Optical and Raman spectroscopical properties of the shocked olivines from ALHA 77005 sample. Sz. Nagy[1] (ringwoodit@yahoo.com), S. Józsa[1], A. Gucsik[2], Sz. Bérczi[1], K. Ninagawa[3], H. Nishido[4] and M. Veres[5] [1]Eötvös Lóránd University of Budapest, H-1117 Budapest, Pázmány Péter sétány 1/c., Hungary; [2]Max Planck Institute for Chemistry, Department of Geochemistry, Becherweg 27, D-55128, Mainz, Germany; [3]Department of Applied Physics, Okayama University of Science, 1-1 Ridai-cho, Okayama, 700-0005, Japan; [4]Research Institute of Natural Sciences, Okayama University of Science, 1-1 Ridai-cho, Okayama, 700-0005, Japan; [5]MTA-SZFKI, H-1121 Budapest, Konkoly-Thege M. út 29-33., Hungary.

Introduction: Petrographic classifications of shock effects in olivine at different shock pressures, (mainly based on optical analysis), have been reported in previous studies [1,3]. Raman spectral features of the shocked olivine have been described by Turner et al. [4]. In this study, we focus on the shock effects of olivine, and their micro-Raman spectroscopical properties to characterize the crystalline background of the shock-induced microdeformations.

Sample: The ALHA 77005 Martian meteorite (lherzolotic type) was found partially inbedded in the ice at the Allan Hills site during one of the first collecting expedition. A preliminary examination of this sample reported that it is ~55% olivine, ~35% pyroxene, ~8% maskelynite, and ~2% opaques. The olivine (Fa_{28}) occurs as anhedral to subhedral grains up to 2 mm in lenght. The olivine grains show brown color because of the hydrous magma [5]. The ALHA 77005 contains melt pockets too, which are mostly crystallized in the spinifex texture. Additionaly, the intersticial regions contain two phases: pigeonite and residual glass [6].

Shock effects in olivine: The olivine in ALHA 77005 shows shock effects as follows. The olivine exhibit distinct mosaicism. Some olivine grains have reduced interference color, and undulatory extiction. The birefringence is also reduced. Near the melt pocket, olivine shows three regions (Fig. 1). The first region is the host olivine area with lower interference color (orangeyellow). The second region is a transition zone with planar microstructures and some isotropic area (Figs. 1 and 2). The third one is a recrystallized area with irregularly rounded grains. The transition zone is about 20-25 μm wide (Fig. 2). In this part the interference color is drastically reduced, and some places show isotropic areas (Figs. 1 and 3.). In the transition zone Planar Deformation Features (PDFs) occur up to two orientation, and Planar Fractures (PFs) (Fig. 2). The PDFs are slightly curved, occuring between PFs. The spacing of PFs is between 10-15 μm. These orientations are differ from the PDFs orientations. The width of PDFs is > 1 μm, and the spacing is 1-2 μm. The boundary between the transition zone and (low interference color) host grain is relatively sharp. However, the transition between the transition zone and recrystallized area is continuous (Fig. 2). As a function of the increasing shock pressure, the olivine grains have lost its intense brown color, which indicates the loss of Fe^{3+}. We suggest that the Fe^{3+} is not presented in the olivine structure. It is evidently shown, that the olivine grains do not represent pleochroism effect. If the Fe^{3+} could be in the lattice, the grains must have plechroism. The origin of the brown color in the olivine is most likely due to the hydrous magma [5]. Around the shock melt packet, the deviation of olivine is occurred slightly. Within this area the original olivine interference color is significantly reduced to colorless.

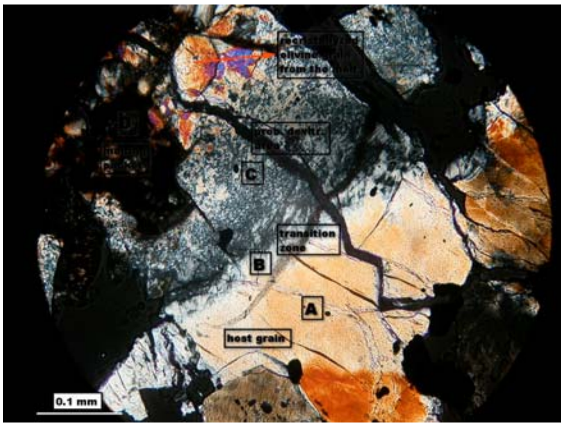

Fig. 1. *Olivine grains from the ALHA 77005 sample. The figure shows three region in the olivine. A, host grain area; B, transition zone; C, recrystallized area. (D, melting pocket) (cross-polarised light)*

The recrystallized area shows numerous irregular olivine grains. Near the shock melt pocket, some olivine grains have recrystallized area from the olivine melt, and these grains optically different from grains, that recrystallized between the melt pocket and the transition zone (Fig. 1, mark C). The olivine does not show shock veins, and the number of fractures is relatively small. We did not observe high pressure polymorph of olivine including spinel-like structure in neither microscopic investigation nor Raman studies. It is probably case of the grain size of olivine. We assume, that the place (Fig. 1, mark C) was isotropic between the melt pocket and the transition zone, but the recrystallization was not formed from the melt, howewer the material recrystallized from a short range order condition.

Raman spectroscopy of shocked olivine: In Raman spectroscopic experiments, minerals are identified by their spectral patterns and mineral compositions based on their peak positions. Olivine contains 81 optic modes, 36 of are Raman active modes [7]. Olivine spectra can be divided into 3 parts: (1) less than 400 cm^{-1}, which corresponds to the lattice modes (rotations and translations of SiO_4 units, and translations of the octahedral cations). (2) between 400-800 cm^{-1}, which is related to the SiO_4 internal bending vibrational modes. (3) 800-1100 cm^{-1}, which is attributed to SiO_4 internal streching vibrational modes; the dominant features in this region are a doublet peaks near at 820 and 850 cm^{-1} [7]. Doublet peak positions are changed as a function of variation of the chemical composition.

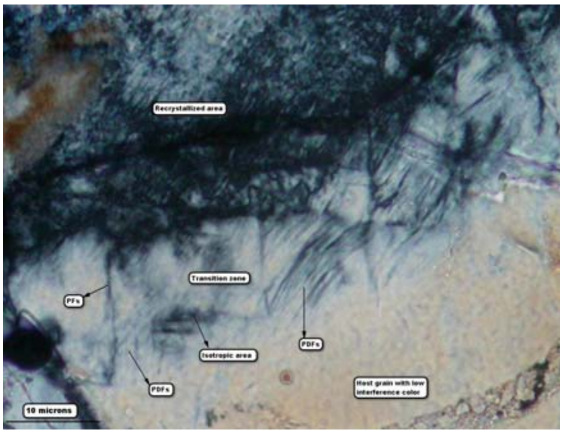

Fig. 2. *The distinctive regions of the shocked olivine. The resolution is 60X. (cross-polarised light)*

The A-area shows the following peaks: 595, 820, 852, and 955 cm^{-1}. The B-area contains: 580, 594, 820, 852, and 950 cm^{-1}. The peaks of the C-area are: 597, 820, 852, and 951 cm^{-1}. All of these peaks correspond to the olivine structure. The high-pressure polymorph of olivine such as ringwoodite and wadsleyite have not been identified. The epoxy related peaks are: 638, 671, 735, 916, 1014, and 1043 cm^{-1} (Fig. 4).

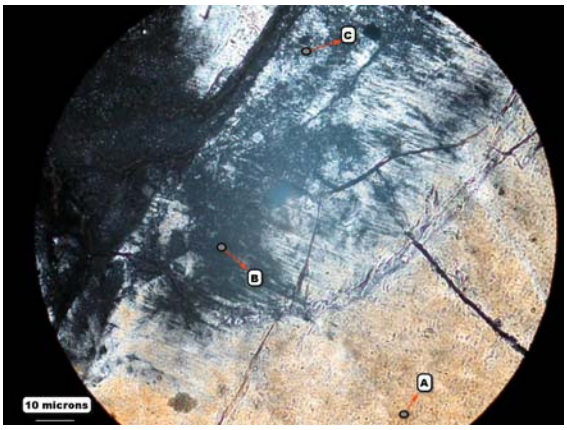

Fig. 3. *The three analysing parts for the Raman investigation. Host grain (A), isotropic area (B), and recrystallized area (C). (cross-polarised light)*

The doublet peak positions of the olivine structure at 820 and 852 cm^{-1} are unchanged during three measurements, which indicates that the chemical composition of olivine is also not changed (Fig. 4). We can observe a change in the B-spectra in comparison with the A and C-spectra. In the B-spectra, the 595 and 597 cm^{-1} peaks (in A and C-spectra respectively) modified to a broadening peak (Fig. 4). But this change is not significant. Therefore, we think that the olivine structure collapsed to numerous domains or crystallites during the shock wave propagation. This condition could represent to the small change in the B-spectra broadening. According to the C-spectra, the recrystallized area might be represent higher range order condition than the B-spectra of isotropic area. The A and C area have identical Raman spectra, but their appearance in the optical microscope are very different.

We suggest that the isotropic area is not a diaplectic olivine glass, because the change of the main peaks is not significant. We think that the isotropic area contains μm and/or nm-size domains, which might be too small for our optical microscopic observations. It is probable, that the irregular grains formation in the C-area, may have been due to the crystallization around the domains or crystallites.

Conclusion: The olivine grains are highly-shocked in ALHA77005 sample. We can identify/characterize three zones in these olivine grains, being near the melt pocket. In the C-area was not hot enough the temperature for the completed recrystallization as in the case of the melt. According to the Raman investigation, the nature of the isotropic area is not diaplectic olivine glass. We did not find high pressure polymorphs of olivine.

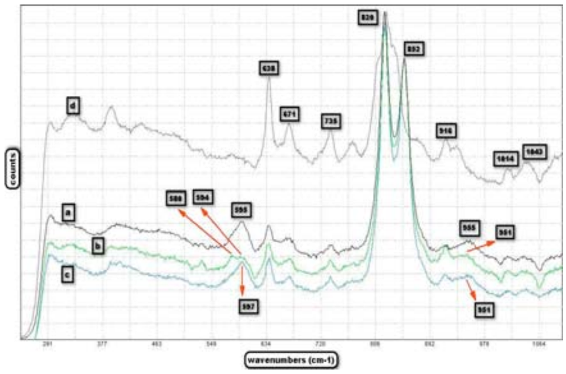

Fig. 4. *Raman spectra of the three area from the Fig. 3. The D-spectra is the epoxy. The low three spectra (A-B-C) correspond to the host grain (yellow area), isotropic area (dark area), and recrystallized area from short range order condition (white-dark mixed area).*

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