Construction of a Self-Consistent Model for Surface Materials in Meridiani Planum using CRISM, CTX, HiRISE, and Opportunity Data

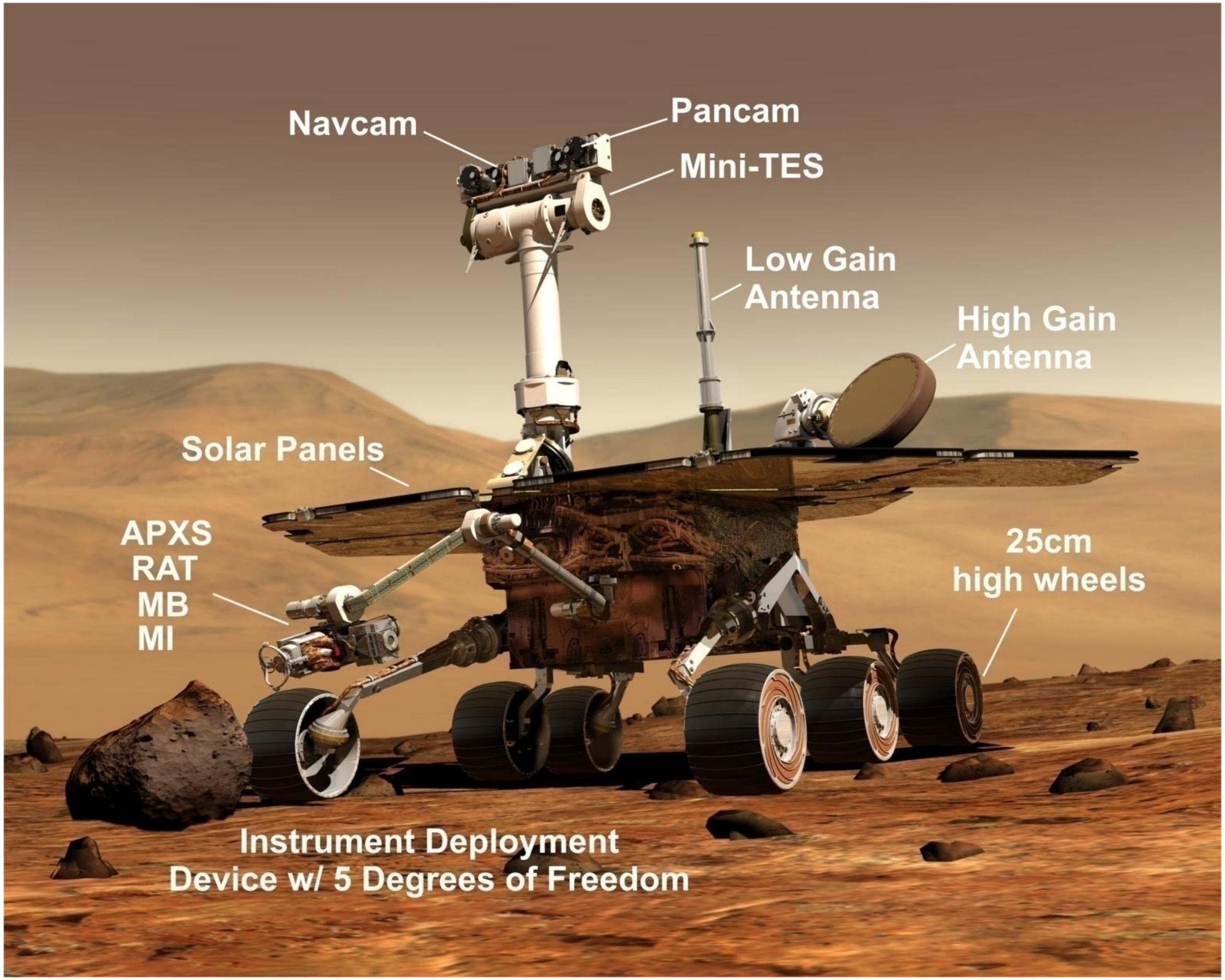
Ray Arvidson and Sandra Wiseman
CRISM Workshop
LPSC
With input from Wendy Calvin, James Wray, Eldar Noe Dobrea, Ron Li, Jue Wang

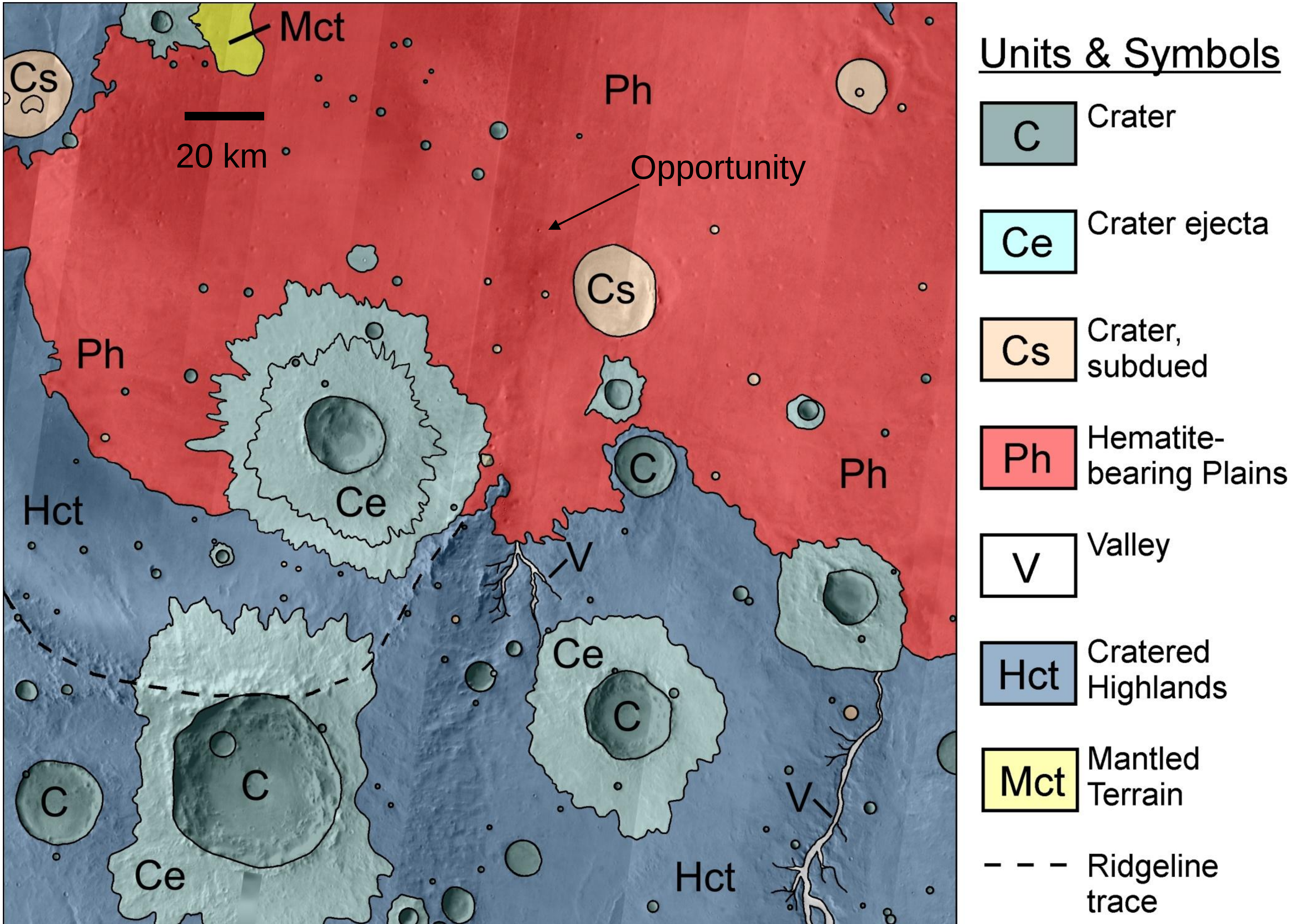
3/13/09

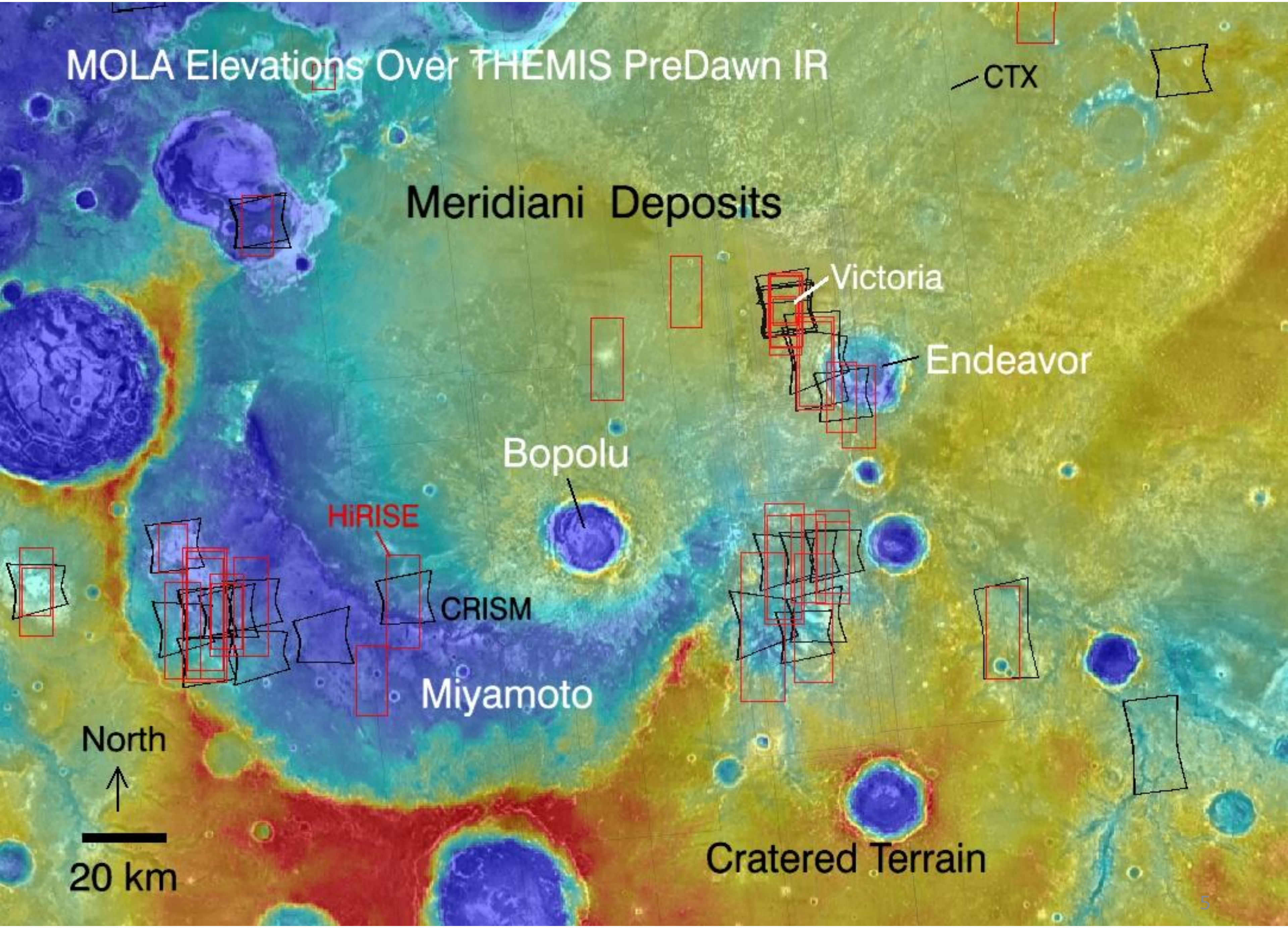
Overview

- Coordinated CRISM FRT, CTX, HiRISE observations acquired while Opportunity conducted traverses in Meridiani Planum, inventorying surface and near surface material textures, compositions, and mineralogy
- Use the orbital and rover-based data jointly to develop a self-consistent model for surface material distribution and properties
- Gain insight into ability to separate atmospheric and surface radiative streams for CRISM and use of surface spectra for textural and mineralogical retrievals
- Look ahead to exploration of Endeavor Crater

Mars Exploration Rover

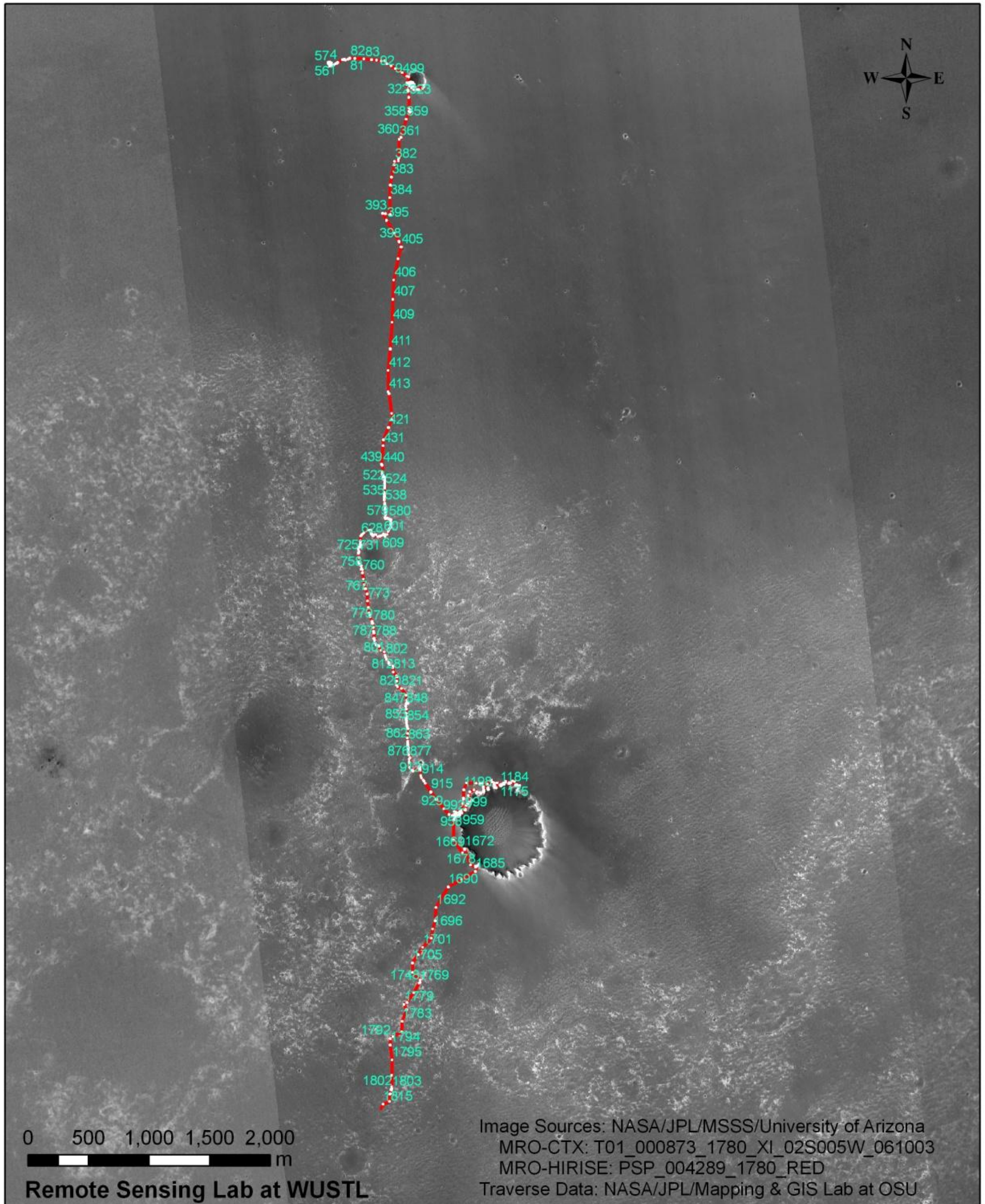



Mct
Cs
Ph
20 km
Opportunity
Cs
Ph
Ce
C
Ph
Hct
V
Ce
C
C
C
Ce
V
Hct
Units & Symbols
C
Crater
Ce
Crater ejecta
Cs
Crater, subdued
Ph
Hematite-bearing Plains
V
Valley
Hct
Cratered Highlands
Mct
Mantled Terrain
Ridgeline trace


MOLA Elevations Over THEMIS PreDawn IR
CTX
Meridiani Deposits
Victoria
Endeavor
Bopolu
HiRISE
CRISM
Miyamoto
North
20 km
Cratered Terrain


HiRISE
Endurance Crater
28A1 CRISM FRT
CTX mosaic
Victoria Crater
CTX mosaic
Endeavor Crater
8541

Opportunity Traverse Map (Sol 1815)



- Opportunity has traversed 14,834 m as of sol 1816 (3/4/09)
- Traverses have been aligned roughly along MRO ground track, providing a “calibration alley” for comparison of orbital and surface observations

Background

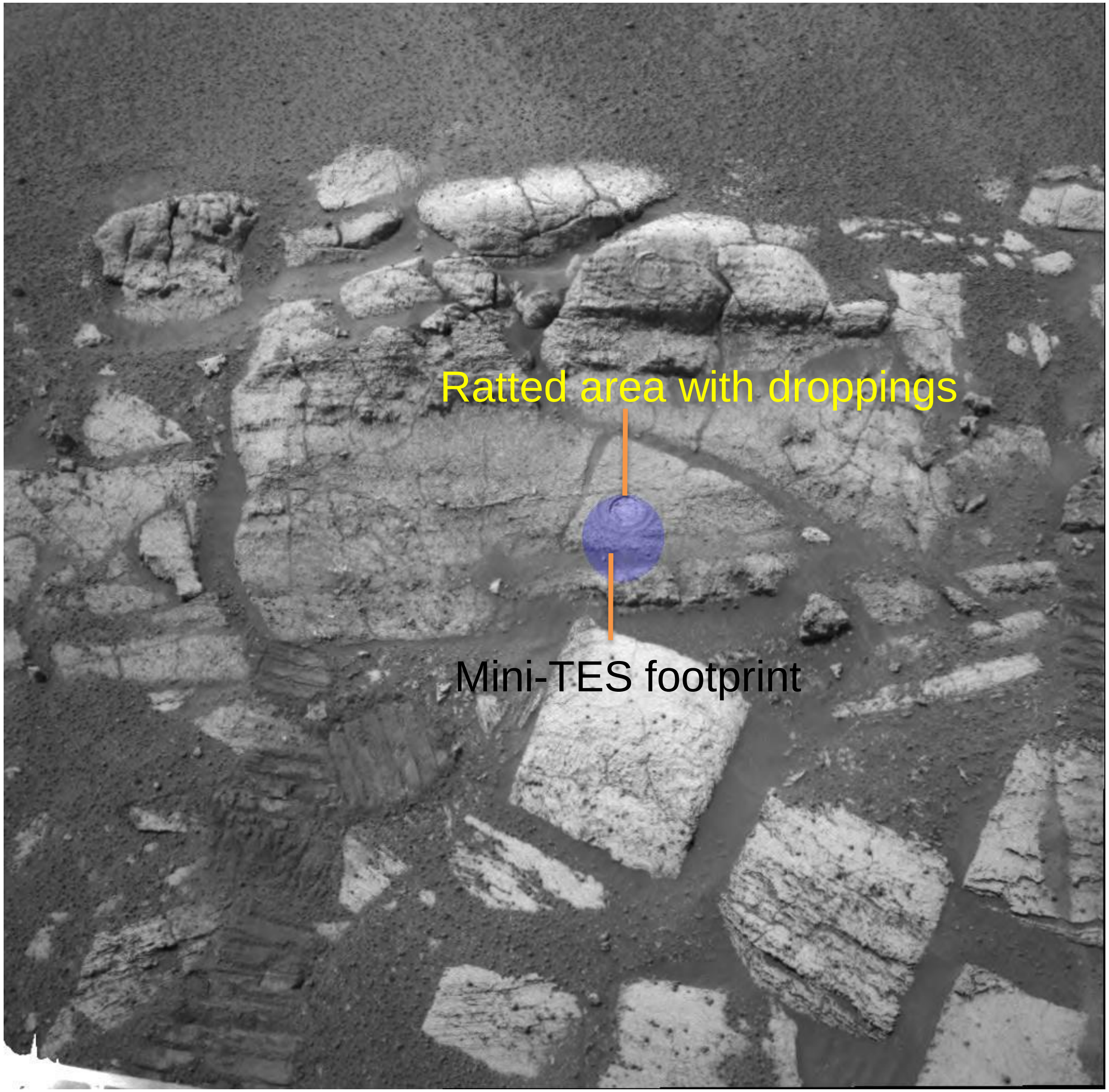
- Opportunity observations are consistent with basaltic sands, hematitic concretions, nanophase iron oxide aeolian cover over altered "dirty evaporite" sulfate-rich bedrock
- OMEGA and CRISM observations of sulfate-dominated bedrock consistent with nanophase iron oxides and ferrous silicates (i.e., electronic transition features)
- OH and H_2O vibrations hidden by alteration rind or coating of dehydrated and SO_3 poor materials

Sol 36 McKittrick
Pancam Image

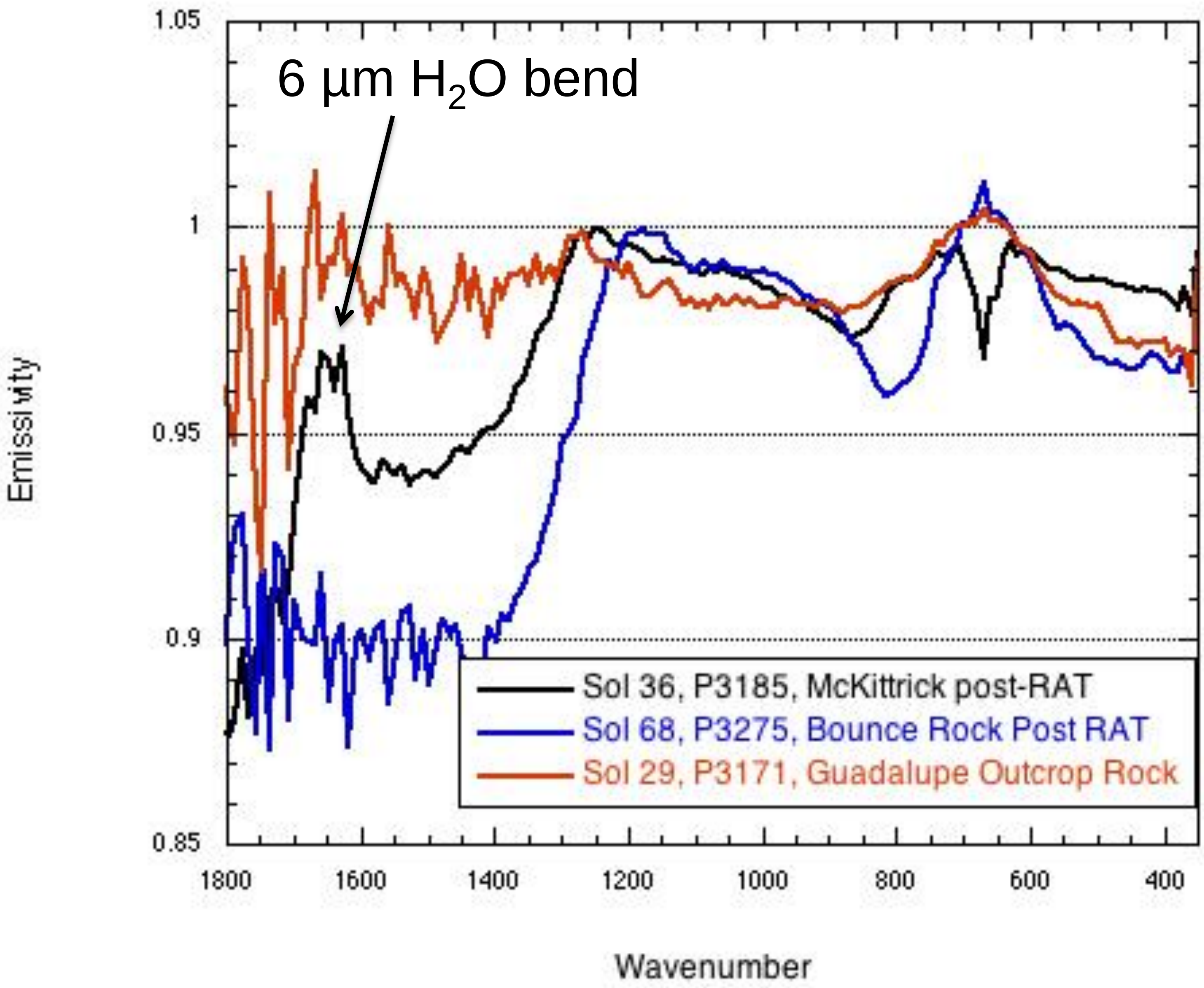
- APXS data show systematic changes from undisturbed, brushed, and ratted surfaces

- Mini-TES sees 6 µm H_2O bending vibration only for ratted surfaces

- Surface is coated or altered, hiding H_2O and OH vibrational modes

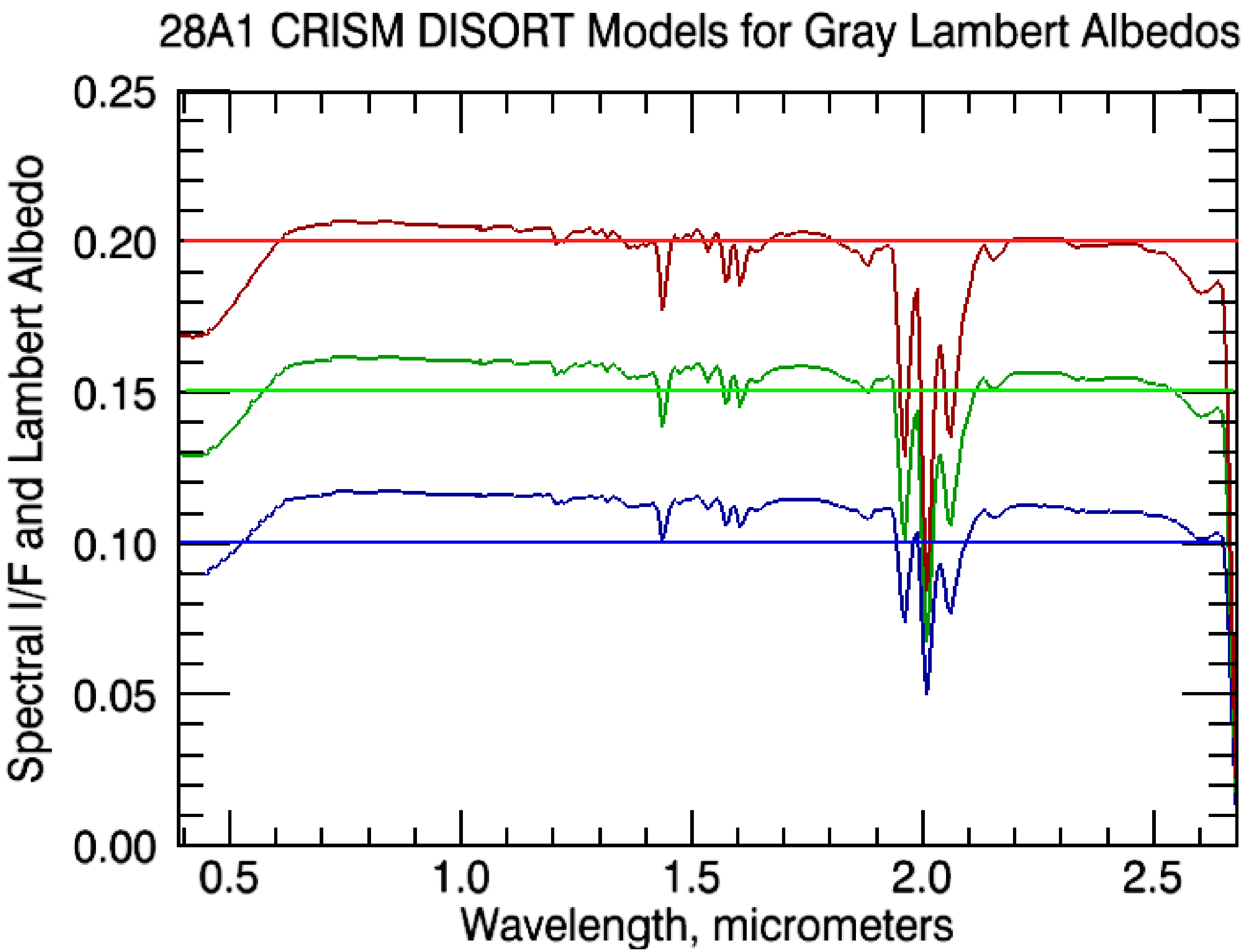


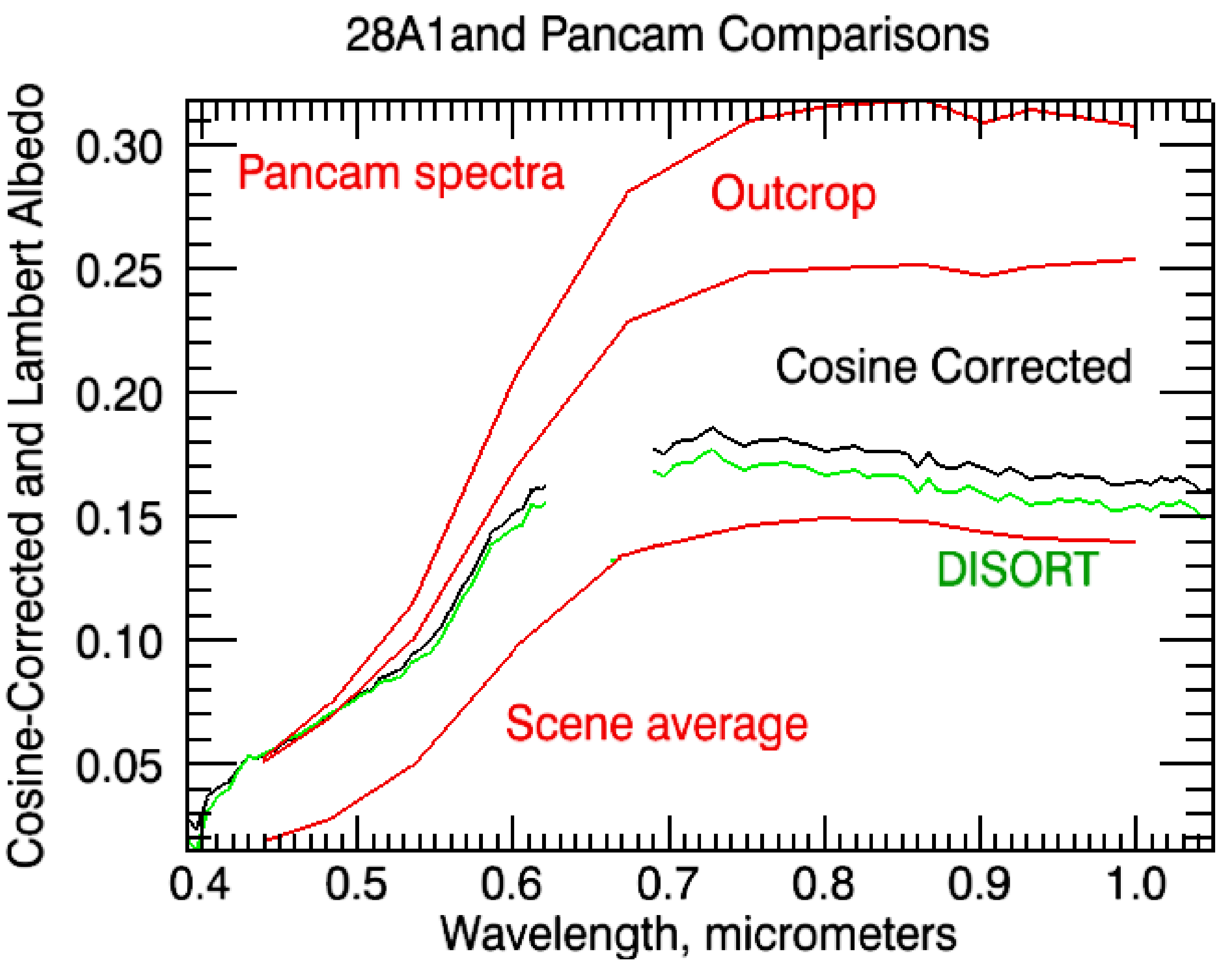
Mini-TES Data



Retrieving Surface Reflectance From CRISM FRT Data

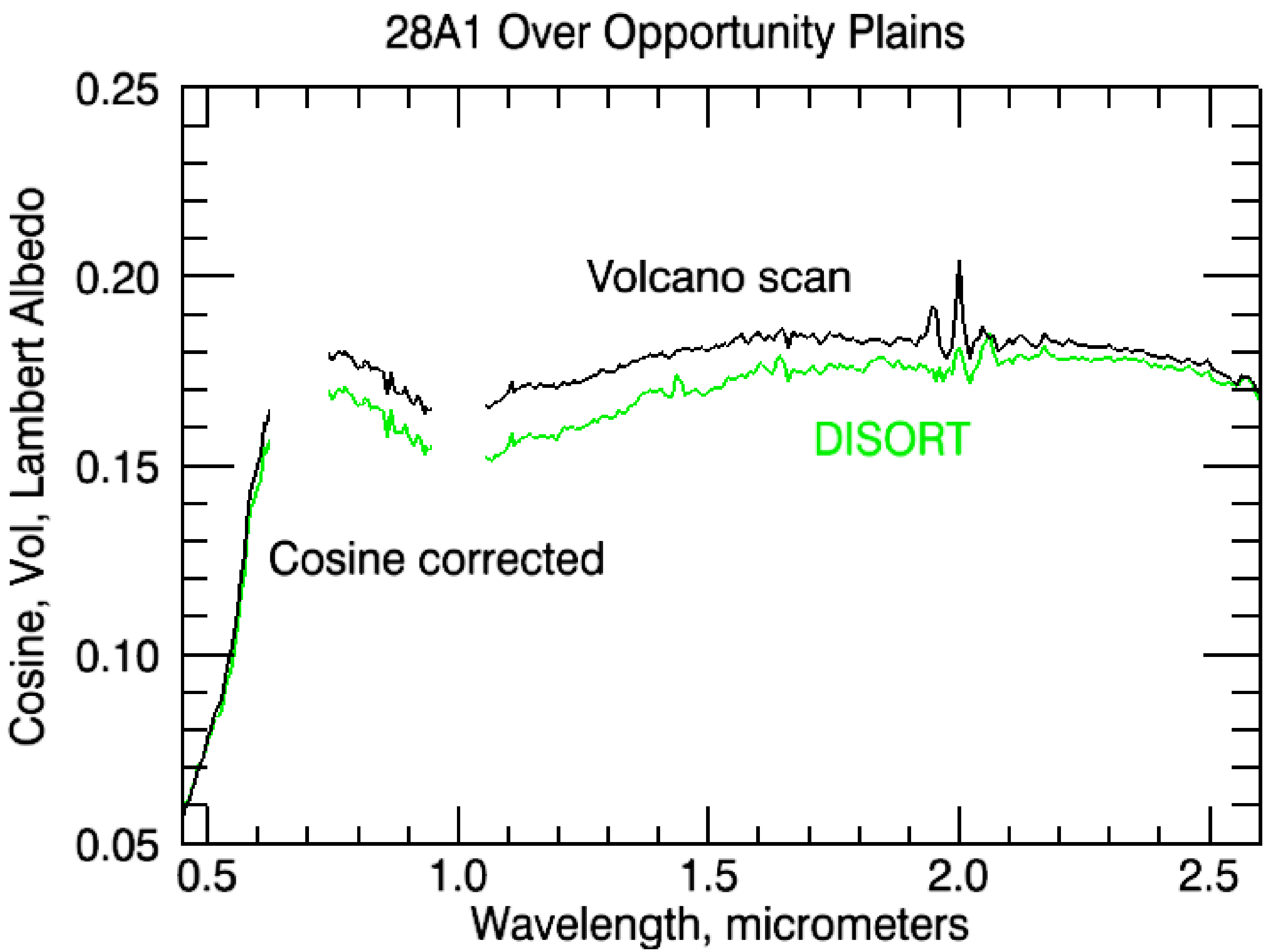
- Volcano-scan method uses gas transmission spectrum derived from observations over volcanoes
- DISORT uses radiative transfer computations to solve for surface Lambert Albedo
  - Use historical observations and Pancam and Mini-TES data to constrain optical depth and temperatures and lighting and viewing conditions for FRT 28A1


28A1 CRISM DISORT Models for Gray Lambert Albedos
Spectral I/F and Lambert Albedo
0.25
0.20
0.15
0.10
0.05
0.00
0.5
1.0
1.5
2.0
2.5
Wavelength, micrometers

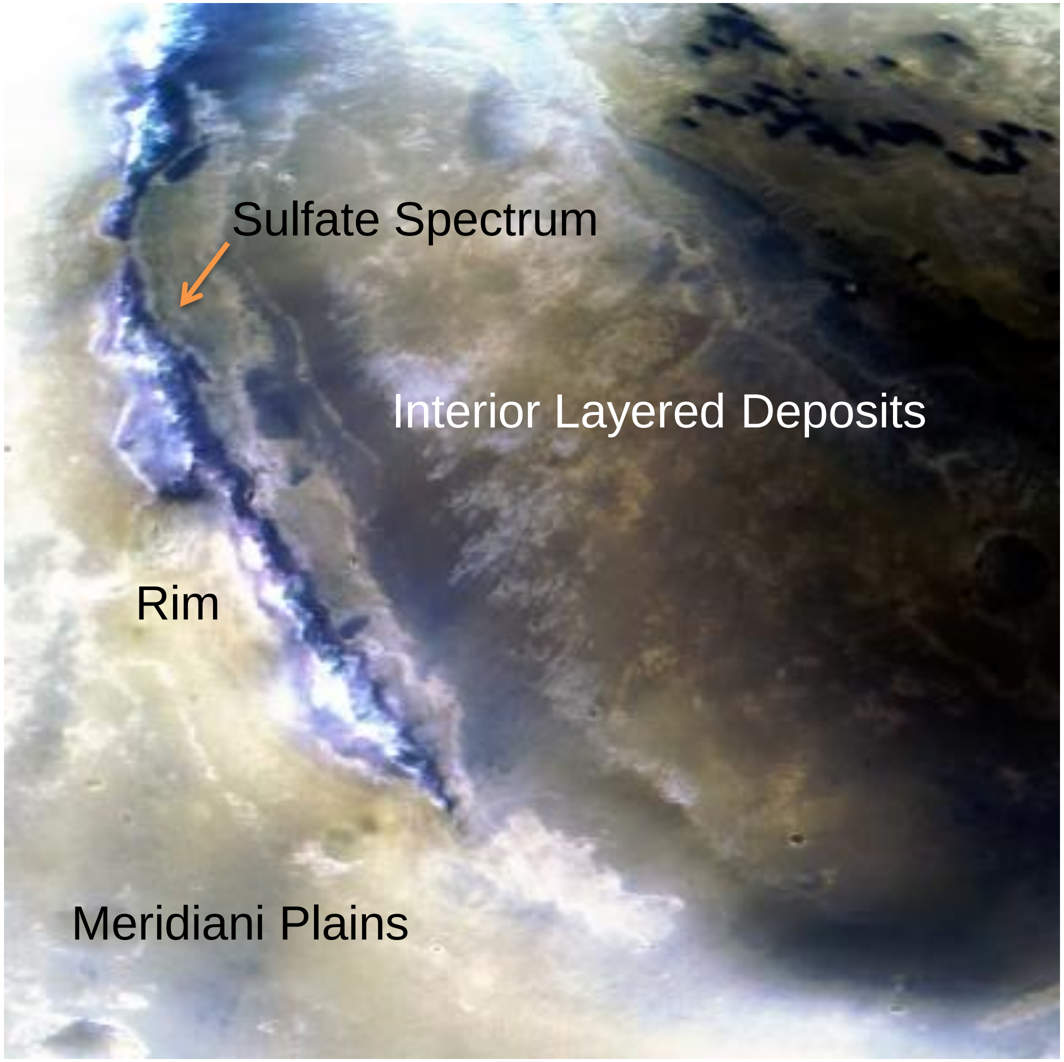


- DISORT removes aerosol radiative contributions, lowering spectral amplitude

Spectra Consistent with Presence of Nanophase Iron Oxides and Ferrous Silicates

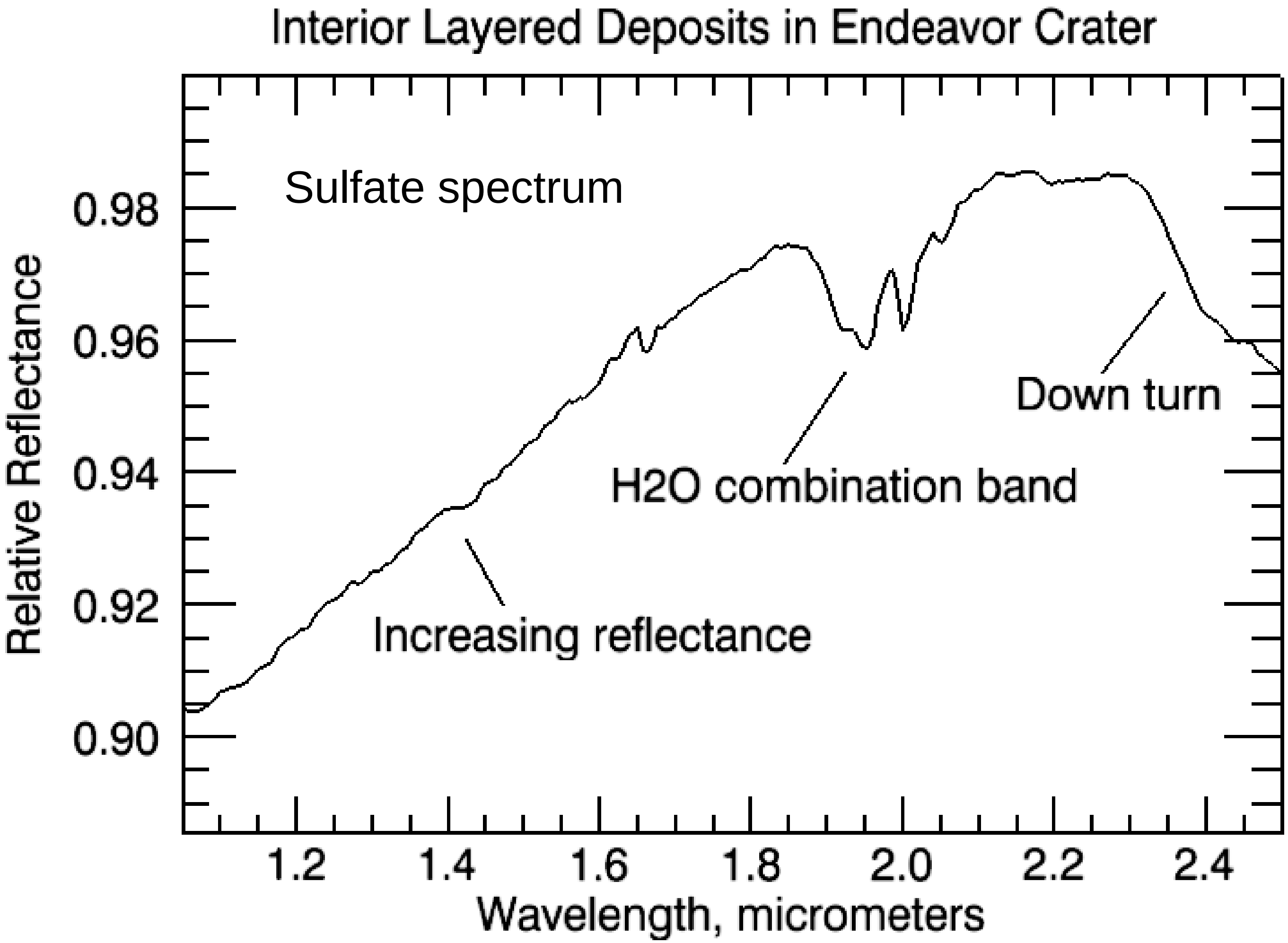


FRT 8541 Endeavor False Color Image



- Portion of frame showing interior layered deposits and rim

- Blue=1.1521 micrometers
- Green=1.7172
- Red=2.3509


Interior Layered Deposits in Endeavor Crater
Sulfate spectrum
Down turn
H2O combination band
Increasing reflectance
0.98
0.96
0.94
0.92
0.90
Relative Reflectance
1.2
1.4
1.6
1.8
2.0
2.2
2.4
Wavelength, micrometers

Summary

- Used CRISM and Opportunity observations jointly to develop self-consistent model for surface materials examined by rover-based instrumentation
- Rover-based atmospheric and surface measurements used to test radiative transfer methods for retrieval of surface reflectance and comparison to Volcano Scan corrections
- Although coating or rind has obscured OH and H_2O signatures in bedrock, Opportunity is on its way to Endeavor where hydrated sulfates are exposed without obscuration

References

- Arvidson, R. E., F. Poulet, R. Morris, J.-P. Bibring, J. Bell III, S. Squyres, P. Christensen, G. Bellucci, B. Gondet, B. Ehlmann, W. Farrand, R. Fergason, M. Golombek, J. Griffes, J. Grotzinger, E. Guinness, K. Herkenhoff, J. Johnson, G. Klingelhofer, Y. Langevin, D. Ming, K. Seelos, R. Sullivan, J. Ward, S. Wiseman, M. Wolff, 2006, Nature and Origin of the Hematite-Bearing Plains of Terra Meridiani Based on Analysis of Orbital and Mars Exploration Rover Data Sets, *J. Geophys. Res.*, 111, E12S08 doi: 10.1029/2006JE002728.

- Murchie, S. L., R. Arvidson, P. Bedini, K. Beisser, J.-P. Bibring, J. Bishop, J. Boldt, P. Cavender, T. Choo, R.T. Clancy, E. H. Darlington, D. Des Marais, R. Espiritu, D. Fort, R. Green, E. Guinness, J. Hayes, C. Hash, K. Heffernan, J. Hemmler, G. Heyler, D. Humm, J. Hutcheson, N. Izenberg, R. Lee, J. Lees, D. Lohr, E. Malaret, T. Martin, J. A. McGovern, P. McGuire, R. Morris, J. Mustard, S. Pelkey, E. Rhodes, M. Robinson, T. Roush, E. Schaefer, G. Seagrave, F. Seelos, P. Silverglate, S. Slavney, M. Smith, W.-J. Shyong, K. Strohbehn, H. Taylor, P. Thompson, B. Tossman, M. Wirzburger, and M. Wolff, 2007, CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) on MRO (Mars Reconnaissance Orbiter), *J. Geophys. Res*., 112, E05S03, doi: 10.1029/2006JE002682.

- Squyres, S. W., R. E Arvidson, D Bollen, J. F. Bell III, J. Brückner, N. A. Cabrol, W. M. Calvin, M. H. Carr, P. R. Christensen, B. C. Clark, L. Crumpler, D. J. Des Marais, C. d'Uston, T. Economou, J. Farmer, W. H. Farrand, W. Folkner, R. Gellert, T. D. Glotch, M. P. Golombek, S. Gorevan, J. A. Grant, R. Greeley, J. Grotzinger, K. E. Herkenhoff, S. Hviid, J. R. Johnson, G. Klingelhöfer, A. H. Knoll, G. Landis, M. Lemmon, R. Li, M. B. Madsen, M. C. Malin, S. M. McLennan, H. Y. McSween, D. W. Ming, J. Moersch, R. V. Morris, T. Parker, J. W. Rice, Jr., L. Richter, R. Rieder, C. Schröder, M. Sims, M. Smith, P. Smith, L. A. Soderblom, R. Sullivan, N. J. Tosca, H. Wänke, T. Wdowiak, M. Wolff, A.Yen, 2006, Overview of the Opportunity Mars Exploration Rover Mission to Meridiani Planum: Eagle Crater to Purgatory Ripple, *J. Geophys. Res.*, 111, E12S12, doi: 10.1029/2006JE002771.