REMOTELY SENSED SIGNATURES OF HYDROVOLCANISM: EXAMPLES FROM THE EARTH AND PRELIMINARY RESULTS FROM MARS. W.H. Farrand[1], [1]Space Science Institute, 3100 Marine St., #A353, Boulder, CO 80303, (farrand@colorado.edu).

Introduction: Maars, tuff rings, tuff cones, table mountains, and pseudocraters; these are all topographic features formed by hydrovolcanic activity. Hydrovolcanic activity can be described as explosions or eruptions that result from the interaction of magma or magmatic heat with surface or near surface water [1]. Because of the ubiquitous presence of water on the Earth, hydrovolcanism is common here. The expectation that water has been abundant on Mars suggests that hydrovolcanism could have been common there as well. Indeed, several landforms on Mars have been theorized to have hydrovolcanic origins [2,3,4]. Hydrovolcanic features are important for two primary reasons: (1) as evidence of past or present environments with surface or near surface water or ice; and (2) because of the frequent association of mantle nodules with maar ejecta. Given the importance of these features, it is reasonable to consider whether there are diagnostic compositional aspects of hydrovolcanic ejecta which could be determined from remote sensing. If there are such compositional signatures, their identification in remotely sensed data would bolster some of the interpretations that have been made thus far from geomorphic evidence. Also, positive identification of these features would make them prime candidates for sample return missions on account of their association with water and/or for the possible presence of mantle xenoliths. In this paper, terrestrial hydrovolcanic landforms and processes will be reviewed, remotely determinable compostional and topographic features will be presented, and preliminary results from the Mars Global Surveyor will be shown.

Hydrovolcanism: Environments where hydrovolcanic activity can occur include: deep submarine, littoral, lacustrine, phreatic and subglacial. With the possible presence of past lakes and oceans on Mars, all of these environments could have hosted hydrovolcanic activity at some point in the Martian past. Examples of submarine hydrovolcanism on Earth are pillow basalts formed at mid-ocean ridge spreading centers. Tuff cones have been associated with littoral and lacustrine hydrovolcanism. Phreatomagmatic eruptions form maars and tuff rings. Subglacial activity can also form pillow basalts as well as massive palagonite breccia deposits and table mountains [5].

There is a continuum of hydrovolcanic landforms. The cause of which type of edifice is formed is dictated by the availability of water. In the order of increasing availability of water (increasing water/magma) ratio this continuum is maars to tuff rings to tuff cones. With complete immersion, pillow lavas are formed.

VNIR and TIR Spectra of Hydrovolcanic Tuffs: Changes in the chemical signature of samples from tuff rings and tuff cones have been observed [1] as have spectral differences [6]. Figure 1 shows typical reflectance spectra of tuffs from a tuff ring and from a tuff cone. The main differences between the two are caused by an increased level of palagonitization in tuff cone deposits. This results in a steeper UV-Vis slope, a “1 μm” band more representative of Fe^{3+} than Fe^{2+}, and deeper water absorption features at 1.4 and 1.9 μm. The emissivity spectra of palagonites have been described as flat and featureless [7]. The palagonite tuff emissivity spectra (of samples from the Koko Crater and Cerro Colorado tuff cones) display some features although it is very likely that they are due to embedded country rock clasts.

Other Types of Remotely Observed Signatures of Hydrovolcanism: Topographic profiles of tuff rings and tuff cones are distinct from those of impact craters although those of maar craters are similar to impact craters [8]. Preliminary results from MOLA [8] have not identified hydrovolcanic craters, but further analysis of the data may identify such features.

While orbital imaging radar systems are not currently planned, such instruments could also play a role in identifying hydrovolcanic tephra blankets. Tuff cone eruptions are more effusive than maar and tuff ring eruptions. Consequently, the latter have a higher percentage of coarse blocks in their ejecta which could be detetectable by a higher radar cross section [9]. Likewise, thermal inertia anomalies might be used in conjunction with other data to help identify hydrovolcanic tephra deposits [9].

Possible Hydrovolcanic Features on Mars: Traditional photogeologic approaches have been used to identify some possible hydrovolcanic features (e.g., craters on recent lava flows observed by the Mars Global Surveyor MOC have been hypothesized as being pseudocraters [2]). However, an example of the detection of possible hydrovolcanic products by their spectral signature was provided by the conjecture in [3] that the interior layered deposits in the Valles Marineris could have resulted from hydrovolcanic activity. The identification of tuff cones has also been suggested as potential evidence for the existence of northern hemisphere ocean [4]. MOLA profiles, MOC images and TES spectra will be presented at the meeting.

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References: [1] Sheridan and Wohletz, 1983, *J.Volc.Geoth.Res.*, 17,1-29. [2] McEwen et al., 1999, [3] Murchie et al., 1991, *LPS XXII*, 945-946. [4] Parker and Banerdt, 1999, *5th Int.Conf. Mars*, (CD-ROM). [5] Walker and Blake, 1966, *Q.J.Geol.Soc. London*, 122, 45-61. [6] Farrand and Singer, 1992, *JGR*, 97,17393-17408. [7] Crisp and Bartholomew, 1989, *LPS XX*, 201-202. [8] Garvin and Sakimoto, 1999, *LPS XXX*, (CD-ROM), [9] McGetchin and Ullrich, 1973, JGR, 78, 1833-1853.

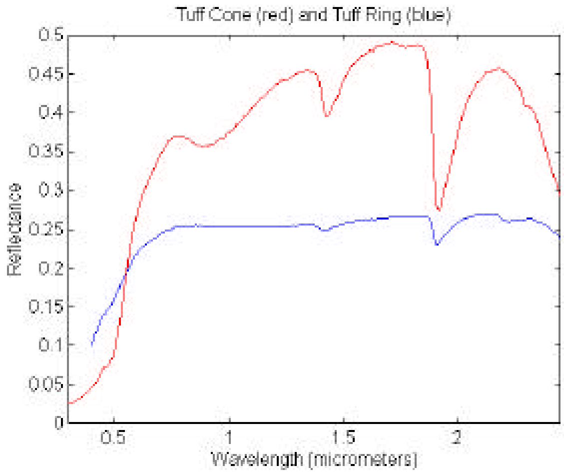

Figure 1. Vis – SWIR reflectance of tuff cone and tuff ring tephra.

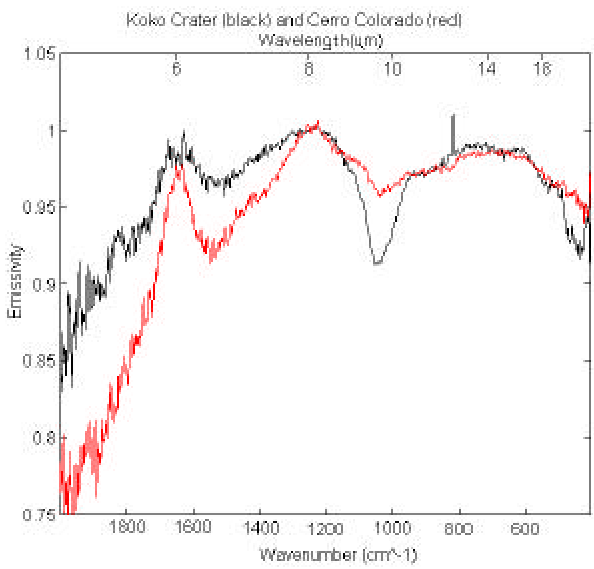

Figure 2. TIR emissivity of palagonite tuffs.