REE-RICH, CA-PHOSPHATE RIM AROUND A PHYLLOSILICATE NODULE IN THE WINCHCOMBE CARBONACEOUS CHONDRITE - WITNESS OF INTENSE AQUEOUS ALTERATION ON THE PARENT BODY. B. J. Tkalcec[1*], E. De Pauw[2], M. Lindner[1], B. Bazi[2], B. Vekemans[2], M. Di Michiel[3], P. Tack[2], L. Vincze[2] and F. E. Brenker, [1]Goethe University, Dept. of Geoscience, Altenhoeferallee 1, 60438 Frankfurt am Main, Germany; [2]Ghent University, Krijgslaan 281 S12, 9000 Ghent, Belgium; [3]ESRF - The European Synchrotron, 71 Avenue des Martyrs, 38000 Grenoble, France.* tkalcec@em.uni-frankfurt.de

Introduction: Recent results of coordinated laboratory analyses of the freshly fallen Winchcombe meteorite have revealed it to be a CM carbonaceous chondrite that has undergone intensive low-temperature aqueous alteration [1]. It is reported to be a breccia consisting of several different lithologies in which chondrules and calcium-aluminium-rich inclusions (CAI) are observed to be heavily altered with cores greatly replaced by phyllosilicates [1].

We analysed a sample of the Winchcombe meteorite applying scanning electron microscopy (SEM) and high-energy synchrotron X-ray fluorescence (SXRF) spectroscopy. Here we report on a Ca-phosphate rim around a (phyllo-)silicate nodule that is substantially enriched in rare earth elements (REE).

Sample and Methods: A thin slab of the Winchcombe meteorite, approximately 6 mm x 6 mm x 3 mm in size, was embedded in epoxy resin. SEM was carried out under low vacuum conditions at the Geoscience Institute at the Goethe University in Frankfurt am Main, Germany, thus avoiding the need for carbon-coating of the sample. BSE imaging and energy-dispersive X-ray spectroscopy (EDX) for semiquantitative elemental analysis were performed using a Phenom World ProX desktop SEM. Regions of interest in the Winchcombe sample identified by SEM were subsequently further analysed by SXRF spectroscopy, carried out at beamline ID15A of the ESRF – The European Synchrotron in Grenoble, France. For this, the embedded and polished sample was further mounted onto a 3D-printed polymer rod. A high-energy (90 keV) incident beam was applied to the sample with a beamsize of 500 x 300 nm (horizontal x vertical). A silicon-based detector and a germanium-based detector were orthogonally mounted for optimal detection of the various emerging element-specific fluorescence signals within the sample.

Results: One of the regions of interest identified by SEM was a sub-rounded nodule (Fig. 1 top left), about 50 µm x 70 µm in axis-length, that resembles the phyllosilicate "clumps" reported by [1]. This nodule has a magnesium-rich (Mg# 78) silicate core (Fig. 1 bottom left) surrounded by a distinct and sharp rim that is clearly enriched in both calcium and phosphorous (Fig. 1, top and bottom right). In comparison, the surrounding matrix material is clearly Ca-poor and P-poor.

A wide feature dissects the nodule through the core and appears at least partly to be of similar material to that of the rim (Fig. 1 top left). Acicular or fibrous growth is observed in several places along the inner margins of the upper subgrain, particularly from the dissecting feature, growing inwards towards the subgrain core. The margins of the lower subgrain appear to be free from this acicular growth, suggesting a change in ambient conditions.

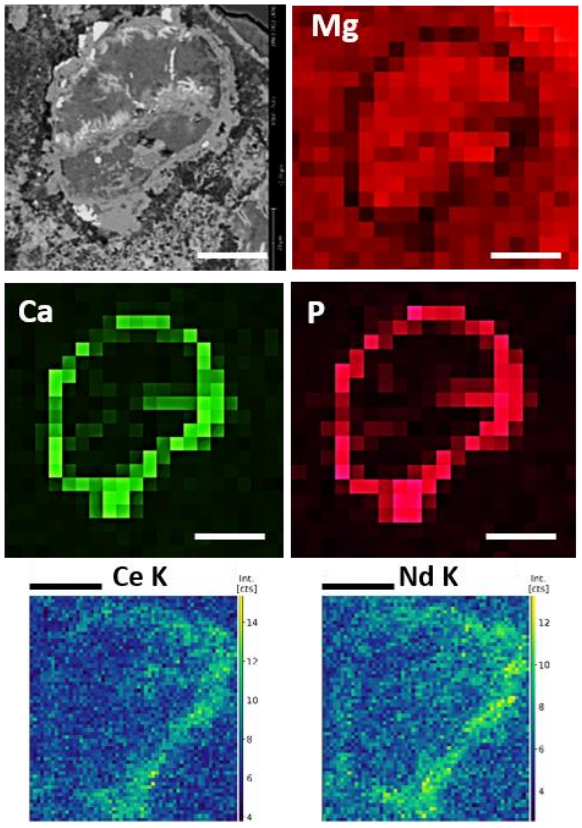

Fig. 1: BSE image (top left) and EDX elemental maps (top right image and middle images) showing the Ca-P-rich rim around a Mg-rich silicate nodule in the Winchcombe CM chondrite. SXRF elemental maps (bottom two images) demonstrate REE enrichment (here, for example, Ce and Nd) in the calcium-phosphate rim. All scale bars are 20 µm.

Results of subsequent SXRF analysis further reveal that the rim material of this nodule is enriched in REEs, particularly in Ce, Nd and Gd as well as in other non-REE trace elements such as Sr and Ba.

Discussion: Although, unlike the Fe- and S-rich rims frequently observed in Winchcombe, Ca-phosphate-rich rims around (phyllo-)silicate grains have not yet been reported for the Winchombe chondrite [1], they have been observed around several chondrules in other CM chondrites. One chondrule analysed in the CM2 chondrite Mukundpura is reported to have a Ca-P-rich rim [2] and several chondrules in the CM2 chondrites Mighei, Yamato 791198 and Allan Hills A81002 have been reported to bear Ca-phosphate rims [3]. The presence of Ca-phosphate rims is further evidence for low-temperature aqueous alteration, in which Ca and P likely dissolve in chondrule cores and migrate outwards. It has been suggested that such sharp Ca-phosphate rims around chondrules in CM2 chondrites may arise from an abrupt drop in acidity at the chondrule boundary to the surrounding material, halting or reducing the further migration of Ca and P [3]. It is likely that similar REE behaviour may also explain their enrichment in the observed rim in Winchcombe.

Acknowledgments: The SXRF experiments were performed under LTP ES-1018 on beamline ID15A at the European Synchrotron Radiation Facility (ESRF), Grenoble, France. We thank the German Research Foundation DFG grant BR2015/38-1, Dr. Rolf M. Schwiete Stiftung, Ghent University Special Research Fund Grants BOF20/PDO/037, BOF17-GOA-015, Research Foundation Flanders grants G0D5221N,1205322N for funding.

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