CHEMICAL WEATHERING TRENDS FROM TIR SPECTRAL MODELS: IMPLICATIONS FOR DERIVING WEATHERING TRENDS FROM MARTIAN SPECTRAL DATA. E. B. Rampe[1], M. D. Kraft[1], and T. G. Sharp[1], [1]Arizona State University School of Earth and Space Exploration (P.O. Box 871404, Tempe, AZ 85287, Liz.Rampe@asu.edu).

Introduction: Chemical weathering and petrologic trends of the martian surface have been estimated from thermal infrared (TIR) spectral models from the Thermal Emission Spectrometer (TES) and Mini-TES on the Spirit and Opportunity rovers [1,2]. Interpretations of chemical data from APXS on the MER rovers and TIR data from TES and the Thermal Emission Imaging System (THEMIS) suggest planet-wide acidic chemical weathering with low water-to-rock ratios, causing the dissolution of olivine and the precipitation of Fe-oxides, Fe-sulfates, and amorphous silica [1,3]. TIR analysis of terrestrial chemically weathered basalts show that chemical weathering causes surface coatings that result in non-linear spectral mixing of rock and coating components [4-6]. If spectral modeling of weathered rocks produces inaccurate mineral models, bulk chemistry derived from those spectral models will also be inaccurate.

The effects of chemical weathering on TIR spectral model-derived chemical trends are not well known. The chemical weathering trends in weathered basalts from Baynton, Australia have been well characterized [7,8]. We have collected weathered basalts from the Baynton region, and, here, we compare our spectral model-derived chemical weathering trends to measured chemical weathering trends. The goal of this study is to understand how chemical weathering affects TIR spectral model-derived chemistry and if accurate chemical weathering trends can be derived from TIR spectral models.

Methods: Weathered basalt samples from Baynton, Australia were cut perpendicular to the weathering rind. TIR spectra of the weathered surfaces and the interiors were measured at the Mars Space Flight Facility at ASU, using a Nicolet Nexus spectrometer configured to measured emitted energy [9]. We modeled the TIR spectra using linear deconvolution [10] with two slightly different spectral libraries containing end-members common in weathered basalt: Library 1 is commonly used to model TES spectra [11]. Library 2 has more clay mineral end-members than Library 1, including kaolinite, halloysite, nontronite, and chlorite. Mineral abundances derived from these models were used to calculate chemical compositions according to the procedure in [12]. The model-derived chemical compositions were compared those measured by Nesbitt and Wilson (1992) [8] to assess the accuracy of the model-derived chemistries. We assume the chemical weathering trends measured by Nesbitt and Wilson (1992) [8] are similar to those in our samples.

Results: The bulk chemistry derived from TIR spectral models using Library 2 is closer to the bulk chemistry measured by Nesbitt and Wilson than bulk chemistry derived from models using Library 1 (Figures 1 and 2). The Baynton rocks contain kaolinite-group minerals, and the occurrence of these end-members in Library 2 and their absence in Library 1 account for this difference in model-derived chemistry. The kaolinite-group end-members in Library 2 also improve some TIR model-derived weathering trends. Model-derived weathering trends using Library 1 show an erroneous enrichment in K_2O because illite, rather than kaolinite, is selected in spectral models using Library 1 (Fig. 1). Conversely, similar, but inaccurate enrichment in FeO_T (Fig. 2) occur in both models because spectral models overestimate the hematite content of the weathered surfaces.

Discussion: Bulk chemistry derived from TIR spectral models of weathered and unweathered basalt surfaces show distinct chemical trends: (1) enrichment in Al_2O_3 and FeO_T from greater illite, kaolinite, and hematite abundances in spectral models of the weathered surface vs. the interiors; and (2) depletion in alkali and alkaline earth metals from a decrease in modeled plagioclase and pyroxene abundances. The presence of these trends demonstrates that TIR spectral data can be used to identify chemically weathered surfaces. However, the chemical weathering trends derived from TIR spectral models are only as accurate as the mineralogical models they are based on. This can be especially problematic for chemical weathering if the spectral library does not include the correct secondary minerals. Similarly, the assumption of linear mixing, used in modeling TIR spectra, may be inappropriate for rocks with weathering rinds or surface coatings. When deriving chemical weathering trends from TIR spectral data from Mars, it is important to use as many constraints as possible to determine the mineralogy of a surface (such as APXS and Mossbauer) so that one can create the most appropriate end-member library. However, non-linear mixing might make determining true chemical weathering trends from TIR spectral models impractical.
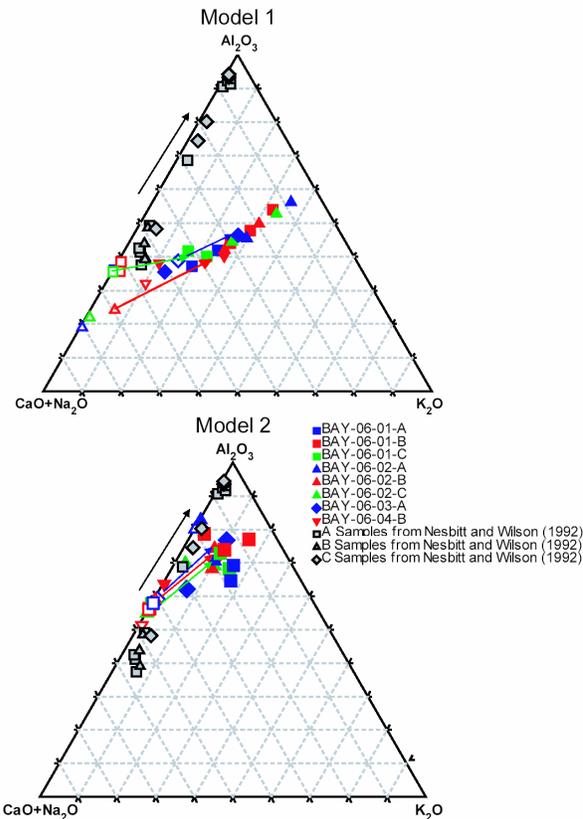
Figure 1. Grey points correspond to bulk chemistry of Baynton basalts measured by Nesbitt and Wilson (1992) [8] and the black arrow shows the chemical weathering trend. Open colored points correspond to TIR model-derived chemistry of interior (unweathered) surfaces and closed colored points correspond to TIR model-derived chemistry of exterior (weathered) surfaces. Colored arrows correspond to weathering trends of samples BAY-06-01-C, BAY-06-02-B, and BAY-06-03-A in green, red, and blue, respectively. The upper ternary diagram contains model-derived chemistry from Library 1 and the lower fro m Library 2. Note the improved model-derived chemical weathering trends with the use of Library 2 because of the presence of kaolinite-group end-members.
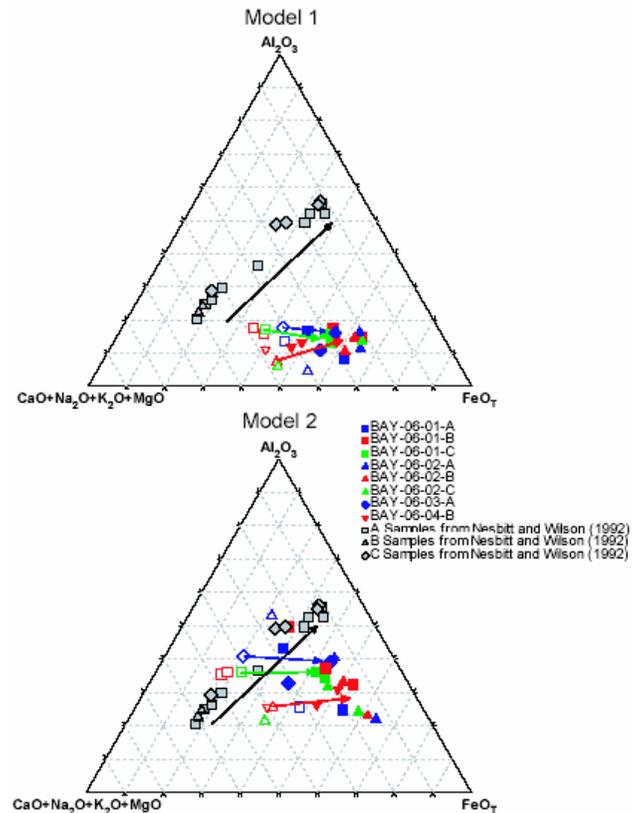
Figure 2. The points and arrows correspond to the same samples and models as in Figure 1. Note that the TIR model-derived bulk chemistry from Library 2 is in a similar region of the ternary diagram as the chemistry measured by Nesbitt and Wilson (1992) [8], but the chemical weathering trends (arrows) are similar for both libraries because both suggest a large increase in hematite concentration in weathered surfaces.

References: [1] Hurowitz J. A. et al. and McLennan S. M. (2007) *EPSL, 260,* 432-443. [2] Usui T. et al. (2008) *JGR, 113,* E12S44. [3] Bandfield J. L. and Rogers A. D. (2008) *Geology, 36*, 579-582. [4] Kraft M. D. et al. (2003) *GRL,* 30, DOI 10.1029/2003GL018848. [5] Michalski, J. R. et al. (2006) *EPSL*, *248*, 822-829. [6] Rampe E. B. et al. (2007) *7th Int. Conf. Mars*, Abstract 3242. [7] Eggleton R. A. et al. (1987) *Clays and Clay Mins.*, *35*, 161-169. [8] Nesbitt H. W. and Wilson R. E. (1992) *Am. J. Sci.*, *292*, 740-777. [9] Ruff S. W. et al. (1997) *JGR*, *102*, 14,899-14,913. [10] Ramsey M. S. and Christensen P. R. (1998) *JGR*, *103*, 577-592. [11] Rogers A. D. and Christensen P. R. (2007) *JGR*, *112*, E01003. [12] Wyatt M. B. et al. (2001) *JGR*, *106*, 14,711-14,732.