The Chelyabinsk meteoroid structure formation

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Chelyabinsk meteorite fell in Russia at 15 February 2013. Many researchers were allowed to study meteorite matter due to abundant meteorite shower. Structure features and different lithologies of this ordinary LL5 S4 W0 chondrite substance were observed in [1-4].

Our investigation involved about 50 specimens with size range from 1 to 25cm. Using macro-, micro- and electron microscopy, we observed different lithologies in large samples (more than 3 cm), while small samples only possessed a single type of lithology. There were slightly shocked light lithology and dark lithology with two visible zones: entirely molted gray zone and partly melted black one.

As light and dark lithologies are of identical LL5 composition [1, 5], there are few explanations of their formation from the initial matter.

We observed in large samples with different lithologies that light lithology parts had typical roundish shapes.

Furthermore, large lithology samples had slickensides across the whole sample. We found them crossing each other in a few cases. At the same time, dark lithology samples had no slickensides. It seems that dark lithology existence was the result of the shock darkening from the events in the space. Melted metal and troilite impact veins were well presented in the dark lithology substance. Dark lithology morphology was found in forms of the individual samples, as well as dykes, and a main mass begirt light lithology parts within the large samples. Moreover, large parts of the dark lithology were adjoined with the grey melted parts.

All three different lithologies are the results of Chelyabinsk parent body complicate shock history. As described in [4], according to history of impacts and heating events, Chelyabinsk chondrite matter experienced at least eight impact events. We suppose that one of them resulted in forming of the crater and the breccia structure at the same time.

Chelyabinsk chondrite matter was initially formed in a meteorite parent body of size consistent with the petrological type 5. Formation was followed by the impacts and/or heat transfer events.

Furthermore, the structure of the main Chelyabinsk fragment looks like suevite structure from the impact craters described in [6]. It appears that Chelyabinsk breccia formation mechanism was similar to the impact cratering on the air-free planets. There were fragments of the host rock that fell into the impact melt and were partly reheated.

As follows from our calculations, cooling rate (from the metal dendrites in the vesicles) was found within the crystallization interval.

Fig 1 Sample with three distinct lithologies

Chelyabinsk meteoroid appears to be derived from a recent breakup event, which initialized its' travel towards the Earth [4]. As the ablation process during the fall removed main mass of the meteoroid, the impact structure either underlaid inside the meteoroid body or was the essential part of the impact brecciated matter. This fact confirmed that we have all the lithologies in the samples.

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