COMPARING AQUEOUS ALTERATION IN COMET WILD 2 AND CARBONACEOUS CHONDRITES

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Introduction: Jupiter Family Comet 81P/Wild 2 was brought into the inner Solar System after a close encounter with Jupiter's gravitational influence in 1974, and thus should contain pristine material from the Kuiper belt [1]. However, NASA's *Stardust* mission, returning grains of Wild 2 in 2006, has shown comets contain many minerals formed at high temperature, and material similar to type II chondrule fragments and CAIs [2-5]. Magnetite has been found along grain tracks and in terminal grains, suggested to be a product of aqueous alteration [6-9]. Various studies suggest mineralogical and isotopic similarities with CR and CV meteorites [5,10-12], prompting our investigations into similarities with CR and CV carbonaceous chondrites. Oxygen isotope and chronology data show that some magnetite and fayalite in CV and CO chondrites formed later, supporting a later aqueous alteration formation mechanism on the carbonaceous chondrite parent bodies [13]. This is also supported by some magnetite crosscutting other phases [14].

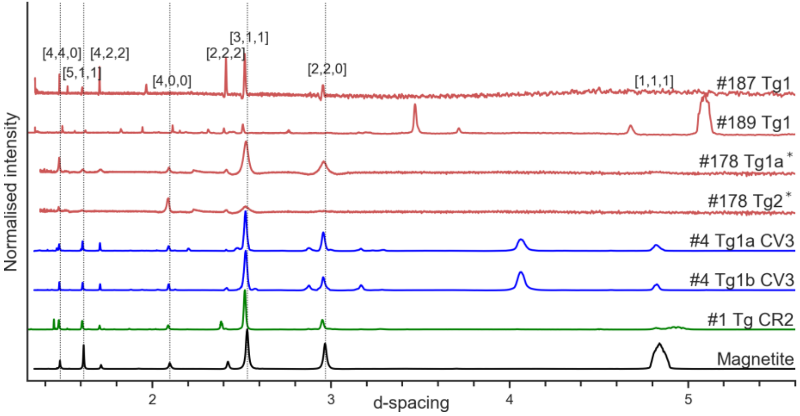

Fig. 1 Normalised SR-XRD *d*-spacing peaks for terminal grains in *Stardust* tracks #178 [8], #187, #189 (red) compared to #4 CV3 (blue) and #1 CR2 (green) terminal grains and a magnetite powder standard (black). Vertical dotted lines show the five most intense *hkl* planes for magnetite.

Methods: 25 - 200 µm powders and thin sections were made from Northwest Africa (NWA) 4502 (CV3) and NWA 10256 (CR2). SEM-EDX and Raman spectroscopy were used to characterize them, before firing into 25-55 mg/cm^3 aerogel at 6.1-6.3 kms^{-1}. Keystones were made from the impact tracks and analysed using Fe-K XANES and XRD with a 3 µm spot size at the *Diamond Light Source* synchrotron [8].

Results: Fig. 1 and Fe-K XAS data show terminal grains in the *Stardust*, CV3 and CR2 tracks to be a close match for magnetite. The unit cell parameter has been calculated for each, showing it to be very slightly more oxidized than magnetite, possibly explained by the presence of Ni and containing a trace amount of trevorite [8].

Discussion: Further evidence for water-rock interaction on Comet Wild 2 is provided by the presence of pentlandite [3], a pyrrhotite/pentlandite assemblage and cubanite [15]. The absence of phyllosilicates observed is interpreted as a lack of hydrothermal alteration [10], though by analogy with a study of CM chondrites it could suggest limited alteration, only sufficient to form magnetite from Fe metal and not form phyllosilicates from ferromagnesian silicate precursors [16]. However, if present in Comet Wild 2, phyllosilicates could have been destroyed in the capture process [17]. The idea that magnetite is preferentially preserved during the capture process is reinforced by the identification of magnetite here in a CV3 track as well as a CR2 track, given that the phase is only ~1% of the CR2 and <5% of the CV3 sample [8]. Given the higher density of magnetite and lower density of phyllosilicates, this also offers an explanation for the lack of phyllosilicates [8]. Our work strengthens the evidence for similarities between the carbonaceous chondrite parent bodies and Comet Wild 2, not just in high temperature fragments like chondrules described previously, but also minerals resulting from aqueous alteration.

References: [1] Brownlee D. E. et al. (2003) *J. Geophys. Res.* 108, 8111. [2] Brownlee, D. et al. (2012) *Meteoritics and Planetary Science* 47 453–470. [3] Zolensky M. et al. (2008) *Meteoritics & Planetary Science* 43, 261–272. [4] Bridges J.C. et al. (2012) *Earth and Planetary Science Letters* 341-344 186–194. [5] Joswiak D. J. et al.(2017) *Meteoritics & Planetary Science 52*, 1612–1648. [6] Bridges J.C. et al. (2010) *Meteoritics and Planetary Science* 45, 55-72. [7] Changela H.G. et al. (2012) *Geochimica et Cosmochimica Acta* 98 282-294. [8] Hicks L.J. et al. (2017) *Meteoritics and Planetary Science* 52 10 2075-2096. [9] Stodolna J. et al. (2012) *Geochimica et Cosmochimica Acta* 87, 35–50. [10] Westphal A. J. et al. (2017) *Meteoritics & Planetary Science* 52, 1859–1898. [11] Nakashima D. et al. (2015) *Earth and Planetary Science Letters* 410, 54–61. [12] Alexander C. M. O. et al. (2012) *Science* 337, 721–723. [13] Doyle P. M. et al. (2015) *Nature Communications* 6, 7444. [14] Krot A. N. et al. (1998) *Meteoritics & Planetary Science* 33, 1065–1085. [15] Berger E. L. et al. (2011) *Geochimica et Cosmochimica Acta* 75, 3501–3513. [16] King A. J. et al. (2017) *Meteoritics & Planetary Science* 52, 1197–1215. [17] Wozniakiewicz P.J. et al. (2015) *Meteoritics and Planetary Science* 50 2003-23.