GAUSSIAN DECONVOLUTION OF THE 3-MICRON HYDRATION BAND OF CARBONACEOUS CHONDRITES FOR IDENTIFYING THEIR PARENT BODIES USING A SPECTROMETER IN SPACE.

T. Hiroi[1], Ralph E. Milliken[1], H. Kaiden[2], S. Sasaki[3], M. Matsuoka[4], T. Nakamura[4], [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: Carbonaceous chondrite (CC) meteorites are believed to come from relatively primitive minor planets such as the C-complex asteroids. The first prominent spectral features of CCs is in the 2.7-3.6 μm region where absorption bands due to hydroxyl group, water, and organics appear. CCs are known to show varying features in this 3-μm band according to their types and compositions. Although every CC sample should ideally be measured in a dry state where adsorbed telluric water is removed [1, 2], deconvolving the band into its component absorption bands may also allow removing the effect. In this study, such an attempt has been made using Gaussian (by wavenumber) functions in view of its application to expected data of asteroid 162173 Ryugu to be collected by the Near-InfraRed Spectrometer (NIRS3) onboard Hayabusa2 spacecraft [3].

Experimental: Reflectance spectra (2.5-4 μm) of powder or pressed pellet samples of CCs (CImix: Ivuna-Orgueil mixture, Murchison (CM), Y-793595 (CM), Renazzo (CR), and Tagish Lake) have been either newly measured using a Thermo Nexus 870 FT-IR spectrometer with a biconical diffuse reflectance accessory at RELAB or taken from the RELAB database [4]. Reflectance spectra of unheated CC samples obtained for this study are plotted in Fig. 1. Another CImix pellet sample was also measured after being heated at 200C in low vacuum using a Bruker Vertex 70v FT-IR spectrometer at Tohoku University to examine its spectral change due to the loss of adsorbed water. Its spectral change in the natural log reflectance scale is depicted in Fig. 2.

Method: As shown in Fig. 2, the effect of adsorbed water in the ambient air mostly lies in the longer wavelength region starting around 2.8 μm. Therefore, if the composite 3-μm absorption band is deconvolved into individual absorption bands, it may be possible to derive the absorption bands solely due to the CC sample itself (mostly structural hydroxyl group) to recreate the likely reflectance spectrum of its parent body such as a C-complex asteroid. Although the true absorption band shape of adsorbed water is probably not Gaussian [5], just for practical purposes a linear continuum background and Gaussian functions by wavenumber has been used in this study.

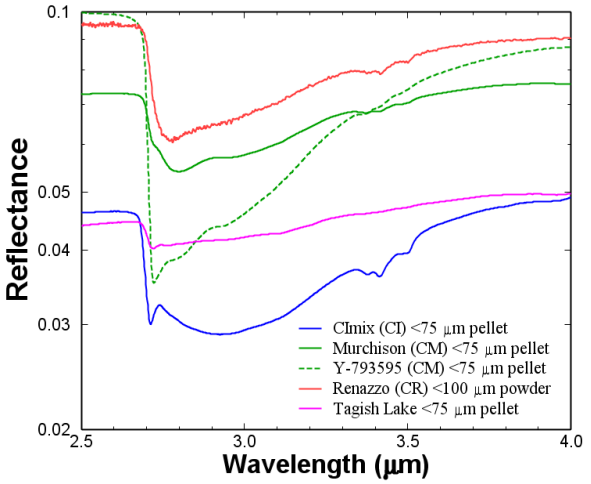

Fig. 1. Biconical reflectance spectra of powder or pressed pellet samples of carbonaceous chondrites.

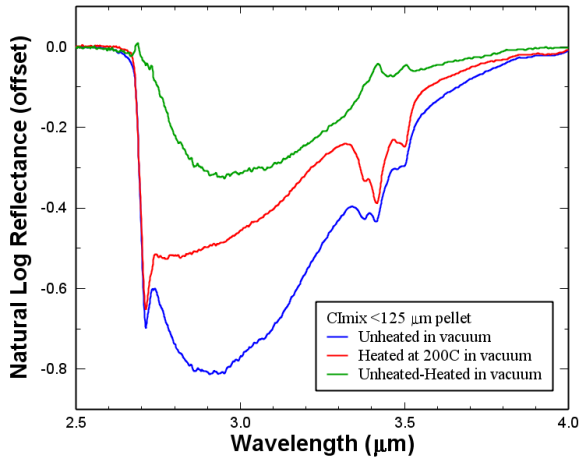

Fig. 2. Spectral change in natural log reflectance of another CImix pellet sample by heating at 200C in low vacuum.

Results: Two examples of Gaussian deconvolution of CC spectra (CImix and Murchison in Fig. 1) are shown in Fig. 3. These deconvolution calculations used two Gaussians for the short-wavelength hydroxyl bands, four Gaussians for the longer water bands, and three Gaussians for the organic C-H bands. Although increasing the number of Gaussians would improve the fits, using the same and minimum number of Gaussians for all the CC spectra studied here is considered more

important and useful for its application to be obtained with NIRS3 which has limited wavelength coverage (1.8-3.2 μm) and resolution (18 nm).

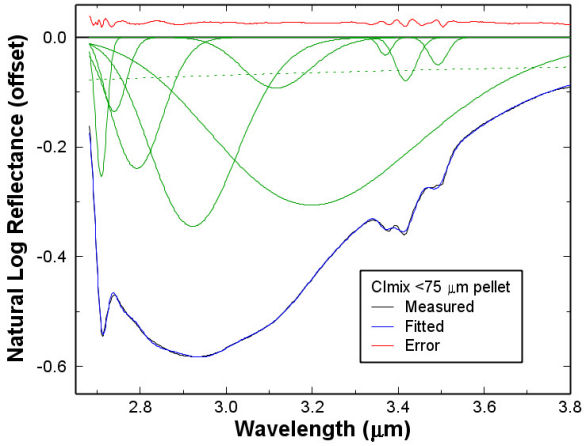

Fig. 3. An example of Gaussian deconvolution of the CC spectra in Fig. 1 using two hydroxyl bands, four adsorbed water bands, and three organics bands. The measured, fitted, and residual error spectra are offset for clarity.

Plotted in Fig. 4 are the center and width values of Gaussians obtained by deconvolving the 3-μm bands of the CC spectra in Fig. 1 and the model adsorbed water spectrum in Fig. 2. The center and width values combined are believed to identify approximately the cause of each absorption band, and it is encouraging that in Fig. 4 the points for different CCs appear to cluster together. Because there is no bands due to the model adsorbed water below 2.8 μm in wavelength, the first two bands of CCs seem independent of it.

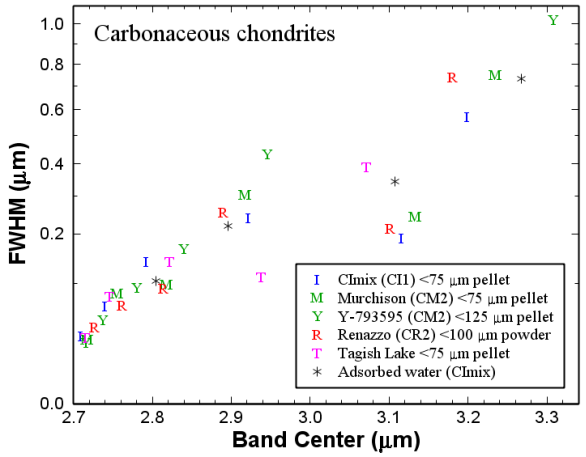

Fig. 4. Plot of center and width (full width at half maximum) values of deconvolved absorption bands of the CC spectra in Fig. 1 and the model adsorbed water spectrum in Fig. 2.

Based on the above idea, the relative strengths of the first (2.72-μm) and the second (2.75-μm) bands of the CC have been calculated and plotted in Fig. 5 in an attempt to identify unique characteristics of different CC groups. CImix shows the shortest band centers and a weaker 2.75-μm band than its 2.72-μm band. CM chondrites and Tagish Lake show a diverse range of band center values and 2.75-μm bands on the stronger side. Renazzo (CR) shows even longer band centers and a 2.75-μm band falling in the middle of the CM range in strength.

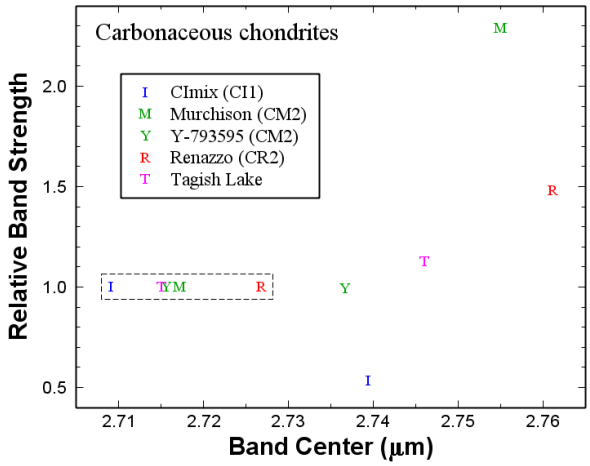

Fig. 5. Center vs. relative strength of the two shortest wavelength hydration bands (around 2.72 and 2.75 μm) of the CC spectra in Fig. 1. Their band strengths are normalized by the strength of the first band (inside a broken-line rectangle).

Discussion: In spite of a very simple approach of deconvolving the 3-μm hydration band into Gaussians, this method may prove useful for identifying the CC groups based on the band center and relative strength of the first two Gaussians. However, more diversity of CM chondrite samples should be studied to define its parameter range, and the challenge for applying this to the NIRS3 data is how to set the initial parameters including the continuum background to obtain a stable convergence of the eight parameters needed to obtain two Gaussians and the background function using only about ten data points over the same wavelength range.

Acknowledgment: Y-793595 sample was loaded from NIPR. Part of this research was supported by NASA PDART grant to T. H.

References: [1] Beck P. et al. (2010) *Geochim. Cosmochim. Acta 74*, 4881. [2] Takir D. et al. (2013) *Meteoritics Planet. Sci. 48*, 1618. [3] Iwata T. et al. (2017) *Space Sci. Rev. 208*, 317. [4] RELAB database: http:// www.planetary.brown.edu/relabdata/. [5] Davis K. M. and Tomozawa M. (1996) *J. Non-Crystalline Solids 201*, 177.