The post-impact metamorphism of Chelyabinsk meteorite in shock experiments

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The shock processes play the main role in space weathering of airless meteoroids and the evolution of extraterrestrial matter. The shock waves in a matter affect the structure of minerals and changes in reflectance spectra as a result.

The Chelyabinsk chondrite is a fresh fall from February 2013 in Russia. The meteorite was officially classified as LL5 S4 W0. Its complex structure with different lithologies was described before in [1-4]. Light-colored and dark-colored lithologies of Chelyabinsk LL5 are supposed to be of identical LL5 composition mostly [1]. There are few explanations of different lithologies formation from the initial substance [5]. We observed different lithologies in the main mass fragments recovered from Chebarkul Lake. However, small samples mostly possessed a single type of lithology. Relatively large sections of the massive Chelyabinsk meteorite fragments look like suevite structure from the impact craters described in [6]. We suppose that Chelyabinsk meteoroid was formed at a similar mechanism as suevite because it appears as the fragments of the host rock fell into the impact melt and were partly reheated [7]. In this study, the intensive shock impact on the initial material of the light-colored lithology of Chelyabinsk LL5 meteorite was experimentally performed. The method of spherically converging shock waves is a useful technique for modeling the effect of wide ranges of pressure and temperature on studied materials.

Spherical shock experiments with Chelyabinsk meteorite were done at the Russian Federal Nuclear Center - VNIITF. A sample was prepared in the shape of the ball of 40 mm in diameter. The experiment setup allows gradual shock increase from sample rim towards the interior. Spherical shock experiments produced gradual pressure changes from S4 level up to complete melting. The individual fragment with light-colored lithology was used in the current experiment. From the naked eye observation of the diameter section of the experimentally shocked Chelyabinsk sample four visually different zones were distinguished. At the distance of 0,25 of the ball radius (R) from the center is the shock melted zone. From the 0,4R to 0, 45R from the center the dark-colored ring is situated, while a brighter zone is situated between them. Further at the distance of 0,45 - 1,0 R light-colored lithology presented.

Possibility of various lithologies formation in one sample has been demonstrated during the converging shock waves experiment. The reflected light spectra from 0.4 to 100 µm of a shocked Chelyabinsk meteorite demonstrate darkening under certain loading conditions [8].

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