Investigations of Geologic Units and Structural Features on the flanks of Elysium Mons, Mars Using Visible Images and General Thermal Signatures from THEMIS

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Overview

• Mars and Elysium Mons

• Thermal Emission Imaging System (THEMIS) data
  – Acquisition
  – Processing

• Results

• Conclusions
Elysium Mons
Elysium Mons

- Radial fossae occur on the flanks of this young Martian volcano.
  - Pit chains
  - Grabens
  - Wide gently curving troughs

- Outflow channels originate from some of the fossae.

- Fossae at elevations greater than -3500m are not origins of outflow channels.

(Russell and Head 2001,
Mars Data Sources

- **Viking:** visible images
- **Mars Global Surveyor:**
  - MOC Visual images
  - MOLA elevation data
  - Thermal Emission Spectrometer (TES)
- **Odyssey:**
  - THEMIS
- **Mars Express**
  - OMEGA - hyperspectral
  - Stereo Camera
THEMIS

• Aboard Mars 2001 Odyssey

• Visible and infrared camera

• Visible
  – 5 bands (at 0.425 microns, 0.540 microns, 0.654 microns, 0.749 microns and 0.860 microns)
  – 19 meters pixel

• Infrared (IR)
  – 10 bands (6.78, 6.78, 7.93, 8.56, 9.35, 10.21, 11.04, 12.57, and 14.88 microns)
  – 100 meters per pixel
Original Goals of THEMIS

- determining the mineralogy of localized deposits (primarily in hydrothermal or subaqueous environments)
- finding subsurface hydrothermal systems
- investigating 100-m scale processes
- determining landing site characteristics
- studying polar cap processes (Christensen et al., 2003).
Results of THEMIS Goals

- No evidence of recent geothermal activity has to date been unsuccessful.

- THEMIS has been used to detect and investigate
  - outcrops of exposed bedrock
  - ejecta from impact craters
  - landslides, sand and dust

- Surface compositional variations
  - formation and recession of polar caps
Difficulty in Mineral Detection

• Difficulties caused by:
  – atmospheric errors
  – surface dust.
    • THEMIS can see through only a small amount of atmospheric dust and even a thin layer of surface dust (~100μm) will obscure any underlying thermal IR signatures (University of Arizona).
  – surface roughness and particle size cause spectral effects (Kirkland, 2003).

• Corrections
  – Complex and simple correction methods for atmospheric errors have been developed (Bandfield et al., 2004a; Mustard, 2004; Anderson et al, 2005)
  – have been applied to correct THEMIS data to find minerals, including possible granitoid exposures in crater centers (Bandfield et al., 2004b).

• While the thermal signature of the surface rocks is obscured by atmospheric and surface dust, gross thermal signatures from THEMIS can be used to distinguish and map separate rock and surface units (Farrand, 2003; Pelkey, 2003; Keszthelyi et al., 2004).
THEMIS Acquisition

• Data provided by Arizona State University (themis.asu.edu)

• Released on regular intervals since October 2002 and most recently in January of 2005.

• The data is provided in three formats:
  – Raw Radiance cube file (EDR) - original data
  – Calibrated Radiance Cube file (RDR) – corrections to remove “duplicates” and transmission errors
  – Brightness image
    • an apparent Brightness Record image for visual images (band 3)
    • a Brightness Temperature Record for IR images (band 9).
THEMIS Processing

• Integrated System for Imagers and Spectrometers (ISIS) software
  – Developed/maintained by the United States Geologic Survey.
  – Processes data from spacecraft missions as well as perform many common image processing operations.

• Processing steps
  – Convert THEMIS QUB to ISIS File
  – Process a simple cylindrical and a Mercator projection of this file
  – Output for use in ENVI, Imagine, ArcMap, etc.

```bash
#input the data into ISIS, define coordinate system as geographic, # and output a RAW image
thm2isis.pl V05550017RDR.QUB.txt -- -- -- -- -- 180
thmvismc.pl V05550017RDR.lev1.cub -- -- -- SIMP:0,OCENTRIC
./isis2world_dd_slcfix.pl -e V05550017RDR.vismc.cub
```
THEMIS Acquisition and Processing

• Acquired and processed
  – 5 acquired visual images (V02167008RDR, V04414006RDR, V05550017RDR, V05912011RDR, and V06299019RDR) were processed.
  – Five thermal infrared (I02167007RDR I05213010RDR I07017013RDR I07404019RDR I08521011RDR)

• Successfully Acquired and processed
  – 3 of the thermal infrared images (I02167007RDR, I05213010RDR, and I07404019RDR)
    • I05213010 and I02167007RDR contain all 10 bands
    • Nighttime image I07404019RDR contains bands 4, 9, and 10.
  – All 5 of the visual images
    • V02167008RDR contains all 5 bands
    • Other visible images only contain band 3
Results

• Learned to acquire and process THEMIS data
• Explored Elysium Mons
• Noted slope and morphology of surface
• Noted general surface properties
• Did not detect stratigraphic unit differences in IR