COMPARISON OF THE BRIGHT BOULDERS ON THE SURFACE OF THE B-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. 1) 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. 1; [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 isotopic composition of the clasts in order to confirm their classification, and discuss their possible relationship to Bennu.

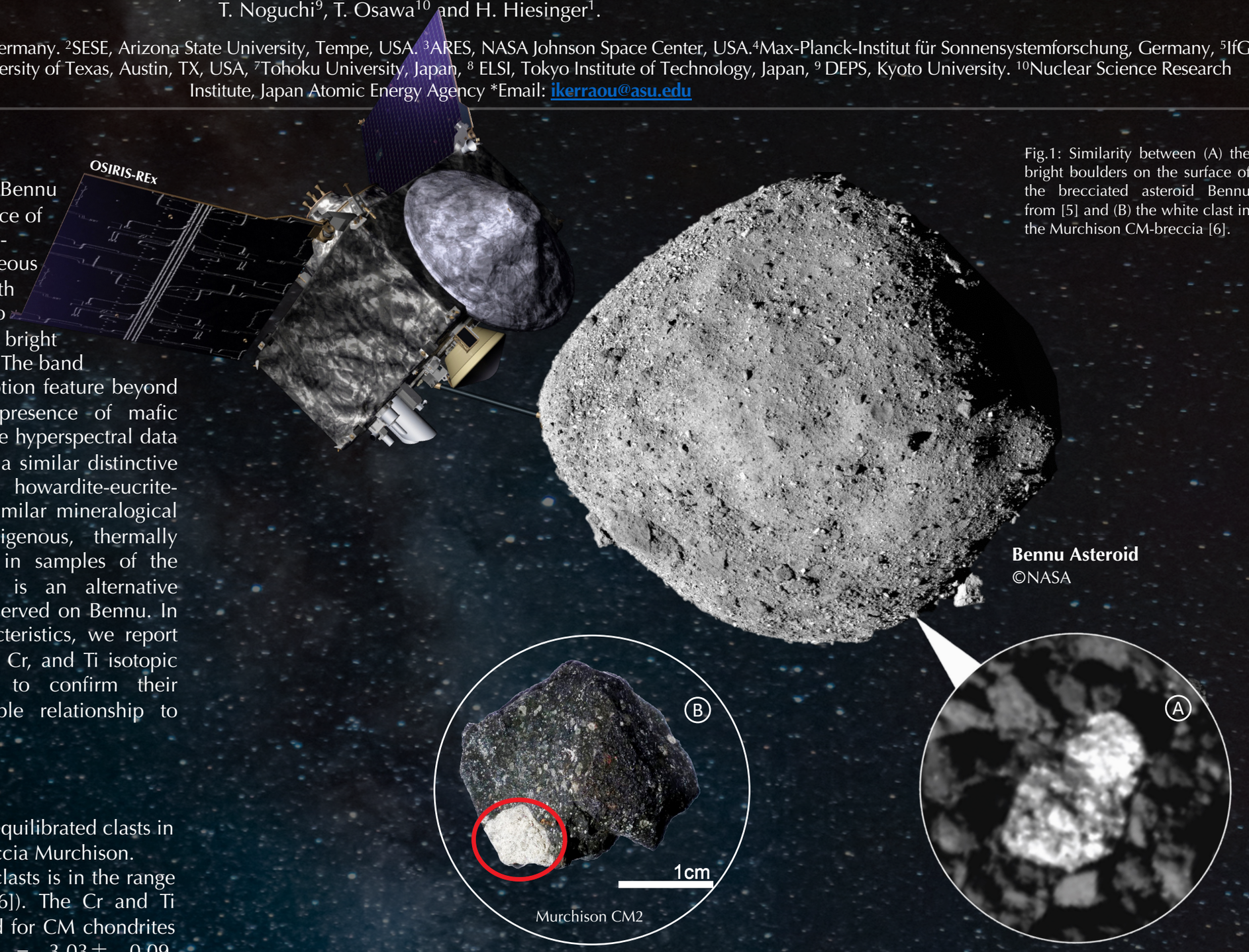

Fig.1: Similarity between (A) the bright boulders on the surface of the brecciated asteroid Bennu from [5] and (B) the white clast in the Murchison CM-breccia [6].

Isotopic composition

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 isotopic 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, Fig. 2). 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.

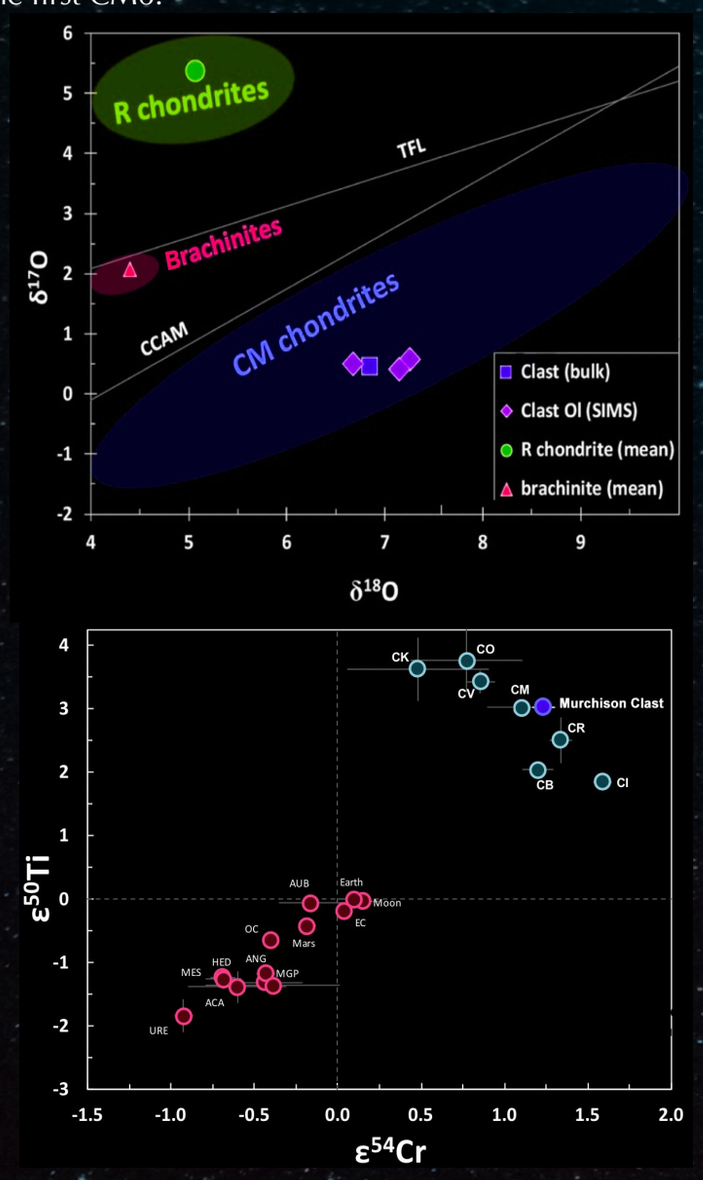

Fig. 2: Bulk O, Cr and Ti isotopic compositions of the white clasts in the Murchison CM2 chondrite compared to other chondrite groups.

Comparison with bright boulders on the Bennu asteroid

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 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).

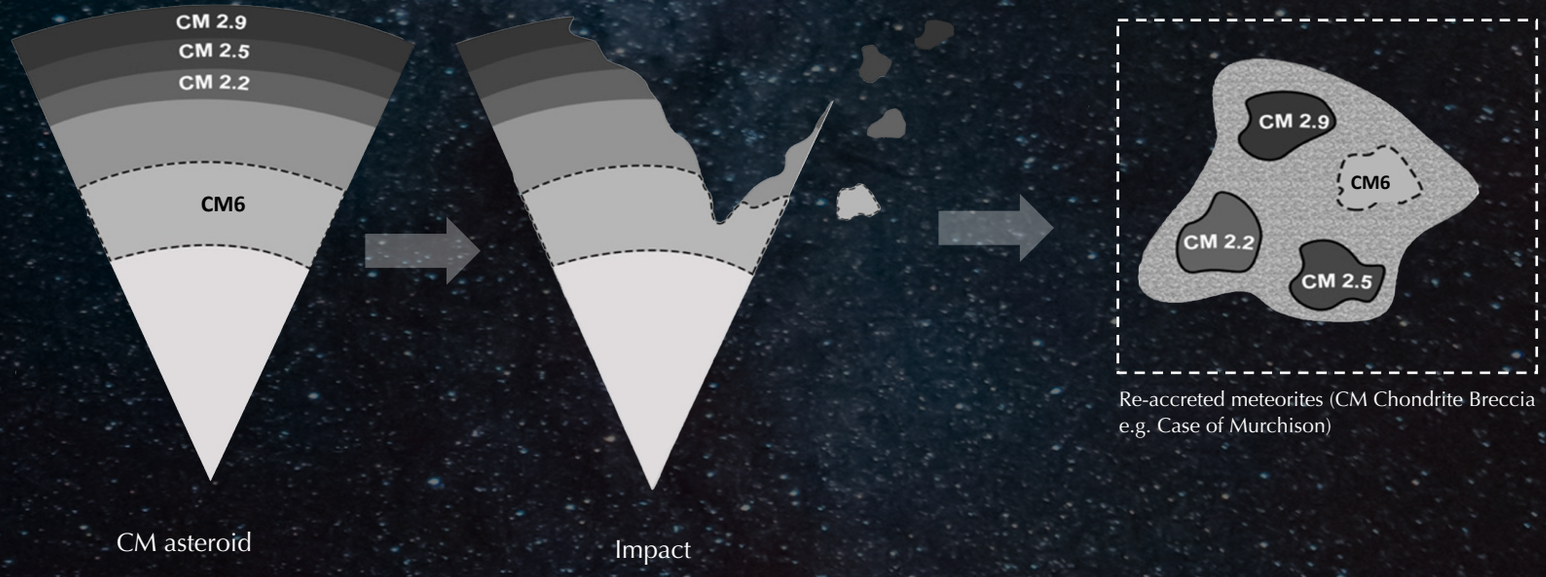

Fig.3: Formation of lithologies with different degree of aqueous alteration and impact-related mixing of different lithologies in order to build up a genomic CM chondrite breccia.

In addition, numerical simulation studies suggest that Bennu formed from the destruction of a larger parent asteroid and re-accretion 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 re-accretion.

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

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.

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