

tively bright region) [Smith *et al.*, 1997; McSween *et al.*, 1999]. In fact, recent refinements of the APXS data acquired by Mars Pathfinder south of Acidalia Planitia indicate a silica content of ~58 wt % for soil-free rock [Foley *et al.*, 2000], which is equivalent to a low-silica andesite. Thermal infrared (~8–18  $\mu\text{m}$ ) telescopic spectra of Acidalia Planitia analyzed by Moersch *et al.* [1997] were found to be comparable to a glassy terrestrial basalt; however, the description of the terrestrial sample as “basalt” was based on petrographic analysis not sample chemistry, and thus the term may not accurately reflect the true composition of the sample, which could be more silicic (J. Moersch, personal communication, 2001).

Our work further refines the interpretations of Bandfield *et al.* [2000a] and Christensen *et al.* [2000a], which indicate the presence of basaltic and andesitic materials in Martian dark regions. The goodness of our model fits to the two TES spectra indicates that no major components are missing in our spectral library. Current interpretations of the mineralogies represented by TES data are less consistent with some of the studies above and more consistent with others. TES-derived mineralogies for both surface types do not include low-calcium pyroxenes (orthopyroxene and/or pigeonite) at abundances above the current detectability limit for large regional averages [Bandfield *et al.*, 2000a; Christensen *et al.*, 2000a; this work]. However, small amounts of low-Ca pyroxenes were included in our best fit model of the surface type 1 spectrum and in the fit of Bandfield *et al.* [2000a] (8 and 5 vol %, respectively), hinting that such a component might be real, perhaps in the form of smaller local enrichments rather than as a ubiquitous component in the regional average. Additional work with individual spectra in smaller regions may provide greater confidence in the presence of this phase. Previous data also suggest that Martian surfaces may be dark and altered [Calvin, 1998]; TES-derived mineralogies include small amounts (~5–15 vol %) of sheet silicates [Bandfield *et al.*, 2000a; Christensen *et al.*, 2000a; this work]. These abundances are also at or below current detectability limits, but as in the case of low-Ca pyroxene, further studies may be able to place better constraints on the possible presence of these phases. Telescopic and in situ analyses of intermediate to dark regions in the northern hemisphere are suggestive of lesser amounts of pyroxene and more silicic (or glassy) compositions that are consistent with TES-derived mineralogies for surface type 2. In fact, the most current estimate of the silica and alkali content of the soil-free rock at the Mars Pathfinder landing site ( $\text{SiO}_2 = \sim 57.8$  wt % and  $\text{Na}_2\text{O} + \text{K}_2\text{O} = 3.7$  wt %) [Foley *et al.*, 2000] is quite close to the composition derived in the present work ( $\text{SiO}_2 = 58.2$  wt % and  $\text{Na}_2\text{O} + \text{K}_2\text{O} = 4.1$  wt %). Merényi *et al.* [1996] observed that compositional differences in their data generally corresponded to the global crustal dichotomy of Mars, an observation similar to one previously made for the two TES surface types [Bandfield *et al.*, 2000a]. The mineralogies derived from TES data thus reflect a continuum that spans many of the previously suggested compositions for Martian dark regions. Further work with smaller averages or individual spectra will surely shed light on the more subtle local variations in composition and may identify regions where some of the minerals subdued in the regionally averaged spectra are present in greater abundances.

## 6. Conclusions

1. Convolution of terrestrial laboratory data to the lowest spectral resolution of the TES instrument does not produce

significantly degraded deconvolution results: modeled spectra provide similarly good matches to the measured spectra, modal mineralogies obtained at low ( $10\text{ cm}^{-1}$ ) spectral sampling typically do not differ significantly from those obtained at high ( $2\text{ cm}^{-1}$ ) spectral sampling, and bulk chemistries derived from data at reduced spectral sampling are virtually identical to those obtained from data at high spectral sampling. These results demonstrate the feasibility of using similar techniques and classification schemes for the interpretation of terrestrial laboratory samples and TES-resolution data.

2. Two distinctly different TES Martian surface spectra [Bandfield *et al.*, 2000a] lie within spectral envelopes that distinguish basaltic and andesitic compositions [Wyatt *et al.*, this issue], further supporting previous results indicating that these spectra represent surfaces with different mineralogies and chemistries.

3. A limited end-member set tailored to the identification of volcanic igneous rocks provides deconvolution results (modal mineralogies) for Martian spectra that are comparable to those obtained with the larger end-member sets of Christensen *et al.* [2000a] and Bandfield *et al.* [2000a]. Therefore an iterative approach to deconvolution, starting with a large set of varied end-members and working down to a smaller set of end-members that exploits solid solution variability, is justifiable.

4. The two primary Martian surface types of Bandfield *et al.* [2000a] are easily distinguished and classified here by their modal mineralogy as basaltic (surface type 1) and andesitic (surface type 2). Local-scale variations in the composition of the Martian surface were not examined but should also be distinguishable and classifiable if the variations are greater than our uncertainties. The spectra are also easily distinguished, although one (surface type 2) is not as easily classified, by their normative plagioclase composition and color index. These results are consistent with results obtained for terrestrial rock samples [Wyatt *et al.*, this issue] and suggest that the plagioclase composition versus color index classification scheme should not be considered as strongly as other schemes when classifying high-silica samples. (High-silica samples can be identified by other means, such as their spectral shape and derived mineralogy.)

5. Bulk chemistries derived from our deconvolution of Martian surface spectra classify the two surface types as basaltic andesite and andesite, in general agreement with the results of previous works [Christensen *et al.*, 2000a; Bandfield *et al.*, 2000a].

6. In summary, the surface type 1 Martian spectrum is classified as basalt in three out of four classification schemes (the bulk chemistry scheme indicates a composition of basaltic andesite for surface type 1); we believe that this spectrum most likely represents a high-silica basaltic composition. The surface type 2 Martian spectrum is classified as andesite in three out of four classification schemes. This spectrum's mineral chemistry (color index versus plagioclase composition) plots outside the fields defined by terrestrial igneous rocks. However, this scheme is less reliable than the others in classifying deconvolved silica-rich samples [Wyatt *et al.*, this issue]; therefore we believe that this spectrum is most consistent with an andesitic composition. These compositional refinements are in agreement with previously published results [Bandfield *et al.*, 2000a; Christensen *et al.*, 2000a].

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