The nature of the martian surface and poles as viewed by the Mars Odyssey Thermal Emission Imaging System

P. Christensen(1), and the THEMIS Team

(1) Department of Geological Sciences, Arizona State University

The Thermal Emission Imaging System (THEMIS) on the Mars Odyssey spacecraft has returned over 100,000 multi-spectral visible and thermal infrared images of Mars. These images have produced global day and night infrared coverage at 100-m resolution, and extensive coverage in the visible at 18-m resolution. THEMIS has provided new insights into (1) the composition of the surface at scales appropriate for the study of geologic processes; (2) the nature of the polar ices and unusual polar processes; and (3) the distribution of bedrock, sand, and dust. The multi-spectral infrared mapping at 100-m scales has produced petrologic maps that are, for the first time, at scales appropriate for studying local geologic processes. This compositional mapping has revealed that the martian crust, while dominated by basalt, contains a remarkable diversity of igneous materials whose range in composition - from ultra-mafic basalts to granitoids - rivals that found on the Earth. At the scale mapped by THEMIS rock units in basaltic terrains have been identified that have olivine abundances of $>$20%. These olivine-rich basalts are observed on crater floors and in layers exposed in canyon walls up to 4.5 km beneath the surface. This vertical distribution suggests that olivine-rich lavas were emplaced at various times throughout the formation of the upper crust; their growing inventory suggests that olivine basalts may be relatively common. In the Syrtis Major caldera volcanic evolution has produced compositions from low-silica basalts to high-silica dacite. The existence of these dacite lava flows demonstrates that highly evolved lavas have been produced, at least locally, by magma evolution through fractional crystallization in martian magma chambers. These sequences are analogous to those found in large volcanic complexes on Earth. Rare occurrences of exposed quartz-bearing granitoid rocks have also been found, indicating the formation of highly evolved magmas. No evidence of carbonate rock layers has been found by the THEMIS, TES, or OMEGA instruments. Data from the TES and Mini-TES spectrometers have shown that the ubiquitous martian dust does contain small amounts of carbonate, but these minerals may have formed by direct interaction with water vapor in the atmosphere.

The existence of extensive, nearly pristine, ancient volcanic rocks provides strong evidence that much of Mars has not been exposed to any significant amount of water since these lavas were produced. These surfaces may have been wetted, as evidenced

by thin coatings on some basaltic rocks at the Gusev rover site, but they have not been soaked. The lack of thick carbonate rock layers indicates that if Mars ever had large bodies of water, they were either too cold, too short lived, were covered by ice that limited interactions with the atmosphere, or had unique chemical conditions that prevented carbonates from forming.

In the polar regions, dark spots are observed to form on the seasonal CO_2 ice. These have been discovered to remain at CO_2 ice temperatures into summer, and must be granular materials brought to the surface of the ice, rather than defrosted ground. Spots evolve to fans that can lengthen over time, suggesting grain transport across the surface. Spots often occur above radial channel networks. In places the substrate albedo patterns are visible, requiring translucent ice. Transient surface brightenings may indicate the deposition and subsequent removal of water ice. These observations are consistent with a translucent, impermeable CO_2 ice cap that sublimates from the base, producing gas flow beneath the ice that erodes the channels and jets that erupt sand-sized grains through vent. These processes are unlike any observed on Earth. The vertical stirring of the polar-layered deposits by this process may have significantly altered the sedimentary record, and may complicate the interpretation of the sedimentary record as it relates to climate history.