

CHEMICAL WEATHERING RECORDS OF MARTIAN SOILS PRESERVED IN THE MARTIAN METEORITE EET79001. M. N. Rao¹, S. J. Wentworth¹ and D. S. McKay², ¹Lockheed Martin, 2400 NASA Road one, Houston. TX. 77058, ²NASA, Johnson Space Center, Houston. TX. 77058 (e-mail: david.s.mckay@jsc.nasa.gov).

Introduction: Impact-melt glasses, rich in Martian atmospheric gases, contain Martian soil fines (MSF) mixed with other coarse-grained regolith fractions which are produced during impact bombardment on Mars surface. An important characteristic of the MSF fraction is the simultaneous enrichment of felsic component accompanied by the depletion of mafic component relative to the host phase in these glasses [1,2]. In addition, these glasses yield large sulfur abundances due to the occurrence of secondary mineral phases such as sulfates produced during acid-sulfate weathering of the regolith material near the Martian surface [2-5]. Sulfurous gases released into atmosphere by volcanoes on Mars are oxidized to H₂SO₄ which deposit back on the surface of Mars as aerosol particles. Depending on the water availability, sulfuric acids dissolve into solutions which aggressively decompose the Fe-Mg silicates in the Martian regolith. During chemical weathering, structural elements such as Fe, Mg and Ca (among others) are released into the transgressing solutions. These solutions leach away the soluble components of Mg, Ca and Na, leaving behind insoluble iron as Fe³⁺ hydroxysulfate mixed with poorly crystalline hydroxide- precipitates under oxidizing conditions. In this study, we focus on the elemental distribution of FeO and SO₃ in the glass veins of EET79001, 507 sample, determined by Electron Microprobe and FE SEM measurements at JSC. This glass sample is an aliquot of a bigger glass inclusion, 104 analysed by [6] where large concentrations of Martian atmospheric noble gases are found.

Results and Discussion: We present the FeO and SO₃ abundances determined at various points (by raster mode using standard techniques with Cameca SX100 electron microprobe at JSC) along the line-traverses in impact melt glass veins of EET79001,507. Earlier, some of the results were reported in Fig.1 of [2]. The sulfur abundances reported here as SO₃ (sulfate) includes sulfide which occurs in varying proportions in these glasses. Hence, they are labeled as 'SO₃'. At some measuring sites in these glass veins, SO₃ abundance as high as ~18% was found which is much higher than that determined by Viking and Pathfinder [7,8]. The FeO and SO₃ data for ,507 plotted in Fig.1 vary over a wide range showing an excellent positive correlation between the two. This is consistent with the supposition that the Lith B soil fines might have undergone closed system acid-sulfate dissolution instead of random open-system leaching by

the transgressing solutions. As a result, the fluids became enriched in dissolved iron which eventually lead to insoluble ferric iron hydroxysulfate precipitation as poorly-crystalline coatings on etched grains. This iron deposition presumably took place under oxidizing conditions near the Martian surface, where the released Fe²⁺ from pyroxenes into solution is converted to Fe³⁺ and precipitated as hydroxysulfate / hydroxide.

Here, we plot FeO (Fe₂O₃) abundances for Viking and Pathfinder soils and rocks in Fig.1 and compare the correlation profile with that determined for EET 79001,507 glass veins. The FeO (Fe₂O₃) and SO₃ abundance data for Viking and Pathfinder rocks and soils are taken from [9,10]. Note that the Fe content in soils is reported as Fe₂O₃ (oxidised) and the Fe content in rocks is reported as FeO (reduced). Extrapolating the correlation line between FeO (Fe₂O₃) and SO₃ for Viking and Pathfinder, [10] earlier deduced a FeO content of ~12% for the soil free rock (SO₃ = 0%) near the Pathfinder. However, in Fig.1, as we used selected data points from the corrected abundances for Viking and Pathfinder given by [9] for fitting the regression line, we obtained a slightly higher value for the FeO (Fe₂O₃) content of soil-free rock at Pathfinder. Furthermore, in the case of EET 79001 ,507 glass sample, the correlation line between FeO and SO₃ (Fig.1), on extrapolation, yields an FeO content of ~11% for the soil-free rock component (SO₃ = 0.6% corresponding to Lith B) at the EET79001 regolith site on Mars. Note that the sulfur-free rock component prevailing at these three geographically widely-different Martian sites (Viking, Pathfinder and EET79001) yield a somewhat similar FeO (Fe₂O₃) content of 11-12 %. Also, the positive slopes of the correlation lines between Viking / Pathfinder and EET 79001,507 shown in Fig.1 are similar, though there is an off-set for the end-member FeO (Fe₂O₃) abundance between the Viking/ Pathfinder and EET79001 data sets. This off-set is a result of the fact that EET79001,507 glass contains much higher proportions of comminuted Martian soil fine (MSF) fraction which is depleted in the mafic component relative to the Lith B host. On the other hand, the soil and rock mixture at the Viking and Pathfinder sites contains relatively abundant coarse-grained material which did not register the mineral-specific comminution effects [2]. The similarity of the FeO (Fe₂O₃) vs SO₃ abundance line profiles between the EET79001,507 glass constituent Martian soil materials and the Viking and Pathfinder

soils and rocks, combined with the fact that these impact glasses contain large abundance of Martian atmospheric gases [6], indicate that the ,507 impact glasses are indeed made up of Martian soil fines which had undergone acid-sulfate weathering. This material underwent incipient melting during impact and quenched into glass in Lith B rock fractures.

Sulfur Speciation: The distribution of sulfur as sulfate and sulfide in these glass veins is studied using the state of art Field Emission SEM at JSC. Under high magnification (X 5000-15000), one finds that the fine-grained particulate matter is well-dispersed in the silicate glass. In localized glass pockets, we observe clusters of finely-dispersed globules in micron to sub-micron range. These globules occur in two groups, one as small and sharp globules (micron size) showing Fe and S signals and the other as relatively large and diffuse ones (4 to 6 microns) showing Fe, S and O signals. The elemental spectra for the two varieties of globules are shown in Fig.2. The smaller sharp globules are probably sulfides and the larger diffuse ones are sulfates. They seem to be intermixed in random proportions. Because of low H₂O and O₂ availability and extremely low temperatures (poor oxidation) near the Martian surface [11], iron sulfides and sulfates may exist together under favorable conditions. Sometimes, these iron sulfate globules also show Cl and P signals, indicating that they are associated with other secondary mineral phases. At shergottite liquidus temperature, a basaltic melt cannot contain more than 0.4-0.6% S without spawning an immiscible sulfide liquid [3]. The sulfide globules derive from the immiscible sulfide liquid contained in the impact melts of Martian soils. These results suggest that sulfur may occur as mixtures of sulfates and sulfides in some regions near the Martian surface under favorable conditions. Further work on these globules is in progress.

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Fig.1. Comparison of the FeO (Fe₂O₃) and SO₃ profiles in EET79001,507 and Viking / Pathfinder soils.

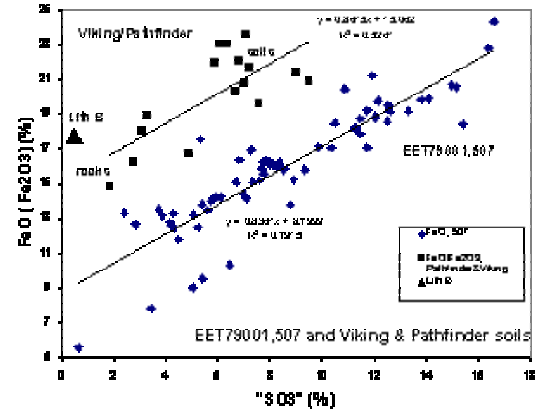


Fig.2. 'Fe-S' (small) and 'Fe-SO₄' (big) globules in EET79001, 507 glass

