RAMAN CHARACTERIZATION OF CRYSTALLINE AND AMORPHOUS MATTER IN METEORITE "CHELYABINSK" (SOUTH URALS, RUSSIA).

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Introduction: The large asteroidal fireball has exploded over the Ural region of Russia on February 15, 2013, giving many fragments. The meteorite flew at supersonic speed and with bright flashes of light along the trajectory of the Chelyabinsk-Miass-Satka. Acoustic wave brought some minor damages in the form of broken glasses and some damages of old buildings. The resulting fragments of meteorite were scattered over a wide area. The largest from found fragments fall into the Lake Chebarkul. The piece of the falling bolide having a total mass of 654 kg was raised from the bottom of the Chebarkul Lake on October 16, 2013. In this study, we write about Raman spectra of samples collected on February 22-23, 2013 and April, 18, 2013, which are considered as more fresh and non-contaminated.

We studied the fragments (up to 4 g) collected in the areas of abundant meteorite shower (the Etkul region of Chelyabinsk district, south Urals, Russia); between villages of Deputatskoe and Bereznyaki and villages of Emanzhelinka and settlement of Baturinsky (Emanzhelinsk town), and settlement of Pervomaisky. The fragment of Kunashak meteorite falling to earth on June 11, 1949 (Chelyabinsk region, South Urals, Russia) was investigated by means of micro-Raman spectroscopy also. The meteorite "Chelyabinsk" was classified as an ordinary LL5 chondrite (S4, WO) [1, 2]. It is very similar in mineral compositions to other LL5 chondrites [3]. The data on mineral content and structure of some "Chelyabinsk" fragments have been published, based on optical reflection, SEM, X-ray diffraction, TGA X-ray fluorescent analysis, infrared, Raman and Mössbauer spectroscopy and etc. methods as well as chemical analysis. Many minerals and chemical elements were found, the latter being mainly Si, Fe, Mg, etc. [1, 2]. Olivine, pyroxene, plagioclase are major minerals, and iron oxides and sulfides as well as calcite are minor phases according Raman spectroscopy [4, 5]. Wide development planetary Raman spectroscopy for mineral identification and characterization of materials make it a useful analytical method for investigation of unprepared meteorite samples [6]. The purpose of this studied was obtain information on mineral composition, polymorph modifications, impact effect and crystalline and amorphous phases of meteorite "Chelyabinsk" samples using Raman peak positions, peak widths, and correlation Raman peaks with composition of solid solutions.

Raman spectra were obtained on a LabRam HR800 Horiba Jobin Yvon spectrometer, equipped with an optical microscope (Olympus BX41). The 514.5 nm Ar+ laser line was used for spectra excitation.

Comparison with the main composition of LL chondrites , the meteorite "Chelyabinsk" is enriched in olivine content (about 60%) and depleted in orthopyroxene (about 12%) [1]. The estimation of composition for major mineral of the samples – olivine, $(Mg,Fe)_2SiO_4$, using the difference between the peak positions of doublet at ν_1~850 cm^{-1} and ν_2~820 cm^{-1}, lying in the range of 848.4–856.4 cm^{-1} and 817.5–824.5 cm^{-1}, correspondingly (fig.1), show weighted array with Mg/(Mg+Fe) from 0.04 to 1, according

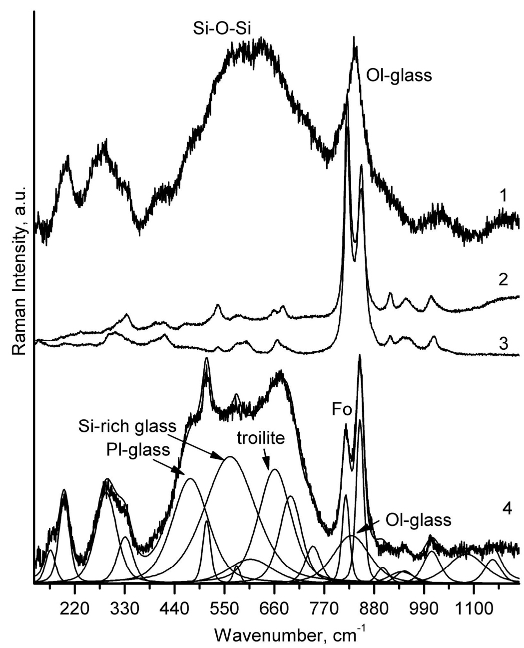

Fig. 1. Raman spectra of meteorite Chelyabinsk. 1- olivine and Si-rich glass; 2, 3 – olivine, 4- mixture of olivine-forsterite (Fo), Si-rich and plagioclase (Pl) glass; troilite

Huang [7], The main group has Mg/(Mg+Fe) in range 0.74–0.86.

Among pyroxenes we recorded orthopyroxene in general (fig. 2, 1 curve). Some spectra without doublet in region at 650–679 cm^{-1} have 668 cm^{-1} peak of clinopyroxene. Observed peak position correspond to Mg/(Mg+Fe+Ca) about 0.7 [8].

The Raman spectra of olivine and pyroxene were

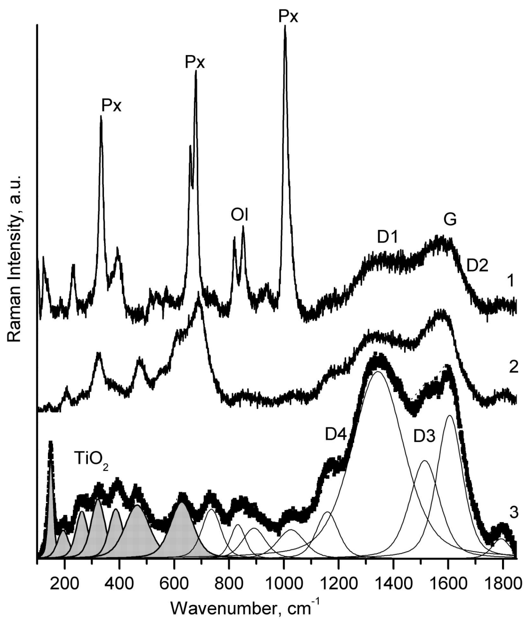

Fig. 2. Raman spectra of meteorite Chelyabinsk. 1- orthopyroxene, olivine and carbonaceous matter (CM), 2 – chromite and CM; 3 – deconvolution of the TiO_2 oxide and CM first-order region. G – graphite mode, D1 - disorder graphite, D2 - disordered sp^2 lattice, D3 – amorphous carbon, D4 – sp^3 bonds or C-C and C=C stretching vibration of polyene like structures

recorded in fragment of Kunashak meteorite also. The one spectrum, as few ones for meteorite "Chelyabinsk" similar to spectrum of sulphide arzakite, $Hg_2S_2(Br, Cl)_2$ from Rruff.info basedata [9].

Identification of the major type of feldspar in the fragments of meteorite "Chelybinsk" was made on peak position between two group peaks I –lying in the range of- 450-520 cm $^{-1}$ and III - below 200 cm^{-1} according Freeman [10]. Raman spectra of FS in samples of meteorite "Chelyabinsk" are the high temperature plagioclases [11].

The presence of disordered carbonaceous materials was confirmed by means of Raman spectroscopy for the surface of many samples, as for example (fig. 2, curves 1, 2), and glassy carbon for freshly cleaved surface (fig. 2, curve 3). The analysis by curve fitting provide the evidence of G, D1, D2, D3 and D4 band in the first-order Raman scattering region. Raman lines G at 1605 cm^{-1}, D1 at 1343 cm^{-1}, D3 at 1511 and D4 at 1159 cm^{-1} were detected.

The accessory phases are chromite $(Fe,Mg)Cr_2O_4$, ilmenite $FeTiO_3$, TiO_2 oxides, merrillite [12] (fig.1-3). The observed bands of TiO_2 are 149, 258, 327, 393, 467 and 628 cm^{-1}. Raman bands of troilite, ilmenite and Fe-, Cr-, Mg-, Al- oxides are recoded in 600-700 cm^{-1} region. The Raman spectrum of merrillite with

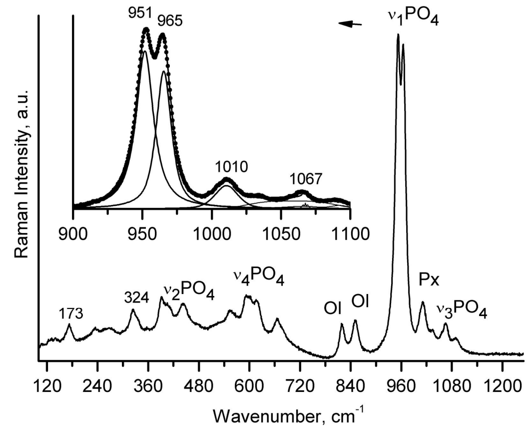

Fig. 3. Raman spectra of merrilite in meteorite "Chelyabinsk". Insert – fitting spectra on Gaussian-Lorentzian functions

doublet in region at 950–965 cm^{-1} is shown on fig.3.

Thus, the major, minor and trace minerals in the fragments of meteorite "Chelyabinsk"which have subjected extreme thermodynamic influences have been identified by means of micro-Raman spectroscopy.

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