ISOTOPIC COMPOSITION, MORPHOLOGIES, AND FUNCTIONAL CHEMISTRY OF ORGANIC MATTER WITHIN THE RECENT OBSERVED FALLS TARDA AND WINCHCOMBE.

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Introduction: Organic Matter (OM) is an important constituent in a variety of extraterrestrial materials such as carbonaceous chondrites [1] or returned mission samples [2]. Its isotopic composition, morphology, structure, elemental composition, and functional chemistry record a combination of presolar, nebular, parent-body, and terrestrial processes, leaving a complex fingerprint on the OM. These manifold processes have to be disentangled by either bulk extraction methods [3] or high-spatial resolution "in-situ" studies [4]. In-situ studies have the advantages that they also allow study of the petrographic relationship to the surrounding matrix and require only minimal chemical treatment. Moreover, the exclusion or identification of any terrestrial overprint on the makeup of OM is of paramount importance to understand early Solar System processes. In this study, we investigate OM properties within two recent observed falls, Tarda and Winchcombe, by a combination of high-spatial resolution analysis techniques, to gain further insight into OM formation and modification processes.

Samples and Methods: Tarda is an observed fall from Morocco (2020) and has been classified as C2-ungrouped showing oxygen isotopic and petrographic affinities to the Tagish Lake meteorite [5]. Winchcombe has been classified as CM2 and is the first recovered observed fall in the UK for 30 years. Both meteorites offer a unique opportunity to investigate OM within fresh samples that have not been severely overprinted by terrestrial contamination. The C- and N-isotopic composition of Tarda was studied by NanoSIMS applying standard ion imaging protocols. OM was characterized in thin sections by SEM at NHM London and then FIB-prepared for synchrotron and TEM experiments at SuperSTEM using a Hitachi Ethos NX5000 FIB-SEM. Scanning Transmission X-Ray Microscopy (STXM) was performed on several lamellae prepared from Winchcombe at the I08 beamline of Diamond Light Source. Further mineralogical and low kV STEM-EELS analyses in the vibrational and core loss regimes will be performed with a monochromated, aberration-corrected Nion UltraSTEM 100MC (60 kV) at SuperSTEM.

Results and Discussion: OM identified in the mildly, intermediately, and highly altered lithologies of the Winchcombe and Tarda meteorites shows globular, multi-globular, diffuse and vein-like morphologies. Based on SEM observations, silicates (most likely phyllosilicates) and carbonates are intimately associated with the OM. Nitrogen and carbon isotopic compositions of OM aggregates and nanoglobules within Tarda show a range of δ^{15}N values from close-to-terrestrial to ~ 600‰ with close-to-terrestrial or slightly heavy δ^{13}C values, which is, as expected, more extreme than reported bulk isotopic compositions (δ^{15}N = 55‰, δ^{13}C = 11‰) [6]. Single hotspots can reach >1000‰ in δ^{15}N and ~80‰ in δ^{13}C. No negative δ^{15}N values similar to Maribo OM have been detected [7]. Further isotopic analyses on Winchcombe OM will be presented at the meeting.

STXM analyses at the CK-edge show that OM in Winchcombe is typical for pristine OM in primitive extraterrestrial samples, with strong absorption at the aromatic C=C (~285 eV) and the ketone/aldehyde (~286.6 eV) bands. The COOH carboxyl absorption feature (~ 288.5 eV), however, is diminished or absent in all measured areas. It has been suggested that the appearance of this bonding feature could be indicative of more advanced OM alteration and the formation of smaller, more soluble molecules [7,8]. Fine structure at the NK-edge shows two dominant bands at around 398.8 eV and 399.8 eV, which can be attributed to C-N double (imine) and triple (nitrile) bonding environments. The functional chemistry of nitrogen in meteoritic OM is very sensitive to aqueous alteration reactions, with the abundance of oxygenated [9] and hydrogenated, i.e., $N\text{-}H_x$- bonds [10] correlating with advancing alteration. The presence of the highly reactive double and triple C-N bonding environments is therefore a strong indicator that the Winchcombe OM is still very pristine.

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