STRUCTURAL CHARACTERISTICS OF TROILITE FROM ORDINARY CHONDRITES

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Introduction: Troilite (FeS) is the most common sulfide mineral which presented in meteorites of different types. Troilite is an important mineral for the investigation of shock metamorphism in meteorites. Its spectral properties are sensitive to the space weathering of planetary bodies, as well as to the shock or thermal history of the matter [1]. In the present work we discuss of a troilite macro- and microstructure characterization by the means of scanning electron microscopy (SEM) with energy dispersive spectroscopy (EDS), X-ray diffraction (XRD) and X-ray spectroscopy.

Materials and methods: Small samples of ordinary chondrites Chelyabinsk (LL5, S4, W0), Northwest Africa 869 (L4-6, S3, W1), Tsarev (L5), Ravar (H4, S1, W3), Kharabali (H5, S2, W1) and Marsa Alam 009 (H6, S3, W3) were powdered at the agate mortar. Then troilite grains were isolated from the powders using a method of magnetic separation.

Polished sections of meteorites were studied by scanning electron microscopy using ΣIGMA VP (Carl Zeiss) with EDS X-max 80 (Oxford Instruments). The phase composition of the meteorite samples and structural parameters of troilite were investigated using diffractometer Bruker D8 Advance (Bruker) with the monochromatic Co Kα radiation. Their chemical composition was determined by the WDXRF spectrometer Supermini 200 (Rigaku).

Results and Discussion: From the data on the phase composition of the before mentioned ordinary chondrites, it was noted that troilite was presented in all the samples. The parameters of the unit cell for FeS phase were determined as following: Chelyabinsk - «a» = 5.954 (2) Å, «c» = 11.517 (1) Å, V = 353.638 (1) $Å^3$; NWA 869 - «a» = 5.995 (3) Å, «c» = 11.448 (1) Å, V = 356.382 (5) $Å^3$; Tsarev - «a» = 5.953 (2) Å, «c» = 11.500 (6) Å, V = 352.96 (3) $Å^3$; Ravar - «a» = 5.958 (3) Å, «c» = 11.515 (1) Å, V = 354.03 (4) $Å^3$; Kharabali - «a» = 5.964 (5) Å, «c» = 11.498 (1) Å, V = 354.24 (7) $Å^3$; Marsa Alam 009 - «a» = 5.960 (3) Å, «c» = 11.604 (2) Å, V = 357.06 (7) $Å^3$. The difference between cell parameters obtained and parameters of stoichiometric troilite FeS («a» = 5.961 (3) Å, «c» = 11.519 (2) Å, V = 354.47 $Å^3$ (Powder Diffraction File ICDD)) is due to a deficiency of the iron cations in the troilite crystal lattice. Therefore, it confirms that the troilite of the ordinary chondrites has non-stoichiometric composition $Fe_{1-x}S$.

The paper [2] presented experimental data for the compound $Fe_{1-x}S$ in a range of degrees of non-stoichiometry $0.004 \leq x \leq 0.143$. The functional dependence of the interplanar distance (d) of the main troilite peak (114) as a function of x turned out to be almost linear for small values of x. Using that dependence, we determined the degree of non-stoichiometry x for the troilite from samples: Chelyabinsk - x = 0.087; NWA 869 - x = 0.099; Tsarev - x = 0.086; Ravar - x = 0.084; Kharabali - x = 0.086; Marsa Alam 009 - x = 0.052. These results correlate well with the previously obtained data on the chemical composition of troilite.

Parameters of the fine structure of troilite such as microstrains $\varepsilon = \Delta d/d$ and coherent length (crystallites size) D were calculated from the X-Ray spectra using Williamson-Hall method. It was noted, that the values of microdeformations of troilite from chondrites correlate well with the degree of the impact load which meteorites experienced during their cosmic evolution. It was confirmed by the data for all the meteorites involved in the current study. Moreover, this tendency allows this method to be applied to the samples with an unknown degree of shock metamorphism. For example, as far as there are no data on the shock stage of Tsarev L5 at the Meteoritical Bulletin, it was noteworthy to estimate it. Furthermore, by this method we determined the degree of shock metamorphism for the troilite from Tsarev ordinary chondrite between S3 and S4. This estimation corresponds to the degree of metamorphism from [3], established previously by optical microscopy method.

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