ORIGIN AND COMPOSITION OF CARBONATES, SULPHATES AND HALITE ON MARS A.W.Needham[1,2], N. A. Starkey[1], D. Johnson[1], T. Tomkinson[1,3], C. Guillermier[1,4], R. L. Abel[2,3], I. A. Franchi[1], M. M. Grady[1,2] [1] PSSRI, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK. (A.W.Needham@open.ac.uk). [2] Department of Mineralogy, The Natural History Museum, London, SW7 5BD, UK. [3] SUERC, [4] Harvard Medical School, [5] Imperial College, London

Introduction: The nakhlite meteorites, widely accepted to originate on Mars, preserve complex mixtures of silicate alteration, carbonates, sulphates, halides, oxides and iron oxy-hydroxides [1-3]. These phases may have formed at different times, under different fluid flow regimes (groundwater, hydrothermal, crater lake), experiencing a range of water-rock ratios, evaporative histories, and varying degrees of interaction with the atmosphere and bedrock [2,3].

Using information gathered from our 3D investigations of Nakhla's fluid pathways [4] we have undertaken a range of in-situ geochemical and isotopic analyses of carbonate, sulphate and halite in the Nakhla meteorite.

Samples and methods: The 3D mineralogy of a small section of Nakhla was analysed by computed tomography (CT) [4]. Using a Metris X-Tek HMX ST 225 System a resolution of ~5µm per voxel was acheived, producing several thousand CT 'slices', subsequently reconstructed to provide 3D representations of the sample. Several sites of interest were identified in the CT data and the section of Nakhla was physically cut to reveal these sites for in-situ studies. High-resolution backscatter electron and false-colour EDS images were obtained using a FEI Quanta 200 dual-beam system; the Focused Ion Beam (FIB) capabilities of this instrument have been used to extract FIB sections ranging from electron-transparent (~100nm) to ~5µm thick sections for Raman spectroscopy, electron microprobe, and NanoSIMS analyses. We have previously demonstrated the capabilities of the NanoSIMS 50L for analyzing the range of carbon and oxygen isotope compositions in the martian meteorite ALH84001 [5]. Continuing improvements in the precision of oxygen isotope analyses (presented by [6]), especially including ^{17}O measurements, are essential for analyses of samples with smaller isotopic differences, such as for our analyses of Nakhla secondary minerals e.g. carbonates with <10‰ $\delta^{18}O$ variations [7, 8] in order to understand the nature of the fluids and formation conditions.

Summary: Combining 3D mineralogy with subsequent high-precision and high-spatial resolution 2D mineralogical, chemical and isotopic analyses, provides detailed information on the formation and alteration of secondary minerals on Mars. Understanding all aspects of these minerals is essential to reconstructing the true history of water on Mars, and the inherent implications for past climate and potential habitability.

References: [1] Gooding. J. L. et al. (1991) *Meteoritics*, 26, 135-143. [2] Bridges. J. C and Grady. M. M. (2000) *EPSL*, 176, 267-279. [3] Grady M. M. et al. (2007) *LPSC XXXVI*II, 1826. [4] Needham A. W. et al. (2011) *72nd Annual Meeting of the Meteoritical Society abs #5440*. [5] Tomkinson T. et al. (2010) *72nd Annual Meeting of the Meteoritical Society abs #5368* [6] Starkey et al. (2011) *73rd Annual Meeting of the Meteoritical Society*. [7] Vicenzi and Eiler (1998) *MAPS 33*. [8] Saxton J. M. et al. (2000) *GCA 64, 1299-1309*