DEFORMATION AND MINERAL RELATIONSHIP IN ACHONDRITE METEORITES TO RECONSTRUCT THE GEOLOGICAL HISTORY OF THEIR PROTOPLANETS

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Introduction: Achondrite meteorites are igneous rocks or breccias from differentiated asteroids and planetary bodies [1]. The ureilite, aubrite and anomalous achondrites are of particular interest as there are no good candidates for the original parent body in our Solar System suggesting many early formed planets did not survive the embryo-embryo collisions during Solar System formation [2]. The textural relationships within these meteorites provide important evidence of the formation, size, evolution and destruction of the Solar System’s first planets. Here we have applied scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS) and electron backscatter diffraction (EBSD) to extract quantitative textural, chemical and microstructural information from a range of meteorite samples from the achondrite sub-groups: ureilites which contain graphite in the form of diamond suggesting a Mars size protoplanet [3]; aubrites containing a high percentage of enstatite pyroxene indicating formation in highly reducing conditions [4] relative to the other samples in this study; an anomalous achondrite, which was originally missclassified as a ureilite and has many textural similarities with the other samples of this study.

Methods: Thin sections of ureilites: Nova 001, Reid 016, Havero; Aubrite: Cumberland Falls; and anomalous achondrite: Miller Range (MIL) 090356 were mapped using EDS and EBSD at the University of Glasgow using a Zeiss Sigma variable pressure field emission gun SEM (VP-FEG-SEM). EDS chemical maps were collected at 0 ° tilt while EBSD data was collected at a 70 ° tilt. For both EDS and EBSD an accelerating voltage of 20 kV was used.

Results:

Ureilites: Imaging reveals a clear shape preferred orientation (SPO) of olivine and pyroxene crystals within Reid 016 (Fig. 1), however this SPO is not observed in the pyroxene and olivine of the Nova 001 and Havero. The ureilite meteorites have Fe-rich rims which vary in thickness, in Reid 016 the Fe-rich rims vary from 9.04-24.3 µm, within Nova 001 the Fe-rich rims range from 11.3-26.4 µm, while the Havero samples shows no Fe-rich rims and instead exhibits a Fe-rich vein of 61.8 µm at the top of the sample. No veins are observed in the lower half of the thin section (Fig. 1).

Aubrites: Cumberland Falls has the classic brecciated texture typical for aubrites [4] with a heterogeneous distribution of shock features. The section contains two lithologies: one has a courser ‘classic’ brecciated compared to that of the more shocked second lithology. While no fracturing or veining is observed, Fe inclusions are dominant in the heavily shocked lithology.

Anomalous achondrites: MIL 090356 olivine grains have Fe-rich rims similar to the ureilite samples however, these rims are generally thinner at 12-7.48 µm compared to the ureilite samples. In addition, the olivine grains within MIL 090356 are more equant and subequal than those in the ureilites.

Discussion and conclusions: The ureilite thin section samples show a range of thickness for the Fe-rich rims suggesting different alteration and deformation events of the protoplanets with a possible relationship between the Fe-rich rims and graphite content of these meteorites. The Cumberland Falls meteorite shows multiple lithologies with brecciated textures and varying degrees of shock implying multiple shock events throughout the history of the protoplanet. The anomalous achondrite demonstrates similarities with the ureilites. However, the euhedral shape of the olivine grains suggests less stress and strain deformation when compared to the ureilites. EBSD data will further quantify the microstructures and infer their origins and will be presented at the meeting.


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