FORMATION OF BERTHIERINE IN THE MARTIAN METEORITE NAKHLA BY REPLACEMENT OF ALUMINOSILICATE GLASS.

M. R. Lee[1] and E. Chatzitheodoridis[2]. [1]School of Geographical and Earth Sciences, University of Glasgow, Glasgow G12 8QQ, U.K. E-mail: Martin.Lee@Glasgow.ac.uk. [2]Department of Geological Sciences, School of Mining and Metallurgical Engineering, National Technical University of Athens, Greece.

Introduction: Serpentine is an important mineral to identify in the crust of Mars because its presence is diagnostic of a certain fluid chemistry, including high pH and low Eh [1], and it has also been linked to the generation of methane [2, 3]. Whilst uncommon, serpentine (Mg-rich) has been identified in several regions of the planet using data returned by the Mars Reconnaissance Orbiter [1], and this phyllosilicate has also been described from the nakhlite meteorites [4-6]. Here we describe evidence from the Nakhla meteorite for the occurrence of berthierine, a Fe-Al serpentine, which has formed by the replacement of glass.

Methods: We studied two thin sections of Nakhla, both loaned by the Natural History Museum (London): BM1911,369, P7963 and 1913,26 no.2. Backscattered electron (BSE) images and quantitative X-ray analyses were obtained using a Zeiss Sigma SEM operated at 20 kV/1 nA. Foils for TEM work were extracted using a FEI DuoMill FIB instrument, and then imaged and quantitatively chemically analysed using a JEOL ARM TEM.

Results and discussion: This study has focused on sub-millimeter sized melt inclusions within olivine phenocrysts that are composed of Na-K aluminosilicate glass and augite. The glass contains hemispherical patches and veins of a hydrous Fe-rich aluminosilicate. High-resolution BSE images show that these patches and veins contain ~1 micrometre long fibrous crystals, which often occur together in radiating arrays. The fibres have a 0.7 nm basal layer spacing, which together with the compositional data indicates that they are berthierine.

The petrographic context of the berthierine patches and veins shows that they have formed by fluid-mediated replacement of the glass. The hemispherical shape of the patches indicates that the berthierine crystals started to grow at the point where aqueous solutions first came into contact with the glass, then they expanded radially outwards. In order to form phyllosilicates of this composition, Mg and Fe must have been imported into the glass and Na and K exported; the retention of Al is consistent with alkaline solutions. Our results provide further evidence for the formation of secondary minerals in the nakhlites by replacement [7], and this process also accounts for the strong control on phyllosilicate chemical composition by their host mineral/glass.

References: [1] Ehlmann B. L. et al. 2010. *Geophysical Research Letters* 37:L06201. [2] Wray J. J. and Ehlmann B. L. 2011. *Planetary and Space Science* 59:196-202. [3] Parnell J. et al. 2015. *Nature Communications*, in press. [4] Treiman A. H. and Gooding J. L. 1991. *Meteoritics* 26:402. [5] Nogouchi T. et al. 2009. *Journal of Geophysical Research* 114:E10004. [6] Hicks L. J. et al. 2014. *Geochimica et Cosmochimica Acta* 136:194-210. [7] Lee M. R. et al. 2015. *Geochimica et Cosmochimica Acta* 154:49-65.

Additional Information: We thank the Natural History Museum (London) for loan of the samples. We are also grateful for funding from the STFC and the COST Action ORIGINS T1308.