PROBING METEORITE MATRIX USING NON-DESTRUCTIVE TECHNIQUES.

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Introduction: The minute quantities or particle size of samples returned from future space missions makes it vital to develop non-invasive diagnostic research methods to study these precious materials. The mineralogy of such samples is a key parameter to determine, but presents many challenges when material is limited or high spatial resolution is required. In this study we have carried out a combination of several non-destructive analysis of selected matrix regions of primitive carbonaceous chondrites ALHA77307 and QUE 99177 to investigate their nature.

Experimental methods: Ultra high-resolution image maps were acquired using a Carl Zeiss Ultra Plus Field Emission SEM. Image manipulation software "Image J" was used to estimate the clast and pore abundances by thresholding different grey-scale values from the image maps. Element maps of the same matrix regions were acquired, at 15kV and 5kV using a FEI Quanta 650 SEM with an innovative XFlash QUAD 5060F Bruker detector. [1]. Micro-XRD analyses were directly collected from the selected areas on the thin section using the 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 [2].

Results: The micro-XRD patterns indicate the presence of olivine, clinoenstatite, pyrrhotite, magnetite and kamacite in the matrix of the meteorites studied. Clast and pore abundances in 5 image maps of each meteorite (each map having an area of ~ 20 x10 μm) show the average abundance of metal grains in ALHA77307 and QUE 99177 is 3±2.3% and 2±0.8% respectively, the average porosity is 6±4.1% and 3±1.6% respectively, and the average abundance of crystalline silicates and oxides are 65±12.1% and 46±4.8% respectively. A groundmass of amorphous material accounts for 26±16.2% in ALHA77307 and 49±4.0% in QUE 99177. In both samples the element maps acquired show that the main cations of the amorphous groundmass are Al, Si and Fe, consistent with previous works e.g. [3], [4]. The matrix of ALHA77307 contains some acicular grains of Mg-silicate grains, a morphology indicative of condensation from solar nebular.

Conclusions: The phase identification using in situ micro-XRD demonstrates that this technique has the potential to be a useful tool in the characterization of minute samples or local areas of interest. The element maps acquired, using a FEI Quanta 650 SEM with an innovative Bruker detector, demonstrated to be capable of providing chemical information at spatial resolution down to a volume of 200 nm in depth by 100 nm in radius at 5kV. This has proved to be a useful tool for non- destructive chemical analysis at high spatial resolution.

References: [1] E. Vaccaro et al., Abstract #5327. *MetSoc 2014* [2] E. Vaccaro et al., Abstract #5348. *MetSoc 2014.* [3] A. Brearley, 1993, *Geochim. et Cosmochim. Acta* 57. [4] M. Neyda, A. Brearley, 2010, *Geochim. et Cosmo-chim. Acta* 74.