SPECTRAL, CHEMICAL, AND PETROGRAPHIC COMPARISONS OF HYDROVOLCANIC TEPHRAS WITH BASALTIC IMPACT EJECTA: RELEVANCE FOR MARS. W.H. Farrand[1], S.P. Wright[2], T.D. Glotch[3] and C. Schröder[4]. [1]Space Science Institute, 4750 Walnut St., #205, Boulder, CO 80301, farrand@spacescience.org, [2]Auburn University, Auburn, AL, [3]Stony Brook University, Stony Brook, NY, [4]University of Tübingen, Tübingen, Germany.

Introduction: Pyroclastic volcanism and impact processes have generated many of the materials making up the martian surface and near surface. It is difficult to distinguish between the products of these two processes with rover-based instrumentation. In its exploration of the Columbia Hills, the Mars Exploration Rover Spirit encountered clastic rocks on Husband Hill and layered rocks at Home Plate [1-2]. Mini-TES observations of rocks on Home Plate and of the Clovis class on the West Spur of Husband Hill indicated high component fractions 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 geologically recent example of an impact into a basaltic substrate is Lonar Crater on the Deccan Plateau in India [5]. A primary objective of this investigation is to better characterize basaltic volcanic and impact generated glasses and to seek observable differences between them as well as to characterize their alteration products (palagonitized glass, smectites, zeolites, carbonates, etc.).

In this investigation, we have begun to characterize a set of hyalotuffs from hydrovolcanic vents as well as basaltic impact ejecta and alteration products from Lonar Crater using measurement tools available to current and planned rovers (e.g., reflectance and thermal emission spectroscopy, Mössbauer spectroscopy, major element analysis and X-Ray diffraction) along with terrestrial laboratory methods such as thin section petrography and SEM/BSE imaging.

Field Sites: A large number of hydrovolcanic tuff samples from a number of tuff rings, tuff cones, tuyas, and tindars are in the team's possession from past studies. In addition, further sampling and field work was conducted in the summer of 2012 at multiple hydrovolcanic eruption sites in the western and eastern Snake River plains of Idaho. These included Sinker Butte [6], Split Butte [7] and North Menan Butte [8]. In addition, one of our team has also conducted extensive field work at Lonar Crater [e.g., 5].

Analysis Techniques: The 0.3 – 2.5 μm reflectance of samples was measured with the University of Colorado Earth Science and Observation Center's ASD FieldSpec reflectance spectrometer. MWIR emissivity was measured at Arizona State University and at Stony Brook University. Emissivity spectra were examined using a linear deconvolution approach [9] and reflectance spectra were examined using a non-linear unmixing approach based on the Shkuratov scattering model [10-11]. Additionally, thin sections were prepared and examined using standard petrography and with a micro-FTIR reflectance spectrometer at the Stony Brook University Vibrational Spectroscopy Laboratory. Several samples are being examined with standard Mössbauer (MB) transmission spectroscopy at the University of Tübingen.

Hyalotuff Results: Relatively unaltered and more palagonitized hyalotuffs have reflectance spectra (**Fig. 1**) consistent with earlier studies [e.g., 12-13]. Namely, glass-dominated reflectance in the relatively unaltered samples with an increase in reflectance and growth of hydration absorptions at 1.4 and 1.9 μm and often a Si-OH feature at ~2.24 μm in lighter-toned gray tuffs and, with increasing palagonitization, increased iron oxidation (resulting in an orange color) and incipient development of a Fe/Mg-OH absorption near 2.3 μm. MB results indicate a broad Fe^{2+} doublet in glassy samples and in palagonitized samples the development of a narrower Fe^{3+} doublet attributable to nanophase Fe^{3+} in palagonite (**Fig. 2**).

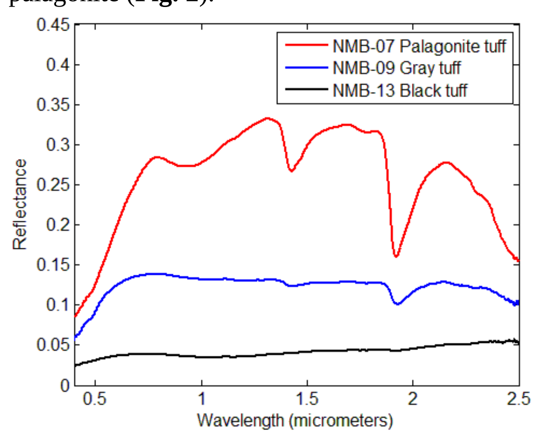

Fig. 1. Reflectance spectra of increasingly altered tuffs from unaltered (NMB-13) to palagonitized (NMB-07).

The linear deconvolution of the emissivity data and the Shkuratov model-based non-linear unmixing of the reflectance data produced sometimes contradictory results. Specifically, linear deconvolution of the MWIR data of the relatively unaltered samples generally indicated more phyllosilicates in the samples than glass and for the more highly palagonitized samples, the reverse was often indicated. In contrast, nonlinear unmixing of the reflectance spectra indicated more glass in the unaltered samples and more phyllosilicates in the palagonitized samples. The ambiguous results from the MWIR data were resolved in the MWIR Micro-FTIR thin section analyses. There is a marked difference between the relatively unaltered samples and the palagonitized tuffs with the former hosting few, if any, alteration products and the latter displaying smectites and also carbonates and zeolites. Also by being able to resolve individual grains, there were clear differences in the spectra of the glass grains, palagonite rinds and more developed smectites (**Fig. 3**).

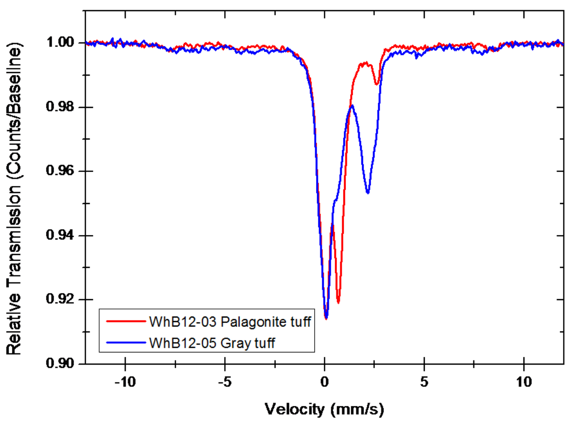

Fig. 2. Mössbauer spectra of minimally altered gray tuff from White Butte in Idaho (WhB12-05) and highly palagonitized tuff also from White Butte (WhB12-03).

Lonar Crater Comparisons: The most glass-rich hyalotuff samples have thermal emission spectra that are equivalent to the "class 5B" melt spectra found at Lonar crater in [5]. In the micro-FTIR thin section analysis, individual glass grain spectra could be extracted and these were generally indistinguishable between the glassy hyalotuffs and the Lonar Crater glassy samples (**Fig. 4**).

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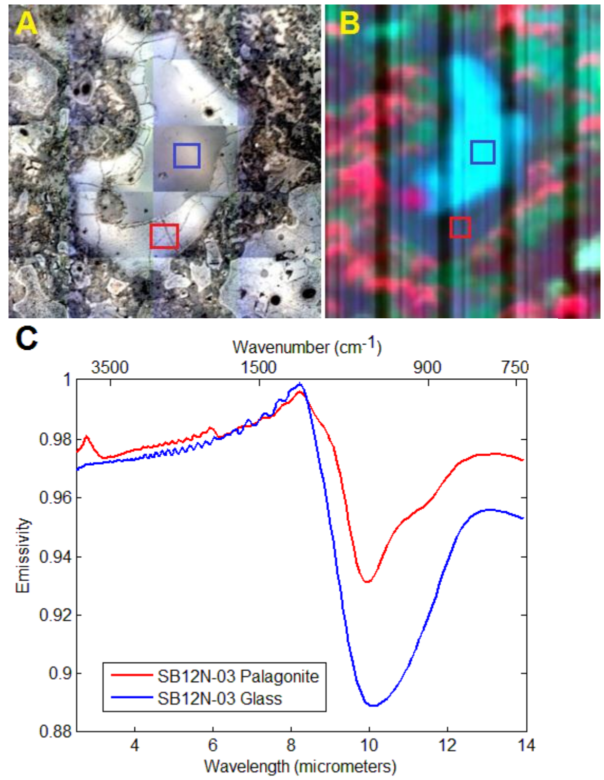

Fig. 3. **A**. Plane polarized light view of glass grain with palagonite rind in sample SB12N-03. **B**. Micro-FTIR multispectral view of that grain with blue box over glass and red box over palagonite rind. **C.** Micro-FTIR spectra converted to emissivity and wavelength space of glass and palagonite spectra.

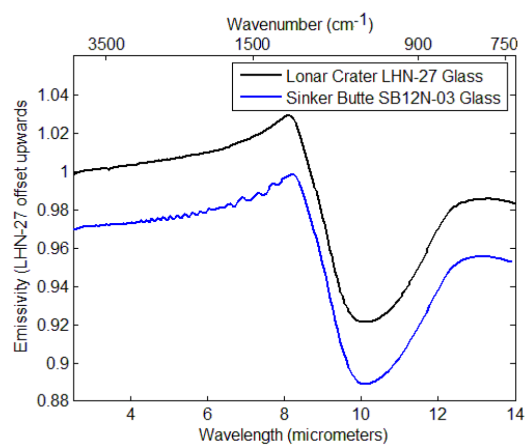

Fig. 4 Spectra from micro-FTIR thin section analysis of glass grain from Sinker Butte hyalotuff and glassy sample from Lonar Crater.