The influence of shocked minerals in the spectra and albedo of Chelyabinsk

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Many near-Earth asteroids (NEAs) of few tens of meters in diameter like Chelyabinsk have presumably experienced a significant degree of shock and brecciation [1]. These processes make them weak bodies preferentially disrupting in Earth's atmosphere, but still their sizes are placing them as projectiles capable to deliver significant shock-wave energy and meteorites to the ground, being a significant source of hazard to humans. For this reason, the study of Chelyabinsk meteorites is an opportunity to use them as analogues of NEAs with significant collisional processing. The Chelyabinsk chondrite (LL5-6) is a genomic breccia formed by LL5 and LL6 lithologies as well as clasts of shock melt and shock-darkened lithologies [2,3]. The rock has also experienced significant shock that produced severe mineral transformations in the rock-forming minerals [4]. Among the most relevant shock-induced features, shock veins are filled with Fe-Ni, troilite and other shocked mixtures all over the meteorite.

We have obtained the reflectance spectra of different Chelyabinsk meteorite samples using a Shimadzu UV3600 UV-Vis-NIR spectrometer in order to obtain the characteristic reflectance spectra of these meteorites like in our previously published work [5]. The standard stage for the spectrometer is an integrating sphere with a working range from 200 to 2,000 nm when we use a conventional barium sulfate substrate for calibration. The sample beam interacts with the sample at a phase angle of 8°.

Two Chelyabinsk thin sections provided by the Institut für Planetologie in Münster have been also analyzed to characterize the complex minerals formed during shock. We selected different veins of Chelyabinsk that were analyzed using micro-Raman spectra in backscattering geometry at room temperature using 5145 Å line of Argon-ion laser with a Jobin-Yvon T-64000 Raman spectrometer attached to an Olympus microscope and equipped with a liquid-nitrogen-cooled CCD detector. The lateral spatial resolution was about 1 micrometer and the laser power onto the sample was kept below 0.5 mW to avoid degradation due to sample overheating. The Raman spectrometer provided spectra in a working range between 100 and 1,400 cm^{-1} [see e.g. 3].

Shock-darkened lithologies and clasts of impact-melt breccias occur as (almost) opaque areas with deep influence of reflectance spectra as previously found [6]. The meteorite spectra are darker than expected for ordinary chondrites, but exhibit distinguishable absorption bands. The differences between ordinary chondrites reflectance spectra exhibiting different degrees of shock will be compared in the talk. On the other hand, our Raman analyses identified the high-pressure trigonal merrillite blended with olivine close to shock veins. The mere presence of this mineral indicates that the materials experienced peak shock pressures higher than 25 GPa. Consequently, the occurrence of shock-darkened minerals and other dark lithologies has a strong influence on the reflective properties of asteroids. Thus, shock- processing greatly reduces the chance of discovery of these dangerous projectiles in space.

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