mate weathering and alteration phases on the determination of bulk mineralogy, chemistry, and classification. Also, the addition of data in the 400–200 cm^{-1} (25–50 μm) region will allow for a more accurate analogy to TES data and potentially will provide even better results.

5. Comparison to Martian Meteorite Compositions and Previous Results

The TES-based mineralogical results presented here and elsewhere [*Bandfield et al*., 2000a; *Christensen et al*., 2000a] indicate that the majority of Martian dark regions are broadly characterized by surface materials that are basaltic and andesitic in character. These results do not attempt to address local-scale variations in composition and thus do not preclude the existence of such variations. These spectra do not match known Martian meteorite spectra, are consistent with some interpretations of previously acquired data from various instruments, and are inconsistent with other previous interpretations. When considering such comparisons, it is also important to remember that different techniques are sensitive to different characteristics of the Martian surface and do not provide the same types of mineralogical information; thus some discrepancies are likely and are not necessarily problematic.

5.1. Comparison to Martian Meteorite Compositions

Martian (or shergottites, nakhlites, and chassigny (SNC)) meteorites represent lithologies ranging from basalt or lherzolite (shergottites) to clinopyroxenite (nakhlites), orthopyroxenite (ALH84001), and dunite (Chassigny). Meteorites from and within each class have clearly distinguishable thermal infrared emission spectra [*Hamilton et al*., 1997; V. E. Hamilton, unpublished data, 2001]. The two primary surface spectral types measured by TES are not similar in shape to emission spectra of any of the Martian meteorites [*Bandfield et al*., 2000a; *Christensen et al*., 2000a], and the mineralogies derived from the TES spectra are not very similar to those of the Martian meteorites (summarized by *Meyer* [1998] and numerous references therein) despite the fact that surface type 1 is basaltic (as are most shergottites). We believe that this result is entirely consistent with what is known about Martian meteorites, as there are several reasons why the meteorites and their spectra should not necessarily be observed in wide distribution on the surface of Mars. First, the plutonic/cumulate nature of many of the meteorites suggests that their source regions may be at some modest depth below the surface and may not be visible at the uppermost surface, regardless of location and dust cover (see below). Second, clustering of cosmic ray exposure data suggests that a small number of craters may be responsible for all 14 Martian meteorites. The nakhlites and Chassigny share one ejection age, and the shergottites may exhibit two to three (and possibly as few as one) ejection ages on an area representing only ~15% of the Martian volcanic surface area [*Nyquist et al*., 1998, and references therein; *Treiman*, 1995]. Therefore all of the Martian meteorites may represent as few as three ejection events (ALH84001, the nakhlites and Chassigny, and then the shergottites) if the shergottites were all ejected simultaneously [*Nyquist et al*., 1998]. Furthermore, the likelihood of these ejection sites being clearly visible at large areal scales is decreasing as dynamical considerations of cratering events are revised. Work by *Gladman* [1997] and *Head and Melosh* [2000] has reduced the minimum crater diameter of the Martian meteorite parent craters to 3 km, which is coincident with the approximate spatial resolution of the TES instrument and below the resolution of most previous orbital instruments and telescopes (none of which have conclusively identified Martian meteorites or their source regions on Mars). On the basis of the above reasons it is not clear how representative of the uppermost Martian surface these meteorites really are, and we probably should not assume or expect that they are ubiquitous on the surface of the planet.

The TES instrument has clearly and convincingly demonstrated its ability to measure silicate and oxide minerals on the surface of Mars [*Bandfield et al*., 2000a; *Christensen et al*., 2000a, 2000b]. Because the spectra of the meteorites do not match the regional average spectra of the Martian surface [*Bandfield et al*., 2000a; *Christensen et al*., 2000a] it is reasonable to conclude that if Martian meteorite lithologies are presently exposed at the surface, they may be either limited in their areal extent or could be covered by dust. This conclusion differs from those of some previous studies [*Singer and McSween*, 1993; *Mustard et al*., 1997] that suggested basaltic shergottites might be common on the Martian surface on the basis of visible and near-infrared (VNIR) spectra. Martian meteorites (with the exception of ALH84001) represent relatively young rocks. Geologic mapping suggests that most of the youngest rocks on Mars are in the Tharsis region [*Scott and Tanaka*, 1986]; visible images, radar, and thermal inertia data clearly demonstrate that Tharsis is among the dustiest regions on the planet as summarized by *Simpson et al*. [1992] and *Christensen and Moore* [1992]. If the meteorites' parent craters and/or units are located in Tharsis, they are quite probably covered by a thick mantle of dust that will be impenetrable to all remote-sensing instruments. In fact, many bedrock units on the surface of Mars, including the source units of the Martian meteorites, may be covered by areally extensive layers of subsequently deposited materials (e.g., dust, duricrust, or basaltic and andesitic sands) that prevent identification of bedrock lithologies. Despite all of these reasons that may help to explain why the Martian meteorites' source regions have not yet been located, TES data are still being searched for the locations of the parent regions, and local variability may provide clues to the source regions of these meteorites [e.g., *Hamilton et al*., 2001].

5.2. Comparison to Previous Remote Sensing Results

Previous remotely acquired measurements have led to a variety of interpretations of the mineralogic composition of Martian dark regions. Visible and near-infrared spectroscopic data of some dark regions are characterized by ~1 and 2 μm absorptions that are commonly attributed primarily to the presence of ferrous (Fe^{2+}) iron in the form of pyroxene and hematite (both nanophase and crystalline) [e.g., *Adams and McCord*, 1969; *Singer et al*., 1979; *Morris et al*., 1989; *Mustard et al*., 1993]. On the basis of the observation of such features, spectral signatures in Phobos-2 ISM spectra of Syrtis Major have been interpreted to represent two-pyroxene basalts similar to SNC meteorites [*Mustard and Sunshine*, 1995]. *Calvin* [1998] suggested a different perspective that attributes the observed signatures in dark regions to lesser amounts of pyroxene plus dark altered minerals that are more consistent with the observation of a 3 μm water band in intermediate- to low-albedo regions. Telescopic spectra of Acidalia Planitia by *Merényi et al*. [1996] do not exhibit a 1 μm pyroxene band (consistent with the presence of high-Ca pyroxene, olivine, mafic glass, or coatings) nor do 12 point spectra acquired by the Imager for Mars Pathfinder (which was located in a rela-