Workshop on Water in Asteroids and Meteorites
Observatoire de Paris, September 29 & 30, 2011

Hydrated minerals on asteroids in the Main Belt

J. de León[1], R. Duffard[1], Z. Lin[2], J. L. Ortiz[1], L. M. Lara[1]

(1) Instituto de Astrofísica de Andalucía – CSIC (Granada, Spain)
(2) Institute of Astronomy, National Central University (Taiwan)

Introduction

- Presence of liquid water under low temperature conditions chemically alters minerals producing oxides, carbonates, phyllosilicates and sulfates.
- Detection of absorption bands due to presence of hydrated minerals (Vilas & Gaffey 1989, Vilas 1994, Rivkin 2002)
- Two diagnostic spectral regions: visible and infrared

    - 0.43,0.60-0.65, 0.7, 0.80-0.90 μm

      (charge transfer transitions in oxidized iron)

    - 3.0 μm

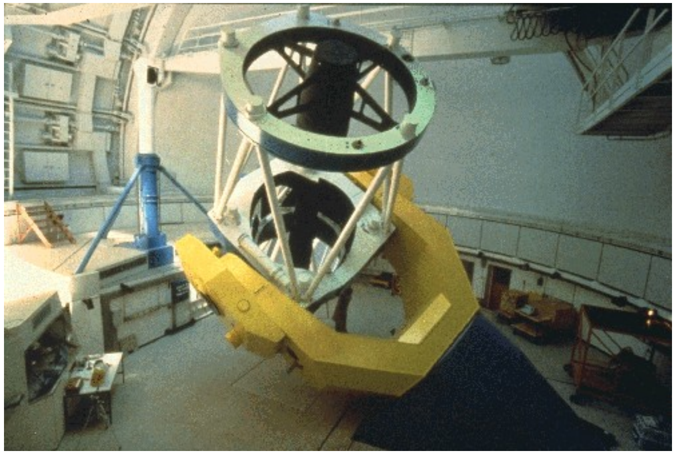
      (free water molecules, OH ion in crystal lattice)

- <u>Motivation:</u> homogeneity of HM on the surface ? Fragments of a larger hydrated body ?

Rotational Resolved Visible Spectroscopic Survey (R^2vS^2)

- Spanish guaranteed time (2 years program)
- Using CAFOS@2.2m in Calar Alto Observatory
- Spectral Range → 0.46 – 0.95 µm

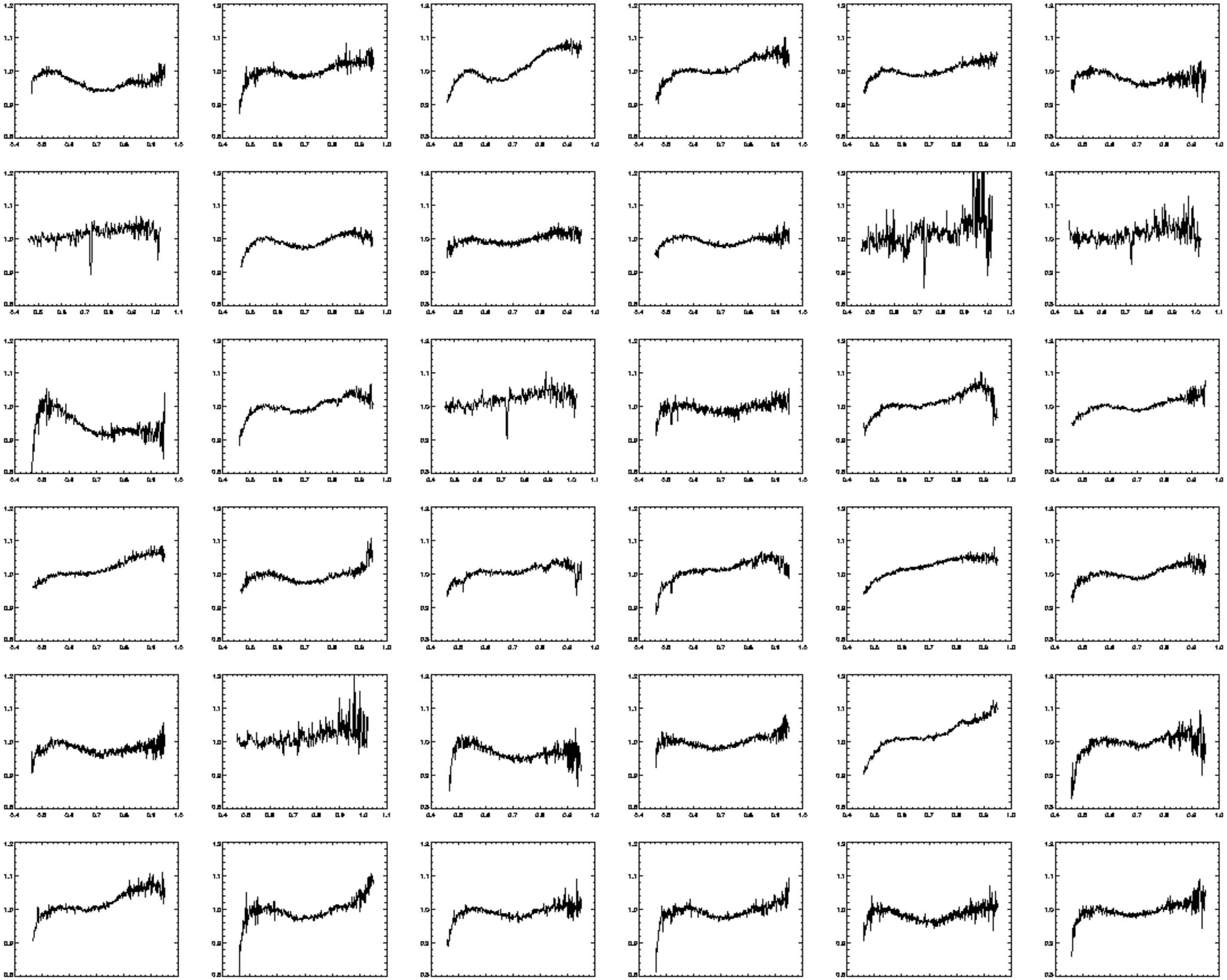
  (R = 400, 0.0009 µm/px)



Rotational Resolved Visible Spectroscopic Survey (R^2vS^2)

- Searching for variation on the 0.6 – 0.7 μm hydration absorption band
- Selection of hydrated asteroids from SMASSII (Bus & Binzel 2002) and S^3OS^2 (Lazzaro et al. 2004)
- Using asteroid lightcurve database for Rotational Periods
- 63 observed hydrated asteroids, covering different rotational phases (minimum = 2; maximum = 5)

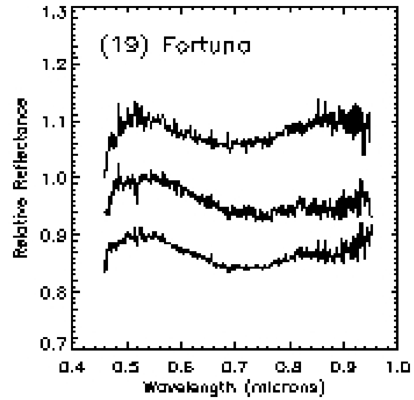
Rotational Resolved Visible Spectroscopic Survey (R^2vS^2)

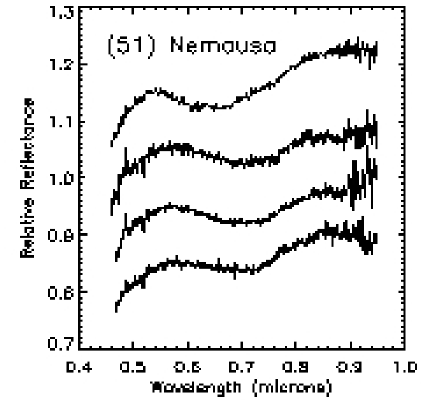


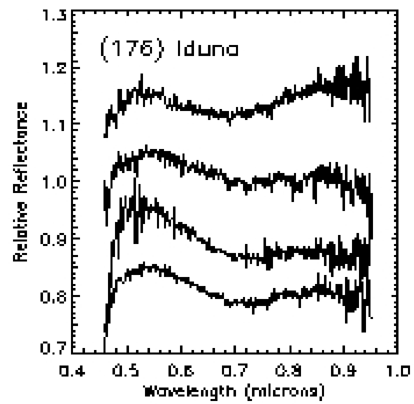
Analysis of rotational variation

Preliminary study of variation of absorption band centers, width and depths with rotational phase for 3 asteroids

	Taxonomy Tholen/Bus	Size (km)
(19) Fortuna	G/Ch	220
(51) Nemausa	CU/Ch	150
(176) Iduna	G/Ch	121
(392) Wilhelmina	---/Ch	62
(2378) Pannekoek	---/Cgh	72



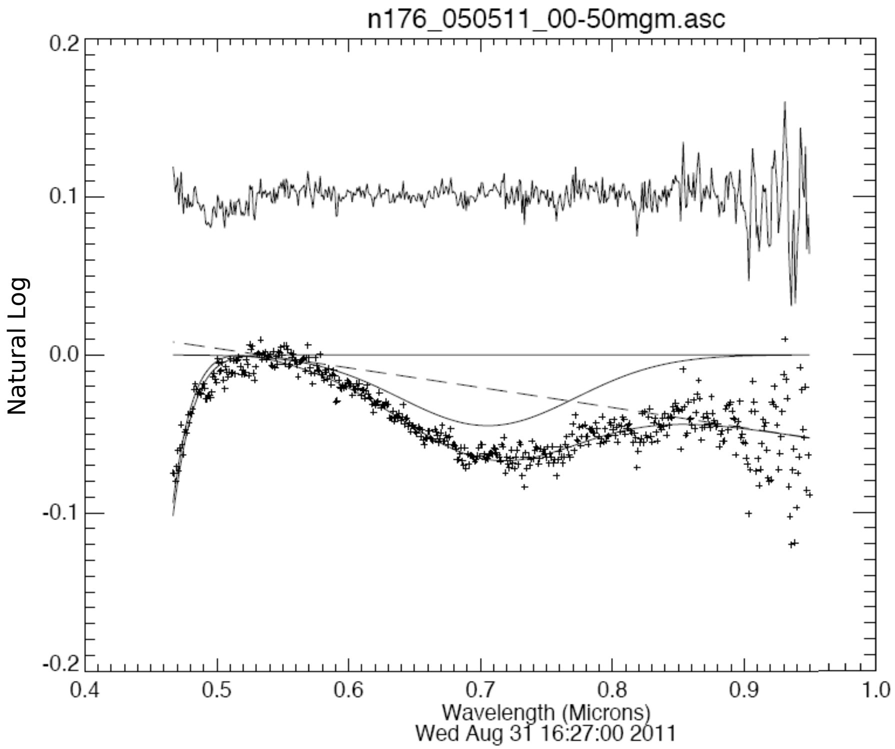




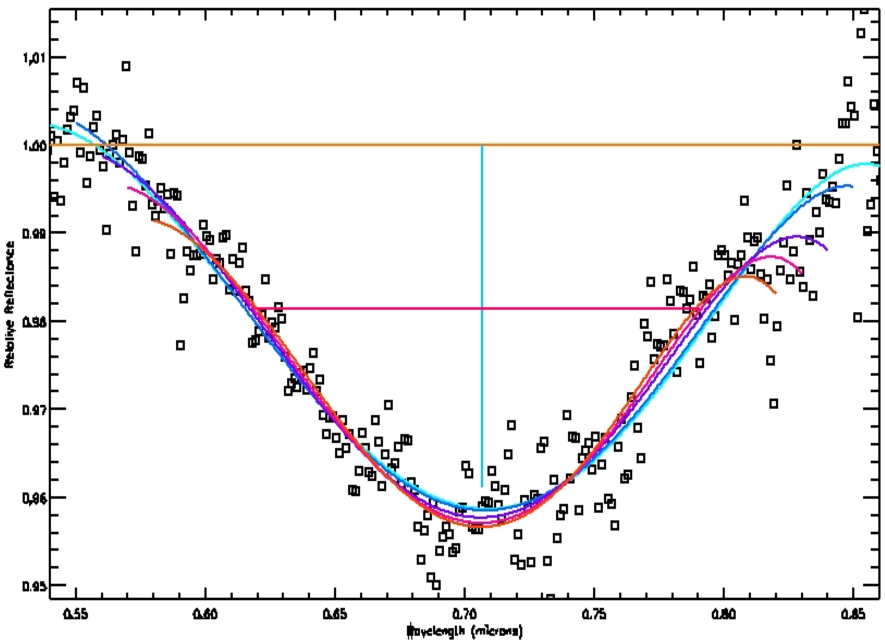
Band Center/Width/Depth determination

Two methods: MGM and Polynomial fit

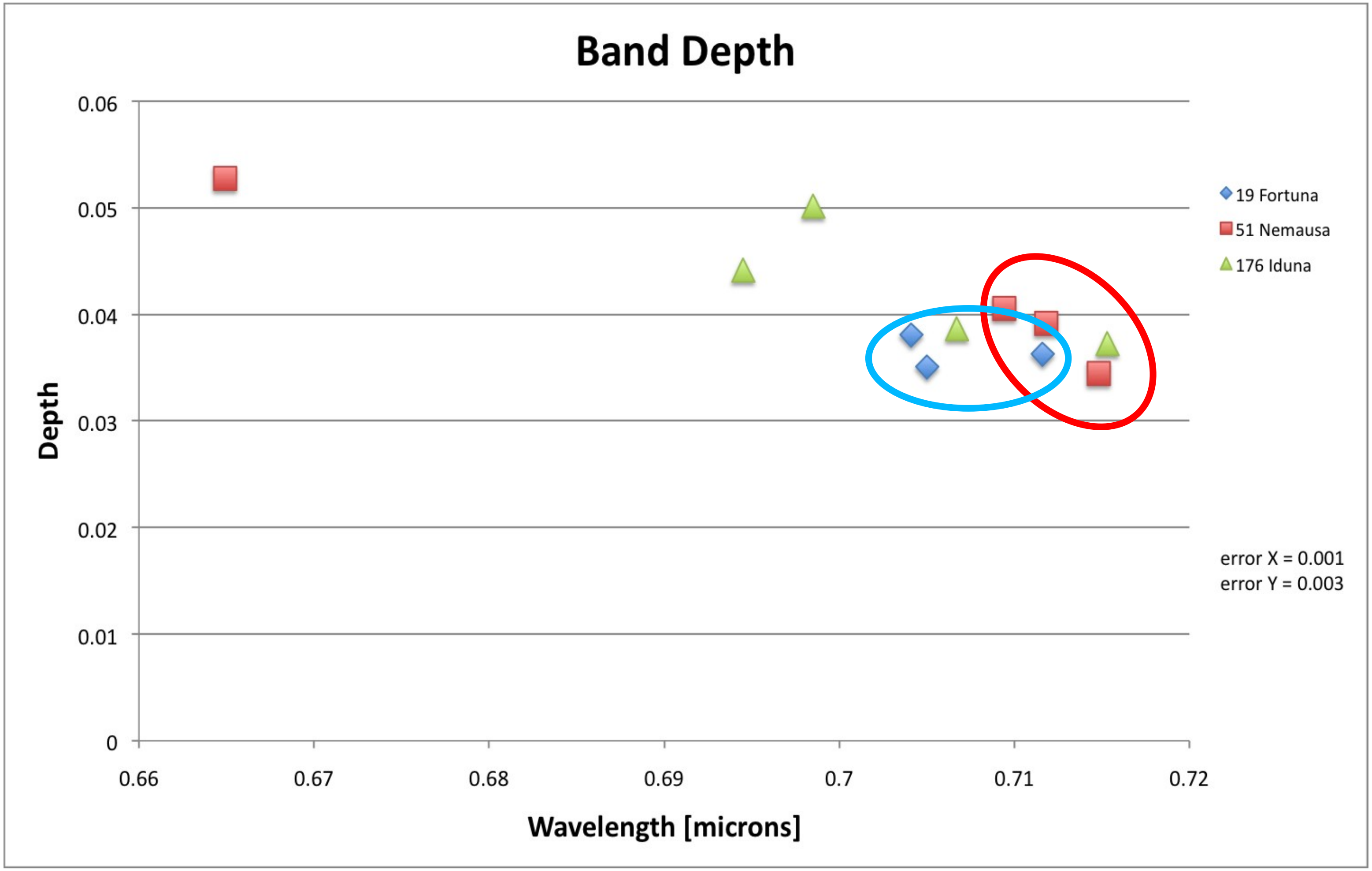
MGM: linear continuum in natural log space added to modified gaussians



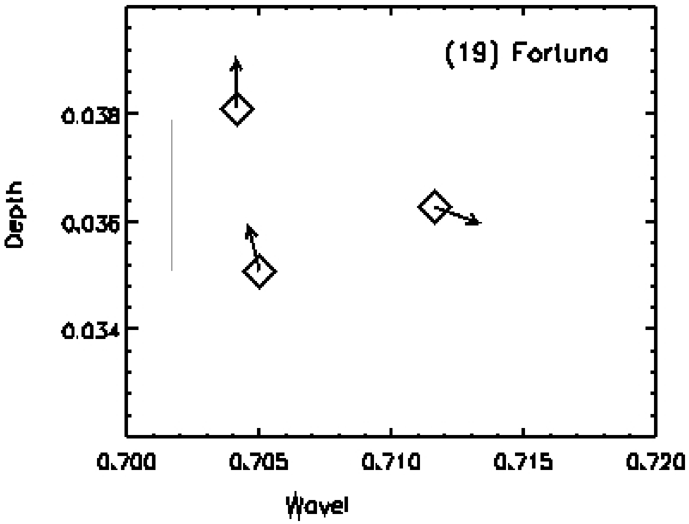
Polynomial fit: continuum removal / varying order and extension of the polynomials

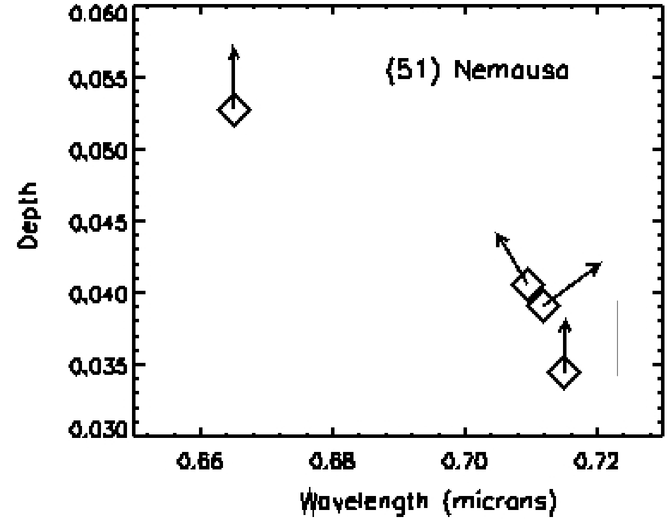


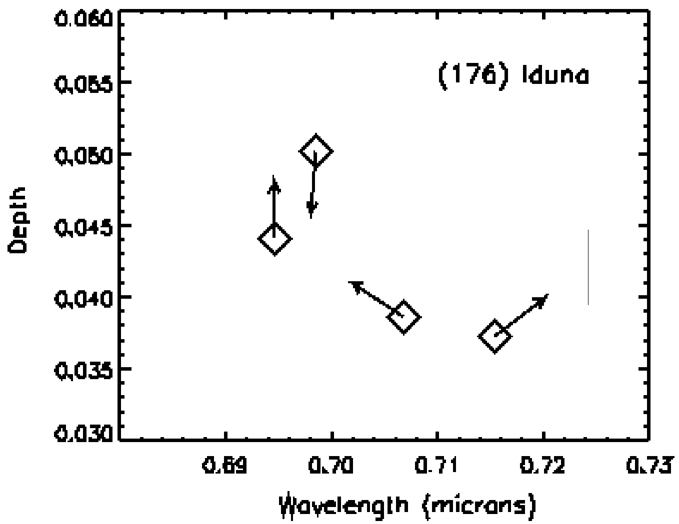
Results (Depth)



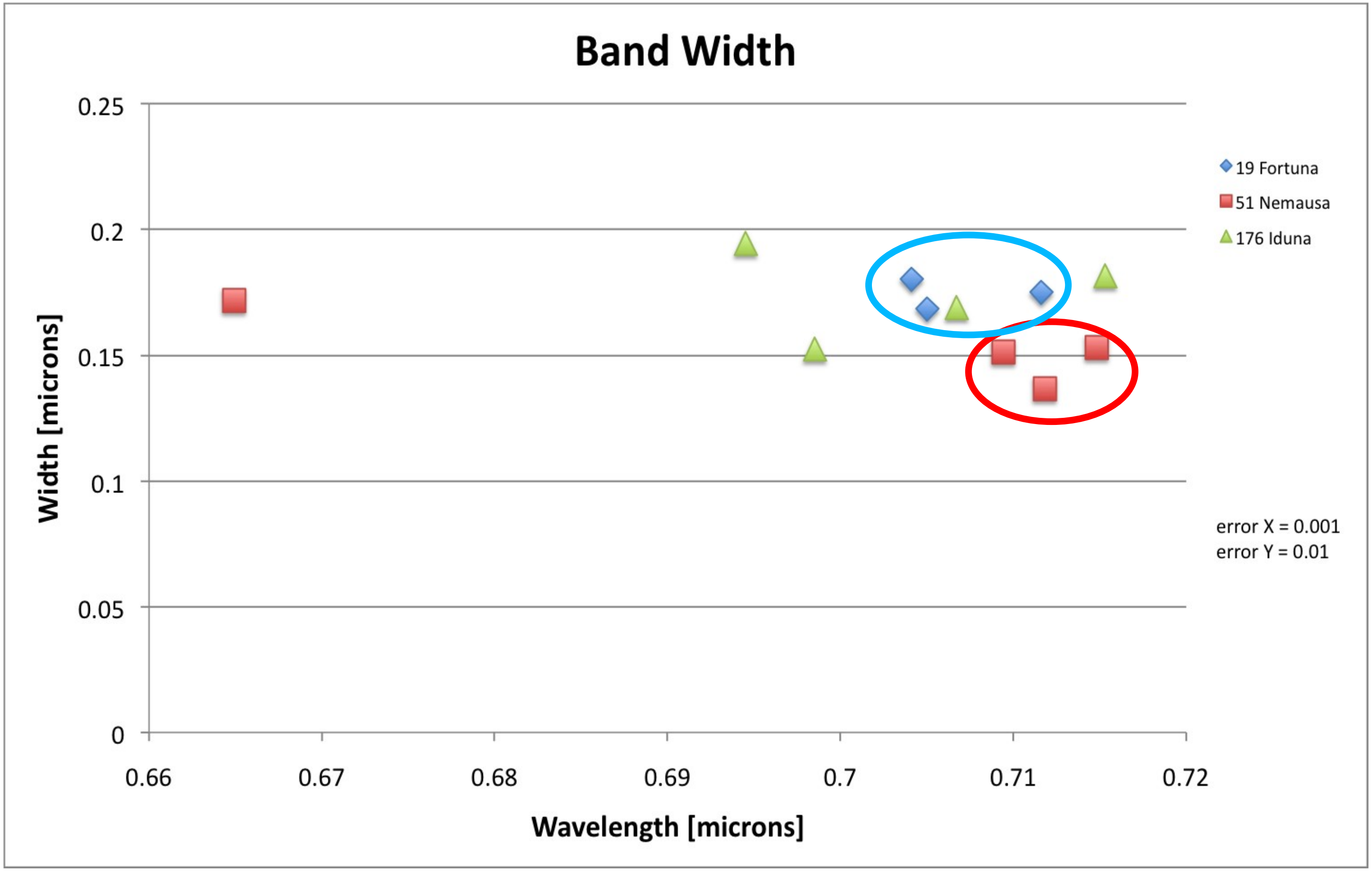
Results (Depth)



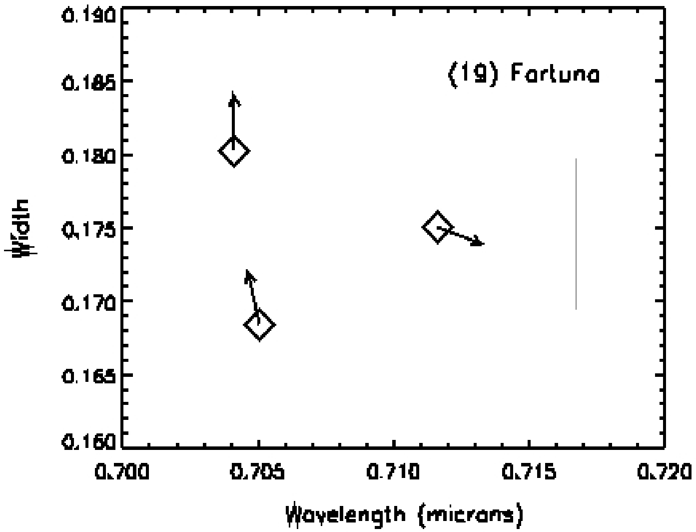


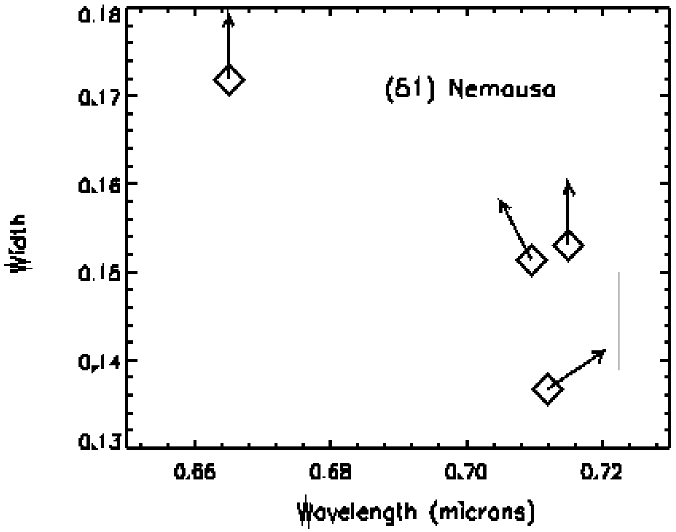


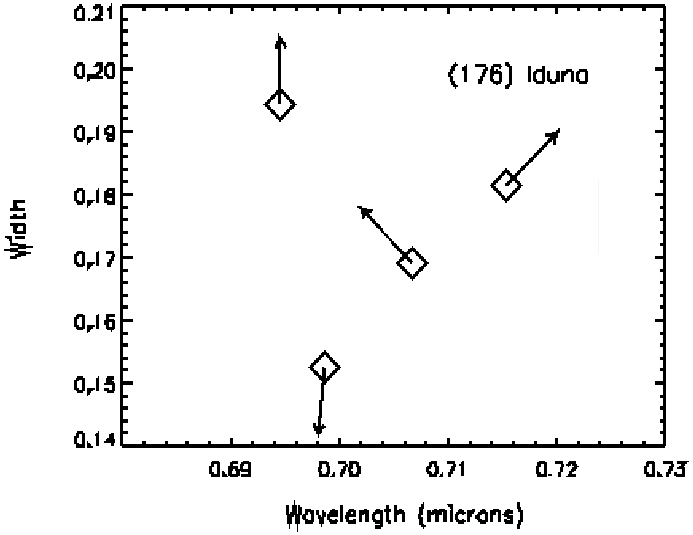
Results (Width)



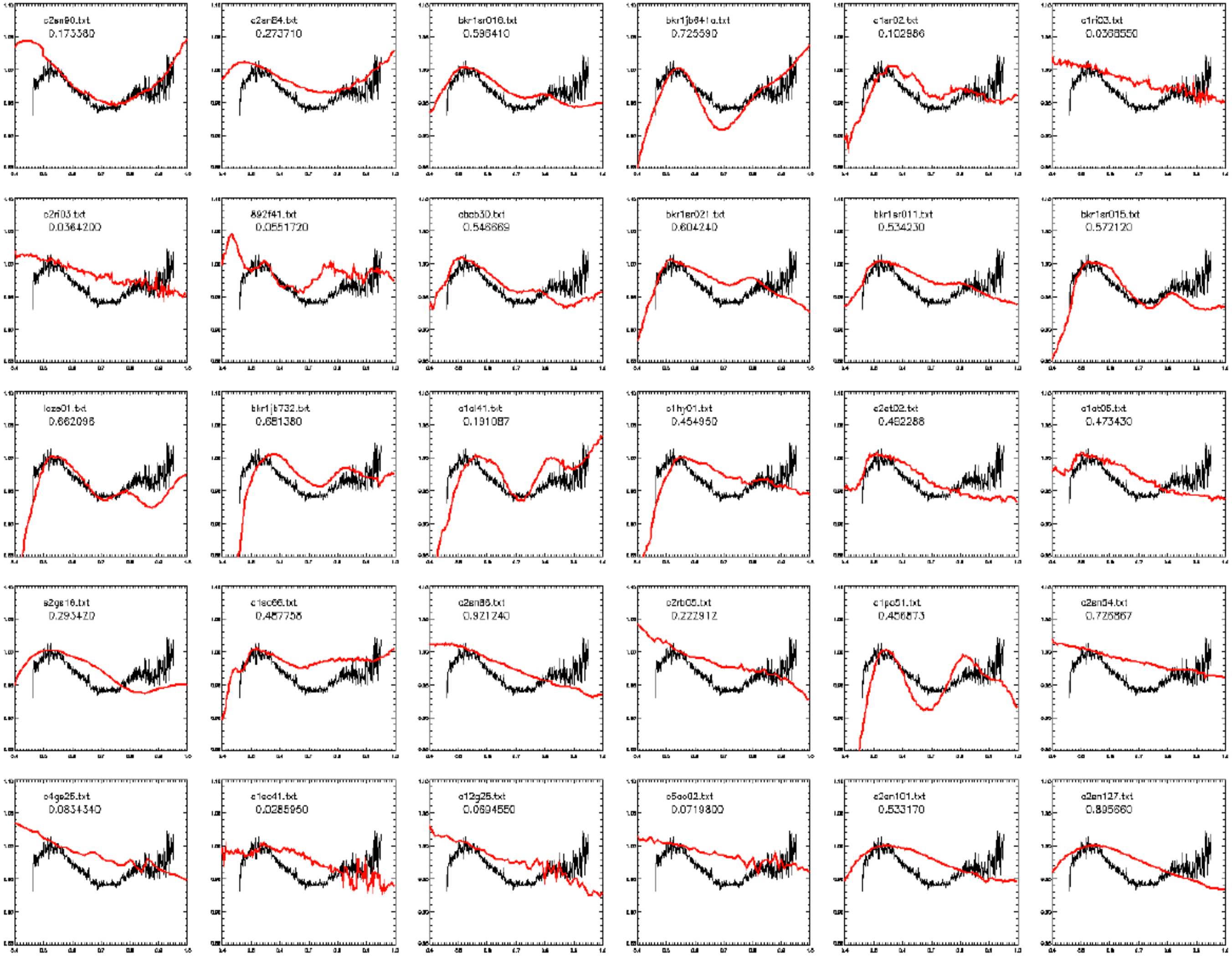
Results (Width)





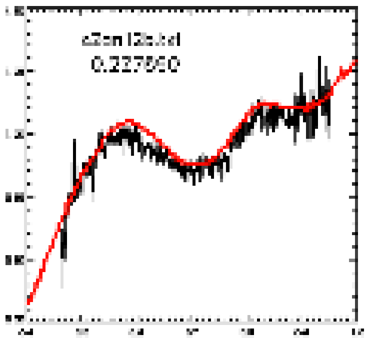


Comparison with minerals (RELAB database)

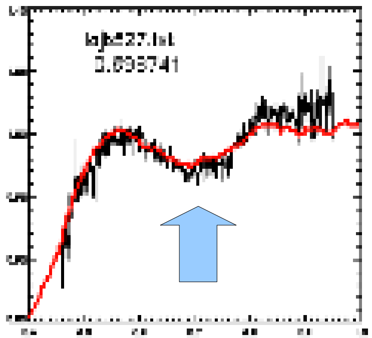


Comparison with minerals

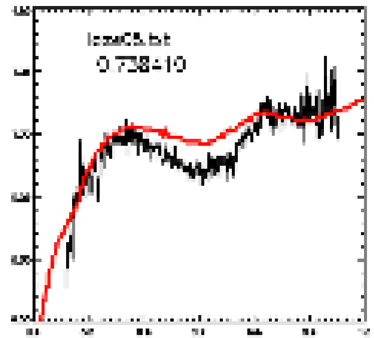
Example: first 6 best fits (lowest X^2)



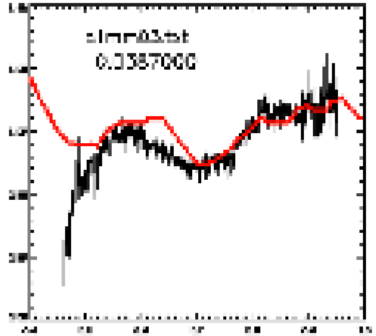
Gabbro



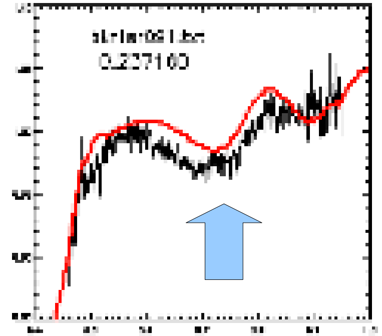
Serpentine
Chrysotile



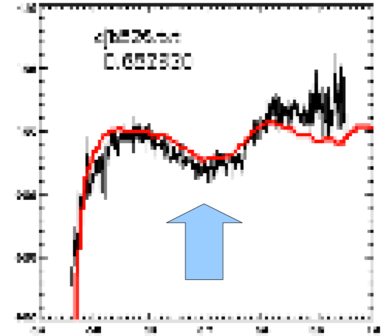
Zeolite
Wairakite



Synthetic Basalt
Oxidized



Serpentine



Serpentine
Lizardite

INSTITUTO de ASTROFISICA de ANDALUCIA CSIC I·A·A

Comparison with minerals

Focus on the overall shape and center of the 0.7 µm absorption band

	$\Phi = 0$	$\Phi = 0.30$	$\Phi = 0.92$	
(19) Fortuna	Serpentine	Serpentine (Chrysotile/Lizardite)	Serpentine (Chrysotile)	
	$\Phi = 0$	$\Phi = 0.03$	$\Phi = 0.88$	$\Phi = 0.15$
(51) Nemausa	???	Serpentine Chrysotile Lizardite	Serpentine Carbonate	Shocked Serpentine
	$\Phi = 0$	$\Phi = 0.13$	$\Phi = 0.56$	$\Phi = 0.83$
(176) Iduna	Serpentine Carbonate	Serpentine Chrysotile Carbonate	Serpentine (Chrysotile)	Serpentine

Conclusions

- Different positions of the center for different objects --> different materials
- Movement of the band center with rotational phase: compositional differences on the surface? Not significant
- Possible origin: different degrees of hydration depending on the temperature / samples of a differentiated hydrated asteroid (Ceres like)

Future work

- Still a lot of work to do!

- Extend the analysis to the whole sample.
- Extend the spectral range to the NIR for a selected sample.