

## IRON MINERALOGY AND OXIDATION STATES OF THE WINCHCOMBE METEORITE

E. Bonsall<sup>1</sup>, H.C. Bates<sup>2</sup>, A.J. King<sup>2</sup> and C. Schröder<sup>1</sup>, <sup>1</sup>Biological and Environmental Sciences, University of Stirling, FK9 4LA, UK, [christian.schroeder@stir.ac.uk](mailto:christian.schroeder@stir.ac.uk), <sup>2</sup>Natural History Museum, London, SW7 5BD, UK.

**Introduction:** The Winchcombe meteorite fell on the 28<sup>th</sup> February, 2021 in Gloucestershire, UK [1]. Following the fall, samples were quickly collected by several members of the public and scientific community, allowing minimal terrestrial alteration to occur [1]. Based on its petrographic and chemical characteristics, the Winchcombe meteorite has been classified as a CM2 chondrite [1]. Four of the collected samples were analysed in the Mössbauer Spectroscopy laboratory for Earth and Environment (MoSEE) at the University of Stirling. This analysis gave information on the Winchcombe meteorite's iron mineralogy and oxidation states, which constrain alteration processes on its parent body.

**Method:** A powder sample (BM.2022,M3-4;138.7 ± 5 mg) was placed into an acrylic glass sample holder (~1.3 cm circular diameter), loaded into a standard Wissenschaftliche Elektronik transmission spectrometer and measured at 3 different temperatures (room temperature, 77 and, 4.2 K). Low temperatures were achieved with an ICEoxford Dry ICE 4K closed-cycle helium gas cryostat. Spectra from the powder sample were evaluated with Recoil software using Lorentzian line profiles. Three rock chip samples (BM.2022,M1-1, BM.2022,M3-27 and BM.2022,M8-14) were measured without any further sample preparation at room temperature with a Miniturised Mössbauer spectrometer MIMOS II [2], which is set up in backscattering geometry. Spectra from this were evaluated with an in-house software routine (Mbfite) using Lorentzian line profiles. Mbfite is based on the least-squares minimization routine MINUIT. No f-factor correction was applied.

**Results:** Spectra obtained from the rock chips indicated the presence of Mg- and Fe-rich serpentine (cronstedtite as the Fe-rich phase) and tochilinite. The same phases are seen in the room temperature transmission spectrum, along with the addition of two magnetite sextets (Fig. 1). As the temperature is decreased to 77 K, we see an additional sextet appear which could indicate the presence of an Fe,Ni sulfide (Fe<sup>2+</sup>). When the temperature is decreased further to 4.2 K, magnetic ordering occurs, resulting in a complex spectrum (Fig. 1). As the spectrum is complex, only locations of peaks characteristic for cronstedtite and Fe<sup>2+</sup> were identified.

**Discussion:** Temperature dependent transmission spectra are similar to other reported CM2 chondrites: Mighei [3], Murchison [3,4], Cold Bokkeveld [5], and Mukundpura [6,7]. As the spectra show no evidence of metallic Fe, it can be concluded that any metallic Fe originally present in these samples has been altered into tochilinite but, with the exception of minor magnetite, not into iron (hydr)oxides. Ferric iron is exclusively hosted in the clay mineral cronstedtite. Ferric iron abundances range from 25 to 30% of the total iron. This is lower than the values between 49 and 71 % reported for other CM2 chondrites [3,7-9], but these studies included spectral features that we have attributed to tochilinite in their calculations. Cronstedtite and serpentine formed from the aqueous alteration of olivine and pyroxene, while the initial presence of metallic iron might have played a role in the serpentinization process.

**References:** [1] Grossman J. (2021) *Meteoritical Bulletin Database*, <https://www.lpi.usra.edu/meteor/metbull.php?code=74388>. [2] Klingelhöfer G. et al (2003) *JGR: Planets* 108:8067. [3] Roy-Poulsen H. et al (1981) *Physica Scripta* 23:11313. [4] Burns R. G. and Fisher D. S. (1994) *Hyperfine Interact.* 91:571-576. [5] Burns R. G. and Fisher D. S. (1990) *NASA, Washington, Reports of Planetary Geology and Geophysics Program*. [6] Dixit A. et al (2019) *MaPS* 54:2902-2907. [7] Tripathi R. P. et al (2018) *Current Science* 114:214-217. [8] Bland P. A. et al (2008) *71<sup>st</sup> MetScoc*, 5304. [9] Sephton M. A. et al (2004) *MaPS* 39:747-754.

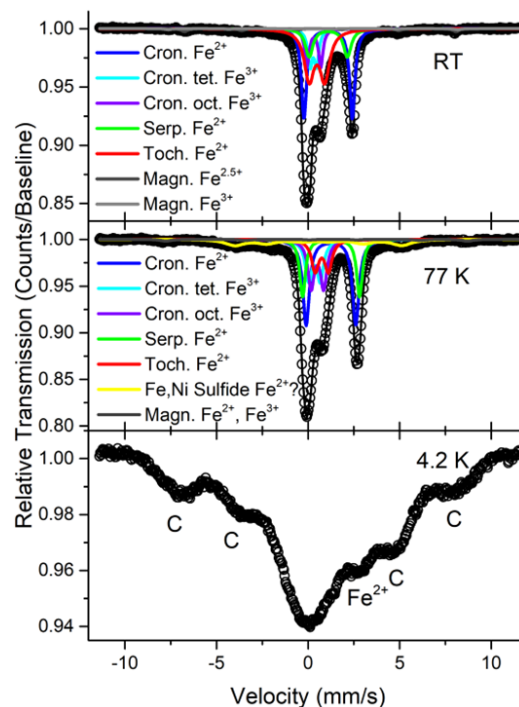


Fig. 1. Temperature-dependent Mössbauer spectra of the powdered Winchcombe sample at room temperature, 77 K and 4.2 K. The black solid line represents the overall fit to the measured spectrum (black open circles) and is the sum of all subspectra (coloured lines). Cronstedtite (Cron.) contains Fe<sup>2+</sup> and Fe<sup>3+</sup>, the latter in tetrahedral (tet.) and octahedral (oct.) coordination. Serpentine (Serp.) and tochilinite (Toch.) contain Fe<sup>2+</sup>. The RT and 77 K spectra also reveal magnetite (Magn.). The 77 K spectrum shows a potential Fe,Ni sulfide (sulf.) phase. In the 4.2 K spectrum, peaks 1,2,5 and 6 of a sextet corresponding to magnetically ordered cronstedtite (C) are indicated, as well as the high velocity peak of a Fe<sup>2+</sup> doublet.