CHELYABINSK LL5 CHONDRITE – INSIGHT INTO SHOCK EFFECTS ON S-TYPE ASTEROIDS. T. Kohout[1, 2], M. Gritsevich[3, 4, 5], V. I. Grokhovsky[5], G. A. Yakovlev[5], J. Haloda[6, 7], P. Halodova[7], R. M. Michallik[8], A. Penttilä[1], K. Muinonen[1,3], [1] Department of Physics, University of Helsinki, Finland (tomas.kohout@helsinki.fi), [2] Institute of Geology, The Czech Academy of Sciences, Prague, Czech Republic, [3] Finnish Geospatial Research Institute, Masala, Finland, [4] Russian Academy of Sciences, Dorodnicyn Computing Centre, Department of Computational Physics, Moscow, Russia, [5] Ural Federal University, Ekaterinburg, Russia, [6] Czech Geological Survey, Prague, Czech Republic, [7] Oxford Instruments NanoAnalysis, High Wycombe, Bucks, United Kingdom, [8] Department of Geosciences and Geography, University of Helsinki, Finland.

Introduction: On February 15, 2013, at 9:22 am, an exceptionally bright and long duration fireball was observed by many eyewitnesses in the Chelyabinsk region, Russia. Two days later the first fragments of the Chelyabinsk meteorite were reported to be found. Among recovered meteorites materials with various shock effects are present.

Shock effects: Three lithologies, the light-colored, dark-colored, and impact melt lithologies, were found within the recovered meteorites [1]. The light colored lithology (Fig. 1) is a LL5 ordinary chondrite (Fa 28, Fs 23) shocked to S4 level.

The dark colored lithology (Fig. 1) is of identical LL5 composition (Fa 28, Fs 23). However, it is shocked to higher level (shock-darkened) with fine grained metal and sulfide-rich melt forming a dense network of fine veins impregnating the inter- and intra-granular pore space within crushed silicate grains.

The impact melt lithology is a whole-rock melt derived from the same LL5 source.

Physical properties: Physical properties of Chelyabinsk meteorites are summarized in Fig. 2. The measured bulk and grain densities and the porosity closely resemble other LL chondrites as summarized in [2]. Shock darkening does not have a significant effect on the material physical properties.

Based on the magnetic susceptibility (Fig. 3), the Chelyabinsk meteorites are richer in metallic iron as compared to database of other LL chondrites [3]. The shocked and unshocked material does not show significant difference in metal amount.

Reflectance spectra: Both impact melting and shock darkening causes a decrease in reflectance and a suppression of the silicate absorption bands in the reflectance spectra (Fig. 2) similarly as observed in earlier studies [4]. Such spectral changes are similar to the space weathering effects observed on asteroids. However, space weathering of chondritic materials is often accompanied with a significant spectral slope change (reddening). In our case, only negligible to minor change in the spectral slope is observed. Thus, it is possible that some dark asteroids with invisible silicate absorption bands may be composed of relatively fresh shock-darkened chondritic material. The main spectral difference of chondritic asteroid surfaces dominated by impact melt, shock darkening, or space weathering, is a significant slope change (reddening) in the latter case.

Conclusions: All three Chelyabinsk lithologies are of identical LL5 composition and origin. The difference among them is shock level. Shock does not have significant effect on meteorite physical properties, but causes spectral darkening and suppression of silicate absorption bands.

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References:

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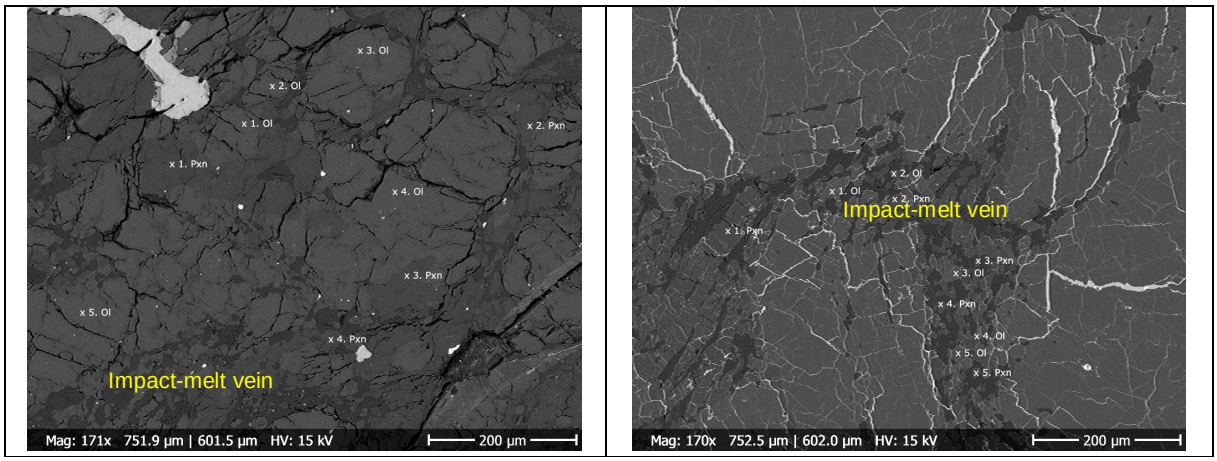
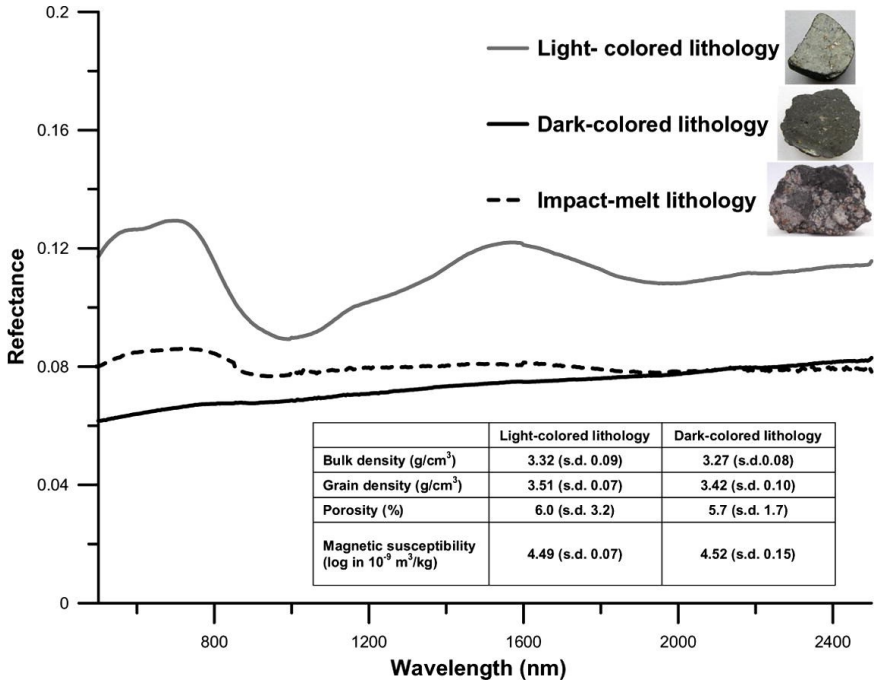


Fig. 1. SEM-BSE images of light-colored (left) and dark-colored (right) lithology.



	Light-colored lithology	Dark-colored lithology
Bulk density (g/cm^3)	3.32 (s.d. 0.09)	3.27 (s.d.0.08)
Grain density (g/cm^3)	3.51 (s.d. 0.07)	3.42 (s.d. 0.10)
Porosity (%)	6.0 (s.d. 3.2)	5.7 (s.d. 1.7)
Magnetic susceptibility (log in 10^{-9} m^3/kg)	4.49 (s.d. 0.07)	4.52 (s.d. 0.15)

Fig. 2. Physical properties and reflectance spectra of the light-colored, dark-colored, and impact melt lithologies.

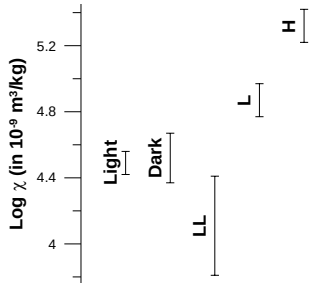


Fig. 3. Magnetic susceptibility of the light-colored and dark-colored lithologies compared to other H, L, and LL ordinary chondrites as reported in [3].