"DOGGED" SEARCH OF FRESH NAKHLA SURFACES REVEALS NEW ALTERATION TEXTURES

T. Tomkinson[1], M.R. Lee[2], D.F. Mark[1], F.Stuart[1]. [1]SUERC, East Kilbride, Glasgow, U.K. [2]GES, Glasgow University, U.K. (tim.tomkinson@glasgow.ac.uk).

Introduction: Nakhla is the only nakhlite fall and hence is the best sample available for investigating products of aqueous alteration on Mars. Alteration products including clays, salts, carbonates and Fe-silicate gels have been previously observed filling fractures within this meteorite [1-3]. These materials have been interpreted as remnants of an ancient aqueous alteration event related to an impact-induced hydrothermal system or sustainable subsurface brine [3, 4]. However, the poor crystallinity of the Fe-silicates suggests a short formation timescale on Mars. Given their microstructural, crystallographic and chemical complexity these alteration products are still not fully understood. Hitesh and Bridges [3] have examined the fine-scale structure of the Fe-silicate gels and clays by transmission electron microscope (TEM) study of foils cut from veins exposed in polished thin sections using the focused ion beam (FIB) technique. Here we have chosen to examine alteration product-coated grain surfaces in freshly broken samples of Nakhla, and we have also extracted layers of alteration products using a micromanipulator for high-resolution chemical and microstructural characterisation.

Methods: The sample studied (BM1913, 25) was kindly loaned by the Natural History Museum (London). It is a fresh interior surface fragment (1.6 g) prepared by Dr Caroline Smith and has not been carbon or gold coated or washed. The zones of weakness along which the sample has broken expose large areas of alteration products. These samples were characterised by field-emission SEM, low-voltage scanning transmission electron microscopy, and by TEM.

Results: We have observed a variety of alteration products that have not been previously described. The Fe-silicate gels are composed of multiple thin sheets, some of which are concetrically zoned with respect to Si, Cl, Ca, Mn and Fe and over scales of ~0.1 mm. The gels are also cross-cut by veins of a Cl-rich material that have a nanoscale fibrous structure and are decorated by tens of nanometre sized euhedral calcium sulphate crystals. Additionally we have observed radial growth structures emanating from halite grains, and sites displaying stages of nucleation and growth of the gel.

The features that we have observed suggest that the Fe-silicate gel formed during fluctuations in fluid compositions, and the presence of Cl–rich alteration products cross-cutting the gel indicates subsequent injection of a saline fluid. The sharp contacts of this later material with the gel suggest that this brine percolated through Nakhla at very low temperatures [5] thus not remobilising and equilibrating with the surrounding material. One important message of this study is that caution is required when samples are being prepared. The nanoscale features that we have found would undoubtedly be lost in conventional thin section manufacture and may explain why they have not been observed previously.

References: [1] Bunch, T.E. and Reid, A.M. (1975) *Meteoritics*, 10, 303-324. [2] Gooding J. L. et al. (1991) *Meteoritics*, 26, 135- 143.[3] Changela, H.G. and Bridges J.C. (2011) *MAPS*, 45, 1847-1867. [4] Rao. M. N. et al. (2006) *LPSC* abs 1969. [5] Hausrath, E. M. and Brantley S. L. (2010) *J. Geophys. Res* 115.