PHOTOLUMINESCENCE THERMAL QUENCHING IN CHELYABINSK LL5 CHONDRITE WITH LIGHT-COLORED LITHOLOGY

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Introduction: The presence of different types silicates in the composition of virtually all known ordinary chondrites leads to the appearance of interacting charge-carrier traps system in the energy structure of extraterrestrial matter. These capturing centers form discrete levels and defective subbands in the energy gap, which provide the accumulation and storage of radiation history and are responsible also for the mechanisms of anomalous fading with the tunnel effects manifestation. In this connection, it is necessary to have information on the microscopic parameters of the multitrap system for the correct dating of meteorites and for the study of radiation-induced processes involving known thermally and optically stimulated luminescence techniques. Numerous fundamental and microstructural factors can influence the evaluation of these characteristics: the mechanisms of the luminescence quenching with temperature rise, the ratio of various silicate structures, the aftermath of extreme thermal, impact and radiation effects, the presence of different and mixed lithology types etc. [1 – 3]. The purpose of this work is to study the kinetic features of the photoluminescence (PL) thermal quenching in samples of Chelyabinsk meteorite with a distinct light-colored lithology.

Experimental: The fragment of Chelyabinsk LL5 chondrite characterized by light lithology predominantly was selected. The core of the meteorite was separated from fusion crust and crushed into micropowder, which was treated in hydrochloric acid to remove metal particles. Photoluminescence emission and excitation spectra were registered in phosphorescence regime using a LS55 Perkin Elmer spectrometer in λ_{em} = 290 – 700 nm range with 20 nm slit and in λ_{ex} = 200 – 370 nm range with 10 nm slit, respectively. During the PL registration scanning speed was 120 nm/min. PL thermal quenching measurements of the samples were carried out with original heating accessory module [4]. The corresponding temperature dependences were measured in cooling regime within 773 K – RT range with 1 K/s rate under excitation in λ_{ex} = 210 and 230 nm and registering emission in λ_{ex} = 330, 440, 480 and 530 nm bands.

Results and Discussion: The measurements results of the excitation and emission spectra at different temperatures are presented. It is shown that the luminescence spectra are characterized by a broad structured band in the range of 300 – 650 nm. Several overlapping components with maxima of $\lambda_{em} \approx$ 330, 440, 480 и 530 nm can be distinguished. All the components have similar excitation spectra with a sharply increasing intense short wavelength edge in 200 – 210 nm range and a shoulder at 230 nm. The intensity of emission significantly decreases by more than 100 times with temperature increasing and is characterized by background values at > 600 K. The observed temperature dependences with a high degree of accuracy are numerically analyzed using the model approaches of Mott [5] and Street [6]. It is established that the values of the parameters calculated using the approximation of all the investigated PL quenching curves vary in the following ranges: pre-exponential factor of $C = (2 – 30)\cdot 10^4$ and activation energy of W = 0.29 – 0.36 eV – for Mott equation; pre-exponential factor of $P = (1 – 8)\cdot 10^{-4}$ and characteristic temperature of T_S = 34 – 42 K – for Street equation. The values obtained are somewhat lower than the Mott quenching parameters – $C = 10^7$ и W = 0.6 eV [7]. The independent analysis of processes under study in silicate structures using the Street model are unknown. In this connection it is necessary to perform measurements in the range below room temperature. Nevertheless, we note that the estimated quenching parameters do not depend on the excitation and emission wavelengths, that indicates the presence of a single mechanism for the temperature-dependent luminescence in the samples under study.

Conclusion: In the present work the temperature behavior of the photoluminescence spectra in specially selected samples of the Chelyabinsk LL5 chondrite with light-colored lithology is studied. It is shown that the observed PL processes undergo strong quenching when heating in the temperature range of RT – 773 K. The intensity of the luminescence decreases more than 100 times and reaches background values at 600 K. The studied temperature quenching curves are numerically analyzed in the framework of the Mott and Street mechanisms. The calculated values of the model parameters are discussed in comparison with the data of independent works. It is supposed that a single channel of non-radiative relaxation of excitations operates in the investigated temperature range for various spectral components characterizing the emission of Chelyabinsk meteorite samples with light lithology.

Acknowledgements: This work was supported by contract № 02.A03.21.0006 Act 211 Government of Russia.

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