FTIR-ATR SPECTROSCOPY OF SHOCK VEIN IN MÓCS L6 CHONDRITE

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Introduction: The Mócs L6-type chondrite was a fall in Kolozs-county (Transylvania) in 1882. Mócs is a heavily shocked meteorite showing well-developed shock veins. Its modal abundance consists of olivine, pyroxene, plagioclase feldspars, and opaque minerals. Raman spectroscopy of the sample revealed the shock-induced deformation microtextures in the vein-forming olivine, exhibiting strong mosaicism [1]. Hence this process has been investigated in our fracture/vein system of Mócs sample, as a signature of shock- induced melting. The shock-metamorphic classification of Mócs meteorite was identified as S3 (15-20 GPa, 100°C) - S5 (45-55 GPa, 600°C) by optical microscope according to Stöffler's shock-metamorphic scale [2]. The cited works used FTIR-ATR powder and reflection methods, which detect more grain or larger area. We used FTIR-ATR microscope which detect 2 μm area in single grain. Thus, we measured individual minerals and not average, but single orientation, hence our peak positions could be shifted from those in the references. Hence we compared FTIR data not only to references, but to our earlier Raman measurements and petrographical observation [3] too.

Analytical background: The thin section was mounted in epoxy material and the sample thickness was 30 μm. The mineral assemblages and textures were characterized with a Nikon Eclipse LV100POL optical microscope at Eötvös University, Department of Petrology and Geochemistry, Budapest, Hungary. The IR measurements were utilized by Bruker VERTEX 70 Fourier transform infrared spectrometer (equipped with a Bruker Hyperion 2000 microscope with 20x ATR objective, with MCT-A detector) at the Research Center of Astronomy and Earth Sciences, Hungarian Academy of Sciences, in Budapest, Hungary. During ATR analysis the samples were contacted with a tip of Ge crystal (0.5 micron) on selected 1 N pressure. The measurement time performed 32 seconds with 4 cm^{-1} resolution at each locations. Opus 5.5 software was used for development and deconvolution of spectra. Spectra data were collected in range of 600-4000 cm^{-1}. At some locations our FTIR device measured the peaks of neighboring minerals (in case of opaque phases, and tiny minerals, as well as grain boundary). The FTIR peaks were interpreted following de Benedetto et al. [4] ATR powder references. The spectra with thin section including measuring points are shown at Fig. 1.

Results: *Area 9A*: The infrared spectra have been taken on shocked olivine, which shows strong mosaicism. This grain shows light grey color and dark, and short irregular lamellae crossing each other. These dark irregular short lamellae appearing in 3 orientations, and distributed in this large olivine grain showing strong mosaicism of smaller domains. The brighter units are normal olivines which have IR peak positions at 831 cm^{-1}, 935 cm^{-1}, 966 cm^{-1}. The spectra of dark patches (dark patches show dense, lamellar structure) have broader peaks and contain additional peaks at 1045 cm^{-1}, 1125 cm^{-1}, 1580 cm^{-1}, 1670 cm^{-1}. The peak at 1045 cm^{-1} corresponds to shocked olivine [5], the other bands on higher wavenumber correspond to organic material.

The *„Area 3A"* profile crosses a shock vein with fractured boundary, which starts from edge of troilite grain and olivine grains (red spectrum). The red spectrum of olivine has high level background (explained by fluorescence) and shows olivine peaks at 828, 863, and 968 cm^{-1}. The second, greyish-green spectrum is olivine glass with very broad peaks at 833, 866, 919, and 968 cm^{-1}. The third, pink spectrum is taken at better crystallized olivine clast inside the shock vein which has IR bands at 829, 865, 917, 968, and 1000 cm^{-1}. The forth, light blue spectrum were taken at boundary of olivine (830, 861, 968 and 1000 cm^{-1}) and feldspar (639, 687, 723, 742, 924, 1000, 1045, and 1120 cm^{-1}), the less intensity and broader IR bands indicate less crystallized material due to shock loading. The fifth (light green) and sixth (dark blue) spectra were taken on feldspar grain (639, 687, 723, 742, 866, 926, 1000, 1048 and 1121 cm^{-1}) at the boundary of the shock vein.

The spectra group *Area 4A* was taken from the vicinity and across the shock vein, which contains troilite along the vein wall inside the vein. The dark blue spectrum along the vein wall near to troilite is diopside with peaks 639, 678, 720, 870, 917, 1002, 1025 cm^{-1} with additional peaks of 1662 and 1558 cm^{-1} which possibly correspond to organic material. The red spectrum was taken from subvein branching from the main shockvein, consisting of olivine and pyroxene (830, 866, 915, 958, 1085, and 1664 cm^{-1}). The light green spectrum (828, 866, 915, 961 and 1000 cm^{-1}) has broader peaks with lower intensities, belong to olivine melt or/and less ordered olivine. The pink spectrum belong to olivine (830, 868, 915, 961, 1000 cm^{-1}). The spectrum of Na feldspars are separated as grey, dark green, and light blue spectra groups. The best crystallized one is the grey spectrum, showing peaks at 636, 678, 720, 740, 866, 926, 1001, and 1100 cm^{-1} which corresponds to unshocked feldspar. The dark green and light blue spectra are feldspar glasses showing broad band near 950 cm^{-1}, peaks at 678 and 740 cm^{-1} appear as shoulders or have been disappeared. But a new band, a low intensity one appeared at 796 cm^{-1} which is a forbidden peak due to crystal lattice defect. The center of spectra appears as broad peaks at 942 cm^{-1} (light blue

spectrum) and 958 cm^{-1} (dark green spectrum) which have a shoulder peaks at 998 and 1100 cm^{-1}. The broadening of peaks indicate crystal lattice defect.

The spectral group of „*Area 5A*" was taken from large chromite grain (black) at edge of vein, mineral melt inside the shock vein (orange, dark blue), in elongated troilite (light blue), silicate phase in shock vein (red, green), well crystallized olivine (pink). The FTIR spectrum of chromite grain shows bands at 935, 1179, 1420, 1459, 1547, and 1649 cm^{-1}. The neighboring area of chromite (orange, blue spectra) is olivine melt (broad bands at 832 and 872 cm^{-1}), and bands of chromite (1420, 1459, 1547, and 1649 cm^{-1}). The black, red and dark blue spectra belong to olivine (833, 868 cm^{-1}). The pink and light green spectra have sharp peaks at 835, 862, and 967 cm^{-1} belongs to olivine.

Discussion: The 4A feldspar and feldspar glasses spectral groups were compared to spectra of Palomba et al. [6]. Similarly to maskelynite spectrum of Palomba et al. [6], we have broad peaks of feldspar glass between 800 to 1200 cm^{-1}, which are centered near to 950 cm^{-1} position as signature of disordering of SiO_4 tetrahedra, and have shoulders at 875 an 1100 cm^{-1}. But our feldspar glass includes broad, low intensity peaks at 640 and 722 cm^{-1} of normal feldspar too. In this case, we guess that our feldspar glass is transient state to the maskelynite formation. The vibration types of pyroxenes (enstatite) were obtained by Saikia et al. [7]. The peaks at 693-95, 719-28 belong to O-Si(Al)-O symmetrical bending vibration of enstatite. The 873-80 (T2O7) and 915-20 (TO3), 958-65 (TO3), 1010-1020 and 1056-1070 and 1104-1128 (TO2-TO5), corresponds to Si-O asymmetrical vibration of enstatite. The ATR-IR bands of olivine are added by Lane et al. [8]. According to Hamilton [9], the cation (Fe2+ for Mg2+ in M2 position) distribution's that stretch the vibration in octahedral layer is centered at 929 and 2010 cm^{-1}. According to Jovanovski et al. [10], the Si-O deformation of pyroxenes is centered at 640 and 670 cm^{-1}, the Si-O-Si vibrational bands occur between 850 and 1100 cm^{-1}. The reflectance spectra of pyroxenes in meteorite, especially enstatite (910, 930, 975, 1010, 1050, 1100, and 1120 cm^{-1}) and augite (880, 912, 925, and 1075 cm^{-1}) are obtained by Palomba et al. [6]. The Si-O symmetrical stretching of forsterite is centered at 824 and 555 cm^{-1}, the antisymmetrical stretching is centered at 964 cm^{-1}[6]. The fayalite endmember peaks as follows [11]: 832 (v3), 840 and 814 (v1+v3), 947 (v3).

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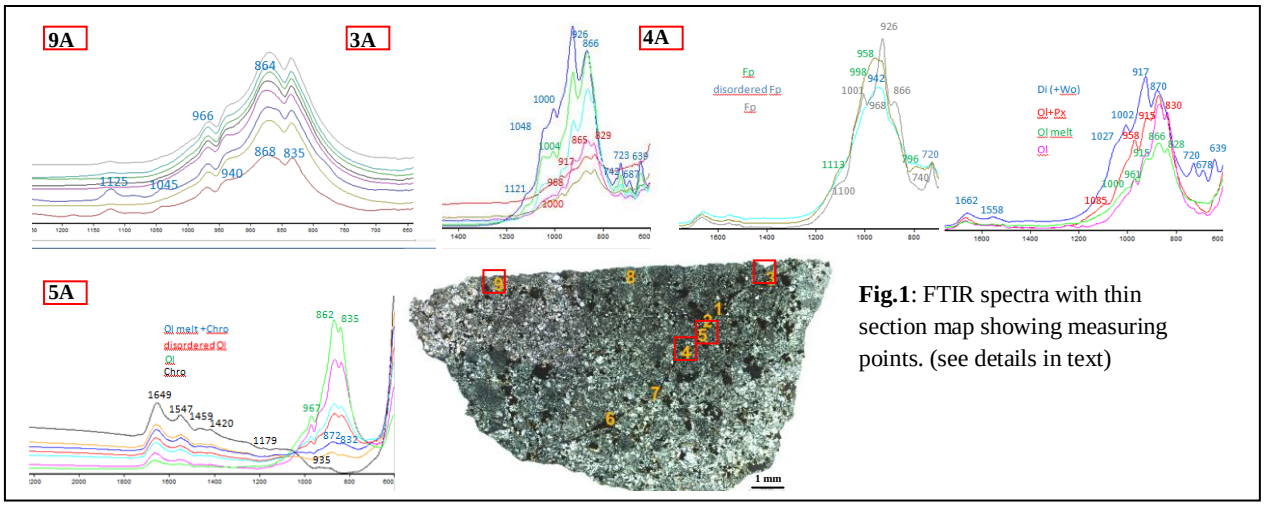

Fig.1: FTIR spectra with thin section map showing measuring points. (see details in text)