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**COATED SILICA NANOPARTICLES IN NAKHLA
IDDINGSITE VEINS: IMPLICATIONS FOR WATER-
ROCK INTERACTION WITHIN THE MARTIAN CRUST.**

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Introduction: Nakhla is a martian olivine-bearing clinopyroxenite fall that contains 0.11-0.13 wt. % water [1, 2]. Most of this water is contained within olivine-hosted veins of 'iddingsite', whose principal constituent is a Mg- and Fe-bearing hydrous silicate [3]. Since the discovery of iddingsite in 1975 [4], the Mg-Fe silicate has proven difficult to identify, largely owing to its very fine grain size. Findings from examination of this material by transmission electron microscopy (TEM) are contradictory, and include: smectite [3]; smectite plus hematite, goethite, quartz, cristobalite, tridymite and amorphous silica [5]; amorphous gel [6]. We have sought to resolve this debate by high-resolution electron imaging and spectroscopy of Nakhla iddingsite veins.

Methods: Using a FEI Duomill focused ion beam instrument, an electron transparent foil was cut from a vein in a polished thin section prepared from Nakhla BM1913,25. The foil was milled initially to ~100 nm and then further thinned to ~50 nm by argon ion milling using a Fischione Nanomill operated at 500 eV. (Scanning) TEM was performed using a JEOL ARM200F including electron energy loss spectroscopy (EELS) with a Gatan GIF Quantum. EELS was used to map chemical compositions and Fe valence states at nanometre resolution.

Results and discussion: We focused on an iddingsite vein containing a central band of Mg-Fe silicate that is flanked by siderite, itself partially altered to goethite. The Mg-Fe silicate yields diffraction rings with d-spacings of 0.254 and 0.154 nm, and dark-field TEM imaging using the 0.254 nm ring demonstrates that it is formed by scattering from numerous ~2-5 nm sized crystals. STEM imaging and EELS mapping shows a structure of globular nanoparticles embedded in a matrix; most of the nanoparticles are 3-5 nm in diameter, although a small proportion are larger, up to 30 nm. The nanoparticles are almost pure silica, and the O- Mg- and Fe³⁺-rich composition of their matrix is consistent with a ferrihydrite/goethite coating, probably intergrown with smectite. Our discovery of embedded silica nanoparticles agrees well with previous mineral identifications by Thomas-Keptra et al. [5]. Nakhla vein formation started by dissolution of olivine [7], and the challenge now is to determine why this reaction produced nanoparticles, and the implications of their discovery for understanding water-rock interaction within crust of Mars.

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