SPECTRAL CHARACTERISTICS OF ORDINARY CHONDRITE IMPACT MELTS. J. A. Sanchez[1], V. Reddy[2], L. Le Corre[1], T. Campbell[2], O. Chabra[3], [1]Planetary Science Institute, 1700 East Fort Lowell, Suite 106, Tucson, AZ 85719-2395, [2]Lunar and Planetary Laboratory, University of Arizona, 1629 E University Blvd, Tucson, AZ 85721-0092, [3]Catalina Foothills High School, 4300 E Sunrise Dr, Tucson, AZ 85718

Introduction: Impacts are the most ubiquitous of all the processes that shape solar system bodies. Evidence for these collisions is visible on a macro scale in the form of impact craters and collisional fragments (i.e. asteroids). Impacts on larger bodies such as terrestrial planets and our own Moon modify the initial target material texture and composition creating impact melts that can be detected from remote sensing and also in returned samples. The production of impact melt is a function of impact velocity. Most asteroidal collisions take place at velocities of ~5 km/sec [1], which is sufficient to produce impact melt deposits as seen on the Moon where the impact velocities are much higher (~15 km/sec). However, porosity and composition (presence of metal/metal sulfides) play an equally important role as impact velocity [2].

Several meteorites derived from asteroidal sources show evidence for shock-darkening and impact melt. Ordinary chondrites (H, L and LL subtypes) are the most common type of meteorites that fall on Earth making up about 86% of all meteorites in terrestrial collections. A subset of S-type asteroids has been suggested to be the source of ordinary chondrites. In this work we present results of our laboratory spectral measurements of impact melts and unaltered material from the three ordinary chondrite types (H, L, and LL). Our goal is to understand the spectral changes between the unaltered and the impact melt materials and quantify its effects on taxonomic classification of asteroids.

Samples and data acquisition: Three ordinary chondrite meteorites were analyzed for this study: Chelyabinsk (LL5), Mreïra (L6), and Chergach (H5). All samples exhibit both shock-blackened/impact melt material and a light (unaltered) lithology. Figure 1 shows an example of one of the samples used, a slab of the Chelyabinsk meteorite, that exhibits two very distinct lithologies. For each sample, the two lithologies were carefully separated under the microscope and then crushed and sieved to a grain size of < 45 μm. Near-infrared (NIR) spectra (0.35-2.5 μm) were obtained relative to a Lab-sphere Spectralon disk using an ASD FieldSpec Pro spectrometer at an incident angle i=30° and emission angle e=0°. For each measurement, 2000 scans were ob-tained and averaged to create the final spectrum.

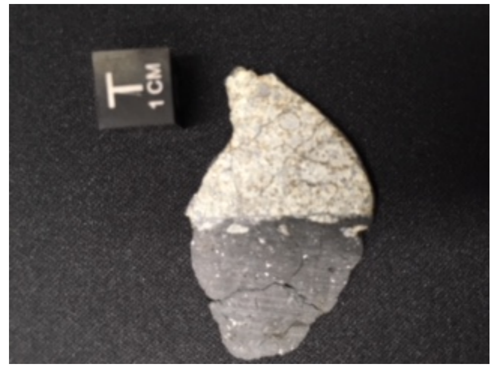

Figure 1: Sample of Chelyabinsk LL5 chondrite. Half of the sample is formed by a light (unaltered) lithology while the other half by shock-blackened/impact melt material.

Results: Figures 2 to 4 show the NIR spectra of the studied samples. The impact melt spectra of all samples exhibit a significant decrease in reflectance compared to the light lithology, with the LL chondrite Chelyabinsk decreasing from 29% to 9% at 0.55 μm (a proxy for the visual albedo), the L chondrite Mreïra decreasing from 27% to 18% at 0.55 μm, and the H chondrite Chergach dropping from 19% to 9%. The intensity of the absorption bands at 1 and 2 μm also decreases, most noticeably for Chelyabinsk and Chergach, where the 1 μm band appears subdued and the 2 μm band almost disappears.

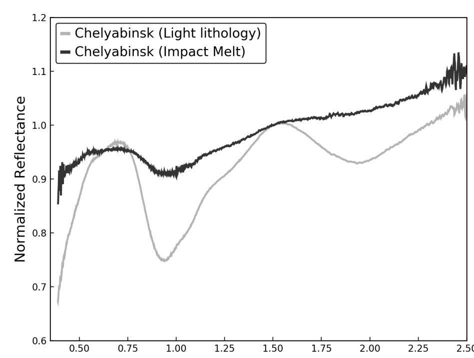

Figure 2: NIR spectra of Chelyabinsk corresponding to the light lithology and the shock-blackened/impact melt material. Spectra are normalized to unity at 1.5 μm.

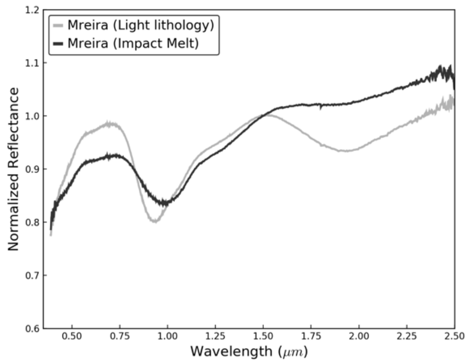

Figure 3: NIR spectra of Mreïra corresponding to the light lithology and the shock-blackened/impact melt material. Spectra are normalized to unity at 1.5 µm.

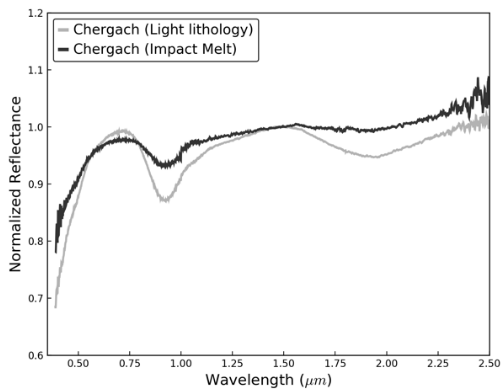

Figure 4: NIR spectra of Chergach corresponding to the light lithology and the shock-blackened/impact melt material. Spectra are normalized to unity at 1.5 µm.

Taxonomic classification: The spectral changes seen in the shock-blackened/impact melt material have important implications for the study of asteroids, since the taxonomic classification of these objects relies in parameters such as albedo, colors, and the presence and intensity of absorption bands [3]. The albedo variations described above are comparable to those seen, for instance, between S- and C-type asteroids [4], suggesting that the presence of impact melt could potentially lead to an ambiguous classification. Therefore, in order to investigate in more detail the effect of these spectral changes on taxonomic classification, we have used the Bus-DeMeo taxonomy [3] to classify our samples. Figure 5 shows the principle components PC2' vs. PC1' diagram from [3]. In this taxonomic system, spectra corresponding to the light lithology are classified as Sq/Q-types, while the impact melt spectra are classified as C/X-complex. In the Bus-DeMeo taxonomy, the C- and X-complexes are separated from the S-complex by a line called "the grand divide". Thus, objects whose spectra have the 2 µm band will fall to the right of this line, and those whose spectra have a very weak (or absent) 2 µm band will fall to the left, i.e., in the C/X-complex region. Our results are consistent with the findings of [5] and highlight the importance of studying impact melt material, not only in ordinary chondrites, but also in other meteorites, this in turns could help to identify their parent bodies and aid in the interpretation of asteroid photometric and spectroscopic data.

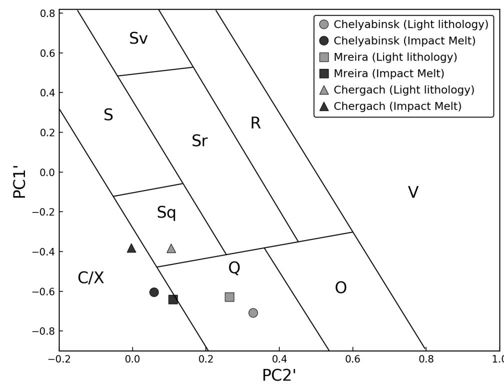

Figure 5: Plot showing the principle components PC2' vs. PC1' from [3]. All spectra corresponding to the light lithology are classified as Sq/Q-types in this taxonomic system. In contrast, spectra of impact melt samples are classified as C/X-complex likely due to the suppression of the absorption bands.

Summary: We have obtained NIR spectra of three ordinary chondrites that contain shock-blackened/impact melt material in addition to the light (unaltered) lithology. A decrease in reflectance was observed for the impact melt material compared to the spectra of the unaltered lithology. This trend is more pronounced for the LL chondrite (20% at 0.55 µm) than for the L and H chondrites (~ 10% at 0.55 µm). Absorption bands are also subdued in all the impact melt spectra. We found that these spectral changes can lead to an ambiguous taxonomic classification, making S- and Q-types look like C/X-complex asteroids.

Acknowledgements: This research was supported by NASA NEOO Program Grant NNX17AJ19G (PI: Reddy).

References: [1] Bottke et al. 1994, in *Hazards due to comets and asteroids*, 337-357. [2] Horz et al. 2005, *MPS* 40, 1329-1346. [3] DeMeo et al. 2009, *Icarus* 202, 160-180. [4] Thomas et al. 2011, *AJ* 142 (85), 12 pp. [5] Reddy et al. 2014, *Icarus* 237, 116-130.