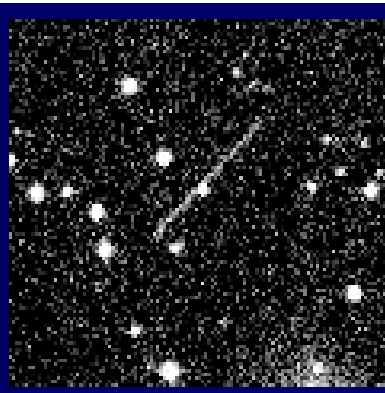

Can NEAs be Grouped by Their Common Physical Characteristics?

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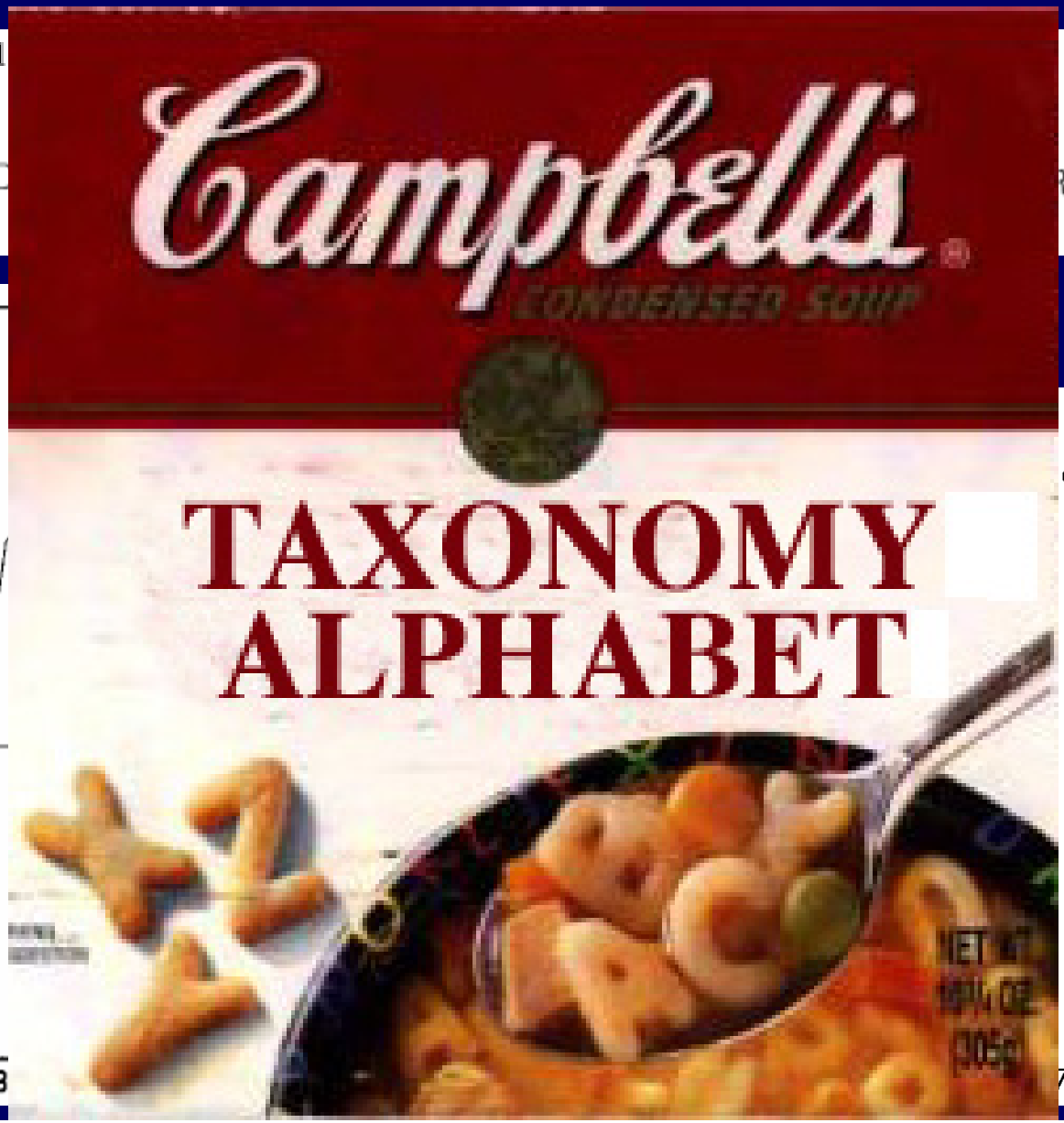
Can NEAs be Grouped by Their Common Physical Characteristics?

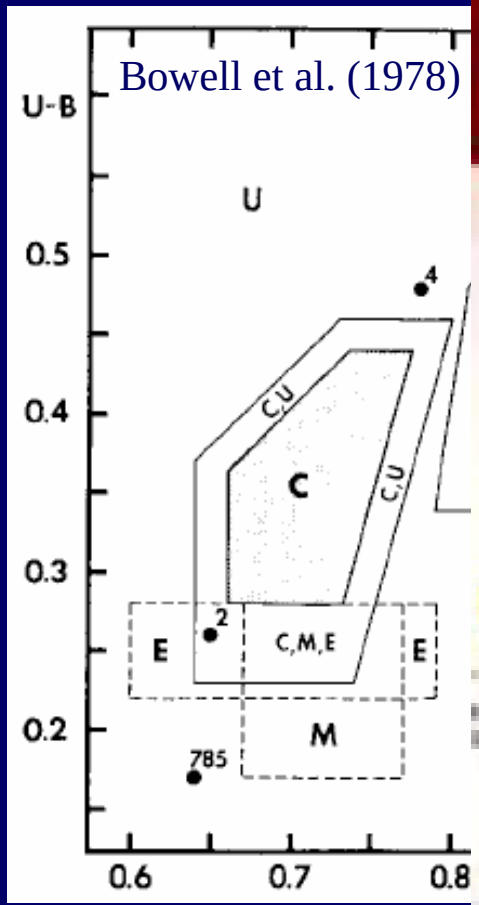
Yes.

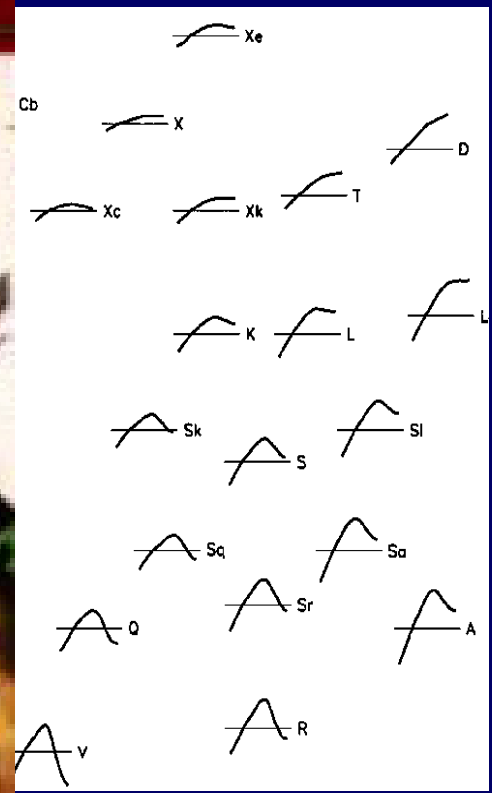
- Asteroids can be grouped together by their colors.
- Asteroids can be grouped together by their albedos.
- Asteroids can be grouped together by their meteorite associations.

We can make an educated assessment of the size, composition, and structure of potentially hazardous asteroids.

Grouping Asteroids by Color

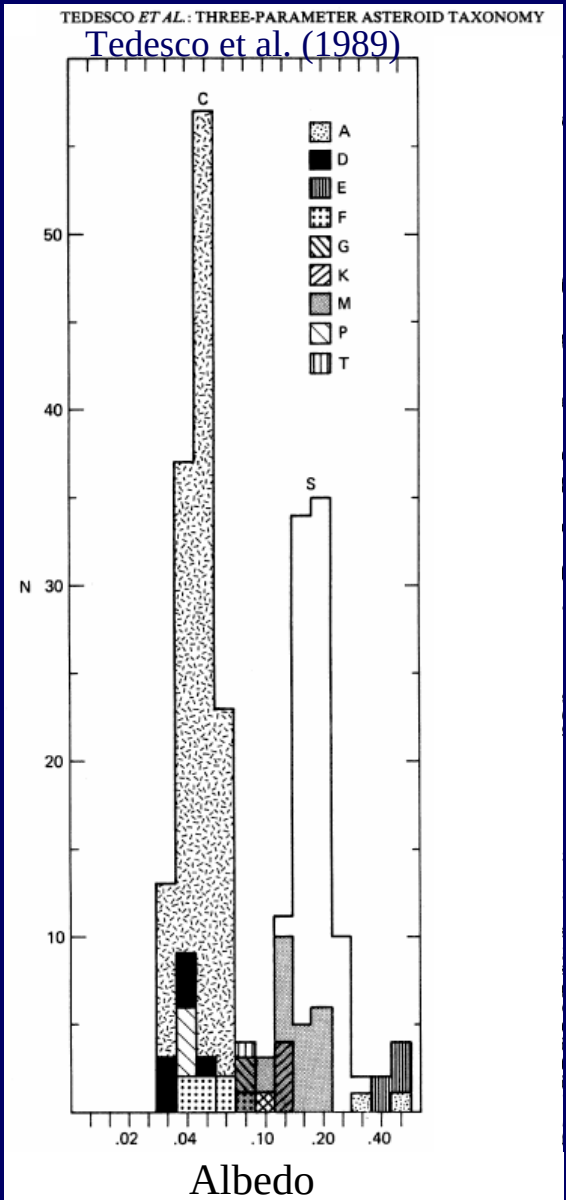






Grouping Asteroids by Albedo

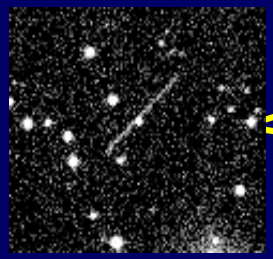
(Reflectivity)



Tedesco et al. (1989)

- There is a strong **correlation** between color group (taxonomy alphabet type) and albedo.
- Therefore, by grouping by **colors**, we can constrain the albedo.
- By **constraining** the **albedo**, we **reduce** the **uncertainty** in the **size** estimate.

Illustrating the Size Uncertainty



Assumed albedo
= 0.04

Big and dark.

These solutions are equivalent !

Assumed albedo
= 0.34

Small and bright.

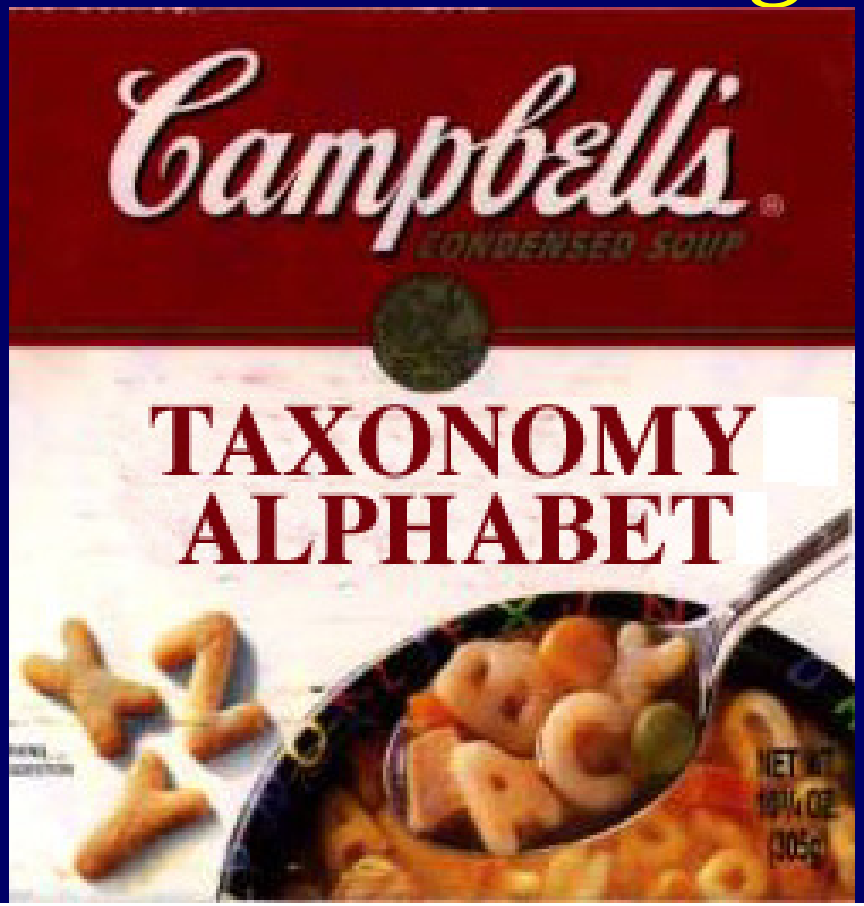
Must have **color** or **albedo** information to know the size.

Otherwise there is up to 300% uncertainty in the diameter.

Diameter uncertainty creates factor of 20 uncertainty in energy.

Lesson # 1

Basic characterization, such as color and albedo, is the first line of defense against NEAs.



Goals and Limits of Characterization

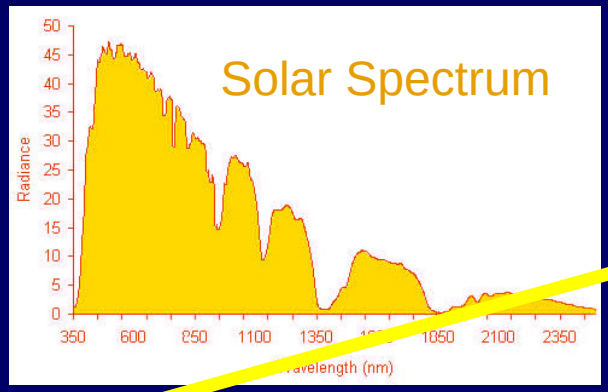
- Determine the bulk physical properties such as size, mass, density.
- Determining the bulk properties requires knowledge of the composition.
- Most detailed knowledge of composition comes from direct samples: **Meteorites !**

We have thousands of direct samples of NEAs in the form of Meteorites.

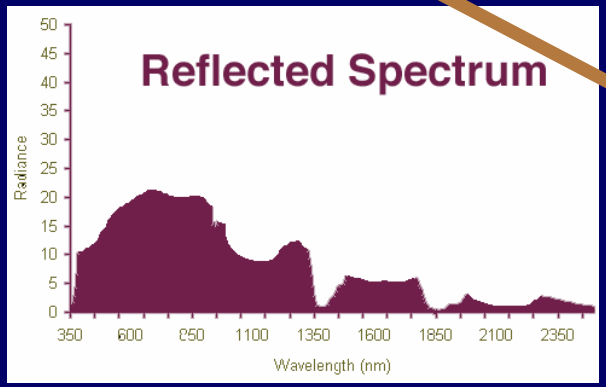
Lesson # 2

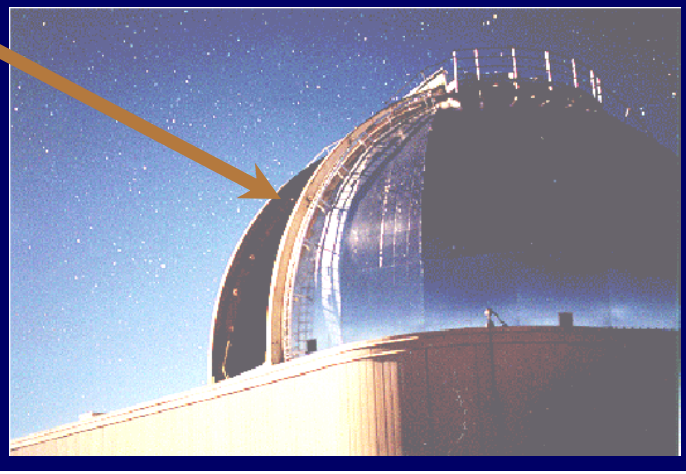
Direct correlation between NEAs and meteorites provides the most detailed (and lowest cost) initial assessment of NEA physical properties.

How Does It Work ?

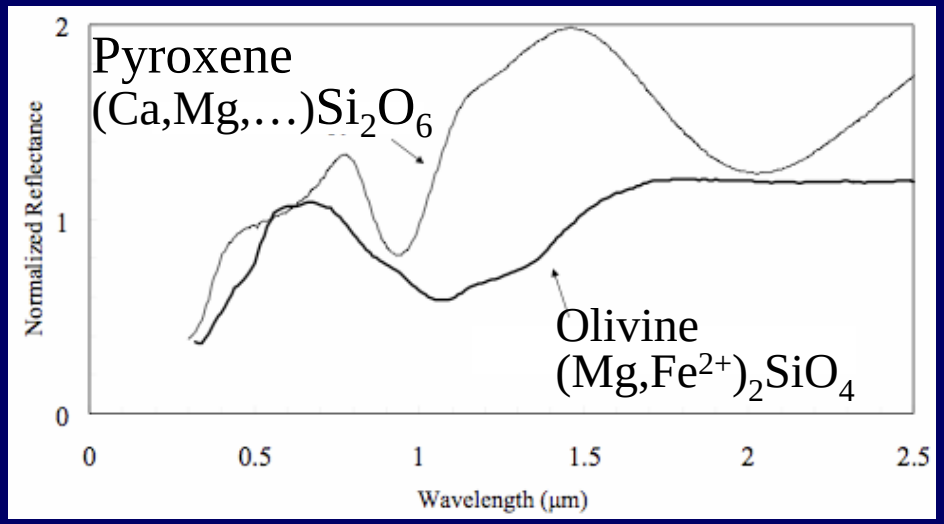


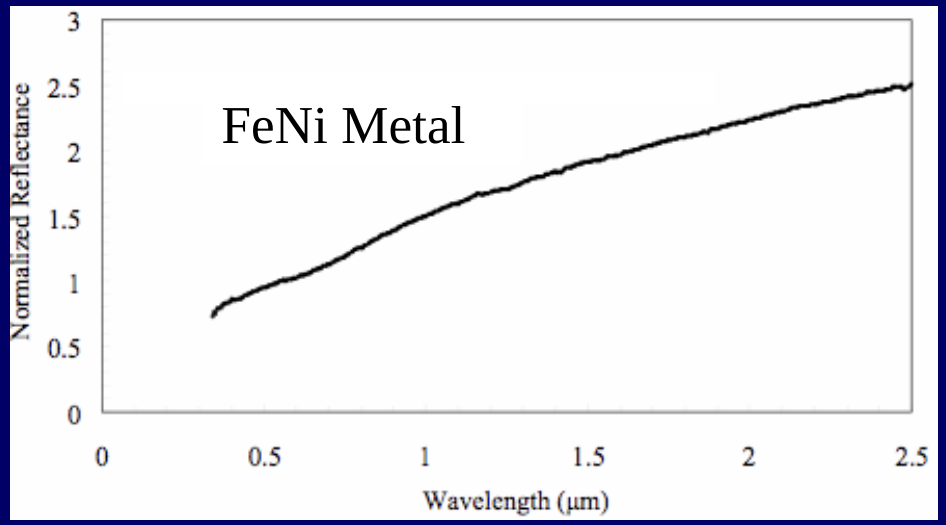
Ratio between the Solar Spectrum and the Reflected Spectrum reveals the composition.

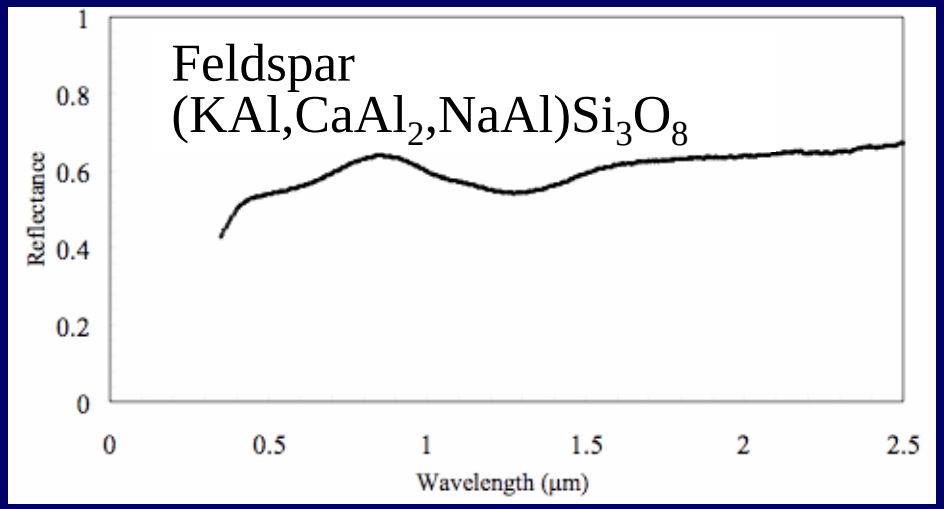


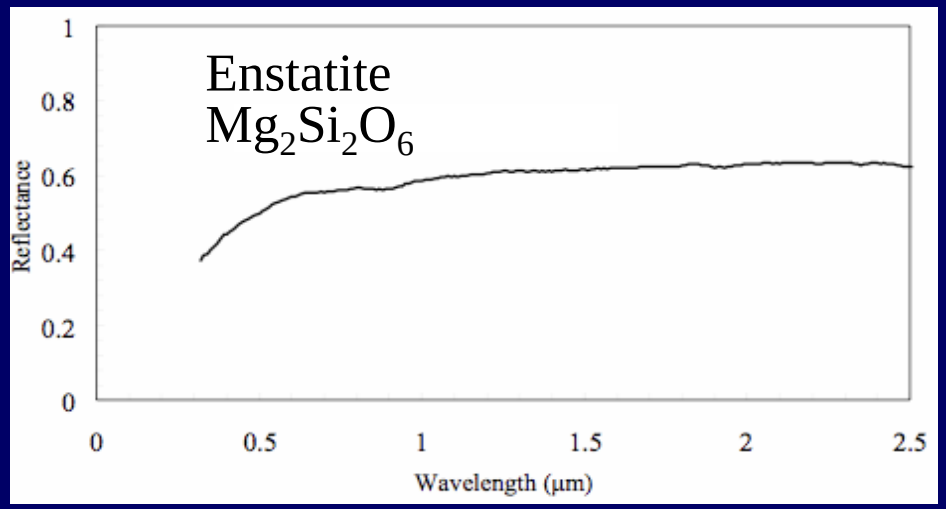


The Power of Reflectance Spectroscopy:
Mineral Analysis

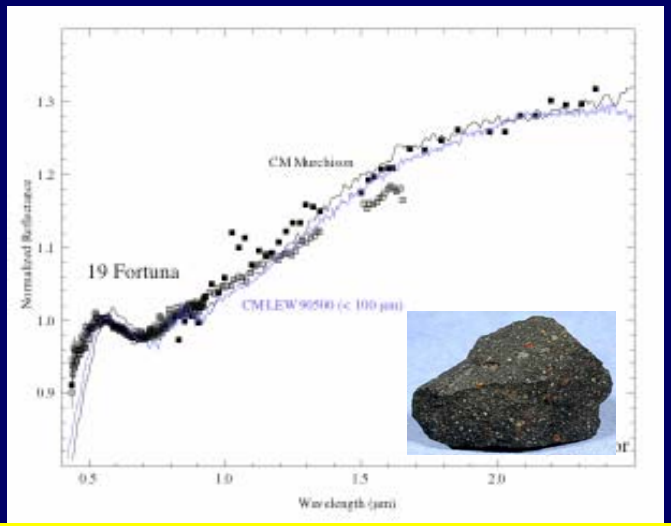




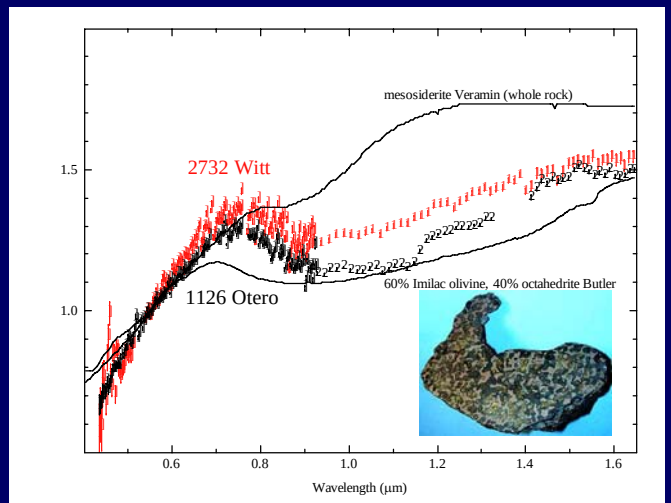




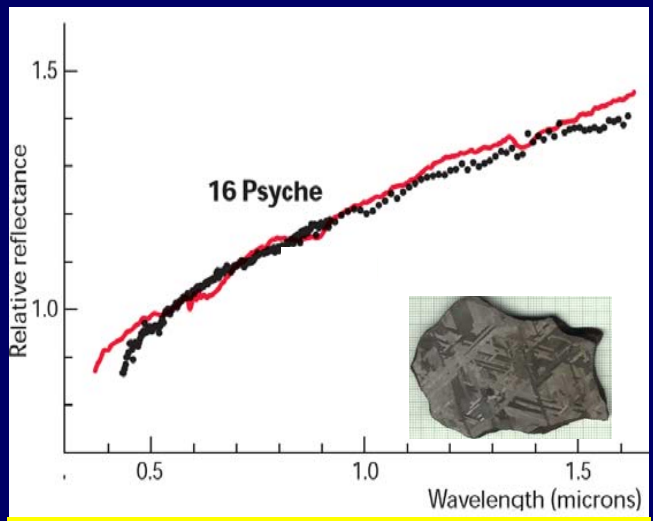
The Power of Reflectance Spectroscopy:
Meteorite Comparison



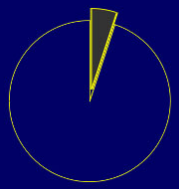
Carbonaceous
Albedo 0.05 - 0.10.
Density 2.1-3.1 g cm^{-3}



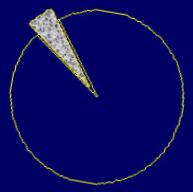
Chondrite or Stony Iron
Albedo 0.15 - 0.25.
Density 3.0-4.8 g cm^{-3}



Iron
Albedo 0.10 - 0.20.
Density 7-8 g cm^{-3}



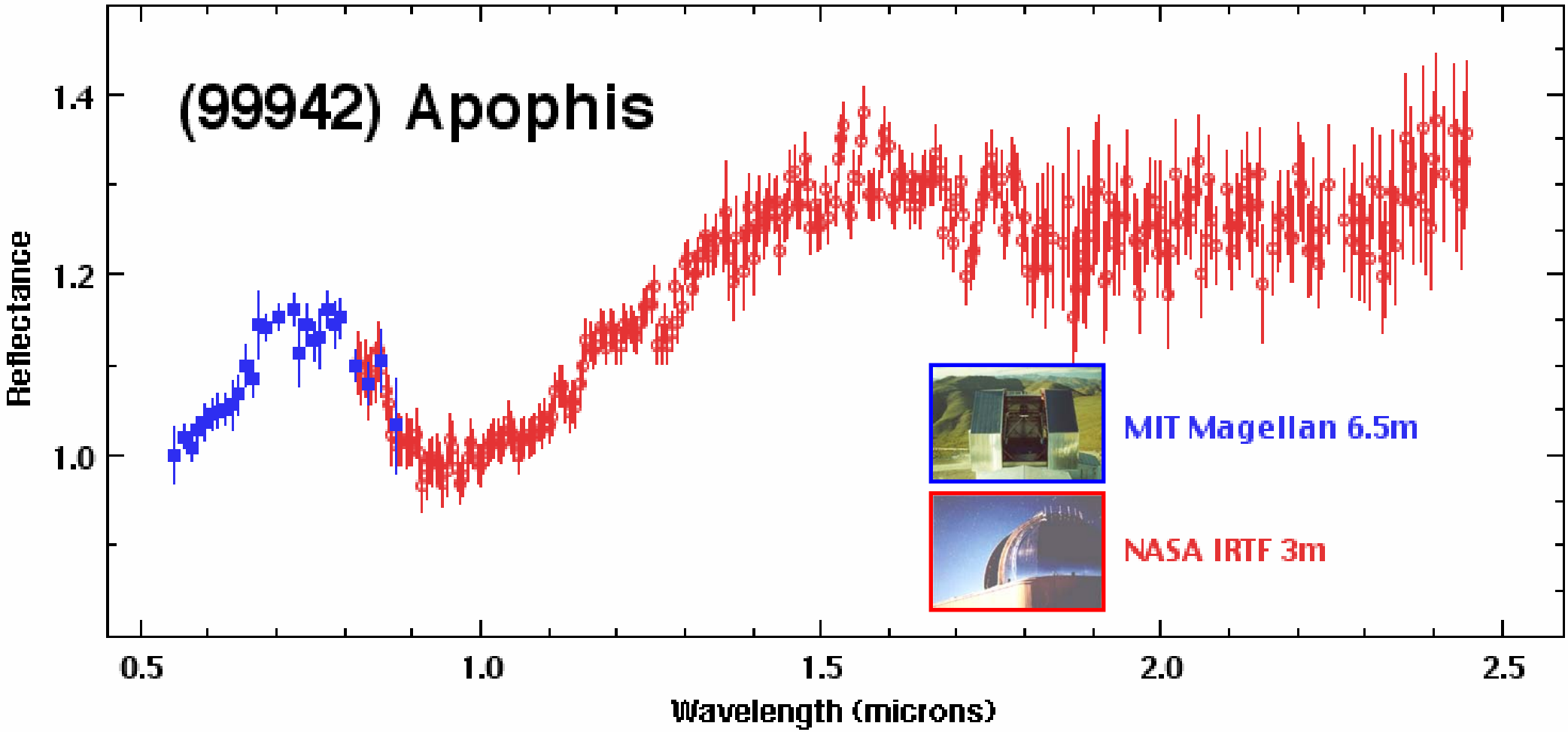
Percentage of all meteorite falls



Meteorite data from Britt & Consolmagno (2003). Asteroid data from Burbine (2000) Ph.D. Thesis M.I.T.

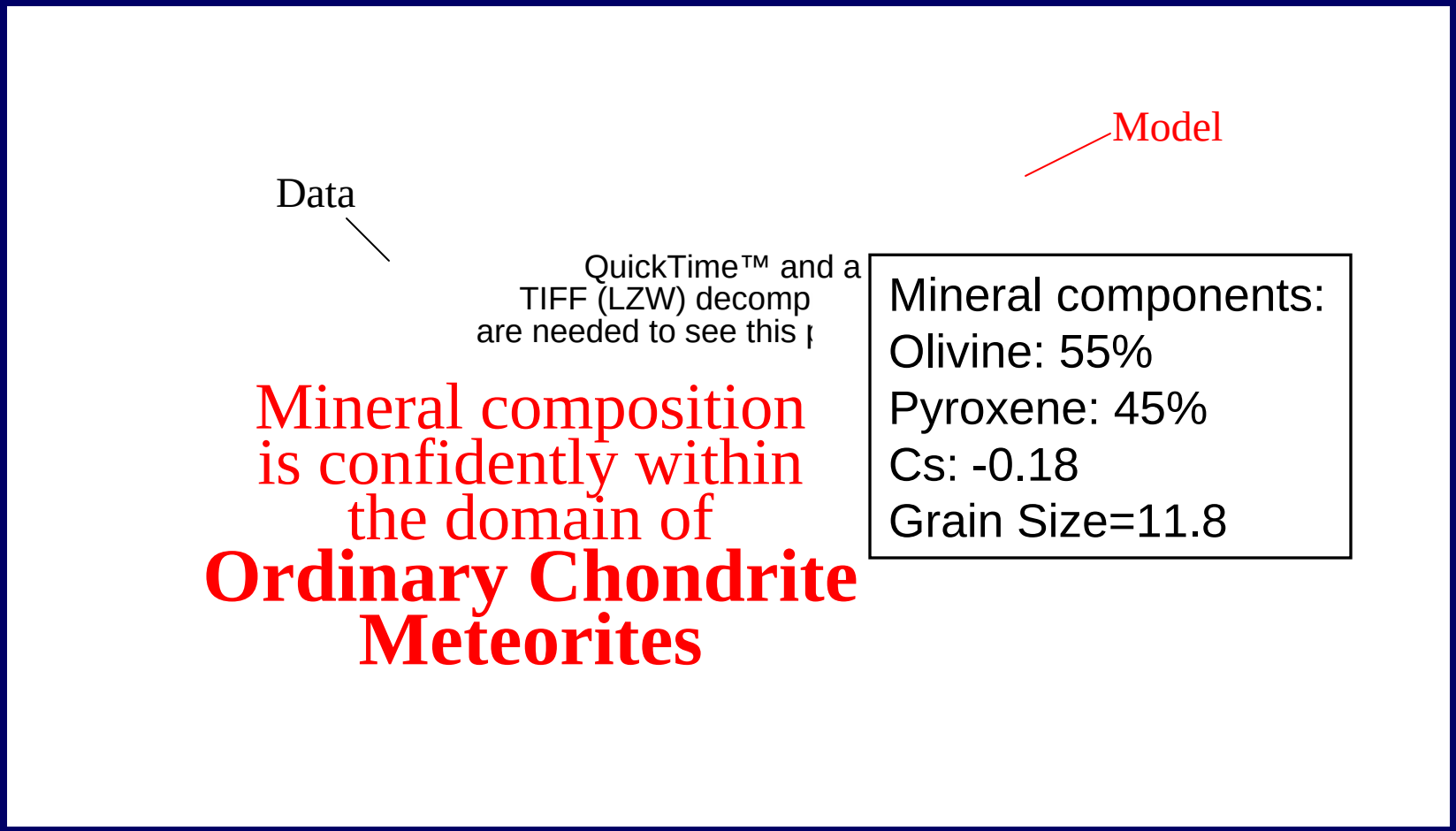
Case Study: (99942) Apophis

Reflectance spectrum from groundbased telescopes.



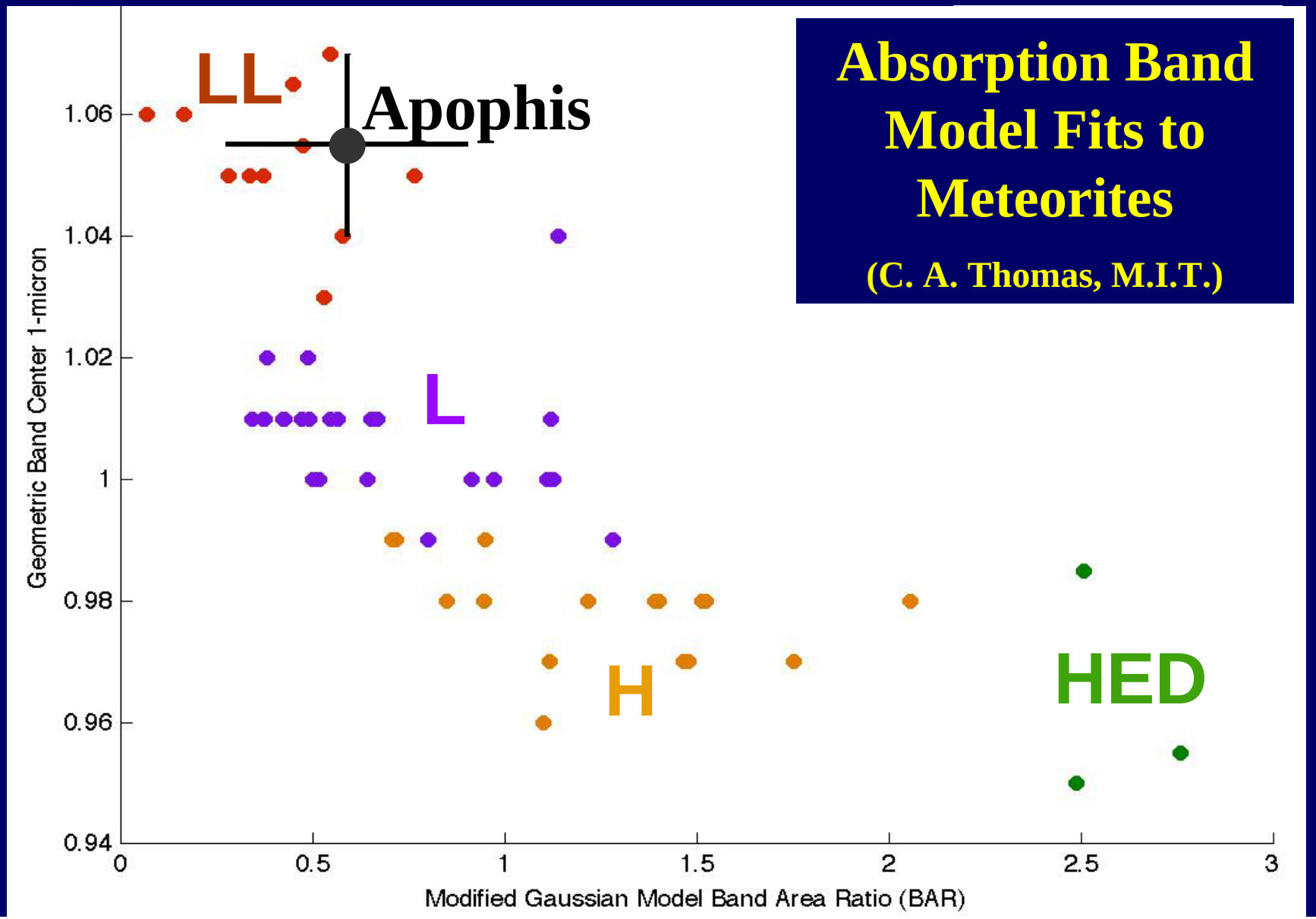
Case Study: (99942) Apophis

Mineral analysis to forge meteorite link.



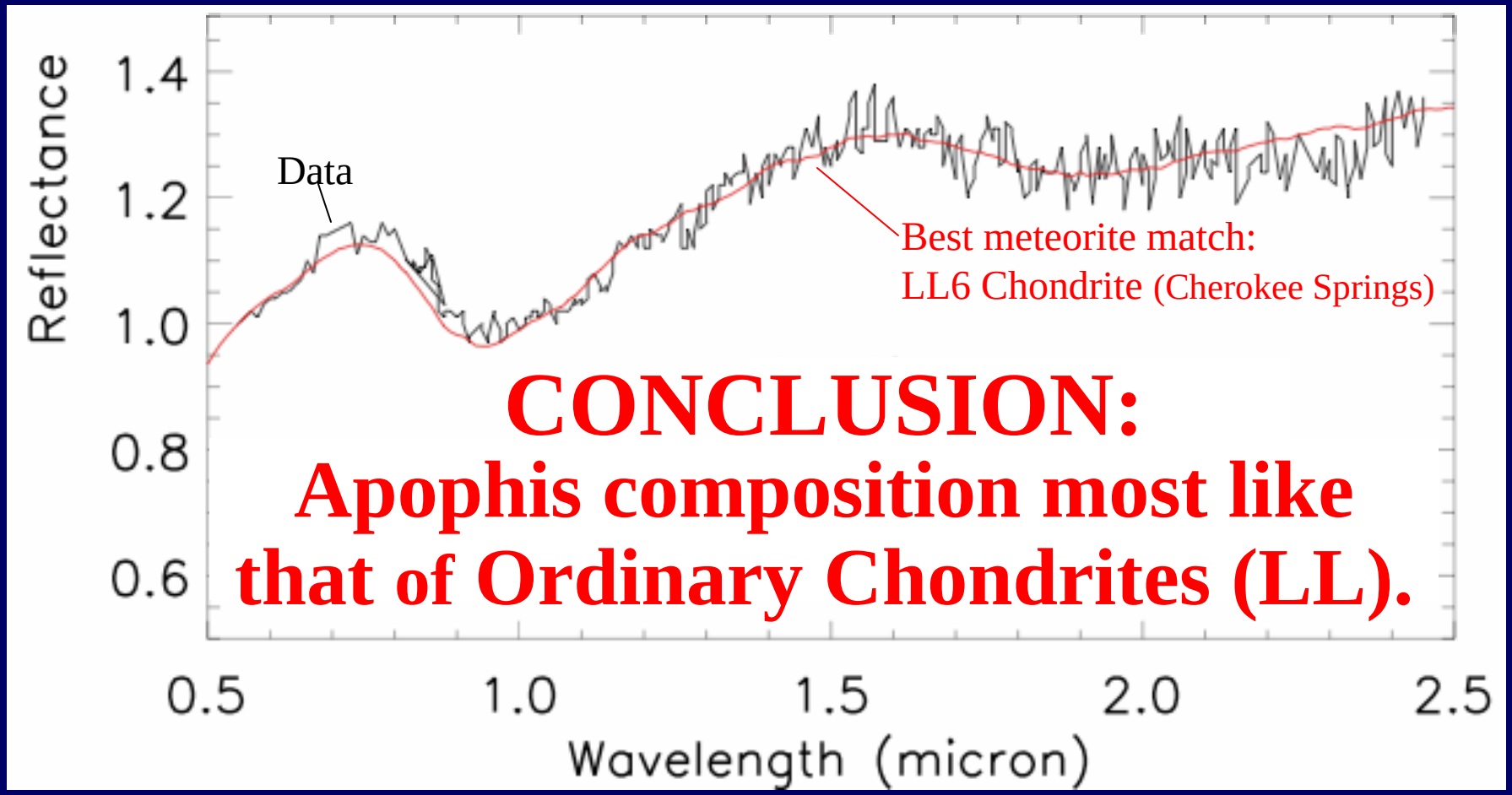
Model method by Shkuratov et al. (1999). Fitting by P. Vernazza.

Case Study: (99942) Apophis



Case Study: (99942) Apophis

Direct comparison to forge specific meteorite link.



Meteorite Data: RELAB. Model by Brunetto et al. (2006). Fit by P. Vernazza using Cs=-0.22.

Apophis as an LL Chondrite

- Grain density 3.5 ± 0.1 g cm^{-3}
- Bulk density 3.2 ± 0.2 g cm^{-3}
- Micro-porosity 7.9 ± 4.2 %
- Composition is olivine, pyroxene, relatively low metal.
- For 270 m diameter [1], resulting mass estimate $= 3.3 \pm 1.5 \times 10^{10}$ kg
- Corresponding energy in the range 500 ± 200 megatons.

[1] Current size estimate from Delbo et al. (2007).

Meteorite data from Britt & Consolmagno (2003).

Groundbased Track Record

Meteoritics & Planetary Science 36, 1167–1172 (2001)
Available online at http://www.uark.edu/meteor

MUSES-C target asteroid (25143) 1998 SF36: A reddened ordinary chondrite

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(Received 2001 April 25; accepted in revised form 2001 May 16)

25143 Itokawa - Binzel et al. (2001)

Remaining Uncertainties

- Spectral interpretation also allows L chondrite and some partial melting to achieve the "best fit."

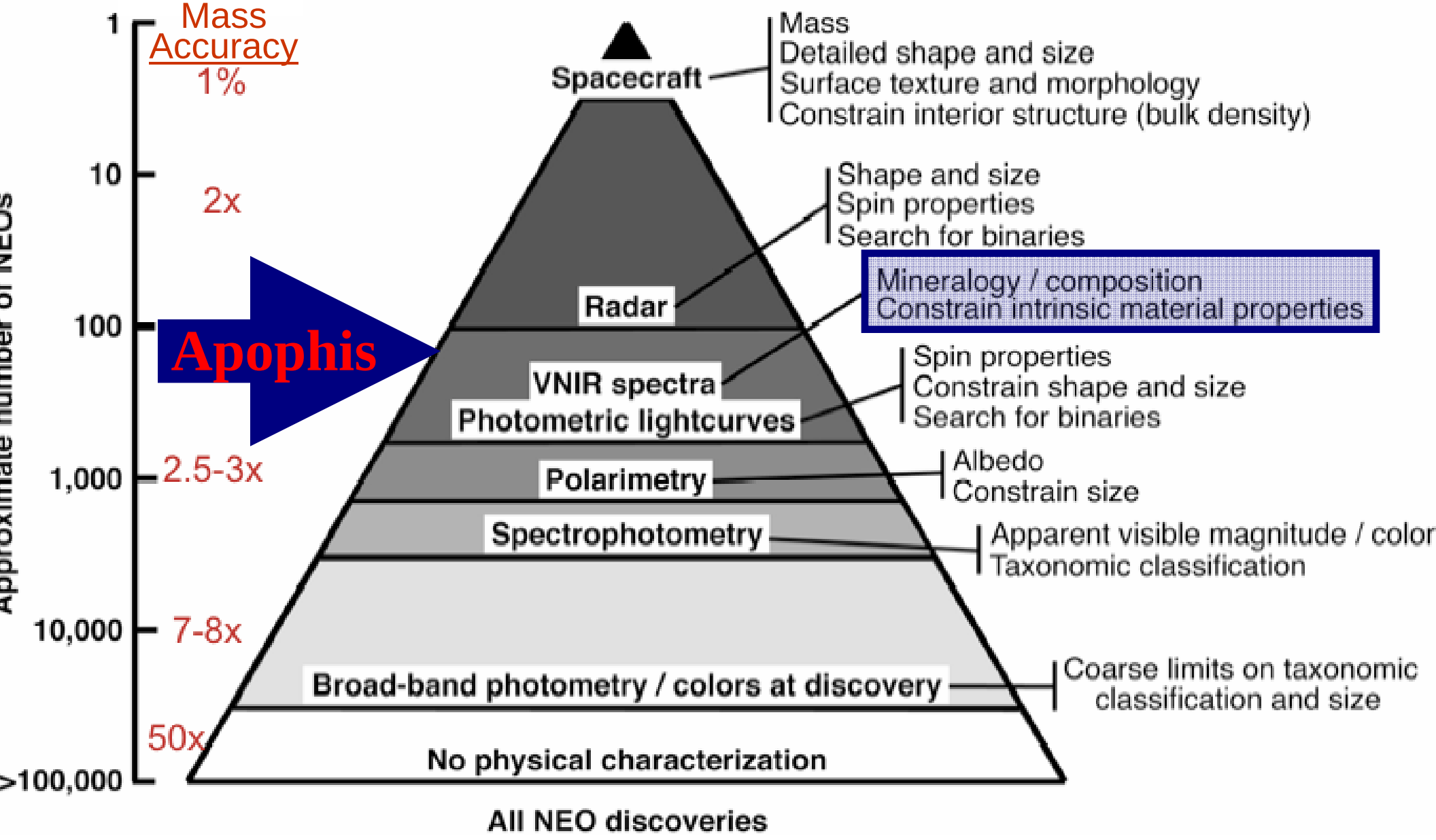
  (But no significant changes to the physical parameters.)

- Macro-porosity on the scale of 10-100 meters remains an unkown.

Ordinary Chondrite (Type LL)

- Grain density 3.5 ± 0.1 g cm^{-3}
- Bulk density 3.2 ± 0.2 g cm^{-3}
- Micro-porosity 7.9 ± 4.2 %
- For 270 m diameter, resulting mass estimate $= 3.3 \pm 1.5 \times 10^{10}$ kg
- Corresponding energy in the range 500 ± 200 megatons.

Current Status for Apophis



CONCLUSIONS

- Basic characterization is the first line of defense against NEAs.
- Spectral matching to meteorites is very effective for achieving a detailed initial physical characterization.
- **Apophis case study**: High confidence in link to a specific well-studied meteorite group, the ordinary chondrites.