INDIGENOUS CARBONACEOUS MATTER AND BORON ASSOCIATED WITH EVAPORITE HALITE CRYSTALS IN THE MARTIAN METEORITE NAKHLA. K. L. Thomas-Keprta[1] (Kathie.Thomas-Keprta-1@nasa.gov), Everett K. Gibson[2], S. J. Clemett[3], and Wentworth S. J.[4]; [1]Barrios Inc., Jacobs JETS Contract, NASA/JSC, Houston, TX 77058; [2]NASA/JSC Houston, TX 77058; [3]ERC, Inc., Jacobs JETS Contract, NASA/JSC, Houston, TX 77058; [4]Hepco, Jacobs JETS Contract, NASA/JSC, Houston, TX 77058.

The Martian meteorite Nakhla contains indigenous organic matter spatially associated with halite crystals located in alteration veins. The alteration veins were produced when low-temperature Martian fluids interacted with primary silicates producing iddingsite clays bearing the reported secondary evaporate minerals containing the carbonaceous matter. Furthermore, we have also detected enrichments of boron (*B*) in these halites far in excess of those previously reported in bulk Martian meteorites. Boron in Martian halites had been reported earlier [8]. Curiosity's ChemCam instrument has recently reported boron at the Gale crater on Mars [7].

Introduction: Secondary minerals in the form of iddingsite alteration phases and evaporites are present as vein fillings along fracture surfaces within the Nakhla meteorite. Their pre-terrestrial origin has been previously established; for example, by their truncation and decrepitation at the fusion crust, indicating formation prior to atmospheric entry, *e.g*. [1]. Consequently, the study of secondary minerals in Martian meteorites is of great importance in deciphering the low-temperature, aqueous geochemistry of early Mars. It has also slowly become apparent that many Martian meteorites contain organic matter, and in the case of Nakhla, appears to be predominately associated with the secondary alteration phases. We have previously documented that some of this organic matter is present in the form of discrete, well-defined, micron-sized hollow spherical assemblages encapsulated within iddingsite [2].

Procedure and Results: The Nakhla sample used in this study was gratefully received from the British Museum of Natural History. The sample was freshly fractured with resulting chips, ranging up to ~5 mm in diameter, mounted on SEM stubs using double sticky *C* tape. Samples were analyzed at 5, 10, and 15 keV using FESEM-EDX imaging and mapping. Prior to FESEM analysis, a *Pt* surface coating ~1 nm thick was applied to enable imaging and chemical characterization of light elements including *C*. One freshly fractured chip with a layer of iddingsite also contained ~15 euhedral crystallites of *NaCl*. Embedded within two adjoined crystallites, *C*-rich matter was identified. The *C*-rich region of interest measured ~2x2 m and was located near the center of the adjoined crystals. High-resolution element maps showed the location of the *C*-rich matter and the composition of the halite crystals which were composed of major *Na* and *Cl* with minor *B*. FESEM-EDX spectra taken at 10 kV and 100 s. showed a peak for *B*, primarily associated with *NaCl* although one spectrum of the carbonaceous matter appeared to contain *B* The background spectra showed no evidence of *B*. For comparison, a flat, polished, *C*-coated *BN* standard was analyzed under the same conditions (10 keV, 100 s). The presence of the *B* peak in the standard indicates this element can be detected using our FESEM-EDX system.

Discussion & Conclusion: We have identified arguably indigenous carbonaceous matter embedded within *B*-rich, *NaCl* crystals spatially associated with an iddingsite vein in the Martian meteorite Nakhla. Both the iddingsite and halite crystals are interpreted to have formed by interaction with low-temperature aqueous fluids that permeated fractures within the Nakhla groundmass while it was in the Martian regolith. The association, and in some cases encapsulation, of carbonaceous matter with the halite suggests that the C-rich matter provided a nucleation site for halite crystallization, as seen in terrestrial evaporite deposits. The presence of wt.% concentrations of *B* in the halite has not been previously observed in Martian meteorites. However, we note that similar *B* abundances have been observed in some terrestrial evaporite salts, *e.g*., teepleite ($Na_2B(OH)_4Cl$) [4]. Recently, the Curiosity's Chem-Cam instrument has detected B in association with "evaporate-related phases" [7].

The presence of *B* in association with organic matter is particularly important because it has been argued that presence of *B* was essential to early development of life on Earth. This is because, in the early "*RNA world*," borate minerals would have provided an inorganic pathway for the synthesis of ribose (a key component in RNA [5, 6]) and other pentoses [6]. The association of *B* and *NaCl* in Nakhla indicates evaporitic environments containing *B* were present on Amazonian Mars. Work is ongoing to identifying the nature of the *B* containing phase and establish the molecular composition of the carbonaceous matter [8].

The proximity of secondary minerals, formed in a low-temperature aqueous environment, with organic matter has implications for astrobiology and the historical habitable potential of the Mars regolith [3].

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