"EXOTIC" CLAST IN QUEEN ALEXANDRA RANGE 99177 MATRIX: A NOVEL INVESTIGATIVE APPROACH UNFOLDING ACCRETIONARY PROCESSES.

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Introduction: Queen Alexandra Range (QUE) 99177 is a very low petrologic type 3 CR chondrite that has escaped the effects of aqueous alteration and appears to be significantly less altered than most members of this group [1]. Matrix in QUE 99177 is characterized by significant FeO-enrichments with respect to other CR chondrite matrices. The mineralogy is dominated by amorphous silicate material acting as groundmass within which occur Fe,Ni sulphides such as troilite, pyrrhotite, and pentlandite. These sulphides appear to be coated with a thin layer of carbonaceous material, often present as either amorphous C or very poorly graphitized C (PGC) [1]. CR chondrites contain dark inclusions [e.g. 2, 3]. These dark clasts may represent fragments of different lithologies of the same parent body or accreted as xenoliths to the same time with other components during parent-body formation [4].

Experimental methods: Five regions, each approximately 100 μm^2, were identified as most representative of the matrix of QUE 99177. For each region, high-resolution images and element maps were acquired using Carl Zeiss Ultra Plus and FEI Quanta 650 FEG SEM respectively [5, 6]. Micro-XRD analyses were directly collected from the five selected areas on the thin section using a Rigaku D max Rapid II. A pin-hole of 30 µm was used to achieve an X-ray beam footprint on the sample of ~50 x 500 µm. Two cubic matrix samples, adjacent yet distinct, of approximately 30×30×30 µm in size were extracted with FIB technique at Kyoto University using the Helios FEG-SEM/FIB (FEI Helios NanoLab Dual Beam). CT data of the cubic matrix samples were acquired at SPring8 synchrotron facility in Japan using a Frenel zone plate BL-47XU X-ray synchrotron radiation in order to obtain 3D internal structures [7, 8]. Tomographic analysis was carried out at energies of 7keV and 8keV, corresponding to voxel sizes of > ~ 35.9 nm and > ~ 41.1nm respectively. This allowed for discrimination between mineral phases.

Result and discussion: Textural observations of the five matrix regions were made using the high definition image maps acquired. All the areas investigated appear to be similar in the texture, with the exception of one area which exhibits remarkable differences. This area (which was sampled for CT) displays a rather uniform platy texture. Element maps acquired at 6kV using a FEI Quanta 650 SEM confirmed the textural heterogeneity and complexity of the different matrix regions in QUE 99177 previously revealed by the image maps. The S present in the matrix shows a different distribution between the different textural areas. Generally the matrix regions show enrichments in S which appear to be associated with fluid percolating within the fractures, whereas the only matrix area with uniform platy texture seems to have experienced a different alteration history exhibiting a modest S distribution and much higher Mg enrichment.Micro-XRD patterns acquired on the matrix of sample QUE 99177 have shown the following crystalline phases were identified: forsterite, enstatite, pyrrhotite, metal-iron and kamacite. Diffraction patterns look similar showing no significant differences between different areas with the exception of the pattern acquired in the area characterized by textural differences, where kamacite is not present, and the magnetite peak, is considerably more intense compared to the other areas. CT investigation of the matrix region characterized by textural heterogeneity highlighted the presence of large crystals of ~ 4 µm in size. The high intensity pixels of these phases, points to a Fe-rich phase, and along with the crystal habit suggest they are magnetite crystals. This is in good agreement with the micro-XRD data. The region of the matrix exhibiting remarkable textural and chemical differences also shows a clear neat boundary with the adjacent matrix in 3D. This matrix region has been interpreted as being an exotic clast which has experienced heavy aqueous alteration compared to the adjacent matrix. This clast is thought to have been produced by brecciation, and subsequently transported and incorporated into the meteorite parent body. This is in agreement with the brecciated nature of CR chondrites and with the model of chondrule redistribution in the CV chondrite parent body [9].The differences in these matrix regions, and how these differences may be evidence of parent body processes (e.g. aqueous alteration) and accretionary processes will be discussed.

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