, Optical Navigation Camera - Telescopic (ONC-T) and Near-InfraRed Spectrometer (NIRS3) whose data can reveal the compositional information of the target C-type asteroid Ryugu. ONC-T is a multiband imaging camera, having 6 color filters at 390, 480, 550, 700, 860, and 950 nm [1]. NIRS3 is a single-pixel spectrometer, covering a wavelength range of 1.8-3.2 μm with 20 nm resolution [2]. We have studied how to estimate the carbon contents and distinguish the types of carbonaceous chondrite (CC) regoliths using select spectral bands of these instruments.

Experimental: Visible and near-infrared (VNIR) reflectance spectra (0.3-3.6 μm) of about 20 fresh CC power samples were taken from RELAB database [3]. In addition, a similar spectral set of about 50 CC chip samples stored at NIPR taken by our recent VNIR spectral survey [4] was also utilized as a reference. Carbon abundances of fresh CC powder samples whose visible spectra are available in RELAB database were taken from [5, 6, 7] and references therein.

Method: Shown in Figs. 1 are RELAB spectra of fresh CC powder samples over the wavelength range corresponding to Hayabusa2 ONC-T and NIRS3. Each VNIR spectrum was resampled into simulated ONC-T and NIRS3 spectral band data. For practical purposes, only four bands were chosen for each instrument: 390, 550, 700, and 860 nm for ONC-T, and 2650, 2800, 2950, and 3100 nm for NIRS3. For our analyses, the following band strength (*BS*) parameters are defined:

$$BS_{UV} = lnR_{390} - lnR_{550}$$
$$BS_{700} = lnR_{700} - (160\, lnR_{550} + 150\, lnR_{860}) / 310$$
$$BS_{2800} = lnR_{2800} - lnR_{2650}$$
$$BS_{2950} = lnR_{2950} - lnR_{2650}$$

where R_λ denotes reflectance at λ nm in wavelength.

Also, the four band data were normalized by one band data (550 nm for ONC-T, and 2650 nm for NIRS3) in our principal component anaalysis (PCA), employing only three band ratio data as the PCA variables for each instrument.

Select Results: Shown in Fig. 1 is a plot of the RELAB 390 nm reflectance value vs. the total carbon contents of fresh CC powder samples. Distributions of carbon contents by different studies are expressed as the mean and standard deviation (error bar) values. There appears to be an excellent negative correlation.

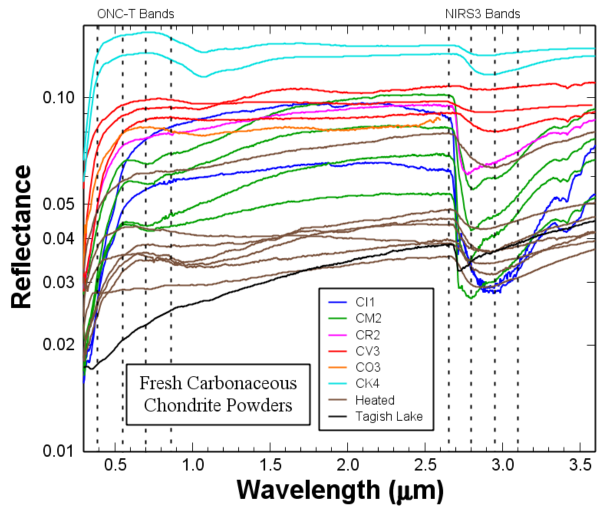

Fig. 1. RELAB reflectance spectra of fresh CC powders plotted with select bands of Hayabusa2 ONC-T and NIRS3.

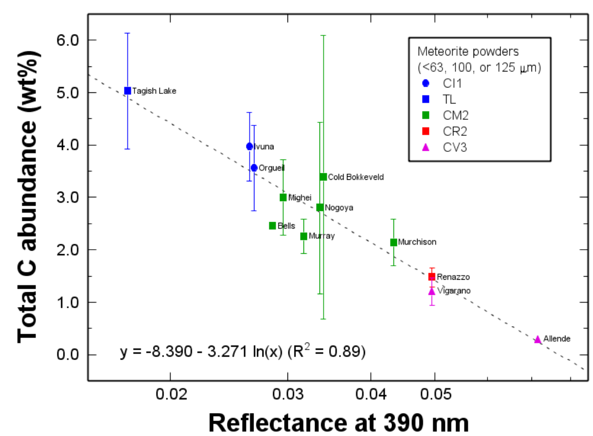

Fig. 2. RELAB 390 nm reflectance values [3] vs. total carbon contents [5, 6, 7] of fresh CC powders.

Shown in Figs. 3 and 4 are plots of the UV vs. 700 nm band strengths, and the 2800 nm band strength vs. the 2950 nm / 2800 nm band strength ratio of fresh CC powder spectra in Fig. 1, respectively. They suggest that ONC-T could distinguish up to four groups of CC types: CI, CM, CR, and others, while NIRS3 could distinguish up to six groups: CI, CM, CR, Tagish Lake, CV/CK, and the dehydrated.

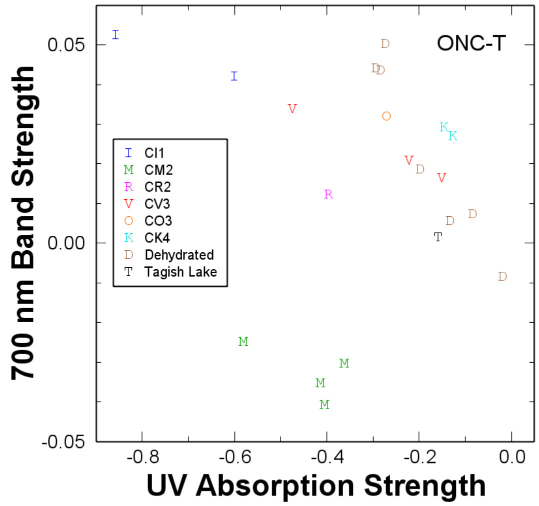

Fig. 3. ONC-T band strength plot of fresh CC powders.

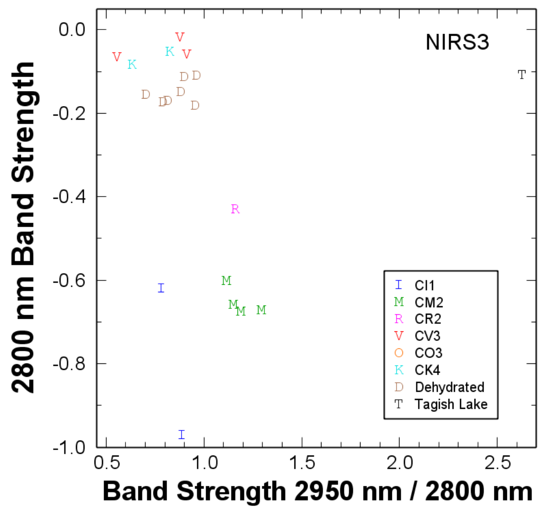

Fig. 4. NIRS3 band strength plot of fresh CC powders.

On the other hand, shown in Figs. 5 and 6 are plots of the principal components (PCs) 1 and 2 for the simulated three band ratios of ONC-T and NIRS3, respectively. They suggest that ONC-T could distinguish up to four groups: CI, CM, Tagish Lake, and others, while NIRS3 could distinguish up to six groups: CI, CM, CR, Tagish Lake, CV/CK, and the dehydrated.

Discussion: Space weathering may increase the UV reflectance and decrease the spectral slope [8, 9, 10] of hydrous CC regoliths, affecting the ONC-T results. Furthermore, adsorbed (telluric) water, which would not exist on a small asteroid such as Ryugu, may have systematic effects on these NIRS3 results.

Summary: The most pristine CC materials that are rich in carbon and low in the degree of space weathering can be identified based on the lowest 390 nm reflectance. In that case, even four select spectral bands each of ONC-T and NIRS3 onboard Hayabusa2 together could distinguish up to six groups of CC types.

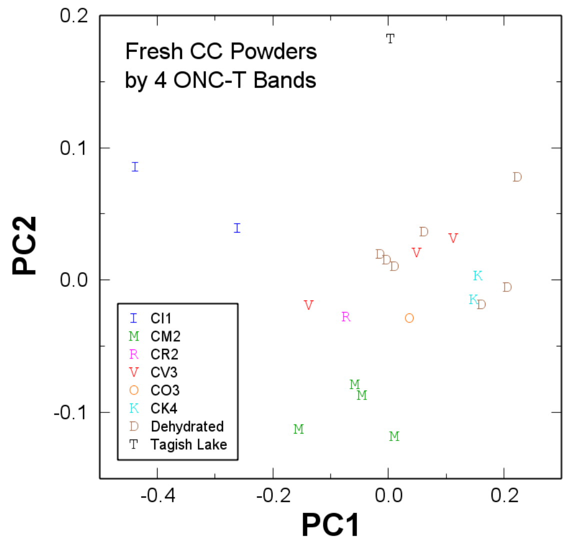

Fig. 5. Plot of principal components 1 and 2 for three scaled ONC-T bands of fresh CC powders.

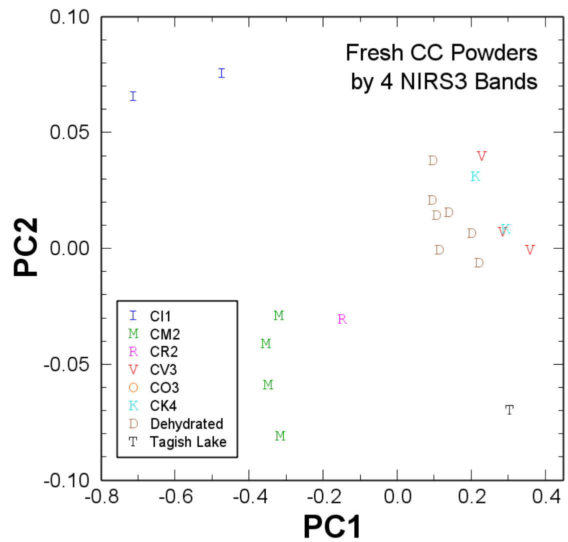

Fig. 6. Plot of principal components 1 and 2 for three scaled NIRS3 bands of fresh CC powders.

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