Remote Sensing of Mars

Focus on Relevance to Terramechanics

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KISS xTerramechanics Workshop
6/20/11

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MER Athena Science Team
Coordinated Orbital and Opportunity Rover Observations

• Opportunity has traversed ~30 km mainly NS over past 7 ½ years, a “calibration alley” for coordinated rover and orbital observations and analyses
  – Extends retrieval of rock & soil properties and environmental history reconstructions beyond traverse sites
  – Allows better understanding of mobility issues and path planning to minimize sinkage and slip
Opportunity Rover

- Right front wheel left rotated ~8 deg inward when azimuthal actuator failed.
- Shoulder IDD actuator failed so driving uses “fishing stow” and have limited deployment work space.
- Mini-TES no longer responding.
Key Orbital Instruments

• Odyssey
  – Thermal Emission Imaging System (THEMIS) with 5 multispectral visible (5 bands, 0.43-0.86 μm, 18 m/pixel) and thermal coverage (10 bands, 6.78-14.88 μm, 100 m/pixel)

• Mars Reconnaissance Orbiter (MRO)
  – Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) 544 band (0.362 to 3.920 μm) hyperspectral imager with 18 m/pixel (and other modes)
  – Context Imager (CTX) 6 m/pixel (0.5-0.8 μm)
  – HiRISE with 0.25 m/pixel 3 bands (0.55-0.85 μm)
  – Coordinated and nested observations
  – Stereo for CTX and HiRISE using data from two or more orbits
20 km
North
Opportunity
Thermal Inertia

• Predawn THEMIS thermal IR observations used to derive thermal inertia:
  – $TI = (K \rho c)^{1/2}$
  – $K =$ thermal conductivity
  – $\rho c =$ heat capacity
  – Values indicate dominance by soil cover for Mars

• Integrated effect over thermal skin depth (cm’s)
  – Skin depth = $K/\rho c (P/\pi)^{1/2}$
  – $P =$ period of observation, typically diurnal
Ada area A

Ada crater eastern wall

\( \sim 170 \text{ m} \)
Ada crater red=bright wall brown=plains

Processed using DISORT to model atmosphere and surface together

Monohydrated sulfate
Kieserite ($\text{MgSO}_4 \cdot \text{H}_2\text{O}$)

Ferric oxides

Ferrous silicates

CRISM FRT000199D5

8 by 8 means

Spectral LA

Wavelength, micrometers

0.10
0.12
0.14
0.16
0.18
0.20

0.5
1.0
1.5
2.0
2.5

53
CRISM Along Track Oversampled (ATO) Observations

- New observing scheme where pixels overlap in the along track direction (see figures)
- Allows detection of small scale features (<18 m/pixel)
- Pixel size and noise trades
FRT001B8A4 oversampling

Column 433
Distances between adjacent pixels

Distance (m)

Row number
FRT001B8A4 oversampling

Moving backwards

Santa Maria
S data show interesting color properties for same location that L data indicate hydrated sulfate is exposed in 5 to 6 pixels aligned NS.
Santa Maria red = Yuma and Haomate, blue = floor

Monohydrated sulfate
Kieserite (MgSO$_4$ H$_2$O)

Iron oxides

Ferrous silicates

1 by 3 means
CRISM FRT0001B8A4 oversampled
Luis de Torres IDD target before brush
With MB down now on brushed surface

Yuma

Pancam mosaic Haomate
Enhanced MgO and SO$_4$
CRISM FRT0001C7D2 12/19/11

BGR (1.08, 1.51, 2.53 micrometers)

Bottomless Bay

Duck Bay

Projected 6m/pixel

Spectrally distinct pixels
Portion of Pancam Cape Verde Panorama

Crater

Spectrally interesting outcrop
1 by 3 means

Monohydrated sulfate
Kieserite (MgSO₄ H₂O)

Iron oxides

Spectral LA

Victoria crater red=wall, brown=plains

Wavelength, micrometers

CRISM FRT0001C7D2

Oversampled
False color composite:
\[ R = 2.3, \ G = 1.5, \ B = 1.08 \ \mu m \]

Previous Results:
Parameter maps overlain (R=D2300, G=Sindex, B=D1900)

Red=phyllosilicates
Blue=hydrated
Green=hydrated sulfates

Cape York
Botany Bay
Cape Tribulation

Similar to results of
Wray et al. 2009 GRL 36 L21201
ATO Observations Over Endeavour’s Rim

ATO Observations are shorter in the along-track direction due to overlap of pixels.
CRISM ATO Image Centered Over Cape York

Normal FRT000CE1D

ATO FRT0001D86B
CRISM ATO FRT0001D86B False Color IR Using 3, 6, 12 m/pixel

Opportunity 6/17/11
Botany Bay

Cape York
Antares

Endeavour
CRISM ATO FRT0001D86B

12 m/pixel projection

3,6,12 m/pixel sharpened

HiRISE color
ESP_021892_1775

Cape York

Botany Bay
Surface Spectral Reflectance Retrievals

• ATO FRT0001B8A4 spectral retrievals require:
  – Understanding of trade-off between sharpened pixel size and decrease in S/N of retrieved spectra
  – High fidelity radiative modeling of the atmosphere and surface
  – Validation using ability to model sharp CO$_2$ bands
  – Parameter mapping and mineral inferences

*WORK IN PROGRESS*
Plains

Hydrated Phases

Terraces

Noachian with Fe/Mg smectites

Botany Bay

Spirit Point

Mineral inferences from Wray et al.
View from South
3X VE HiRISE

Spirit Point
Botany Bay
Cape York
Sedimentary cover
Noachian Crust

Arvidson 6/1/11
HiRISE image and associated DEM with OSU processing