AQUEOUS CORROSION TEXTURES OF OLIVINE IN MARS METEORITE MIL03346. M. A. Velbel, Department of Geological Sciences, 206 Natural Science Building, Michigan State University, East Lansing, MI 48824-1115 (velbel@msu.edu).

Introduction: Olivine is a geochemically important mineral on Mars. It has been identified in Mars surface materials by instruments on the Mars Exploration Rovers [1-8] and several Mars orbiters [9-12]. Olivine dissolution is inferred to have contributed significantly to the solute composition of inferred Martian groundwaters [13-16]. Olivine is also a major constituent of Mars meteorites, including nakhlites [17, 18], chassignites [18], and many shergottites [18]. Many Mars meteorites contain small quantities of aqueous alteration minerals, some of which are associated with olivine [17-27]. In freshly fallen meteorites (falls), aqueous alteration minerals are pre-terrestrial, and record aqueous alteration on their parent body [20-27]. Most Mars meteorites available for scientific study are finds, recovered after some exposure to the terrestrial surface environment, with associated effects of terrestrial aqueous weathering and contamination superimposed upon the mineral assemblages of pre-terrestrial origin [22, 28-30].

This paper reports investigation of weathering textures of olivine in the Mars meteorite MIL03346 [17, 18, 31-32], recovered in Antarctica. Alteration phenomena include pre-terrestrial alteration of olivine along fractures to veins of iddingsite (a clay-oxide mixture), thermal pyrometamorphism of the Martian iddingsite near the meteorite surface during passage through Earth’s atmosphere, and terrestrial corrosion of olivine.

Sample and methods: MIL03346 is an Antarctic nakhlite find. Original recovered mass was 715.2 g. At weathering category B, it is more weathered than at least half of all other U.S. Antarctic Mars meteorites. It is also the most fractured U.S. Antarctic Mars meteorite recovered to date. (Info from Astromaterials Curation at NASA JSC website, http://curator.jsc.nasa.gov/antmet/, U.S. Antarctic Meteorite Classification Database). Its petrology, geochemistry and mineralogy have been previously described [17, 18, 31-32].

A polished thin-section was examine using transmitted polarized-light microscopy and scanning electron microscopy in backscattered electron imaging mode (SEM-BEI) with energy-dispersive spectroscopy (EDS).

Results: Both olivine and pyroxene are crosscut by alteration veins that also crosscut fusion crust. Consequently, vein materials (including Martian iddingsite) and their olivine host may have been influenced by terrestrial processes and contaminants [22, 28-30].

Corrosion of olivine. Crystallographically controlled aqueous corrosion of olivine surfaces during terrestrial weathering of terrestrial olivine forms small funnel-shaped etch pits [33]; the pointed end probably defines the dislocation around which the etch pit develops [33-34]. Olivine etch pits are associated with, or proximal or directly connected to, fractures (the avenues along which aqueous solutions come into contact, and react, with the olivine) or exposed outcrop surfaces [34]. In SEM-BEI images of polished thin sections, olivine etch pits at grain boundaries, fractures, and contacts with veins appear as triangular (wedge-shaped) cross-sections through the funnels [34]. In weathered terrestrial olivine, individual etch pits range in size from as small as the limit of SEM resolution to as large 80 µm in longest dimension [34].

Incipient corrosion of olivine in MIL03346 occurs as individual etch pits with wedge-shaped cross-sections of typical form for olivine [33-34] but with maximum dimensions of only 1-2 µm, comparable to the onset of weathering in terrestrial olivine-bearing rocks [34]. As in the weathered terrestrial olivines, etch pits in MIL03346 olivine are at or near fractures or iddingsite veins. Olivine etching in MIL03346 occurs only in olivine within a few hundred microns of the meteorite’s surface.

Timing of iddingsite formation and subsequent alteration. Iddingsite veination of olivine is clearly pre-terrestrial (Martian), as it is truncated and metamorphosed by the fusion crust. Vesiculation in vein material near the fusion crust indicates that the vein material was devolatilized by heating during passage of the meteoroid through Earth’s atmosphere, and further indicates the vein material was volatile-rich prior to the meteoroid’s arrival at Earth [19, 22]. The volatile-rich material is thus pre-terrestrial (Martian) alteration of olivine as known from all other nakhlites [17-20, 24-25]. However, in the vicinity of the fusion crust, several chemical elements (K, Ca, Al(?), & S) have been redistributed into spatial associations not found in the meteorite’s interior. Like incipient olivine etch pits, such elemental redistribution into and within iddingsite is localized within a few hundred microns of the meteorite’s surface. This mobile-element redistribution is likely of terrestrial origin, occurring only in entry-metamorphosed vein material, and only near the meteorite’s terrestrially exposed surface.
Implications: When subjected to aqueous solutions undersaturated with respect to olivine, Martian olivine corrodes in the same manner as terrestrial olivine from a variety of olivine-bearing parent rocks [34]. Incipient crystallographically controlled corrosion of olivine (small etch pits of typical form for olivine) occurs only along fractures or veins (avenues for solutions), and only within a few hundred microns of the meteorite’s surface. This association of olivine etching with the meteorite’s terrestrially exposed surface indicates that olivine corrosion is a terrestrial weathering effect, not the result of aqueous alteration of olivine on Mars. It also indicates that small quantities of cold dilute water (Antarctic supraglacial meltwater) are sufficient to weather olivine in Martian igneous rocks.

Olivine in Mars meteorite falls (Chassigny; Nakhl) lacks etch pits [19]. Therefore, either the water to which Mars meteorite falls were exposed on Mars was of a composition that did not corrode olivine (unlikely in light of the inferred importance of olivine in the evolution of Mars’ groundwater chemistry [13-16]), or the olivines of Mars meteorite falls were exposed to even less water over their entire 1.3 Ga history on Mars than MIL03346 has been exposed to during its short residency on Earth.

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