Visible and Near-Infrared Spectral Survey of Select Carbonaceous Chondrite Samples of the National Institute of Polar Research: Results of CI/CM Chondrites. T. Hiroi[1,2], H. Kaiden[2], N. Imae[2], A. Yamaguchi[2], H. Kojima[2], S. Sasaki[3], T. Misu[4], M. Matsuoka[4], T. Nakamura[4]. [1]Department of Geological Sciences, Brown University, Providence, RI 02912, USA, [2]Antarctic Meteorite Laboratory, National Institute of Polar Research, 10-3, Midori-cho, Tachikawa, Tokyo 190-8518, Japan, [3]Department of Earth and Space Sciences, Osaka University, 1-1 Machikaneyama-cho, Toyonaka, Osaka 560-0043, Japan, [4]Department of Earth and Planetary Materials Sciences, Tohoku University, 6-3, Aoba, Aramaki, Aoba-ku, Sendai, Miyagi 980-8578, Japan.

Introduction:

In June 2010 we started a visible and near-infrared (VNIR) spectral survey of meteorite samples stored at the National Institute of Polar Research (NIPR) and finished lunar, Martian, and HED meteorite samples. Then, we started surveying carbonaceous chondrite (CC) samples since November 2012. In this presentation we are reporting the initial results of CI and CM chondrite chip samples.

Experimental:

Out of 95 catalogued CCs of the NIPR, 3 CI/C1 and 17 CM samples were selected and studied so far by considering weight, freshness, and texture (having a natural, broken surface). Bidirectional VNIR diffuse reflectance spectra of one or two spots on each chip sample were obtained at every 5 nm over the wavelength range of 0.25-2.5 µm at RISE Project of the National Astronomical Observatory of Japan (NAOJ). A detailed description of the procedure is described in a separate paper on Martian meteorite samples [1]. For this study, incident beam size was about 3 × 2 mm. In addition, biconical Fourier Transform infrared (FTIR) reflectance spectra of those spots were measured at 4 cm^{-1} resolution over the wavelength range up to either 15 µm at Tohoku University or 25 µm at RELAB [2]. The FTIR spectra were scaled to connect with the VNIR spectra at 2.5 µm in wavelength.

Preliminary Results:

An example of CC chips and measured spots is shown in Fig. 1. Two spots were chosen for each of the CI/C1 chip samples: Spot A from fresh-looking, dark areas, and Spot B from light, weathered (evaporite?) areas.

Shown in Fig. 2 are VNIR-FTIR combined reflectance spectra of three CI/C1 chondrite chip spots. As expected, Spot B spectra have high visible albedos and totally different (negative) spectral slopes from those of typical CC spectra. In addition, while Spot A spectra show very shallow 3-µm hydration bands, Spot B spectra shows deeper and more complex 3-µm absorption bands. The shallow 3-µm bands combined with the absence of UV absorption of Spot A spectra may indicate that these CI/C1 chondrites were dehydrated by thermal metamorphism based on our previous study [3].

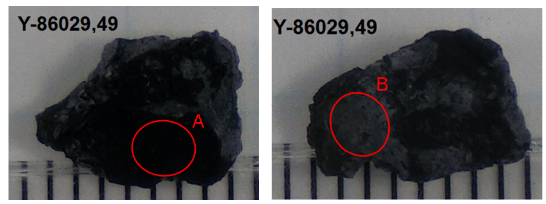

Fig. 1. Example images of measured spots on a Y-86029 chip sample viewed from two different sides, showing fresh dark Spot A and terrestrially-weathered light Spot B. The spot size is about 2 × 3 mm, and the scale is 1 mm.

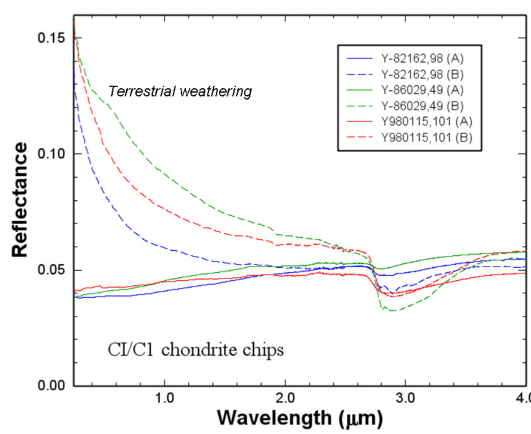

Fig. 2. VNIR-FTIR combined reflectance spectra of CI/C1 chondrite chip samples.

Shown in Fig. 3 are examples of CM chondrite chips and measured spots. Most of the CM chips studied here show fine dark-light textures as on the A-881458 chip, while some of them showing relatively large, 1-mm size clasts as seen on the B-7904 chip.

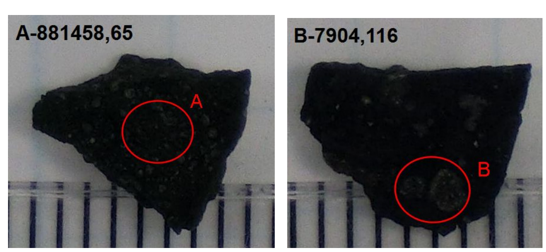

Fig. 3. Example images of two of CM chondrite chip spots measured here. The scale is 1 mm.

VNIR reflectance spectra of these CM chip spots are grouped into the following three plots. Although their FT-IR spectra were also measured, their data have not been processed yet and will be presented at the meeting.

Shown in Fig. 4 are VNIR reflectance spectra of select CM chondrite spots showing prominent UV abosortion and extended visible absorption bands near 0.7, 0.9, and 1.1 µm allegedly due to Fe^{2+}-Fe^{3+} charge transfer in certain types of serpentine. These serpentine absorption features can be detected by the ONC multicolor images onboard Hayabusa 2 spacecraft if present on its target asteroid (1999 JU_3).

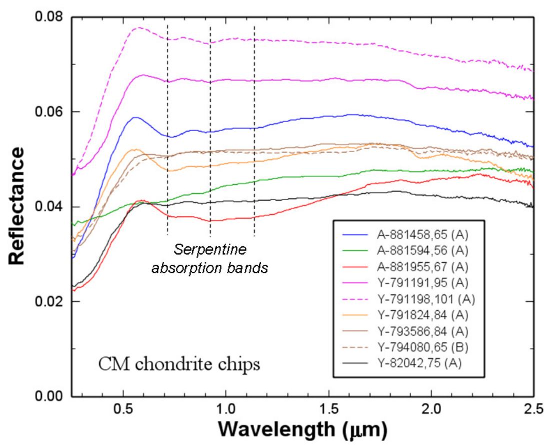

Fig. 4. VNIR reflectance spectra of CM chondrite chip spots showing Fe^{2+}-Fe^{3+} charge-transfer absorption bands of certain types of serpentine.

Next, shown in Fig. 5 are VNIR spectra of CM chip spots showing no or little serpentine absorption bands other than some UV absorption. Especially, B-7904 is known well as a thermally-metamorphosed CM chondrite and thus exhibits a totally feature-free VNIR spectrum with moderately weak UV absorption, consistent with our previous study [4].

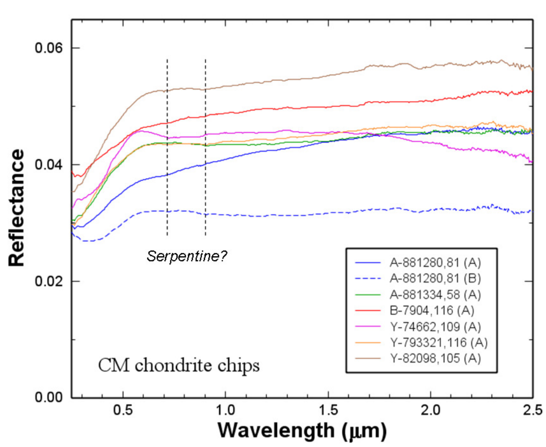

Fig. 5. VNIR reflectance spectra of CM chondrite chip spots showing no particular absorption features or possible serpentine bands as in Fig. 4.

Lastly, shown in Fig. 6 are VNIR spectra of CM chip spots showing olivine absorption bands near 0.85, 1.05, and 1.3 µm in wavelength. Based on these results, the large 1-mm size clasts on B-7904 chip in Fig. 3 are now identified as olivine-rich ones formed probably by thermal metamorphism. The A-881655 spectrum shows much weaker olivine bands than the B-7904 Spot B spectrum. The Y-793601 spectrum also shows a weak 0.7-µm band and an upward-pointing 0.55-µm feature, suggesting serpentine coexisting with olivine.

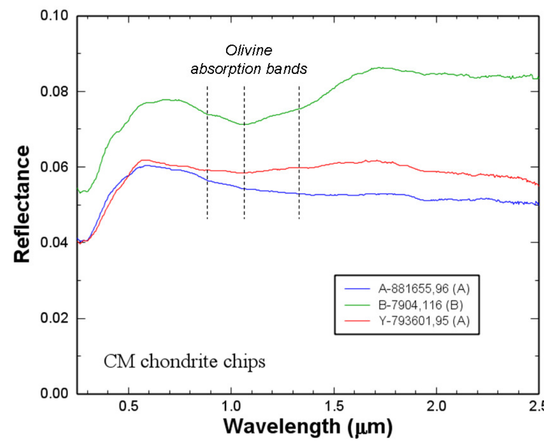

Fig. 6. VNIR reflectance spectra of CM chondrite chip spots showing olivine absorption bands.

Conclusions:

This study has proven that VNIR spectral measurements of CC chips is highly useful for identifying and characterizing meteorite types, major component minerals, and parent-body or terrestrial alterations. Therefore, this technique will be valuable in future spacecraft missions to small primitive asteroids such as Hayabusa 2 and OSIRIS-REx, especially during their close-up observation and touch-down phases and lander/rover operations. Because of its nondestructive nature, this survey can potentially be done for all the samples of our meteorite collections if proper arrangement is made in terms of security and contamination control. In addition, future analyses may include spectral deconvolutions employing the modified Gaussian model [5].

References: [1] Hiroi T. et al. (2011) *Polar Sci. 5*, 337-344. [2] Pieters C. M. and Hiroi T. (2004) *LPS XXXV*, Abstract #1720. [3] Hiroi T. et al. (1996) *Meteorit. Planet. Sci. 31*, 321-327. [4] Hiroi T. et al. (1993) *Science 261*, 1016-1018. [5] Sunshine J. M. et al. (1990) *JGR 95*, 6955-6966.

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