PARENT BODY/TERRESTRIAL ALTERATION OF FE,NI METAL IN CARBONACEOUS AND ORDINARY CHONDRITES: IMPLICATIONS FOR SAMPLE RETURN.

C. Floyd[1] and M. R. Lee[1]
[1]School of Geographical and Earth Sciences, University of Glasgow, Glasgow, G12 8QQ, U.K. (2118495F@student.gla.ac.uk)

Introduction: Fe,Ni metal is one of the most reactive constituents of carbonaceous chondrites when exposed to low temperature oxidizing aqueous solutions. It can be altered pre-terrestrially in a parent body environment [1] and after the meteorite's fall to Earth (i.e., terrestrial weathering) [2]. Discriminating between these two environments is crucial for understanding parent body evolution but can be particularly challenging, as discussed for altered metal grains in the Antarctic CM chondrite Yamato 791198 [3]. Even meteorite falls are not free from these uncertainties as their metal can undergo significant terrestrial weathering during museum curation [4]. Here we have sought to establish criteria to help differentiate between parent body and terrestrial alteration of Fe,Ni metal by comparing Antarctic equilibrated ordinary chondrites (whose alteration should be solely terrestrial) with Antarctic carbonaceous chondrites (potentially altered in both parent body and terrestrial environments).

Samples and methods: Fe,Ni metal grains and their alteration rims were studied in thin sections of two Antarctic ordinary chondrites (OCs) and two CM carbonaceous chondrites: Dominion Range (DOM) 14010 (L5), Allan Hills (ALH) 77180 (L6), Lewis Cliff (LEW) 85311 (CM), LaPaz Icefield (LAP) 02239 (CM). These samples were imaged and chemically analysed using SEM and energy-dispersive X-ray spectroscopy (EDS). Their alteration rims were further analysed by Raman spectroscopy using a 514 nm laser source and 2400 mm grating.

Results: Fe,Ni metal within the OCs is characterized by Fe-oxide alteration rims that range in thickness from 5 µm to 100+ µm. Imaging shows two distinct textures within the rims; an ordered texture with fine laminations that is heavily fractured, and a disorderd texture with coarser and more chaotic laminations. Any one alteration rim may display one or both textures. Where they occur together, the ordered texture is closest to the remaining Fe,Ni metal with fractures trending perpendicular to the metal. The disordered texture is present on the periphery of the rim and cross-cuts the fractures. Raman spectroscopy indicates that the ordered material is dominantly akaganeite whilst the disordered material returns spectra for both akaganeite and goethite. EDS analysis of these rims reveals differences in Cl concentrations, with the ordered material containing ~1.2 wt% Cl and the disordered material ~0.4 wt.% Cl.

Most alteration products of Fe,Ni metal in the CM samples are dominated by S-rich material (tochilinite) of a parent body origin. However, some metal grains have thick 'halos' of Fe-oxide, probably a terrestrial weathering product. SEM imaging shows these 'halos' can have ordered and disordered textures. In LAP 02239 Raman and EDS analysis revealed that the ordered texture comprises akaganeite with ~1.9 wt% Cl and disordered texture goethite with ~0.7 wt% Cl. By contrast, both textures in LEW 85311 are composed of akaganeite, but blocks of tochilinite occur around the edge of the disordered texture and are broken up by veins of goethite.

Discussion: The presence of two textures within the alteration rims of OC metal demonstrates the evolution of terrestrial alteration from Cl bearing akaganeite to goethite. Akaganeite forms during the initial stages of alteration when Cl is freely available. As alteration progresses and sample porosity begins to decrease (a result of weathering) [5] an outer layer starts to develop and thicken (the disordered texture). This outer layer limits the ability of Cl ions to reach the metal [6]. With Cl now limited the remainder is concentrated in the ordered material closest to the metal grain and is consumed in final phases akaganeite production [7] facilitating the gradual transition to goethite [6]. Similar textures observed within the CM's suggests that they too have experienced significant terrestrial alteration. The fragments of tochilinite detected show that prior to terrestrial weathering the Fe,Ni metal grains had undergone parent body aqueous alteration, but that this material has subsequently been almost entirely destroyed. Nonetheless, the presence of these relict fragments of tochilinite allows a complete evolutionary history of the Fe,Ni metal alteration to be inferred, from initial parent body alteration (tochilinite) to advanced terrestrial weathering (goethite). Our results highlight the need for thorough analysis of Fe,Ni metal grains within CMs to accurately determine the extent to which pre- and post-terrestrial processes may have affected these meteorites. Samples soon to be returned from Bennu and Ryugu will help greatly in unambiguously identifying pre-terrestrial alteration products of Fe,Ni metal.

References: [1] Palmer E. and Lauretta D. S. (2011) *Meteoritics & Planetary Science* 46:1587–1607. [2] Buchwald V. F. and Clarke R. S., Jr. (1995) *American Mineralogist* 74:656–667. [3] Chizmadia L. J. et al. (2008) *Meteoritics & Planetary Science* 43:1419–1438. [4] Lee M. R. and Bland P. A. (2004) *Geochimica et Cosmochimica Acta* 68: 893–916. [5] Bland P. et al. (1996) *Geochimica et Cosmochimica* Acta 60: 2053–2059. [6] Xiao H. et al. (2017) *Materials* 10:1262. [7] Rémazeilles C. and Refait P. (2007) *Corrosion Science* 49: 844–857.

Acknowledgements: We thank ANSMET for loan of the Antarctic meteorite samples.