VISIBLE AND NEAR-INFRARED SPECTRAL SURVEY OF CM CHONDRITE SAMPLES OF NATIONAL INSTITUTE OF POLAR RESEARCH AND POSSIBLE DISCOVERY OF UNUSUAL 3-MICRON ABSORPTION BANDS. 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]Carlé M. Pieters. [1]Department of Geological Sciences, Brown University, Providence, RI 02912, USA (takahiro_hiroi@brown.edu), [2]Antarctic Meteorite Research Center, 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 those for lunar, Martian [1], and HED meteorite samples. Then, we began surveying carbonaceous chondrite (CC) samples in November 2012. In this presentation we are reporting the preliminary results for chips of CM chondrite. This study complements the work performed on powders by [2] and extends the wavelength range to longer wavelengths.

Experimental: Out of 95 catalogued CCs of the NIPR, 17 CM samples were selected for study 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 the RISE Project of the National Astronomical Observatory of Japan (NAOJ). A detailed description of the procedure is given in a separate paper [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 [3]. The FTIR spectra were scaled to connect with the VNIR spectra at 2.5 µm.

Preliminary Results: Photos shown in Fig. 1 are examples of measured spots on CM chondrite chips. Most of the chip samples show fine dark-light textures as seen on the A-881458 chip, while some show large 1-mm size clasts as seen on the B-7904 chip.

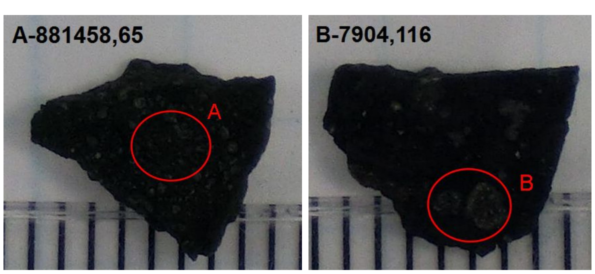

Fig. 1. Example images of two CM chondrite chips and the areas measured. The scale is 1 mm.

Shown in Fig. 2 are VNIR reflectance spectra of select CM chondrite spots showing prominent UV and extended visible absorption bands near 0.7, 0.9, and 1.1 µm allegedly due to Fe^{2+} and/or Fe^{3+} and OH^- in certain types of serpentine.

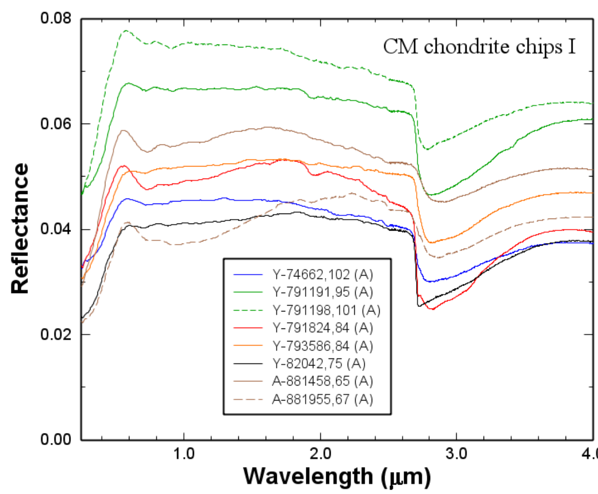

Fig. 2. VNIR reflectance spectra of CM chondrite chip spots showing Fe^{2+} and/or Fe^{3+} and OH^- absorption bands of various forms of serpentine.

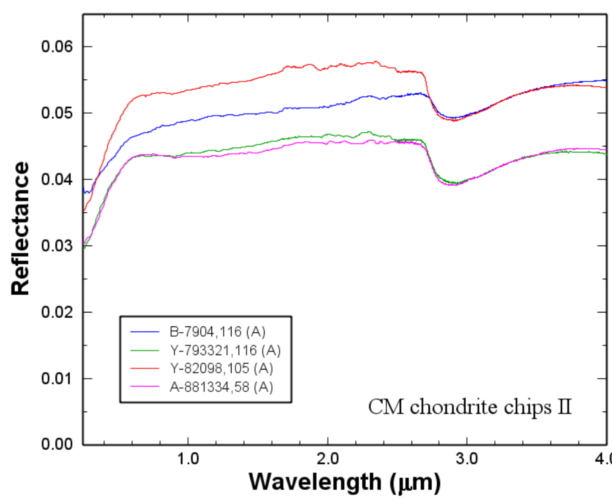

Fig. 3. VNIR reflectance spectra of CM chondrite chip spots showing none of the bands seen in Fig. 2 other than a rounded 3-µm band.

On the other hand, shown in Fig. 3 are VNIR spectra of CM chip spots with little or no serpentine features other than a similar 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 and reduced and deformed 3-µm band, consistent with our previous studies [4, 5].

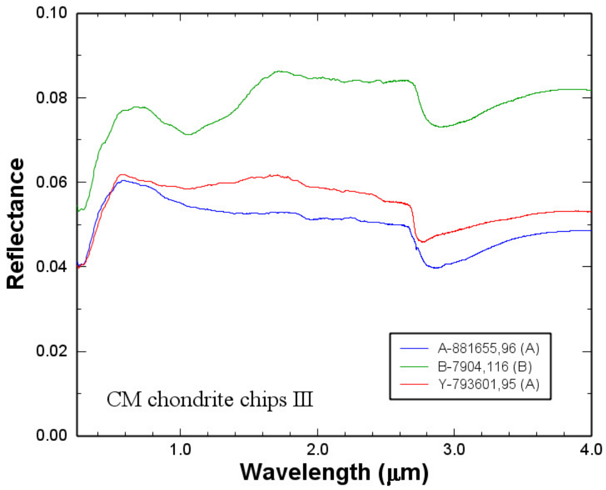

Fig. 4. VNIR reflectance spectra of CM chondrite chip spots showing olivine absorption bands.

Shown in Fig. 4 are VNIR spectra of CM chip spots showing olivine absorption bands at around 0.85, 1.05, and 1.25 µm in wavelength. Based on these results, the large mm size clasts on B-7904 chip in Fig. 1 are now identified as olivine-rich, probably formed by thermal metamorphism. The A-881655 spot A spectrum exhibits a much weaker olivine bands than the B-7904 spot B spectrum. The Y-793601 spot A spectrum also shows a weak 0.7-µm band and an upward-pointing 0.55-µm feature as well as a 2.8-µm band similar to those in Fig. 2, suggesting that serpentines coexist with olivine.

Lastly, shown in Fig. 5 are VNIR spectra of some CM chip spots showing unusual triplet 3-µm absorption bands. Although this hydration feature has been long known to consist of multiple absorption bands, this is the first clear observation of such nature to date.

Discussion:

We are cautious that terrestrial weathering in Antarctic ice could have altered the component minerals or made accessory minerals on these meteorite chips. However, the surfaces of these chip samples look reasonably fresh as shown in Fig. 6, and common terrestrial-weathering products (strong UV, 0.5-µm and 0.9-µm absorption bands) are not apparent.

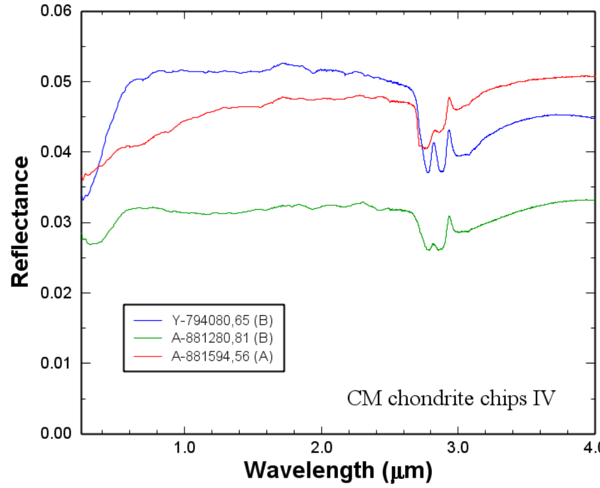

Fig. 5. VNIR reflectance spectra of CM chondrite chip spots showing unusual 3-µm absorption bands.

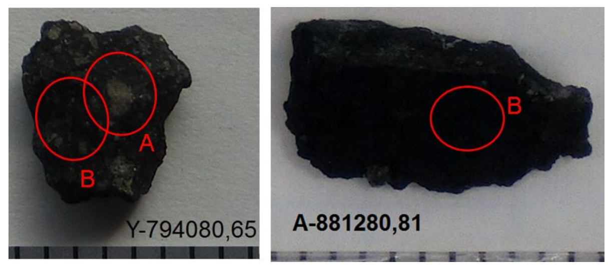

Fig. 6. Spots on two CM chondrite chip samples showing unusual triplet 3-µm absorption bands.

Conclusions:

This study has proven that VNIR spectral measurement of CM chondrite chips is highly useful for identifying and characterizing the major component minerals and alteration products (parent-body or terrestrial). 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. Future analyses may include spectral deconvolutions such as the modified Gaussian model [6] to introduce more quantitative elements to this survey.

References: [1] Hiroi T. et al. (2011) *Polar Sci. 5*, 337-344. [2] Cloutiss E. A. et al. (2011) *Icarus 216*, 309–346. [3] Pieters C. M. and Hiroi T. (2004) *LPS XXXV*, Abstract #1720. [4] Hiroi T. et al. (1993) *Science 261*, 1016-1018. [5] Hiroi T. et al. (1996) *Meteorit. Planet. Sci. 31*, 321-327. [6] Sunshine J. M. et al. (1990) *JGR 95*, 6955-6966.

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