SPECTRAL, CHEMICAL, AND PETROGRAPHIC COMPARISONS OF HYDROVOLCANIC TEPHRAS WITH BASALTIC IMPACTITES: RELEVANCE FOR MARS

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Introduction: Both pyroclastic volcanism and impact processes have shaped the morphology and geologic history of the martian surface. Distinguishing between the products of these two processes is difficult to determine with rover-based instrumentation. In its exploration of the Columbia Hills, the Mars Exploration Rover Spirit encountered a variety of clastic rocks [1,2]. Mini-TES observations of layered rocks on Home Plate and the Clovis class on Husband Hill indicated a high abundance of basaltic glass [3,4]. That glass could be interpreted as resulting from either impact or volcanic activity.

On Earth, basaltic glass can be produced in association with fire fountaining or hydrovolcanic eruptions. The most well-preserved impact site emplaced into basalt is Lonar Crater in India [5]. In the present investigation, we have begun to characterize a set of hyalotuffs from hydrovolcanic vents as well as basaltic impact glass and alteration products from Lonar Crater using measurement tools available to current and planned rovers.

Alteration Processes: Basaltic glass can alter via several pathways. Palagonitic vs. pedogenic alteration of tephras from the summits of Kilauea and Mauna Kea was examined [6]. [6] determined that pedogenic alteration resulted in disaggregated material, generally lacking in smectite, but with more abundant poorly crystalline materials: ferrihydrite, allophane, and imogolite. In contrast, palagonitically altered materials were indurated with abundant smectites along with other secondary minerals (zeolites, serpentines, carbonates). An important environmental difference between these two pathways is that pedogenic alteration involves ambient conditions while palagonitic alteration involves some level and duration of heating of wet tephra. The mineralogic differences between the two pathways are detectable through remote sensing techniques: reflectance and thermal emission spectroscopy [6,7]. A primary objective of this work has been to better characterize the minerals associated with the alteration pathways of basaltic glass to determine possible analogies with martian surface materials [7]

Field Sites and Samples: Hydrovolcanic tuff samples from maars, tuff rings, tuff cones, and tuyas are being examined [7] in addition to impact melts and glasses from Lonar Crater [5,8, abstract #3049 in this LMI volume]. Further sampling and field work was conducted in 2012 at multiple hydrovolcanic eruption sites throughout the Snake River plains of Idaho: Sinker Butte [9], Split Butte [10] and North Menan Butte [11].

Analyses and Results: Thin sections were prepared and examined using standard petrography (Figure 1) [7]. Reflectance spectra (0.3–2.5 μm) of relatively unaltered and more palagonitized hyalotuffs were examined using a non-linear approach [12] and have reflectance spectra consistent with earlier studies [7,13,14]. Unaltered samples have hydration absorptions at 1.4 and 1.9 μm along with a Si-OH feature at ~2.24 μm, whereas with increasing palagonitization, iron oxidation (orange color) increases and a Fe/Mg-OH absorption near 2.3 μm develops [7]. Mössbauer results indicate a broad Fe^{2+} doublet in glassy samples and a narrower Fe^{3+} doublet attributable to nanophase Fe^{3+} in palagonitized samples [7]. Thermal emission spectra of the most glass-rich samples [5,7] display a deeper 9.56 μm and shallower subsidiary 10.9 μm band. Palagonitized samples have a more symmetric 9.7 μm band and, in some samples, a narrow band at 11 μm [7] that indicates carbonate. Linear deconvolution of the emissivity data [15] and non-linear unmixing of the reflectance data produced contradictory results: more phyllosilicates than glass in unaltered samples and the reverse in highly palagonitized samples [7]. This confusion was resolved with μFTIR microscopy which allowed for distinction of palagonite rinds from glass cores and identification of smectites in interstices. This analysis will lead to improved TIR end-members of both glass-rich and altered materials.

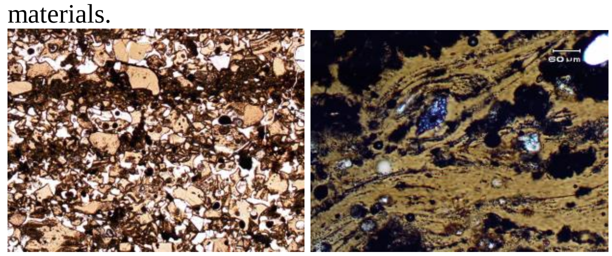

Figure 1. Petrography in plain polarized light of layered palagonite (left) compared to Class 5 impact melt glass from Lonar Crater (right).

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