EVIDENCE OF HEAVILY AQUEOUSLY-ALTERED CLAST IN QUEEN ALEXANDRA RANGE 99177 MATRIX REVEALING INSIGHTS INTO ACCRETIONARY PROCESSES.

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Introduction: Queen Alexandra Range (QUE) 99177 is a very low petrologic type 2 CR chondrite that has escaped the effects of aqueous alteration and appears to be significantly less altered than most members of this group [1]. QUE 99177 is the isotopically lightest whole rock CR chondrite known ($\delta^{18}O = -2.29‰$, $\delta^{17}O = -4.08‰$), possibly due to isotopically light unaltered matrix. Although it experienced aqueous alteration, QUE 99177 provides the best approximation of the pristine CR-chondrite parent body's oxygen-isotopic composition, before aqueous alteration took place [2]. The matrix of QUE 99177 is characterized by significant FeO-enrichment with respect to other CR chondrite matrices. CR chondrites contain dark inclusions [e.g. 3, 4] which 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 [5].

Experimental methods: Five regions, each approximately 100 µm2 , 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 [6, 7]. Two FIB foils were extracted with FIB technique using the Helios FEGSEM/FIB (FEI Helios NanoLab Dual Beam), and TEM observation were carried out using FEG-TEM (JEOL JEM-2100F) at Kyoto University. Two cubic matrix samples, adjacent yet distinct, of approximately 30×30×30 µm in size were extracted with FIB technique at Kyoto University. 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 [8, 9]. 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 for fine-grained matrix.

Result and discussion: Textural observations of the five matrix regions were made using the high definition image maps. All the areas investigated appear to be similar in texture, with the exception of one area which exhibits remarkable differences. 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. TEM observations of this unique area reveal a very complex texture and mineralogy. The porosity varies considerably with regions of the foils characterized by very low porosity, which mainly consists of layered phyllosilicates; smectite and/or chlorite, magnetite crystals are also present. The low porosity regions contain widely distributed altered Al-rich objects characterized by a layered structure. The highly porous regions of the foils are relatively homogeneous in composition, and appear to be rich in Fe-Ni sulfide grains. CT investigation of the matrix region showing 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 TEM observations. 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 [10].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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