RAMAN AND SEM-EDS STUDY OF CHELYABINSK LL5-6 CHONDRITE BRECCIA C.E. Moyano-Cambero[1], J.M. Trigo-Rodríguez[1], A. Bischoff[2] and N. Mestres[3]. [1]Institute of Space Sciences (CSIC-IEEC). Campus UAB, Fac. Sciences, C5-p2, 08193 Bellaterra (Barcelona), Spain. moyano@ice.csic.es, trigo@ieec.uab.es [2]Institut für Planetologie, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany. bischoa@uni-muenster.de. [3]Institut Ciència de Materials de Barcelona (ICMAB/CSIC), Campus UAB, 08193 Bellaterra (Barcelona), Spain. narcis@icmab.es

Introduction: In this study we use Scanning Electron Microsopy (SEM) plus Energy Dispersive X-Ray Spectroscopy (EDS), together with micro Raman spectroscopy, to analyze two thin sections of samples recovered after the Chelyabinsk superbolide occurred on February 15th, 2013, over the southern Ural region [1,2]. By now, the total mass recovered after this event, represented by thousands of different samples (weighting from less than 1 g to around 600 kg), is of ~1000 kg [3].

These meteorite has been classified as an ordinary chondrite genomic breccia of petrologic type LL5-6, as it is formed simultaneously by LL5 and LL6 lithologies as well as clasts of shock melt and shock-darkened lithologies [4]. The huge amount of mostly fresh and well conserved material recovered allows for an unique opportunity to study the physico-chemical properties of the parent bodies of this type of chondrites in general, and specifically of Near Earth Asteroids (NEAs), as most of them are classified as S or Q type asteroids, generally associated to ordinary chondrites [5].

As in this case, several studied chondritic meteorites have been classified as breccias (mixtures of broken fragments of minerals or rocks cemented together by a fine-grained matrix) and, due to the nature of the brecciation process, they exhibit features of shock metamorphism [3, 6-8]. The small asteroids that form the NEAs go through a sequence of events driving them to the near-Earth regions, which probably implies a complicated collisional history, and therefore a significant degree of shock and brecciation. This kind of bodies are usually fragile to the nature of breccias, so they easily break during the entrance in our atmosphere, potentially delivering several rocks and a strong shock wave, like Chelyabinsk [2,9].

Technical procedure: Two thin sections of Chelyabinsk (PL 13049 and PL 13050) were studied. High-resolution mosaics were created from separate 50X images taken with a Zeiss Scope petrographic microscope, both in reflected and transmitted light (Fig. 1). These mosaics allow to study the samples from a general point of view, tentatively identifying the regions of interest and features to be characterized by other techniques.

SEM-EDS techniques. We used a FEI Quanta 650 FEG working in low vacuum BSED mode. The EDS detector used to perform elemental analyses is an Inca 250 SSD XMax20 with Peltier cooling with an active area of 20 mm^2. Some selected areas were explored at different magnification, and SEM elemental mapping together with EDS spectra were obtained, providing both an idea of the elemental trend of a region, and also the specific composition of several points around the sample.

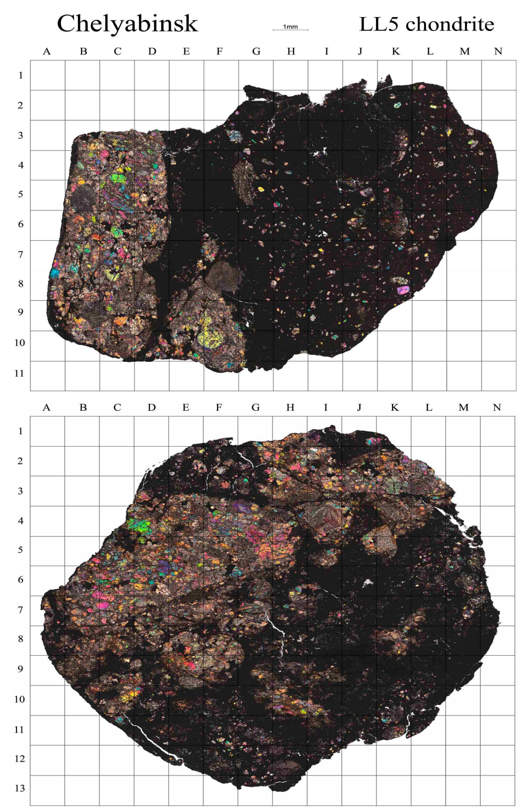

Figure 1. The two analyzed thin sections of Chelyabinsk (PL 13049, top, and PL 13050, bottom) showing at least two different lithologies: a chondritic texture and a darker impact melt breccia. In PL 13049 the lithologies are clearly separated by a shock-darkened area and shock veins. The images were obtained with transmitted light. Each square in the grid is 1 mm^2.

Micro-Raman study. We used a Jobin-Yvon T-64000 Raman spectrometer attached to an Olympus microscope and equipped with a liquid-nitrogen-cooled CCD detector, to obtain several micro-Raman spectra in backscattering geometry at room temperature using 5145 Å line of Argon-ion laser, kept in an energy be-low 0.5 mW to avoid degradation due to overheating. The lateral spatial resolution of ~1µm allows precise characterization of small points in the sample. We mostly took spectra in the 100 to 1,400 cm^{-1} range.

Results and discussion: According to the presence of shock-darkened lithologies (almost opaque in the transmitted light mosaic, in Fig. 1), clasts of impact melt, and shock altered minerals (Fig. 2), the Chelyabinsk meteorite must have experienced a significant degree of shock. We also found several veins filled with Fe-Ni and troilite (see e.g. Fig. 3). The identified merrilite (Fig. 2) corresponds to a high-pressure polymorph of merrillite, $Ca_9MgNa(PO_4)_7$, that has a trigonal structure γ-$Ca_3(PO_4)_2$, as confirmed by Raman analyses that identify this phase due to its characteristic intense peaks at 956 and 972 cm^{-1} (Fig. 2). According to previous studies [10] the presence of this mineral implies a peak shock pressures higher than ~25 GPa, consistent with the shock stage already proposed (S4).

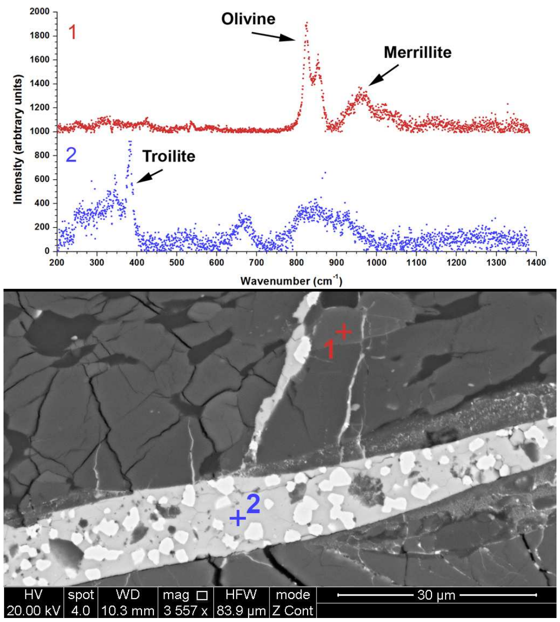

Figure 2. BSE images of a vein located in E7 in the thin section PL 13049, close to a shock-darkened area, showing two points analyzed by Raman. Both spectra, processed in order to substract the slope, and main preliminary identifications, with olivine together with merrilite and possible troilite, are given. The assignment of the other weak peaks in spectrum 2 still remains unclear.

Conclusions: In this ongoing study, two thin sections of the Chelyabinsk LL5-6 ordinary chondrite are being studied to reveal the properties of the main rock and its parent body, which, as explained, can be representative of several common NEAs. According to previous studies and our Raman analyses, in which high-pressure trigonal merrillite blended with olivine close to shock veins was identified, it has experienced a significant degree of shock, with peak shock pressures above 25 GPa. Several other Raman and EDS spectra have been obtained from this sections, in order to identify other possible phases resulting from shock, and will be presented in future studies.

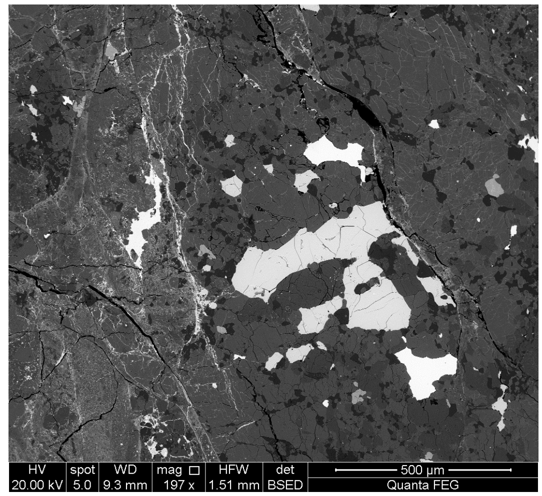

Figure 3. BSE images of region located in F6 in the thin section PL 13049. It shows several thin veins in the left-hand side. The clear grey regions of this image are mainly composed of iron and sulfur, possibly troilite in specific areas, while the almost white regions are Fe-Ni.

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