CALCIUM-ALUMINIUM-RICH INCLUSION POPULATIONS WITHIN THE WINCHCOMBE CM2 METEORITE BRECCIA.

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Introduction: Winchcombe is a CM2 (Mighei-like) carbonaceous breccia composed of eight main lithologies within a cataclastic matrix. These lithologies display varying degrees of aqueous alteration, spanning from 2.0–2.6 **[1]**, according to Rubin's scale **[2, 3]**. CM chondrites are amongst the most common carbonaceous meteorite samples, yet the abundance of Calcium-Aluminium-rich Inclusions (CAI) within them remains poorly constrained. This study is focused on describing and studying the CAI populations found within the Winchcombe lithologies and how they inform our understanding of the formation and evolution of the CM parent bodies.

Methods: CAIs were sought in 18 polished blocks of Winchcombe using sample-wide Backscattered Electron images combined with Ca-Al-Mg Energy-Dispersive X-ray Spectroscopy (EDS) maps. The samples were initially mapped by Scanning Electron Microscopy (SEM) at the Natural History Museum (NHM), London (20 kV/3 nA, live frame time 270s). Three sections (P30540, P30548, and P30552) were further studied to confirm the mineralogy of the CAIs using a Zeiss Sigma Variable Pressure Analytical SEM (20 kV) at the University of Glasgow (UoG), and a Cameca SX100 Electron-Probe Micro-Analyser (EPMA; 15 kV) at the NHM. Another section (P30542) was also further analysed using a Hitachi S3400 SEM (20 kV/20nA) and an Oxford Instrument X-Max SSD Energy Dispersive X-Ray (EDX) spectrometer at the University of Kent (UoK).

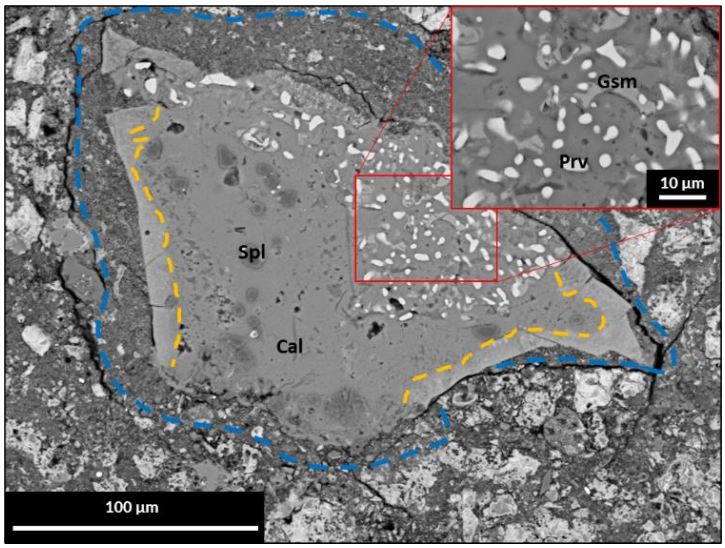

Fig. 1. *BSE image of a heavily calcitised CAI. It is predominantly composed of calcite (Cal) with micrometre-sized globular spinel grains (Spl). Further investigation using EPMA revealed the presence of micrometre-sized grains of perovskite (Prv; white on BSE) and grossmanite (Gsm; light gray on BSE). An alteration rim within the calcite can be distinguished by a lighter shade of grey in BSE image (contact is shown with yellow dashed line). The CAI itself is enclosed within a Fine-Grained Rim (FGR; circled in blue).*

Results: The Winchcombe lithologies have a diverse population of CAIs. They display a wide range of alteration states from near-completely altered (heavily calcitised; cf. **Fig. 1**) to well preserved with a quasi-spherical intact pyroxene rim. The polished blocks contain 18 confirmed CAIs, with 22 potential CAIs requiring further investigation. Most of the CAIs fall into two categories: (1) spinel-rich with a relatively-well preserved diopside rim (Spinel-Pyroxene, **[2, 3, 4]**); (2) a forsterite core with ~2 µm rounded grains of perovskite (Pyroxene-Olivine, **[2, 3, 4]**). Calcitised CAIs seem to be outliers among the observed CAI populations. They are heavily altered and are composed of small Ti-Ca-rich perovskite grains (<10 µm) and long globular Mg-Al-rich spinel (~ 10 µm) within a predominantly calcite matrix, that are, in a few cases, surrounded by a discontinuous diopside rim.

Discussion: Calcitised CAIs occur in CM lithologies of very different degrees of alteration **[5]** and therefore cannot provide context as to the extent of aqueous alteration processes the parent-body or the meteorite itself underwent. The calcite-forming process would have had to occur early as these specimens are visible even in lithologies with lower degrees of aqueous alteration. However, these objects do remain relevant as calcite might originate from the alteration of melilite or anorthite, which could grant us the necessary clues to determining the origin of the many lithological constituents of the meteorite. Future work will focus on the link between CAI abundance relative to the degree of aqueous alteration of the CM lithologies, and will include additional sample-wide EDS mapping, Electron Backscatter Diffraction (EBSD) maps of CAIs, as well as Transmission Electron Microscopy (TEM) analyses of sections of the grossmanite grains within the calcitised CAI.

References: **[1]** Suttle M. D. et al. (This meeting), *85th MetSoc*. **[2]** Rubin A. et al. (2007) *GCA*, 71 (9), 2361–2382. **[3]** Rubin A. (2015) *M&PS*, 50 (9), 1595–1612. **[4]** MacPherson G. R. & Davis A. M. (1994), *GCA*, 58 (24), 5599–5625. **[5]** Lee M. R. et al. (2014) *GCA*, 144, 126–156.