ANALYSIS OF MAGNETIC COMPOUNDS OF KOŠICE METEORITE USING MÖSSBAUER SPECTROMETRY

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1. Introduction

Meteorite fall was observed by the town Kosice in Slovakia in February 2010. The fall itself was imaged by three security video cameras from Hungary. Detailed bolide light curves were obtained through clouds by radiometers on seven cameras of the European Fireball Network. Records of sonic waves were found on six seismic and four infrasonic stations. J. Borovička *et al.* [1] provided detailed description of atmospheric trajectory, fragmentation, and orbit. Meteorite was classified as ordinary chondrite H5 [2].

Mössbauer spectroscopy was used for analysis of iron bearing compounds in ordinary chondrites in various works [3-8]. Due to the high abundance of iron in the solar system and its chemical and physical properties, we can gain insight into the formation and evolution of planets through the study of iron compounds in the planetary bodies. These kinds of analyses can bring important knowledge about phases and compounds formed in extraterrestrial conditions, which have another features than their terrestrial analogues. The ^{57}Fe Mössbauer spectroscopy is one of the most sensitive methods for such studies. In this work Mössbauer spectroscopy will be used for phase analysis of iron bearing compounds with the aim to identify magnetic fractions using magnetic separation.

2. Experimental details

The samples were prepared in powder form. Magnetic separation of the sample *m1* was done by hand magnet. Sample 1 was scrapped directly from the surface approximately 1 mm into the bulk, sample 2 was scrapped at the same place approximately 1 mm deeper into the volume. Similarly, samples 3-6 were prepared. The spectra were measured at room temperature using the Wissel Mössbauer spectrometer with the ^{57}Co(Rh) source in transmission geometry. Hyperfine parameters of the spectra including spectral area (A_{rel}), isomer shift (IS), quadrupole splitting (QS), as well as hyperfine magnetic field (B_{hf}), were refined using the CONFIT fitting software [9], the accuracy in their determination are of ±1 % for relative area A_{rel}, ±0.04 mm/s for isomer shift and quadrupole splitting/shift and ±0.5 T for hyperfine field correspondingly. Mössbauer measurement showed a spectrum with many overlapping subspectra. In order to fit them the fitting procedure was applied as superposition of magnetic and non-magnetic components.

3. Results and Discussion

Six samples were prepared by scrapping from surface into the bulk of the fragment. Measured spectra shoved slight change in relative areas of magnetic part, at surface 22% of kamacite and 18% of troilite was found, in sample taken from bulk of the fragment rel. area of kamacite component has risen to 36%, troilite rel. area has decreased to 13%.

Mössbauer spectra of sample 1 and 6 measured at RT are shown in Fig.1. The spectra consist of components related to iron-bearing phases with different content. After evaluation process we found out that the magnetic fraction consists of two components and non-magnetic fraction of three components.

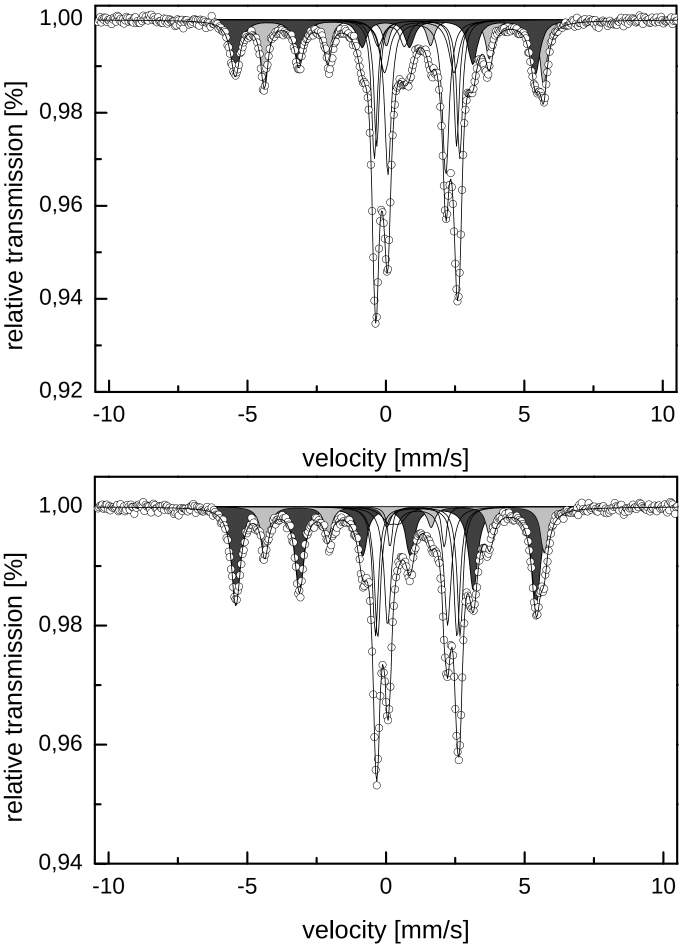

Fig.1: *MS spectra of sample 1(upper part of the figure) and sample 6 (lower part of the figure). Changes in magnetic fraction of the spectra can be clearly seen.*

Values of internal magnetic field of hyperfine magnetic and quadrupole splitting of non-magnetic components are given in Tab.1. Magnetic part forms approximately 40% of the spectra and the rest can be assigned to non-magnetic part. The doublets with quadrupole splitting of approximately 3.0 mm/s and 2.9 mm/s represent M1 and M2 sites of olivine $(Mg,Fe)_2SiO_4$, doublets with QS of approximately 2.5 mm/s and 2 mm/s correspond to M1 and M2 sites of pyroxene $(Ca,Mg,Fe)SiO_3$. Both these minerals contain iron in the form of Fe^{2+}. The doublet with lowest QS corresponds to Fe^{3+} component and/or to small particles of iron in so called superparamagnetic state. Its contribution is small, less than 5 %. From the analysis of magnetic part we can find that the first sextet with hyperfine magnetic field of 33.6 T corresponds to bcc Fe-Ni alloy (kamacite) and the second one with magnetic field value of 31.3 T match with FeS (troilite). Mössbauer parameters of all components are given in Tab.1.

In order to verify our fitting model of the magnetic part of the spectra, magnetic separation of sample 3 was performed and measured at RT (Fig.2). Spectrum shows no important qualitative changes in magnetic fraction, relative areas of magnetic part risen due to magnetic separation.

Tab. 1. *Spectral parameters of sample 1 and 6*

Sample 1

Component	A_{rel} [%]	IS [mm/s]	QS [mm/s]	B_{hf}[T]	Γ [mm/s]
kamacite	22	-0,01	-0,02	33,7	0,41
troilite	18	0,73	-0,16	31,3	0,32
olivine M1	14	1,13	3,08		0,25
olivine M2	13	1,11	2,89		0,24
pyroxene M1	10	1,21	2,51		0,45
pyroxene M2	19	1,12	2,09		0,29
Fe^{3+}	4	0,19	0,95		0,40

Sample 6

Component	Arel [%]	IS [mm/s]	QS [mm/s]	Bhf[T]	Γ [mm/s]
kamacite	36	0,01	-0,01	33,6	0,39
troilite	13	0,75	-0,16	31,3	0,33
olivine M1	14	1,15	3,05		0,25
olivine M2	15	1,13	2,86		0,27
pyroxene M1	15	1,14	2,16		0,31
pyroxene M2	4	1,12	1,96		0,21
Fe3+	3	0,29	0,41		0,60

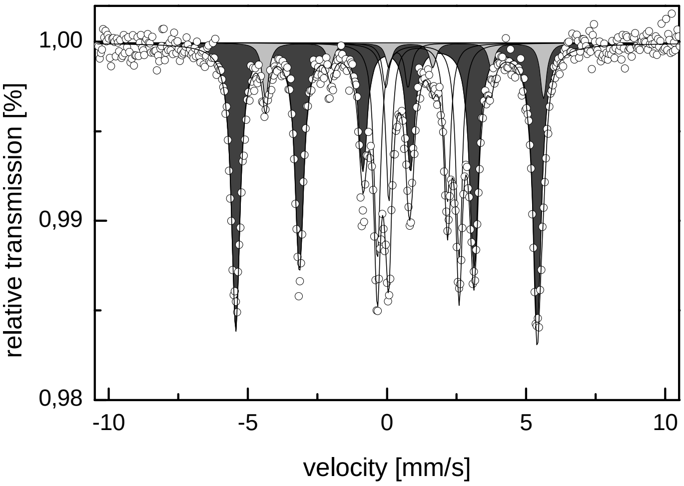

Fig.2: *MS spectrum of magnetically separated sample 3*

4. Conclusion

Phase composition of iron bearing content of Košice H5 meteorite was analysed. We have identified olivine, pyroxene and Fe^{3+} component in paramagnetic part of the spectra, magnetic part consist of kamacite and troilite. Six samples were prepared by scrapping from surface into the bulk of the fragment. Measured spectra shoved slight change in relative areas of magnetic part, at surface 22% of kamacite and 18% of troilite was found, in sample taken from bulk of the fragment rel. area of kamacite component has risen to 36%, troilite rel. area has decreased to 13%. In order to verify fitting model of the magnetic part of the spectra, magnetic separation of sample 3 was performed and measured at RT.

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