THE NATURE OF C ASTEROID REGOLITH REVEALED FROM THE JBILET WINSELWAN CM CHONDRITE. Michael Zolensky[1], Takashi Mikouchi[2], Kenji Hagiya[3], Kazumasa Ohsumi[4], Mutsumi Komatsu[5], Queenie H. S. Chan[1], Loan Le[6], David Kring[7], Michael Cato[8], Amy L. Fagan[8], Juliane Gross[9], Ayuna Tanaka[3], Daichi Takegawa[3], Takuya Hoshikawa[3], Tomoaki Yoshida[3], Naoya Sawa[3]. [1]ARES, NASA Johnson Space Center Houston, TX 77058, USA (michael.e.zolensky@nasa.gov); [2]Univ. of Tokyo, Tokyo 113-0033, Japan; [3]Univ. of Hyogo; [4]JASRI, Hyogo 679-5198, Japan; [5]Graduate University for Advanced Studies, Sokendai, Japan.; [6]Jacobs, Houston, TX 77058 USA; [7]LPI, Houston, TX 77058 USA; [8]Western Carolina University, Cullowhee, NC 28723, USA; [9]Rutgers University, Piscataway, NJ 08854 USA.

Introduction: C-class asteroids frequently exhibit reflectance spectra consistent with thermally metamorphosed carbonaceous chondrites [1], or a mixture of phyllosilicate-rich material along with regions where they are absent [2]. One particularly important example appears to be asteroid 162173 Ryugu, the target of the Hayabusa 2 mission [1], although most spectra of Ryugu are featureless, suggesting a heterogeneous regolith [3]. Here we explore an alternative cause of dehydration of regolith of C-class asteroids – impact shock melting. Impact shock melting has been proposed to explain some mineralogical characteristics of CB chondrites [4], but has rarely been considered a major process for hydrous carbonaceous chondrites [5].

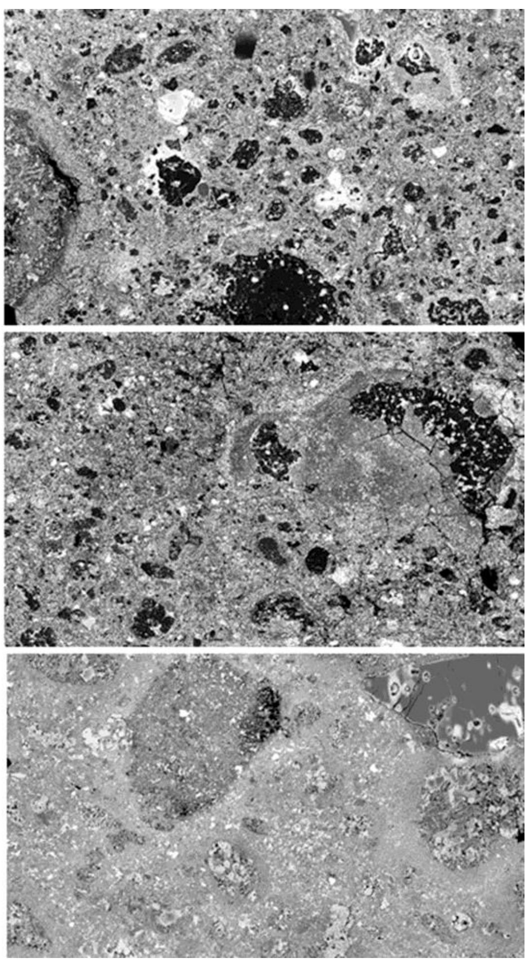

Figure 1. BSE Images of JW lithologies. Degree of heating and brecciation increases downward. 1 mm across.

Jbilet Winselwan (JW) is a very fresh CM breccia from Morocco, with intriguing characteristics. While some lithologies are typical of CM2s (Figure 1, top), other clasts show evidence of brief, though significant impact brecciation and heating. The first evidence for this came from preliminary petrographic and stable isotope studies [6,7]. We contend that highly-brecciated, partially-shocked, and dehydrated lithologies like those in JW dominate C-class asteroid regolith.

Analytical Techniques: We analyzed JW by FEGSEM (at NASA JSC and Rutgers University), Synchrotron X-ray Diffraction (SXRD, Beamline 37XU, Spring 8, Japan), and EPMA (JEOL at NASA).

Results: The heated lithologies of JW are easily identified by high EPMA totals, and spongy texture of matrix and aggregates (altered chondrules?) (Figure 2). SXRD revealed that the bulk of this material is fine-grained olivine, which we propose formed via aqueous alteration followed by heating. The heating duration is uncertain. In places there are aggregates of very well-sorted olivine "granules" (Figure 3), which could have formed by disaggregation of olivine (plausibly by repeated impacts), and shaking of the asteroid, resulting in the size sorting by the "Brazil nut effect". These are the same processes that probably formed the surface ponds observed on asteroids Eros and Itokawa. We have previously observed examples of this lithology in the Vigarano and Allende CV3 chondrites [8].

In some JW lithologies masses of melted sulfides clearly record a flash heating event. Figure 4 illustrates one of many troilites which have apparently been melted, and had matrix silicate grains injected inward. For the sulfur to have not completely evaporated probably requires flash heating. Also, there are vesicular, amorphous beads scattered within the heated JW lithologies, which we interpret as impact-produced microspherules.

Implications: It is usually believed that hydrous asteroids would generally disrupt, and not experience or preserve significant evidence of impact melting. However, we find that even the water-rich CI and CM chondrites contain evidence of impact shock [5]. To see this one must look carefully at the regolith breccias, and see past the post-shock aqueous alteration which has generally obscured mineral textures. A study of shock-melted sulfides in an LL6 chondrite indicated that they produced reflectance spectra that differed significantly from samples with unmelted sulfides [9]. We suggest that these materials will dominate, be detectable, and be sampled on the surfaces of C-class asteroids, initially by the Hayabusa II and O-Rex spacecraft.

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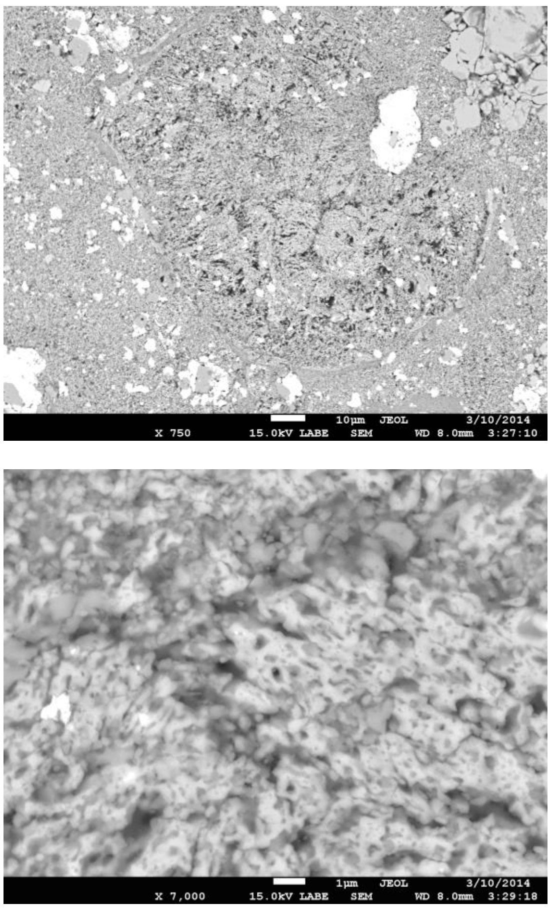

Figure 2. BSE images of an aggregate in heated JW which, at high magnification (Lower image) reveal a spongy texture typical of heated phyllosilicates.

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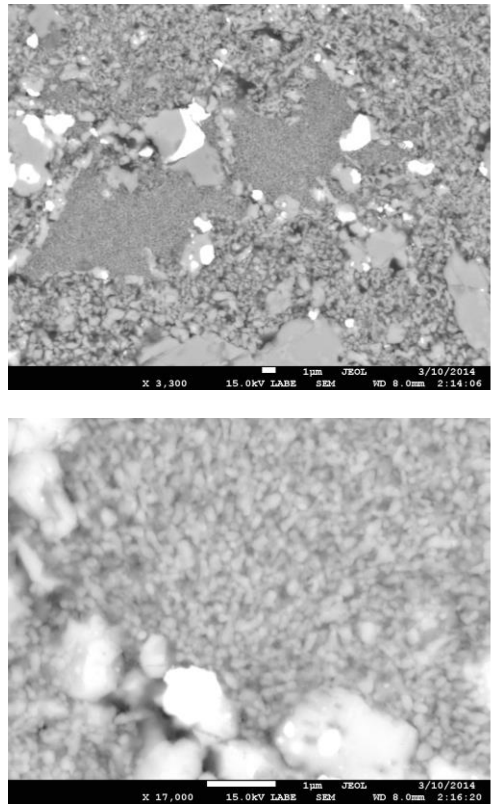

Figure 3. aggregates of very well sorted olivine “granules”. Scale bars measure 1 µm.

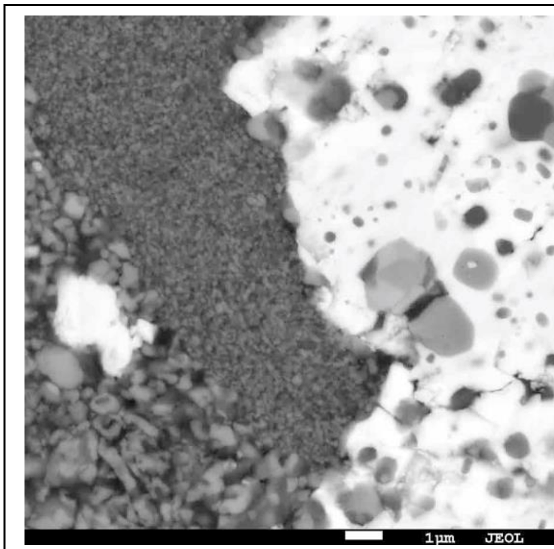

Figure 4: BSE image of melted troilite (white – on the right) in JW. Embedded matrix silicates (grey) in the troilite include olivine and low-Ca pyroxene. Note adjacent, well-sorted olivine .