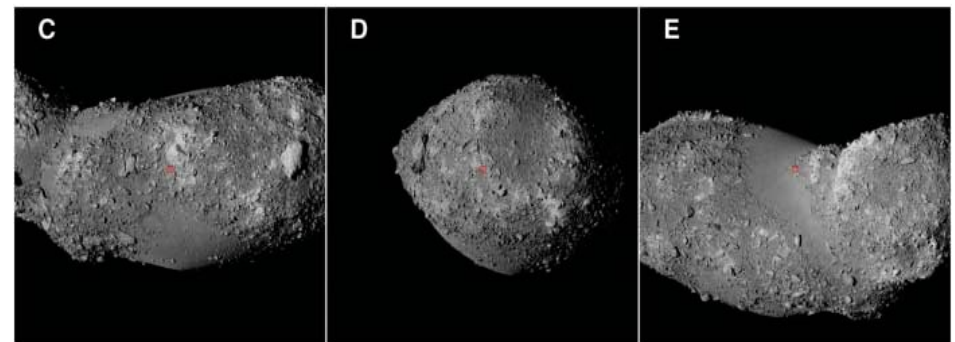
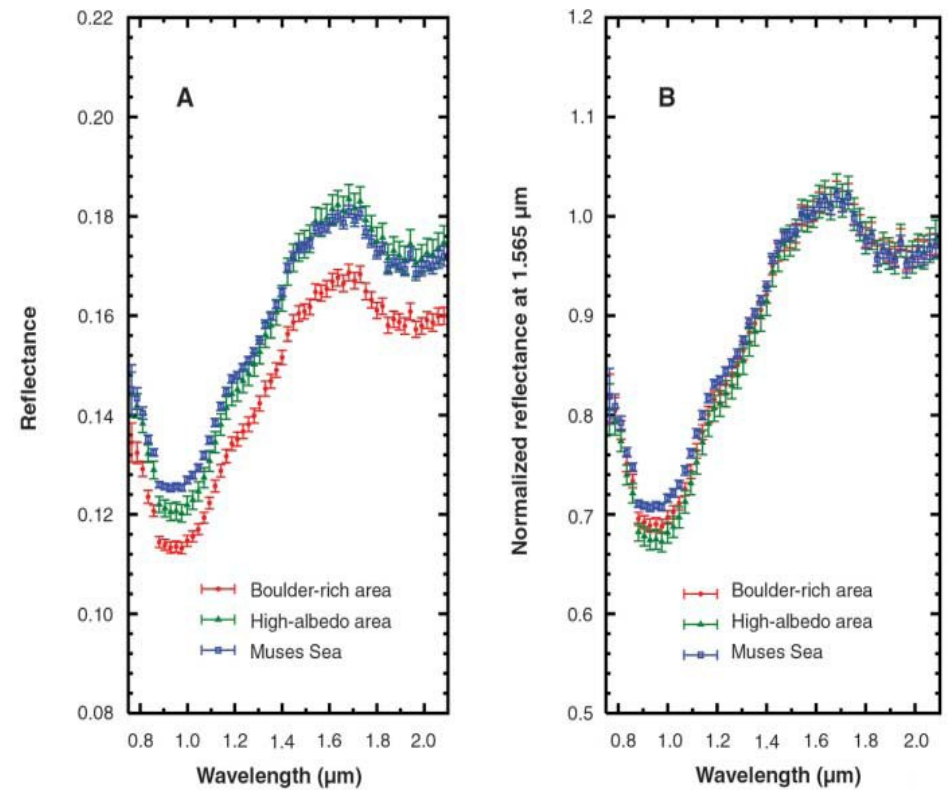
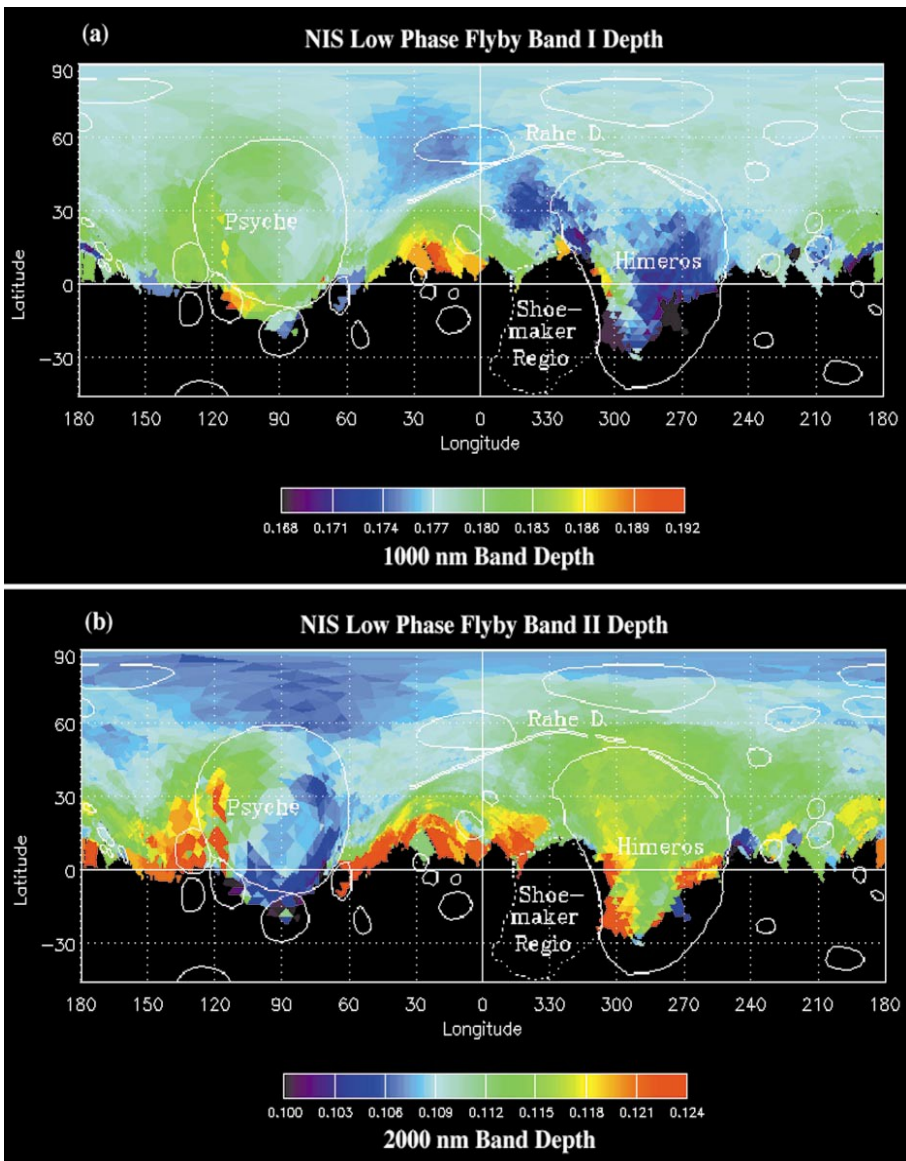


Observações de espectros de asteróides no infravermelho próximo



433 Eros

Paulo Penteado (IAG - USP)

25143 Itokawa

Observações de espectros de asteróides no infravermelho próximo

Taxonomia de asteróides

Asteróides visitados por sondas

Galileo – Gaspra, Ida, Dactyl

Cassini – Masursky

DS1 - Braille

NEAR – Mathilde, Eros

Stardust – Anefrank

Hayabusa – Itokawa

New Horizons – APL

Rosetta – Steins, Lutetia

Espectros NIR de outros corpos

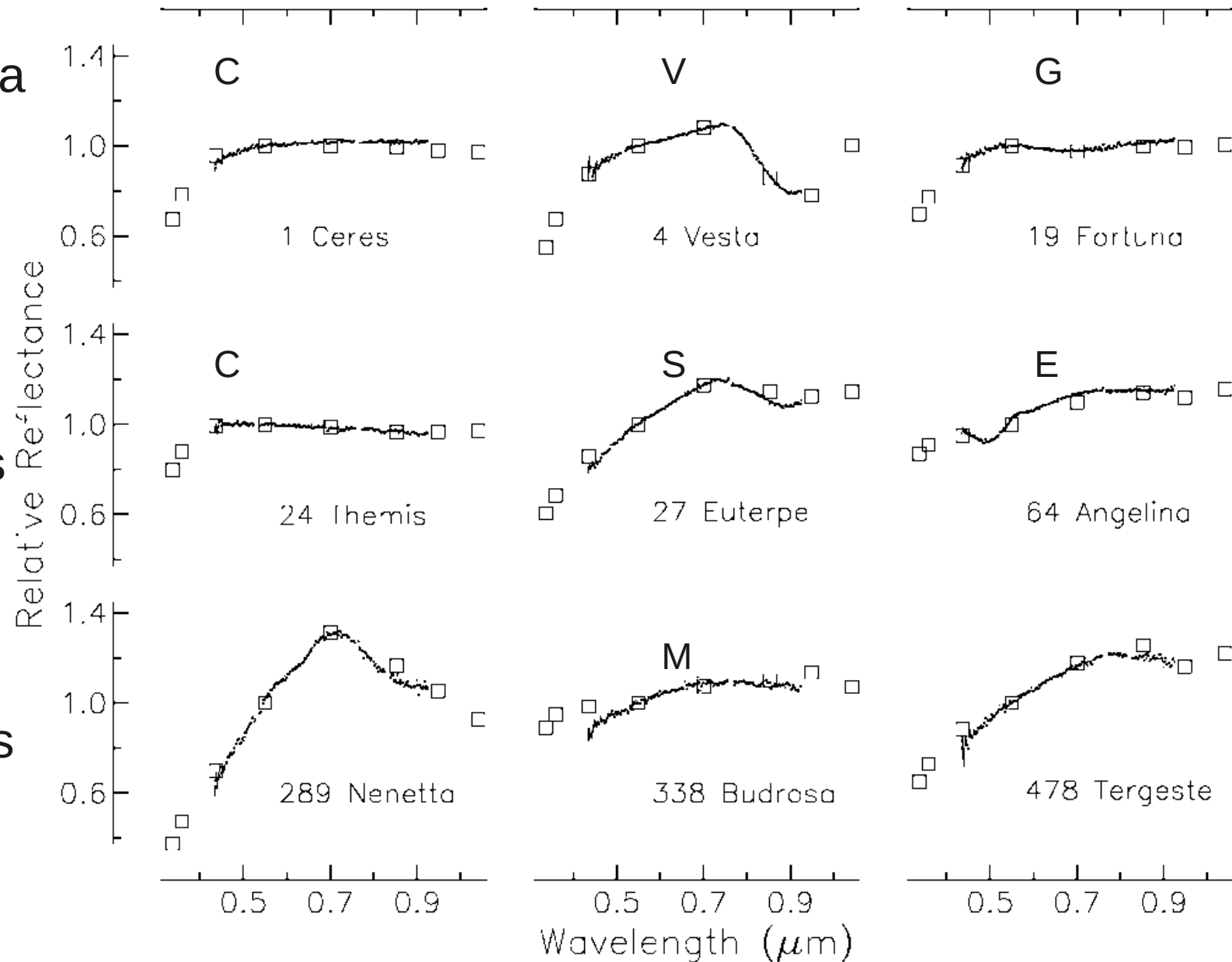
153591 2001 SN263

Taxonomia de asteróides

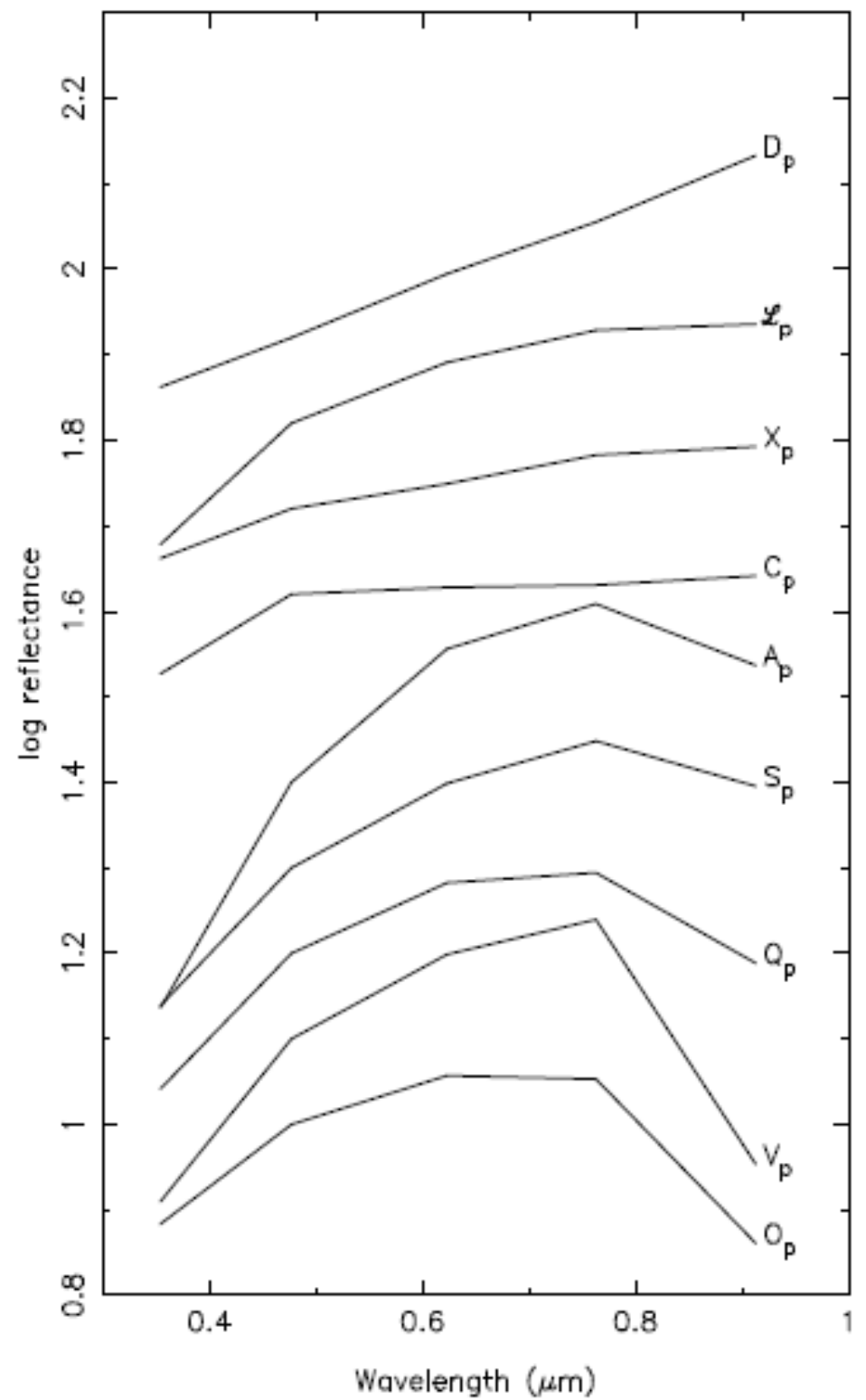
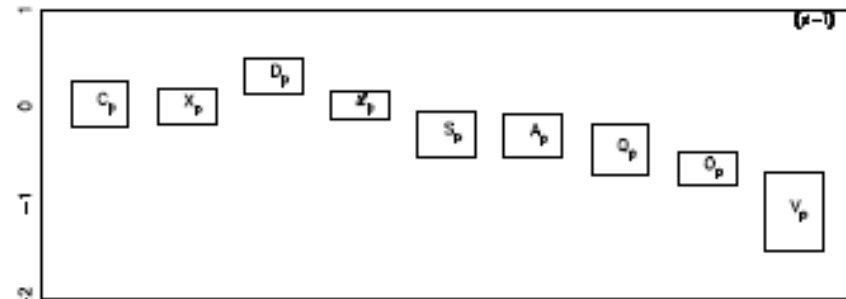
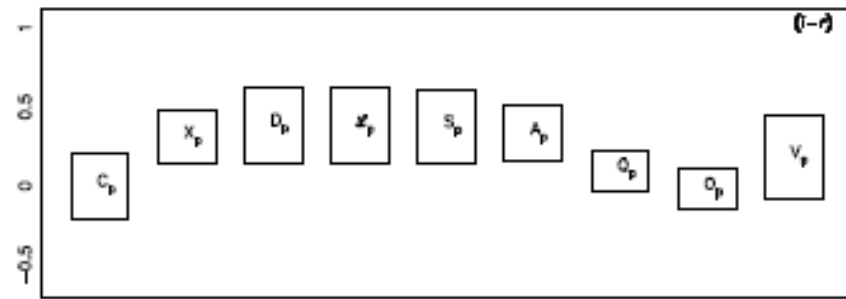
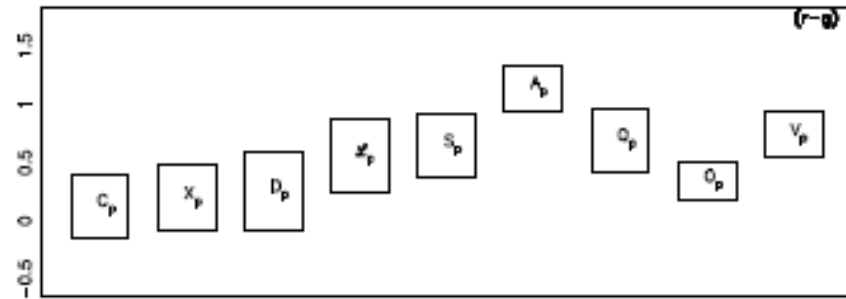
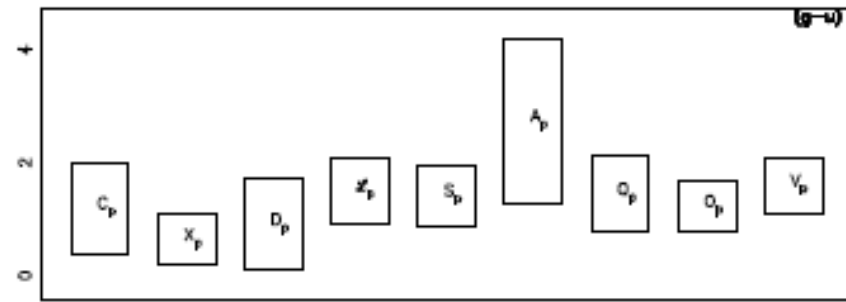
Tipos espectrais de asteróides são bem definidos e estudados, mas não bem ligados a tipos de meteoritos ou composições.

NIR importante para estudar a composição, mas ausente em muitos espectros de terra.

Inomogeneidades e sistemas múltiplos difíceis de estudar de terra.



Taxonomia de asteróides



Galileo – 951 Gaspra (1991)

Tipo S
18.2, 10.5, 8.9 km
1.8-2.6 AU
Família Flora

Primeiro asteróide observado de perto

Espectro NIMS 0.8-5.2 μm :

- 81% olivina, 19% ortopiroxênio (global)
- 87% olivina, 13% ortopiroxênio (local)

Mais vermelho e com mais olivina que condritos ordinários (OC), aproximando de stony-irons (palasitos).



Figure 1: 951 Gaspra SSI/NIMS Spectra

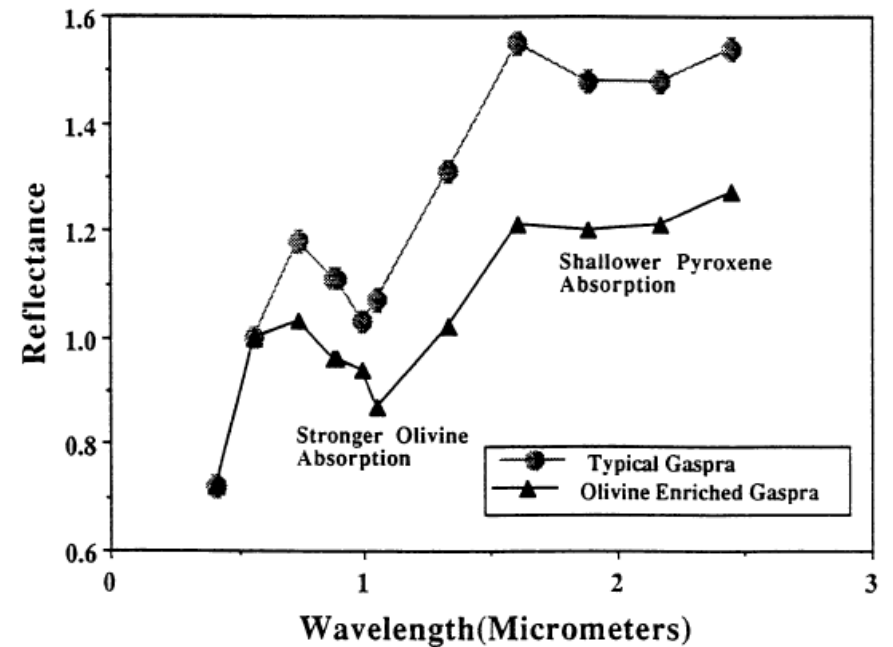
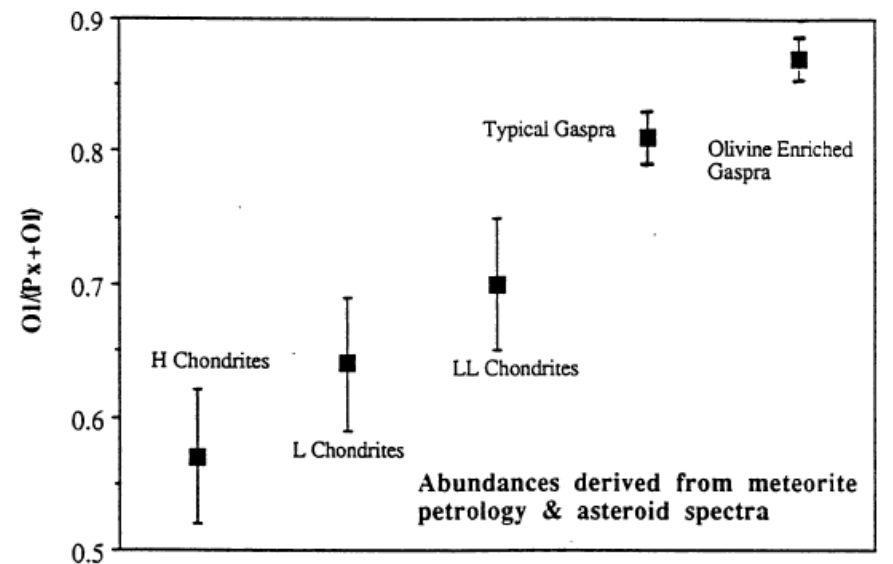


Figure 2: Olivine/(Olivine+Pyroxene)



Granaham *et al.*, 1994

Galileo – 243 Ida, 243 Ida I Dactyl (1993)

Tipo S

53.6, 24.0, 15.2 km

1.6, 1.4, 1.2 km

2.7-3.0 AU

Família Koronis

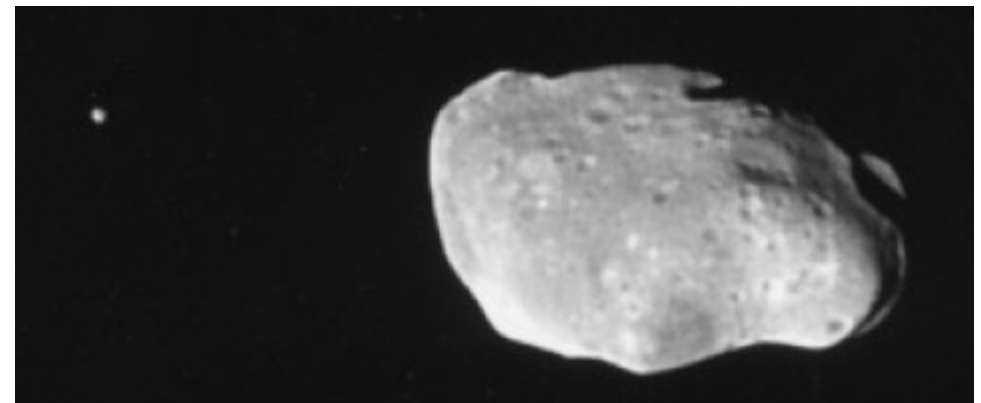
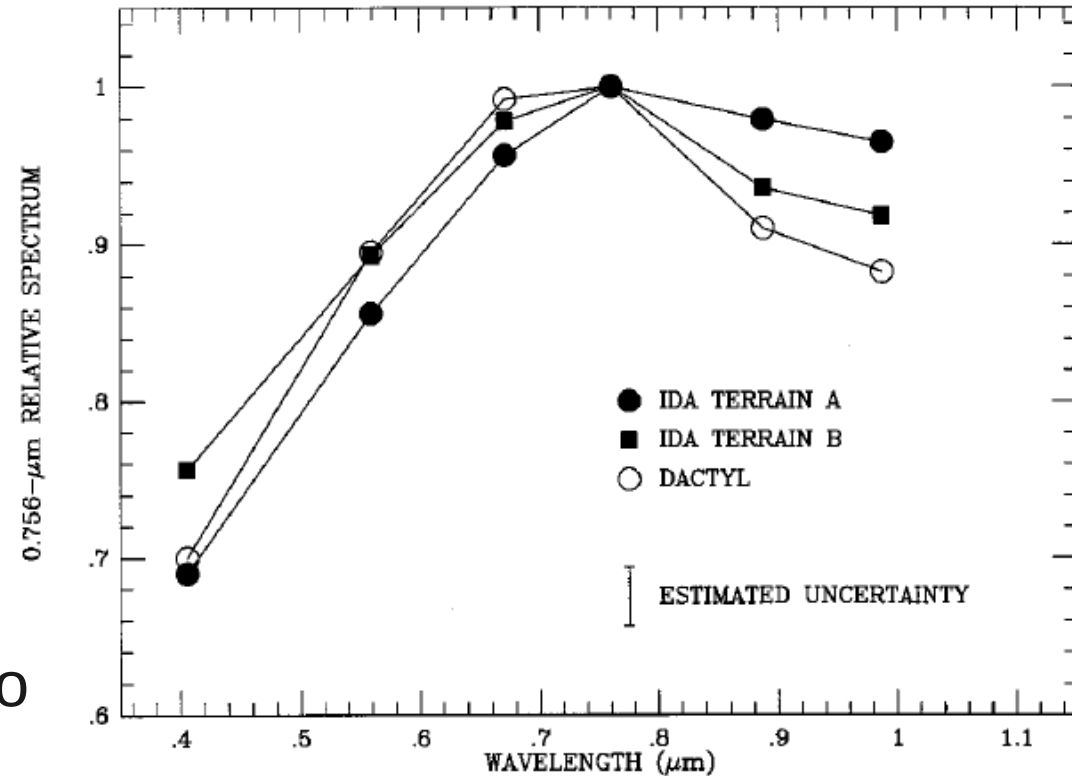
Primeiro asteróide com satélite

Imagens SSI 0.4-1.0 μm :

- Diferença de cor devida à variação piroxênio/olivina

Espectros NIMS:

- Mais semelhantes a OCs
- Variável grau de weathering



NEAR – 253 Mathilde (1997)

Tipo Cb

66, 48, 46 km

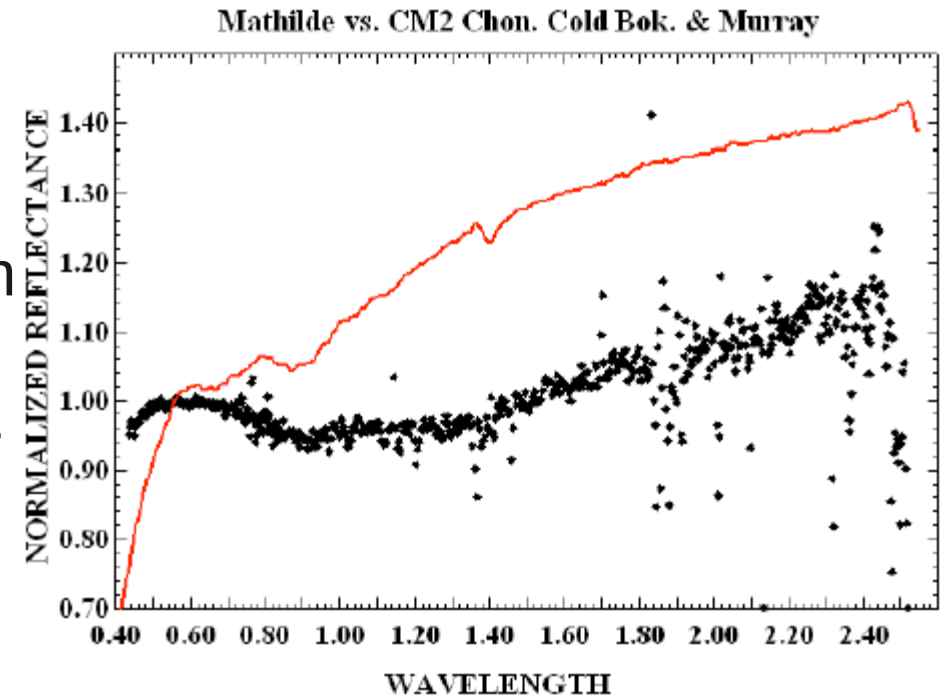
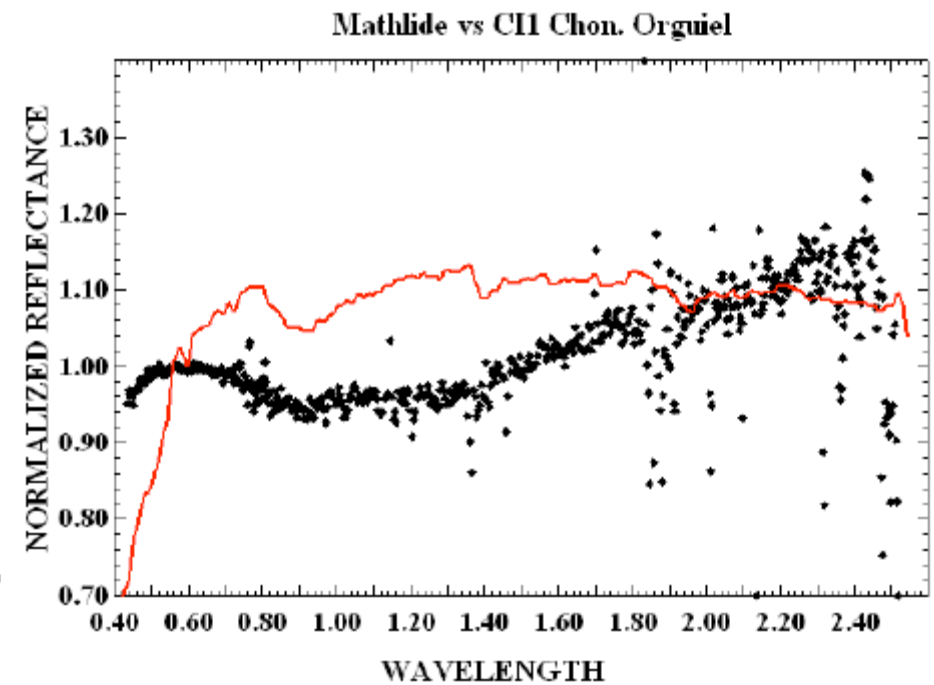
1.9-3.4 AU

Primeiro asteróide não S visitado

Observado só pela câmera NEAR MIS,
espectros só de terra.

Sem a banda de 2 μm de condritos
carbonáceos CV3

Absorção em 0.9 μm não coincide com
água (sólida, líquida, ou vapor),
mas presente em condritos CI1 e CM2



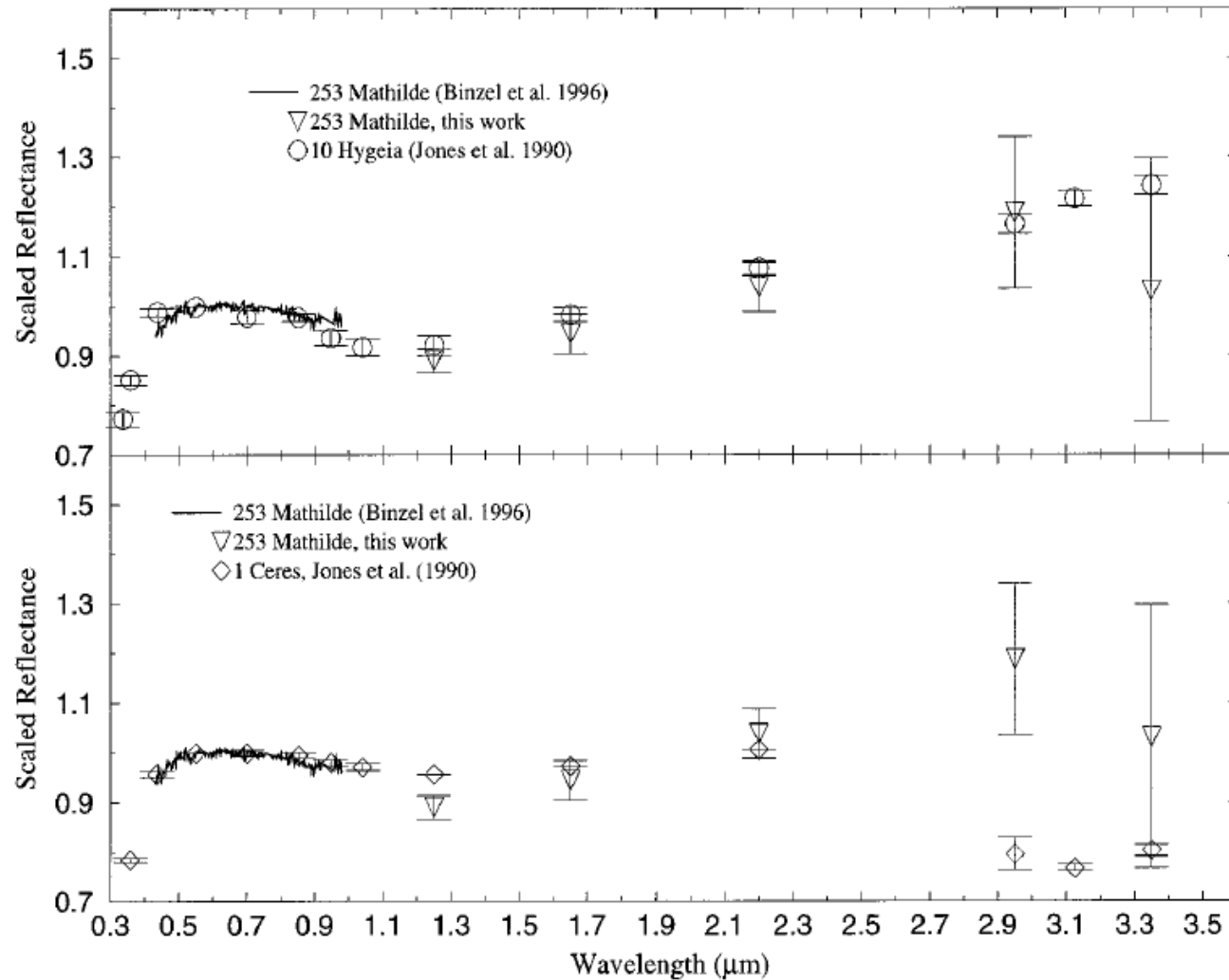
NEAR – 253 Mathilde (1997)

Não consistente com condritos carbonáceos (CC)

Sem a banda de alteração aquosa em $3\ \mu\text{m}$ de outros asteróides C ou de condritos metamorfizados CI/CM

Mais consistente com material carbonáceo aquecido

Rivkin *et al.*, 1997

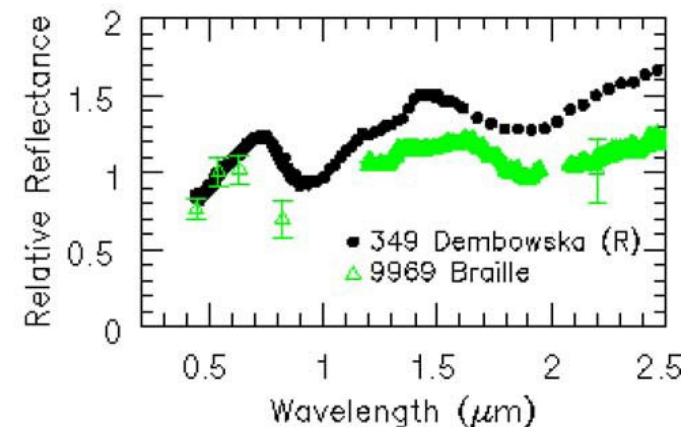
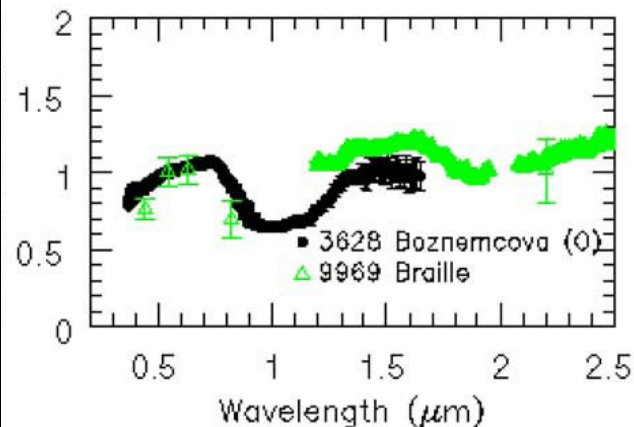
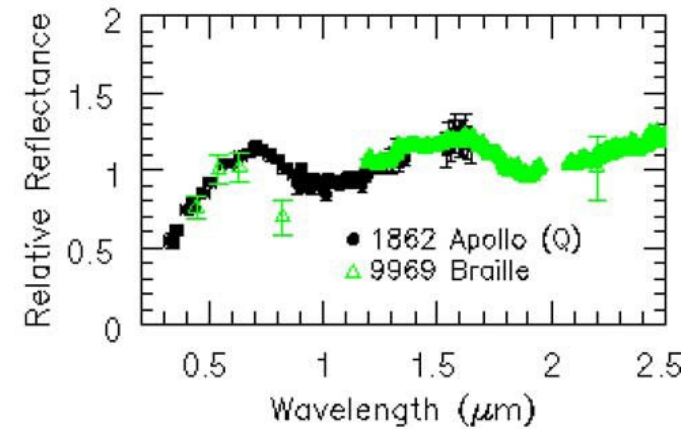
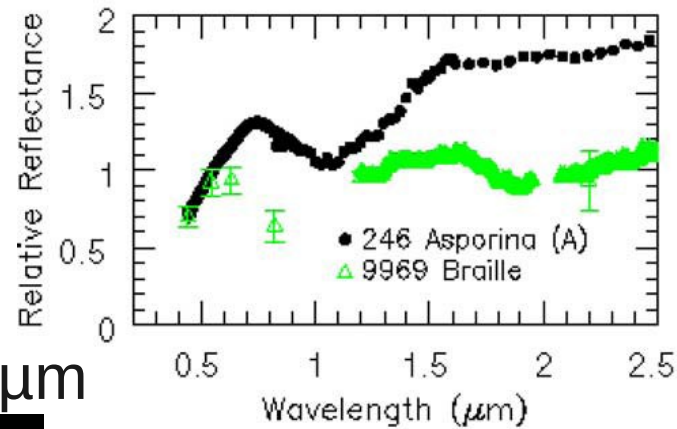
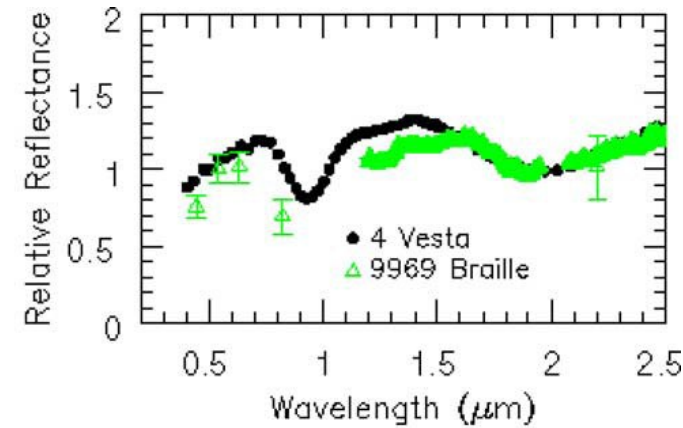
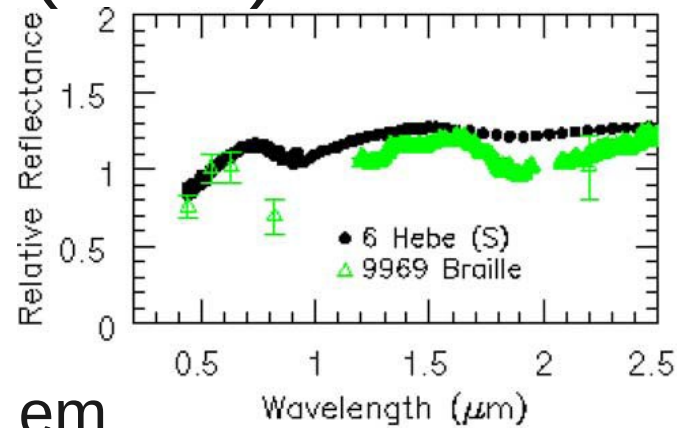


DS1 – 9969 Braille (1999)

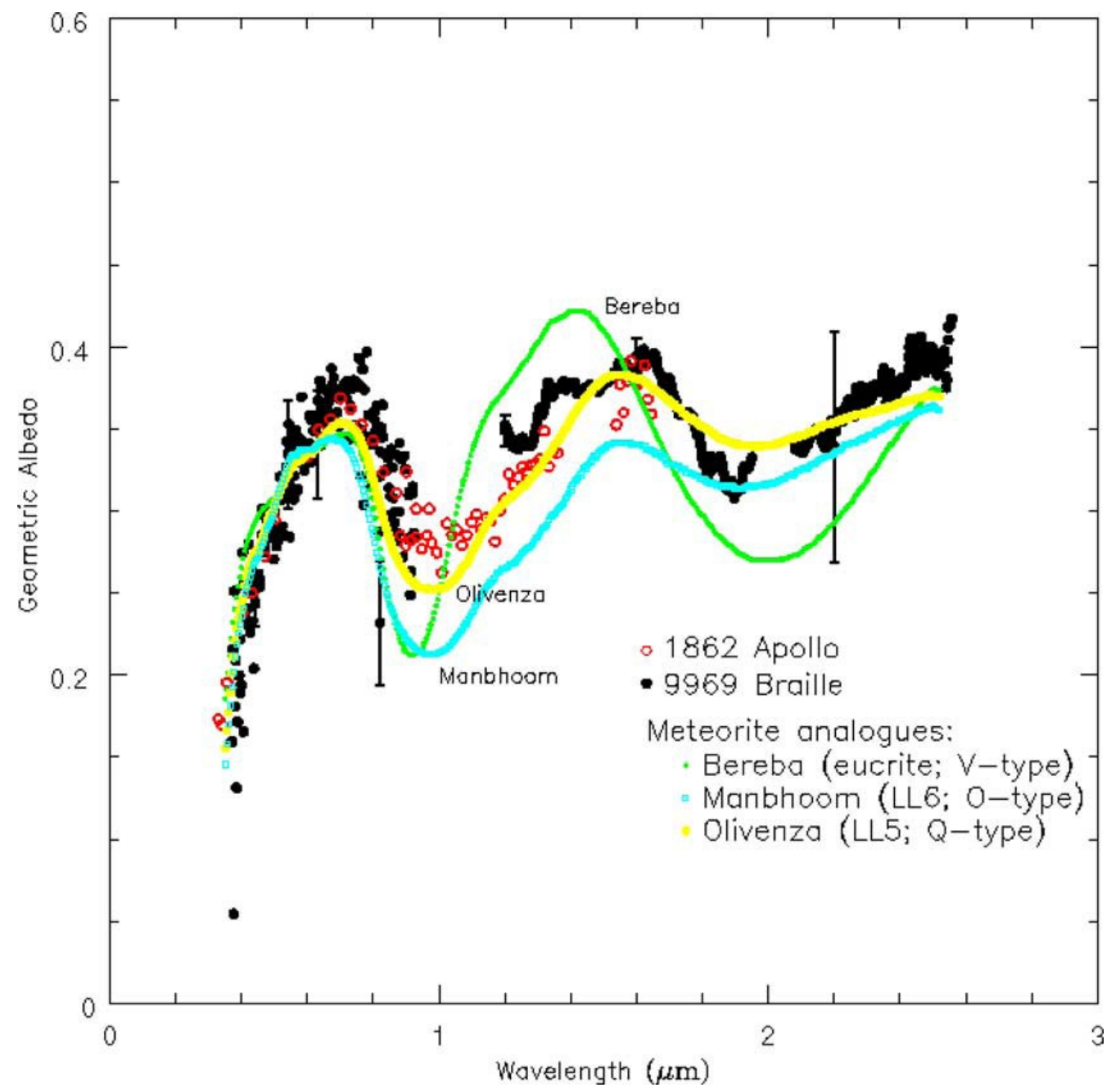
Tipo Q(?)
2.1, 1, 1 km
1.3-3.4 AU

Cruza a órbita de Marte,
cruzará a órbita da Terra em
4000 anos

3 espectros MICAS
(Miniature Integrated
Camera and Imaging
Spectrometer), 1.25-2.6 μm



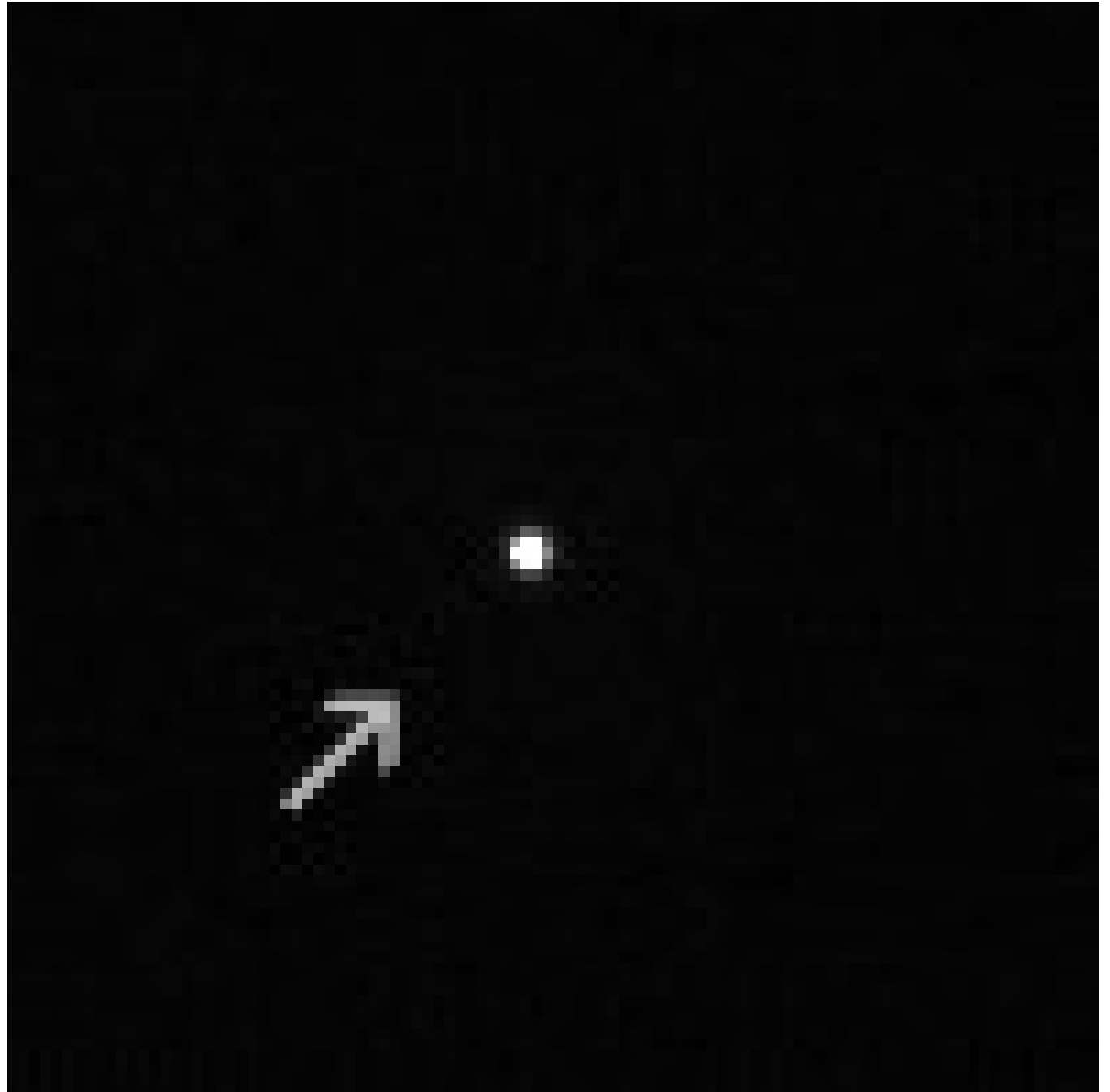
DS1 – 9969 Braille (1999)



Cassini – 2685 Masursky (2000)

Tipo S
15-20 km
2.3-2.9 AU
Família Eunomia

Passagem muito
distante, apenas
tamanho determinado



NEAR – 433 Eros (2000-2001)

Tipo S

34.4, 11.2, 11.2 km

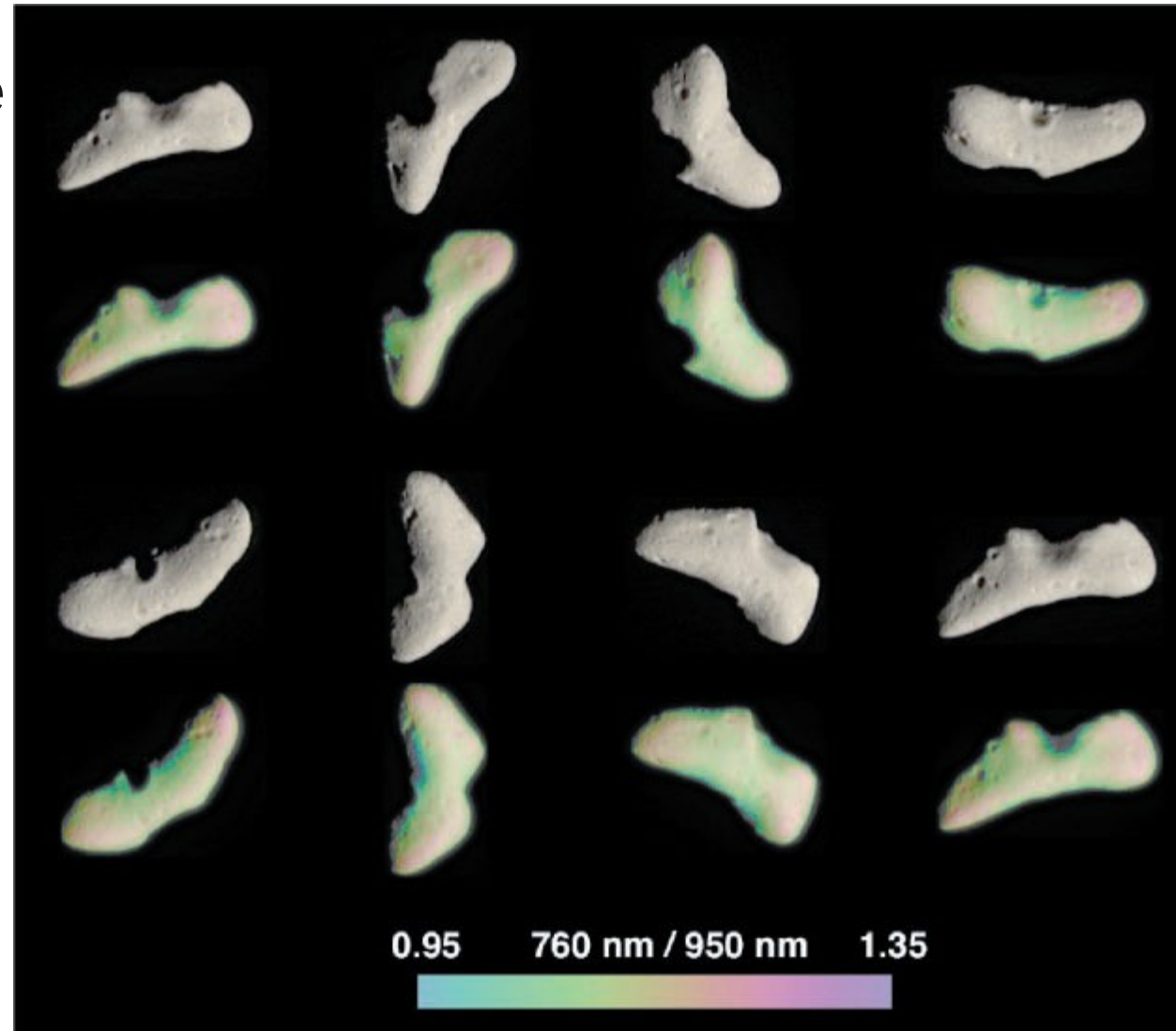
1.1-1.8 AU

Veverka et al., 2000

Primeira missão dedicada a asteróide

NEA, cruza a órbita de Marte

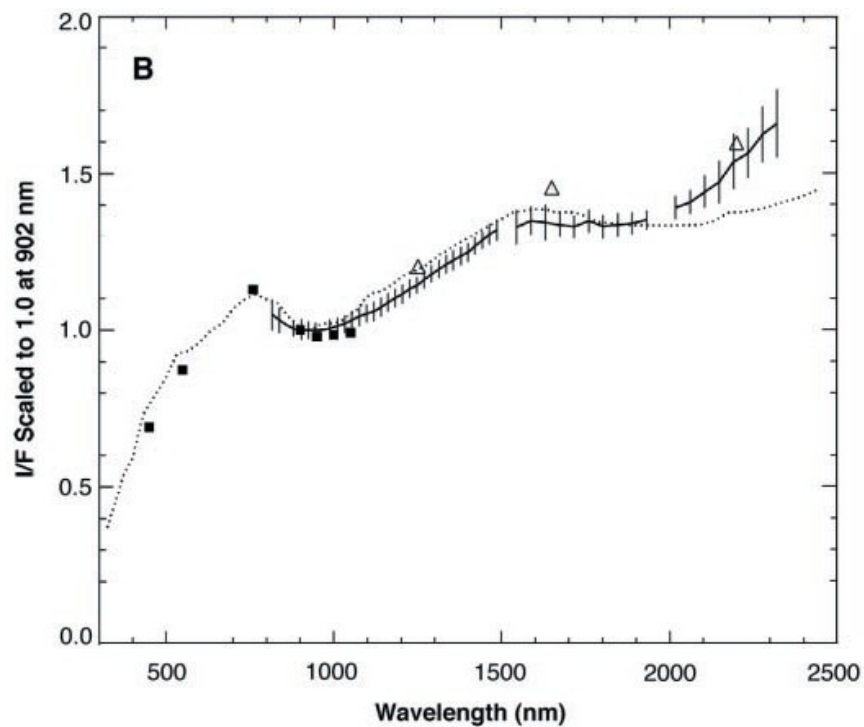
Grande variação na banda
de 1 μm comum em tipos S



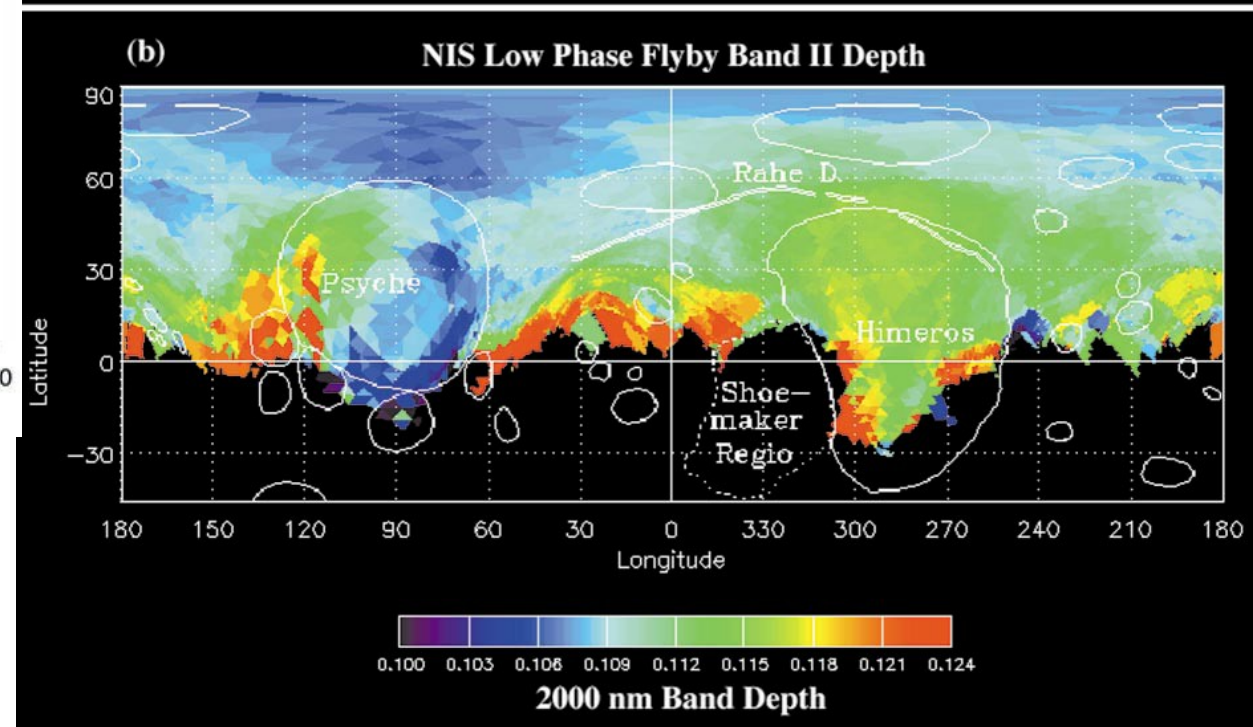
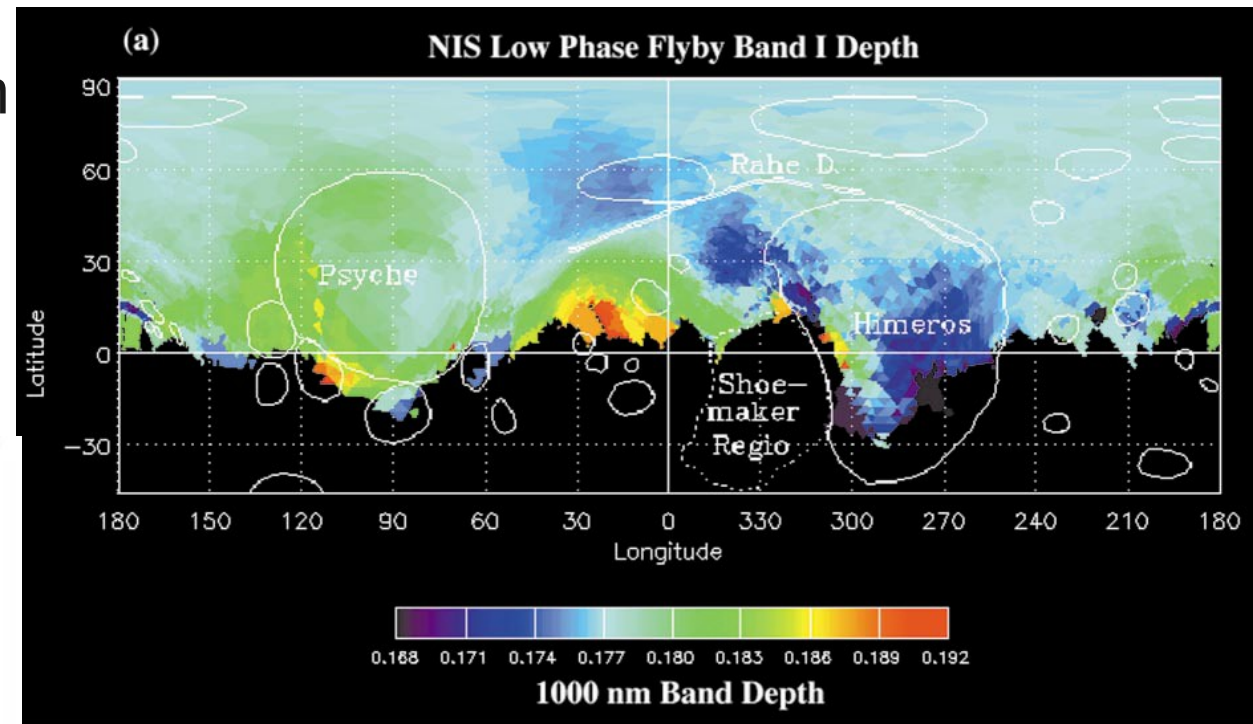
NEAR – 433 Eros (2000-2001)

Bell *et al.*, 2002

Mapeamento das bandas em 1 e 2 μm



Veverka *et al.*, 2000

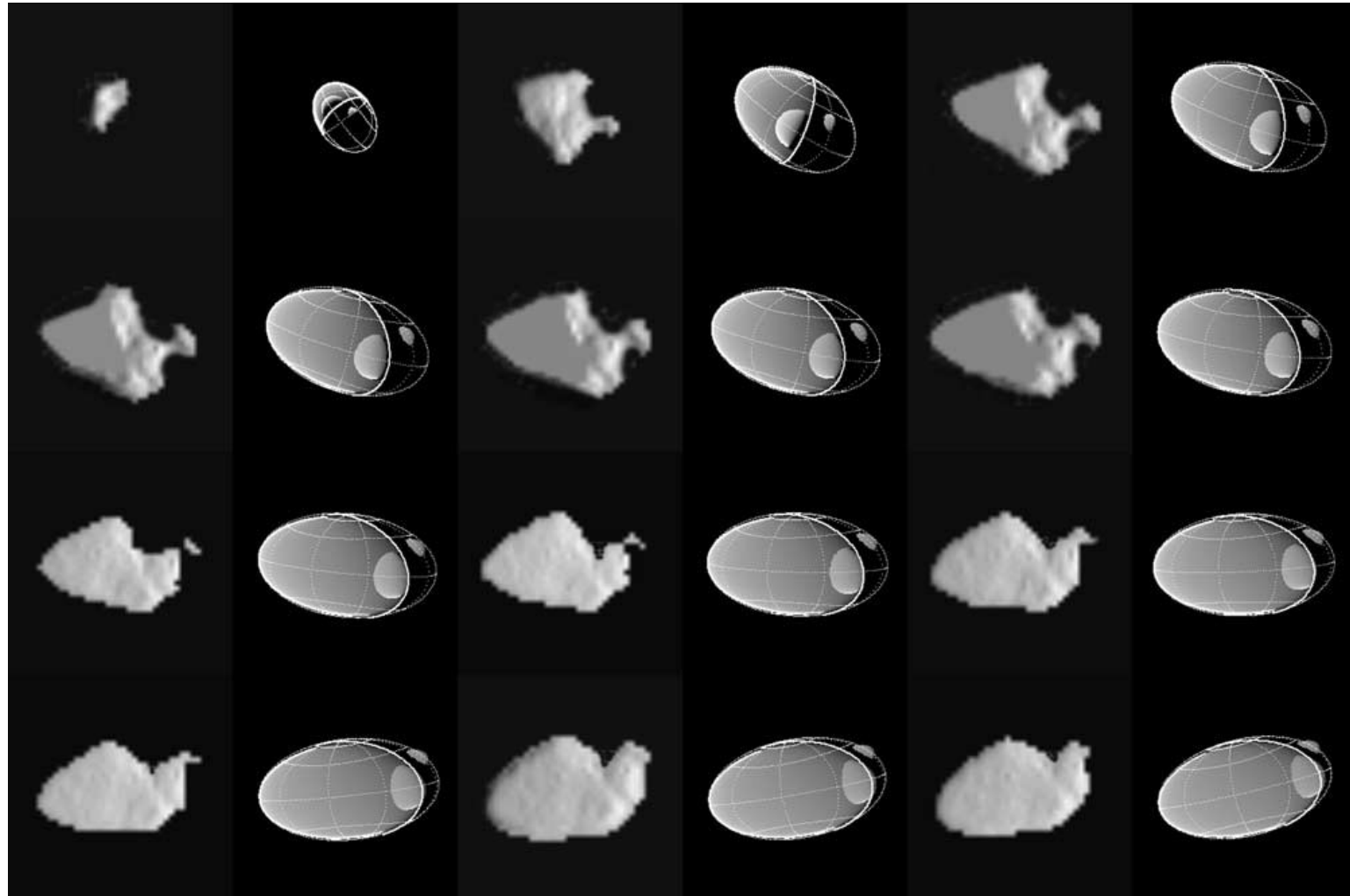


Stardust – 5535 Annefrank (2002)

Tipo S
6.6, 5.0, 6.4 km
2.1-2.4 AU

Duxbury *et al.*, 2004

Apenas forma (?)



Hayabusa – 25143 Itokawa (2005)

Abe *et al.*, 2006

Tipo S

0.54, 0.29, 0.21 km

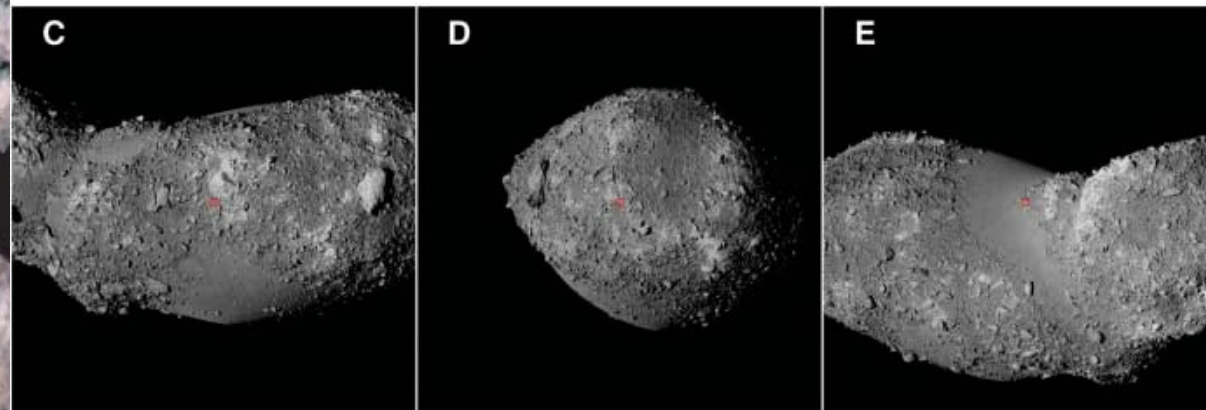
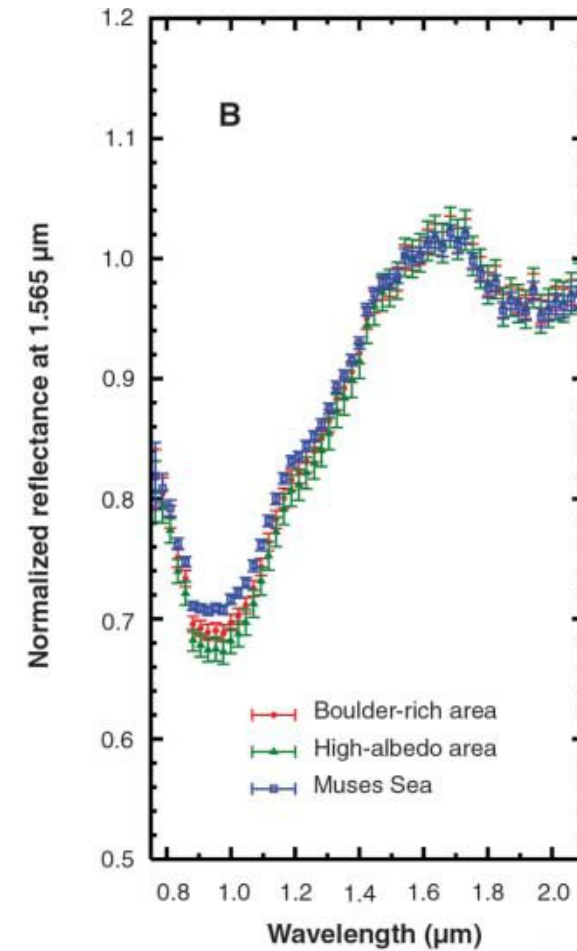
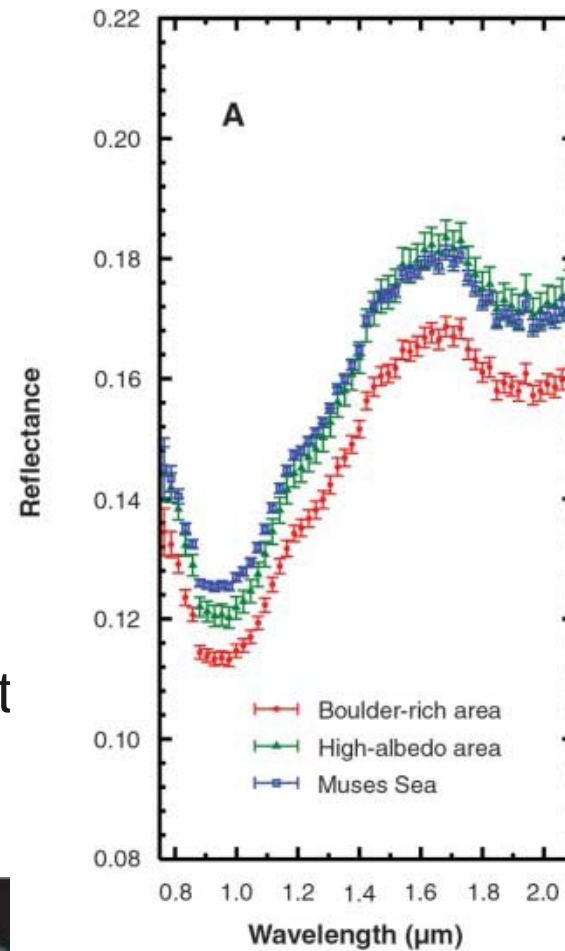
0.96-1.7 AU

Primeira missão a pequeno asteróide

Primeiro retorno de amostra

NEA, cruza as órbitas da Terra e Marte

Mais variável que Eros, semelhante a condritos LL5, LL6

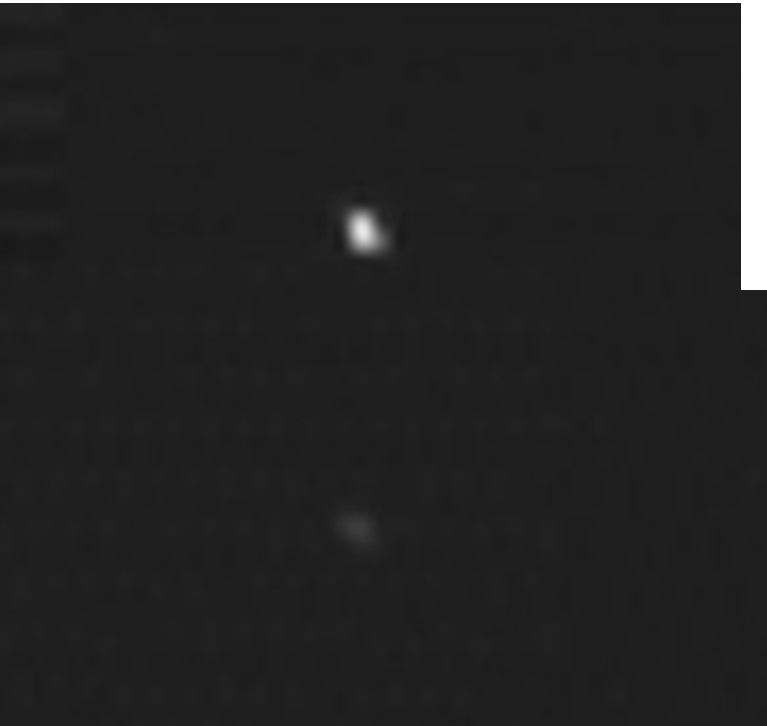
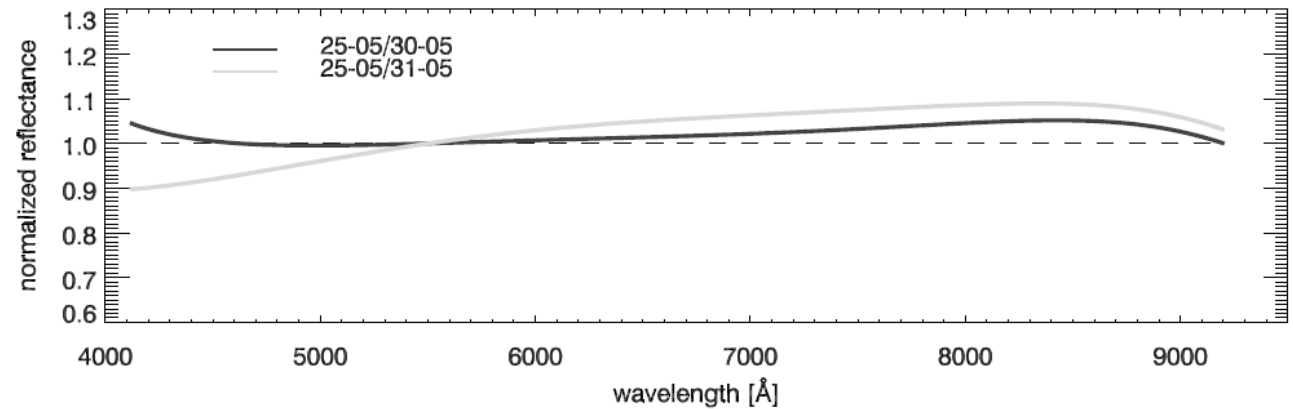
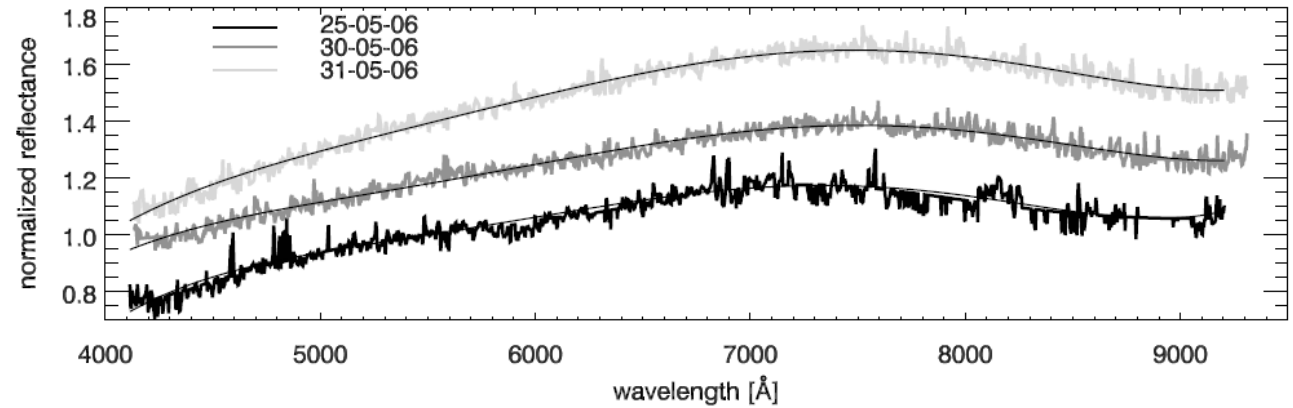


New Horizons – 132524 APL (2006)

Tubiana *et al.*, 2007

Tipo S
1.15 km
1.9-3.3 AU

Espectros da New Horizons ainda não publicados (?)



Rosetta – 2867 Steins (2008)

Keller *et al.*, 2002

Tipo E

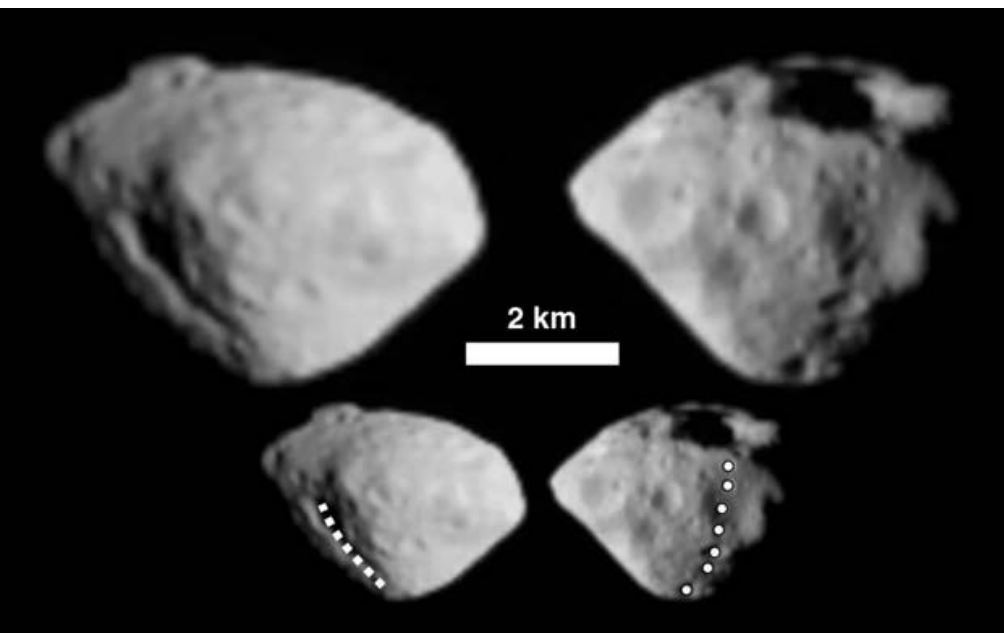
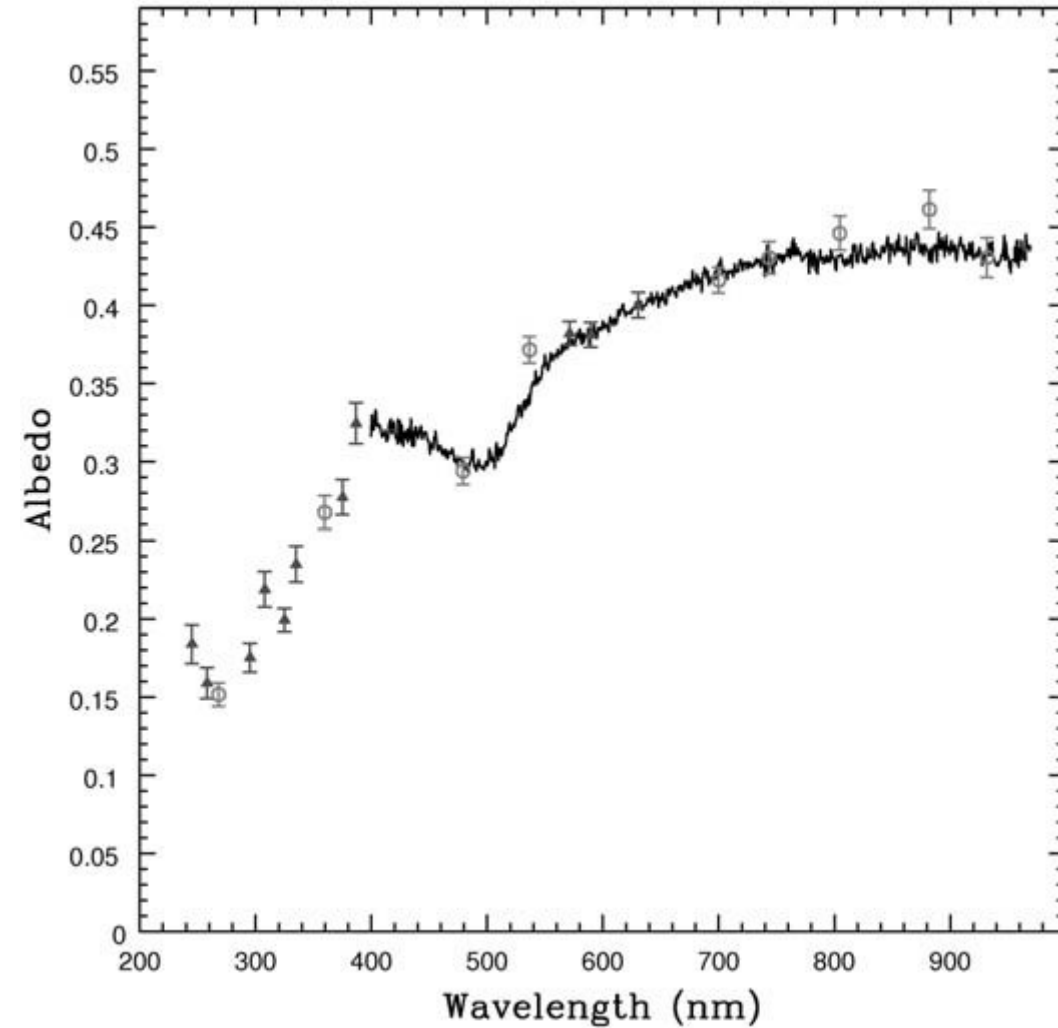
6.7, 5.8, 4.5 km

2.0-2.7 AU

Espectros OSIRIS (Optical,
Spectroscopic and and Infrared
Remote Imaging System)

Relacionado a meteoritos acondritos
(enstatitos)

Cor da superfície homogênea a 1%



Rosetta – 21 Lutetia (julho/2010)

Tipo C ou M

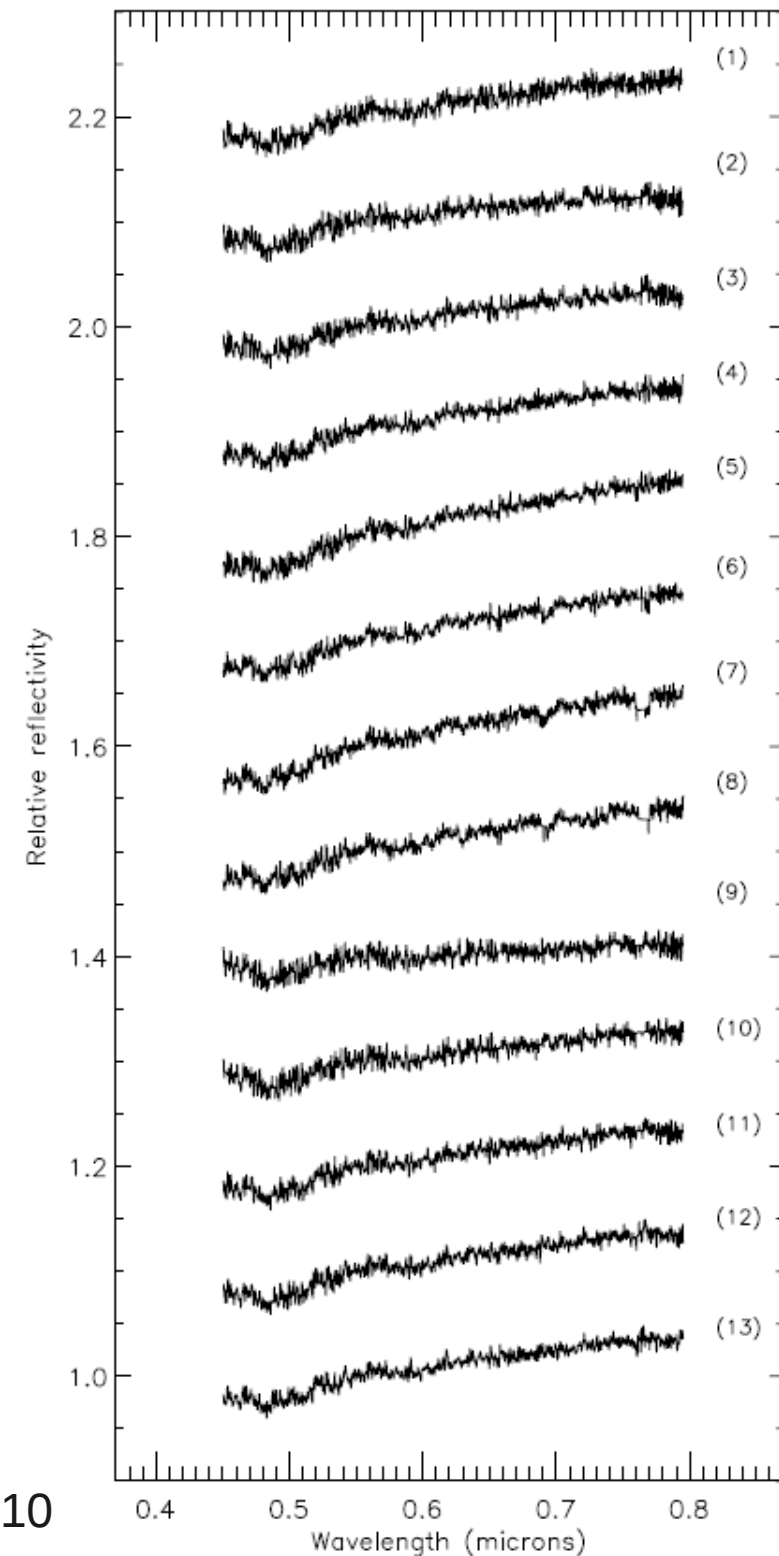
132, 101, 76 km

2.0-2.8 AU

Espectros de terra (Rosetta ainda não publicados):

- Variação detectável com a rotação

Incertezas na classificação por incertezas no albedo.

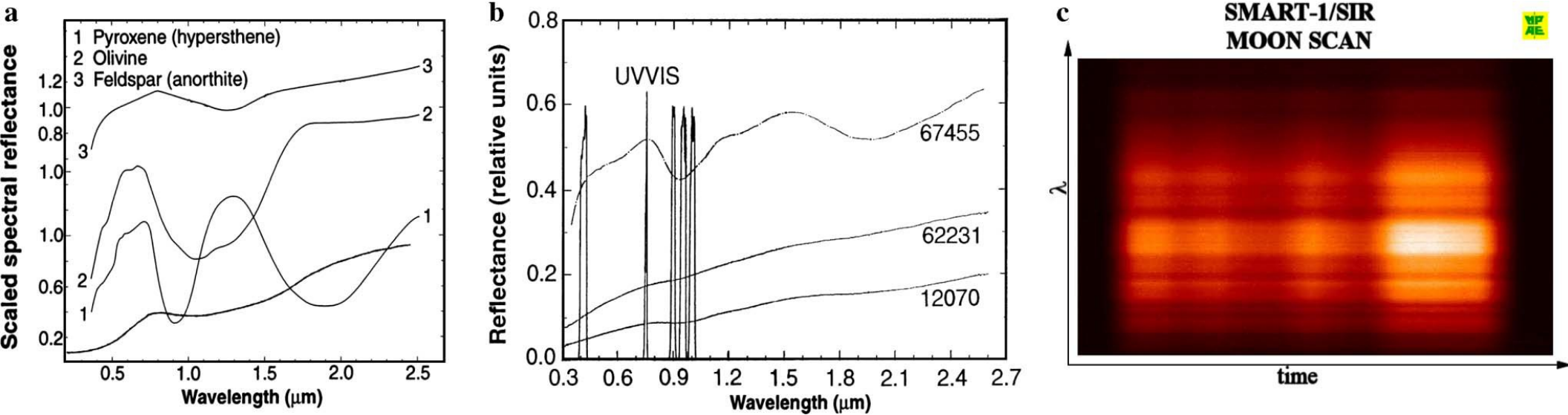


Perna *et al.*, 2010

Espectros NIR de outros corpos

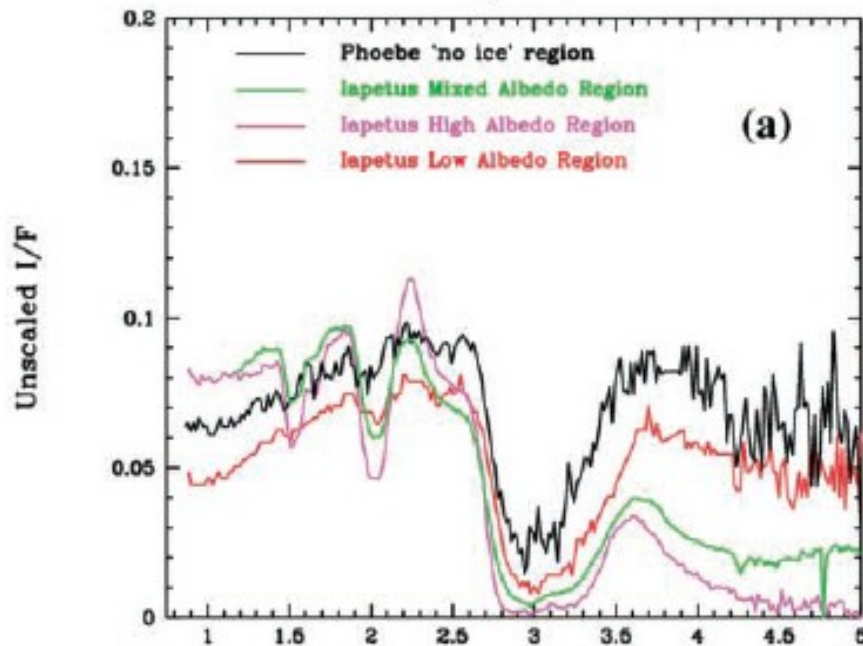
Foing *et al.*, 2006

Lua

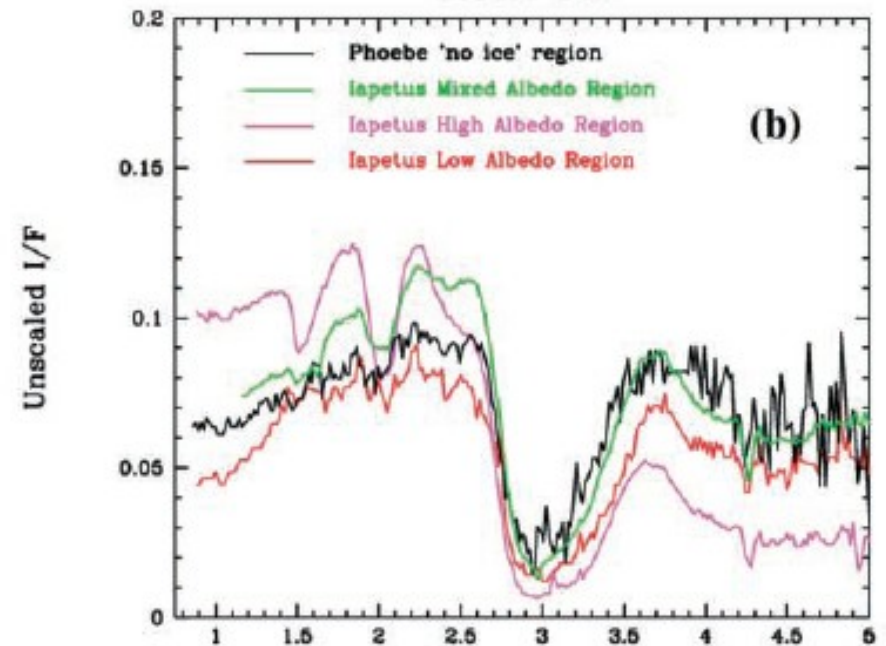


Iapeto (claro, escuro e misturado) e Phoebe (sem gelo), 0.9-5.1 μm , Buratti *et al.*, 2005

July 2004



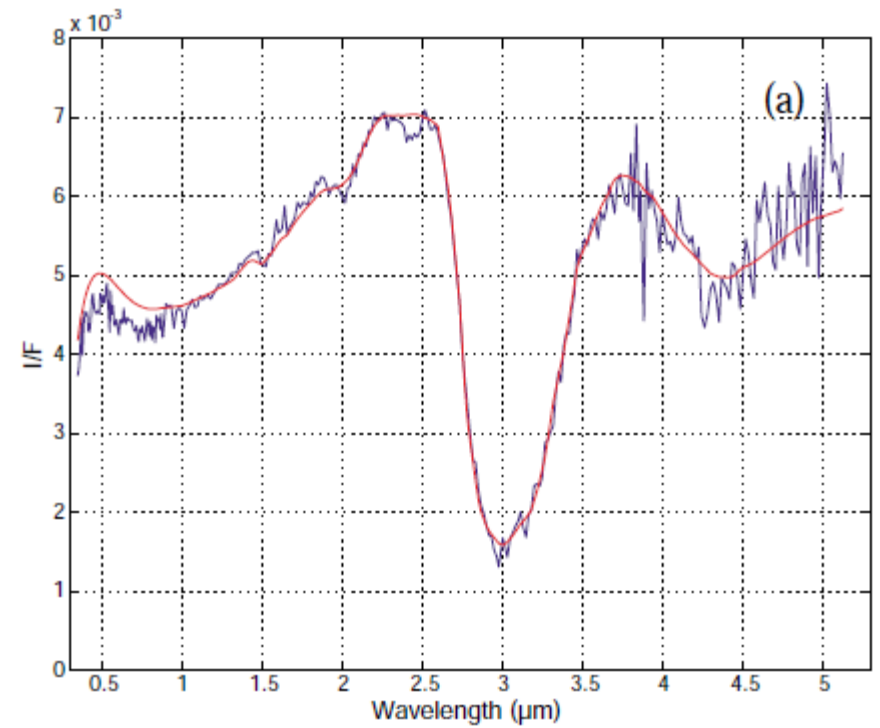
October 2004



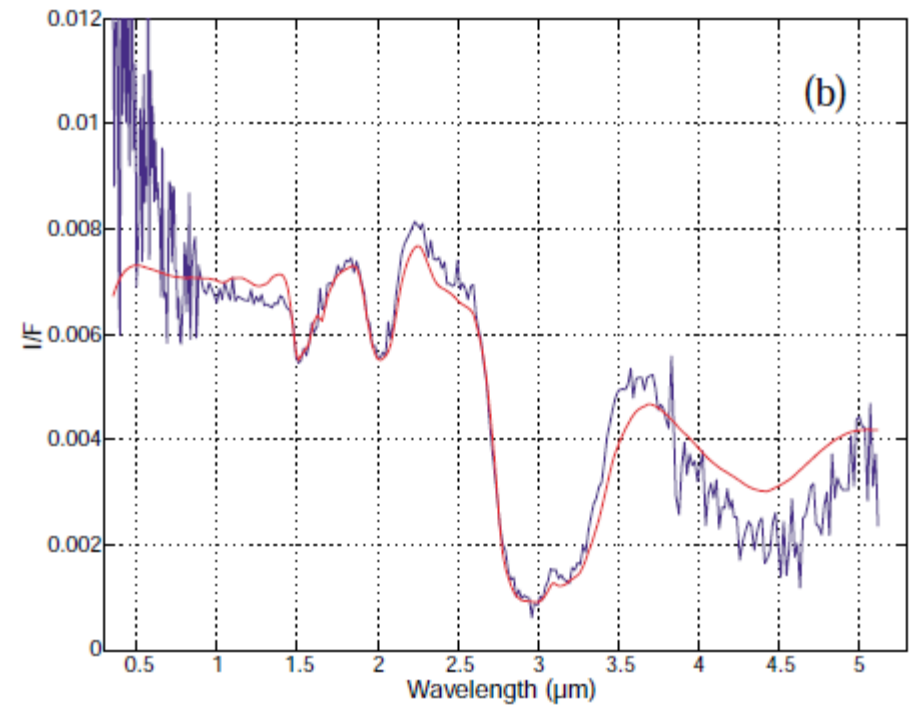
Espectros NIR de outros corpos

Hansen *et al.*, 2009

Phoebe sem gelo



Phoebe com gelo



153591 2001 SN263

Betzler *et al.*, 2008

Tipos ?

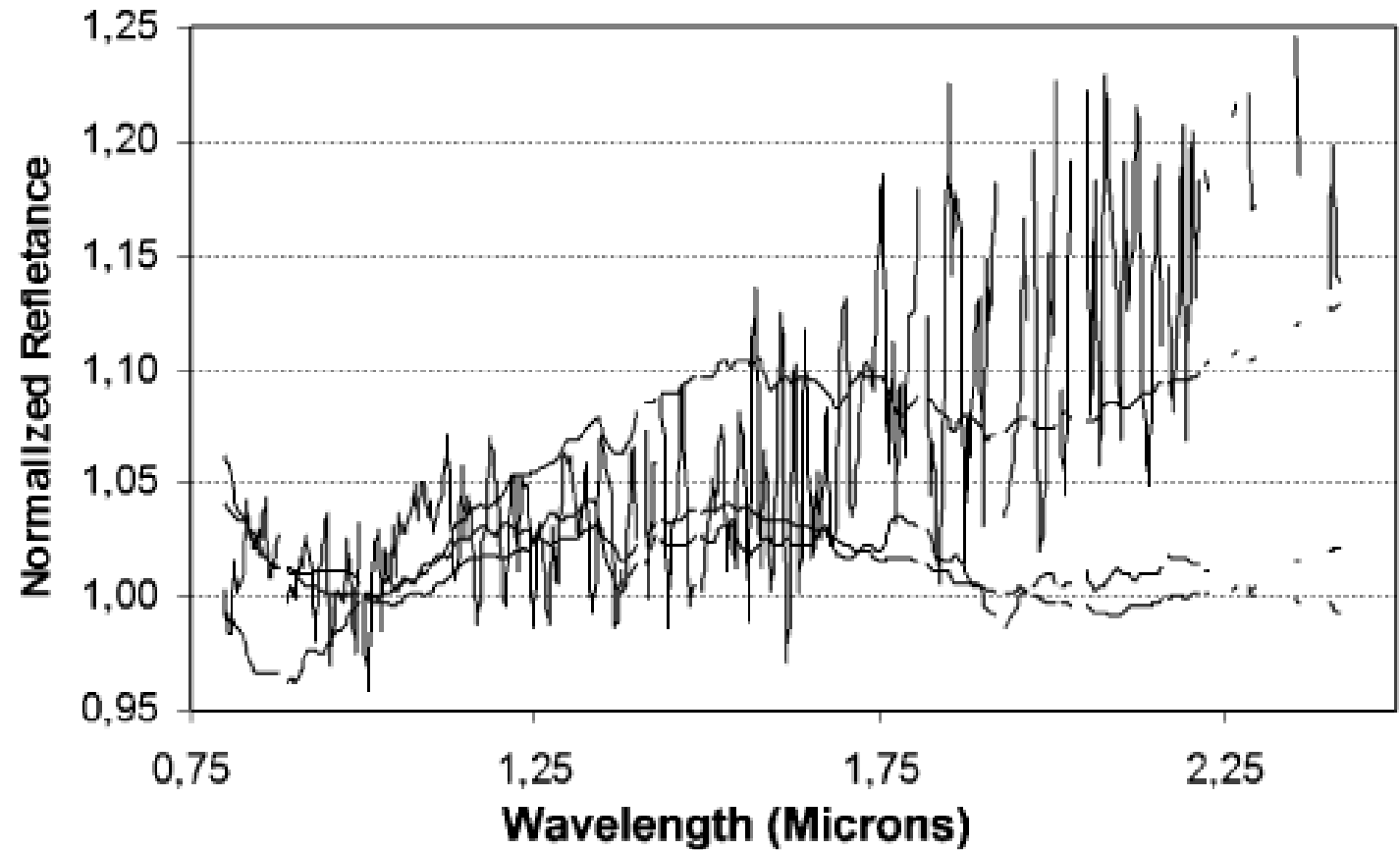
1.0-2.9 AU

1.4 km

0.6 km

0.25 km

Aproximações em
mar/08, set/09,
dez/10, set/12,
out/13



Understanding the nature of these features will require additional work, but the present results indicate that C-type asteroid spectra contain considerably more compositional information than is commonly supposed. Careful observations and data reduction combined with detailed data analysis should open a clear window onto the diversity of materials subsumed within the generic C-classification.

Kelley *et al.* 2007, sobre Mathilde