MICRO-RAMAN SPECTROSCOPY OF ESTHERVILLE MESOSIDERITE.
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Introduction: Estherville meteorite belongs to 3/4A class of mesosiderites [1]. Elemental composition, mineral composition and microstructure of Estherville meteorite have been studied by various analytical techniques since its fall in 1879 [e.g. 1-6]. The aim of this paper was to identify meteorite minerals in silicate part of Esterville meteorite, and to determine pyroxene, olivine, and feldspar composition by micro-Raman-spectroscopy.

Experimental: Raman spectra were recorded at room temperature in back scattering geometry using confocal Raman micro-spectrometer T-64000 (Jobin-Yvon) equipped with the BX-40 microscope (Olympus). To excite the sample minerals Ar laser was applied (514.5 nm Ar line, the beam diameter about 1 μm), and acquisition time and laser power were adjusted to obtain spectra of sufficient quality. To identify minerals the Raman spectra were compared with the literature data, and chemical composition of olivine, pyroxenes, and the feldspar group were determined on the basis of literature data on Raman spectra features and calibration of spectral peak positions [7-11]. The accuracy in determining forsterite content in olivines, and enstatite content in pyroxenes from Raman peak positions is about 0.06.

Results and discussion: Figures 1-4 present Raman spectra from various parts of Estherville meteorite. Different minerals have been identified in the mesosiderite: olivine (Fig. 1), LT anorthite (Figs. 2,3), orthopyroxene (Fig. 3), and whitlockite (Fig. 4).

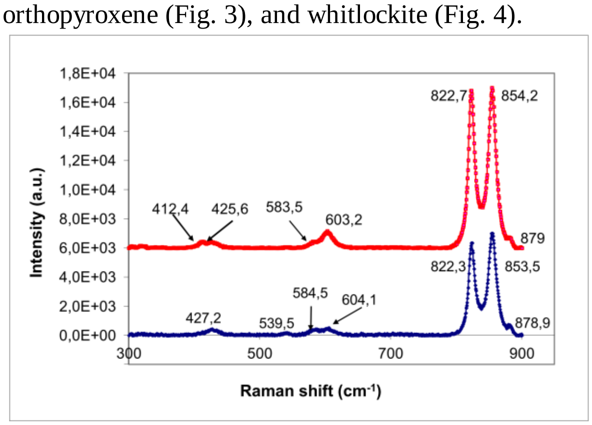

Fig. 1. Raman spectra revealing olivine: Fo89Fa11 (upper spectrum), Fo87Fa13 (lower spectrum). DB1 and DB2 peaks characteristics of olivine: 822.7, 854.2 cm^{-1} (lower spectrum), 822.3, 853.5 cm^{-1} (lower spectrum).

Olivine is an accessory mineral in mesosiderites. Literature data reveal the range of forsterite content in Estherville olivines Fo66-90 [6]. Figure 1 presents two Raman spectra of olivines that reveal the olivine composition: Fo87-89Fa11-13. It is seen that they represent the upper region of forsterite content [6].

Calcic plagioclase and orthopyroxene are two main silicate minerals present in mesosiderites [1]. Nelen and Mason established that Opx content in Esherville is ~70 wt%, and plagioclase content 18.4 wt% [2]. Raman spectrum presented in Figure 2 reveals calcic plagioclase, and spectrum in Fig. 3 reveals orthopyroxene in Estherville mesosiderite.

Raman spectra features: multiplicity of peak groups, peak positions, and peak widths give the possibility to distinguish members within the feldspar group [9,10]. An analysis of the 180 cm^{-1} and 500 cm^{-1} Raman peaks positions indicates that Estherville feldspar must be LT anorthite (~An90, Figs. 2, 3). Literature data indicate that An content in Estherville plagioclase is An89 [2].

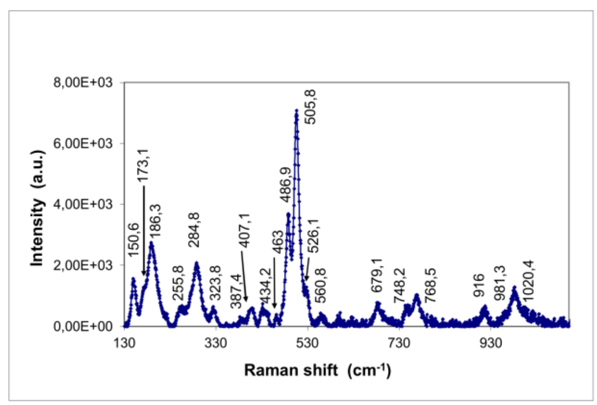

Fig. 2. Raman spectrum revealing calcic plagioclase. Peaks at: 150.6, 186.3, 255.8, 284.8, 486.9 and 505.8 cm^{-1} indicate that the plagioclase must be LT anorthite (~An90). The spectrum shows that apart from the plagioclase certain other minerals (among others pyroxene) are also present in this region of meteorite.

Figure 3 reveals that apart from anorthite also orthopyroxene is important mineral in Estherville meteorite. Similarly as in the case of olivines it was possible to determine the composition of pyroxenes from Raman data basing on previous literature scalling [7, 8].

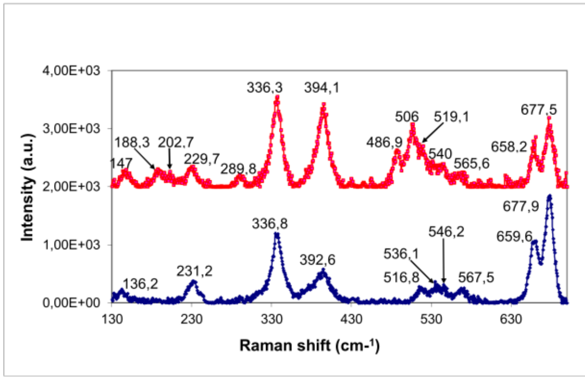

Fig. 3. Raman spectra revealing: i) orthopyroxene and anorthite (upper spectrum), ii) orthopyroxene (lower spectrum). Diagnostic Opx peaks: 658.2, 677.5, and 336.3 cm^{-1}, diagnostic anorthite peaks 188.3, 486.9, and 506 cm^{-1} (upper spectrum), and diagnostic Opx peaks: 659.6, 677.9, 336.8 cm^{-1} (lower spectrum).

Orthopyroxene Raman peak positions presented in Fig. 3 show that the ratio of Mg/(Mg+Fe+Ca) values (values of enstatite En content) in Estherville pyroxenes is 0.73. This means that Raman spectroscopy indicates that the Estherville hyperstene composition is En73Fs27.

Our Raman data on orthopyroxene composition in Estherville are within the range established by earlier researchers who used other analytical techniques [1,3,4,5]. According to the literature data, in which En means enstatite, Fs ferrosilite, and Wo wollastonite, the Estherville orthopyroxene has the composition: En69Fs29Wo1.7 (mean), En66-74Fs24-33Wo1.7 (range) [3,4], En71Fs25Wo4 [2], the range of En content En48-79 [5], and the maximum of the distribution of En content is for En74 [5].

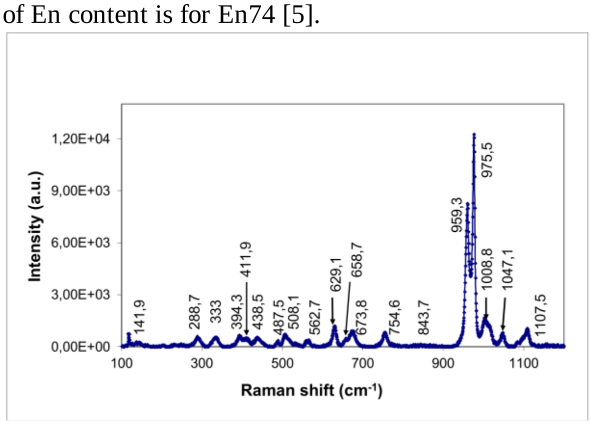

Fig. 4. Raman spectrum revealing withlockite. Diagnostic Raman peaks: 959.3 and 975.5 cm^{-1}.

Conclusion: Main silicate minerals of mesosiderites: orthopyroxene and calcic plagioclase, and two accessory mesosiderite minerals: olivine and whitlockite have been identified in the Estherville meteorite by micro-Raman spectroscopy. Enstatite content in orthopyroxene (En73), forsterite content in olivine (Fo87-89), and anorthite content in plagioclase (An90) established by Raman spectroscopy are within the range of values established for Estherville meteorite and for other mesosiderites.

References: [1] Mittlefehldt D.W. et al. (1998), *Rev. in Mineralogy 36*, 4.1-4.195. [2] Nelen J. and Mason B. (1972) *Smithson Contrib. Earth Sci. 9*, 55-56. [3] Mason B. and Jarosewich E. (1978) *Mineral Mag. 39*, 204-215. [4] Powell B.N. (1971) *Geochim. Cosmochim. Acta 35*, 5-34. [5] Prinz M. et al. (1980) *Proc. Lunar Planet. Sci. Conf. 11*, 1055-1071. [6] Delaney J.S. (1980) *Proc. Lunar Planet. Sci. Conf. 11*, 1073-1087. [7] Huang E. et al. (2000) *Amer. Mineral. 85*, 473-479. [8] Wang A. et al. (2001) *Amer. Mineral. 86*, 790-806. [9] Freeman et al. (2003) *LPS XXXIV*, Abstract #1676. [10] Freeman J.J. et al. (2008) *Can. Mineral. 46*, 1477-1500. [11] Kuebler K.E. et al. (2006) *Geochim. Cosmochim. Acta, 70*, 6201-6222.