EXPERIMENTAL MODELLING OF THE THERMAL EFFECT ON CHELYABINSK METEORITE.

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Introduction: Ordinary chondrites material was affected by various pressures and temperatures during the formation and evolution. Their texture was formed at several processes: accretion from the nebula, thermal metamorphism at the meteorite parent body and, in most cases, shock events. Thermal influence made a significant contribution to the metamorphism of a primitive substance. In the present study, the heating experiments were performed to reproduce the thermal metamorphism. The Chelyabinsk LL5 meteorite material of the light-colored lithology was chosen for the study because it was carefully studied previously [1-3] and Chelyabinsk has the dark-colored lithology, which could be compared with experimental results. Here the thermal effect on the meteoritic texture and composition was analyzed in comparison to the known impact applied.

Samples and Methods: Chelyabinsk LL5 ordinary chondrite samples were cut from the one fragment of the light-colored lithology as the cubes ~1x1x1 cm using water-cooled Buehler IsoMet saw with subsequent drying. Polished sections were prepared using Buehler Beta Grinder-Polisher. The identification of the structural features of the studied fragments was performed using the Carl Zeiss Axiovert 40 MAT optical inverted microscope with AxioVision image recording, as well as an FE-SEM ∑IGMA VP electronic microscope. Heating experiments were carried out using a vacuum electric furnace SNVE-9/18 at a pressure of 10^{-2} Pa. Samples of the bright lithology of the Chelyabinsk LL5 meteorite were subjected to thermal effects up to temperatures of 700, 900, 1100, 1300 and 1500°C.

Results and Discussion: The initial structure of the Chelyabinsk LL5 meteorite samples with light lithology is represented by the chondrite structure, which is composed of groups of silicate minerals of olivine (Fe, Mg) $_2SiO_4$, pyroxene (Fe, Mg) SiO_3, and plagioclase. The silicate matrix contains mainly individual grains of the metal Fe (Ni, Co), troilite FeS and their intergrowing. After the heating up to the 700°C the shape of the metal and troilite grains was sharp, it has not changed, while the metal grains became polycrystalline. The troilite grains and intergrowing of metal and troilite were changed at the samples heated to the 900°C. Moreover, the traces of the grain boundaries migration was observed at the metal structure. Micrograins of troilite at the impact veins were transformed into the small veins and caused spot silicates darkening.

The fragment of the meteorite Chelyabinsk LL5, which was initially of light-colored lithology, got an external similarity with the dark-colored lithology after the heat exposure up to the 1100°C. From the visual inspection of a sample heated to a temperature of 1300°C shows that this sample has acquired an external similarity with the impact melt lithology of the Chelyabinsk LL5 meteorite.

The study of the microstructure of the sample of light lithology after thermal exposure (1100°C, 1300°C) revealed the melting of the metal Fe (Ni, Co) and troilite FeS phases, followed by crystallization upon the surface of the sample. It was noted at the plane of the polished section. For the sample heated up to the 1300°C, a partial changing of the sample shape was observed. While heating to a temperature of 1500°C caused massive melting of the sample, even the fragment completely lost its shape. The study of the sample topology using secondary electron imaging revealed the melt flow and its slow crystallization with the large fragile parallel crystals growth. It should be noted, that the texture of the sample transformed from temperature experiments is different in comparison with the texture of the lithology of the impact melt. It concerns both its external characteristics (color) and the shape and the size of the crystals in the structure.

Conclusions: As a result of the heating experiments with the substance of light-colored lithology of ordinary chondrite Chelyabinsk LL5, it is shown that the structure of the substance was transformed differently depending on the temperatures experienced. The experimentally heated fragments of light-colored lithology have both similarities and differences with the samples of dark-colored lithology and the impact melt of the Chelyabinsk LL5 meteorite, which have been heated under natural conditions during a shock event in space. It was shown that the formation of lithologies was influenced not only by the temperature effect but also by the impact transformation, as it was studied in [Petrova et al., 2018]. The structures obtained after the heating experiments have not found yet among the studied samples of the Chelyabinsk meteoritic shower.

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