Evidence of Shock Metamorphism in Hungarian L-chondrites using Raman Spectroscopy. Sz. Nagy[1], A. Gucsik[2], Sz. Bérczi[1], M. Veres[3], I. Gyollai[1], J. Fürj[1] [1]Eötvös University, Faculty of Science, Institute of Physics, Dept. Material Physics, H-1117 Budapest, Pázmány Péter sétány 1/a, Hungary, [2]Max Planck Institute for Chemistry, Dept. of Geochemistry, Joh.- J. Becherweg 27, D-55128, Mainz, Germany, [3]SZFKI-KFKI, H-1121 Budapest, Konkoly-Thege M. út 29-33.

Mócs meteorite is an L5 and Mezőmadaras is an L3-type chondrites. The chemical composition of these samples were determined the Electron Microprobe Analyses [1]. The shock-metamorphic classification of Mócs and Mezőmadaras meteorites were classified as S3-S5 for Mócs, and S2-S3 for Mezőmadaras by Optical Microscope [2]. We have reinvestigated of these samples using Raman spectroscopy for the identification of any shock-metamorfic effects occured in the structure changes of olivine and pyroxene grains. The detailed OM analyses show mechanical twins in pyroxenes **(Fig. 1)**, planar fractures (PF's), and planar deformation features (PDF's) **(Fig. 2)**. Furthermore shock mosaicism in olivine grains is also discernible **(Fig. 3)**. The Raman spectroscopical investigation revealed β-(Mg, Fe) SiO_4 olivine structure (wadsleyite) in a PDF's enriched and highly deformed olivine grain.

Samples and Experimental Procedure

The mineral assemblages and textures were characterized by a Renishaw-1000 Raman spectrometer, the laser wavelenght was 785 nm, with focused energy of 8 mW. The maximal focus was driven to 1µm spot in diameter. The thin sections were mounted in epoxy material, and the sample thickness is 30 µm.

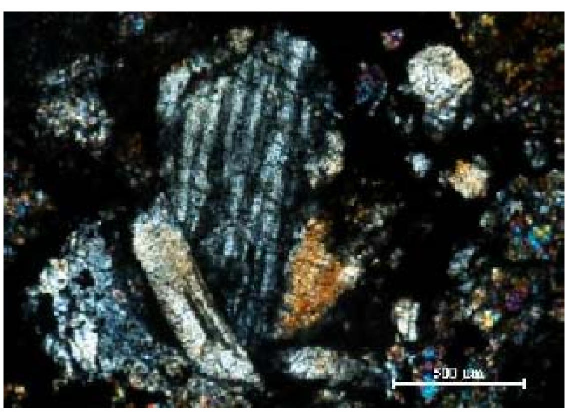

Fig. 1 Optical microscope (cross-polarised) image of pyroxene with mechanical twins in Mezőmadaras meteorite.

Results and Discussion

Mócs meteorite: In a highly deformed and PDF's enriched olivine grain was selected for the Raman investigations representing two analyzing points, as follows. The first point (Mócs I.) was placed on the

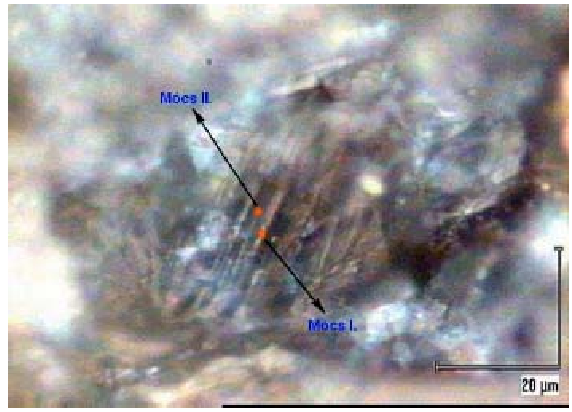

Fig. 2 Places of two points for raman spectroscopical analysis in PDF's rich olivine grain from Mócs meteorite. Reflected light micrograph image.

The characteristic Raman peaks of Mócs I are: 630 (strong-s), 706 (medium-m), 722 (very weak-vw), 751 (weak-w), 852 (very strong-vs), 883 (very strong-vs), and 987 (strong-s) cm^{-1}. The Mócs II-spectrum contains the following peaks: 421 (s), 577 (m), 642 (w), 822 (vs), 854 (vs), 920 (m), and 958 (m) cm^{-1}. We used a reference material from the Trudy's mine olivine to the comparison with the vibrational changes of our spectra **(Fig. 4)**. Note that the spectrum was derived from CALTECH Raman database. The most characteristic changes in the Mócs I-spectrum are. The olivine doublet peak position is shifted to higher wavenumbers, due to partly disordered olivine structure. The doublet peak's shift was also observed in olivine (crystalline forsterite) experimentally shocked between 0-50 GPa [3]. The second important change in the Mócs I-spectrum is in the middle wavenumber region. The olivine structure vibrations are forbidden in this region. The 751 cm^{-1} peak is assigned to the presence of Si-O-Si bridges characteristic of wadsleyite [3,4] indicating the highly deformed olivine structure [2]. The 722 cm^{-1} peak belongs to the wadsleyite Si_2O_7 symmetric stretching vibrational mode [5,6]. However, the 918 cm_{-1} peak is not identical to the wadsleyite SiO_3 symmetric stretching vibrational mode, because of the doublet peak position.

Mezőmadaras meteorite: Mezőmadaras sample contains poikilitic pyroxene condrums, which show elongated shape. Within these condrums, the pyroxenes have mechanical twins.

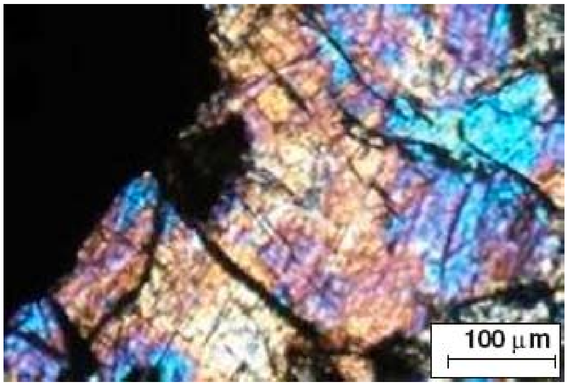

Fig. 3. Moderately mosaicism in olivine from Mócs sample. OM-image

Within the most common (Mg-Fe-Ca) pyroxenes we can distinguish more than ten Raman active vibrational modes [7]. The four spectra **(Fig. 5)** show different chemical composition between the Castle Rock (as a reference spectrum) and three meteorites sample. The Mócs spectrum have the following peaks: 368 (vs), 426 (s), 475 (m)?, 693 (vs), 710 (vs), 1040 (vs) cm^{-1}. The Mezőmadaras spectrum contains peaks: 372 (s), 475 (w)?, 694 (vs), 716 (vs), and 1041 (vs) cm^{-1}. The characteristic peaks of Shergotty pyroxenes are: 359 (vs), 426 (vs), 567 (vw), 590 (vw), 698 (vs), and 1043 (vs) cm^{-1}. The Castle Rock pyroxene exhibits the following peaks: 340 (vs), 402 (s), 439 (s), 538 (m), 661 (vs), 682 (vs), 860 (m), 936 (w), and 1009(vs) cm^{-1}.

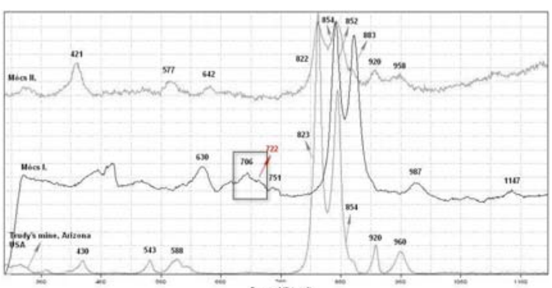

Fig. 4. Raman spectra of olivine in Mócs meteorite sample.

The degree of the structural disordering was determined by FWHM (Full Width at Half Maximum) values. Under the 500 cm^{-1} range the Mócs sample, has the highest rate of FWHM as 17 cm^{-1} but the Castle Rock sample shows 11 cm^{-1}. The Mezőmadaras and Shergotty samples are between two of the above mentioned samples (FWHM rate is 15 cm^{-1}). This indicates the significant changes in the Si-O stretching modes and SiO_4 tetrahedra rotational modes. Above 800 cm^{-1} range, the FWHM rates are: Mócs 21 cm^{-1}), Shergotty 20 cm^{-1}), Mezőmadaras 18 cm^{-1}), and Castle Rock 15 cm^{-1}). These data represent higher structure disordering degree in meteorites than in the terrestrial Castle Rock sample. The higher FWHM rate in meteorites can be due to shock-metamorphic mechanism.

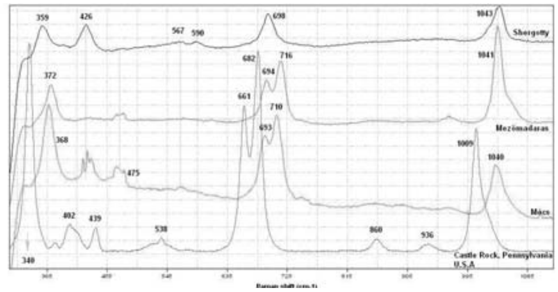

Fig. 5. Raman spectra of pyroyenes from different sources.

On the basis of the measured FWHM, the following structural disordering degree of the selected samples can be determined as a (growing rate): Castle Rock, Mezőmadaras, Shergotty and Mócs. The result reveals that amorphisation rate is the highest in Mócs and Shergotty pyroxene grains.

Conclusion

This study demonstrates that the micro-Raman spectroscopy can aid to understand about the study of shock-induced phase transformation and range of structural disordering in minerals from various meteorites.

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