

GLOBAL CHEMICAL ABUNDANCES AND DISTRIBUTIONS ON MARS FROM MGS-TES SPECTRA.

M. B. Wyatt¹, H. Y. McSween, Jr.², J. L. Bandfield¹, and P. R. Christensen¹ ¹Department of Geological Sciences, Arizona State University, Tempe, AZ, 85287-6305 (michael.wyatt@asu.edu), ²Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN, 37996-1410.

Introduction: We report initial Mars Global Surveyor (MGS) Thermal Emission Spectrometer (TES) derived major oxide abundance maps (4 pixels/degree or 15 km/pixel) of low-albedo surface materials and examine chemical variation diagrams to better understand the relative roles of igneous and sedimentary processes on Mars. Petrologic interpretations of TES mineral-phase and major oxide abundances constrain the bulk composition of the martian surface and provide insight to the degree of differentiation of the crust and mantle and nature of surface-atmosphere interactions [e.g. 1-5]. TES oxide abundance maps will also serve for comparison to 2001 Mars Odyssey (MO) Gamma Ray Spectrometer (GRS) derived element abundance maps (.1 pixels/degree or 600 km/pixel).

Background: *Hamilton and Christensen* [6] demonstrated that chemical compositions of laboratory-analyzed rocks can be accurately calculated from deconvolved modal mineralogies (vol. %) by combining the compositions of the spectral end-members (wt. % oxides) in proportion to their relative modeled abundances. *Wyatt et al.* [7] further quantified the uncertainties in derived chemical compositions and demonstrated their use in correctly classifying volcanic rocks. The one- σ standard deviations of the absolute differences between measured and modeled major oxide abundances (SiO₂, Na₂O, K₂O, CaO, MgO, FeO, Al₂O₃) range from 0.4 to 2.6 wt % [7]. *Hamilton et al.* [8] convolved laboratory spectral data (2cm⁻¹ spectral sampling) of volcanic rocks from *Wyatt et al.* [7] to the lowest spectral resolution of the TES instrument (10cm⁻¹ spectral sampling) and showed that derived bulk rock chemistries were not significantly degraded. These results demonstrate the feasibility of using similar techniques and terrestrial classification schemes for TES spectral resolution data. Derived chemical abundances from thermal emission spectra are thus a recasting of rock compositions into a form which complements modeled mineral abundances.

McSween et al. [5] derived chemical compositions of TES Surface Type 1 (ST1) and Type 2 (ST2) global spectral endmembers [2] from previously modeled mineral abundances [2-3,8] and calculated new chemistries over an extended spectral range. The chemistries from different endmember sets were shown to be very similar and used to suggest two formation mechanism hypotheses for ST1 and ST2 materials: 1)

Andesitic ST2 formed by hydrous melting and fractional crystallization of a ST1 basaltic andesite parent magma 2) Partly altered basalt ST2 formed by limited chemical weathering of a ST1 basalt.

Data: TES emissivity spectra are binned and averaged at 4 pixels/degree (15 km/pixel) and linearly deconvolved from 1301-825 cm⁻¹ and 508-233 cm⁻¹ using a spectral end-member set that includes a broad range of igneous and sedimentary minerals, martian atmospheric dust and water ice, and epf derived martian surface dust [4]. Mineral abundances (vol. %) of low-albedo surfaces are converted to oxide abundances (wt. %) using the methods described by [6,7]. The derived compositions are calculated on both a H₂O-free and CO₂-free normalized basis and without normalization. The normalization has the effect of increasing other oxide components, especially silica contents, in deconvolution results that contain more hydrous minerals. Data are limited to spectra of surface temperatures >250K, dust extinctions of < 0.18, water ice extinctions of < 0.1, and emission angles < 30°.

Global TES Chemistry: Figure 1 shows an example of the mapped abundances and distributions of TES derived SiO₂ and CaO of low-albedo surfaces calculated on a H₂O-free and CO₂-free normalized basis with a global context image made from MGS Mars Orbiter Camera (MOC) and Mars Orbiter Laser Altimeter (MOLA) data. Near-equatorial regions are enriched in CaO while mid- to high-latitude regions are enriched in SiO₂. The CaO trend reflects higher modeled abundances of clinopyroxene which characterize Syrtis Major and surrounding ST1 materials [1]. The SiO₂ trend reflects higher modeled abundances of silica glass (volcanic and/or sedimentary coatings) and possible alteration phases characteristic to ST2 materials [e.g. 2,3,9-11]. MgO and FeO are similar to CaO and enriched in Syrtis Major and near-equatorial regions while Al₂O₃ is similar to SiO₂ and enriched in mid- to high- latitudes. Na₂O dominates the southern highlands while K₂O does not appear to reflect any global trends.

Figure 2 shows the total alkalis (Na₂O+K₂O) versus SiO₂ classification scheme for volcanic rocks [12] with a contour data cluster of derived global chemistries with red points representing the highest concentrations and blue points the lowest. Assuming unaltered volcanic compositions, the highest density of

points plots within the field of basaltic andesite. It was noted by [5] that ST2 compositions not recalculated as H₂O-free plot within the basaltic andesite field closer to the ST1 compositions. Derived chemistries from this study show a trend similar to ST1 and ST2 chemistries from [5], but suggest more of a continuum of compositions existing between the global spectral endmembers.

A FeO/MgO vs SiO₂ variation diagram, which delineates tholeiitic and calc-alkaline magmatic trends [13], shows data clustered where [5] proposed ST1 and ST2 endmember compositions are similar to those found in terrestrial subduction zones and could have formed by extensive melting of hydrated mantle rocks with accompanying hydrous fractionation. This petrogenesis challenges our understanding of anorogenic magmatism, and suggests a much wetter ancient martian mantle. A Mg/Si vs Al/Si variation diagram, which distinguishes terrestrial and martian igneous rocks and the effects of alteration processes [14], shows data clustered off the trend defined by martian ultramafic and basaltic rocks. This result is similar to ST1 and ST2 compositions from [5] who suggested the positions of surface compositions and slope of the trend resemble chemically weathered basalts, not martian igneous rocks.

Summary: The different interpretations of TES surface lithologies have profound significance for understanding the petrogenesis of the martian crust and its subsequent alteration. Results that will be presented include global maps of TES derived oxide abundances as well as global maps of chemical variation trends to address the geologic context of martian surface compositions.

References: [1] Christensen P. R. et al. (2000) *JGR*, 105, 9609-9621. [2] Bandfield J. L. et al. (2000) *Science*, 287, 1626-1630. [3] Wyatt M. B. and McSween H. Y., Jr. (2002) *Nature*, 417, 263-266. [4] Bandfield J. L. (2002) *JGR*, 107 (E6), 10.1029/2001JE00151. [5] McSween H. Y., Jr., et al. (2003) *JGR*, 108 (E12), 10.1029/2003JE002175. [6] Hamilton V. E. and Christensen P. R. (2000) *JGR*, 105, 9717-9733. [7] Wyatt et al. (2001) *JGR*, 106, 14711-14732. [8] Hamilton et al. (2001) *JGR*, 106, 14733-14746. [9] Morris R. V. et al. (2003) 6th Int. Conf. Mars, Abstract # 3111. [10] Kraft M. D. et al. (2003) *GRL*, 30, 10.1029/2003GL018848. [11] Ruff S. W. (2003) 6th Int. Conf. Mars, Abstract # 3258. [12] Le Bas et al. (1986) *J. Petrol.*, 27, 745-750. [13] Miyashiro A. (1974) *Am. J. Sci.*, 274, 321-355. [14] Rieder et al. (1997) *Science*, 278, 1771-1774.

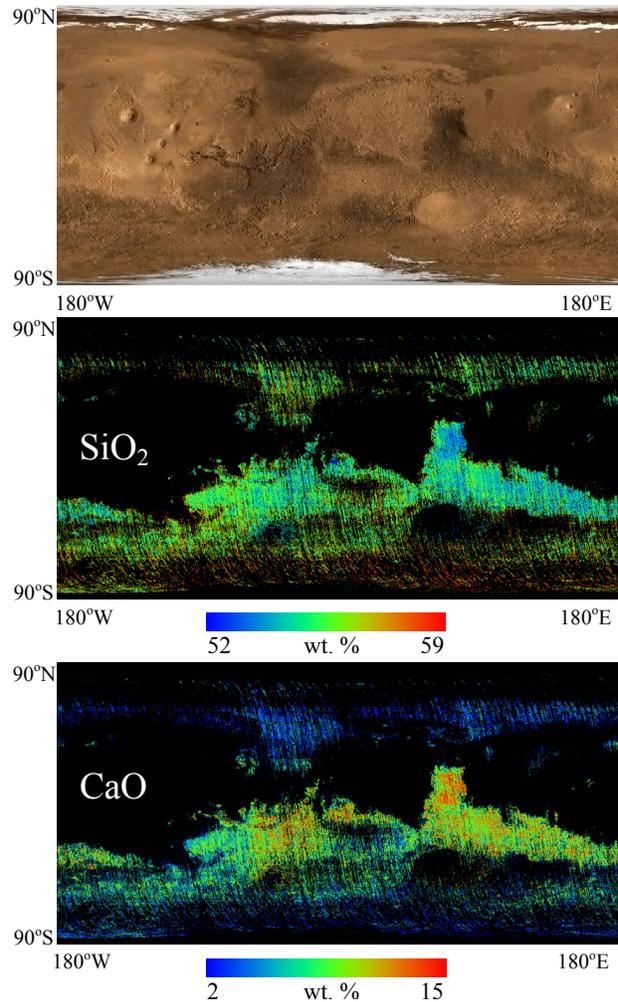


Figure 1: TES derived SiO₂ and CaO of low-albedo surfaces and a global context image made from MGS MOC and MOLA data. High-albedo surfaces are shown as black in TES maps.

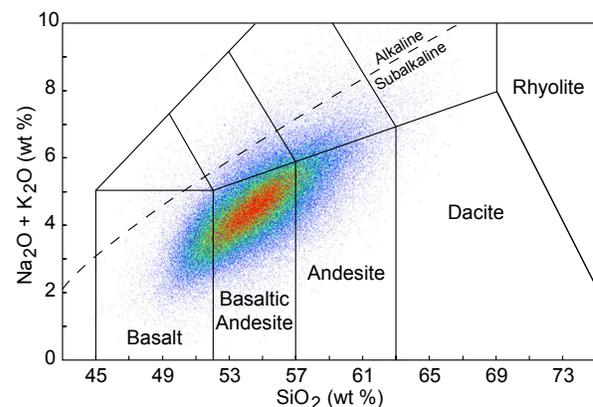


Figure 2: Volcanic rock classification scheme with contour data cluster of global TES derived chemistries. The highest density of compositions plot within the field of basaltic andesite.