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
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
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.
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.
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