Spectral and Thermophysical Properties of Phobos from the Mars Global Surveyor Thermal Emission Spectrometer

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• We observe a 6 µm water feature in Mars Global Surveyor Thermal Emission Spectrometer data

• Tantalizing suggestion of finely-mixed secondary phase (carbonate?) in regolith

• Phyllosilicates, as suggested by previous authors, may explain mid-IR spectral observations
3 µm band depth limited to < 5-10%

Rivkin et al. (2002), with assists from Murchie and Erard (1996) and Murchie et al. (1999).
VNIR SPECTROSCOPY

- 3 µm band depth limited to < 5-10%
- Weak 2.8 µm M-O-H band in CRISM data

Fraeman et al., 2014
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Weak 2.8 µm M-O-H band in CRISM data

No 1 or 2 µm features, but weak 0.65 µm feature consistent with desiccated Fe-phyllosilicate or Fe⁰ particulates embedded in a neutral matrix.

Best spectral analogs are red, low albedo asteroids (C, D, P, and T-class) and metamorphosed CI/CM chondrites

Fraeman et al., 2014
• Silicate Christiansen and transparency features; Restrahlen bands

Giuranna et al., 2011
- Silicate Christiansen and transparency features; Restrahlen bands
- CF position consistent with phyllosilicates and/or feldspathoids
- Feldspars best match for Phobos red unit spectra—inconsistent with Fraeman et al. observations

Giuranna et al., 2011
NEW LOOK AT OLD DATA

- Michelson interferometer: 6 TO 50 µm in 143/286 bands
- Thermal bolometer: 5 to >100 µm
- Visible/Near-IR reflectance: 0.3 to 3 µm
- 3x5 km spatial resolution
- Nadir-to-limb viewing
- Uncooled pyroelectric (DTGS) detectors
- NEDT @ 270K AND 10 µm: 0.1 K

Mars Global Surveyor
Thermal Emission Spectrometer (TES)
NEW LOOK AT OLD DATA

- > 9 year mission at Mars
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- 4 (!) orbits with observations of Phobos
- 1 orbit (ock 551) with close flyby of day-time side
NEW LOOK AT OLD DATA

• Several hundred observations from OCK 551
• Downselect to only observations with $T > 240$ K
• Project TES footprints using knowledge of TES boresight and MGS distance from Phobos
  • Different pointing than shown in Giuranna et al., 2011
TES DATA FEATURES

- 88 spectra with $T_{\text{bol}} > 240$ K
- Radiance spectra fit with 3 blackbodies of different temperatures to calibrate emissivity
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• Emissivity minima at ~460, 820, and 1015 cm$^{-1}$ (21.8, 12.2, and 9.9 µm)
• CF is broad, centered at ~1130 cm$^{-1}$ (8.85 µm)
• Short-wavelength “roll-off”, structure, and 1590 cm$^{-1}$ (6.3 µm) feature
• Use factor analysis and target transformation (FATT) to assess short-wavelength structure
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• Poor fit to rest of MIR phyllosilicate spectrum
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- Good fit to 6 µm feature and short-wavelength “roll-off”
- Poor fit to rest of MIR phyllosilicate spectrum
- Fit to vacuum-desiccated phyllosilicate provides noisier fit at short wavelengths—still poor fit at long wavelengths
• Average spectrum shows emissivity minima at ~1340 and 1522 cm\(^{-1}\) and a maximum/shoulder at ~1415 cm\(^{-1}\)
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- Similar to martian dust, with ~5% carbonate mixed with silicates.

Bandfield et al., 2003
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Short-wavelength structure well-fit using FATT.
SUMMARY

• Mid-IR data provide important leverage in interpreting the composition, and, therefore origin of Phobos.
• TES data show:
  • Mid-IR stretching and bending modes (~10-20 µm)
  • Broad “ultramafic” CF position at 8.85 µm
  • 6 µm fundamental vibrational mode indicative of H2O
  • Short wavelength structure indicative of carbonate
• Mid-IR data strengthen comparison of Phobos to CI/CM chondrites
  • ~1.5-3% carbonate in mean CM
  • >10% carbonate in Tagish Lake