

Raman Spectroscopic Study of Roosevelt County (RC) 075 Chondrite. P. V. Zinin, G. R. Huss, S. K. Sharma, A. N. Krot, and L. Bonal, School of Ocean and Earth Science and Technology, Hawai'i Institute of Geophysics and Planetology, University of Hawai'i at Manoa, Honolulu, HI 96822, USA (zinin@soest.hawaii.edu).

Introduction: Interplanetary dust particles (IDPs) and meteorites provide a unique opportunity to study extraterrestrial materials in the laboratory [1,2]. Although several studies have been conducted on meteorites using micro Raman spectroscopy [3,4], the power of Raman mapping technique has not been fully explored yet. Here, we apply new confocal Raman system (WiTec 300), recently installed at UH, to study mineral distribution in meteorite RC 075. A previous petrological, chemical and isotopic study of RC 075 has established it to be the most unequilibrated known H-chondrite yet recovered [5]. We demonstrate that the UH Raman system is capable to map distribution of mineral phases with high spatial and spectral resolutions. This technique will allow us to study two-dimensional distribution of shock effects in meteorites, including high-pressure mineral phases in CH and CB chondrites, distribution of organics in meteorites, IDPs and cometary particles, distribution and identification of secondary minerals in Martian meteorites, and search for micron-sized grains of interest in polished sections and acid residues of meteorites (e.g., corundum, hibonite, SiC).

Analytical techniques: Mineral identifications and mapping were done in a thin polished section of RC 075 using optical microscopy, scanning electron microscopy (JEOL 5900LV scanning electron microscope equipped with EDS system), and confocal Raman microscopy (WiTec *alpha300 R*) with the excitation laser of a 532 nm-wavelength YAG (frequency doubled Nd:YAG laser). The Raman spectral images are of spatial resolution of 0.5 μm and spectral resolution of 1 cm^{-1} .

Results: One area of the meteorite selected for Raman mapping is shown in Fig. 1. The optical image obtained in reflected and cross-polarized transmitted light (Fig. 1) reveals three minerals – olivine, pyroxene, and plagioclase.

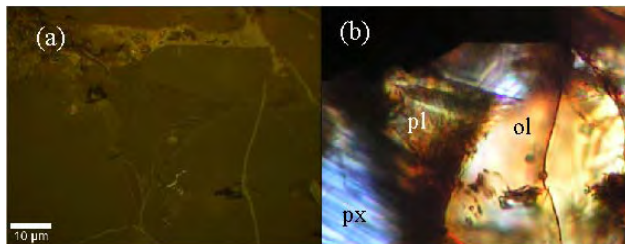


Fig. 1. Reflected (a) and cross polarized transmitted (b) light images of RC 075: ol = olivine; pl = plagioclase; px = pyroxene.

Raman spectrum taken inside the bright yellowish area of the polarized optical image (Fig. 1b) is shown in Fig. 2a. The Raman spectrum has two distinct peaks centered at 855 and 823 cm^{-1} characteristic for olivine. Position and boundary of the olivine grain can be easily identified in a two-dimensional map of the Raman peak centered at 855 cm^{-1} (Fig. 2b).

Raman spectrum taken inside the bluish area in Fig. 1b is shown in Fig. 3a. It has two doublets centered at 663, 685 and 1010, 1029 cm^{-1} and characteristic to pyroxene structures, and can be identified as clinoenstatite. Spectrum of clinoenstatite is very close to that of orthoenstatite; the former, however, should have peaks at 430 and 581 cm^{-1} [6]. The peak at 430 cm^{-1} is hidden by a shoulder of the 417 cm^{-1} peak, however, peak at 581 cm^{-1} is seen in the Raman spectrum of the enstatite (Fig. 3a).

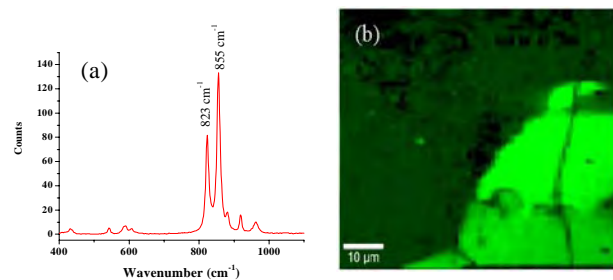


Fig. 2. Raman spectrum of olivine (a) and map of the Raman peak centered at 855 cm^{-1} (b). The intensity of the 855 cm^{-1} peak is shown in a green color scale.

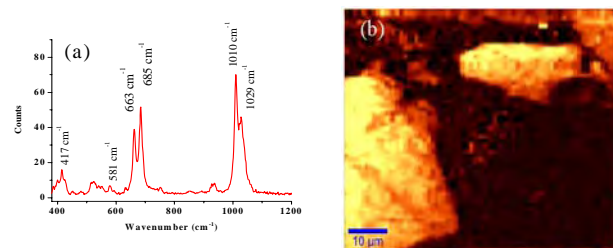


Fig. 3. Raman spectrum of the clinoenstatite (a) and map of the Raman peak centered at 1010 cm^{-1} (b). The intensity of the 1010 cm^{-1} peak is shown in a yellow color scale.

A mineral located in the center optical image (Fig. 1b) is plagioclase (Fig. 4). Its Raman spectrum contains a doublet centered at 479 and 509 cm^{-1} characteristic to plagioclase minerals. The presence of crystalline plagioclase supports the suggestion that this meteorite is very weakly shocked (S2) [5].

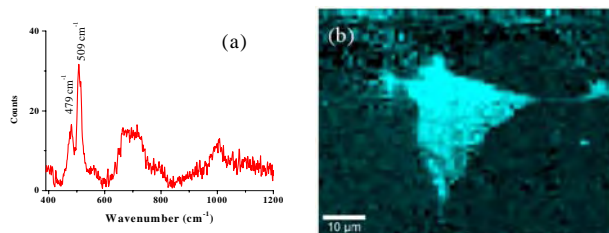


Fig. 4. Raman spectrum of the plagioclase (a) and map of the Raman peak centered at 509 cm^{-1} (b). The intensity of the 509 cm^{-1} peak is shown in a blue color scale.

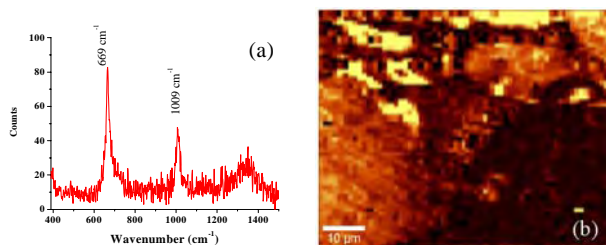


Fig. 5. Raman spectrum of the clinopyroxene (a) and map of the Raman peak centered at 1009 cm^{-1} (b). The intensity of the 1009 cm^{-1} peak is shown in a yellow color scale.

Another interesting feature found by Raman imaging is a different type of pyroxene (Fig. 5). Its Raman spectrum has two peaks centered at 669 and 1009 cm^{-1} . Unlike to the spectrum of the clinoenstatite (Fig. 3) these peaks are not split, which is characteristic of clinopyroxenes, such as augite and pigeonite, with average composition $\text{Wo}_{40}\text{En}_{40}\text{Fs}_{20}$ [7,8].

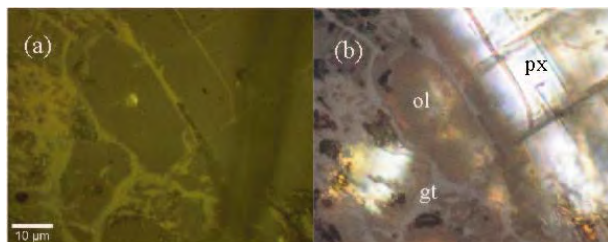


Fig. 6. Reflected (a) and cross polarized transmitted (b) light images of RC 05: ol = olivine; gt = goethite; px = pyroxene.

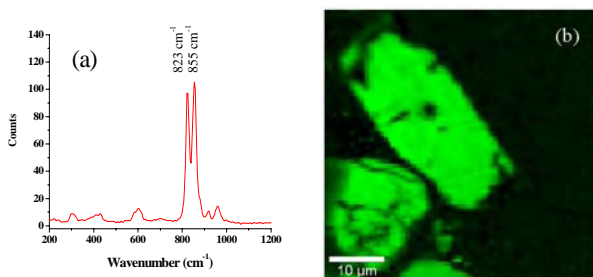


Fig. 7. Raman spectrum of the olivine (a) and map of the Raman peak centered at 854 cm^{-1} (b). The intensity of the 854 cm^{-1} peak is shown in a green color scale.

Grains of the clinopyroxene are found in another area of the specimen as well (Fig. 6). Again, olivine grains can be easily distinguished by using Raman imaging (Fig. 7). Clinopyroxene is present only as a $20\text{ }\mu\text{m}$ size grains (Fig. 8). The area between olivine and clinopyroxene grains is filled with goethite (Fig. 9), a hydrated Fe oxide of terrestrial origin [9]. Its presence is attributed to the weathering processes of RC 075 on the Earth [5].

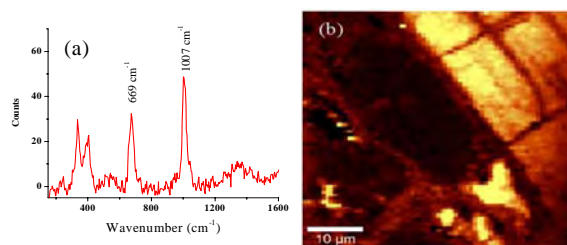


Fig. 8. Raman spectrum of the clinopyroxene (a) and map of the Raman peak centered at 1007 cm^{-1} (b). The intensity of the 1007 cm^{-1} peak is shown in a yellow color scale.

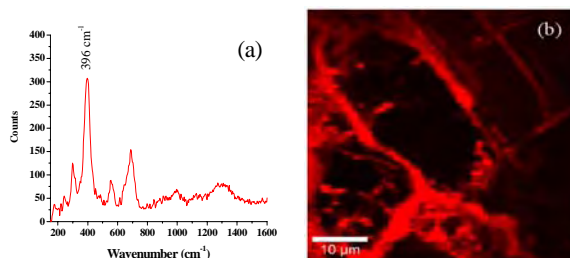


Fig. 9. Raman spectrum of the goethite ($\alpha\text{-FeOOH}$) (left) and map of the Raman peak centered at 396 cm^{-1} (right). The intensity of the 396 cm^{-1} peak is shown in a red color scale.

Conclusions: This preliminary investigation with confocal Raman spectroscopy and Raman mapping of RC 075 illustrates nondestructive capability for analyzing minerals at sub-micron scale in thin section of meteorites.

References: [1] Sharma, S.K. et al. (2003) *Spectrochim. Acta A*, 59, 2391-2407. [2] Sharma, S.K., (1989) *Vibrat. Spectra Structure*, 17B, 513-567. [3] Wang, A., et al. (2004) *J. Raman Spectrosc.*, 35, 504-514. [4] Wang, A., et al. (2004) *Amer. Mineral.*, 89, 665-680. [5] McCoy T.J. et al (1993) *Meteoritics*, 28, 681-691. [6] Ulmer, P. and A. Staldert (2001) *Amer. Mineral.*, 86, 1267-1274. [7] Sharma et al. (2002) *Appl. Spectrosc.*, 56, 699-705. [8] Rull, F. et al. (2004), *J. Raman Spectrosc.* 35, 497-503. [9] Zeigler, J. et al. (2001). *LPS XXXII*, 1243-1244.