MARS SURFACE ROCK ABUNDANCE FROM THERMAL EMISSION SPECTROMETER (TES) MAPPING DATA .

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Introduction: The global abundance of rocks on the surface of Mars is being mapped using Thermal Emission Spectrometer (TES) data from the Mars Global Surveyor spacecraft in mapping orbit around Mars. The TES data can be directly compared to the Viking Infrared Thermal Mapper (IRTM) data previously used to map the abundance of rocks on Mars [1,2]. TES provides hyperspectral information covering the 1700 to 200 cm^{-1} (wavenumber) range. The spatial resolution of TES data is an order of magnitude greater than IRTM, with a 3 km pixel at nadir, as compared to 30 km resolution in the IRTM observations. The method used to determine rock abundance in TES data is the same as was used on IRTM data, with only minor variations due to the different data type. The higher resolution rock abundance data should be able to differentiate surfaces of varying rock abundance on a scale that is comparable to geomorphic features observed in orbiter imagery. Due to the fact that previous rock abundance mapping was done with a different data type than is being returned from the TES instrument, a comparison of data is made here to show the variation and the steps that have been taken to produce a map that is more sensitive to surface rocks, and less subject to atmospheric and surface emissivity problems.

Rock Abundance Method: The method for rock abundance determination is the same as used for the Viking IRTM data [1,2]. The radiant flux in two spectral bands are converted to brightness temperature, and differenced to measure the radiance contributions of multiple temperature components in a single field of view. The difference value indicates the amount of energy being detected from two surface components at different temperatures. The thermal inertia, controlled by grain size and bonding are the most important characteristics affecting the night time temperature. Fine-grained, poorly-bonded materials such as dust cool quickly at night, while rocks cool more slowly. Thus, nighttime temperatures are higher for rock than dust and sand relative to the daytime temperatures. This temperature difference value is modeled to produce the temperature of each surface component using the Viking thermal model [3].

Data: There are spectral characteristics present in the data which have an effect on the rock abundance determination. At present there is a minor, systematic radiance error in the TES data due to subtle differences in the fore optic orientation when viewing the calibration sources and Mars. This effect is present in all TES data, but it is most noticeable in nighttime observations, due to the lower surface temperatures and lower signal to noise ratio. A number of space observations were made to isolate this effect and determine a correction. The radiance error is different for each detector and for different mirror pointing angles. Since all data used for rock abundance has a zero degree pointing angle, the radiance error could be isolated to only nadir observations. The space observation data were averaged for each detector, and the resulting average spectra were subtracted off of the TES data in radiance space.

In order to simulate the IRTM results for a direct comparison, TES data are convolved to the IRTM spectral bands. The IRTM surface-sensing bands that were used occur from 1640 to 1205 cm^{-1}, referred to the 7 μm band, and 417 to 565 cm^{-1}, referred to as the 20 μm band. Night-time TES data is subject to a spectral mask in order to reduce data volume. This spectral mask integrates the flux across the 1200 to 1700 cm^{-1} range, and matches the IRTM 7 μm band very well. The 20 μm band can be simulated exactly using TES data.

The TES spectral mask fixes the 1700 to 1200cm^{-1} into a spectral band similar to the IRTM 7μm band. The rest of the spectrum is not subject to this filter, so the location of the TES equivalent to the IRTM 20 μm band can be modified. The spectral difference can be improved over what was available from IRTM because the TES spectral resolution is higher, and the range is wider, allowing bands to be used that are less influenced by atmosphere, dust, or surface emissivity effects. In order to avoid spectral features which are observed in TES data, a new spectral band has been selected for temperature differencing. The 300 to 400 cm^{-1} region lacks major absorption features due to dust, atmosphere, and basalt, and can better resolve the characteristics of radiance curves.

Results: The radiance correction has an observable effect on the brightness temperature spectral difference values. Subtraction of the correction spectra from radiance data results in a temperature difference of -0.25, -2.6, -2.7, -1.6, -1.9, and 0.1 for each detector. This correction is on the order of a few percent rock abundance for detectors two through five, and less for detectors one and six.

The new TES spectral bands vary only slightly from the IRTM bands, but have a significant effect on the T_7-T_{20} values. The new bands raise the temperature difference up to 4 degrees. The selection of new spectral bands in TES data which avoid atmospheric and surface emissivity features results in a rock abundance map that is more sensitive to surface rocks than the IRTM bands.

Conclusions: Careful correction for the subtle, systematic calibration errors is a necessary step in the data processing for nighttime rock abundance determination. When converted to brightness temperature, it has a significant influence on rock abundance numbers. Thus, as improvements are made in this correction, the rock abundance values will be modified.

Spectral convolution that simulates the IRTM bands is used to directly compare the IRTM data to TES data. This spectral convolution is applicable for comparison of IRTM to TES data, but the spectral resolution of TES provides more freedom for band selection. A new spectral band has been identified for use in further TES rock abundance mapping. This new band has been changed from the IRTM 20 μm spectral location to avoid emissivity effects that are unrelated to rock abundance, and thus produce a map that is more sensitive to surface rock abundance.

References: [1] Christensen, P. R. (1982) *JGR, 87, B12*, 9985-9998. [2] Christensen, P. R. (1986) *Icarus, 68, 217-238*. [3] Kieffer, H. H., et al. (1977), *JGR, 82, 28,* 4249-4291.