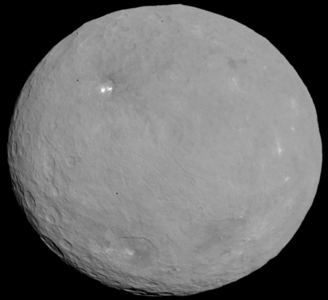
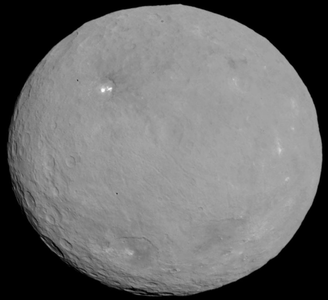


Carbon in Main-Belt Asteroids

Faith Vilas
(& Amanda Hendrix & Andy Rivkin)

Carbon in the Solar System Workshop



What constitutes an identification of carbon in main-belt asteroids?

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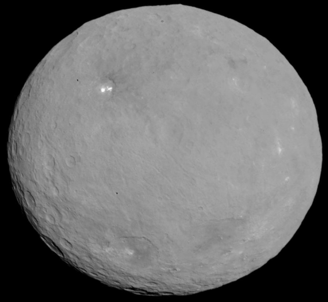
Surface Science



What constitutes an identification of carbon in main-belt asteroids?

Two findings

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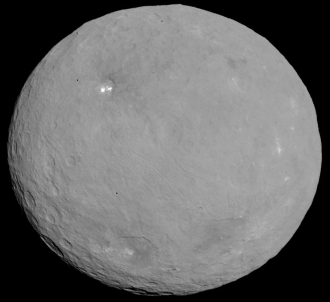
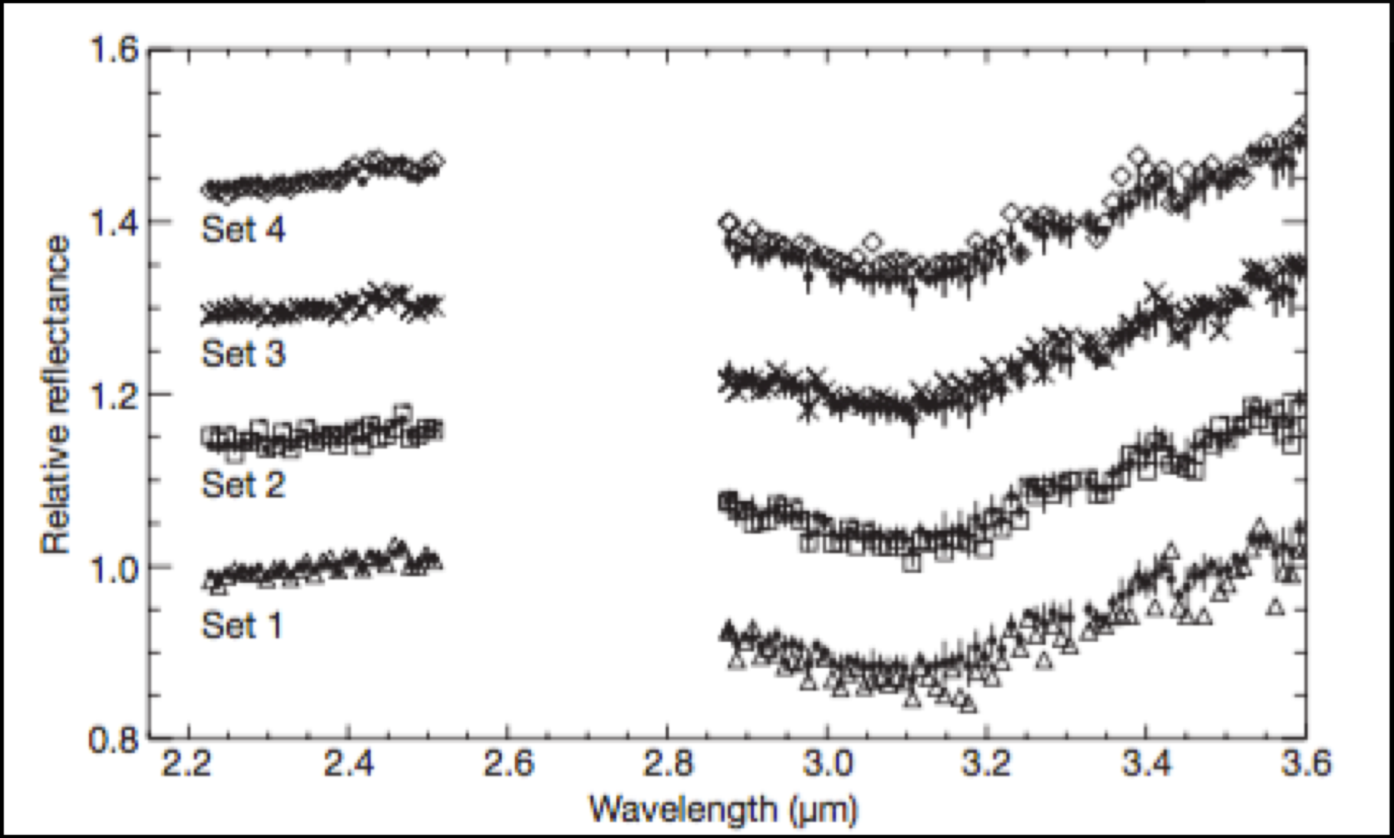


24 Themis Water Ice and Organics



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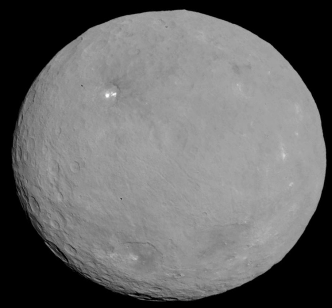
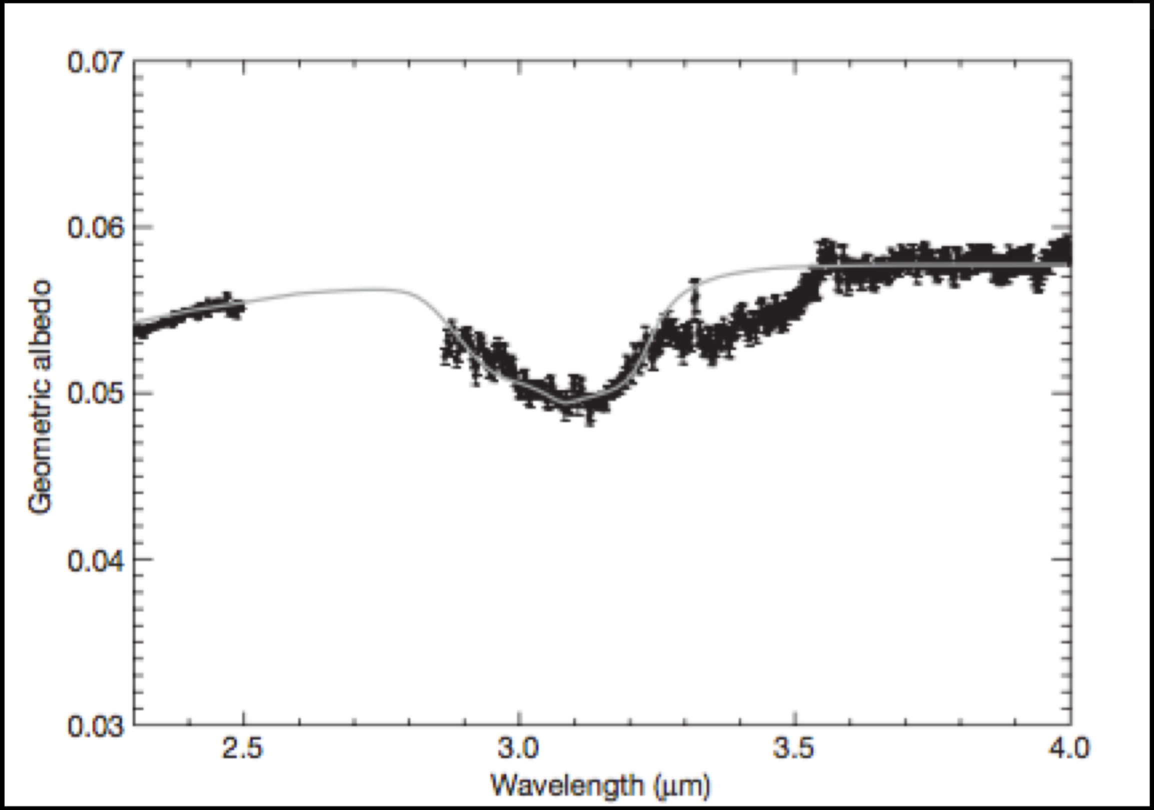
Campins et al., 2010

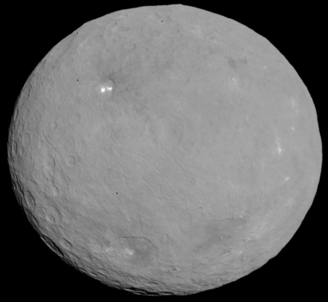
24 Themis Water Ice and Organics





Rivkin and Emery, 2010

TREX



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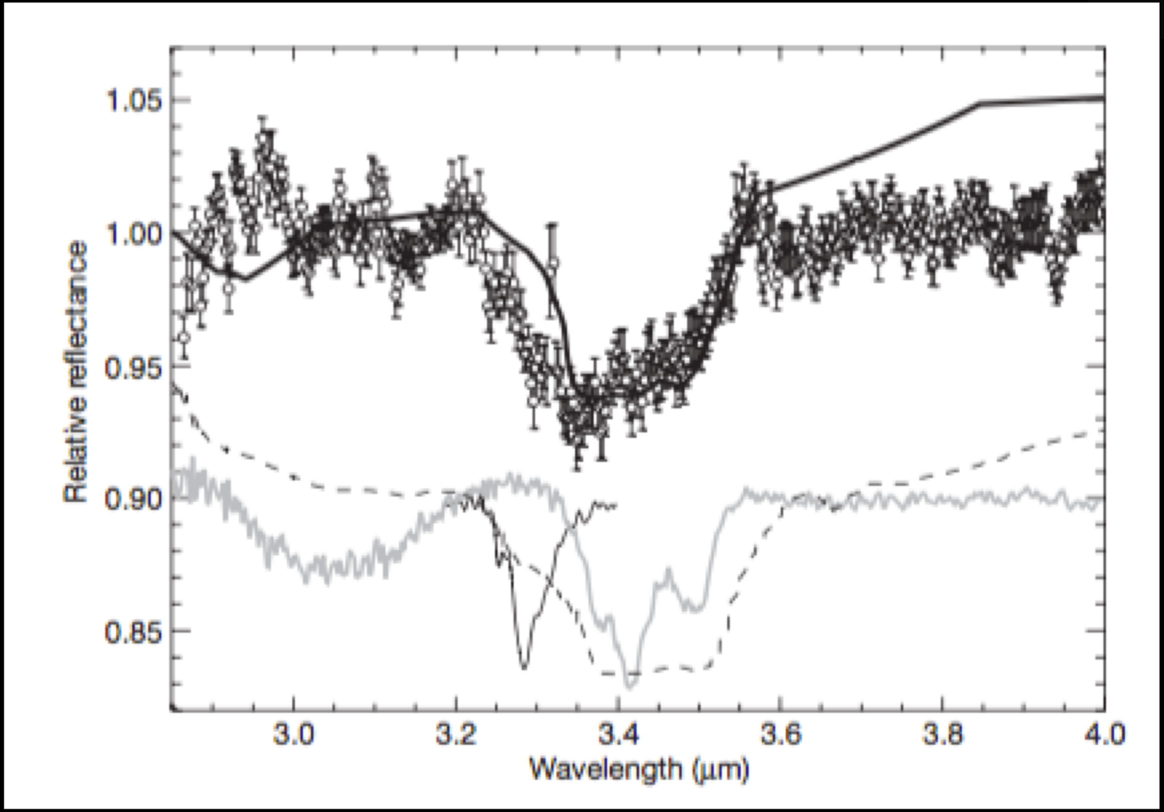

Rivkin and Emery, 2010

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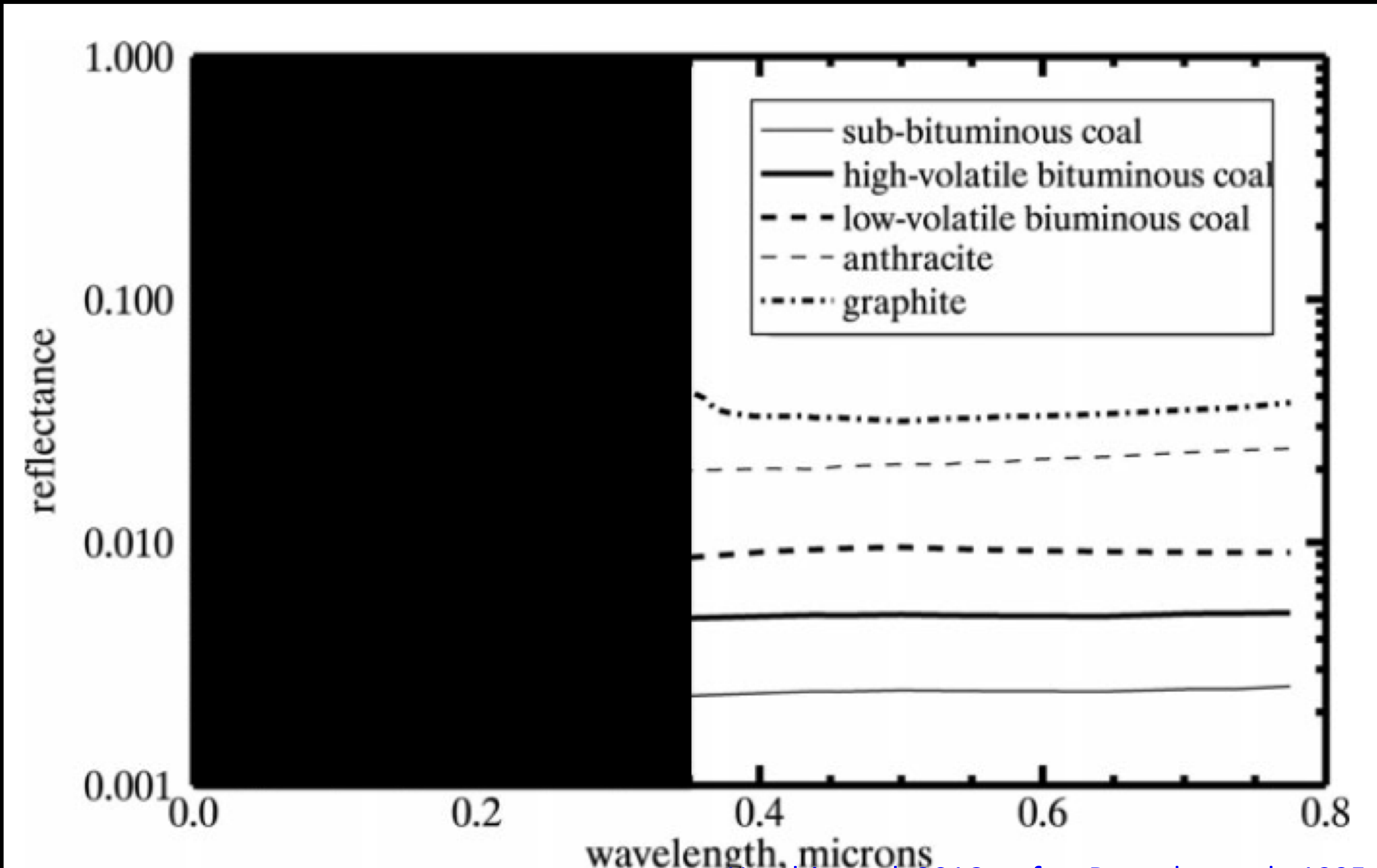
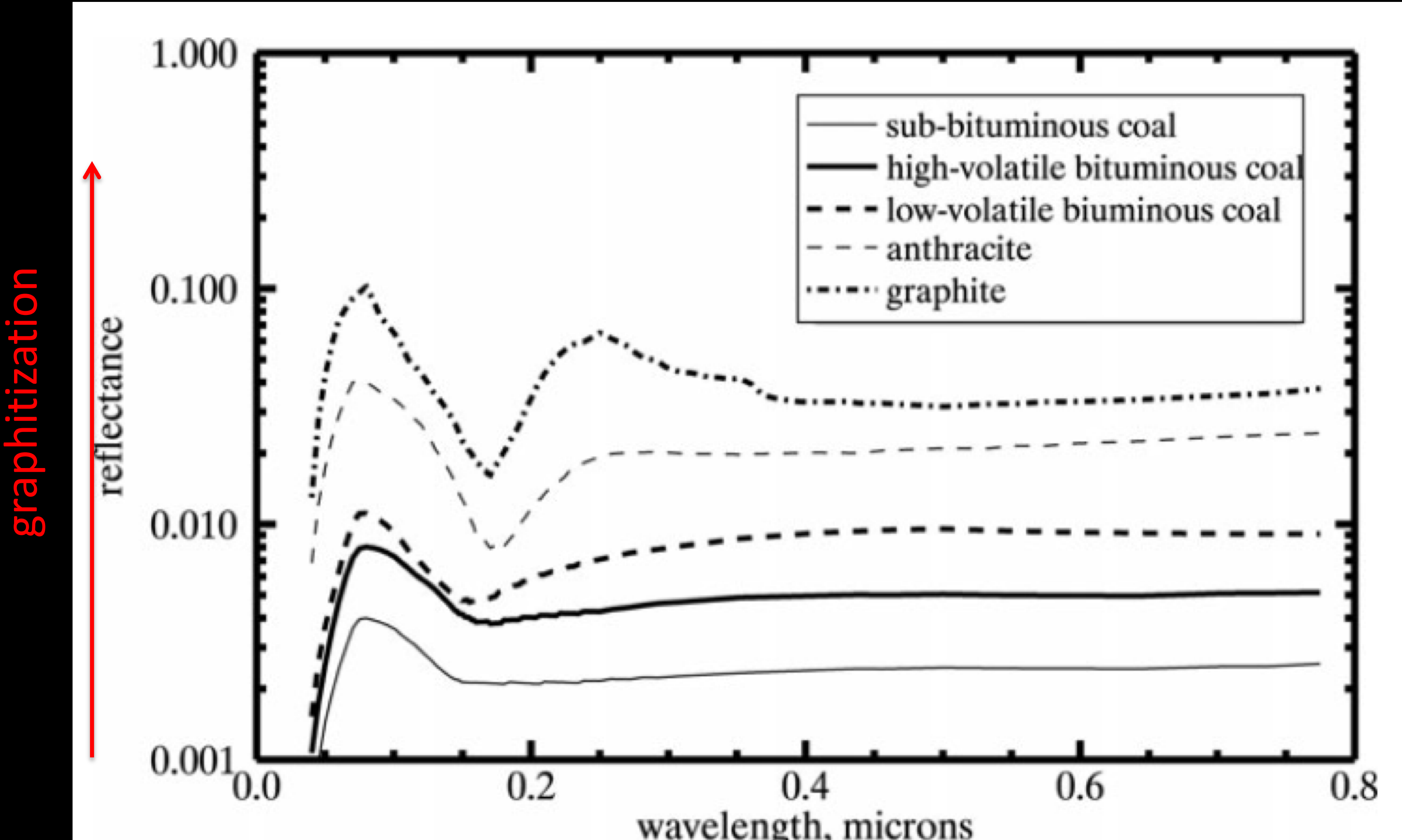
Terrestrial coals/carbon compounds: featureless in VNIR

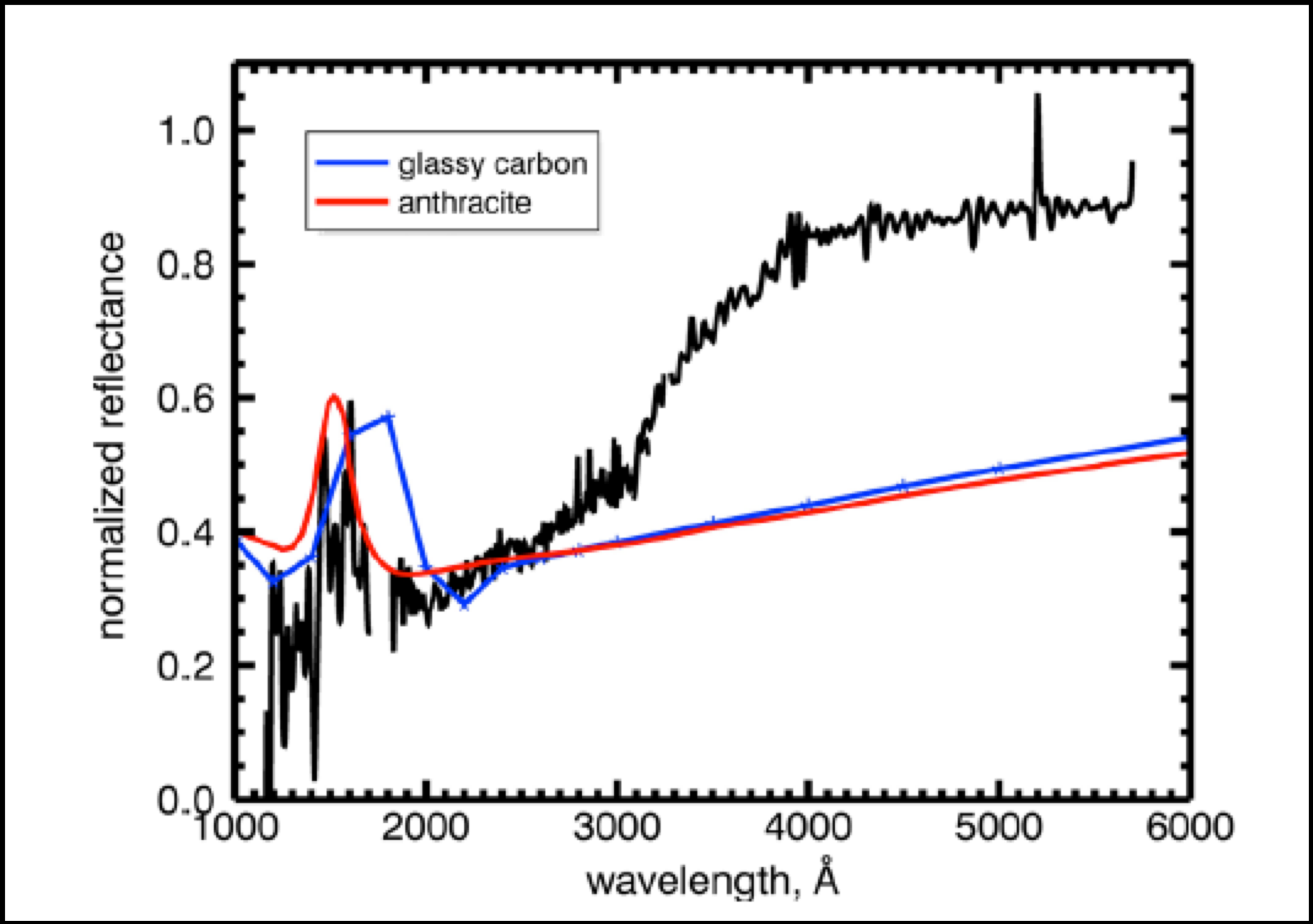


Hendrix et al. 2016a; after Papoular et al., 1995

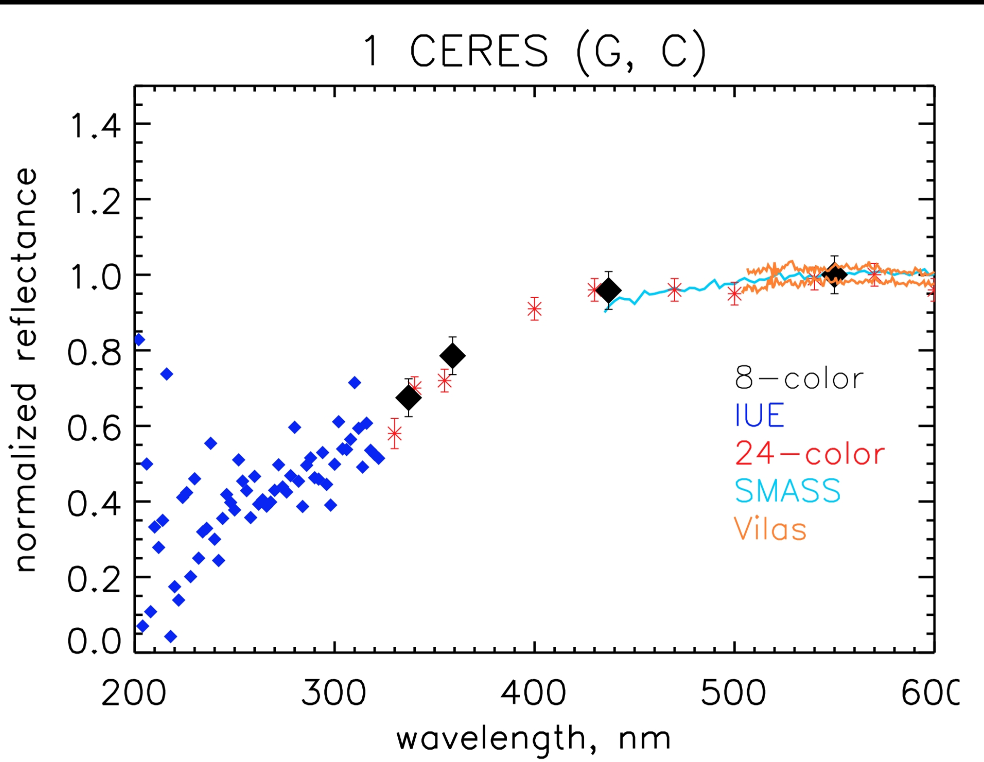


Hendrix et al. 2016a; after Papoular et al., 1995

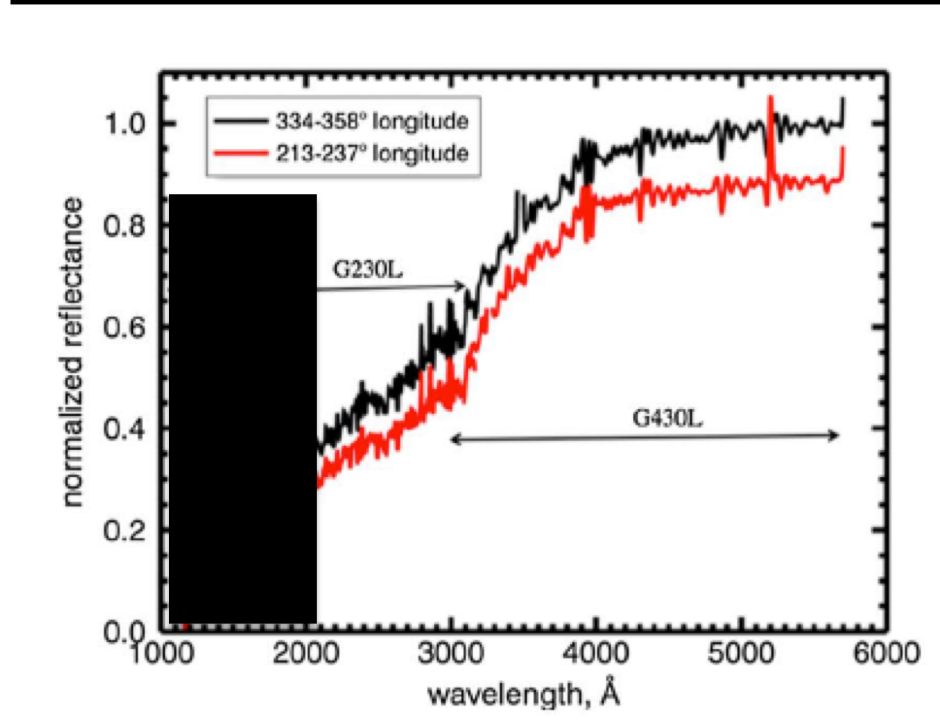
1 Ceres



Hendrix et al., 2016



CERES: IUE + ground-based



CERES: STIS/HST

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Data Sets & Asteroids

- IUE
- SMASS
- 8-color
- 24-color
- Vilas
- Sawyer

- 1 Ceres (G, C)
- 2 Pallas (B)
- 10 Hygiea (C)
- 41 Daphne (Ch)
- 51 Nemausa (Ch, Cgh)
- 54 Alexandra (C, Cgh)
- 88 Thisbe (CF, B)
- 324 Bamberga (C)
- 410 Chloris (Ch)
- 511 Davida (C)
- 654 Zelinda (Ch)
- 702 Alauda (C, B)
- 704 Interamnia (F, B)

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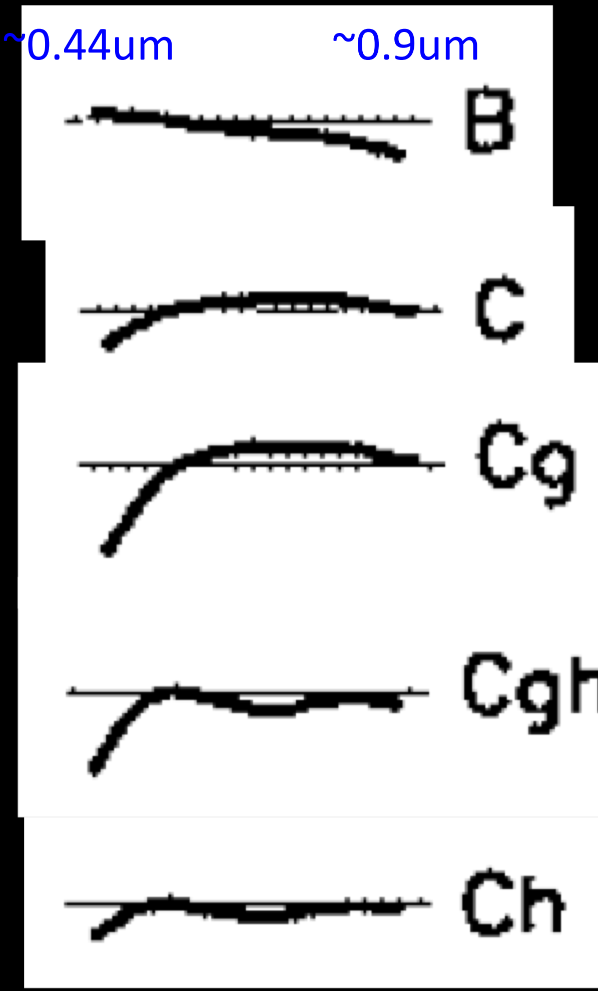
Low Albedo Class Asteroid Taxonomies

(Bus & Binzel, 2002)

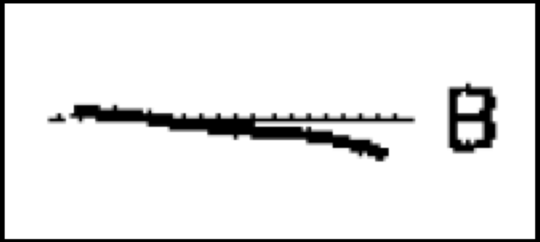
- **B-types.** Linear, featureless spectrum over the interval from 0.44 to 0.92 µm, with negative (blue) to flat slope.
- **C-types.** Weak to medium UV absorption shortward of 0.55 µm, generally flat to slightly red and featureless longward of 0.55 µm.
- **Cg.** Strong UV absorption shortward of 0.55 µm and generally flat to slightly reddish slope longward of 0.55 µm. Occasionally a shallow absorption feature is seen longward of 0.85 µm.
- **Cgh.** Similar to Cg spectrum with addition of a broad, moderately shallow absorption band centered near 0.7 µm.
- **Ch.** Similar to C spectrum with addition of a broad, relatively shallow absorption band centered near 0.7 µm.

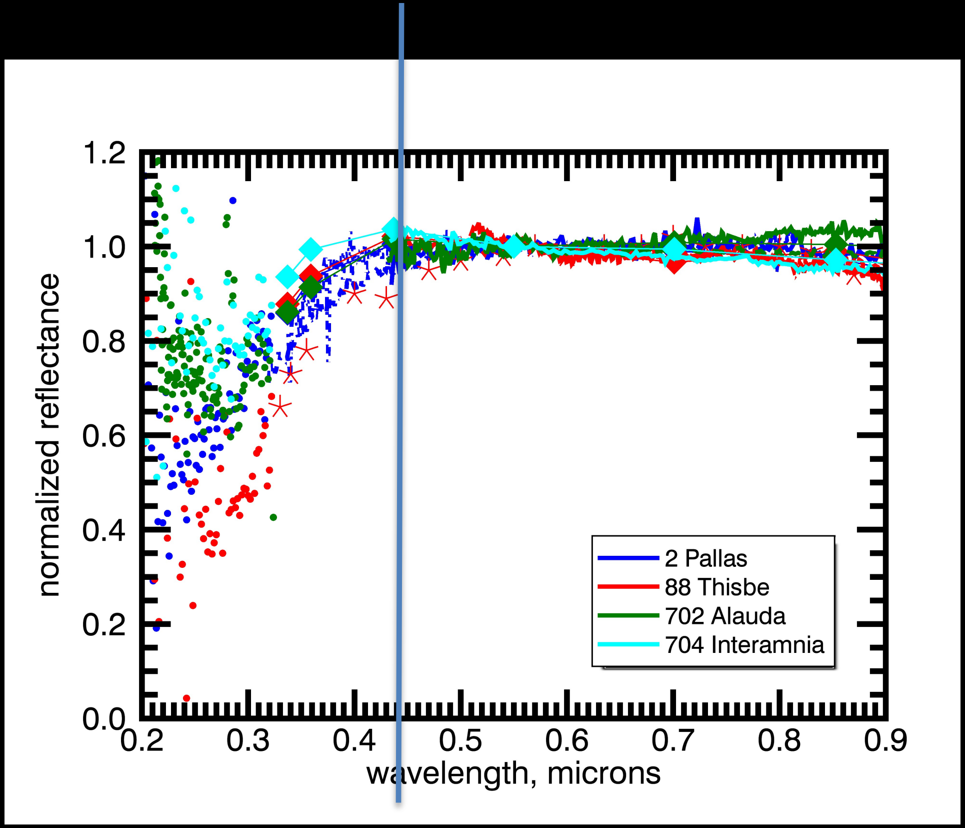


What changes the UV part of the spectrum, and what can we learn by observing deeper into the UV?

A stronger UV absorption is seen in Cg, Cgh asteroids: why? Hydration-related?

B-class

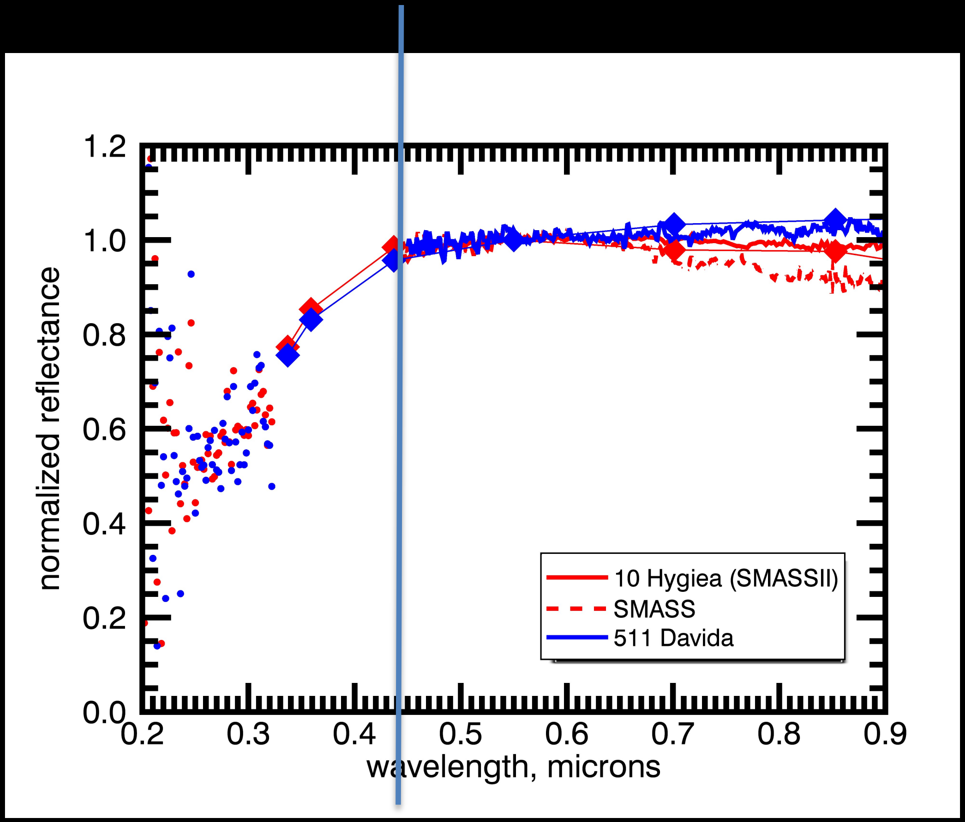


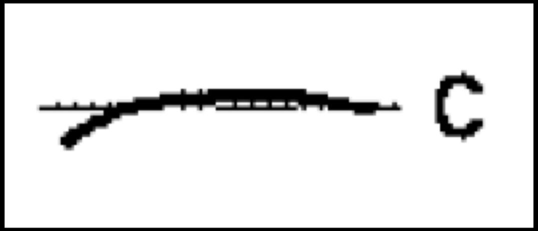


Significant UV differences among B-types

B-types. Linear, featureless spectrum over the interval from 0.44 to 0.92 µm, with negative (blue) to flat slope.

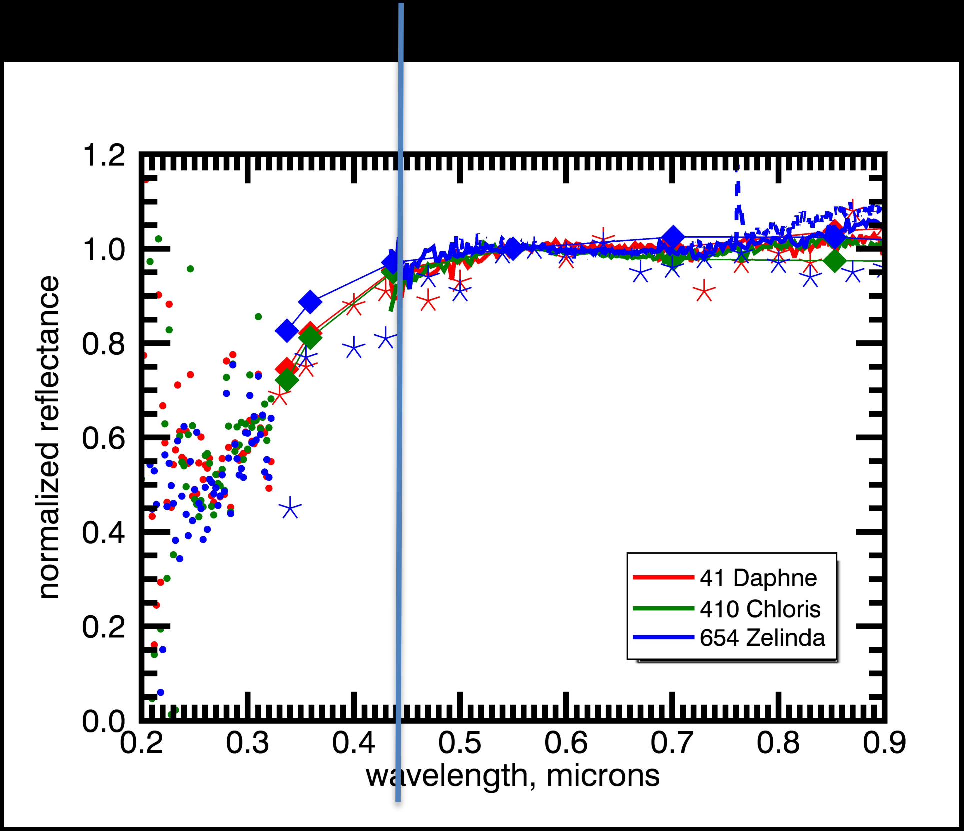
TREX





Weak to medium UV absorption shortward of 0.55 µm

Ch-types



Ch types are pretty similar in UV

Ch. Weak to medium UV absorption shortward of 0.55 µm, generally flat to slightly red and featureless longward of 0.55 µm. A broad, relatively shallow absorption band centered near 0.7 µm.

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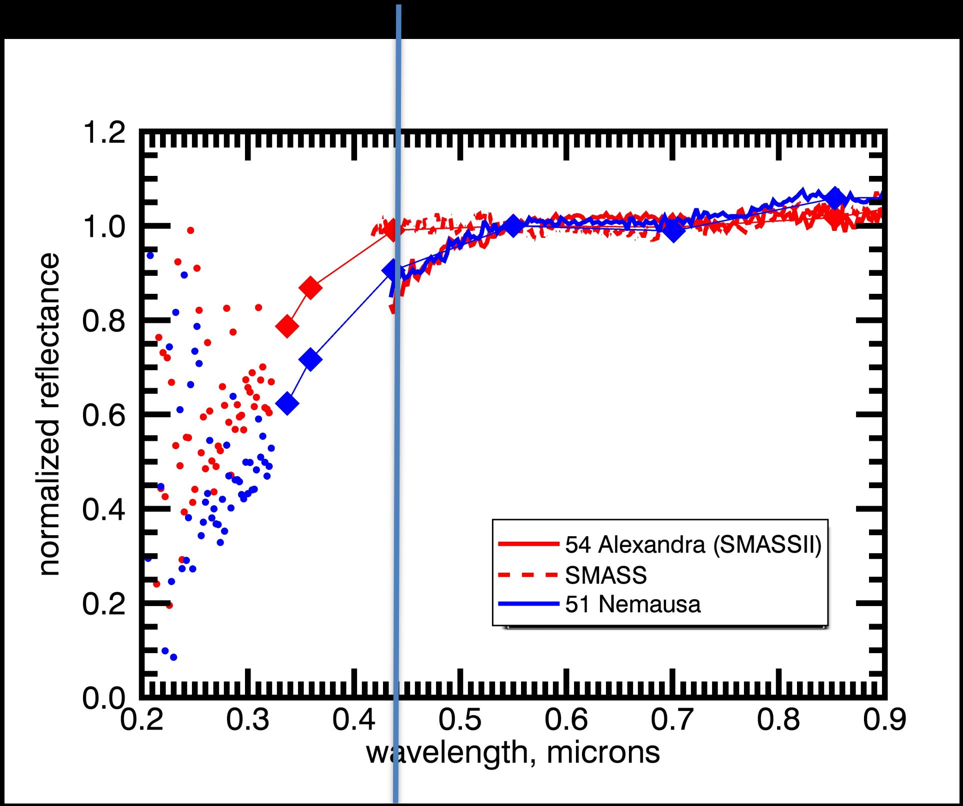

Strong UV absorption shortward of 0.55 µm

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What causes the differences in UV spectral shape?

- **Why do C/Ch asteroids have a somewhat less pronounced UV absorption than Cg/Cgh?**
- **Why do B-types have less of a UV absorption than C-complex?**
  - B-types DO have a UV absorption, it's at shorter wavelengths (why?)
- (For most materials, the main cause of UV absorption is Fe–O charge transfer absorptions (IVCT))

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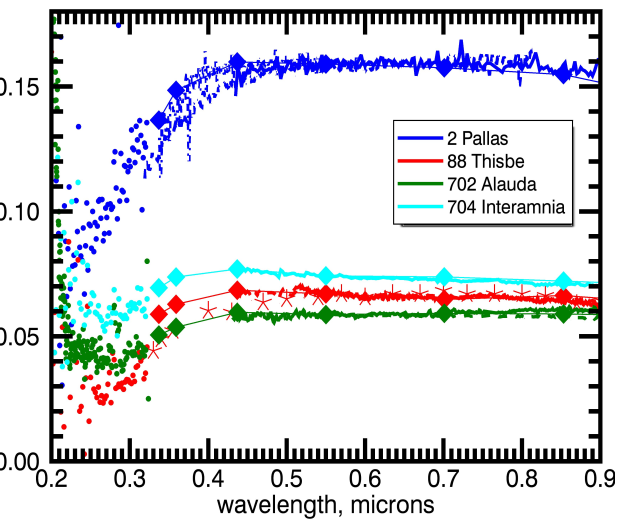
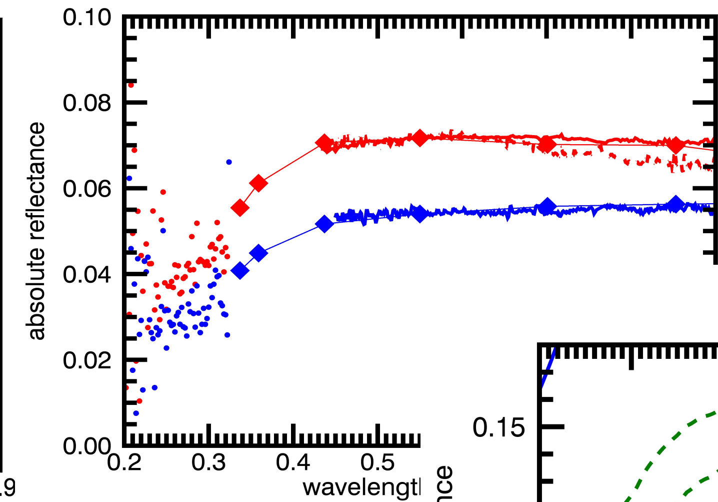
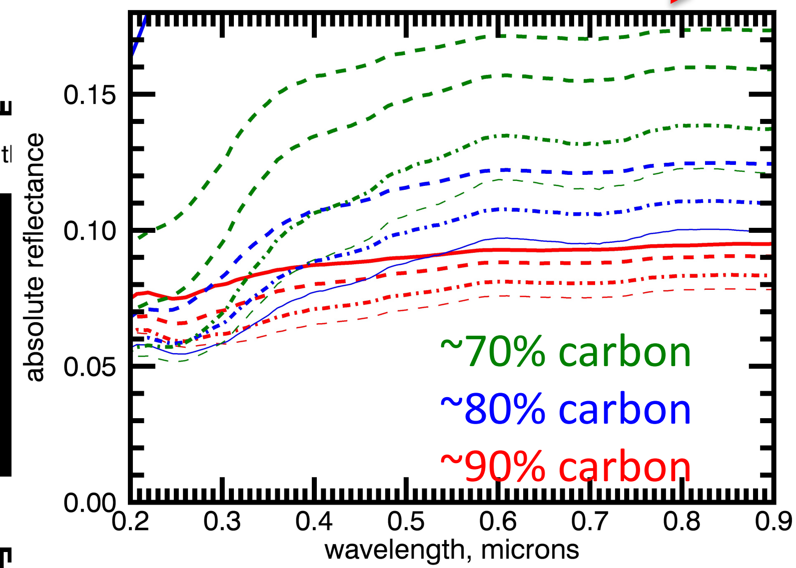
- Hypothesis: Among low-albedo class asteroids, the UV absorption shape (i.e. the IVCT edge) is affected by the presence of opaque weathering products
- Test: spectral models (intimate mixtures) of
  - Phyllosilicate (a serpentine) + carbon (a:C)

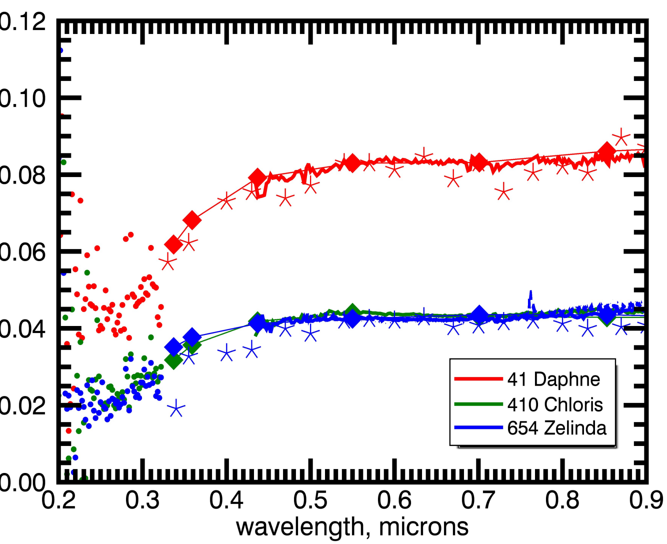
PRELIMINARY
phyllosilicate + a:C models

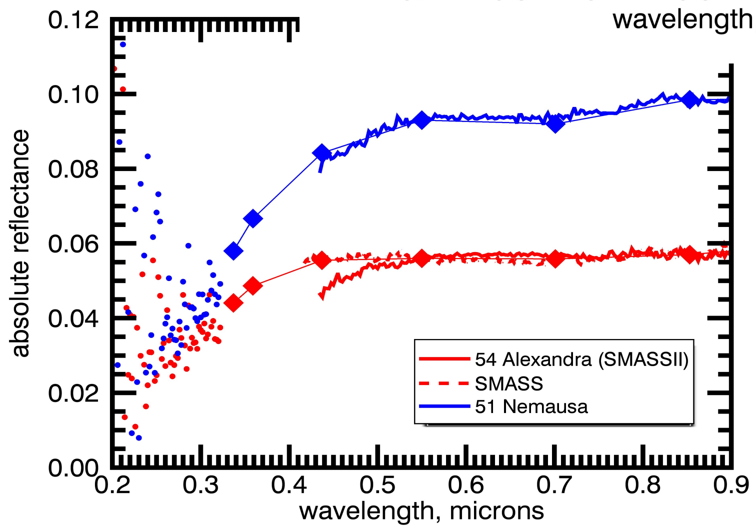




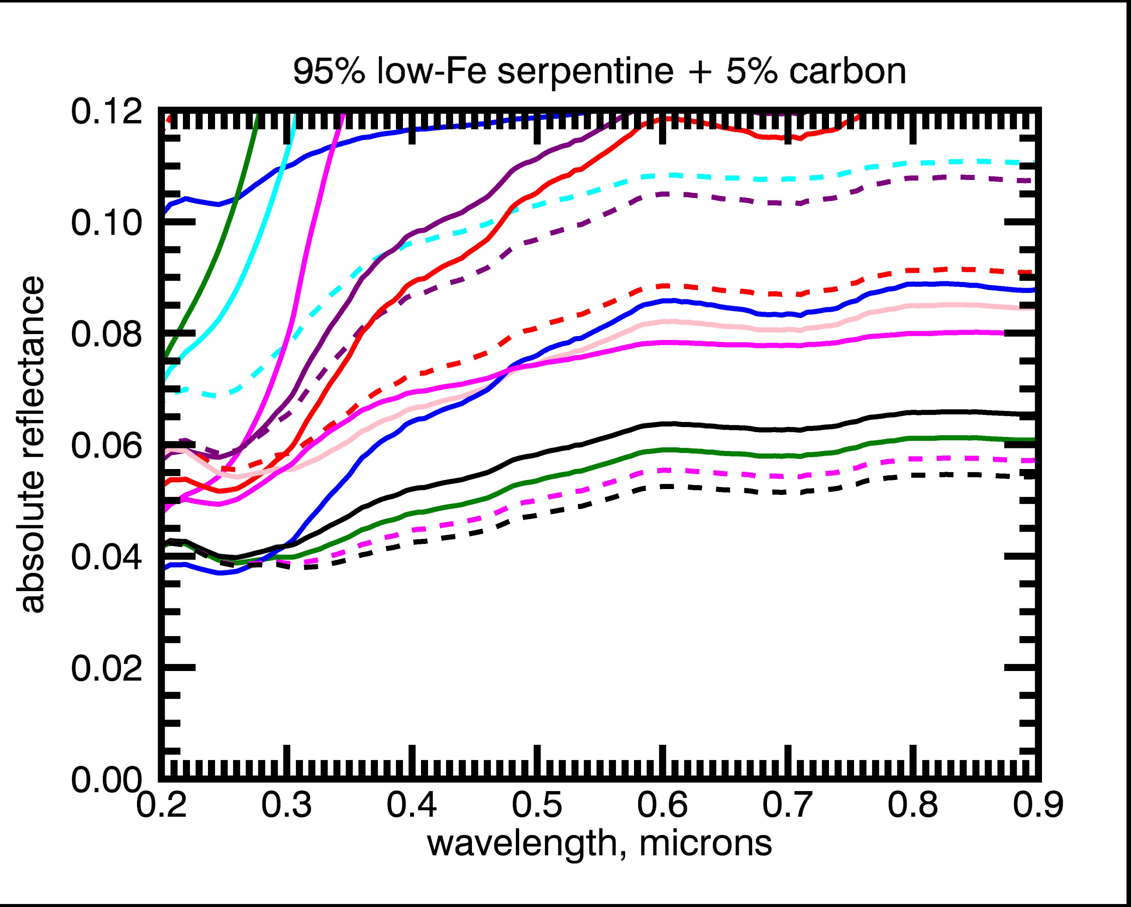


absolute spectra





Particle size mixtures models reduce % carbon needed to produce spectra



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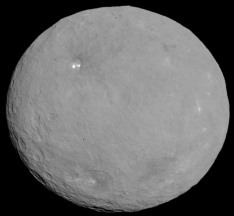

Summary

- Extending spectral coverage of low-albedo class (primitive) asteroids into the UV can provide clues to surface composition
- Intimate mixtures of phyllosilicate + amorphous carbon can reproduce the overall characteristics of a range of UV-visible primitive asteroid spectra
- Adding amorphous carbon
  - Has a spectral signature in the UV
  - Weakens UV absorption edge, moves to the blue
  - can retain the 0.7um feature
- Amorphous carbon:
  - a weathering product of native carbonaceous compounds
  - Brought in by micrometeoroid impacts

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