THE GRADUATE SCHOOL
of
THE UNIVERSITY OF COLORADO AT BOULDER

DISSERTATION DEFENSE
of

NATHANIEL E. PUTZIG

FOR THE DEGREE

DOCTOR OF PHILOSOPHY

2006 August 29 at 9:30 AM

Duane Physics D142

Examining Committee Members:
Dr. Michael Mellon, Chair
Dr. Bruce Jakosky
Dr. Larry Esposito
Dr. Brian Hynek
Dr. Joshua Colwell

OUTLINE OF STUDIES

Major Field:
GEOPHYSICS

Subfield:
PLANETARY SCIENCE

Specialization:
REMOTE-SENSING STUDY OF MARS

BIOGRAPHICAL NOTES

Nathaniel began his explorations in planetary science in the 5th Grade at Berne-Knox-Westerlo Elementary School, with a wall-size scale diagram of the Solar System and a condensed summary of the known features of each planet. His analysis relied heavily on Mariner and Pioneer data as reported in Scientific American. He went on to more focused studies of the Earth, receiving a Bachelor of Science in Geophysical Engineering from the Colorado School of Mines in 1986 and a Master of Arts in Geophysics from Rice University in 1988. At Rice, he began computational data analysis in earnest, working with Dr. Alan Levander to examine remnants of the Farallon tectonic plate beneath the central California margin using wide-angle seismic data that they acquired on Halloween night in 1986. Subsequently, he spent five years applying seismic remote-sensing techniques to oil and gas plays in Michigan Basin, West Texas, and Yemen on behalf of Shell Oil Company. Three years in the geophysical software industry with Photon Systems Inc. and CogniSeis, Inc. followed, culminating in a management position that inspired his abandonment of corporate employment. In 1996, he founded GEOMANCER ("Divining Futures by Signs from the Earth"), supplying exploration geophysics and software consulting services to over 20 companies during the four years leading up to the Millennium. He then took a sabbatical year for exploration of a different sort, traveling to over 40 countries. In 2001, He returned to Colorado and the wider study of the planets, beginning here with Mars.

DISSERTATION

Thermal inertia and surface heterogeneity on Mars

Faculty Advisor: **Dr. Michael Mellon**

ABSTRACT

Thermal inertia derived from temperature observations is critical for understanding surface geology and assessing potential landing sites on Mars. Derivation methods generally assume uniform surface properties for any given observation. Consequently, horizontal heterogeneity and near-surface layering may yield apparent thermal inertia that varies with time of day and season. To evaluate the effects of horizontal heterogeneity, I modeled the thermal behavior of surfaces containing idealized material mixtures (dust, sand, duricrust, and rocks) and differing slope facets. These surfaces exhibit diurnal and seasonal variability in apparent thermal inertia of several 100 tiu† even for components with moderately contrasting thermal properties. To isolate surface effects on the derived thermal inertia of Mars, I mapped inter-annual and seasonal changes in albedo and atmospheric dust opacity, accounting for their effects in a modified derivation algorithm. Global analysis of three Mars years of MGS-TES‡ data reveals diurnal and seasonal variations of 200 tiu in the mid-latitudes and 600 tiu or greater in the polar regions. Correlation of TES results and modeled apparent thermal inertia of heterogeneous surfaces indicates pervasive surface heterogeneity on Mars. At TES resolution, the near-surface thermal response is broadly dominated by layering and is consistent with the presence of duricrust over fines in the mid-latitudes and dry soils over ground ice in the polar regions. Horizontal surface mixtures also play a role and may dominate at higher resolution. In general, thermal inertia obtained from single observations or annually averaged maps may misrepresent surface properties. In lieu of a robust heterogeneous-surface derivation technique, repeat coverage can be used together with forward-modeling results to constrain the near-surface heterogeneity of Mars.

† tiu ≡ $J\ m^{-2}\ K^{-1}\ s^{-1/2}$ ‡ Mars Global Surveyor Thermal Emission Spectrometer