OBSERVATION AND ANALYSIS OF MARTIAN METEORITE Y000593: EVIDENCE FOR BIOSIGNATURES L.M. Spencer[1*], D. S. McKay,[1] E. K. Gibson,[1] K. L. Thomas-Keprta, [1] S. J. Wentworth, [1] S. J. Clemett[1]
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Introduction: Yamato000593 is a meteorite discovered in Antarctica by JARE in 2000 and identified as a Martian nakhlite [1]. The crystallization age of Y000593 is ~1.3Ga and comparable to the 1.3Ga Nakhla Martian meteorite studied previously [1-3]. Within Y000593 secondary phases, truncation and alteration due to heating upon entering Earth's atmosphere has been suggested as evidence that such phases were preterrestrially formed. Optical and FE-SEM analysis of a thin section revealed iddingsite filled impact-derived microfractures. The meteorite contains 1-4 μm tunnels and galleries extending outward from fractures within grains of olivine and silicon glass similar to Nakhla [2-4]. Such features are especially intriguing since Fisk et al. [4] suggest similar features as possible evidence of microbial activity on Mars. EDX analysis of such features not only reveal iddingsite clay near these unusual alteration features but also reduced carbon phases with high Mn and Ca abundances; this material is almost certainly carbonate. To our knowledge, this is the first report of carbonate phases within the Y000593 meteorite. No evidence of terrestrial contamination has yet been found. Iddingsite can only be formed, under terrestrial conditions, when olivine comes into contact with water [2]. Therefore, the presence of this mineral as well as carbonate may be further evidence supporting a past history of warmer and wetter climate on Mars [3]. Since the secondary phases are present near tunnels and galleries, the results are also comparable with previously studies of oceanic basalts showing similar morphologies and weathering compositions. Samples investigated by [4] included both recent sea floor and ancient oceanic basalts dating as old as 170 million years, of comparable age to Y000593. DNA staining of the recent oceanic basalts revealed that tunnels and galleries observed in clay-filled fractures of olivine and glass substrates were likely the result of live mocriobial activity.

Optical imaging of Y000593 dendritic alterations were also compared with those reported in previous-Nakhla studies as a possible biosignature formed before the rock eject from Mars.

Samples and Methods: A thin section of the meteorite was mounted with epoxy by Japanese researchers associated with JARE and sent to NASA Johnson Space Center for analysis. A non-Martian angrite meteorite thin section was observed under optical micros-

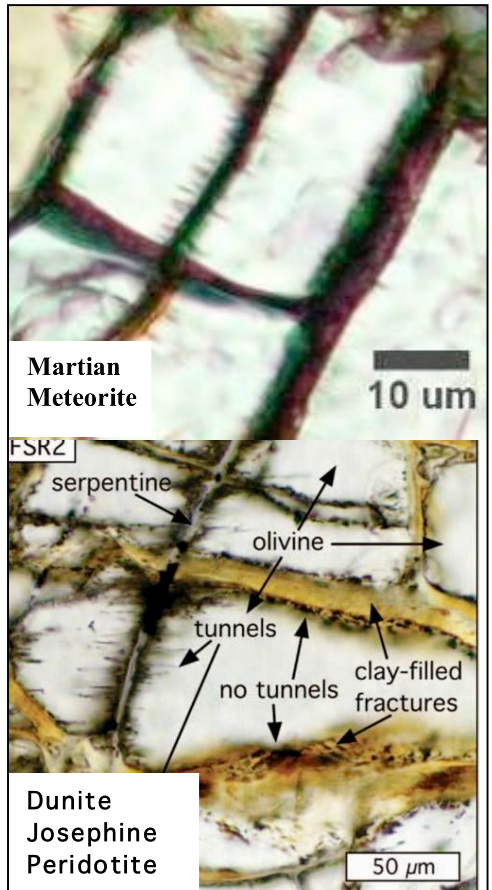

Figure 1. Optical image of unusual tunnel alterations in Y000593 (top) and in oceanic basalts containing live DNA (bottom) [Fisk et al., 4]

copy and used as a control sample to Y000593. Two thin sections of Nakhla meteorite, which fell in Egypt in 1911, were examined by optical and scanning electron microscopy. Since the Y000593 meteorite was discovered in the Yamato mountains of Antarctica, contamination features should be different from those found in Nakhla [1]. Thus, a comparison of alterations within Nakhla and Y000593 should provide more clear distinctions between alterations native to the Martian surface and those resulting from terrestrial contamination. Nakhla and Yamato both contain clinopyroxenes with traces of secondary phases including carbonates, iddingsite, and magenetite [1]. The control sample, LEW87051, is an angrite containing grains of olivine, pyroxene, and glass. FE-SEM and EDX data were collected on both Y000593 and Nakhla.

Results: Optical examination of the control sample showed no direct correlation between alteration features observed in Y000593 and those in the angrite. No tunnels, galleries, or iddingsite-rich veins could be found in the angrite thin section but were widely

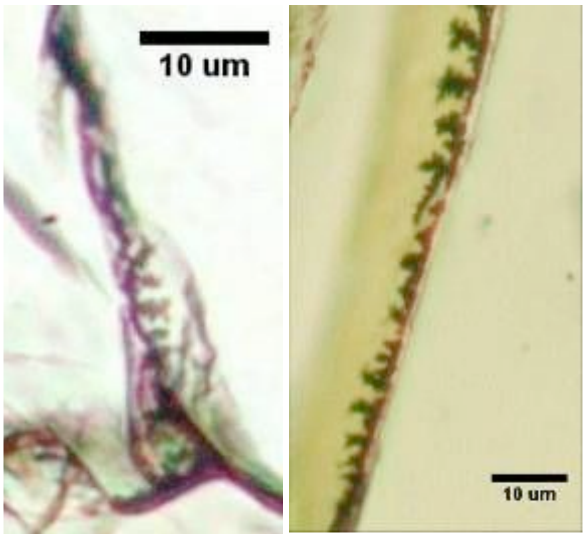

Figure 2. Unusual dendtric alterations in Y000593 (left) and previously reported Carbon-rich dendtritic features in Nakhla (right)

distributed throughout the sample of Y000593. However, alterations in Y000593 did appear similar in size and distribution to tunnels and galleries previously observed in Nakhla as well as oceanic basalts containing live DNA (figure 1)[4]. Our optical and SEM analysis of Nakhla showed tunnels and galleries within or near to iddingsite rich veins and carbonates.

Dendritic alterations were also observed Y000593. These alterations appear similar in size and distribution to those previously reported in Nakhla as possible evidence of microbial activity (figure 2)[4].

Elemental compositions of the phases near alteration features in Y000593 were obtained by EDX analysis. While initial weight percents can only be taken as semi-quantitative, analysis did indicate the presence of several secondary phases in and around unusual alteration features. High resolution SEM images clearly show the presence of several different phases near the alteration features. Analyses taken on some of these phases appear to indicate the presence of carbonates (figure 3).

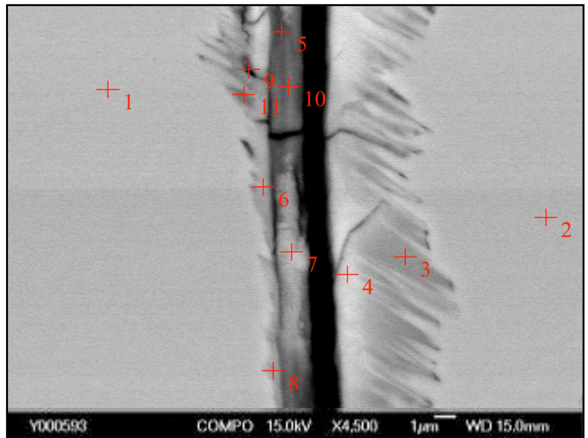

Figure 3. FE-SEM image of secondary phases near alterations in Y000593

Discussion: Previous studies suggest that fine tube-like projections form fractures in terrestrial olivine are the result of microbial activity in oceanic basalts [4]. Similar tube-like projections were observed in both the Nakhla and Y000593 meteorite. EDX analysis of both martian meteorites appears consistant with phases observed in oceanic basalts and attributed to biotic weathering of olivine grains. Unusual dendtritic alterations were also observed in Y000593 and appear similar to suggested evidence of biogenic processes within Nakhla. The presence of similar alteration features within both the Nakhla and Y000593 may verify these alterations as native to Mars rather than resulting from terrestrial contamination since the meteorites fell in very different terrestrial climates.

References:

[1] Meyers C. (2003) *Mars Meteorite Compedium*, XXII, 1-5. [2] Gibson E. K. Jr., McKay D.S., Thomas Keprta K., Wentworth S. J., Westall F., Steele A., Romanek C. S.,Bell M.S., Toporski J. (1999) *Precambrian Res.*, 106 (2001), 15-34. [3] Wentworth S. J., Gibson E.K. Jr., Velbel M. A., McKay D.S. (2005) *Icarus,* 174, 382-395. [4] Fisk M.R., Popa R., Mason O.U., Storrie-Lombardi M.C., and Vicenzi E.P. (2006) *AST.*, 6 (1), 48-68