A HOST FOR LITHIUM IN MIL03346 AND IMPLICATIONS FOR AQUEOUS ALTERATION ON MARS.

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Introduction: Products of low-T aqueous alteration processes on Mars are relatively abundant in the nakhlites [1]. This includes mixtures of poorly crystalline clays and amorphous material, often dubbed iddingsite. They can be found in the mesostasis or forming veinlets in olivine [2] as well as being part of mineral assemblages, e.g. inside carbonate veinlets in Lafayette [3,4], in association with halite [5], or riming anhydrite in Nakhla [5], or within melt inclusions in Nakhla olivines [6].

The major and minor element contents of these clays vary with respect to the location, potentially representing the heritage of the precursor material. Although the trace element concentrations are also not uniform, our recent ToF-SIMS studies [4–6] indicated a persistent enrichment in some trace elements, especially Li.

Because Li is highly soluble, understanding the reason for this finding should provide more insight into the responsible aqueous processes that occurred on Mars. There are three potential explanations: (1) The Li stems from a dissolved (magmatic) precursor mineral from within the nakhlitic flow(s) that has not been recognized yet. (2) A concentration mechanism followed the dissolution of larger amounts of Li-poor material. (3) Percolating fluids transported Li from outside sources.

While (1) and possibly (2) would allow for small quantities of water being sufficient to explain the clay formation, (3) would suggest that water was ubiquitous and affected all nakhlites at the same time.

Method: Uncoated polished sections were used for ToF-SIMS analyses (IONTOF TOF-SIMS IV) and confocal Raman examination (WITec α-SNOM). EDX analyses (NSS on a JEOL 840A) were performed on coated specimens. ToF-SIMS quantification: Li/Si ratios corrected for the respective secondary ion sensitivities were normalized to EDX derived Si concentrations. While the statistical error is negligible for the results presented here, there is an uncertainty of ~30% due to the very nature of quantitative ToF-SIMS evaluation using glass standards [7]. However, this uncertainty does not apply to relative variations among data from the same mineral type.

Results: Table 1 provides a preliminary compilation of the measured Li contents; a range is given for multiple results. Included are literature data on Lafayette iddingsite [8] and all known bulk measurements [9–11]. These Li whole rock concentrations are in excellent agreement with those reported in this study for the respective pyroxenes (compare NWA817 to MIL03346). On the other hand, the reported Li abundance in Lafayette iddingsite [8] is somewhat lower yet still close to our measurements of clays in mesostasis and carbonate assemblages. However, clays in halite assemblages (44–60 ppm) and melt inclusions (100–160 ppm) feature even more dramatic Li enrichments compared to bulk, pyroxene, and olivine concentrations.

For the first time, we could identify a highly Li-enriched magmatic phase: predominantly small grains in the mesostasis of MIL03346 (Fig. 1). EDX and ToF-SIMS derived compositions indicate Fe-rich olivine. This mineral identification has been in some cases confirmed by Raman spectroscopy.

Phase	Li (ppm)
clay, assemblage with halite, Nakhla	44–60
clay, riming anhydrite, Nakhla	2.0–8.2
clay, in MI in olivine, Nakhla [6]	100–160
clay, assemblage with carbonate, Lafayette	9–29
clay, in mesostasis, Lafayette	18
“iddingsite”, 10 µm SIMS spots, Lafayette [8]	6.8–12
olivine (Li-rich), in mesostasis, MIL03346	44–79
olivine (Li-poor), in mesostasis, MIL03346	7.5
olivine, Nakhla	4.8–11
pyroxene, MIL03346	8.8
pyroxene, Nakhla	2.1–5.7
pyroxene, Lafayette	5.6
bulk, NWA817 [10]	7.43
bulk, Y000593 [11]	4.6
bulk, Nakhla [9]	3.8
bulk, Lafayette [11]	3.9

Table 1. *Lithium concentrations in ppm by weight. MI = melt inclusion. Data are from this study if not indicated otherwise.*

Conclusion: Despite potential uncertainties, the presented ToF-SIMS data provides a consistent picture. The finding of unaltered, albeit readily dissolvable, Li-rich olivine in the MIL03346 mesostasis avoids the necessity of large quantities of water to explain the Li enrichment in secondary clay minerals.

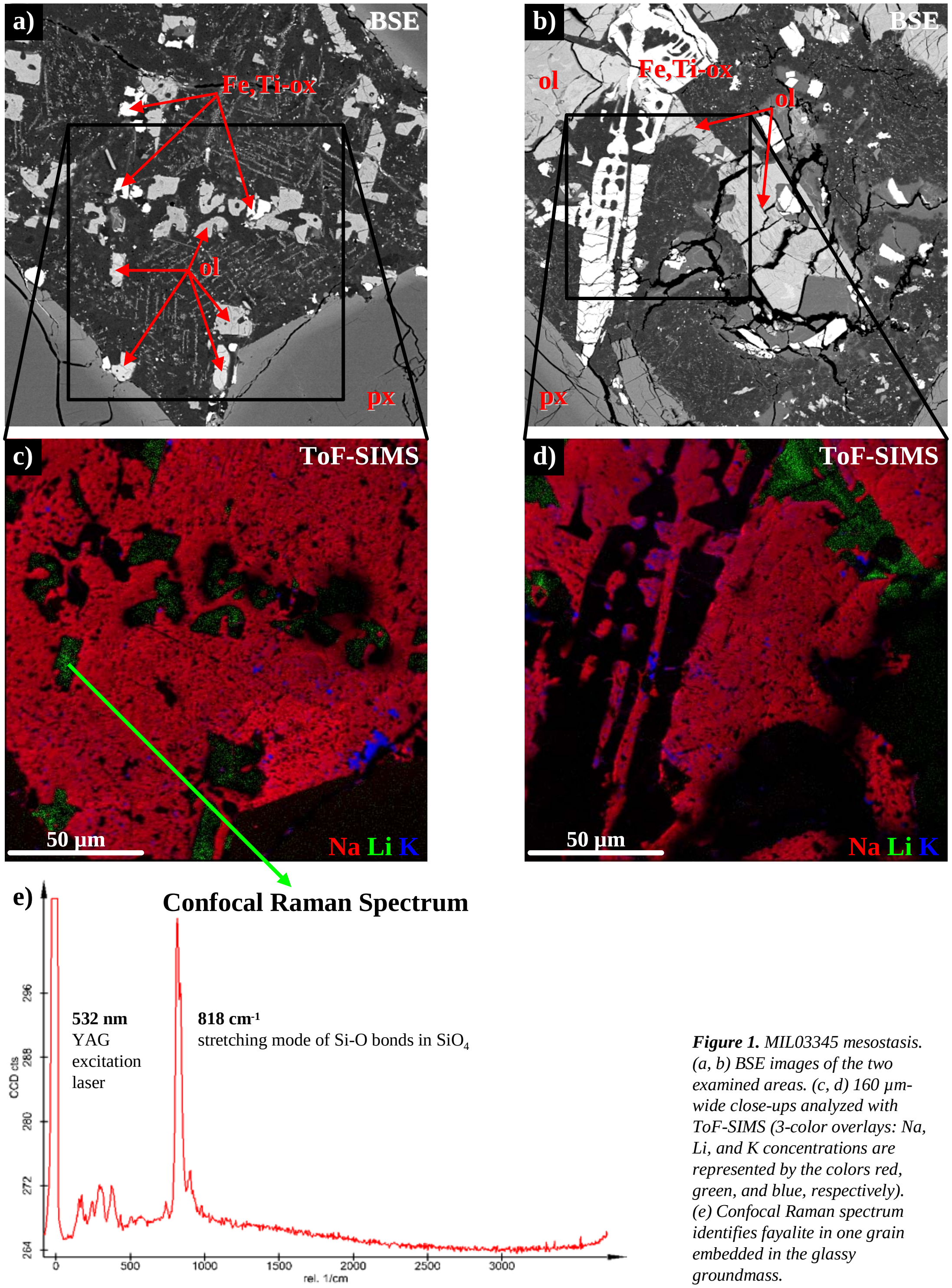

Figure 1. MIL03345 mesostasis. (a, b) BSE images of the two examined areas. (c, d) 160 µm-wide close-ups analyzed with ToF-SIMS (3-color overlays: Na, Li, and K concentrations are represented by the colors red, green, and blue, respectively). (e) Confocal Raman spectrum identifies fayalite in one grain embedded in the glassy groundmass.

References: [1] Gooding J. L. et al. (1991) *Meteoritics, 26,* 135–143. [2] Treiman A. H. et al. (1993) *Meteoritics, 28,* 86–97. [3] Vicenzi E. P. and Heaney P. J. (1999) *LPS XXX,* #2005. [4] Rost D. and Vicenzi E. P. (2004) *Meteoritics & Planet. Sci. 39,* A92. [5] Rost D. et al. (2005) *LPS XXXVI,* #2306. [6] Rost D. et al. (2003) *Meteoritics & Planet. Sci. 38,* A127. [7] Stephan T. (2001) *Planetary and Space Science 49,* 859–906. [8] Newsom H. E. et al. (2001) *LPSC XXXII,* #1396. [9] Dreibus G. (1982) *LPSC XIII,* 186–187. [10] Sauter V et al. (2002) *EPSL 195,* 223–238. [11] Dreibus G. (2003) *LPS XXXIV,* #1586.