VARIABILITY IN THE PHASE COMPOSITION IN CHELYABINSK LL5 FRAGMENTS WITH DIFFERENT LITHOLOGIES: STUDY USING X-RAY DIFFRACTION AND MÖSSBAUER SPECTROSCOPY.

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Introduction: Five fragments of Chelyabinsk LL5 ordinary chondrite (meteorite fall was on February 15, 2013) collected by the Meteoritical Expedition of the Ural Federal University on the next day after fall were chosen for comparative study by means of optical microscopy, scanning electron microscopy (SEM) with energy dispersive spectroscopy (EDS), X-ray diffraction (XRD) and Mössbauer spectroscopy. These samples demonstrate different lithologies such as: light lithology (two samples marked No 1 and No 1a), mixed light and dark lithologies (two samples marked No 2 and No 2a) and black lithology (one sample marked No 3). The dark lithology of samples No 2 and No 2a was different from the black lithology of No 3. The latter lithology was similar to the dark lithology mentioned in [1].

Materials and Methods: The polished thin sections of Chelyabinsk LL5 fragments were prepared by the standard methods for optical microscopy and SEM with EDS characterization. Then powdered matter was prepared from the slice surface for XRD and Mössbauer spectroscopy. Optical microscopy was done using an Axiovert 40 MAT microscope (Carl Zeiss) and SEM analysis was carried out using a ΣIGMA VP electron microscope (Carl Zeiss) with an X-max (Oxford Instruments) EDS device. Similar measurements were performed using an AMRAY 1830 scanning electron microscope equipped with EDAX PV9800 energy dispersive spectrometer. The XRD study was carried out using the XRD–7000 powder diffractometer (Shimadzu) while the ^{57}Fe Mössbauer spectra were measured at 295 K using SM-2201 spectrometer with a high velocity resolution. Detailes were described in [2].

Results and Discussion: Characterization of Chelyabinsk LL5 fragments by means of optical microscopy and SEM with EDS showed the presence of silicate matrix with Fe-Ni-Co alloy grains and inclusions of troilite FeS, chromite $FeCr_2O_4$ with hercynite $FeAl_2O_4$ and ilmenite $FeTiO_3$ which was found in fragment No 2a only. The results of the full profile Rietveld analysis of the XRD patterns and the best fits of the Mössbauer spectra of the studied Chelyabinsk LL5 fragments are collected in Table 1. The data from XRD were obtained in wt.%. Mössbauer spectroscopy permits to estimate the subspectra relative areas of the iron-bearing phases only which can be roughly considered as the relative Fe content in these phases. The results obtained for Chelyabinsk LL5 meteorite fragments demonstrated some variations in the phase composition for all fragments with the same and different lithologies studied by two techniques.

Table 1. Comparison of various phases obtained using XRD and corresponding relative areas revealed from the Mössbauer spectra (MS) in different fragments of Chelyabinsk LL5 ordinary chondrite.

Phase	No 1		No 1a		No 2		No 2a		No 3	
	XRD (wt.%)	MS (%)	XRD (wt.%)	MS (%)	XRD (wt.%)	MS (%)	XRD (wt.%)	MS (%)	XRD (wt.%)	MS (%)
Olivine	56.0	59.97	50.6	51.56	48.6	46.32	55.8	58.64	52.0	54.45
Orthopyroxene	25.9	22.48	24.8	13.70	25.2	12.34	25.8	15.09	21.2	11.89
Clinopyroxene	3.9	–	5.5	4.62	6.9	6.98	5.9	5.17	6.2	5.49
Anorthite	9.0	–	8.2	–	8.2	–	6.1	–	10.7	–
Troilite[a]	4.1	13.25	6.7	20.53	6.2	19.77	3.7	11.44	6.3	18.47
Chromite	0.5	0.83	1.5	1.63	1.5	2.69	0.6	1.18	1.8	2.51
Kamacite[b]	0.4	1.98	1.4	5.05	1.8	7.26	1.0	4.53	0.6	2.56
Taenite	0.2	1.50	0.9	2.19	0.8	2.90	0.7	2.44	0.7	3.86
Hercynite	–	–	0.4	0.72	0.8	1.73	0.3	0.69	0.5	0.78
Ilmenite	–	–	–	–	–	–	0.1	0.82	–	–
Total	100.0	100.01	100.0	100	100.0	99.99	100.0	100.00	100.0	100.01

[a]For fragments No 1a and No 3 the total relative area for FeS and $Fe_{1-x}S$ is shown.

[b]For fragments No 1a, No 2 and No 3 the total relative area for the α_2-Fe(Ni, Co) and α-Fe(Ni, Co) phases is shown.

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