

MINERAL COMPOSITION AND ABUNDANCE OF THE ROCKS AND SOILS AT GUSEV AND MERIDIANI FROM THE MARS EXPLORATION ROVER MINI-TES INSTRUMENTS. P. R.

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Introduction: The Miniature Thermal Emission Spectrometer (Mini-TES) has provided remote measurements of mineralogy, thermophysical properties, and atmospheric temperature profile and composition of the outcrops, rocks, spherules, and soils surrounding the Spirit and Opportunity Rovers [1, 2]. The mineralogy of volcanic rocks provides insights into the composition of the source regions and the nature of martian igneous processes. Carbonates, sulfates, evaporites, and oxides provide information on the role of water in the surface evolution. Oxides, such as crystalline hematite, provide insight into aqueous weathering processes, as would the occurrence of clay minerals and other weathering products. Diurnal temperature measurements can be used to determine particle size and search for the effects of sub-surface layering, which in turn provide clues to the origin of surficial materials through rock disintegration, aeolian transport, atmospheric fallout, or induration. In addition to studying the surface properties, Mini-TES spectra have also been used to determine the temperature profile in the lower boundary layer, providing evidence for convective activity, and have determined the seasonal trends in atmospheric temperature and dust and cloud opacity [3].

Mini-TES is a Michelson interferometer that collects infrared spectra from 5-29 μm (339 to 1997 cm^{-1}) at a spectral sampling of 10.0 cm^{-1} [4]. Nominal spatial resolution is 20 mrad; an actuated field stop can be used to reduce the field of view to 8 mrad. The radiometric precision of the instrument is similar to its pre-launch precision [1, 2]. Spectra were acquired using up to several hundred spectra summed for a single pointing location to increase the radiometric precision. Target temperature was determined by fitting a Planck function to the calibrated radiance, giving a temperature precision and accuracy of ± 0.5 K and ± 2 K respectively for

typical nighttime and ± 0.1 K and ± 0.5 K for daytime measurements.

A full 360°, 20-mrad Mini-TES Mission Success panorama was acquired before egress from both landers [1, 2]. Mini-TES rasters with 3x3 pointing locations were collected regularly along with co-registered 13-filter Pancam images [5] during rover traverses to sample surface diversity. Many other rasters of various sizes and dwell lengths have been acquired, tailored to the requirements of targeted observations.

Gusev: At Gusev undisturbed soil spectra closely match MGS TES bright-region dust spectra, with features interpreted to be due to minor carbonates and bound water. Dark-toned soils observed on rover-disturbed surfaces are likely derived from rocks and has a derived mineralogy, with uncertainties of 5-10%, of 45% pyroxene (20% Ca-rich pyroxene, 25% pigeonite), 40% sodic/intermediate plagioclase, and 15% olivine (Fo45 ± 10). Rocks have complex spectra that are influenced by coatings and atmospheric downwelling radiance, as these high-thermal-inertia rocks are typically colder during the day than the atmosphere. Their Mini-TES spectra are consistent with olivine-rich basalts with varying degrees of dust and other coatings. Aeolian drift material has a unique spectral character with higher oxide abundances than disturbed soil. One (or possibly two) spectrally distinct coatings are observed on rocks, a possible indicator of the interaction of water, rock, and airfall dust.

Meridiani: At Meridiani, the Mini-TES has identified coarse crystalline hematite and olivine basalt sands as predicted from orbital TES spectroscopy [6, 7]. Light-toned outcrops of aqueous origin exposed in crater walls are composed of 20 to 40% Mg and Ca sulfates, a high-silica component that is modeled as glass/feldspar/sheet silicates (~20-30%), and hematite. The Fe-bearing sulfate, jarosite,

that was identified by the Mössbauer spectrometer [8], was detected in deconvolutions of several Mini-TES outcrop spectra, but never in concentrations >5%. The outcrop has 17 wt % FeO [9], with 28% of this Fe as jarosite [8]. Together these data indicate that ~10 wt % of the outcrop is jarosite. The average density of the outcrop derived using the Mini-TES mineral abundances [2] is similar to the density of jarosite, indicating that the jarosite volume abundance is also ~10%. Given the low spectral contrast of this outcrop, this value is consistent with the marginal detection of jarosite by Mini-TES. The finding that Mg and Ca sulfates dominate is consistent with the Alpha Particle X-ray Spectrometer (APXS) results, which show that Mg and Ca are present, and that there is significantly more S and too little Fe for the sulfates to be jarosite alone [9, 10].

The presence of coarsely crystalline hematite exposed on the surface was predicted from orbital TES data [6, 7], and was confirmed in the Mission Success panorama acquired beginning on sol 3. The Mini-TES spectral signature of hematite is associated with spherules 0.6 to 6 mm in diameter [11]. Mini-TES vertical scans of the plains were acquired from the near field to the horizon. These observations show a systematic increase in the depth of the diagnostic 450 and 550 cm^{-1} hematite absorption bands with decreasing elevation angle, and a corresponding decrease in the depth of the basalt/dust component in the 700 to 1200 cm^{-1} region. The spectral shape of the hematite bands does not vary with elevation angle, indicating that viewing geometry does not affect the spectral character of the spherules down to emission angles of ~85°. With an average diameter (d) of 3 mm for the hematite spherules and only ~0.1 to 0.2 mm for the intervening sand [12], the spacing (x) of spherules needs to only be $x \leq d/\tan(90-e)$, or ~25 mm, on the flat plains for the spherules to dominate the observed emission. This spacing is consistent with typical spherule spacing observed for plains soils [12].

Differencing the spectra from the highest and lowest elevation angles effectively isolates the spherule component of the soil. The match of this derived spectrum with a laboratory hematite sample [13] indicates that the spherules are dominated by hematite. No other components, including silica, carbonates, sulfates, silicates, or other oxides, are detected in the derived Mini-TES spherule spectra at a total abundance for non-hematite components of 5 to 10%. While Mini-TES only directly samples the outermost 50-100 μm of the spherules [14], many of the spherules are eroded or broken [12] suggesting

that the interiors of these particles are also dominated by hematite.

Basaltic materials have more plagioclase than pyroxene, contain olivine, and are similar in inferred mineral composition to basalt mapped by TES from orbit. Bounce Rock is dominated by clinopyroxene and is closer in inferred mineral composition to the basaltic SNC meteorites.

Bright wind streak material downwind of Eagle crater closely matches the IR spectrum of global dust, suggesting that these materials were deposited as fallout from global dust storms as predicted by Veverka and colleagues.

The occurrence of waterlain rocks covered by olivine, pyroxene, and feldspar in basaltic sands suggests a significant change from an aqueous environment at the time the rocks were deposited to one dominated by physical weathering. The occurrence of basalts and olivine basalts throughout much of the equatorial and mid-latitude regions suggests that chemical weathering may have been a relatively minor process, at least in low- to mid-latitudes, throughout much of martian history. Thus, the presence of a body of water may represent a relatively brief, localized phenomenon early in Mars history.

Recent Results: The most recent results from the Mini-TES experiments at Gusev and Meridiani, with particular emphasis on the exploration of the Columbia Hills of Gusev crater, and the rocks and sands on Endurance crater in the Meridiani plains, will be presented and discussed

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