**DISCRIMINATION OF HYDROVOLCANIC TEPHRAS FROM VOLCANIC AND NON-VOLCANIC BACKGROUNDS IN HYPERSPECTRAL DATA OF PAVANT BUTTE AND TABERNACLE HILL, UTAH: RELEVANCE FOR MARS.** W.H. Farrand, Space Science Institute, 3100 Marine St, Suite A353, Boulder, CO 80303, farrand@colorado.edu.

**Introduction:** Water-magma, or ice-magma, interactions have long been theorized as an important process in the Martian geologic record [1-3]. The ability to unambiguously recognize tephra deposits and volcanic edifices produced by $H_2O$-magma interactions is important for understanding the geologic history of Mars and for understanding the genesis of the major components of the Martian surface layer.

Recognizing volcanic edifices produced by $H_2O$-magma interactions on the basis of morphology alone is difficult. Analysis of Viking imagery led to the tentative identification of numerous tuyas, moberg hills and ridges [1]. Likewise, rootless cones have been identified in MOC Narrow Angle camera imagery [4,5]. However, the identification of tuyas, moberg hills and tuff cones is not definitive and supporting evidence will be requird before these features can be definitively identified as such.

One means of providing supporting evidence for the identification of hydrovolcanic landforms and tephra deposits is through spectroscopy. Tephras produced by hydrovolcanic activity range from fresh basaltic glass (sideromelane) to glasses that have been completely altered to palagonite. A study of the visible through short-wave infrared (Vis-IR) reflectance of tephras composing tuff rings and tuff cones showed that the different stages of this alteration sequence have recognizable reflectance signatures [6,7]. However, the ability to recognize these different types of tephras against volcanic and non-volcanic background materials has yet to be fully demonstrated. In this research, hyperspectral Vis-IR data over volcanic and hydrovolcanic terrains in the Black Rock Desert of Utah were analyzed in order to determine the separability of the component materials from volcanic and non-volcanic backgrounds.

**Study Area.** Pavant Butte is a tuff cone erupted into Pleistocene Lake Bonneville in west-central Utah approximately 15,600 years ago [8]. It consists of a highly palagonitized tuff cone which lies atop fresh to poorly palagonitized ash beds. South of Pavant Butte lies the younger moderately palagonitized Tabernacle Hill tuff ring and between them lies a more recent basalt flow. Laboratory reflectance spectra of the principal hydrovolcanic tephras are presented in **Figure 1**. The reflectance of the Tabernacle hill tuffs is approximately the same as that of the gray, moderately palagonitized tuff shown in **Figure 1**. The well palagonitized tuff is distinguished by a distinct $Fe^{3+}$ crystal field band just shortwards of 1 µm, deep water absorption features and a small sheet silicate vibrational overtone at 2.3 µm. In the poorly palagonitized material the "1 µm" feature is caused by both $Fe^{3+}$ in the palagonite and $Fe^{2+}$ in the unpalagonitized glass and water absorption features are weak to absent.

**Data.** The hyperspectral data set examined here was collected on October 8, 2002 by NASA's Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) [9]. AVIRIS collects 224 visible through short-wave infrared (0.4 to 2.45 µm) bands. The approximate ground resolution of this data is 17 m per pixel. The data were corrected to surface reflectance by means of the HATCH atmospheric correction software [10].

**Results**. A number of standard processing tools resident in the commercial ENVI software were used for initial analysis of the data. The high reflectance orange palagonite tuffs that form the steep walls of Pavant Butte are easily distinguished in the 2002 AVIRIS data and were also identifiable in an earlier study using lower signal-to-noise 1989 AVIRIS data [11]. Distinguishing the lower albedo, poorly palagonitized hydrovolcanic tephras has not been previously demonstrated. Since the lava flow and the poorly to moderately palagonitized tephras are of low albedo, a hyperspherical directional cosine (HSDC) transformation [12] was applied to the data to compensate for albedo differences. In **Figure 2**, a three band color composite of the AVIRIS data is shown along with a composite of fraction images of the volcanic products. These fraction images were produced via application of constrained energy minimization (CEM) [13] and foreground / background analysis (FBA) [14].

**Conclusions**. The CEM and FBA techniques that were applied to the data, map materials according to their fractional abundance within a pixel. The highest fractions of well palagonitized tuff and poorly palagonitized ash and tuff were thresholded for a subsection centered on Pavant Butte and this is shown in **Figure 3**. The mapping approaches reveal the presence of ash in the soil beyond Pavant Butte (yellow in the upper left of Fig. 3). The success demonstrated here in mapping low albedo volcanic tephras bodes well for achieving similar success with Mars Reconnaisance Orbiter CRISM [15] data.

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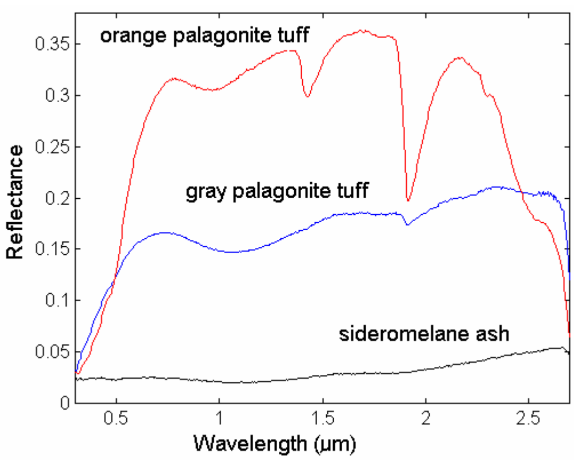
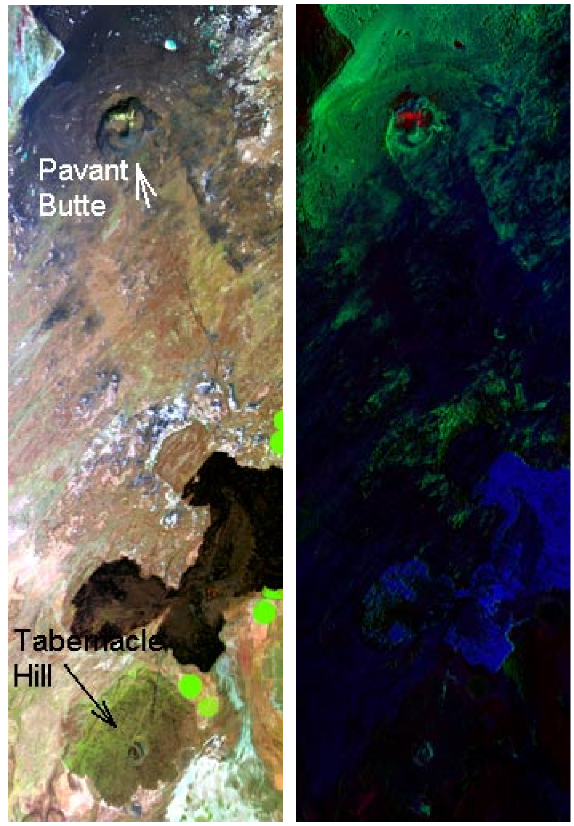



**Figure 1.** 0.3 to 2.7 µm reflectance of Pavant Butte tephras.

**Figure 2.** (next column) Image on left (2a) is composite of AVIRIS 1.7, 0.8 and 0.45 µm bands. North is at the top of the image. Image on the right (2b) is a composite of fraction images of palagonite tuff (red), poorly palagonitized tuff and ash (green), and basalt flow (blue).



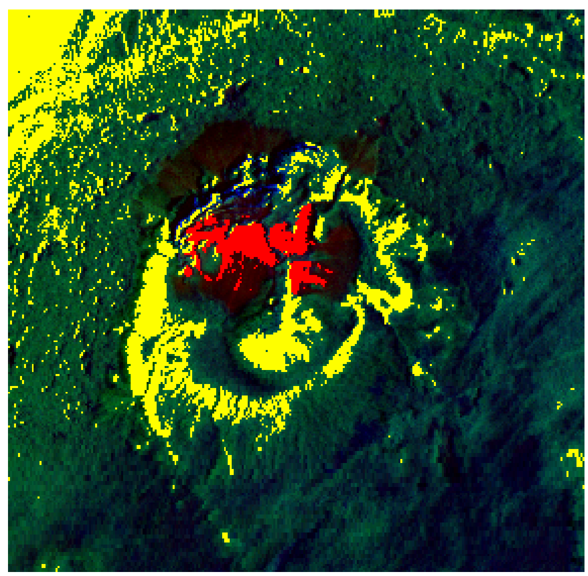



**Figure 3.** Enlargement of Fig. 2b centered on Pavant Butte. Thresholds have been applied to the fraction image so that high fractions of palagonite tuff are in red and high fractions of poorly palagonitized tuff and ash are in yellow. The best exposures of the poorly palagonitized ash are in the flanks of the tuff cones base and in the valley floor to the northwest.