COMPARISON OF THE BRIGHT BOULDERS ON THE SURFACE OF THE C-TYPE ASTEROID BENNU WITH WHITE CM6 CLASTS IN THE MURCHISON CM CHONDRITE BRECCIA.

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Introduction: Spectroscopic observations of asteroid Bennu suggest that the materials on the surface of the asteroid are most similar to aqueously-altered CM- or possibly CI-type carbonaceous chondrites [1], although a relationship with heated CM [2] or CR chondrites [3] is also possible. Recently, [4] detected unusually bright boulders (Fig. 1A) on the surface of Bennu. The band ratio indicates the presence of an absorption feature beyond 0.85µm and is consistent with the presence of mafic minerals such as pyroxene or olivine. The hyperspectral data suggest that the exogenic boulders have a similar distinctive pyroxene composition similar to the howardite-eucrite-diogenite (HED) meteorites. However, similar mineralogical features were also observed in indigenous, thermally metamorphosed white clasts reported in samples of the Murchison CM2 (Fig. 2B; [5-6]) and is an alternative interpretation for the bright boulders observed on Bennu. In addition to detailed petrographic characteristics, we report here further results on the chemistry, O, Cr, and Ti isotopes of the clasts in order to confirm their classification, and discuss their possible relationship to Bennu.

Results and discussion: We have identified two similar well-equilibrated clasts in two different pieces of the CM-breccia Murchison. The oxygen isotopic composition of the clasts is in the range of CM chondrites ($\Delta^{17}O$ = -3.16 ‰; [6]). The Cr and Ti isotope data overlap with those reported for CM chondrites as well ($\varepsilon^{54}Cr$ = 1.23±0.07, $\varepsilon^{50}Ti$ = 3.03± 0.09, respectively). Detailed petrographic characterization and the well-equilibrated texture indicate that the clasts were formed in the interior of the CM parent asteroid by fluid-assisted percolation during metasomatism, triggered by shock-induced annealing [6], consistent with classification as the first CM6.

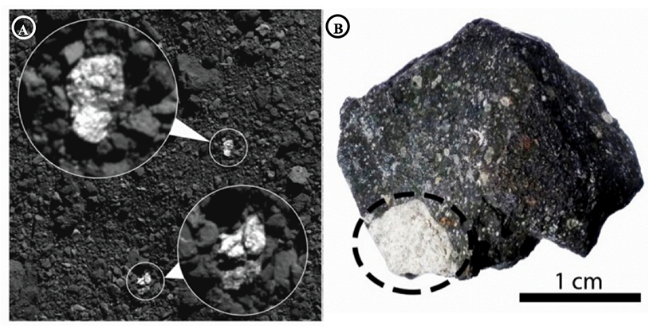

Fig.1: Similarity between (A) the bright boulders on the surface of the brecciated asteroid Bennu from [5] and (B) the white clast in the Murchison CM-breccia [6].

CM chondrites are usually impact breccias in which lithic clasts that exhibit various degrees of aqueous alteration are mixed together, possibly from different parent bodies (e.g., [7]). Clasts in CM chondrites have experienced various degrees of aqueous alteration, expressed by petrologic subtypes ranging from 2.0 to 2.9 [8,9], but have never undergone differentiation processes. This is distinct from HED meteorites whose parent body ((4) Vesta) has undergone extensive igneous processing [10] leading to differentiation.

Comparison of these white CM6 clasts with the bright boulders on the surface of Bennu, and given that the main lithology of Bennu is similar to CM chondrites (Figs. 2,4 from [1]), lithic debris of the same origin seems a simpler scenario than that of achondrites (HED asteroid). In addition, numerical simulation studies suggest that Bennu formed from the destruction of a larger parent asteroid and reaccretion to form a brecciated asteroid [11,12] that likely contains a mixture of hydrated and dehydrated phases [12,13]. Accordingly, the bright boulders on Bennu's surface could have been formed by thermal metamorphism within the carbonaceous chondrite asteroid (possibly CM), and were mixed during Bennu's reaccretion.

For further comparison, VIS-IR spectroscopic studies are being conducted on the Murchison white clasts for comparison to the Bennu spectra.

Finally, a study of such a clast will help to decipher the timing of thermal metamorphism relative to aqueous alteration in the CM parent body(ies) to enhance our understanding of the thermal evolution of these bodies that are good analogues for the types of materials that will be returned from asteroid Bennu.

References: [1] Hamilton et al. (2019) *Nat Ast* 3:332–340 . [2] Hanna et al. (2019) *LPI Contrib.* Abstract # 2189. [3] Hamilton et al. (2022) *Icarus* 383 :115054. [4] DellaGiustina et al. (2021) *Nat Ast* 5:31–38. [5] Bischoff et al. (2018) *Metsoc* abstract #6217. [6] Kerraouch et al. (2019). *Geo- Chem der Erde* 79:125518. [7] Kerraouch et al. (2021) *MAPS* 56: 277-310. [8] Rubin et al. (2007) *GCA* 71:2361-2382. [9] Lentfort et al. (2021) *MAPS* 56, 127-147 [10] Russell et al. (2012). *Science* 336: 684–686. [11] McCoy et al. (2019) *Metsoc* abstract #6428 [12] Michel et al. (2020) *Nature* 11:2655. [13] Lauretta et al. (2019) *Science* 366:6470.