BULK MINERALOGY OF THE "CT" CHONDRITES: RESULTS FROM POWDER X-RAY DIFFRACTION.

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Introduction: A re-evaluation of recent meteoritical data along with a suite of new classifications advocates for a new carbonaceous chondrite group designated CT after Telakoast 001 [1]. The oxygen isotopes for this proposed group plot on a single linear array spanning 20 per mil in $\delta^{18}O$ and displaced by 1.3 per mil below the almost collinear arrays for CV, CO, CK and CL chondrites [1]. These CT meteorites are typically "Murchison-like" in appearance, i.e., dark grey to black, with an abundance of fine-grained, friable matrix, in which are embedded small (mean apparent diameter 280 µm) chondrules [1].

Characterization of these "Murchison-like"-in-appearance carbonaceous chondrites (CC) can be challenging since the fine-grained matrix minerals are typically submicron in size and thus smaller than the excitation volume used during EPMA. Whereas the presence of phyllosilicates can be suggested by EPMA, powder X-ray diffraction (XRD) provides definitive insights into the bulk nature of the phyllosilicates [e.g., 2]. Further, modern desktop diffractometers allow for the acquisition of suitable signal-to-noise XRD patterns from <1 mg of sample. Nevertheless, detailed insights into individual phyllosilicates require the high-spatial-resolution afforded by TEM and associated spectroscopies [e.g., 3]. In addition, the presence of amorphous material can be determined from the powder XRD pattern.

Here we describe the bulk powder XRD data for five members of the proposed CT group. These meteorites have been approved by the NomCom under a range of carbonaceous chondrite groups and petrologic types including CM2, C3-ung, and C2-ung.

Materials and methods: Powder XRD data were acquired with a Rigaku MiniFlex 600 diffractometer employing Cu *K*α radiation, equipped with a post-diffraction graphite monochromator and automatic divergence slit. Data were acquired from 2° to 65° 2θ at 0.02° steps, and ~25 s/step. Bulk samples were prepared from fragments ground to a fine powder and mixed with a few ml of methanol. The resulting slurry was spread on a low-background, single-crystal, quartz plate. The clay fraction (particles <2 µm), was separated by centrifugation in water. Five CT chondrites are described, i.e., NWA 14200 (C3-ung), Telakoast 001 (C3-ung), Cimarron (CM2), NWA 11699 (CM2), and Sarir Tazirbu (ST) 001 (C2-ung). Their XRD patterns are compared with that from a typical CM2 (Murchison) and an extra-terrestrially heated CM-like chondrite (Sutter's Mill, stone SM3).

Results: ST 001 and NWA 11699 display a serpentine basal reflection, though of low intensity in the latter (Fig. 1). The 001 maximum for ST 001 is at 7.36 Å, which is higher than that measured from Murchison or Aguas Zarcas, which is between 7.26 to 7.22 Å [2], but matches that for Boriskino [4]. The serpentine 001 maximum for NWA 11699 is at 7.25 Å. Cimarron shows a broad hump centered around 15.7 Å and the two-dimensional *hk* diffraction band around 4.5 Å – data consistent with fine-grained and/or poorly ordered smectite-like material.

The shape of the low-angle background for Sutter's Mill (stone SM3) is taken to represent diffraction from an anhydrous carbonaceous chondrite with a bulk primitive composition and that lacks measurable amorphous material. Compared with SM3, all the CT chondrites studied here show more intense low-angle scattering. This scattering is particularly evident in ST 001 and Telakoast 001, though it does not form a distinct hump as in Cimarron. This increase in low-angle scattering intensity can arise from small particles, micro pores, and crystal defects [5].

In addition to the phyllosilicates and possible amorphous contribution, the diffraction patterns show reflections for olivine, clinopyroxene, pentlandite, magnetite, ±maghemite (?), and ±calcite. In the bulk powder, the olivine 020 and 021 reflections show a low-angle tail (Cimarron) or unresolved low-angle peak (ST 001, NWA 11699, Telakoast 001, and NWA 14200) (Fig. 1). The sharp maximum corresponds to low-Fe olivine, with d-spacings that match end-member forsterite, whereas the low-angle unresolved peak is indicative of a distinct more Fe-rich olivine population. The bulk of the end-member forsterite contribution arises from the olivine-rich chondrules. This contribution is negligible in the <2 µm fraction. For example, the olivine reflections from the NWA 14200 clay (<2 µm) fraction are symmetrical, with d-spacings indicative of more Fe-rich olivine.

Concluding remarks: The suite of CT chondrites studied here shows a continuum from NWA 14200, which has only a minor contribution from amorphous material and no measurable phyllosilicates, to ST 001 with medium intensity serpentine reflections as well as increased low-angle scattering. However, compared with typical CM2s, the serpentine reflections are considerably less intense compared with the bulk pattern intensity. These meteorites also lack reflections for tochilinite/cronstedtite intergrowths (TCI) and ferrotochilinite, minerals that are typically present in CM2 meteorites, including but not limited to Aguas Zarcas, Banten, Cold Bokkeveld, Crescent, Maribo, Mighei, Mukundpura, Murchison (Fig. 1), Murray, and Winchcombe [4]. It remains uncertain whether the mineralogical continuum revealed by the CT chondrites studied here reflect parent-body processing, such as heating of a common phyllosilicate-rich starting material, or a breccia of materials with diverse histories, but with a common oxygen isotopic reservoir.

Acknowledgement: The meteoritical and collector communities continue to benefit from the ongoing cooperation of many private collectors and meteorite prospectors and dealers.

References: [1] Irving A.J. et al. (2022) LPSC, LIII. [2] Garvie L.A.J. (2021) Am. Miner., 106, 1900-1916. [3] Zega, T.J. et al. (2004) EPSL, 223, 141-146. [4] Garvie, L.A.J. unpublished data. [5] van der Gaast, S.J. and Vaars, A.J. (1981) Clay Miner. 16, 383-393.

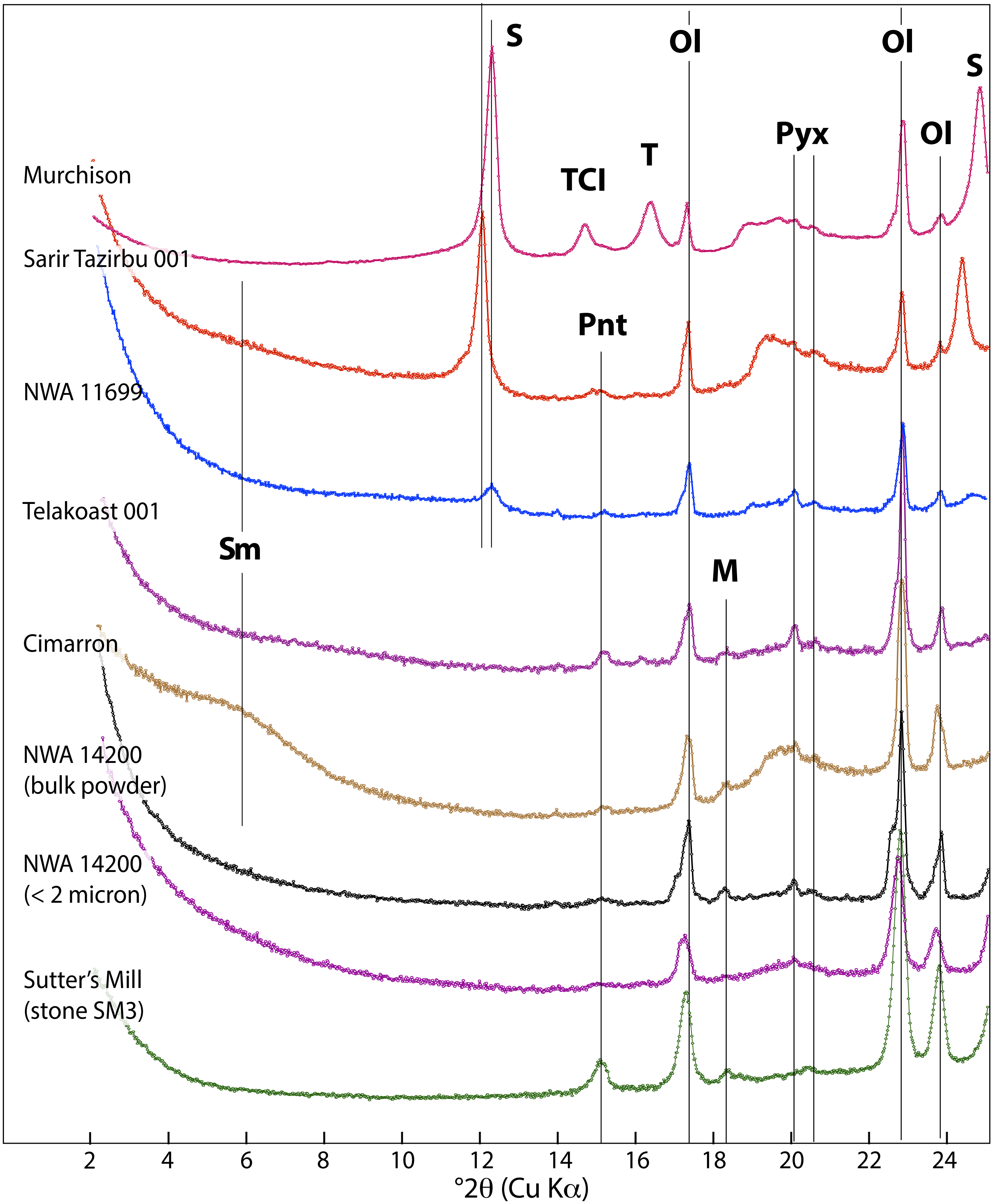

Figure 1. Powder X-ray diffraction patterns from selected CT chondrites compared with patterns from Murchison and Sutter's Mill stone SM3. Patterns are shifted vertically for clarity. **Sm** - broad low-angle hump that overlaps with the smectite 001 reflection. **S** - serpentine, **TCI** - interstratified tochilinite/cronstedtite, **T** - ferro-tochilinite, **Pnt** - pentlandite, **M** - magnetite, **Ol** - olivine, and **Pyx** - pyroxene.