MICRO FT/IR ANALYSIS OF BROWN OLIVINES IN MARTIAN METEORITES. E. Koizumi[1], T. Mikouchi[2], A. Monkawa[3], T. Kurihara[2], and M. Miyamoto[2], [1]Remote Sensing Technology Center of Japan, 1-9-9 Roppongi, Minato-ku 106-0032, Tokyo, JAPAN, [2]Department of Earth and Planetary Science, Graduate School of Science, the University of Tokyo, 7-3-1 Hongo, Bunko-ku, Tokyo 113-0033, JAPAN, [3]Tokyo Metropolitan Industrial Technology Research Institute, 2-11-1, Fukazawa, Setagaya-ku, Tokyo 158-0081, JAPAN.
(E-mail: koizumi_eisuke@restec.or.jp)

Introduction: The second chassignite NWA2737 is a dunite mineralogically and chemically similar to the first member of this group, Chassigny, but they show strikingly different color [1]. Olivine in Chassigny is pale grey whereas that in NWA2737 is dark brown. Among about 50 martian meteorites found so far, some meteorites, especially shergottites contain such brown olivine. The cause of this "brown" color was originally thought to be the oxidization process from Fe^{2+} to Fe^{3+} due to shock event [2]. On the other hand, recent works have revealed that the nano-phase Fe-Ni metal or magnetite particles in olivine make olivines to "brown" [3-4]. Pieters et al. [3] performed visible and near-infrared, midinfrared and other spectral studies on brown olivines in NWA2737 chassignite and ALH77005 lherzolitic shergottite. They reported that the VNIR spectrum did not show the characteristics of olivine, but the midinfrared spectra reveals is the characteristics of crystalline forsteritic olivine.

It is important to investigate and compare the brown olivines in martian meteorites to understand the shock event on martian meteorites, and also important to interpret remote sensing data. However, the availability of martian meteorites is limited and the size of olivines is usually small (commonly micrometer to millimeter size). Therefore, in this work, we performed micro-FT/IR study on the PTS samples of martian meteorites and ATR (Attenuated Total Reflection) analysis on the powder sample.

Sample and Analytical Methods: "Brown color" olivine in martian meteorites shows variation in their intensity of brown color (Fig. 1). We selected several martian meteorites to cover such wide color variations. The samples analyzed in this study are NWA2737 (chassignite), NWA1950 (lherzolitic shergottite), NWA1068 (olivine-phyric shergottite), Y000047 (lherzolitic shergottite), Y000593 (nakhlite), and Chassigny (chassignite). The darkness of olivines in these meteorites decreases in the above order. The PTS of these samples were analyzed in by micro FT/IR (JASCO FT/IR-4100 type A with infrared microscope IRT-3000). Analyzed range of wavenumber is from 350 cm^{-1} to 7800 cm^{-1}, cumulated number is 20, and micro aperture is from 40 μm x 40 μm to 100 μm x 100 μm.

We also analyzed the shocked olivine from shock-recovery experiments by [5]. The starting material was powder of San Carlos olivine (Fo_{89}), and shock pressure was set at 40 GPa (details of the experiment are in [5]). The nano-particle magnetite (5 to 30 nm in diameter) was observed in this sample with TEM works by [5]. Because of the small amount of the experimental shocked olivine (only few grains of sub-millimeter in size), it was difficult to measure its spectrum by micro FT/IR. Therefore, we adopted ATR (Thermo Scientific Nicolet 6700 FT-IR with ATR Orbit), for this sample.

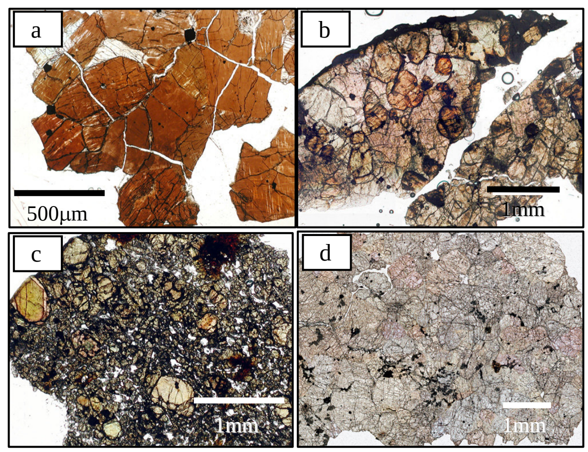

Fig. 1. Photomicrographs of martian meteorites studied. Note the olivine colors show variation. (a) NWA2737, (b) NWA1950, (c) NWA1068, (d) Chassigny.

Results and Discussion: Fig. 2 is the summary of the reflectance spectra from micro FT/IR analysis. All spectra show the peaks between 890 and 940 cm^{-1} probably due to SiO_4. By this "main" peak, their spectral data were normalized. Shift of these main peaks from each meteorites are observed, and this shift corresponds to the Mg contents of olivines. Focus on the "pre" peaks between 1000 and 1065 cm^{-1}, the values of reflectance of these meteorites decrease with the darkness of their olivines. The ratio of the "pre" peak versus the "main" peak of olivine in NWA2737 is approximately 0.11, and increase to about 0.30 for NWA1950 whose olivine shows medium brown color, and the ratio of the sample having brighter olivine color such as Chassigny and NWA 1068 are close to 0.70. Fig. 3 is the reflectance spectra of the olivines in Y000047. This meteorite includes olivines having color variation

[6]. The number of olivine spectrum in Fig. 3 corresponds to the darkness order of olivine. According to this spectral comparison, the reflectance around 1050 cm^{-1} also shows similar results to that of Fig. 2.

We also analyzed the experimental sample from shock-recovery experiments. Because of its small amount, the meaningful spectrum cannot be obtained by micro FT/IR analysis. ATR amplifies the spectrum by projecting a wave into a sample through diamond crystal. The result from ATR is shown in Fig. 4. It is noted that the spectrum from ATR shifted by the technical reasons comparing with the FT/IR result, and needs to be corrected to compare with the results from other spectral analytical methods. Therefore, the direct comparison of this result with results in Figs. 2 and 3 is difficult, but this result implies that the color of the experimental shocked olivine seems to be bright or a little colored, although the nano-particles were identified by TEM observation.

These results indicate that the shocked olivine shows characteristic midinfrared spectrum although its VNIR spectrum sometimes becomes flat [3] by shock event, and this makes it difficult to detect shocked olivine by VNIR. Moreover, the peak of reflectance spectrum around 1050 cm^{-1} (approximately 9500 nm) seems to correspond to the darkness of olivine. According to the assumption that the darkness of olivine in martian meteorites is regular relation with the shock pressure, the reflectance around 1050 cm^{-1} can be the reference index to infer the shock pressure of meteorite. These information from midinfrared spectrum are also important to analyze the remote sensing data from the Moon and Mars.

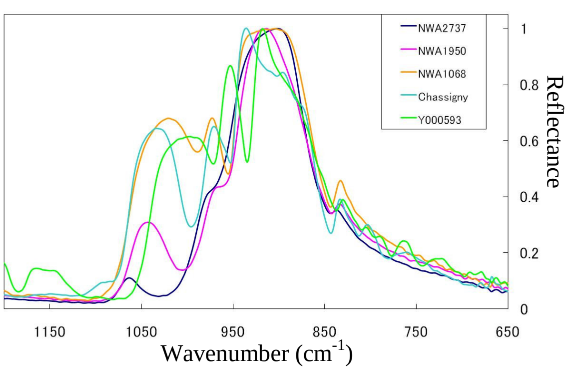

Fig. 2. Midinfrared reflectance spectra of olivines in martian meteorites by micro FT/IR analysis. (Spectra are normalized by the main peaks around 920 cm^{-1}).

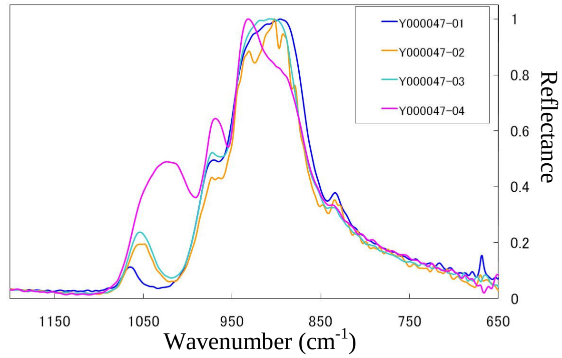

Fig. 3. Midinfrared reflectance spectra of olivines in Y000047 lherzolitic shergottite by micro FT/IR analysis. (Spectra are normalized by the main peaks around 920cm^{-1}).

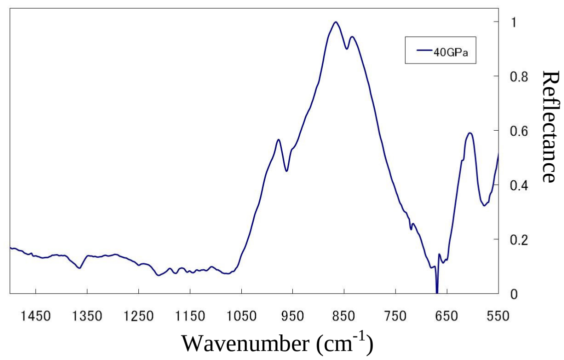

Fig. 4. Midinfrared reflectance spectra of olivine from the 40 GPa impact experiment [5] by ATR analysis. (Spectra are normalized by the main peak around 850 cm^{-1}).

References: [1] Beck P. et al. (2006) *GCA, 70*, 2127-2139. [2] Ostertag R. et al. (1984) *Earth Planet. Sci. Lett., 67*, 162-166. [3] Pieters C. M. et al. (2008) *JGR, 113*, E06004. [4] Kurihara T. et al. (2009) *LPS XL*, Abstract #1049. [5] Kurihara T. et al. (2008) *LPS XL*, Abstract #2505. [6] Mikouchi T and Kurihara T. (2008) *Polar Science, 2*, 175-194.