THE FALL, RECOVERY & INITIAL ANALYSIS OF THE WINCHCOMBE CM CHONDRITE

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Recovery: At 21:54 (UTC) on the 28th February 2021 a bright fireball was observed over the United Kingdom. The fireball, which lasted ~8 seconds, was widely reported on social media and recorded by 16 stations operated by the six meteor camera networks that collaborate as the UK Fireball Alliance (UKFAll). The main mass (~320 g) of the meteorite was discovered the next morning by the Wilcock family on their driveway in the town of Winchcombe, Gloucestershire. Upon landing, the stone shattered into a pile of dark mm- to cm-sized fragments and powder, most of which was collected using rubber gloves and sealed within polyethylene bags ~12 hours after the fall. In total, >500 g of material was recovered from the local area by members of the public and the UK planetary science community within seven days of the fall, during which time there was no rainfall [1]. The largest intact piece of the Winchcombe meteorite is a 152 g fusion-crusted stone found on nearby farmland on the 6th March.

Fireball: The entry velocity of the Winchcombe meteoroid was ~14 kms^{-1} and the recordings clearly show several fragmentation events. Analysis of the video footage combined with the measurement of short-lived radionuclides suggest that the original body was small (<70 kg). The pre-atmospheric orbit of the Winchcombe meteoroid is similar to those previously reported for the Sutter's Mill (C/CM) [2] and Maribo (CM) chondrites [3].

Petrography: A consortium was quickly established to study the Winchcombe meteorite. Petrographic observations of polished samples indicate that Winchcombe is a CM ("Mighei-like") carbonaceous chondrite [4, 5]. It consists of chondrules [6] and calcium-aluminium-rich inclusions (CAIs) [7] set within a matrix of phyllosilicates, tochilinite-cronstedtite intergrowths (TCIs) [8, 9], carbonates [10], magnetite, and sulphides. Many of the samples show evidence for brecciation and contain multiple distinct lithologies with sharp boundaries. Most lithologies are intermediately to highly aqueously altered (CM2.4 – 2.0), although a rare lithology containing unaltered chondrules and metal has also been identified (~CM2.6). The presence of an unusual Zn-Fe sulphide hints at metasomatism on the parent body [11]. Reflectance spectra of the Winchcombe meteorite show absorption features at ~3 µm and in the mid-infrared (IR) region that are consistent with abundant phyllosilicates [12], while it's fusion crust displays several unique textures related to degassing during atmospheric entry [13].

Composition: The classification of Winchcombe as a CM chondrite is further supported by major and minor element abundances [e.g., 14], and oxygen, titanium, and chromium isotopic compositions [15]. The bulk water content of Winchcombe measured within one month of the fall was ~11 wt.%. Analysis by stepped combustion yielded carbon, nitrogen, and noble gas abundances and isotopic compositions largely consistent with other highly altered CM chondrites [16, 17]. Low voltage SEM characterisation less than a week after the fall of fresh, unpolished fragments located several small (~10's µm) carbon- and nitrogen-bearing regions with "globule-like" morphologies. Carbon K-edge spectra of organic matter in the Winchcombe meteorite show a strong absorption feature at ~285 eV that is assigned to aromatic C=C [18]. Initial analysis by both both liquid (LC-) and gas chromatography-mass spectrometry (GC-MS) revealed extraterrestrial organic components including lipids, fatty acids, and amino acids [19].

Outlook: The Winchcombe meteorite is only the fifth carbonaceous chondrite fall with a known pre-atmospheric orbit, and due to its rapid recovery is likely the most pristine member of the CM group. The mineralogical, elemental, and organic properties of the Winchcombe meteorite provide a snapshot of conditions in the outer regions of the protoplanetary disk and new insights into the chemical and dynamic evolution of volatiles in the early solar system. The nature and timing of the Winchcombe meteorite fall also makes it complementary to samples of asteroids Ryugu and Bennu collected by the Hayabusa2 and OSIRIS-REx missions, offering an opportunity to develop and rehearse curation and analytical protocols on fresh, carbonaceous materials [20].

References: [1] O'Brien et al. (2022) this meeting, *85th MetSoc*. [2] Jenniskens et al. (2012) *Science* **338**:1583. [3] Borovička et al. (2019) *Meteoritics & Planetary Science* **54**:1024. [4] Suttle et al. (2022) this meeting, *85th MetSoc*. [5] Daly et al. (2022) this meeting, *85th MetSoc*. [6] Floyd et al. (2022) this meeting, *85th MetSoc*. [7] Martin et al. (2022) this meeting, *85th MetSoc*. [8] Johnson et al. (2022) this meeting, *85th MetSoc*. [9] Bonsall et al. (2022) this meeting, *85th MetSoc*. [10] Lee et al. (2022) this meeting, *85th MetSoc*. [11] Jenkins et al. (2022) this meeting, *85th MetSoc*. [12] Shirley et al. (2022) this meeting, *85th MetSoc*. [13] Genge et al. (2022) this meeting, *85th MetSoc*. [14] Wombacher et al. (2022) this meeting, *85th MetSoc*. [15] Greenwood et al. (2022) this meeting, *85th MetSoc*. [16] Grady et al. (2022) this meeting, *85th MetSoc*. [17] Verchovsky et al. (2022) this meeting, *85th MetSoc*. [18] Vollmer et al. (2022) this meeting, *85th MetSoc*. [19] O'Brien et al. (2022) this meeting, *85th MetSoc*. [20] Almeida et al. (2022) this meeting, *85th MetSoc*.