Mars Surface Compositional Units from the HRSC Color Data

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Goal and Approach

- Determine number and type of compositional units visible with HRSC color data.
- Use photometric properties of the data.
- Determine detailed data characteristics by analyzing example scenes.
- Use spatial and spectral aspects: color images and spectra for each pixel.

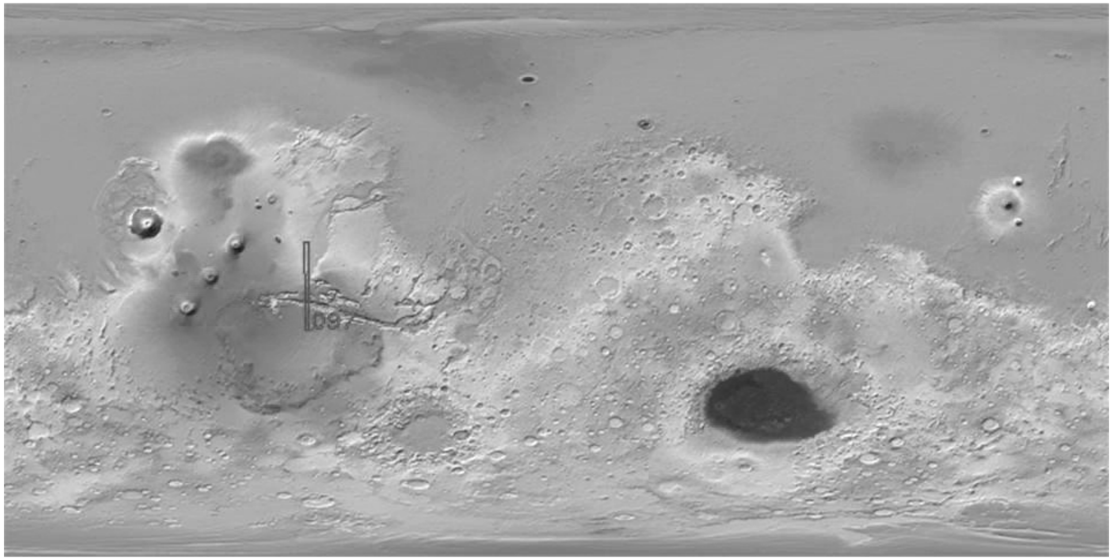
Focus this talk on

Surface Unit Composition Analysis

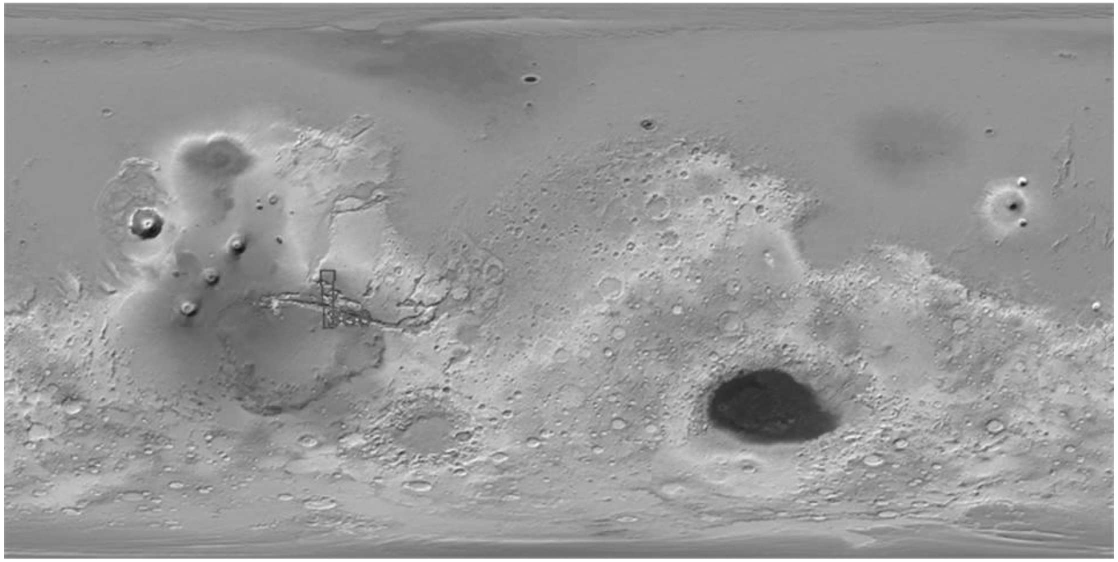
Number and extent of compositional units?

HRSC Data Sets Used

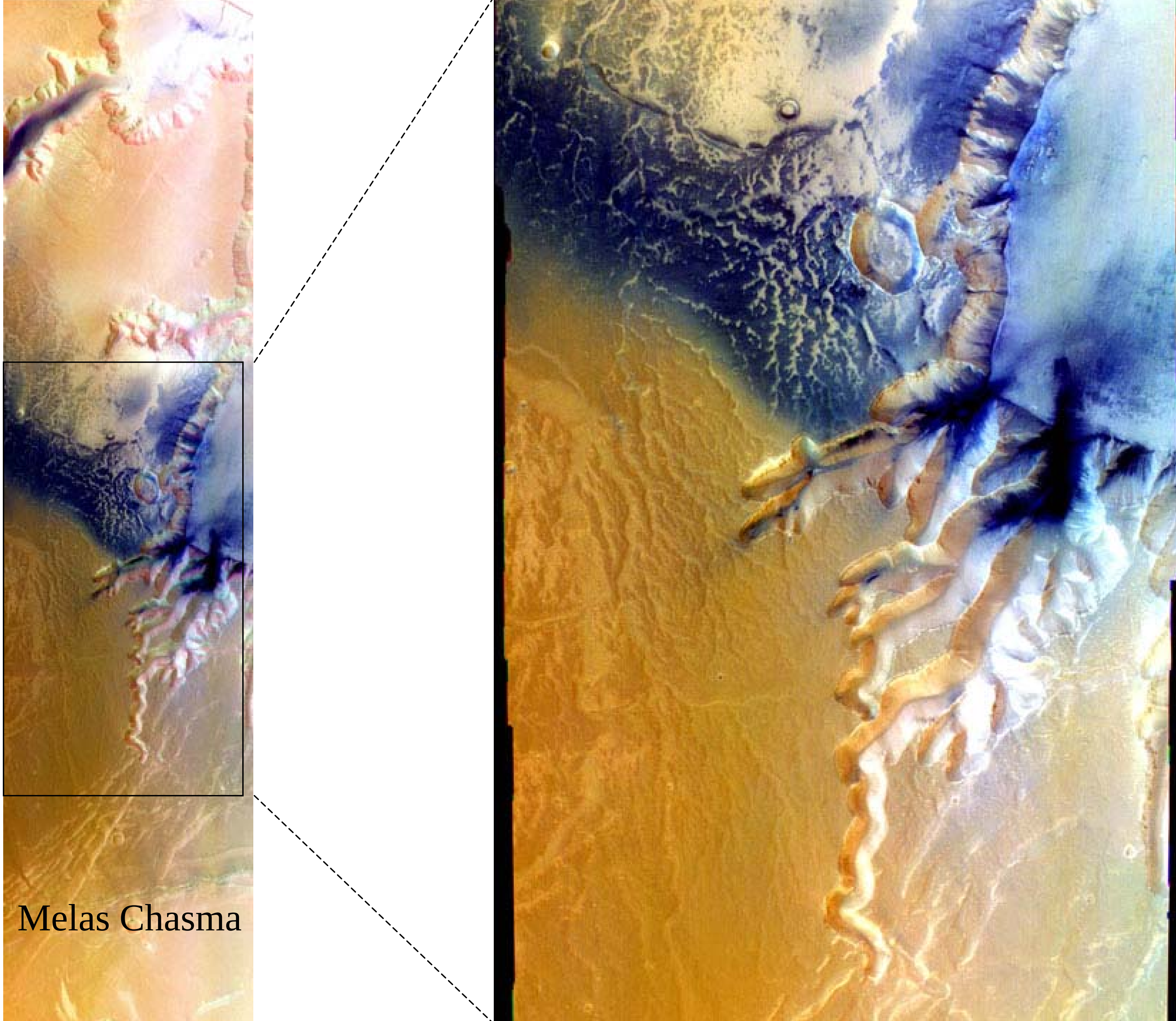
- Orbit 0097



- Orbit 0360

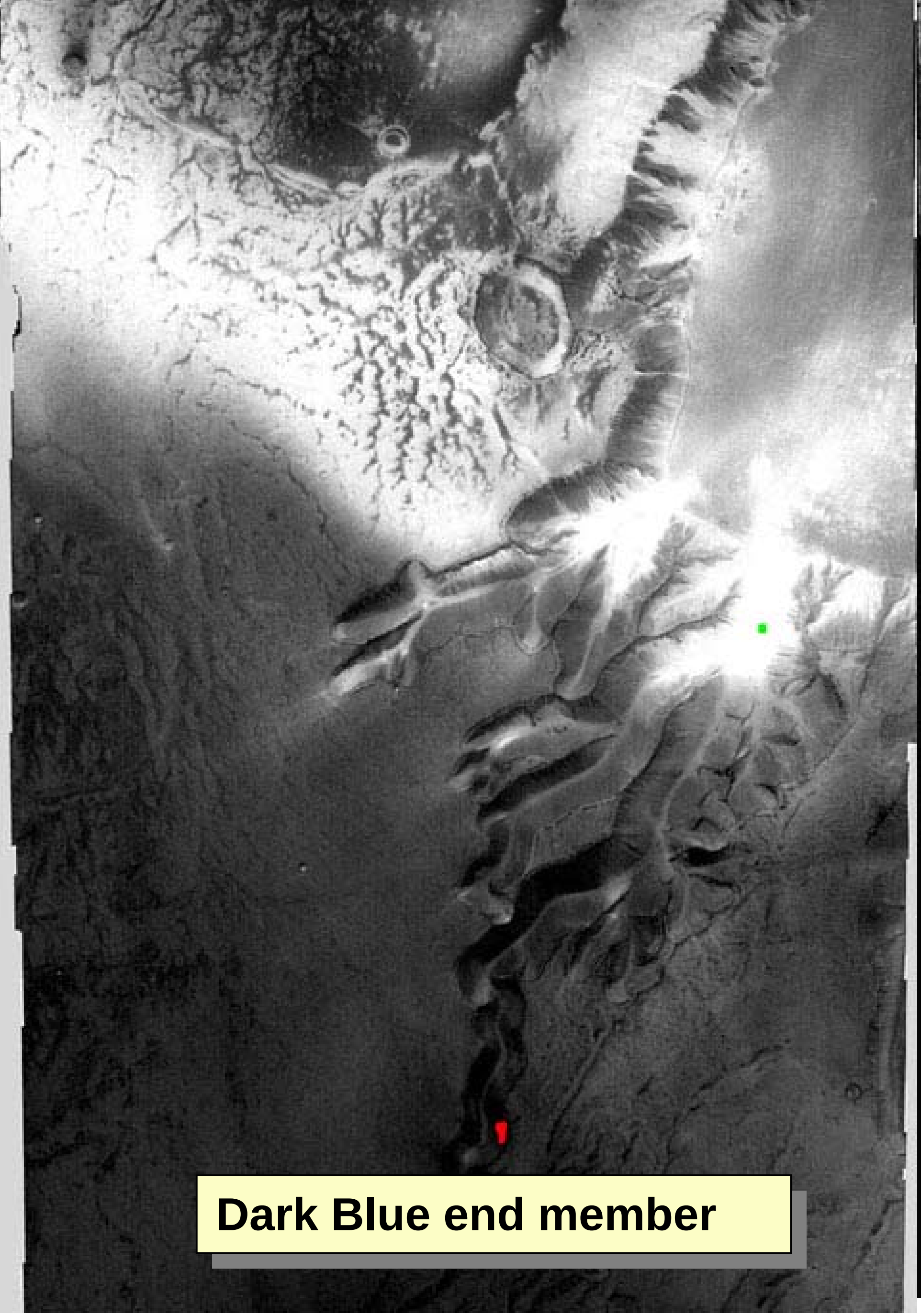


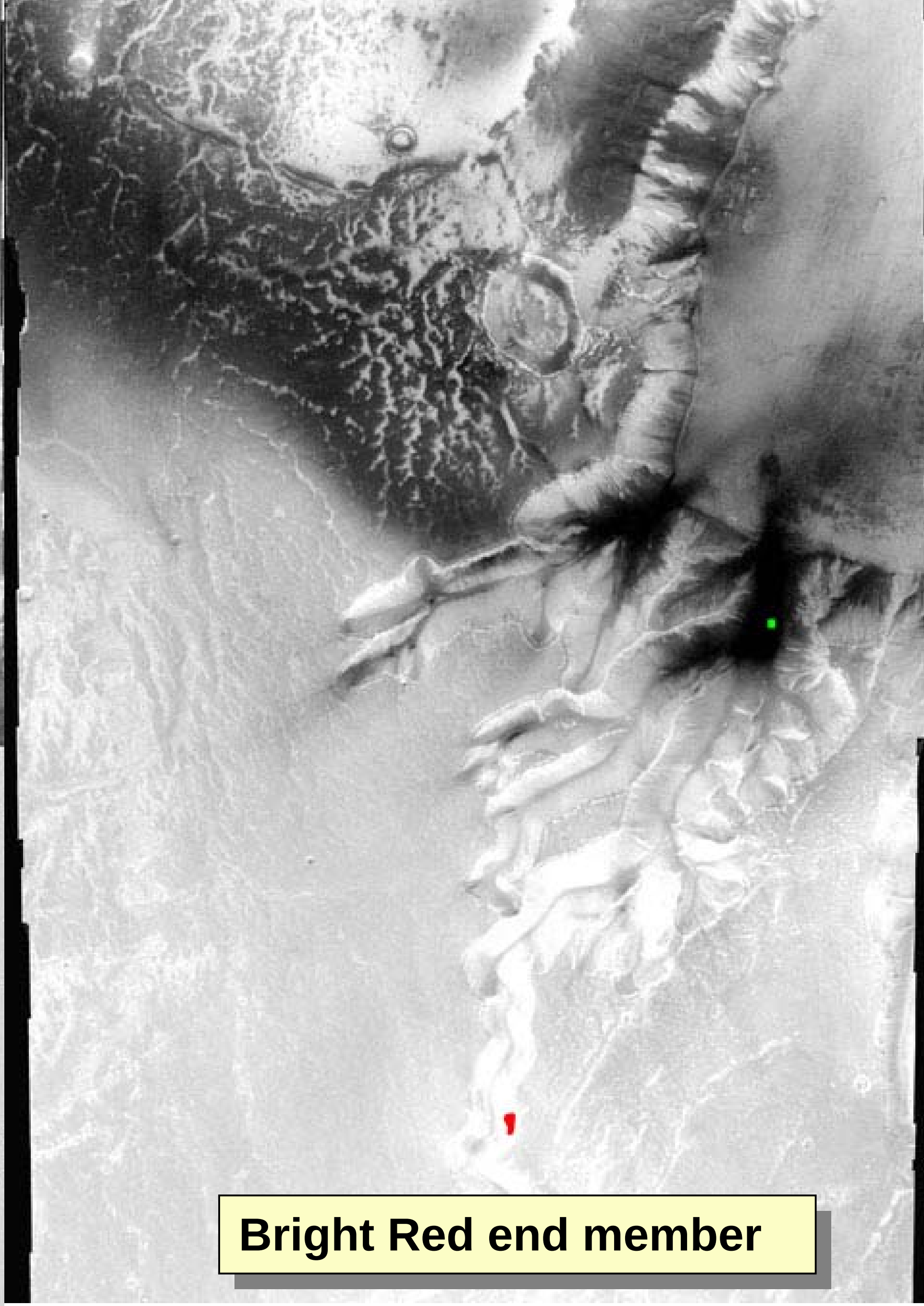
Orbit
0097



Spectral Mixing Analysis (SMA)

- **The two compositional end-members found and used**
  - Bright red exposed on plains and slopes below cliffs
  - Dark “blue,” really less red. Darkest patches.
- **Shade end-member**
  - Shadows
  - Sub-pixel surface roughness
  - Slope photometric function effects
- **The Residual**
  - Mis-registration at sharp edges
  - Faint striping and other “noise” effects
  - Missed, compositional units and shade components


Dark Blue end member


Bright Red end member

shade end member

Bright = less shade (inverted display)

Dark material less textured, less shadowed (smoother).

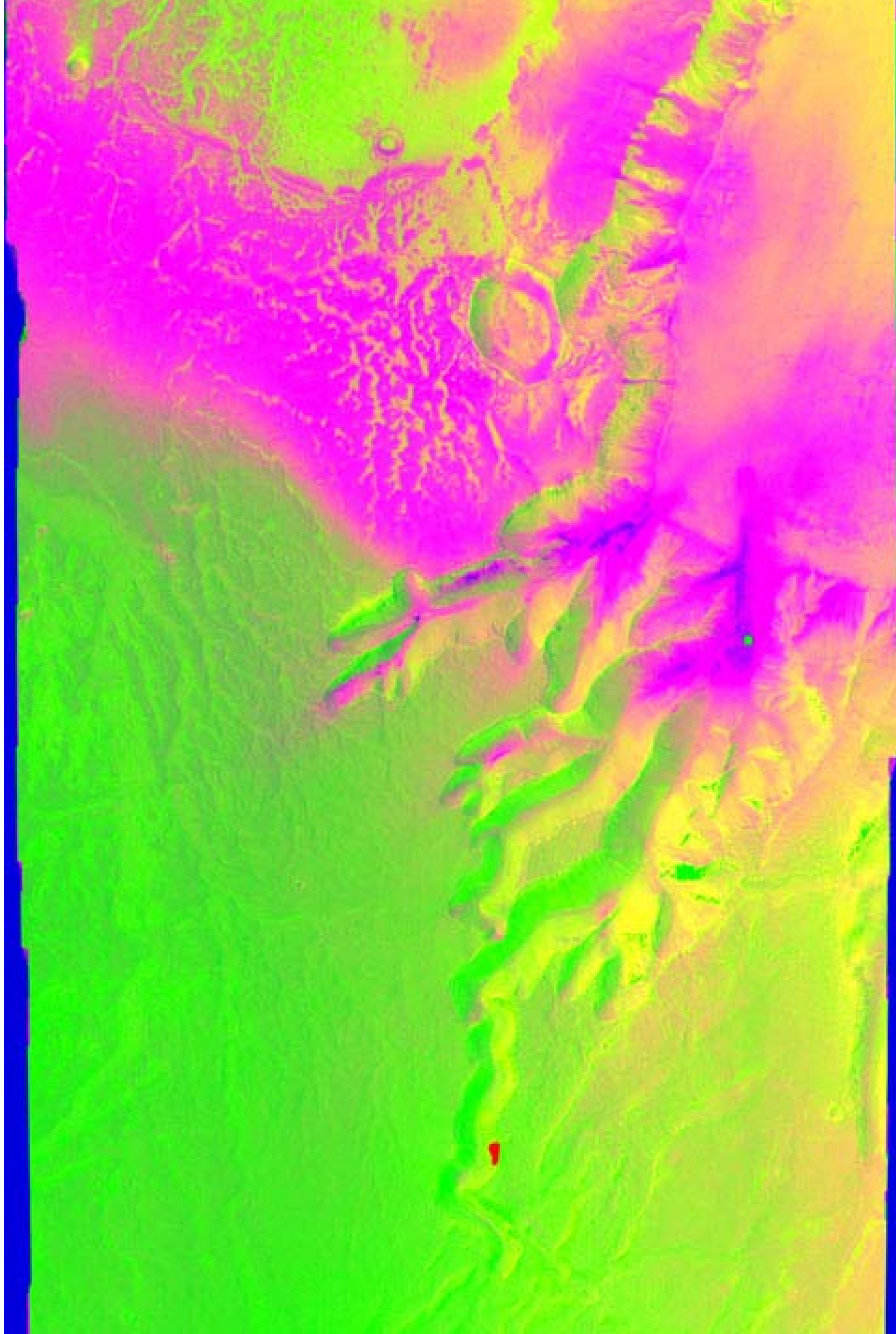
Lower-left red plains may be like rock-strewn plains of Viking and MER.

Combined Endmembers

* Shows mixing:
  R = Shade end member
  G = Bright red end member
  B = Dark blue end member

* Light magenta = less shadowed (smoother) blue material.

* Orange (right) = mixing of blue material (B) and smooth red material (R).



Spectral Analysis Conclusions

- All image analyses consistent with just two basic spectral components.
  - “red” material and “blue” material
  - No convincing evidence for other components in this scene.
- Both components exist in light and dark varieties.
- Topographic shading (photometric function) and roughness superimpose lightness and darkness.
- All components are mixed spatially and spectrally.
  - So difficult to separate by color composite or ratio images.

Geologic Interpretation

- Red material
  - exposed in canyons as ledges and talus slopes
  - forms extensive plains areas.
- “Blue” (dark) material concentrated
  - in protected valleys and low areas.
  - on linear features and cones.
  - overlays red material in all areas.

Geologic Interpretation

- Dark material consistent with volcanic ash deposits
  - Source in linear and cone features.
  - Light version extends farther from the dark source areas ==> fine ash.
  - Deposits relatively young, mobile and thin.
  - Deposits have less “shade component” and apparently are smoother.

Geological Scenario

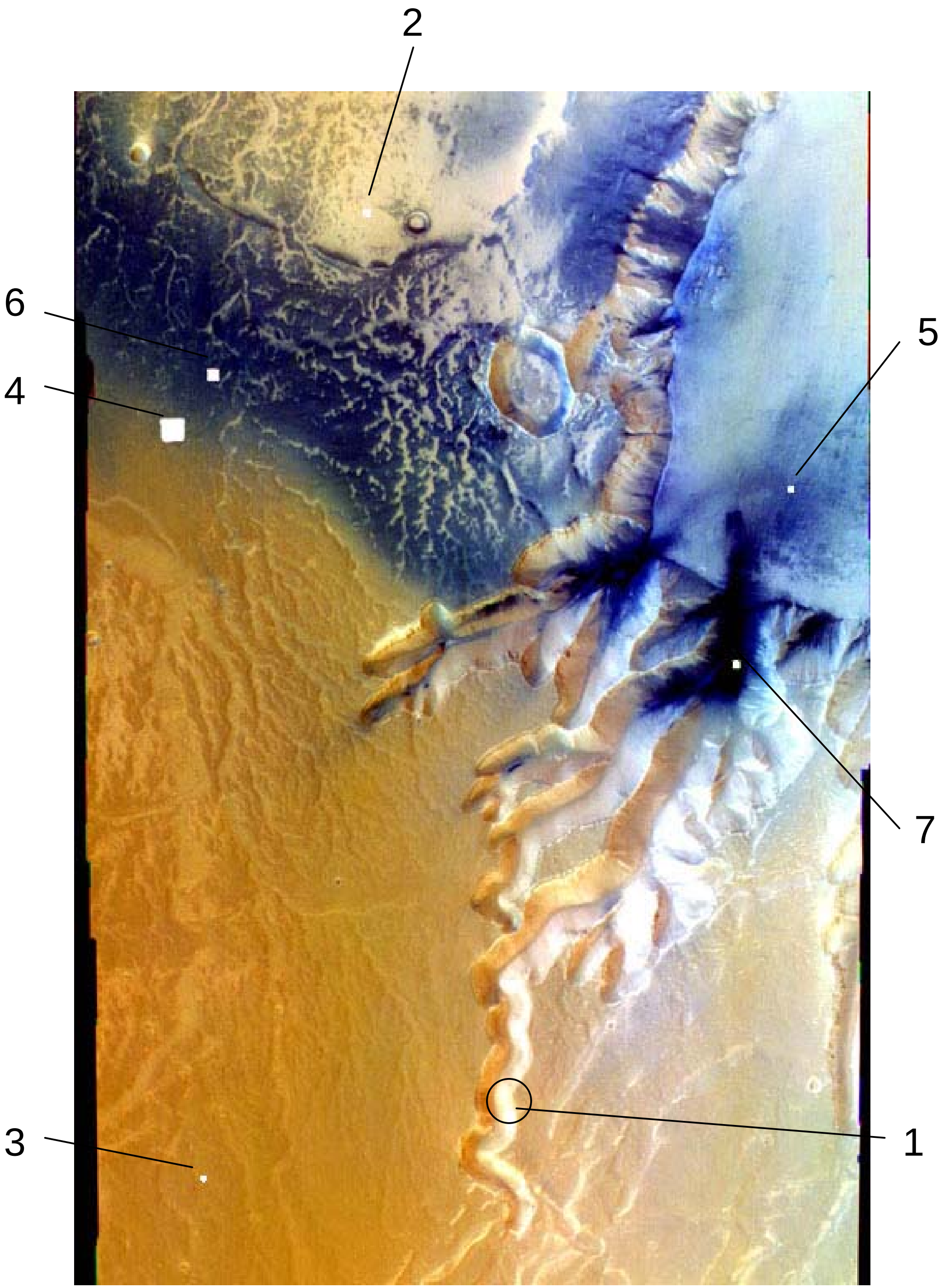
- Old cratered surface (NW) broken by down-dropped block (E) and eroded to form sinuous channels.
- Volcanism activated at margins of the dropped block and faults/cones.
- Extensive volcanism spreads ash over large areas with thick deposits locally.
- Ash deposits redistributed by wind.

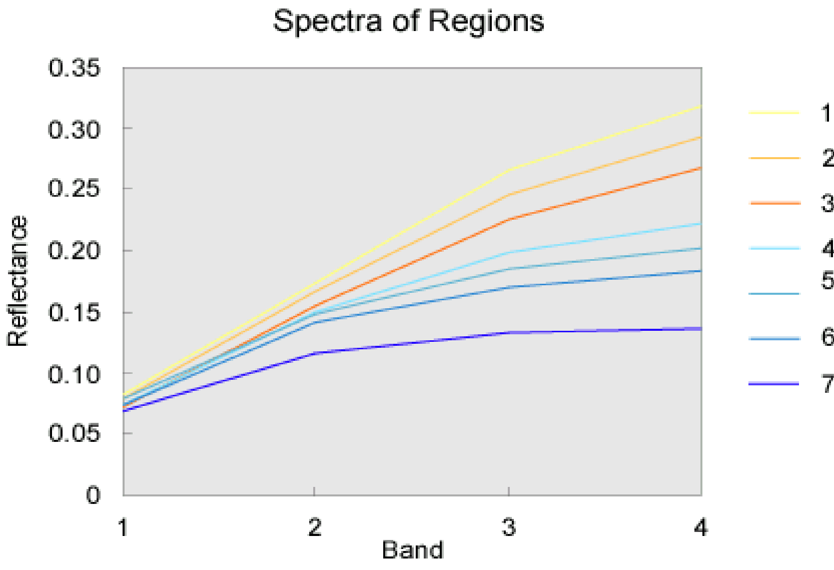
Derive Spectra
Problem = Atmosphere Contributions

- Model the atmosphere effects.
  - Use radiation transfer models
  - Use Viking and MER surface measurements
- *Adams et al*. reported that Viking Lander color data had to be corrected for an atmosphere red irradiance; confirmed by MER.
- Use calibration targets on the surface
  - No man-made cal target has been deployed.
  - Assume knowledge of at least one material on the surface and use laboratory analog spectra.

Derive Spectrum Corrections

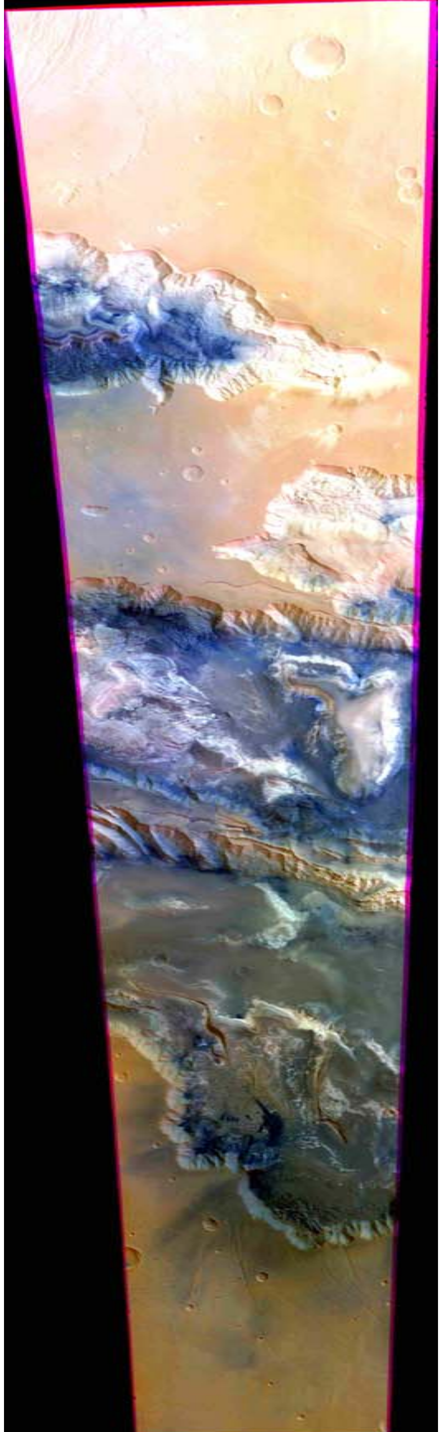
- Darkest material is assumed to be unoxidized basaltic tephra.
- Derive correction to HRSC color data using laboratory spectra.

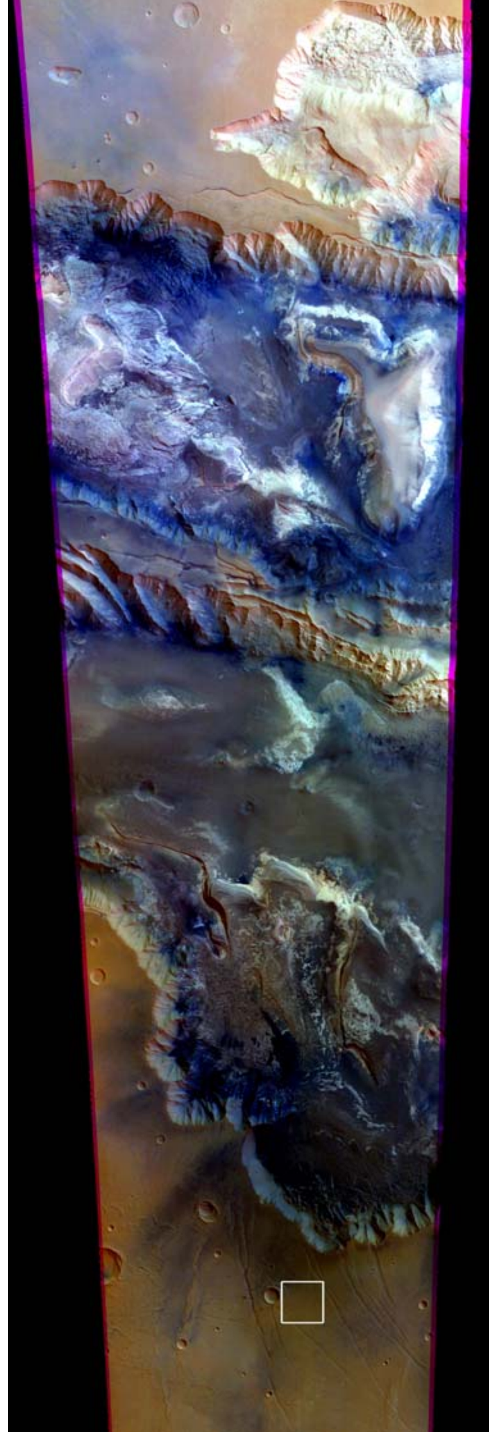




Resulting atmosphere-corrected spectra appear reasonable.

More work on this is needed.

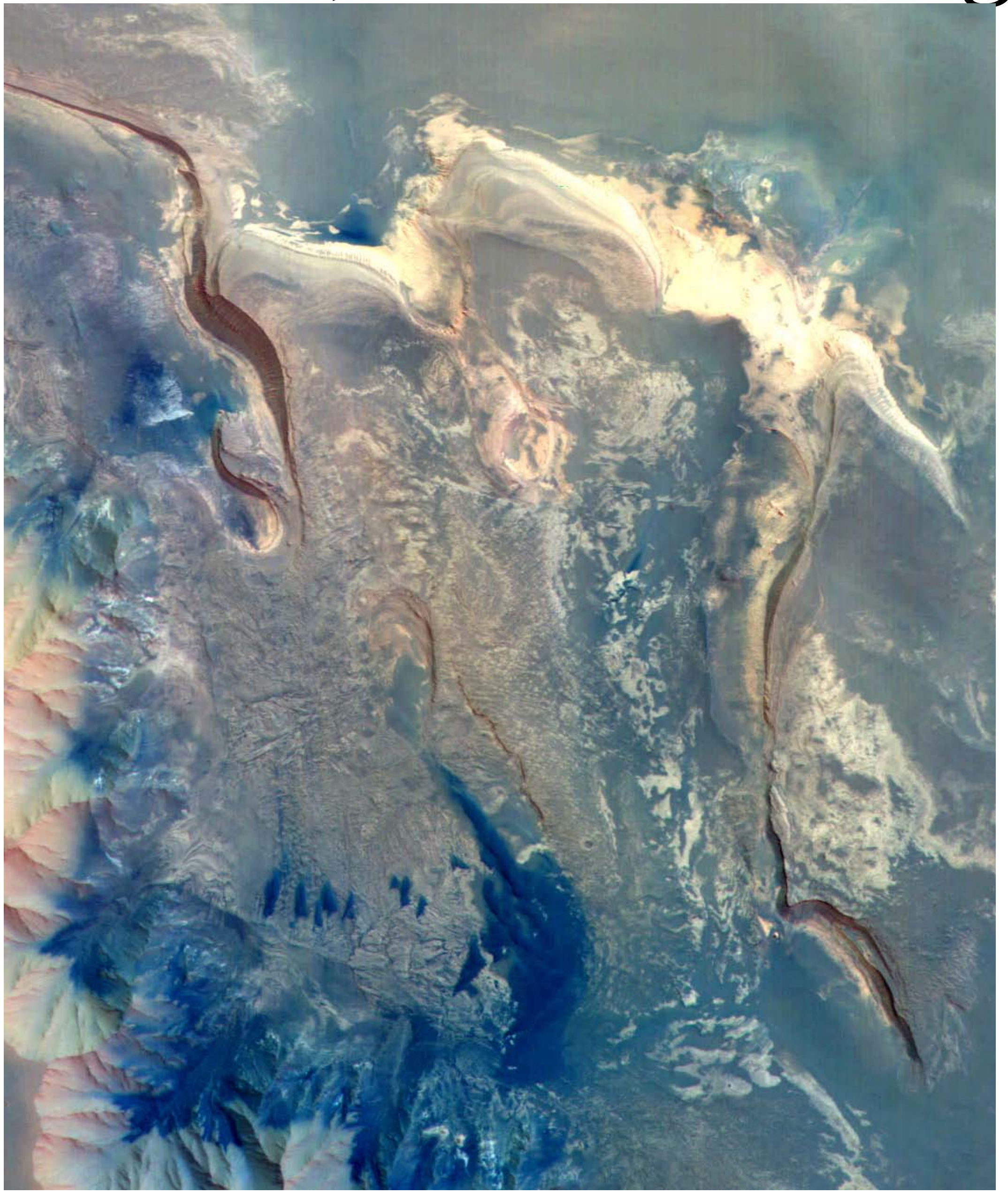




Orbit 360

Hebes Chasma,
Ophir Chasma
Candor Chasma
and
Melas Chasma.

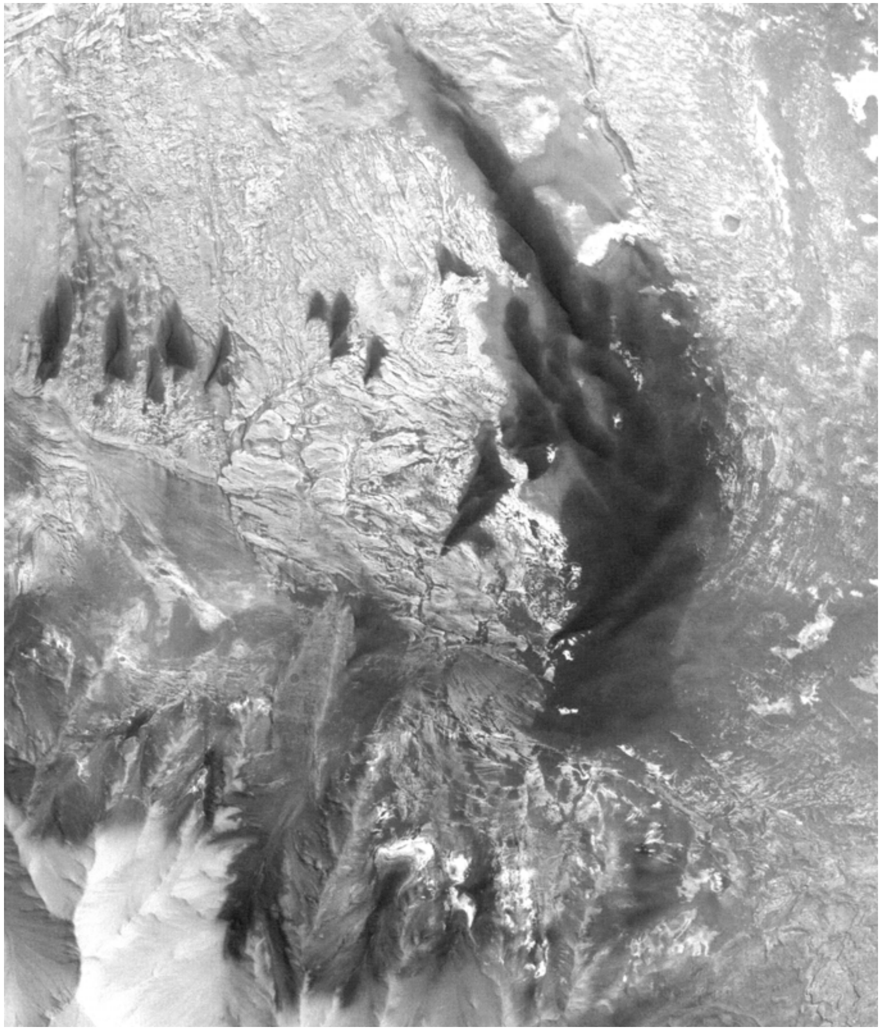
Orbit 360 - Red, Dark and Bright Units

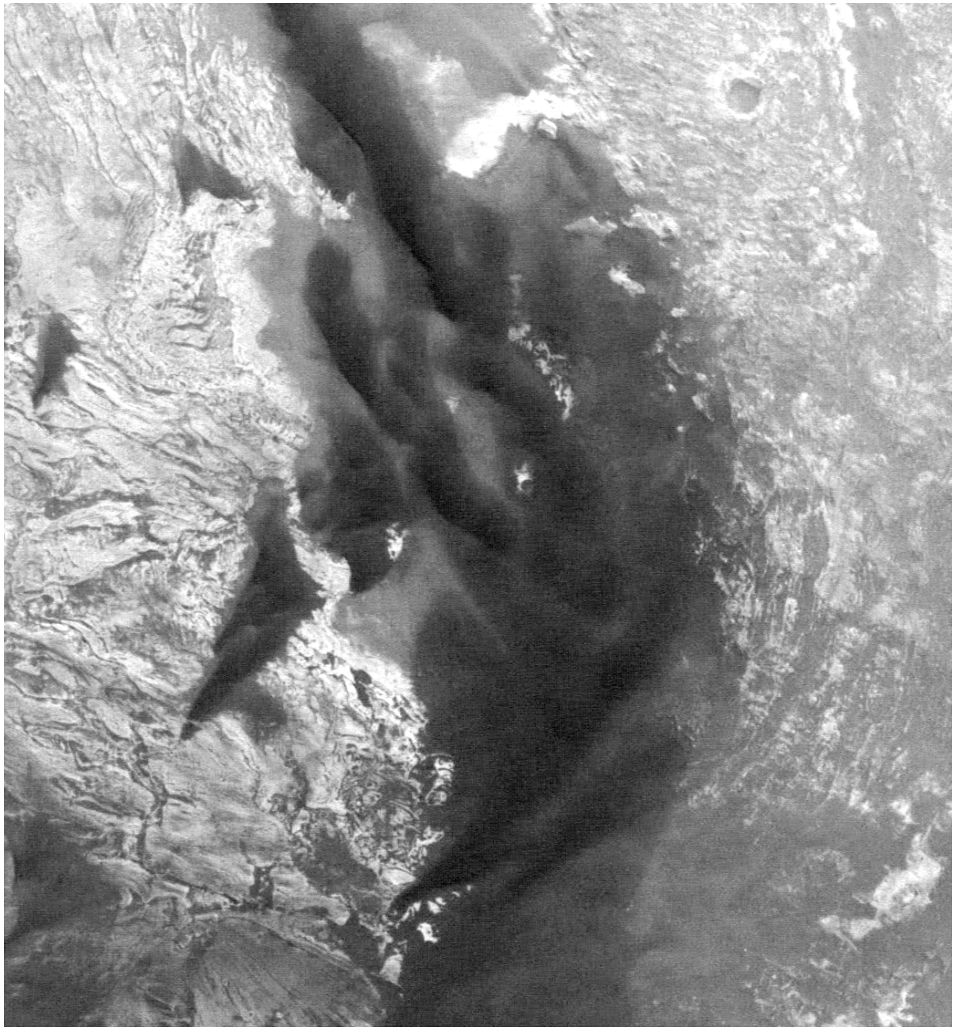


Three End-Members

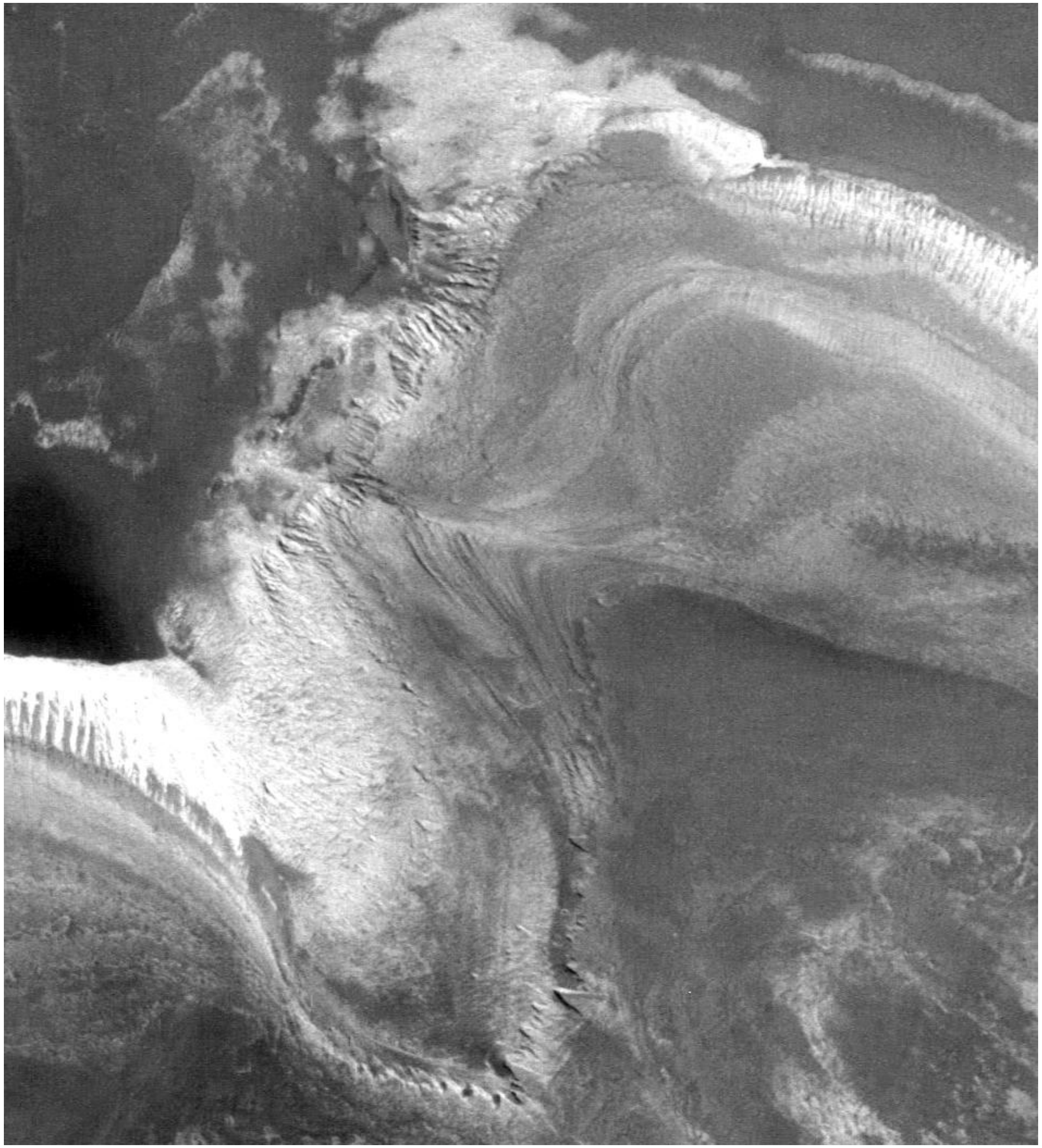
- Bright red material (iron oxide-rich dust)
- Dark, almost gray material (basalt)
- Brighter, less red material (“white”) (salts)
- Shade (shadows and roughness)

Dark Material

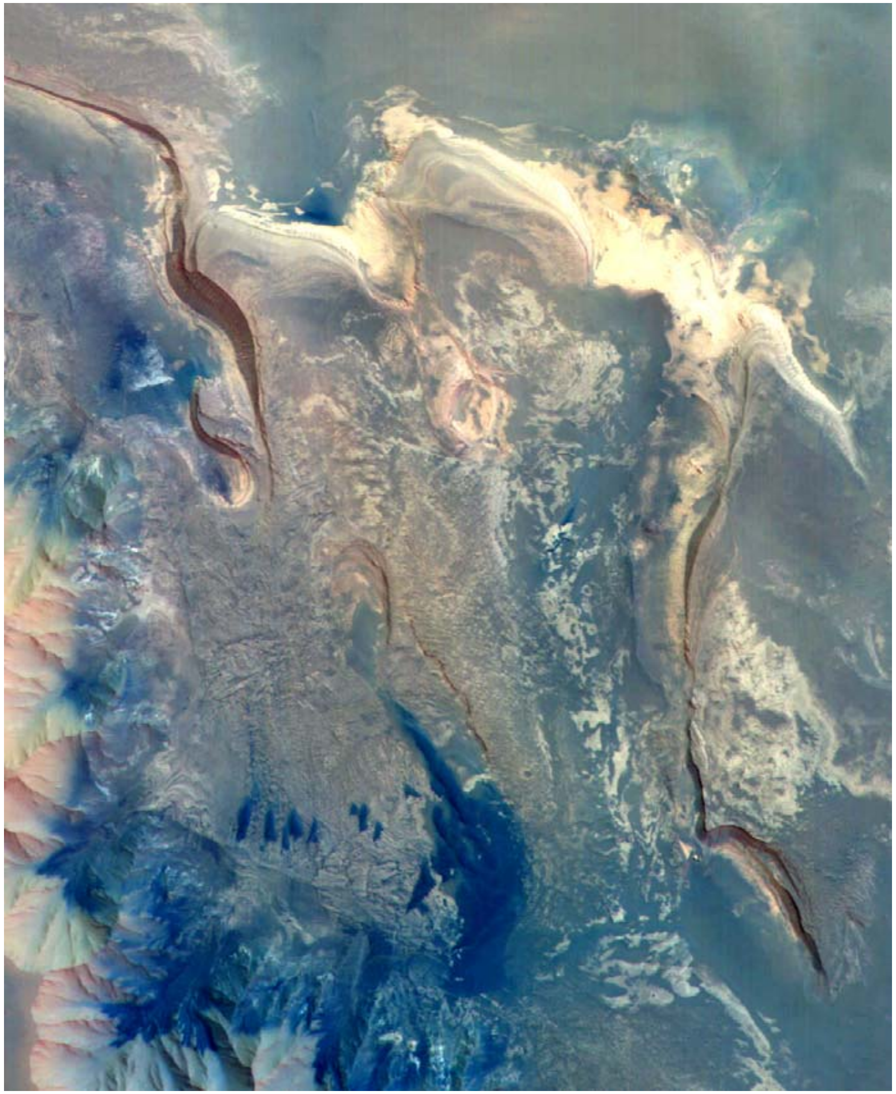




Bright Material

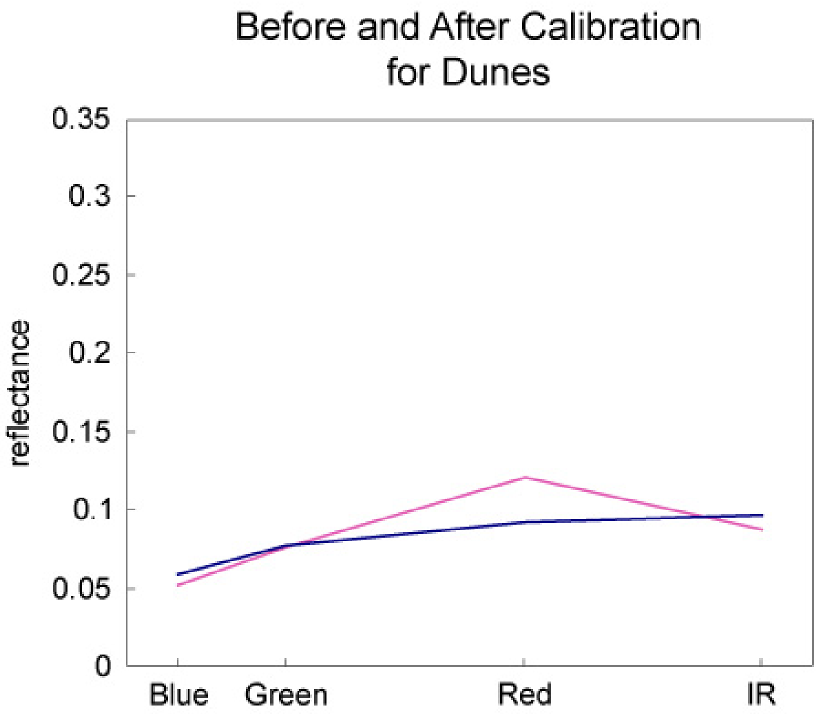


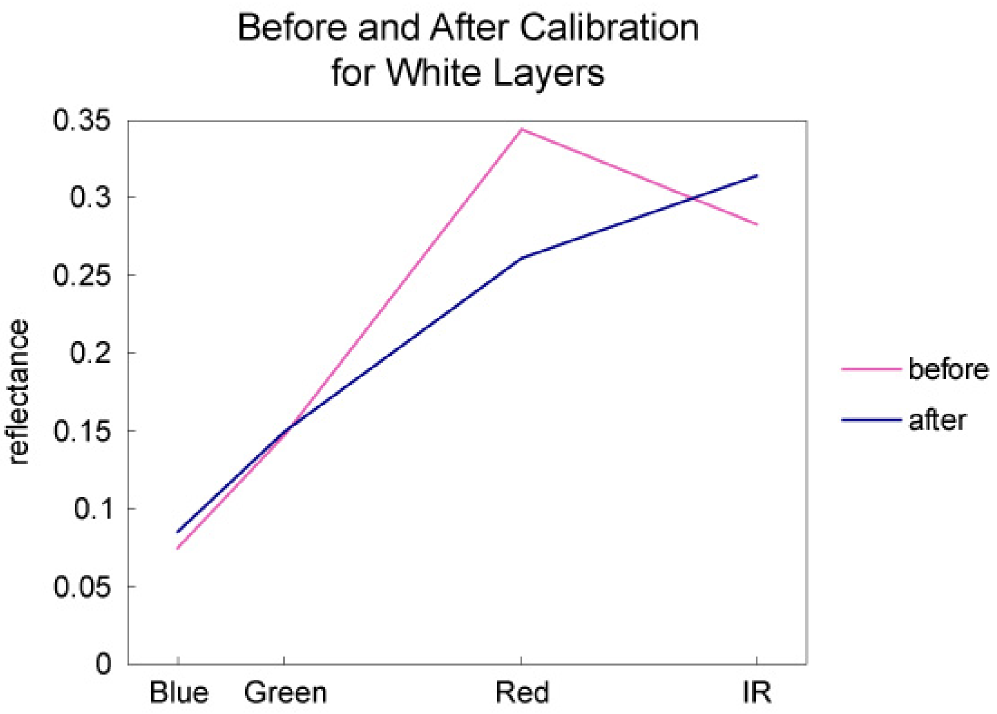
Shade Endmember



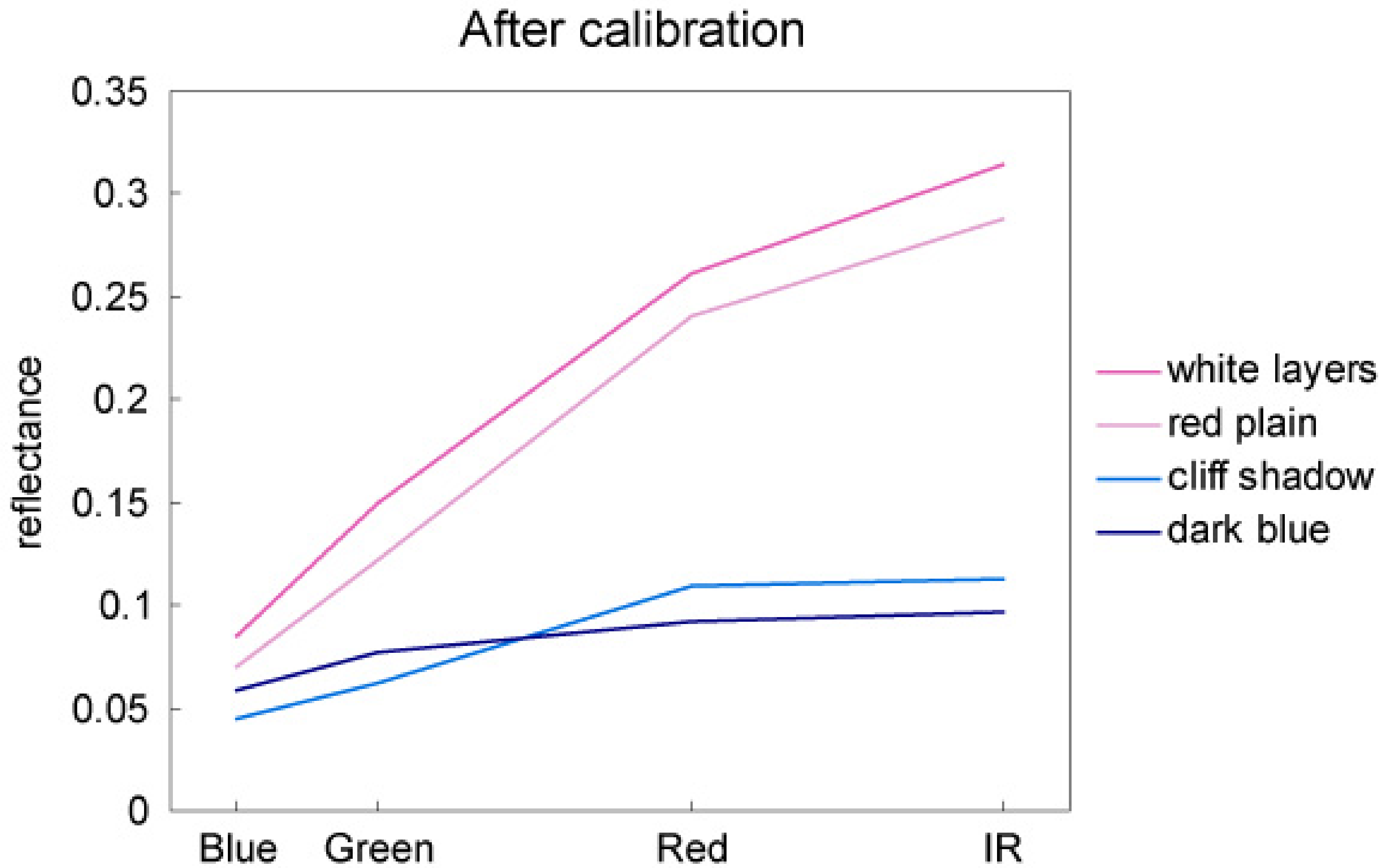
- Bright = less shade.
- All materials mix with shade: Topo shading and shadowing.

Spectra: before and after





- Spectra corrections very similar to those found for orbit 097.


After calibration
reflectance
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Blue
Green
Red
IR
white layers
red plain
cliff shadow
dark blue

Geology

- The rims of the Chasma are all hard rock layers that correspond to Hesperian age lava flows.
- Canyon walls below the rims are “soft” in that there are no ledges of hard rock that resist erosion like the rims.
- Dark materials are most abundant near the base of the cliffs, and there are clear contacts between lighter and darker layered materials in many places.
- Light and dark layers that can be traced throughout the image and beyond.

Geology (cont’d)

- Dark material has “leaked” out of the cliffs, and has moved downhill along channels and puddled in low areas.
- Dark material is (was) mobile, and is volcanic ash that dewatered upon exposure at the cliff face.

Geology (cont’d)

- The layered deposits in the Chasmas are not consistent with lava flows.
- They are consistent with multiple layers of volcanic ash (tephra).
- Ash and sulfate salts can occur together, so there may well be salts mixed in with the ash.
- Thus, our HRSC results are consistent with *Jack Mustard’s* spectra and with *Montgomery and Gillespie’s* (JGR, in press) salt dewatering hypothesis.

Geology (cont'd)

- The layered deposits inside the Chasmas were not deposited after the canyons were formed. They are old (Noachian) deposits.
- Light and dark materials and their mixtures have been blown around since the canyons formed to make dunes and streaks.

The End