COMPOSITIONAL AND TEXTURAL INFORMATION FROM THE DUAL INVERSION OF VISIBLE, NEAR AND THERMAL INFRARED REMOTELY SENSED DATA; Robert A. Brackett and Raymond E. Arvidson, Department of Earth and Planetary Sciences, McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130; 314-935-4888; Internet: brackett@wunder.wustl.edu.

A technique is presented that allows extraction of compositional and textural information from visible, near and thermal infrared remotely sensed data. Using a library of both emissivity and reflectance spectra, endmember abundances and endmember thermal inertias are extracted from AVIRIS (Airborne Visible and Infrared Imaging Spectrometer) and TIMS (Thermal Infrared Mapping Spectrometer) data over Lunar Crater Volcanic Field, Nevada, using a dual inversion. The inversion technique is motivated by upcoming Mars Observer data and the need for separation of composition and texture parameters from subpixel mixtures of bedrock and dust.

*Dataset:* The analysis used data from two instruments flown during the Geologic Remote Sensing Field Experiment (GRSFE) in 1989 at which time remote sensing data from visible to radar wavelengths were acquired over Lunar Crater Volcanic Field, Nevada, simultaneously with ground observations [1]. AVIRIS is a visible and near-infrared spectrometer that acquires 224 channels of data from 0.4 μm to 2.5 μm. TIMS is a thermal infrared spectrometer which acquires 6 bands of data from 8.0 μm to 12.0 μm. These two instruments imaged Lunar Crater Volcanic Field, a Miocene-age caldera complex located in northern Nye County, Nevada, dominated by rhyolite ash-flows, basalt cones and flows, and typical arid to semi-arid landforms (*e.g.*, development of desert pavements, desert varnish, alluvial fans, caliche, and playa and aeolian deposits) [2].

*Inversion:* Initially, field and/or laboratory spectra (both reflectance and emission) are acquired for a set of endmembers that are chosen to represent the lithologic units present in the field area (*e.g.*, rhyolite, basalt, playa, sand, caliche). The AVIRIS and TIMS images are corrected for atmospheric effects using the LOWTRAN-7 software and reduced to units of reflectance and emittance, respectively [3]. The AVIRIS dataset is then used in a linear mixing model to determine for each pixel the areal abundance of each endmember [4]. These endmember abundances are then used as a constraint on the inversion of several TIMS scenes obtained at multiple times during the diurnal cycle. The emittance, $F(\lambda)$, received by a given TIMS band is assumed to be the sum of the radiance of the $N$ endmembers of the pixel:

$$F(\lambda) = \sum_{i=1}^{N} f_i \, \varepsilon_i(\lambda) \, \sigma \, T_{k,i}^4$$

where $f_i$ is the fractional area of endmember $i$, $\varepsilon_i(\lambda)$ is the emissivity spectra of endmember $i$, $\sigma$ is the Stefan-Boltzmann constant, and $T_{k,i}$ is the kinetic temperature of endmember $i$. Note that $f_i$ is known from the linear inversion of AVIRIS data and $\varepsilon_i(\lambda)$ is obtained from

field and/or laboratory spectra. $T_{k,i}$ is the sole unknown parameter in this equation. This equation is cast into the form of a set of linear equations and inverted for the kinetic temperature of each endmember. One inversion is performed for each time of day at which a TIMS scene was acquired. The result is a map of kinetic temperature versus time of day for each endmember. This inversion does not require the assumption of constant emissivity in TIMS band 6 (*cf.* [5]) or isothermal endmembers [6]. A nonlinear inversion is then performed to extract apparent thermal inertia [7] of the endmembers from these thermal histories of each endmember at each pixel. Note that apparent thermal inertia is $\approx\sqrt{k\rho c}$, where $k$ is thermal conductivity, $\rho$ is density, and $c$ is specific heat [8, 9]. The inversion results in maps of the apparent thermal inertia of each of the endmembers.

*Assumptions:* Several assumptions are implicit in this inversion: first, that macroscopic mixing dominates microscopic mixing [4]; second, that the endmember spectra in reflectance correspond to the endmember spectra in emission; third, that the surface is vertically homogenous at the scale of the diurnal skin depth; finally, that environmental parameters (*e.g.*, latent heat, sensible heat flux) are small. This final assumption is testable using a simple one-dimensional thermal conduction model [10], constrained by field meteorological observations acquired during GRSFE.

*Discussion:* The model employed offers the opportunity to extract compositional and textural information for a variety of endmembers within a given pixel. Geologic inferences concerning grain size, abundance, and source of endmembers can be made directly from the inverted data. These parameters are of direct relevance to Mars exploration, both for Mars Observer and for follow-on missions.

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