

SPECTRAL CHARACTERIZATION OF EXPLOSIVE VOLCANIC PRODUCTS. C. J. Leight, M. C. McCanta, and B. J. Thomson, Dept. of Earth & Planetary Sciences, University of Tennessee, 1621 Cumberland Ave, Knoxville, TN 37996 (cleight@utk.edu).

Introduction: Tephra are explosive volcanic deposits that contain a heterogeneous mix of mineral fragments, glass (quenched melt), and debris from previous eruptions. Tephra are associated with all types of terrestrial eruptive environments and span a full range of igneous compositions. Recently, evidence of explosive eruptions on other planetary bodies has been observed, including Mars [e.g., 1], the Moon [e.g., 2], and Mercury [e.g., 3]. As spectral identification methods remain the primary means to remotely characterize these bodies, it is crucial to constrain the spectral properties of tephra materials, on the basis of lab-identified phase assemblages and compositions, in order to better interpret remote observations.

For terrestrial tephra samples, spectroscopic methods present a non-destructive means of identification for materials that are recovered in small quantities, such as those from deep-sea drill cores [4]. However, the variable composition and phase assemblage across tephra samples makes it challenging to fully quantify all spectral components. Specifically, glass compositions are difficult to analyze with spectroscopic methods due to their amorphous structure and variable compositions [e.g., 5]. The effect of glass presence on visible-shortwave-infrared (VSWIR) and mid-infrared (MIR) spectra have been studied, but many complicating factors remain little explored. Here we present VSWIR and MIR data on a suite of well-characterized terrestrial tephra samples to study the spectral effects of glass composition and phase assemblage as an aid for interpreting remotely gathered data.

Methods: Tephra samples from multiple different terrestrial sources spanning a wide range of compositions were selected for this study (**Table 1**). Tephra samples were ground, sieved into a variety of size fractions (>2 mm, 2 mm–250 μ m, >500 μ m, 500–250 μ m, 250–125 μ m, 125–63 μ m, and <63 μ m), and dried. An ASD Fieldspec4 spectrometer equipped with a contact probe was used to gather VSWIR (350–2500 nm) reflectance spectra of each sample size fraction at the Univ. of Tennessee.

Bulk MIR emissivity data were obtained for the four smallest size fractions using a Nicolet 6700 FTIR spectrometer at Stony Brook Univ. Samples were poured into sample cups, heated to remove absorbed

water, then placed in the sample chamber. The chamber was purged of CO₂. 128 scans per sample were averaged into a single resistivity, which was processed into the resultant emissivity spectrum following [6]. A portion of the 250–125 μ m size fraction was cast into resin plugs to provide a random sampling of the minerals and glass present in the deposit. Particulate spectra were collected using a Nicolet iN10MX Micro-Imaging FTIR spectrometer that was cooled using liquid nitrogen. Hyperspectral maps and individual point spectra were collected.

Polished sample plugs were carbon coated for SEM and electron probe microanalysis. SEM backscatter (BSE) images were collected for particle counts to measure the crystallinity of each sample. BSE images were systematically scanned and 500 particles per sample were characterized as glass or mineral type following the methods of [4, 7]. Electron microprobe analyses were obtained using natural mineral standards for calibration and a 15 kV acceleration voltage.

Table 1. Tephra sample locations and phase assemblages.

<i>Volcano</i>	<i>Location</i>	<i>Phase Assemblage</i>
Bishop Tuff	Long Valley, CA	87.0% glass, 0.2% pyx, 5% feld, 7% quartz, 0.2% mica
Pinatubo	Pinatubo, Philippines	74.4% glass, 13.2% pyx, 11.5% feld, 0.6% amph, 0.2% mica
Okmok	Okmok, Aleutian Islands, AK	96.3% glass, 0.6% pyx, 2.3% feld, 0.8% amph
Mt. St. Helens	Mt. St. Helens, WA	81.5% glass, 6.3% pyx, 8.5% feld, 3% oxides, 0.8% apatite
Hotlum	Mt Shasta, CA	93.3% glass, 5% pyx, 0.8% feld
Summerland	Summerland Site, Mt Rainier, WA	91.2% glass, 1.8% pyx, 7% feld
Vesuvius	Vesuvius, Italy	76.5% glass, 0.6% pyx, 20.1% feld, 2.6% mica, 0.2% apatite
Cima	Cima, CA	54.1% glass, 33.5% pyx, 10% feld, 0.8% apatite, 1.4% olv
Crater Flats	Crater Flats, NV	94.0% glass, 6% pyx
Heimaey	Heimaey, Iceland	89.6% glass, 0.6% pyx, 9.2% feld, 0.2% other, 0.4% oxide

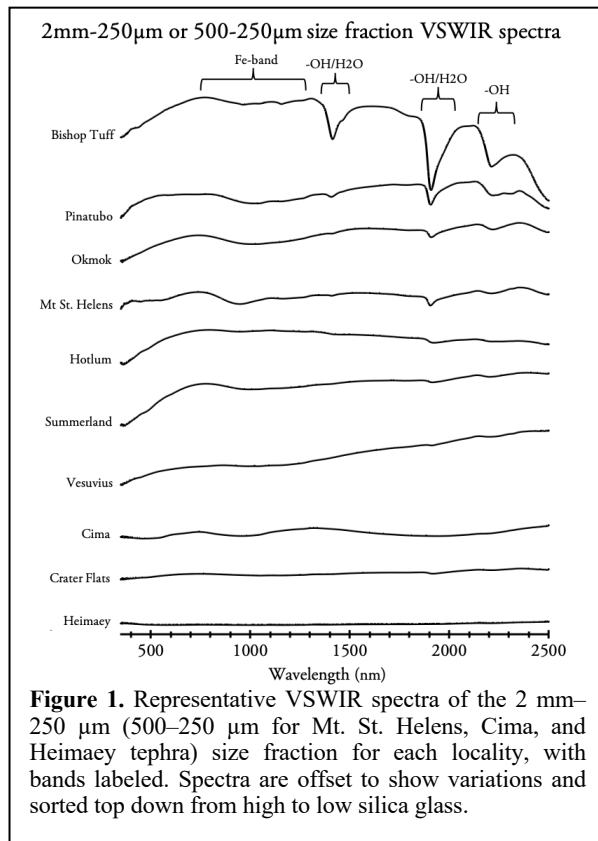


Figure 1. Representative VSWIR spectra of the 2 mm–250 μ m (500–250 μ m for Mt. St. Helens, Cima, and Heimaey tephra) size fraction for each locality, with bands labeled. Spectra are offset to show variations and sorted top down from high to low silica glass.

Results: Point count analysis shows that all tephras studied contain >50% glass (**Table 1**). Glasses range in composition from basaltic to rhyolitic and from low to high alkali contents. All tephras analyzed contain mineral phases, i.e., bulk compositions represent a combination of minerals + glass. The minerals present vary as a function of bulk composition, as expected. The basaltic Crater Flats sample, for example, contains olivine, labradorite, and oxides, while the more siliceous Bishop Tuff contains quartz, sanidine, anorthoclase, and oxides. The more alkaline compositions, such as Vesuvius and Cima, contain leucite and pyroxenes.

The tephra VSWIR spectra show variations based on composition. More basaltic tephras have lower overall reflectance and shallower spectral features than more siliceous samples (**Figure 1**). Within the VSWIR range, four bands of interest were noted, centered on 1, 1.4, 1.9, and 2.2 μ m. The 1.4 and 1.9 μ m bands are consistent with OH and/or H₂O, and 2.2 μ m band is consistent with structural OH in aluminous clays [8], while the band near 1 μ m is attributable to iron [9]. The OH/H₂O bands are present in most of the tephra spectra, but are best seen in samples (e.g., Pinatubo) that contain amphibole and/or mica, which are hydroxyl-bearing phases.

The FTIR emission spectra show the influence of both mineral and glass constituents, particularly in the shallow depth of the reststrahlen bands (between 1200–900 cm^{-1} , or 8–11 μ m [10]) (**Figure 2**). The

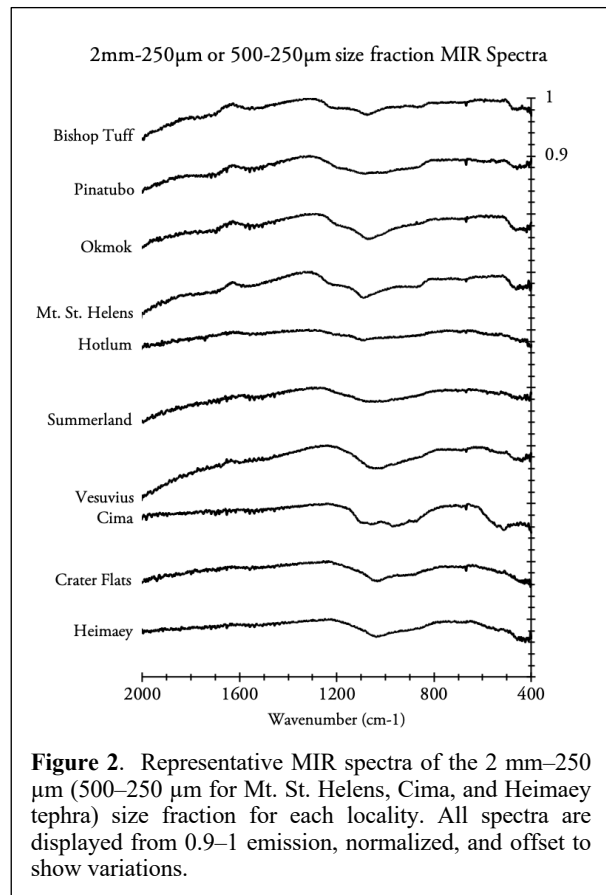


Figure 2. Representative MIR spectra of the 2 mm–250 μ m (500–250 μ m for Mt. St. Helens, Cima, and Heimaey tephra) size fraction for each locality. All spectra are displayed from 0.9–1 emission, normalized, and offset to show variations.

reststrahlen bands of the more basaltic samples appears shifted towards longer wavelengths, likely due to the lower silica content [11]. Most spectra have peaks from residual atmospheric H₂O and CO₂.

Discussion and Future Work: Natural glass samples present unique challenges; masses of glass are discontinuous and frequently contain microlites (<10 μ m diameter crystals), making single-phase point analyses difficult to collect or relate to bulk spectral features. To address this issue, we have collected micro-FTIR spectra of individual glass and mineral components in several tephras. Initial results suggest that glass may not always add linearly in the MIR, unlike pure mineral components [10, 11], and that the glass component may dominate the overall spectrum. These data will be used to further constrain the effects of glasses in spectral deconvolution models.

Acknowledgements: Thanks to T. Glotch and C. Ye at Stony Brook Univ. for assistance with MIR measurements.

References: [1] Hynek B.M. et al. (2003) *JGR*, 108, 5111. [2] Wilson J.T. et al. (2014) *JGR*, 120, 92. [3] Kerber L. et al. (2011) *PSS*, 59, 1895. [4] McCanta, M.C. et al. (2015) *Geochem. Geophys. Geosyst.*, 16, 4029. [5] Minitti M.E. et al. (2002) *JGR* 107, 5030. [6] Ruff S.W. et al. (1997) *JGR*, 102, 14899. [7] Cassidy M. et al. (2014) *ESR*, 138. [8] Bishop J.L. et al. (1994) *Clay Min.*, 42, 702–716. [9] Crown D.A. et al. (1987) *Icarus*, 492–506. [10] Ramsey, M.S. and Christensen P.R. (1998) *JGR*, 103, 577. [11] Feeley K.C. and Christensen P.R. (1999) *JGR*, 104, 24195.