Evidence for Poorly-Crystalline Aluminosilicates at Mawrth Vallis from TES Models

Liz Rampe, Mike Kraft, Tom Sharp

5th MSL Landing Site Workshop

16 May 2011

School of Earth & Space Exploration
Arizona State University

TIR Spectroscopy Sensitive to Weathering Products

- Weathering causes precipitation of secondary silicates in weathering rinds or coatings
  - TIR spectroscopy sensitive to coating geometry
- Very thin silica coatings dominate TIR spectra [Kraft et al., 2003; Minitti et al., 2007]
- Weathering rinds composed of igneous minerals, thin secondary coatings
  - TIR models overestimate high-silica phases [Kraft, 2009]
- TIR models of mixtures with clay overestimate clay [Rampe et al., 2011]
  - Difficult to quantify weathering products in TIR models

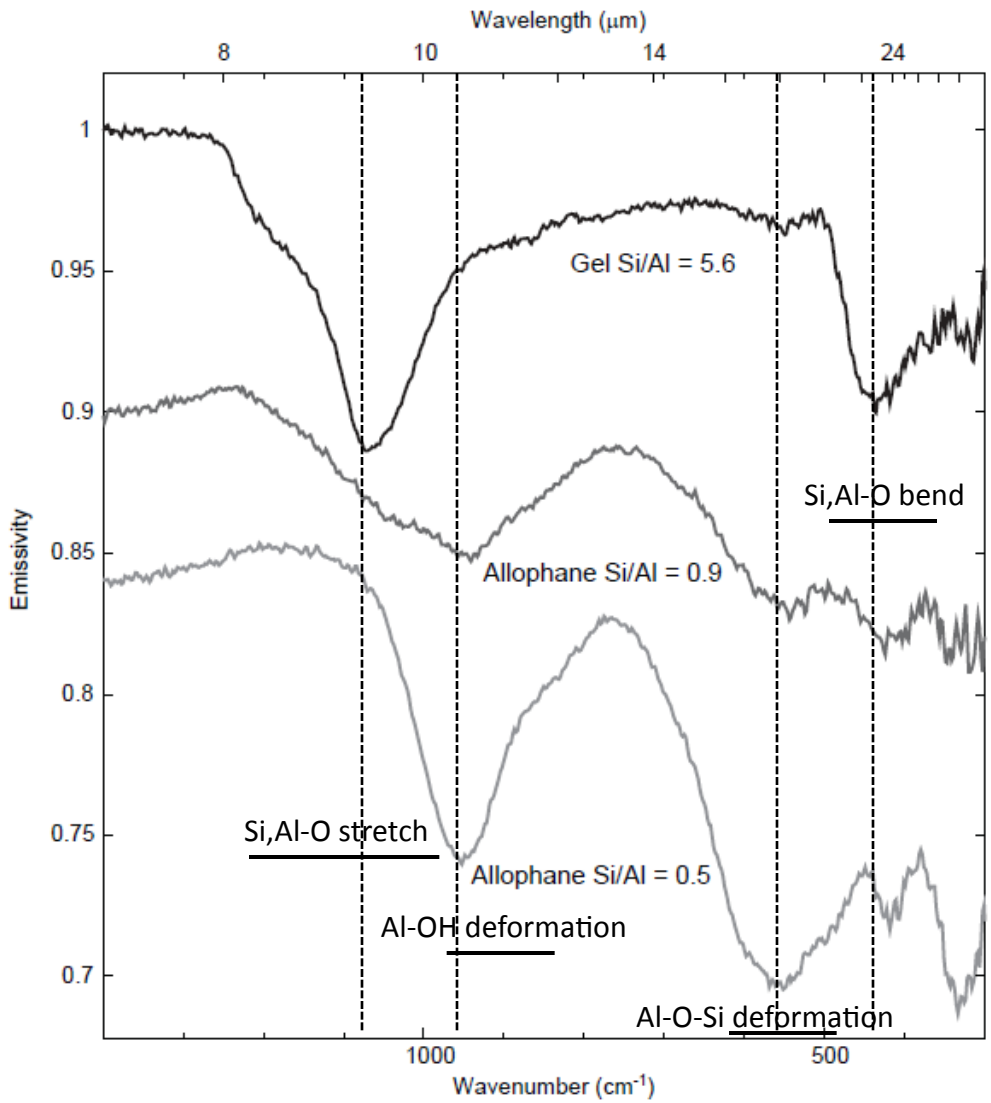
Importance of Poorly-Crystalline Aluminosilicates (PCAs)

- Hydrated, short-range atomic order
- Allophane Si/Al = 0.5-1 [Wada, 1989]
- Common in weathered basalt and soils derived from ash
- Near-neutral to mildly acidic fluids
  - Allophane pH 5-7
- Precursors to clays (kaolinite, halloysite)
  - Volcanic glass → allophane → halloysite → kaolinite
- Structurally similar to clays
  - Expect spectral similarities

3-5 nm

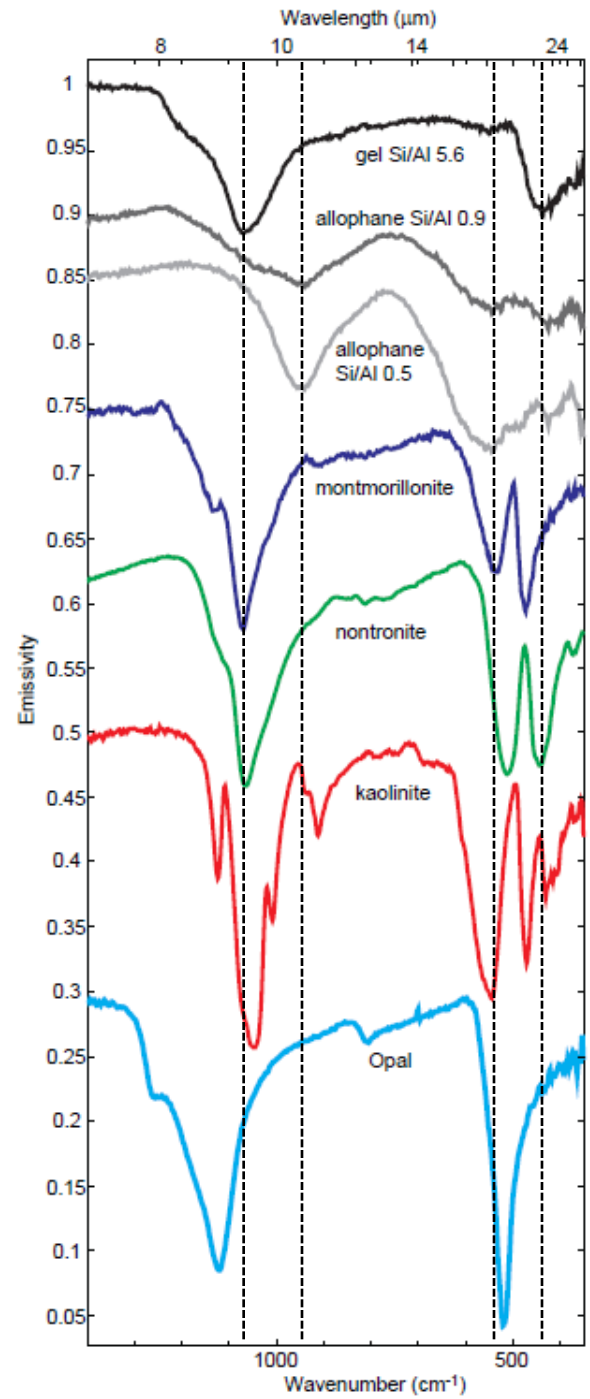
Adapted from Childs et al. [1990]

TIR Spectroscopy of PCAs



Comparing PCAs to Other High-Si Phases

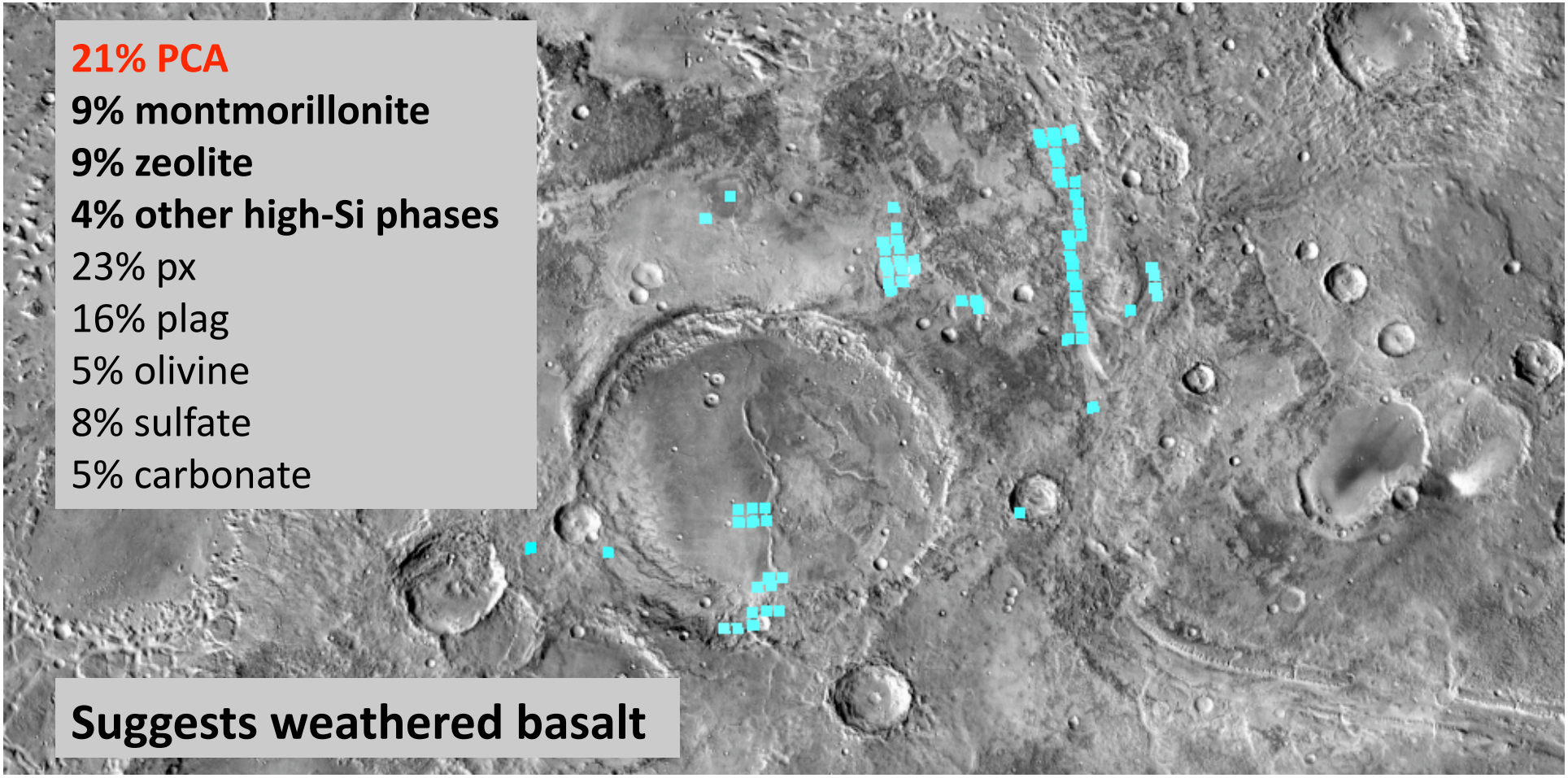
- PCAs different from clays
  - Absorption positions
  - PCA absorptions broader
- Identification in TES models is significant
  - Not replacing spectrally similar materials in models



TES Models of Dark Surfaces

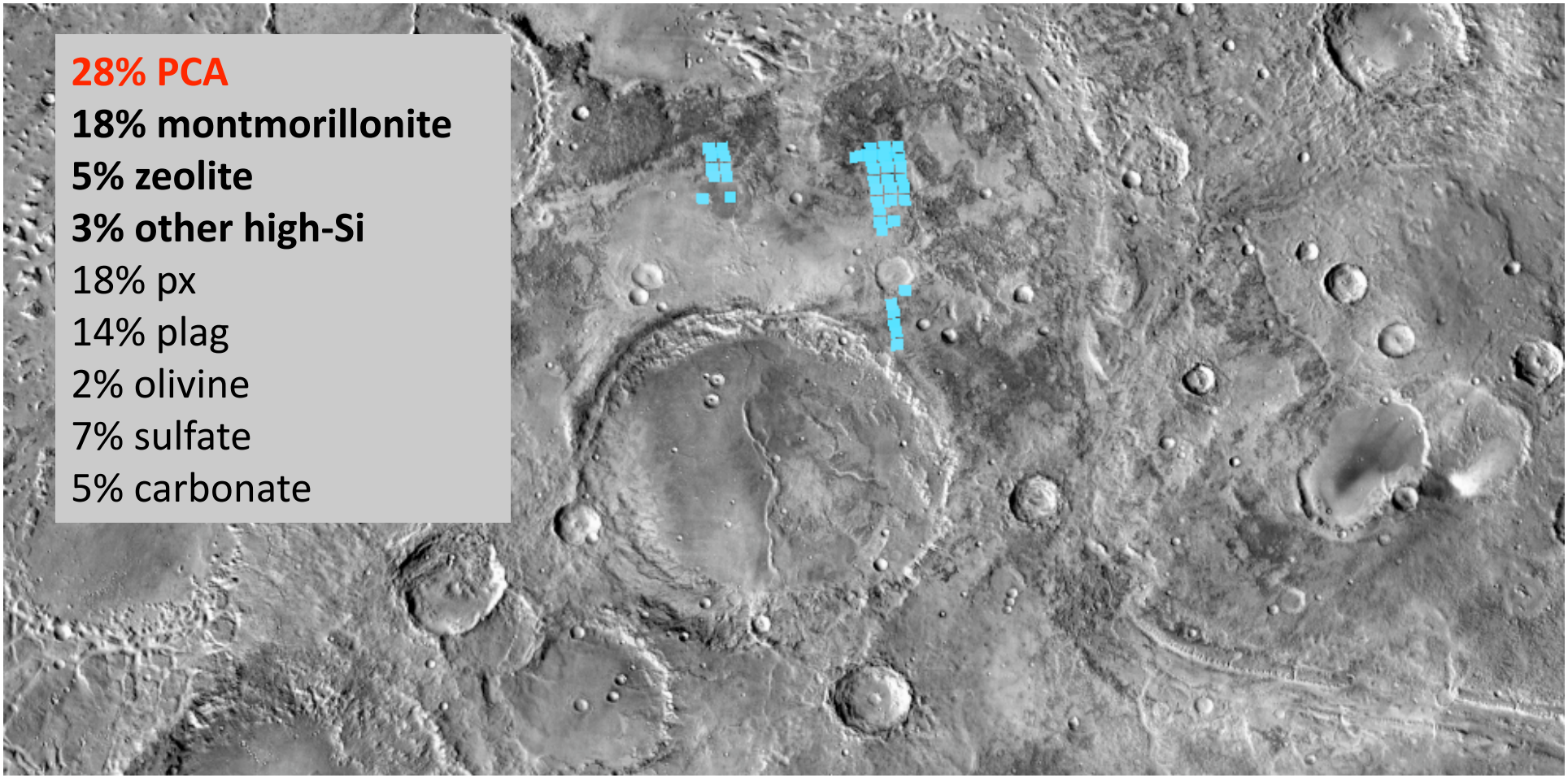
TES Library [Rogers and Christensen, 2007] + 4 PCAs + clays in Mawrth from NIR

Albedo = 0-0.131



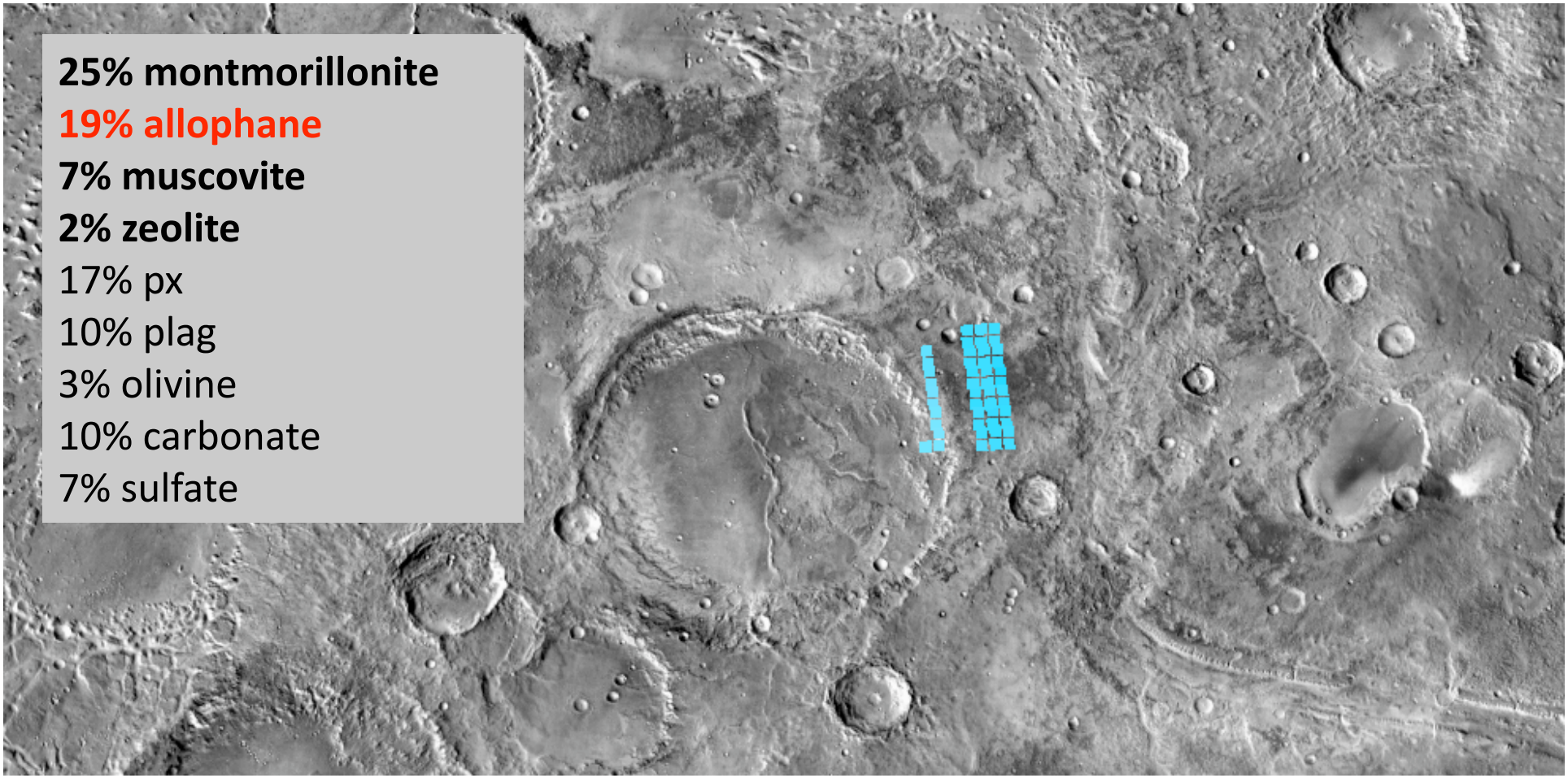
Models of Intermediate and Bright Surfaces

Ellipse 1
Albedo = 0.13-0.23



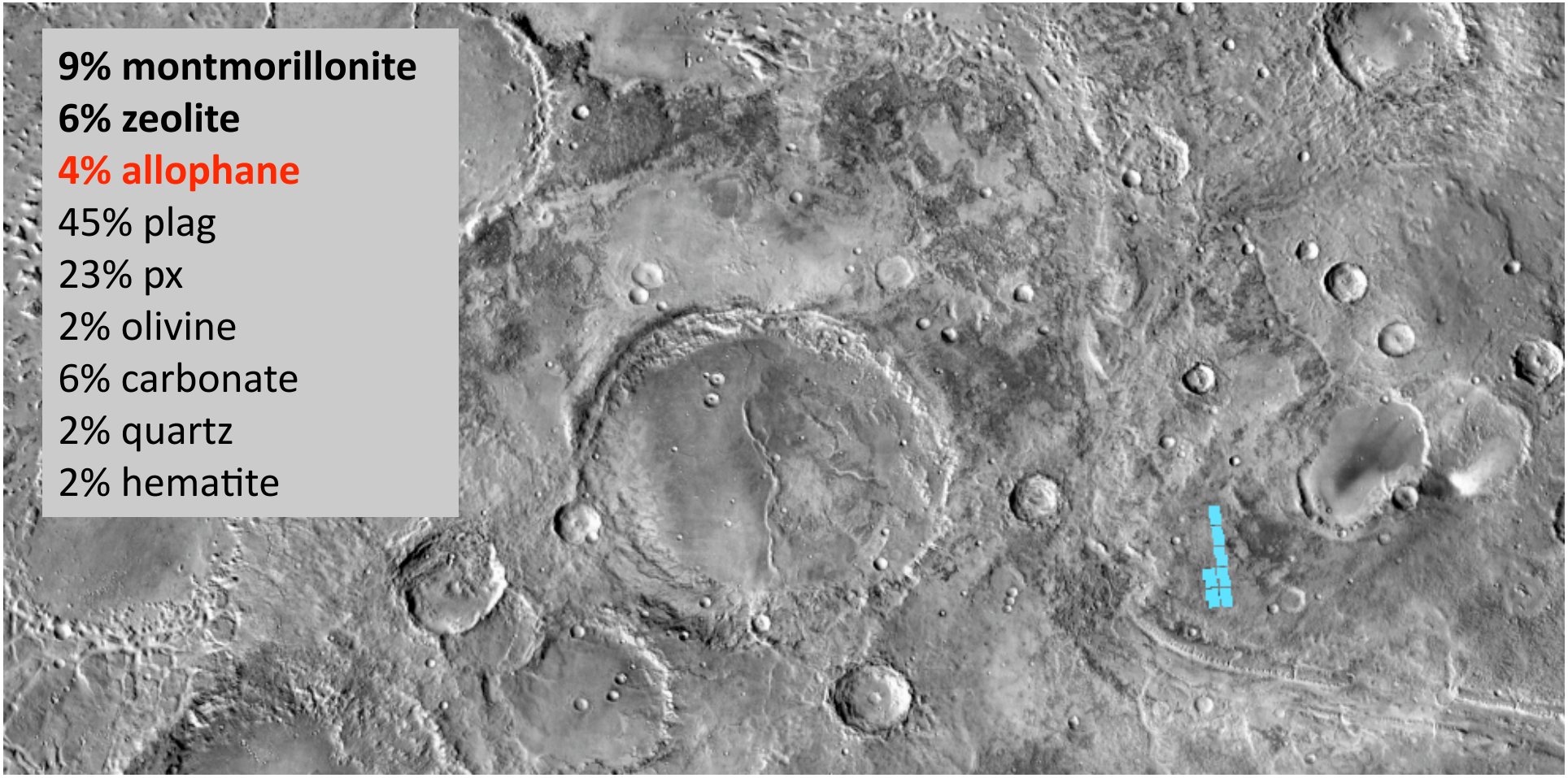
Models of Intermediate and Bright Surfaces

Ellipse 2
Albedo = 0.13-0.23



Models of Intermediate and Bright Surfaces

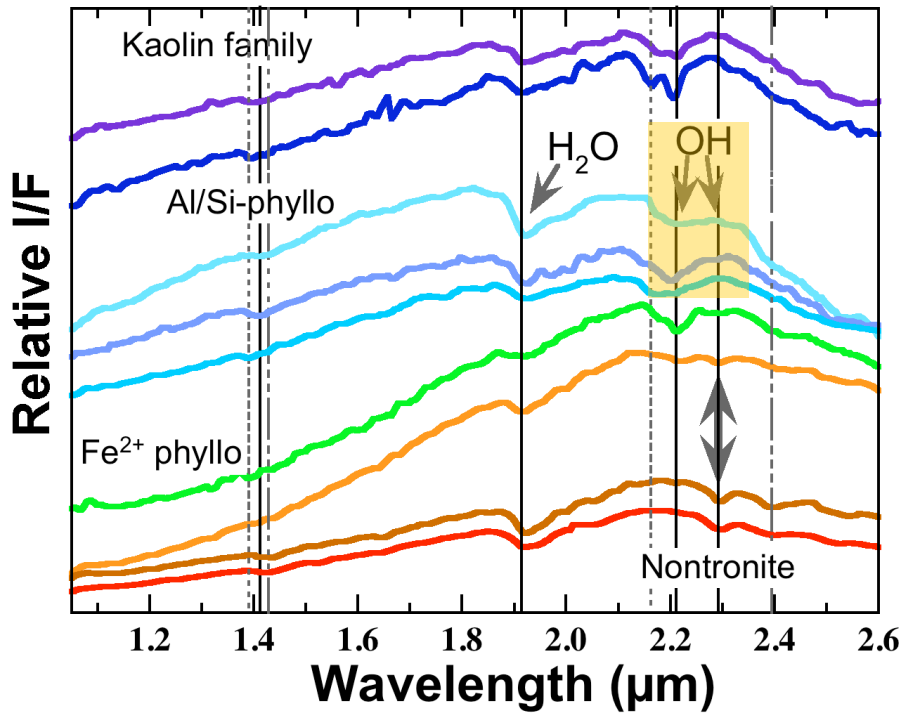
Ellipse 3
Albedo = 0.13-0.23



NIR Evidence for Allophane

NIR Spectroscopy of Al-Phyllo Unit

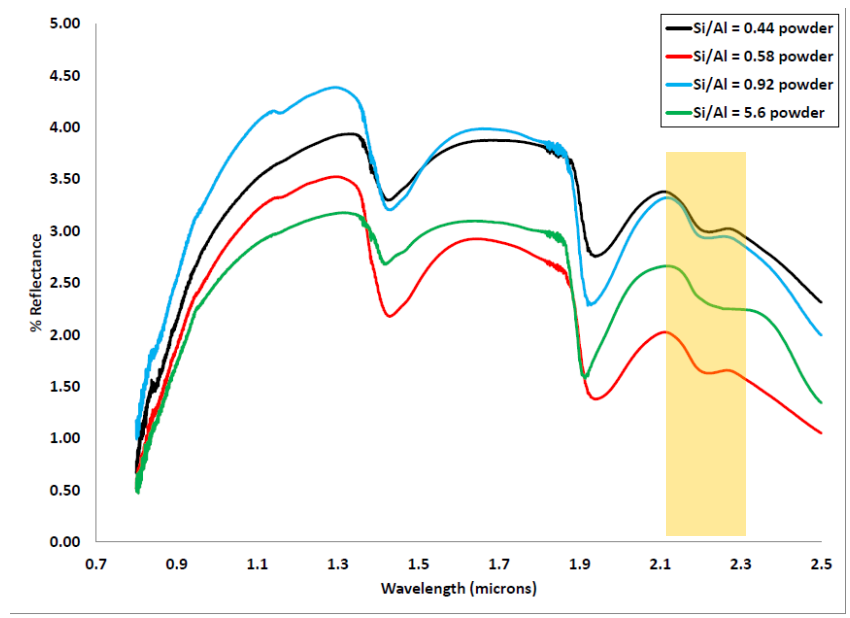
- Montmorillonite, kaolinite, hydrated silica



From Bishop et al. [2010] 4th Workshop

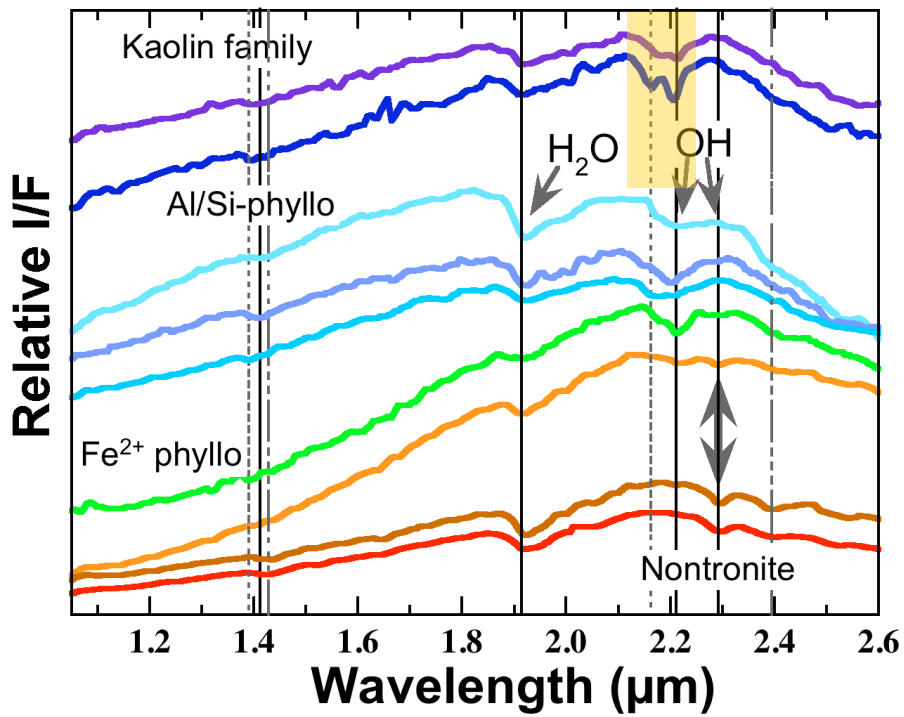
TES Models

- Montmorillonite, allophane

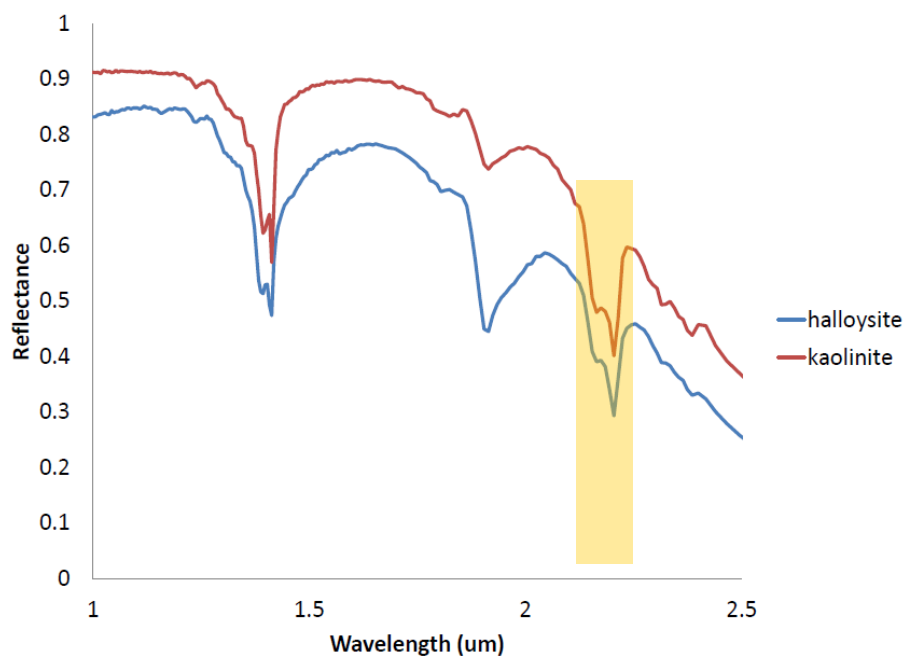


NIR Spectra Consistent with Halloysite?

- Volcanic glass → allophane → halloysite → kaolinite



From Bishop et al. [2010] 4th Workshop



Interpretations of Al-Phyllosilicate Unit

Previous View

- Amorphous silica with kaolinite
- Implies intense acidic alteration

New View

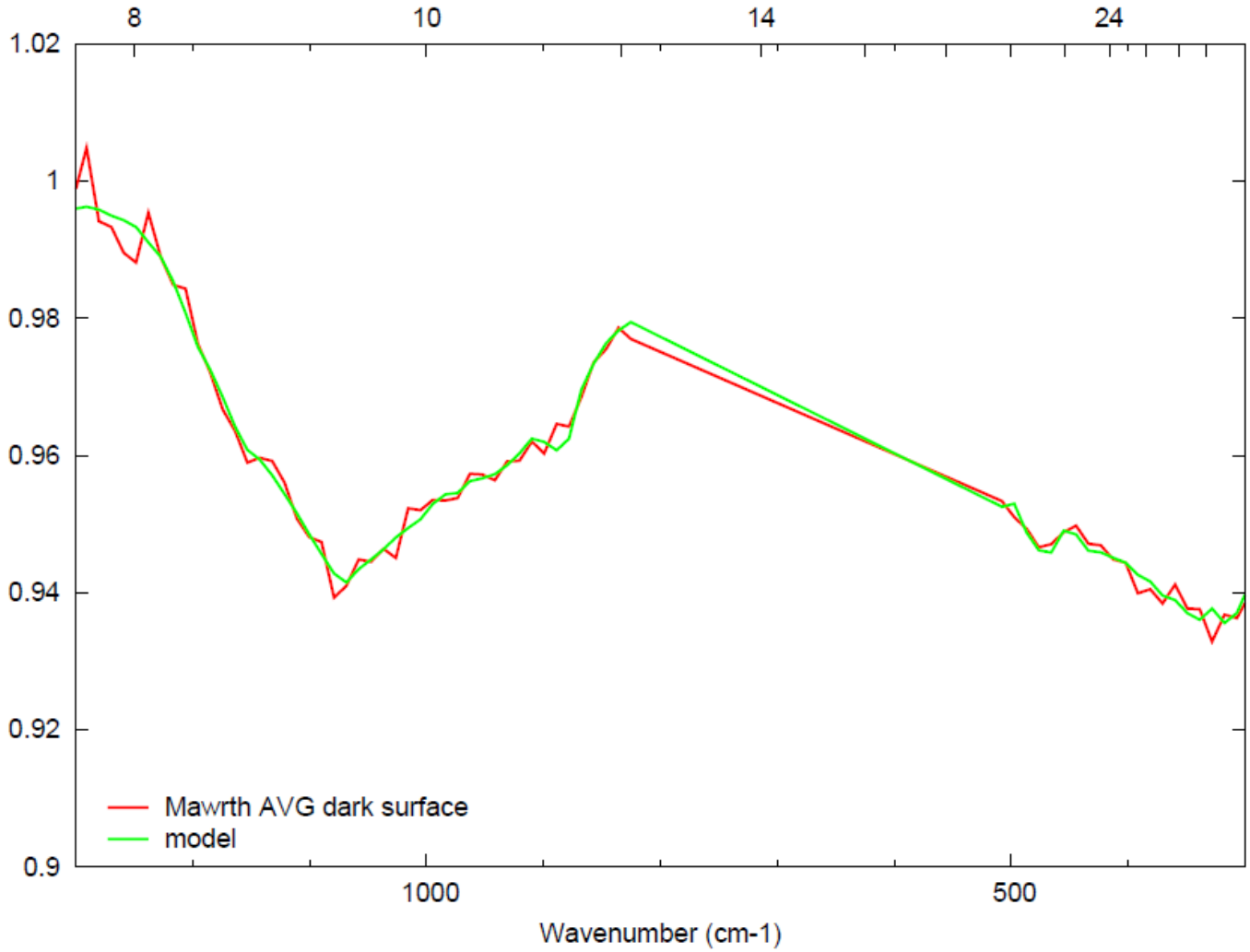
- Allophane
- Implies mild to moderate near-neutral alteration
- Allophane forms from volcanic ash on Earth
- Al-phyllosilicate unit drapes topography [Wray et al., 2008]
- Weathered soil of airfall ash deposit
- Secondary silicates may be overestimated

Implications for Aqueous Processes at Mawrth

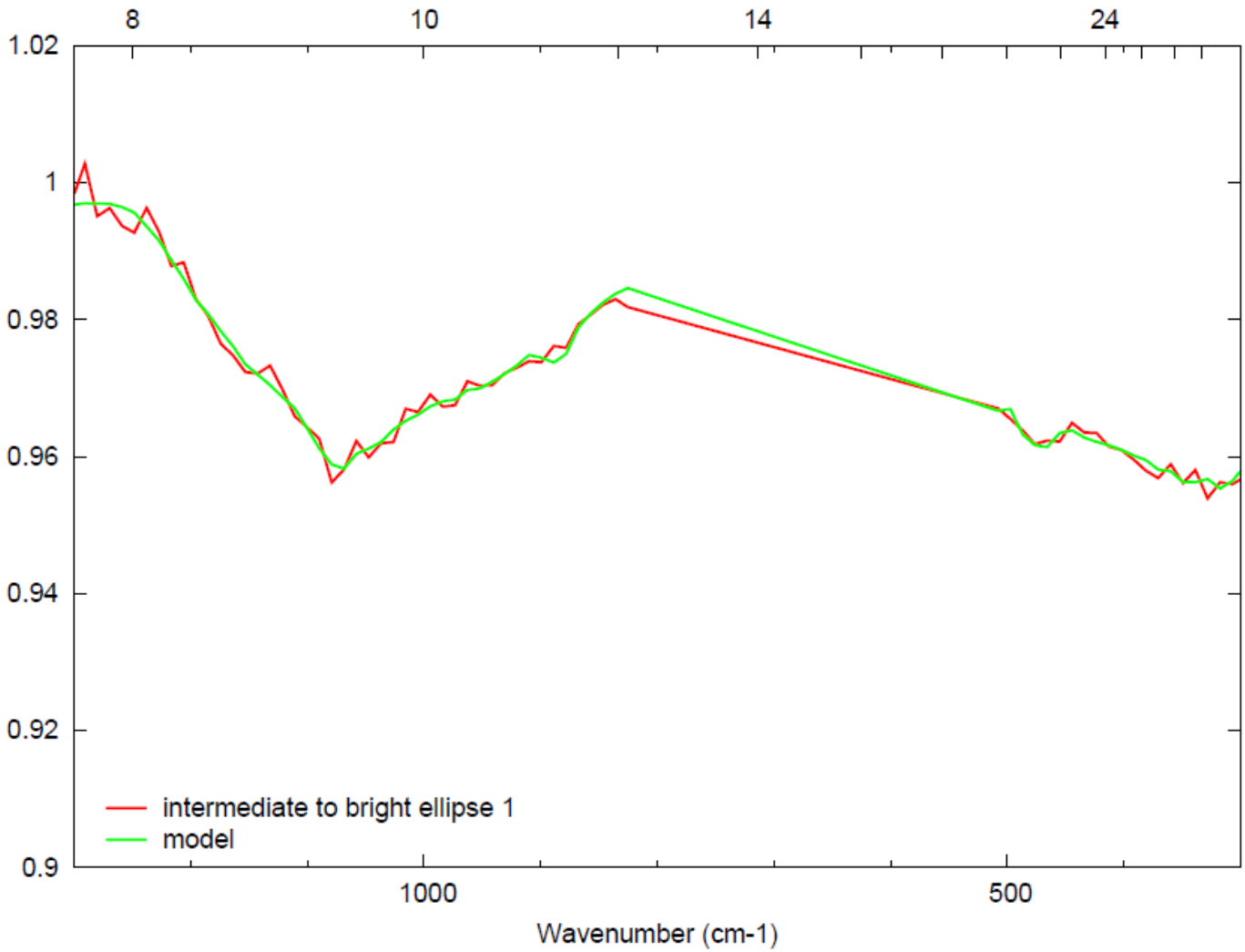
- Dark surfaces mildly to moderately weathered in neutral to mildly acidic fluids
- Aqueous processes in intermediate- and bright-toned surfaces:
  - Montmorillonite: neutral to alkaline fluids, poorly-drained
  - Allophane: neutral to mildly acidic fluids, well-drained, mild alteration
- Allophane common in soils derived from volcanic ash
  - Al-phyllosilicate layer could be weathered ash
  - Mawrth may not have experienced intense alteration

Bonus Slides

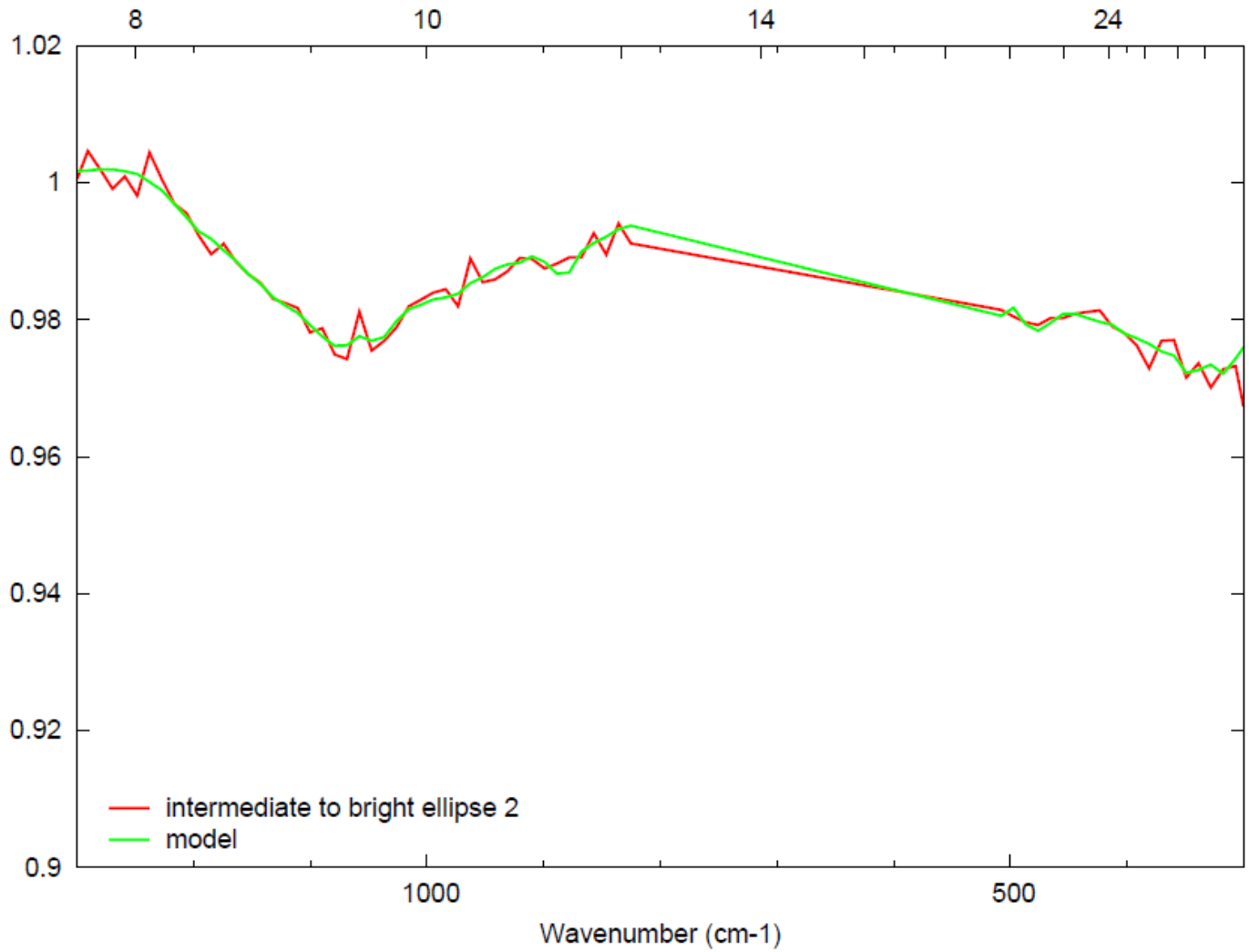
Mawrth Dark Surface Measured and Modeled



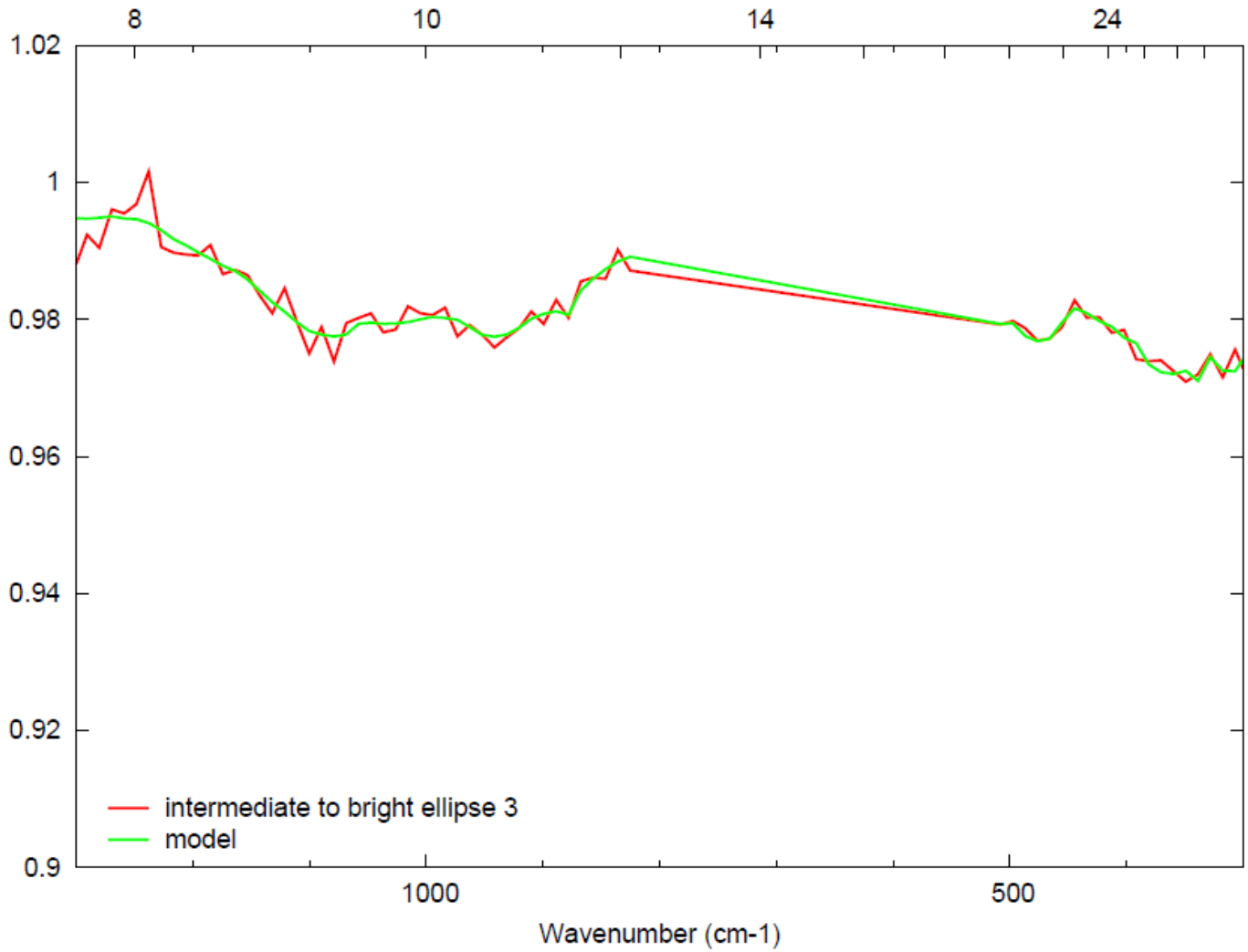
Intermediate to Bright Surface Measured and Modeled – Ellipse 1



Intermediate to Bright Surface Measured and Modeled – Ellipse 2

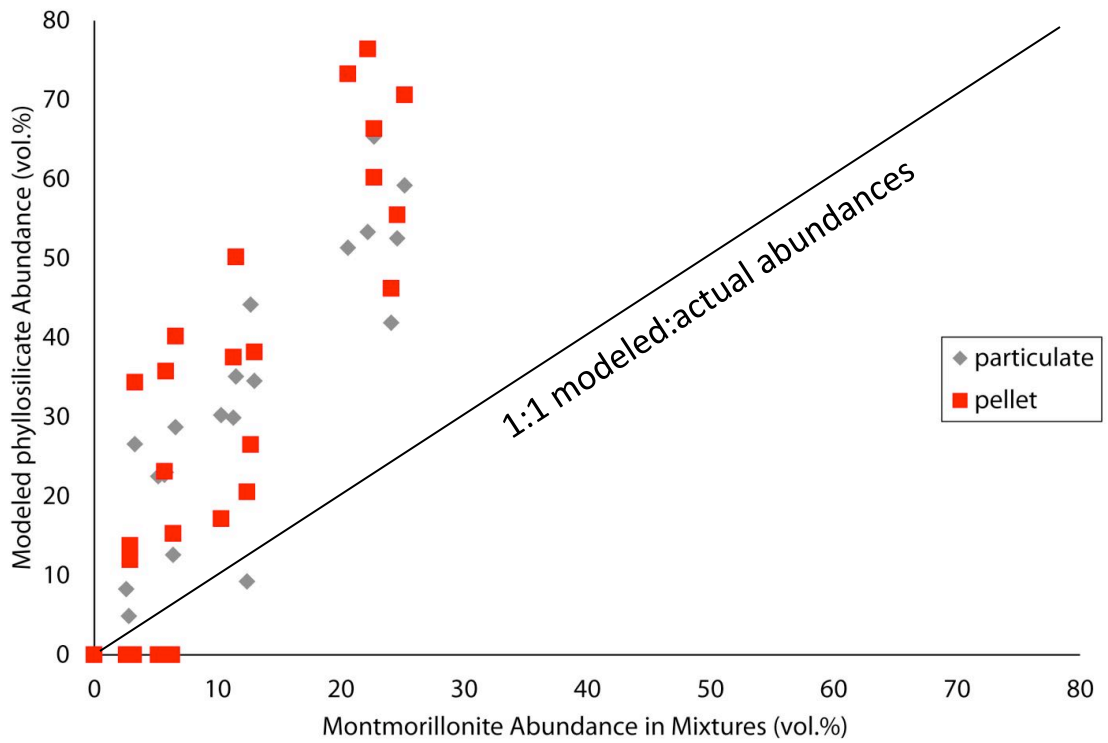


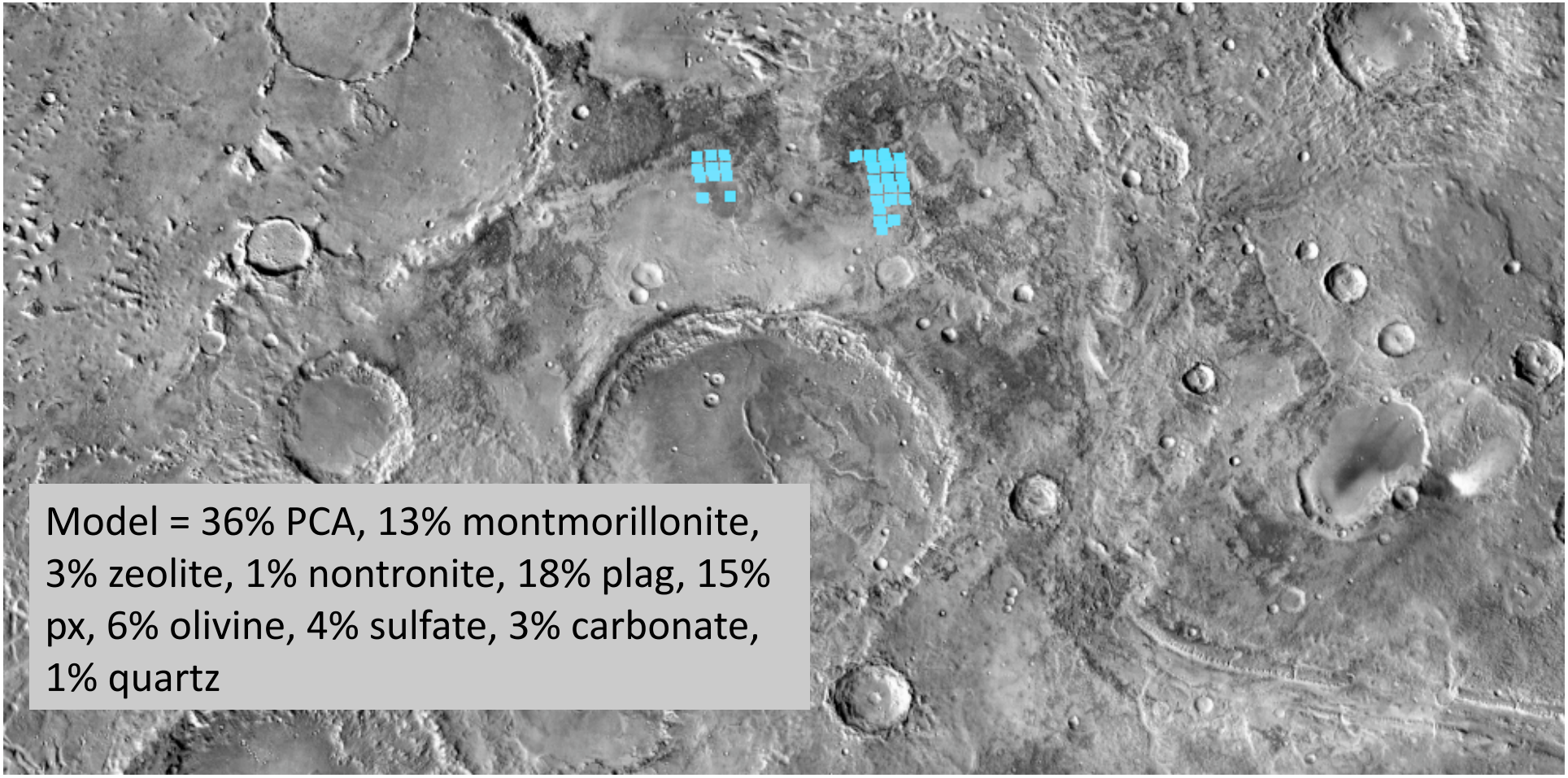
Intermediate to Bright Surface Measured and Modeled – Ellipse 3



TIR Models Overestimate Phyllosilicates

- Models of physical mineral mixtures of basaltic igneous minerals and montmorillonite clay



Models of Intermediate and Bright Surfaces

Albedo = 0-0.131