CHELYABINSK – NOT ONLY ANOTHER ORDINARY LL5 CHONDRITE, BUT A SPECTACULAR CHONDRITE BRECCIA

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Introduction

On February 15, 2013 a meteoroid entered the Earth's atmosphere and exploded over the Chelyabinsk area, Russia. Many thousands of fragments fell about 40 km south of Chelyabinsk. A great number of meteorite pieces were collected shortly after this event by local people. The meteorite was classified as an ordinary chondrite (LL5; [1]). As also noted in [1], a significant portion of the stones collected consists of a dark, fine-grained impact melt embedding mineral and lithic fragments. Here, we are summarizing our observations on 11 fragments from the strewn field.

Results – Lithologies

The Chelyabinsk chondrite is a breccia having different lithologies mixed together. These lithologies include:

(1) light-colored, shocked (S4), LL5-lithologies as described earlier [1] having abundant shock veins;
(2) light-colored fragments having very rare chondrule relicts and minor or no shock veins. Some of these are clearly of petrologic type 6 (LL6) and are also shocked to S4;
(3) similarly, highly recrystallized LL5/6 or LL6 lithologies having abundant shock veins (Fig. 1);
(4) shock-darkened fragments (Fig. 2) in which fractures and interstitial spaces are filled up with opaques (e.g., troilite) due to shock mobilization (Fig. 4);
(5) dark, fine-grained impact melt fragments with variable abundances of mineral and lithic clasts (Figs. 3 and 5). These have also been described earlier in [1].

Fig. 3: Thin section of an individual Chelyabinsk fragment with two different lithologies: (a) impact melt breccia (right side); (b) LL6 chondrite (left side). Within the chondritic fragment and between the two lithologies shock veins are visible.

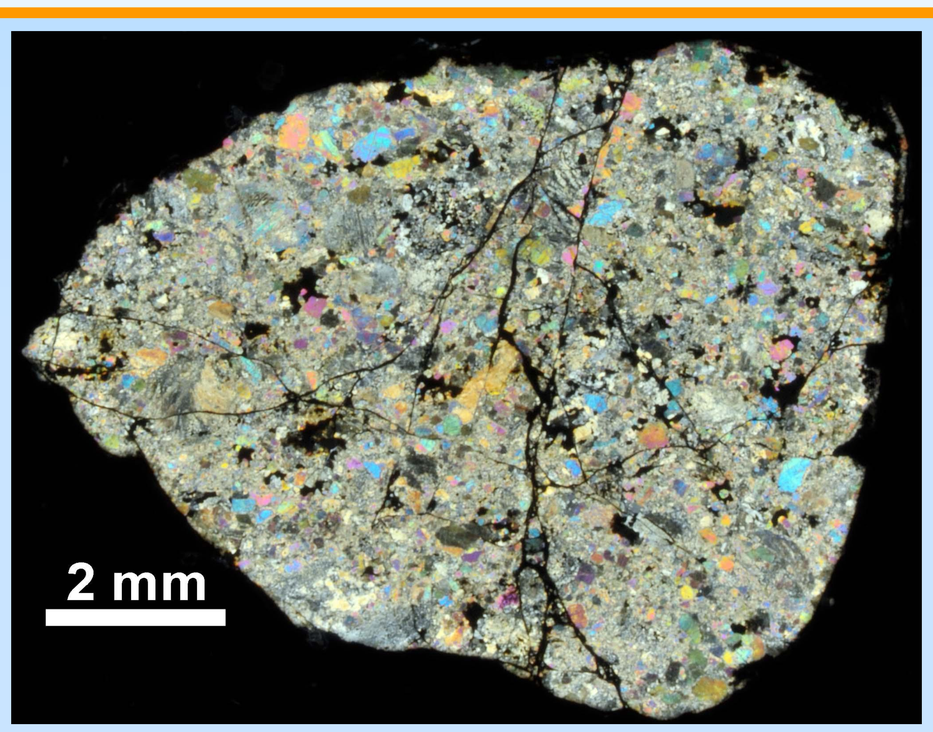

Fig. 1: Chondritic lithology of Chelyabinsk. Relict chondrules are only barely visible (LL 5/6).

Results – Shock features

Shock veins were located in nearly all lithologies (light-colored, shock-darkened fragments), but we did not find distinct veins in the impact melt breccia fragments. Within the shock veins of Chelyabinsk we searched for high pressure minerals like ringwoodite and wadsleyite. High pressure phases like ringwoodite – typical for many shocked L-chondrites – are rarely found in LL chondrites [7]. Some areas of interest were selected by optical microscopy. We looked at two areas about 500 × 300 µm in size within shock veins by point-and-shoot Raman analyses, but so far we did not identify any high-pressure minerals. Since LL5 and LL6 lithologies have crystalline plagioclase (and not maskelynite), the S4 shock classification of these breccia components is appropriate.

Conclusions

The Chelyabinsk chondrite is a breccia having different lithologies mixed together and lithified. In contrast to Kaidun [2] and Almahata Sitta [e.g., 3-6], which contain foreign fragments (both various chondritic and achondritic), Chelyabinsk is polymict only considering the different lithologies, but so far exclusively lithologies related to the LL chondrite parent body have been found (genomict breccia).

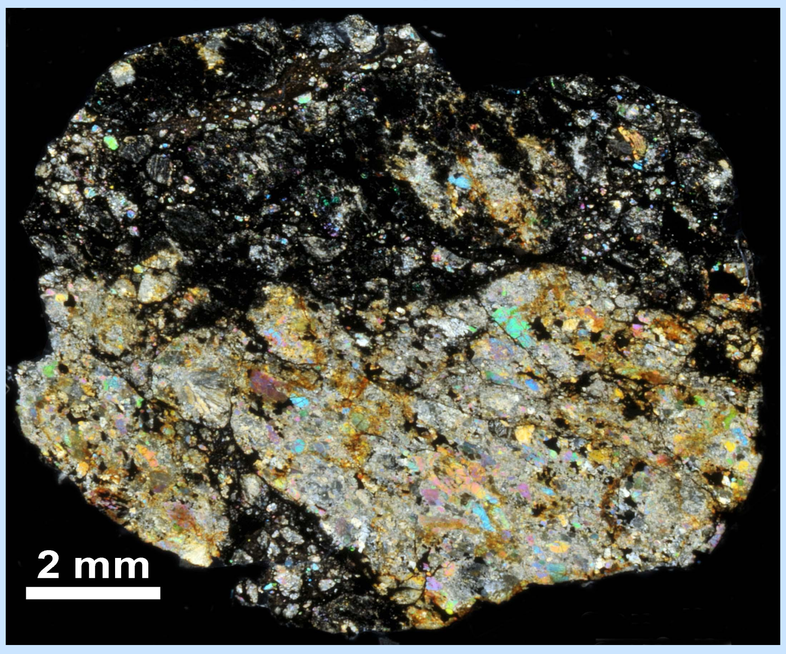

Fig. 2: Individual Chelyabinsk fragment with shock-darkened fragments and chondritic areas with minor shock veins.

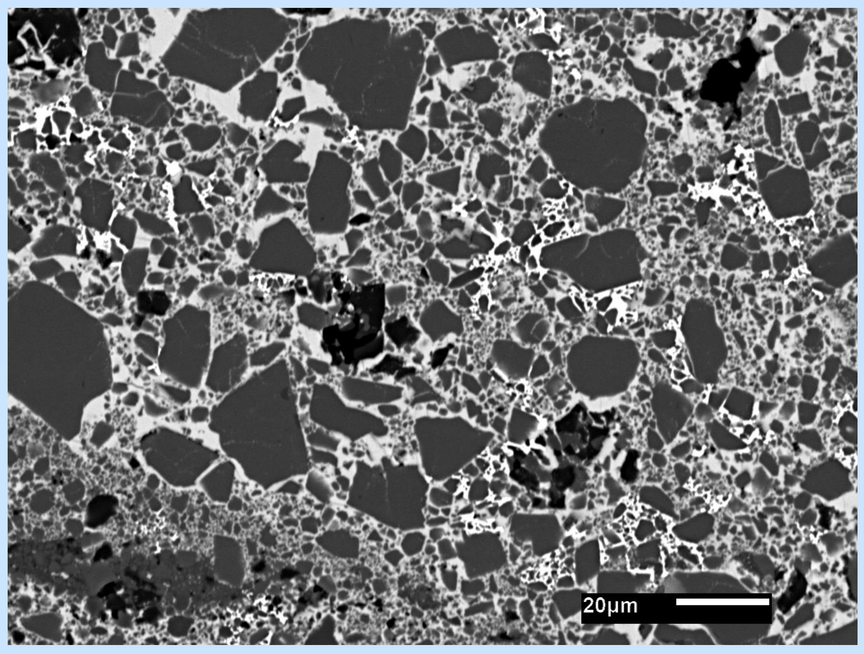

Fig. 4: In some shock-darkened areas silicates (gray) are completely embedded in (mainly) sulfides and metal.

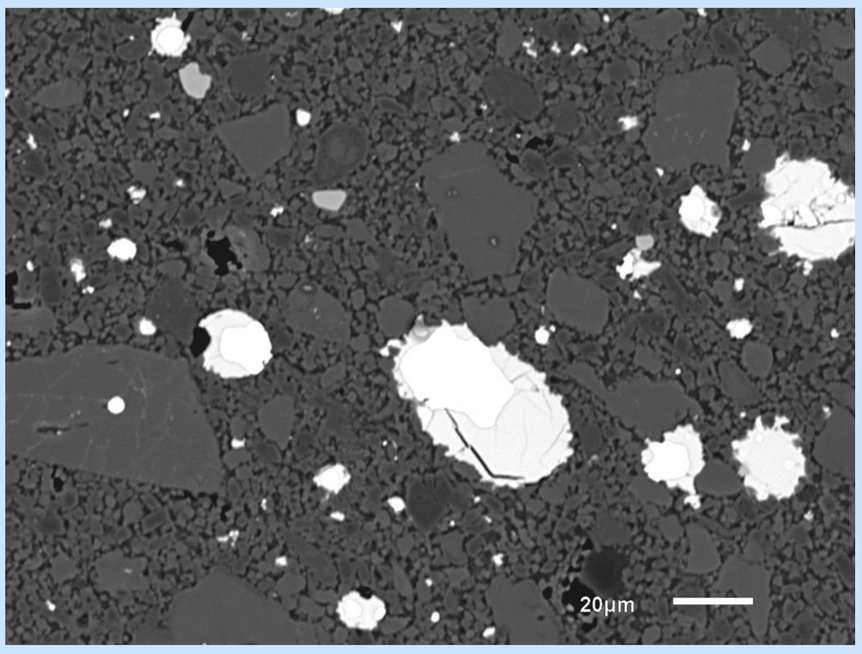

Fig. 5: Fine-grained texture of the impact melt breccias. Mafic silicates are enclosed in plag-normative interstitial material. Rounded metal-sulfide objects are white.

References: [1] http://www.lpi.usra.edu/meteor/metbull.php. [2] Zolensky M. E. and Ivanov A. 2003. *Chemie der Erde—Geochemistry* 63:185–246 [3] Bischoff A. et al. 2010. *Meteoritics & Planet. Sci.* 45:1638-1656. [4] Bischoff A. et al. 2012. *Meteoritics & Planet. Sci.* 47:A71. [5] Horstmann M. et al. 2010. *Meteoritics & Planet. Sci.* 45:1657-1667. [6] Horstmann M. et al. 2012. *Meteoritics & Planet. Sci.* 47:A193 [7] Bischoff A. 2002. *Lunar and Planetary Science XXXIII,* Abstract #1264.