SPECTRA OF CEMENTED, HEMATITE-RICH MATERIAL AND TES SPECTRA OF SINUS MERIDIANI, MARS. L. E. Kirkland, K. C. Herr, P. M. Adams, F. Westall, J. W. Salisbury; Lunar and Planetary Institute, Houston, kirkland@lpi.usra.edu; The Aerospace Corporation, kenneth.c.herr@aero.org, paul.m.adams@aero.org; LPI and via Torino, Bologna, frances.westall@tin.it; Johns Hopkins, retired, saliburs@worldnet.att.net.

Introduction. Lane et al. [1] and Christensen et al. [2] conclude that 1996 Global Surveyor Thermal Emission Spectrometer (TES, ~1700–200 cm\(^{-1}\)) spectra of regions in Sinus Meridiani are consistent with hematite. The observed band strengths are inconsistent with unconsolidated, nanophase hematite dust, but are consistent with laboratory spectra of pure, coarsely-particle hematite.

We seek to extend hematite samples studied past pure end-members to include materials such as naturally occurring hematite-rich cemented materials (e.g. duricrust and desert varnish) in order to determine whether they may match the spectra recorded of Mars. Here we discuss why cemented finely particulate materials can also exhibit good spectral contrast, and we present an interesting spectral signature of a hematite-rich patch on a ferricrete hand sample.

Spectral contrast. A material can scatter light through two processes: surface and volume scattering [3]. A strong band is produced by a Fresnel reflection from the surface (surface scattering) when high opacity within the band gives it a mirror-like property. This mirror-like reflectance produces reflectance peaks called “reststrahlen bands.” In the case of emission, the surface of a body reflects radiance inward at reststrahlen bands [4]. Thus reststrahlen reflectance from the surface of the grain reduces emerging radiation at the reststrahlen feature, causing an emissivity trough.

When unconsolidated particles are small enough for light to survive passage through the grain, volume scattering occurs [5]. When volume scattering dominates, the reststrahlen bands are offset slightly toward longer wavelength, and appear as emission peaks.

Surface scattering dominates for opaque materials, and smooth surfaces enhance spectral contrast [3,6]. Volume scattering dominates for optically thin materials, and most materials become optically thin at small particle sizes. However, when optically thin particles are pressed close (~wavelength) together, they scatter coherently, as if they were larger, opaque particles dominated by surface scattering [5]. When they are both close together and smooth-surfaced, they have high spectral contrast. This occurs for smooth-surfaced cemented, fine particles (e.g. as can occur in duricrust and desert varnish).

Thus when reststrahlen bands are observed as troughs with good spectral contrast, that indicates the presence of large, smooth particles, and/or smooth-surfaced, closely packed or cemented fine particles.

Differences in the relative contribution from surface and volume scattering will affect the band depth and shape. Pecharroman and Iglesias [7] show variations in hematite spectral character caused by different particle shapes and thus scattering effects. In particular, they observe variations in the width of the 575 cm\(^{-1}\) band and in the relative band contrasts.

Fig. 1 shows a spectrum measured of a hematite-rich spot on a ferricrete hand sample. The ferricrete is heterogeneous [9], and spectra of the hand sample varied with the composition. This spectrum is broadly consistent with hematite.

Observations of Mars. Three hematite bands in the ~700–200 cm\(^{-1}\) region are available for interpretation using TES spectra. Fig. 2a and 2b show TES spectra that have had a newly developed atmospheric compensation applied [11,12]. We use only data measured by detector 5 to decrease instrumental effects.

TES bands centered near 575, 450, and 300 cm\(^{-1}\) are broadly consistent with hematite. The Fig. 2a sloping continuum at higher wavenumber (>1250 cm\(^{-1}\)) and no clear 1100 cm\(^{-1}\) (9 µm) are consistent with the presence of fine-grained silicates [10]. The Fig. 2b flat short wavelength continuum and weak 9 µm band is consistent with the presence of coarse silicate particles.
but less dust [10]. Christensen et al. [2] conclude the TES 450 cm\(^{-1}\) band strength does not correlate well with albedo, and this would be the expected result of varying coverage by dust vs. coarse silicate material.

Discussion. Accurate interpretations of remotely sensed spectra require a full understanding of the spectral signatures of all the materials that may be present. It is reasonable to consider whether materials other than a pure hematite end-member may be present on Mars. Thus we have sought examples of hematite-rich materials such as duricrust (e.g. ferricrete) and desert varnish to improve our understanding of the spectral variability and behavior of naturally occurring hematite-rich materials. Several spectral issues need to be addressed. First, the 575 cm\(^{-1}\) feature in 1971 Mariner Mars IRIS [13] and in TES spectra needs further study to better characterize its shape and determine the quality of match to coarsely particulate hematite (Fig. 3). Second, insufficient knowledge exists of the spectral behavior of cemented hematite-rich materials to determine whether or not they match TES and IRIS observations. Nonetheless, the ferricrete spectrum offers an interesting starting point (Fig. 4). In order to constrain what minerals or coatings may be present in the Sinus Meridiani region, materials such as ferricrete and hematite-based desert varnish should be sought or synthesized and studied to determine whether they offer an improved match to the observations.

References: