THE MISCONCEPTION OF A MARS GLOBAL SOIL. S. W. Ruff[1], A. D. Rogers[2], V. E. Hamilton[3], and M. D. Kraft[1], [1]Arizona State University, School of Earth and Space Exploration, Tempe, AZ, steve.ruff@asu.edu, [2]Stony Brook University, Stony Brook, NY, [3]Southwest Research Institute, Boulder, CO.

Introduction: Recent results from the Curiosity rover's investigation of the Rocknest sand shadow have reinvigorated the question of whether soils (surface fines) on Mars are globally mixed or locally derived from chemically similar source materials [1]. Beginning with the chemically similar results from soil sampled at the widely separated Viking 1 and 2 landing sites, the idea arose that such material might be "thoroughly homogenized on a planetary scale" presumably by aeolian processes [2]. Pathfinder results, which for the first time included chemistry of rocks, allowed for the possibility that the soil is an admixture of local and globally-derived components delivered by the wind [3]. Results from Spirit and Opportunity appeared to demonstrate that soil at both sites are the products of wind redistribution rather than local origin [4].

The concept of globally homogenized dust, the finest fraction of the Martian regolith that can be suspended in the atmosphere over long periods and distances, is well established and entirely plausible. Thermal infrared (TIR) spectra measured in orbit and from the surface clearly demonstrate the mineralogical uniformity of this globally distributed material [4; 5]. Globally encircling dust storms represent a documented means for moving dust particles (<10 µm in size) around the planet. This material accumulates in continent-scale deposits recognized by their high albedo and low thermal inertia in places like Tharsis Montes, Arabia Terra, and Elysium Planitia [6]. Incorporation of atmospheric dust into Martian soil is a natural consequence of its fallout onto all surfaces around the globe. But the same has not been demonstrated for the coarser fraction of soil that is not capable of atmospheric suspension. Here we present mineralogical evidence and orbital elemental data that do not support the notion of a globally homogenized soil.

Orbital Measurements: The Mars Global Surveyor Thermal Emission Spectrometer (TES) measured spectral radiance between ~6-50 µm with a nominal spatial footprint of ~3x8 km [7]. Within this wavelength region, nearly all minerals are strongly absorbing and thus the measured spectra are sensitive to variations in bulk composition. TES-derived thermal inertia values [7] indicate that, for most low-dust surfaces, the TES field of view is dominated by radiance from sand-sized particles, rather than rocks. Global distributions of mineral assemblages derived from classification of TES mineral abundances [8; 9] show spatial variability that corresponds with distinct, broad terrains (Fig. 1). In many regions, clear spatial transitions in mineral assemblage are apparent. For example, the southern extent of Syrtis Major lavas corresponds with a transition in pyroxene composition and abundance. The spatial correspondence with geomorphology suggests that the compositional variations observed from orbit are real, and controlled to a significant degree by underlying rock compositions [8; 9]. Most importantly, it demonstrates that global homogenization of soil compositions has not occurred.

The magnitude of these regional differences is an important part of the discussion on global soil. Globally, the standard deviation on abundance for each mineral group ranges from ~4-7% about the mean [9]. An example of two regions with large differences is central Syrtis Major (class 3) and Acidalia Planitia (Class 1), which differ in high-Ca pyroxene and high-silica phase abundance by as much as 10-15%. Differences between mineral assemblage classes found in the Noachian-aged portions of the highlands (e.g. classes 5 and 6) are less extreme, with mean mineral abundance differences varying by a maximum of 4-5% in a single mineral group. The modeled mineralogical compositions from these regions can be converted to chemical compositions by multiplying the known chemical compositions of the spectral end-members by their modeled abundances (converted to weight percent) [10]. In doing this, it can be seen that some of the major oxides (FeO, MgO, CaO, Al_2O) differ by ~2-3 wt% for Syrtis Major and Acidalia, but by <1 wt% for mineral assemblage classes found in the Noachian-aged portions of the highlands (classes 5 and 6). Thus, chemical abundances of dark soils may be similar, but the mineralogical composition can differ significantly.

The Mars Odyssey Gamma Ray Spectrometer (GRS) provides a complementary view of global spatial variability in surface composition. Measured gamma ray intensities can be used to derive elemental mass fractions within the upper ~1 m of regolith [11]. Element mass fraction distributions, once masked to remove dust-covered surfaces, also show spatial transitions that roughly correspond with the TES-derived mineral distributions [9]. For example, the boundary between Syrtis Major and Tyrrhena Terra corresponds with a change in K concentration in GRS. The correspondence between TES and GRS, which have different sensitivity depths, indicates that the mineralogical variations measured by TES are more representative of

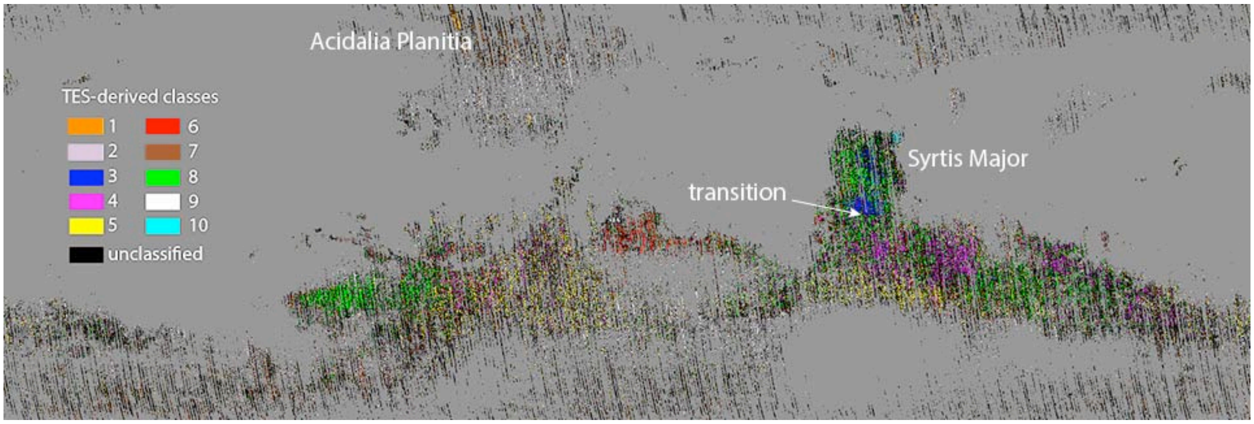

Figure 1. *Global classification map of TES-derived mineral assemblages [9-10]. Arrow points to southern boundary of Syrtis Major, discussed in text. Gray areas are below threshold levels of modeled surface components.*

variations in the bulk composition of materials rather than thin, surficial coatings [9].

Surface Measurements: Some dark soils measured at both MER landing sites are chemically and mineralogically similar [4], but such results are insufficient to demonstrate global homogenization. Measurements by the Miniature Thermal Emission Spectrometer (Mini-TES) of other aeolian bedforms at the Spirit site reveal spectral differences that indicate substantial mineralogical heterogeneity that reflects the local bedrock (Fig. 2). Although the Serpent drift on the rim of Bonneville crater within Gusev crater is spectrally similar to drift material in Endurance crater at Meridiani [4], it does not resemble the Cliffhanger drift on the summit of Husband Hill or the El Dorado bedforms banked up on its southern slope. So despite one example of mineralogical similarity among widely separated sites, the mineralogical heterogeneity among the local aeolian bedforms visited by Spirit calls into question the notion of a global soil.

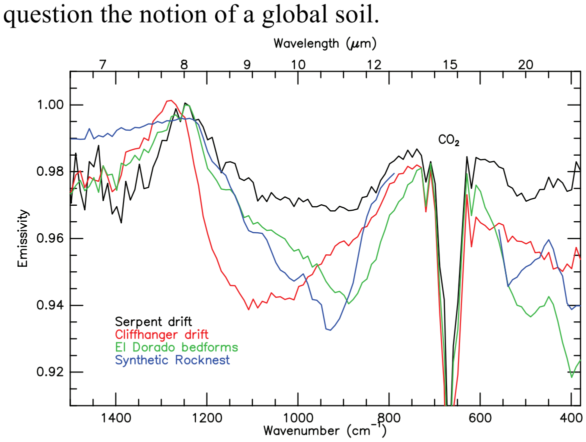

Figure 2. *Mini-TES spectra from aeolian bedforms in Gusev crater compared with a spectrum synthesized from CheMin results from the Rocknest sand shadow.*

The Chemistry and Mineralogy (CheMin) instrument on the Curiosity rover has provided detailed mineralogy of Rocknest, a sand shadow very similar in form to bedforms encountered by Spirit. The accompanying elemental chemistry results provided by the Alpha Particle X-ray Spectrometer (APXS) were shown to resemble APXS results from both Spirit and Opportunity and have been used as further evidence of global soil [1]. We compared the mineralogy of Rocknest obtained by CheMin to Gusev aeolian materials by creating a synthetic TIR spectrum. Using the mineral modes from CheMin, including the amorphous phase best matched by basaltic glass [12], we linearly added laboratory spectra of each phase in the proper proportions, a valid strategy given the known linear mixing behavior of components in TIR spectra [13]. The result better matches the spectrum from El Dorado bedforms than that of Serpent drift used by [4] in comparison with Meridiani soil, demonstrating a lack of uniform mineralogy among aeolian bedforms across the planet.

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