MAGNETITE-RICH C2-UNG CHONDRITES AND THEIR ASTEROIDAL PARENT BODIES.

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Mineralogy-Petrology: Unusual carbonaceous chondrites may be the key to understanding. C2-ung1 chondrites, e.g. NWA 12563, are more δ^{18}O-rich and magnetite-rich than CM2 chondrites [1,2]. Around 50% of the matrix of NWA 12563 is made of amorphous silicate (with nano-sulfide and Fe-oxide inclusions) entangled with clean phyllosilicates. The matrix amorphous silicate in Northwest Africa (NWA) 12563 is more magnesian (Mg# 69.7, excluding sulfide inclusions) than in other chondrites and highly oxidized ($Fe^{3+}/\sum Fe \sim 75 \pm 5\%$). The metal in C2-ung1 chondrites is rarely preserved and often pseudomorphed by serpentine rather than Fe-rich phases. This loss of Fe occurred at higher fO_2, and possibly higher temperature, than for CM2 chondrites and presumably led to magnetite deposition.

The matrix of NWA 12563, with many broken, deformed, and rimmed, partially rimmed, or unrimmed chondrule fragments, resembles regolith material. Olivine bar segments ripped from BO chondrule shards and scattered into adjacent matrix suggest chondrule fragments plunging into an unlithified debris matrix. Shattering of chondrules upon accretion is expected in chondrules formed in impact plumes [3]. The amorphous silicate probably formed as anhydrous condensates [4] and is only partly converted to phyllosilicate. Both Type I and II chondrules in NWA 12563 have totally hydrated mesostasis. Alteration markers found in the matrix and in chondrules suggest simultaneous alteration after accretion of chondrules, dust, and ice.

Parent bodies and Asteroids: Bells is the least altered C2-ung1, with fresh olivine, only partly altered pyroxene, partly altered kamacite and only 3.3% H_2O [5]. Essebi is similar. NWA 12563, though similar in δ^{18}O, differs from Bells and Essebi in δD and in its lack of metal. It is like Niger (C2), WIS 91600, and Tagish Lake, in having metal pseudomorphs, magnetite framboids, matrix saponite and sulfide rosettes [6,7,8] though Tagish Lake is more al-tered. NWA 12563 most resembles WIS 91600, which however contains saponite dehydrated by a milder reheating than for the CY chondrites [7,8]. The similarities suggest that NWA 12563 represents the precursor material that was slightly heated to become WIS 91600, possibly in the same parent body.

Our Vis-NIR spectrum of NWA 12563 matches taxonomic class K [9] like CO3 chondrites, though the more di-agnostic MIR-FIR reflectance spectrum rules this out. In the FIR, NWA12563 and WIS 91600 have similar features at 22.4 μm, and all the C2-ung1 analyzed have similar 28 μm features. The Bennu spectra show features of magnetite at 18 and 29 μm [10]. The 18 μm feature is also seen in Orgueil [10] and WIS 91600 [11], but not in the CM2 chondrites, so CI and C2-ung1 are possible constituents of Bennu. Magnetite-rich Tagish Lake and WIS 91600, however, have red D-type spectra [12]. The petrographic, isotopic and spectral differences within C2-ung1 chondrites require multiple parent bodies, consistent with the large number of C-complex asteroids. Dispersed fine-grained magnetite in NWA 12563 is obscured by other phases both in the Vis-NIR and in the MIR, demonstrating that unambiguous detection by remote sensing requires high mineral abundances. More extensive IR spectroscopy of C2-ung1 chondrites and more remote sensing spectra with smaller footprints on asteroids such as Bennu are needed to decipher the genetic link between C2-ung1 chondrites and their potential parent bodies.

References: [1] Greenwood R. C. et al. (2020) *Geochim. Cosmochim. Acta*, 227, 377-406. [2] Hewins R. H. et al. (2019) *Meteorit. Planet. Sci.* 54 S2 Abs# 6382. [3] Choksi N. et al. (2021) *Monthly Notices of the Royal Astronomical Society* 503, 3297-3308. [4] Dobrică E. and Brearley A. J. (2020) *Meteorit. Planet. Sci.* 55, 649-668. [5] Alexander C. et al. (2010) *Geochim. Cosmochim. Acta* 74, 4417-4437. [6] Zolensky M. E. (2002) *Meteorit. Planet. Sci.* 37, 737-761. [7] Brearley A.J. (2004) *LPS XXXV* Abs #1358. [8] Tonui E. et al. (2014) *Geochim. Cosmochim. Acta* 126, 284-306. [9] DeMeo F. et al. (2009) *Icarus*, 202, 160-180. [10] Hamilton V. et al. (2019) *Nature astronomy* 3(4), 332-340. [11] Hanna R. et al. (2020) *Icarus* 113760. [12] Hiroi T. et al. (2005) *LPS XXXVI* Abs#1564.