TES AND THEMIS ANALYSIS OF MARTIAN CLAY-BEARING DEPOSITS DISCOVERED BY MARS EXPRESS OMEGA. J. R. Michalski, S. W. Ruff, and P. R. Christensen, Dept. of Geological Sciences, Arizona State University, Tempe, Arizona. michalskijoe@gmail.com

Introduction: The Mars Express OMEGA experiment has detected clay mineral-bearing deposits in localized regions of Mars [1-2] from visible-near infrared (VNIR) ($\lambda \cong 0.5$-3 μm) spectral data. In this study, we use thermal infrared ($\lambda \cong 7$-30 μm) spectra from the TES and THEMIS instruments to further constrain the mineralogy of these deposits. Several geologic contexts for these deposits are considered. Are these deposits ancient sedimentary rocks such as mudstones or clay-cemented sandstones? Are the clay-bearing materials altered ash similar to bentonite? Do the clay minerals occur as surface coatings on igneous rocks and detrital materials – similar to rock varnish? We consider these and other hypotheses.

Spectral detection of clays: OMEGA detects clay minerals from vibrational absorptions related to O-H (at $\lambda \cong 1.4$ μm), H-O-H (at $\lambda \cong 1.9$ μm), and M-OH (at $\lambda \cong 2.2$-2.35 μm) (M usually = Al^{3+}, Mg^{2+}, Fe^{2+}, or Fe^{3+}). While VNIR spectra of clays provides information about the hydration state and octahedral sheet crystal chemistry, thermal infrared spectra provide different information related primarily to the tetrahedral sheet crystal chemistry, but also to the octahedral sheet composition. Thermal infrared instruments such as TES detect clays from vibrational absorptions related to their tetrahedral (Si,Al,Fe)-O bonds and M-O-Si bonds between the tetrahedral and octahedral sheets [3]. This provides additional information about the mineralogy of clays present in the martian deposits. In addition, thermal infrared spectra provide mineralogical information about other (non-hydrated) minerals that are not detectable in the VNIR, such as feldspars and anhydrous silica.

The OMEGA clay-rich regions: Several clay-bearing regions have been reported to date by the OMEGA science team [1-2]. These deposits generally occur as dark, unconsolidated materials (soils?) or as layered bedrock deposits [2]. At the present time, we are focusing on layered materials present in the Mawrth Vallis region and layered materials in the Nili Fossae region, but we are planning to extend the study to include other clay-bearing materials discovered by OMEGA.

Thermal infrared data analysis: Daytime THEMIS thermal infrared images are being used to map unique thermophysical units in these regions. Decorrelation stretched radiance and emissivity images are used to identify compositional heterogeneity in the scenes. TES emissivity data (uncorrected for atmosphere) are compared for single orbits between the putative clay-rich regions and the clay-poor regions. The spectra are also corrected for atmospheric absorption and emission according to [4]. Both qualitative analysis of spectral shapes and quantitative analysis of surface spectra by linear spectral unmixing are used to evaluate surface spectra.

Results: In general, the areas studied so far (deposits in the Mawrth Vallis region and layered materials in the Nili Fossae region [Figure1]) have spectral character indicative of mafic-intermediate igneous materials. The surfaces exhibit broad absorptions in the 800-1200 cm^{-1} region [Figure 2] similar to slightly altered basaltic materials. The surfaces have strong absorption in the 300-500 cm^{-1} region, also similar to basaltic materials. Spectral unmixing results so far suggest plagioclase, pyroxene, and clay mineral components to these surfaces. However, note that even typical TES spectra of basaltic surfaces on Mars can be modeled with ~15% clay minerals, which is consistent with the widespread occurrence of small abundances of poorly crystalline clay minerals on Mars [3]. So far, it is not clear from unmixing results that the putative clay-rich deposits have significantly higher abundances of modeled clay minerals. Overall, these preliminary results suggest that the putative clay-bearing deposits are composed of igneous materials in large part. The thermal infrared spectral character of these deposits is not consistent with the expected spectral signature from extremely clay-rich materials such as bentonite layers. The TES spectra do not indicate large quantities of hematite or magnetite – though small abundances cannot be ruled out. Small abundance of poorly crystalline silica (opal-A or opal-CT) could be present, but significant abundances of quartz, cristobalite, or other crystalline silica phases are not observed.

Multispectral THEMIS results suggest subtle compositional uniqueness to some of these deposits [Figure 3]. Some of the apparent emissivity variation in the scene [Figure 2] is due to incomplete separation of temperature from the emissivity data, but this image suggests compositional differences between the ancient crust and embaying lavas. TES spectra of the ancient crust and embaying lavas show some subtle

differences in the 800-1200 cm^{-1} range (where THEMIS observes).

The putative clay-rich deposit in Nili Fossae does contain a stronger absorption near 480 cm^{-1} than typical basaltic surfaces (in both unatmospherically corrected and atmospherically corrected data). This absorption could be explained by Fe^{2+}-O-Si or Mg^{2+}-O-Si deformation in trioctahedral clays. The OMEGA results are interpreted as evidence for nontronite in this deposit [2]. These TES results may suggest trioctahdral ferruginous clays instead of or in addition to nontronite.

Conclusions: Preliminary THEMIS analyses suggest subtle compositional uniqueness to some of the putative clay-bearing deposits discovered by OMEGA. TES spectra show that overall, the deposits studied have spectral character similar to basaltic materials. The deposits are not dominantly clay – they are composed of igneous materials with a limited clay component. Further work will refine the abundances, mineralogies, and styles of occurrence of clay minerals in these deposits.

References: [1] Bibring J. P. et al., Science, 307, 1576-1581, 2005; [2] Poulet F. et al., Nature, 438, 623-627, 2005, [3] Michalski J. R. et al., JGR, in press, [4] Bandfield J. L., JGR, 107, 2002.

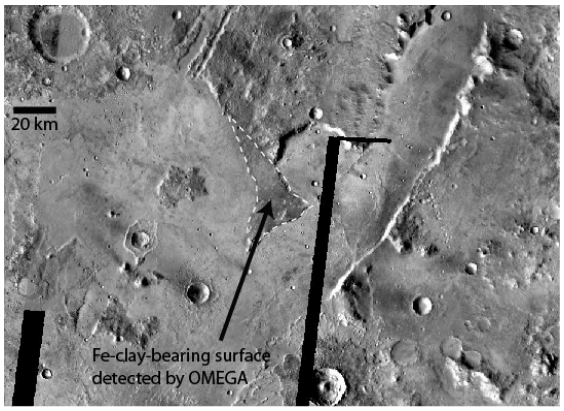

Figure 1: THEMIS daytime infrared mosaic showing the context of a putative clay-bearing deposit discovered by OMEGA [2].

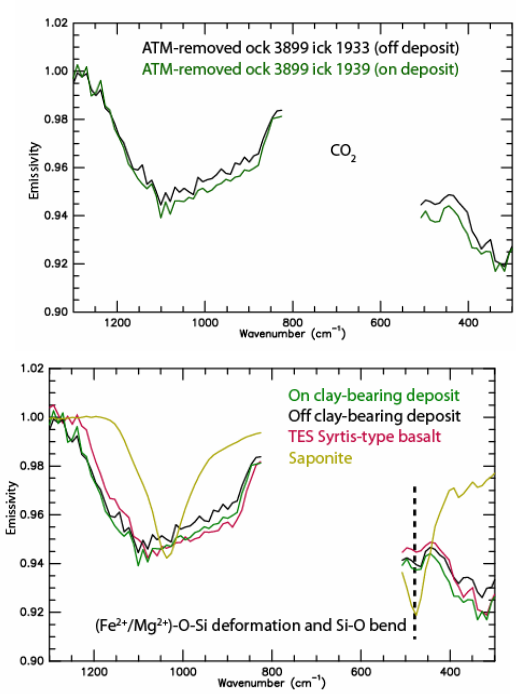

Figure 2: Comparison of TES spectra from ock 3899 between surfaces on and off of the clay-bearing surface in Nili Fossae (top). The spectra from the deposit have a stronger absorption near 480 cm-1 suggestive of saponite.

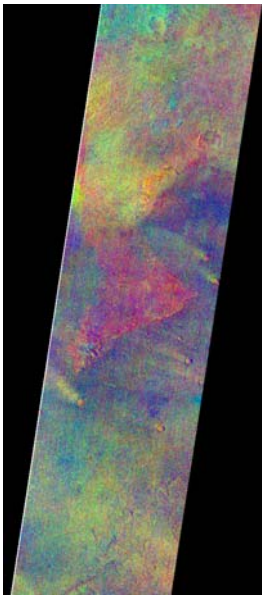

Figure 3: THEMIS emissivity image (bands 5,6,7:R,G,B) showing apparent compositional heterogeneity in the Nili Fossae region. In this band combination, redder colors suggest more clay.