NORTHWEST AFRICA 6286 AND 7857 METEORITES: STUDY USING MAGNETIZATION MEASUREMENTS AND MÖSSBAUER SPECTROSCOPY.

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Introduction: Northwest Africa (NWA) 6286 and 7857 meteorites found in 2010 and 2013, respectively, belong to ordinary chondrites, LL6 type. In the present work the characterization of these meteorites using optical and scanning electron microscopy, X-ray diffraction, magnetization and Mössbauer measurements is presented.

Experimental: Fragments of NWA 6286 and NWA 7857 LL6 meteorites were polished by the standard metallographic procedure for investigation by using: optical microscopy, scanning electron microscopy (SEM) with energy dispersion spectroscopy (EDS) and X-ray diffraction (XRD). Powder samples taken from the surface were used for magnetization measurements and Mössbauer spectroscopy with a high velocity resolution. Optical microscopy was carried out with Axiovert 40 MAT inverted microscope (Carl Zeiss), SEM analysis was done using ΣIGMA VP scanning electron microscope (Carl Zeiss) with an X-max 80 EDS device (Oxford Instruments), XRD patterns were measured using PANalytical X'Pert PRO MPD diffractometer (The Netherlands), magnetization measurements were carried out using SQUID magnetometer (MPMS-5S Quantum Design) and ^{57}Fe Mössbauer spectra at room temperature were measured using high precision and sensitive Mössbauer spectrometric system with a high velocity resolution [1].

Results and discussion: Microstructure of both NWA 6286 and NWA 7857 meteorites appeared to be typical for LL ordinary chondrites. Optical and scanning electron microscopy showed: (i) silicate matrix with metal grains, (ii) troilite (FeS) and (iii) chromite ($FeCr_2O_4$) inclusions. (i) The metal grains consisted of: α-Fe(Ni, Co), α_2-Fe(Ni, Co) and γ-Fe(Ni, Co) phases with corresponding Ni concentration ranges. (iii) Chemical analisis of the chromite particles revealed the presence of aluminium (~3.5 at.%) as well as impurities of titanium and magnesium (less than 1.5 at.%). The Al existence may indicate the presence of hercynite ($FeAl_2O_4$) or mixed spinel $Fe(Al_{1-x}Cr_x)_2O_4$. XRD study of both meteorites revealed the phases of: olivine ($(Fe, Mg)_2SiO_4$), orthopyroxene ($(Fe, Mg)SiO_3$), clinopyroxene ($(Fe, Ca, Mg)SiO_3$), anorthite ($CaAl_2Si_2O_8$), troilite, chromite, hercynite, α-Fe(Ni, Co) and γ-Fe(Ni, Co) phases.

Magnetization measurements showed quite similar features for both NWA 6286 and NWA 7857 meteorites. For example, in the zero-field-cooled curves a peak at 58–59 K was observed for both meteorites. This peak was attributed to the antiferromagnetic magnetic ordering of chromite. On the other hand, NWA 6286 conained a larger fraction of a paramagnetic component whereas a pronounced ferromagnetic component was observed in NWA 7857. The Mössbauer spectra of NWA 6286 and NWA 7857 were fitted by taking into account the same components related to the crystallographically non-equivalent M1 and M2 positions in olivine, orthopyroxene and clinopyroxene, stoichiometric troilite FeS, chromite and hercynite. Whereas other revealed spectral components were associated to various magnetic phases in these meteorites such as: (i) one α_2-Fe(Ni, Co) and two γ-Fe(Ni, Co) components (the latter was due to variations in the local Ni concentrations) in NWA 6286, (ii) two α-Fe(Ni, Co) and one γ-Fe(Ni, Co) components (the former was due to variations in the local Ni concentrations) in NWA 7857 and (iii) two and one non-stoichiometric troilite ($Fe_{1-x}S$) components in NWA 6286 and NWA 7857, respctively. A paramagnetic γ-Fe(Ni, Co) phase (with ~29–33 at.% Ni) was revealed in the spectrum of NWA 6286 meteorite. The larger total relative area of spectral components related to the ferromagnetic α- and γ-phases observed in NWA 7857 correlates with magnetization data. The hyperfine parameters of spectral components related to the M1 and M2 sites in olivine, the M2 sites in orthopyroxene and the M1 sites in clinopyroxene were the same (within the error) for both meteorites while those of spectral components for the M1 sites in orthopyroxene and the M2 sites in clinopyroxene appeared to be different. It was shown that both NWA 6286 and NWA 7857 fall into the LL region within the suggested ordinary chondrites systematics by using Mössbauer parameters (see [2, 3]).

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References: [1] Oshtrakh M.I. and Semionkin V.A. (2013) *Spectrochimica Acta, Part A: Molececular and Biomolecular Spectroscopy* 100:78–87. [2] Oshtrakh M.I. and Maksimova A.A. (2016) *Meteoritics & Planetary Science* 51:A495. [3] Maksimova A.A. et al. (2017) *Spectrochimica Acta, Part A: Molececular and Biomolecular Spectroscopy* 172:65–76.