S6 - Generation of spectral indexes
Brief guide to the activity

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Geology & Planetary Mapping
Winter School

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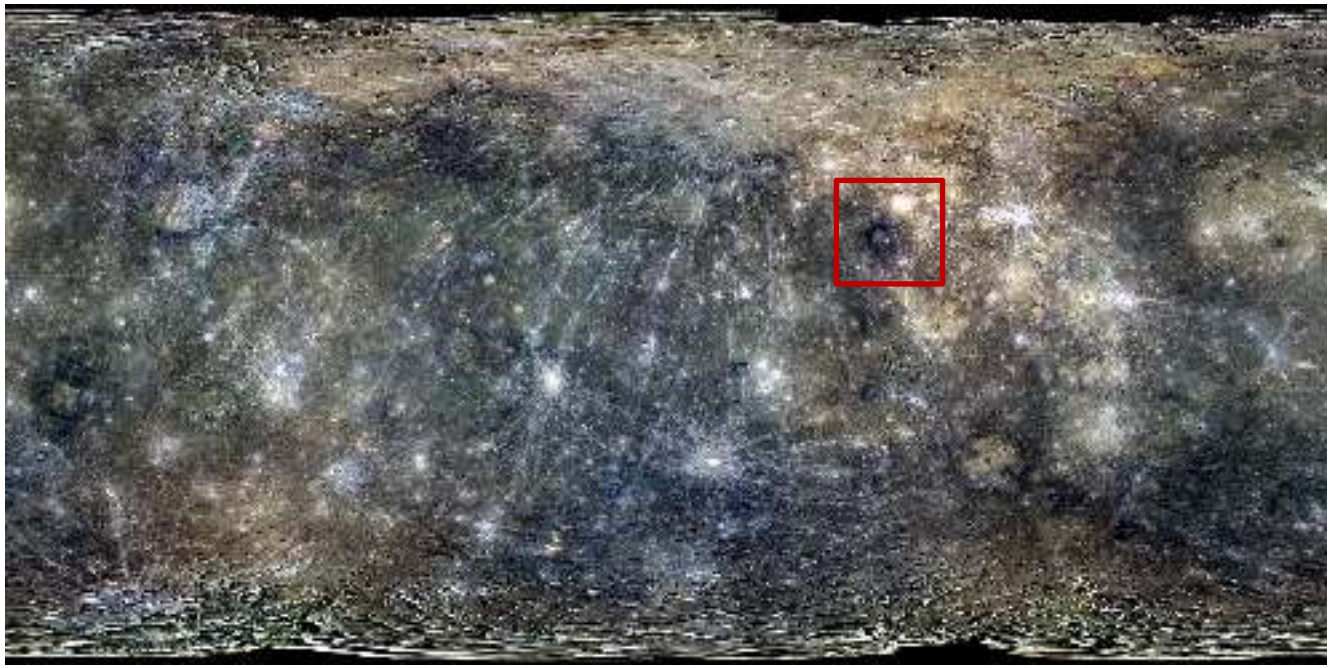
Credits: Jacopo Schiavo / PLANMAP

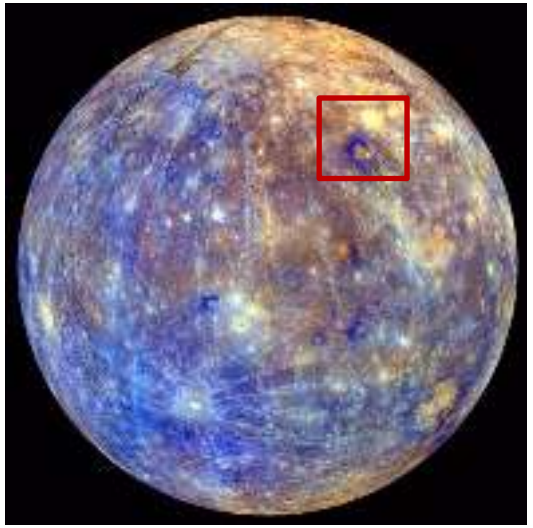
Outline

1. Some information on the region of study;
2. Dataset;
3. Spectral Indexes;
4. The activity of today.

Mercury region of study

We consider the 8-color reflectance map of Rachmaninoff and Nathair Facula region on Mercury obtained by MESSENGER/MDIS- WAC (Mercury Dual Imaging System – Wide Angle Camera)

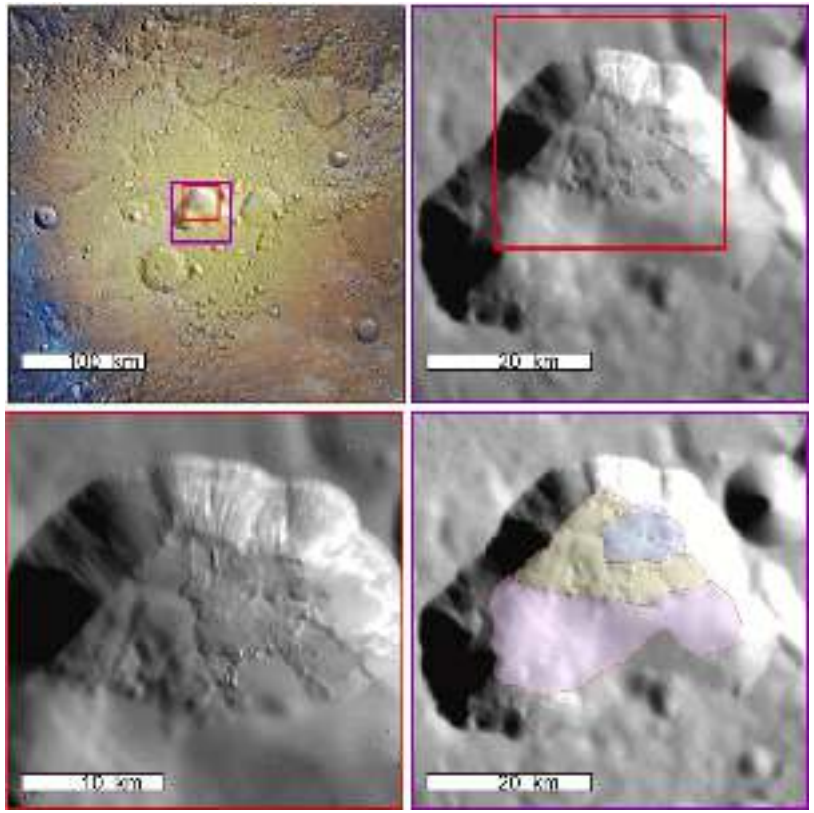




Mercury region of study –Rachmaninoff Basin

- **Rachmaninoff Basin** is a peak-ring basin with a diameter of ~290 km.
- Rachmaninoff materials have been classified as fresh crater materials (see Wright et al, 2019, JoM)
- The inner ring of Rachmaninoff is about 130 km in diameter and slightly elongated in the north-south direction (Prockter et al., 2010). The smooth crater floor within the internal peak-ring, is characterized by a system of concentric grabens.
- It is dated at the beginning of the Mansurian time system on Mercury to
  1.7 Ga (Banks et al. (2017)) .
- The most relevant characteristic is the presence of a high concentration of low reflectance material (LRM) in the annulus surrounding the peak-ring. This area appear darker and 'spectrally bluer'.

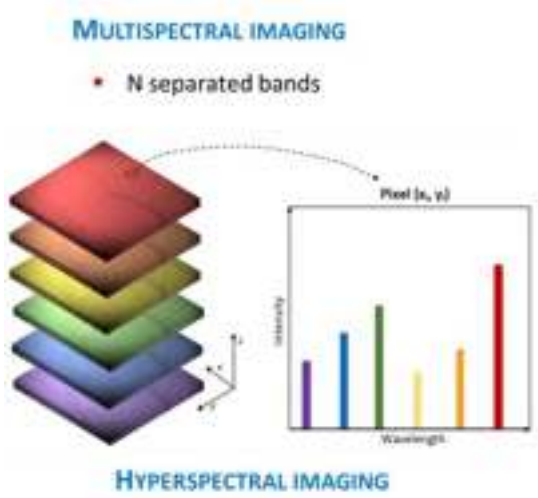
Mercury region of study – Nathair Facula

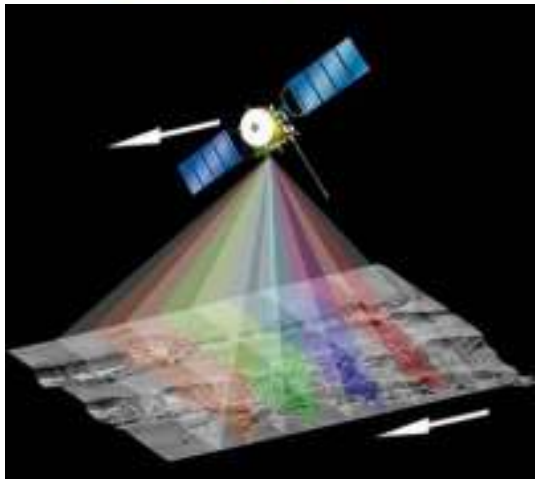


From Rothery et al., 2020, Icarus

- **Nathair Facula** is the largest and most spectrally distinct of nearly 200 ‘bright red’ spots (faculae) on Mercury’s surface, most of which are accepted to be deposits from explosive volcanic eruptions.
- It hosts a non-circular central pit, nearly 40 km wide and 3 km deep.
- The pit area is almost certainly a ‘compound vent’, within which the locus of eruption has migrated between eruptive episodes.
- The asymmetry of the facula and the texture of the vent floor are consistent with the most energetic and/or the most recent eruptions having occurred from the northeastern part of the compound vent.
- The center point of the facula lies outside the vent likely due to additional factor such as asymmetric eruption fountains.

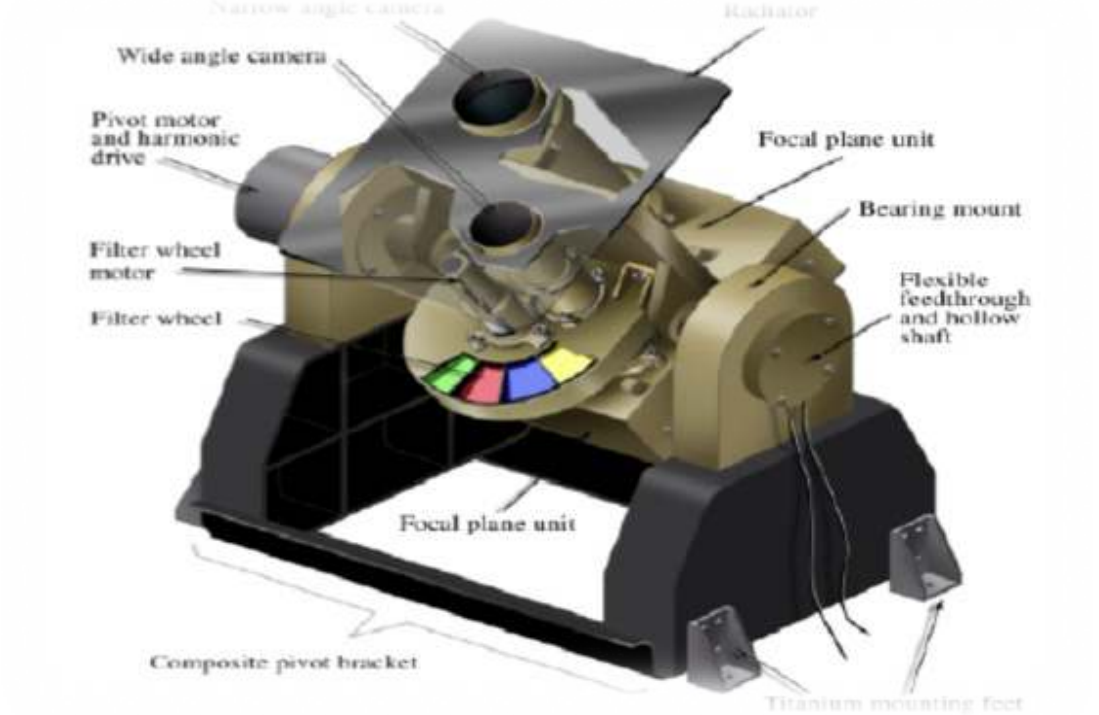
Dataset





Source: Nireos, Adapted from Giannoni et al 2018 J. Opt. 20 044009

- We considered the MESSENGER-Wide Angle Camera (MDIS-WAC) multispectral data (https://ode.rsl.wustl.edu/mercury/).
- MDIS-WAC was equipped with a multi-filter rotating wheel (11 filters), the images were acquired one by one for each filter, therefore images captured in different moments do not exactly overlap each other.



Dataset

MDIS-WAC cover the visible range wavelengths 430-1000 nm with 11 filter. Only 8 are use to to produce the Mercury 8-color mosaic filters (Hawkins et al. 2007, PSS)

Filter	Wavelength (nm)	Bandwidth (nm)
F	430.0	18.0
C	480.4	8.9
D	559.2	4.6
E	628.8	4.4
G	749.0	4.5
L	828.6	4.1
J	898.1	4.3
I	996.8	12.0

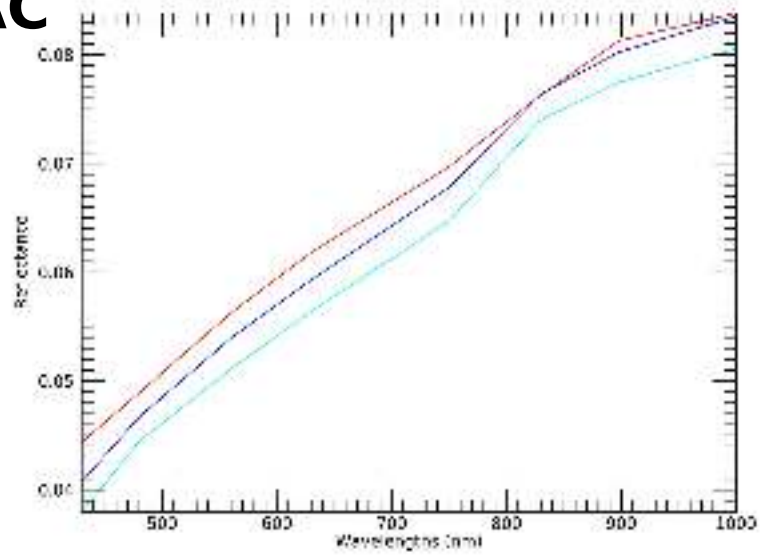
Dataset

We produced the 8-color mosaic of the region of study at 450 m/px.

The 8-color mosaic of the whole Mercury surface at 665 m/px is available at the following link: https://messenger.jhuapl.edu/Explore/Images.html#global-mosaics.

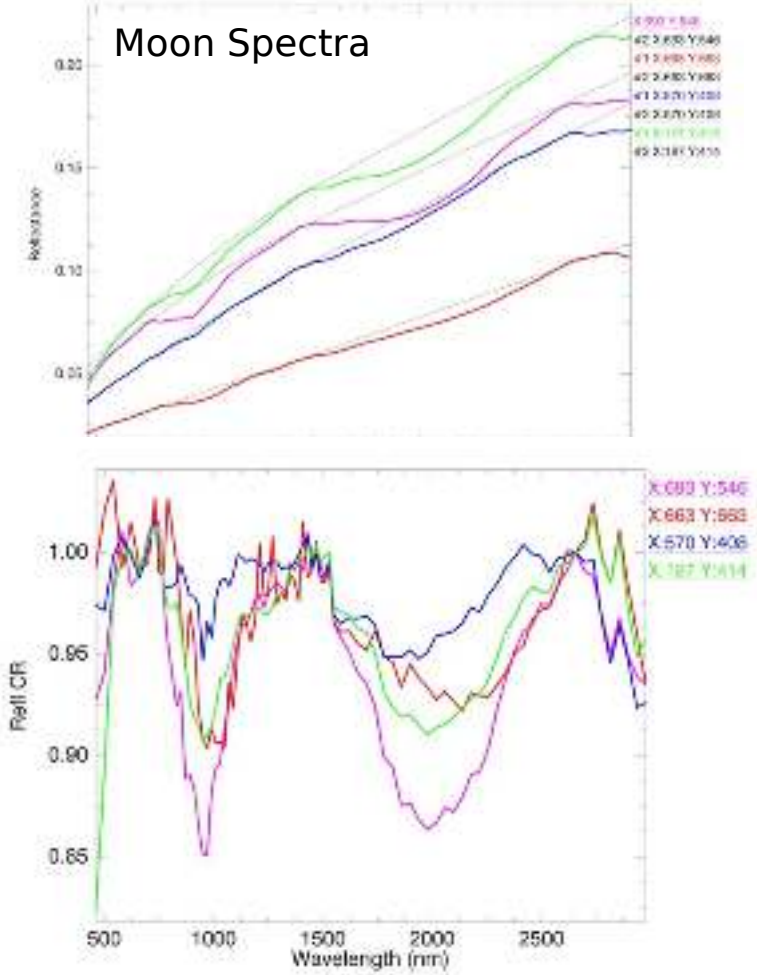
From the 8-color mosaic we obtain the spectral information.

Mercury spectra from MDIS-WAC



Spectral Indexes

The selection of the spectral indexes depends on the characteristics of the spectra



Moon Spectra show the two absorption band at 1 and 2 µm typical of pyroxenes and a very high (red spectral slope).

In this case the most significant parameters are:

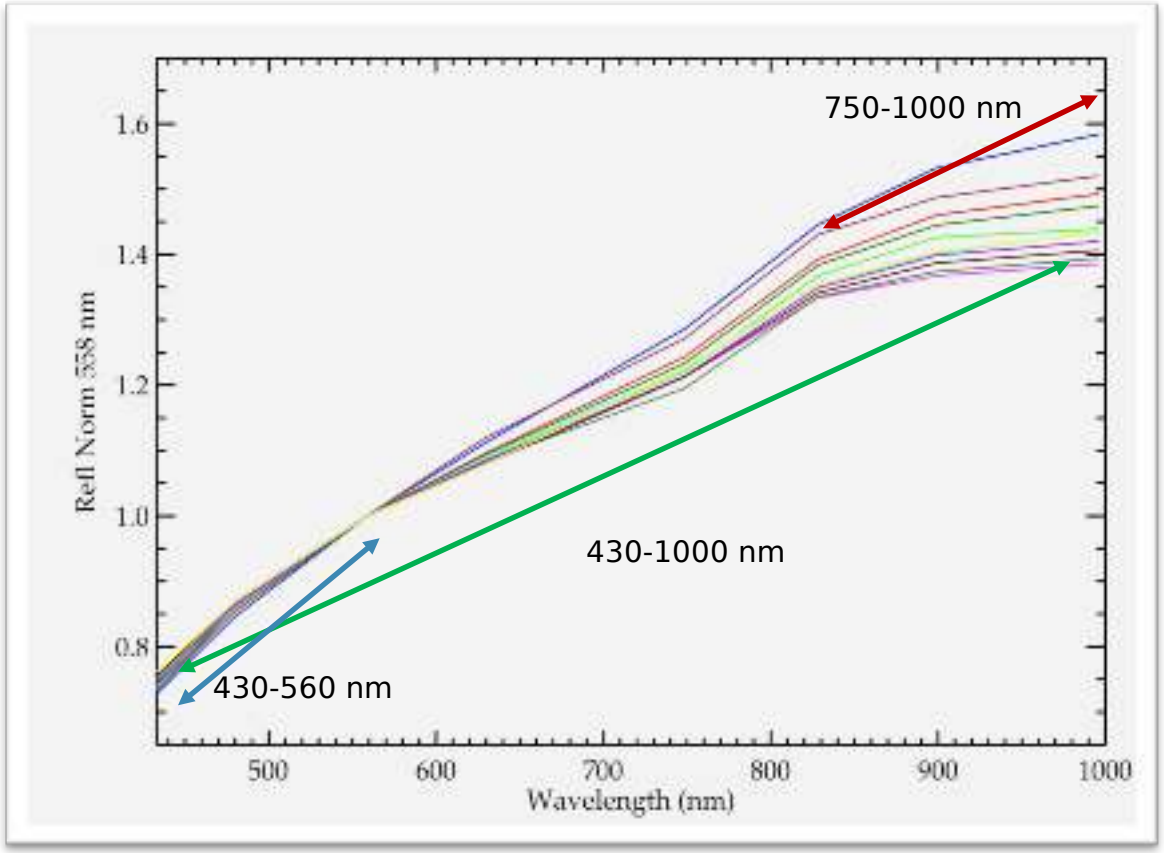
Band center ✉Information on the mineralogy and composition of phases present.

Band depth ✉Mineralogical abundance, grain size variations, opaque material

Spectral slope ✉Terrain maturity, composition and grain size.
Steep (red) spectral slopes: old mature terrains more affected by space weathering, composition, e.g Mercury volcanic origin material (northern smooth plains, Mercury Faculea).
Shallow (blue) spectral slopes: Fresh unweathered material (rays crater ejecta); composition, e.g. dark material, ices

Relevant Spectral Indices for Mercury

Mercury spectra between 400 and 1000 nm at the MDIS-WAC spatial resolution do not show clear absorption bands, the most relevant indices in this case are the spectral slopes.

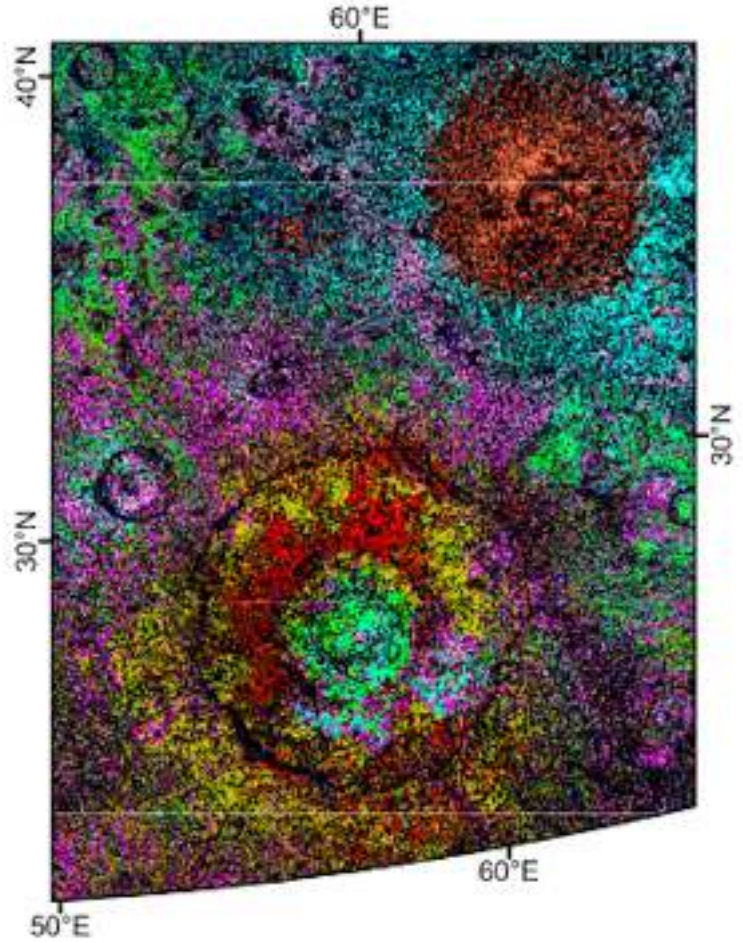


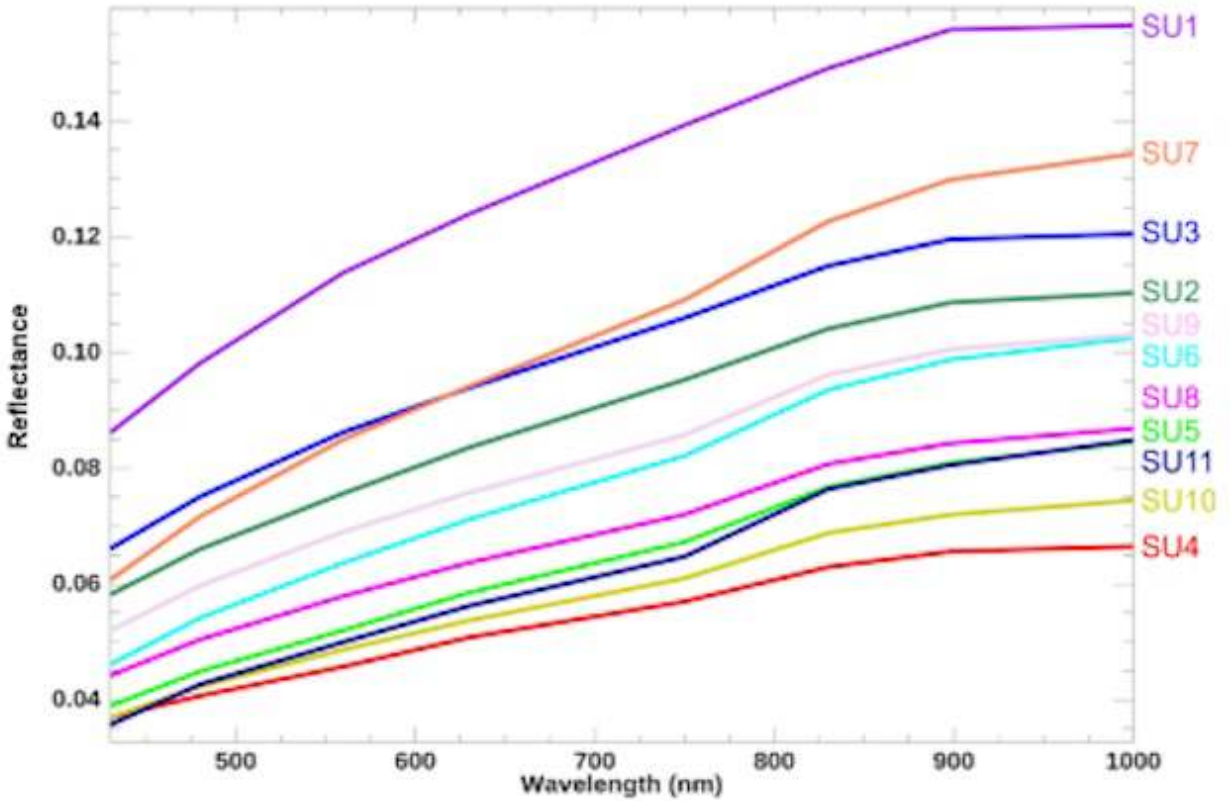
Global Slope 430-1000 nm ✉ Terrain maturity

Spectral Slope 750-1000 nm ✉ possible 1 µm absorption band

Spectral Slope 430-560 nm ✉ Presence of opaque material, Mercury volcanic material

Average Spectra of Different Regions





IDL Package for Spectral Slopes Retrieval – Winter01

Winter01 package is a dedicated software produced with IDL, which permits to calculate spectral slopes from MESSENGER/MDIS 8-color mosaic and it is distributed for Windows, MacOS, and Linux.

What Winter01 does:

- Calculates and shows spectral slope images from MESSENGER/MDIS 8-color mosaic with the relative histogram;

- Divides the spectral slope map in 3 thresholds of intervals, shows the spectral slopes map assigning to each interval a different colour, calculates the average spectra for each interval and shows the relative histogram overlapping the threshold interval lines.

What Winter01 requires:

MESSENGER/MDIS 8-color mosaic in binary format with the related header.

IDL Package for Spectral Slopes Retrieval – Winter01

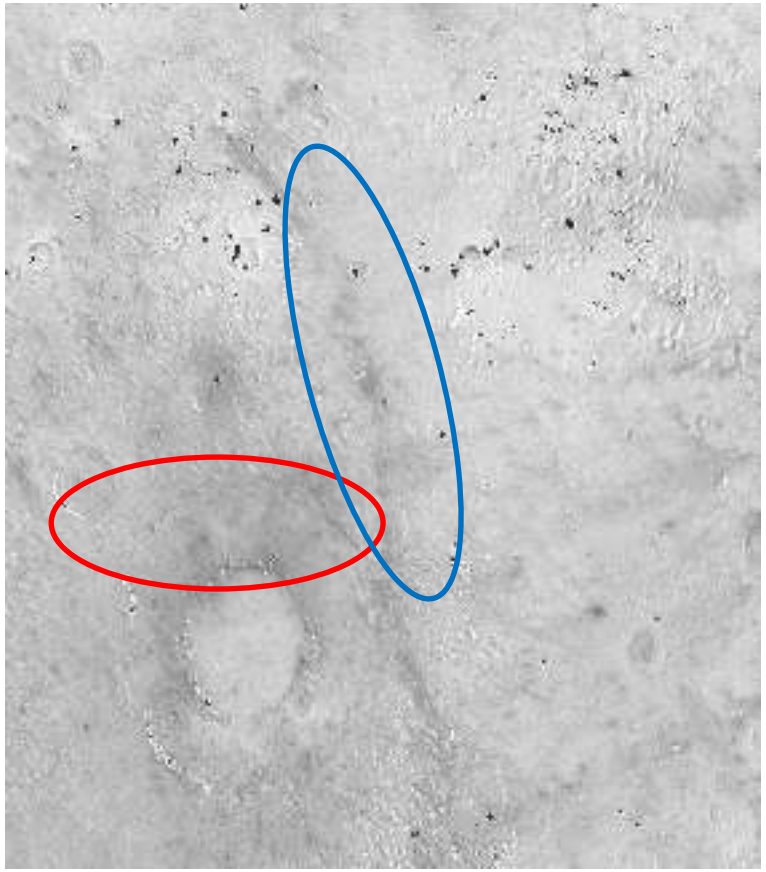
Global Slope 430-1000 nm

UV-VIS Spectral Slope 430-560 nm

UV-VIS Spectral Slope 750 -1000 nm

Global Slope 430-1000 nm

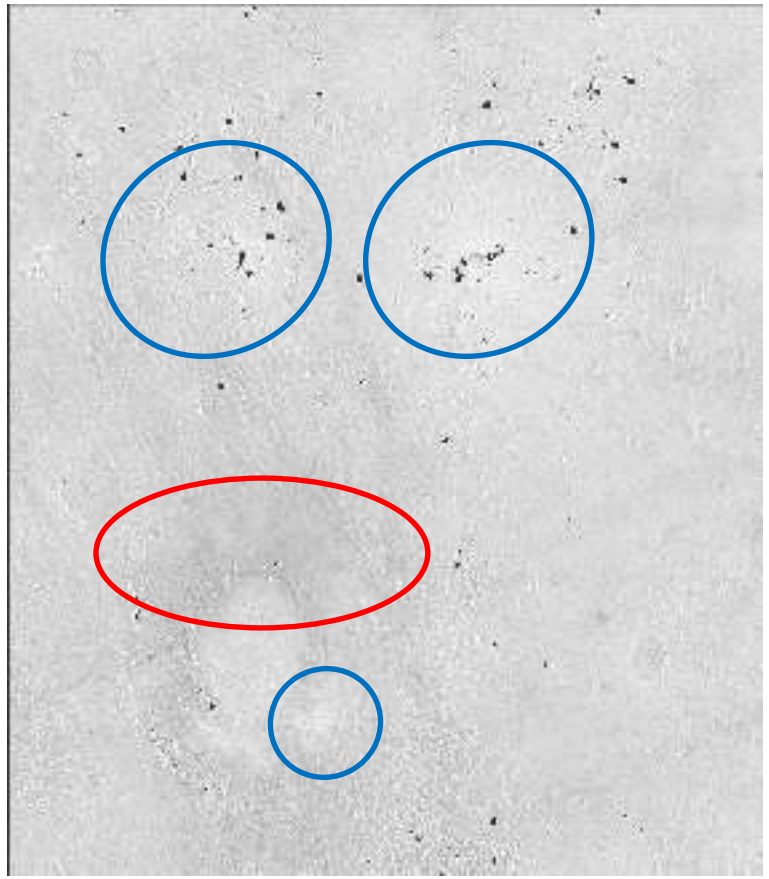
Global Slope 430-1000 nm



- Low global spectral slopes are emphasize crater rays and fresh material, but also LRM
- The support of the reflectance map allows to distinguish the two regions.
- LRM are characterize by low spectra slope (in particular in the UV range), low reflectance.
- Fresh material show low spectra slopes and high reflectance.

UV-VIS Spectral Slope 430-560 nm

UV-VIS Spectral Slope 430-560 nm



- UV slope is typically used to highlights LRM and in Mercury case volcanic origin material (e.g pyroclastic deposits, vents material, northern volcanic smooth plains)
- Nathair, Suge and Neidr Faculae show high reflectance and red UV-VIS slopes
- LRM in Rachmaninoff basin shows low spectra slope, low reflectance.
- Fresh material also show low spectra slopes and high

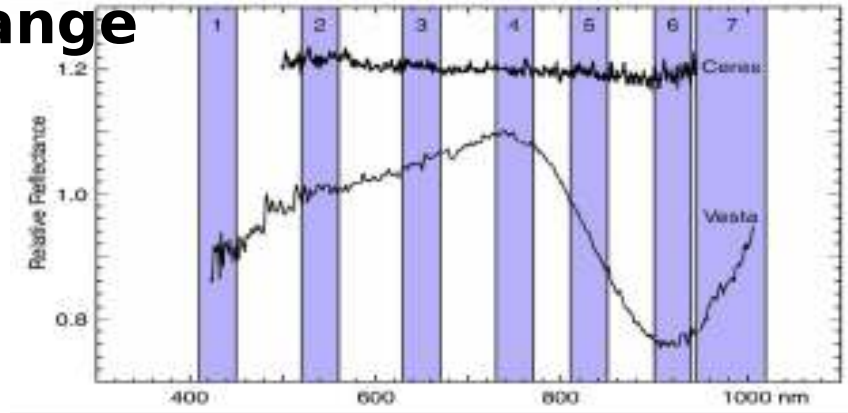
VIS-NIR Spectral Slope 750-1000 nm

UV-VIS Spectral Slope 750 -1000 nm

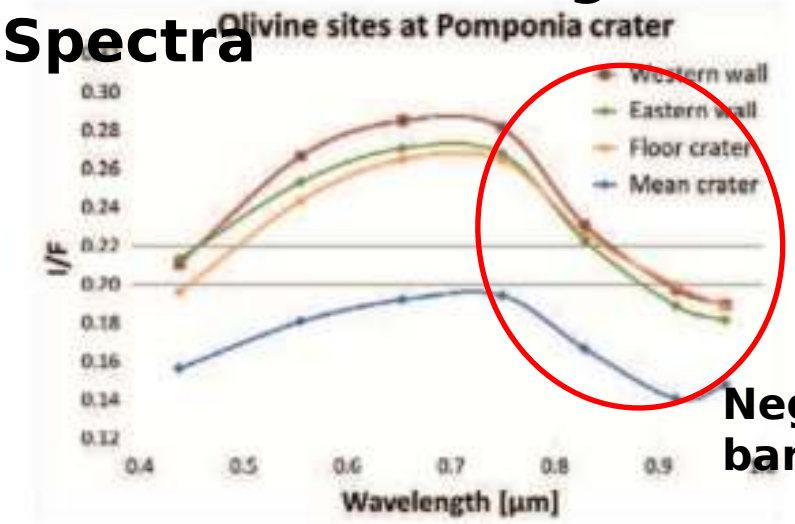
- The VIS-NIR spectral slope can be useful to identify possible absorption at 1 μm. In particular negative slope could be indicative of the presence of this band.
- This spectral slope distribution is quite homogeneous for our region.
- In this case only low reflectance material show lower values of this slope, even if it is not enough blue to infer the presence of the 1 μm band.

VIS-NIR Spectral Slope 750-1000 nm – Spectra in comparison

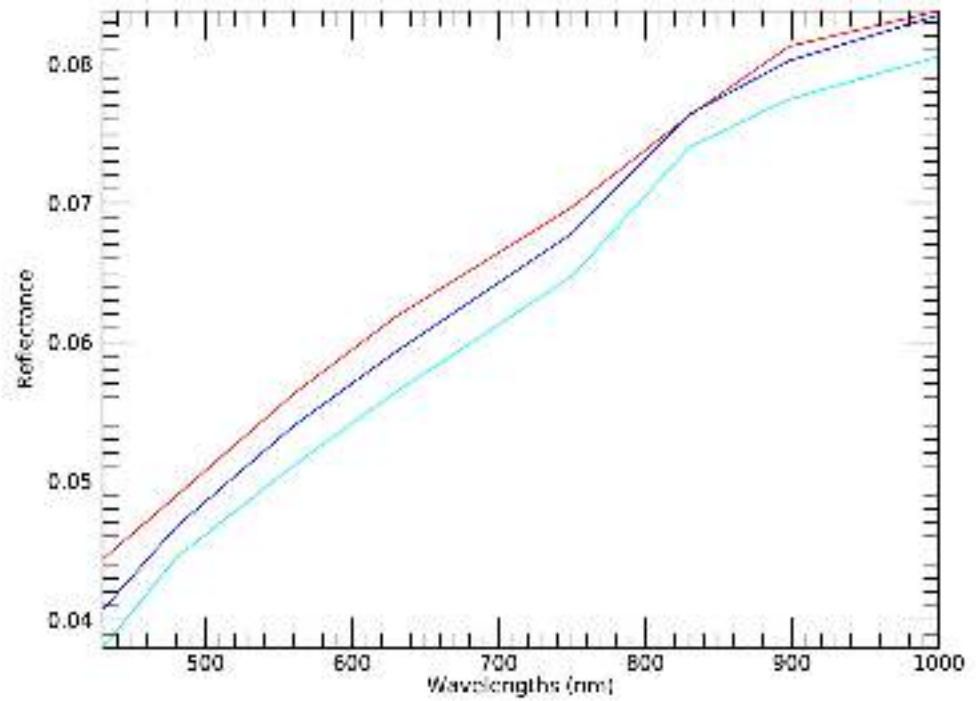
Vesta Framing Camera spectral range



Vesta Framing Camera Spectra



Mercury spectra from MDIS-WAC

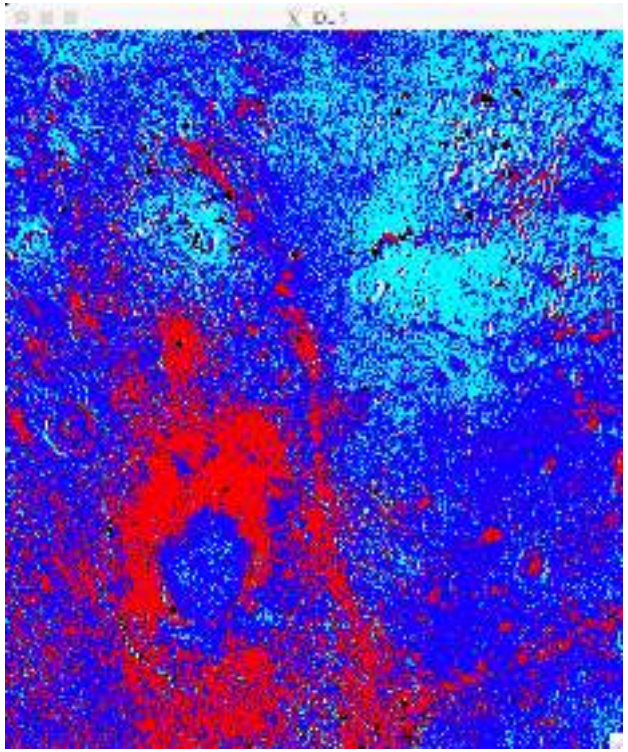


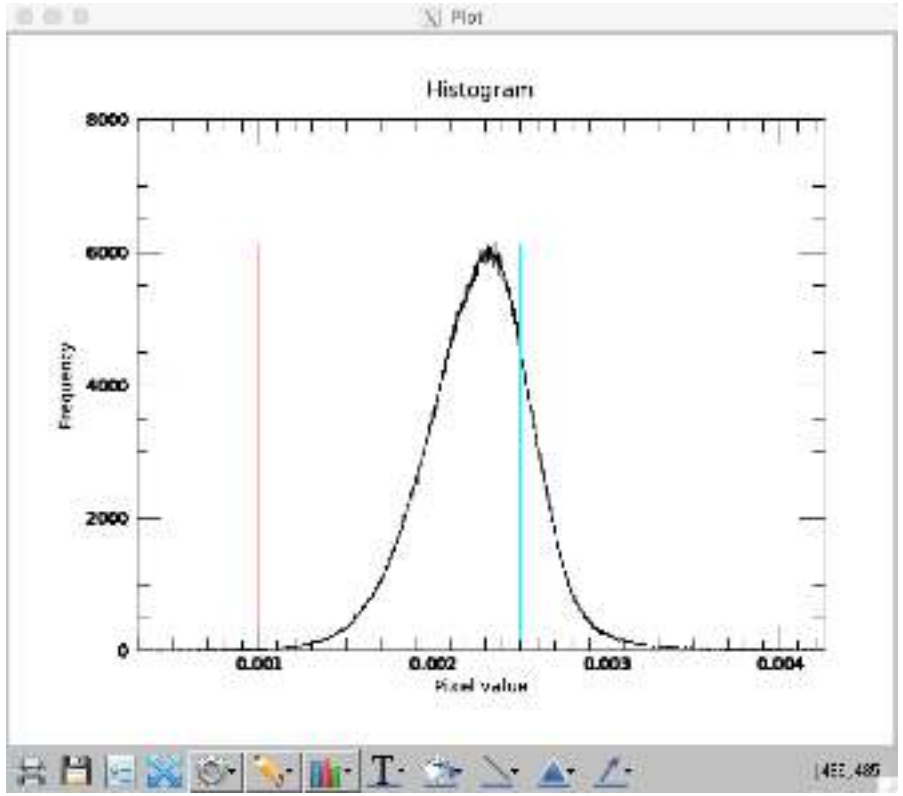
Negative VIS-NIR spectra ≥ 1 µm band

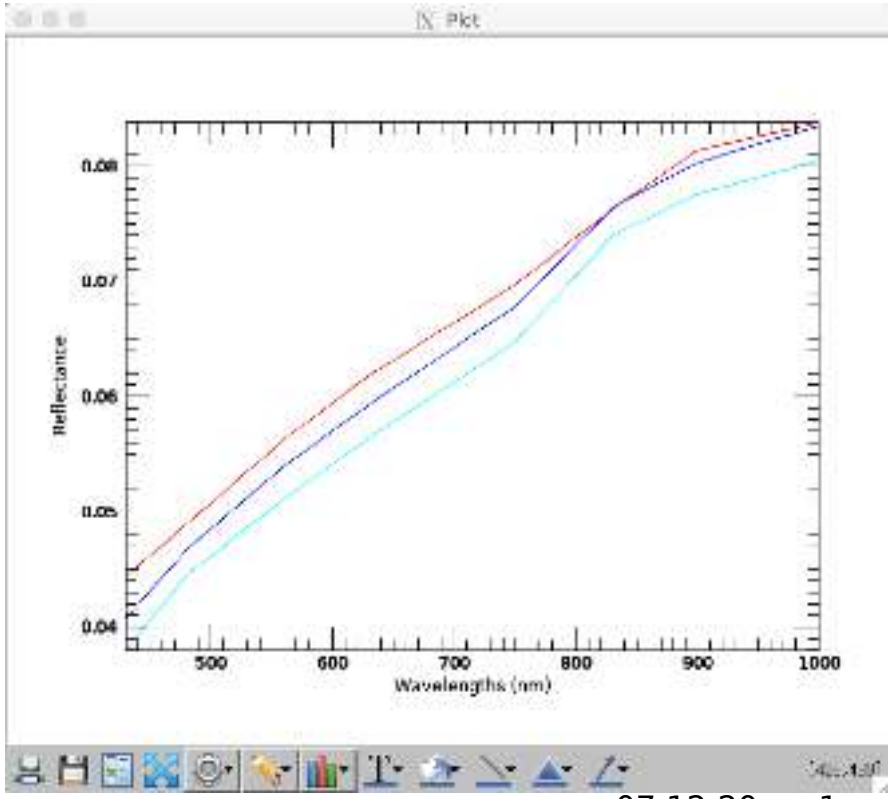
Thresholds

Winte01 allows to divide the spectral slope map into 3 thresholds interval.

The thresholds choice depends on the distribution of the values for the spectral slope selected.







At the end of the group activity (~16:00)
we reconvene all together in the main room
for the final discussion:

A student for group is invited to summarize the results carried out during
the group activity

Groups activity:

Selection of the spectral slopes and threshold intervals setting

Spectral slope selection

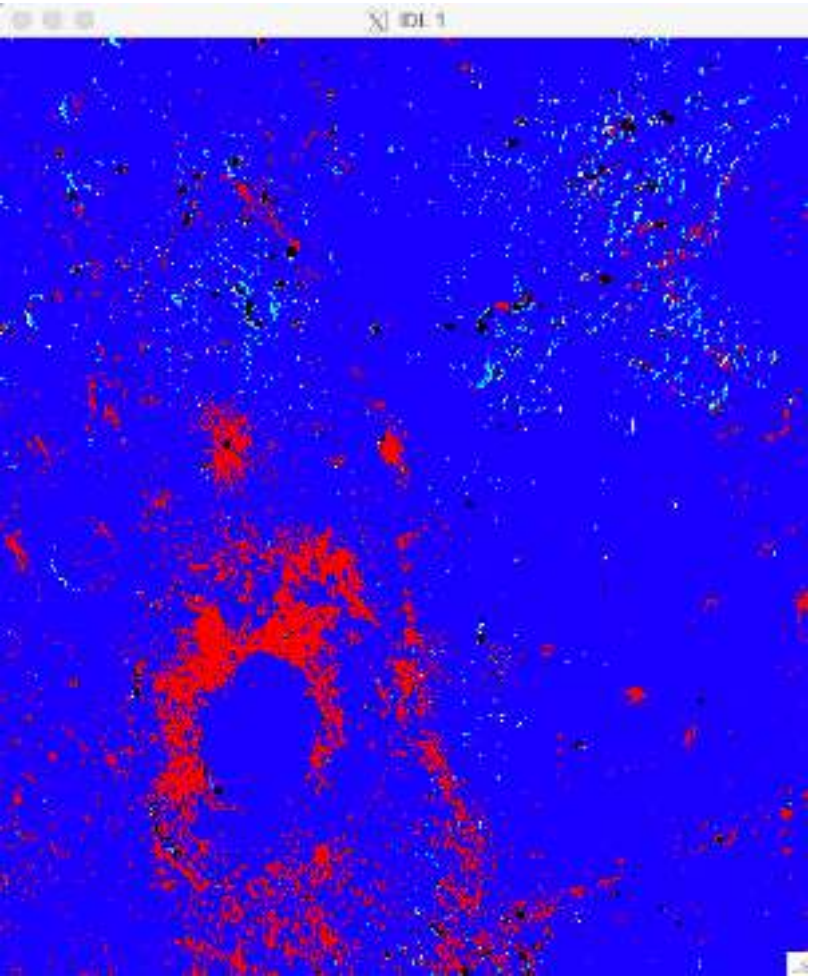
Global Slope 430-1000 nm ✉Terrain maturity

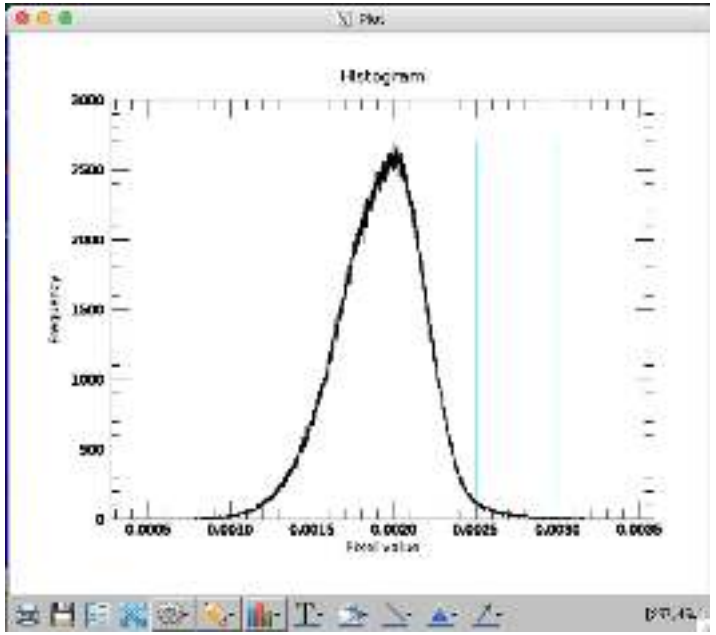
Spectral Slope 430-560 nm ✉Presence of opaque material, Mercury volcanic material

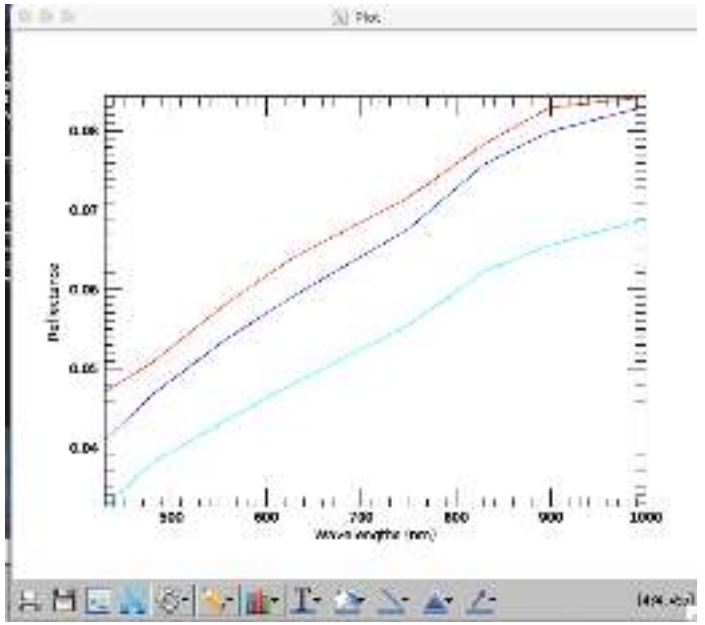
Spectral Slope 750-1000 nm ✉possible 1 µm absorption band

Threshold intervals selection – 430-1000 nm

Case 1



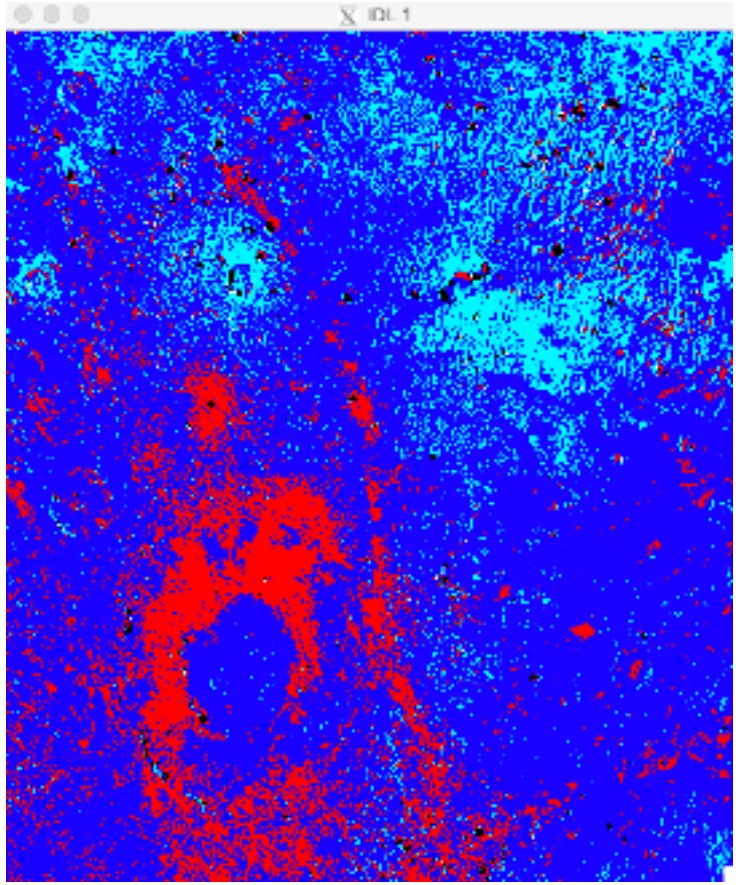


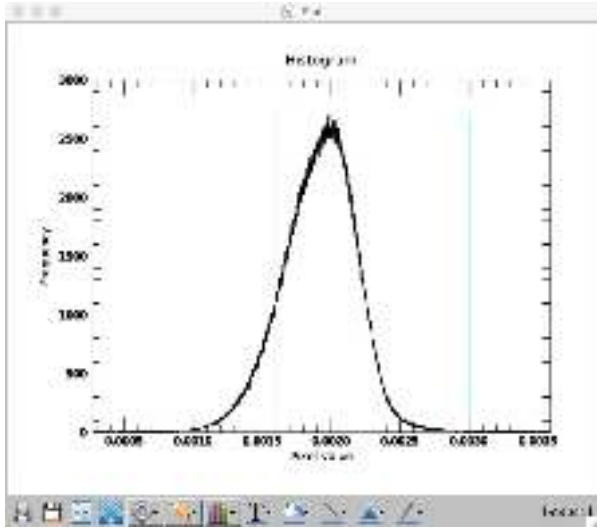


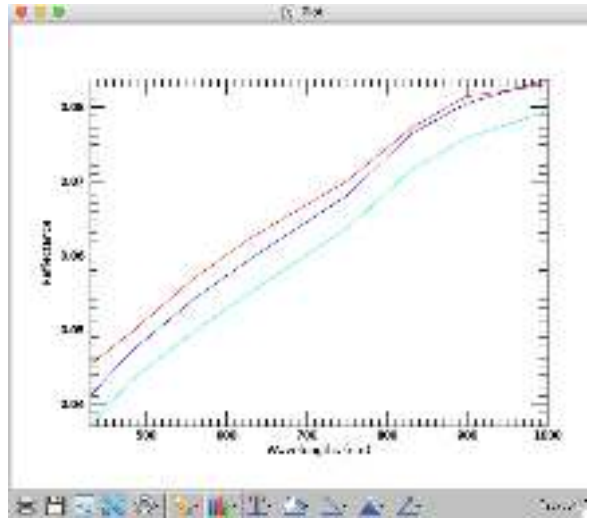
THRESHOLD 1	0	THRESHOLD 2	0.0015	Plot_1
THRESHOLD 3	0.0015	THRESHOLD 4	0.0025	Plot_2
THRESHOLD 5	0.0025	THRESHOLD 6	0.003	

Threshold intervals selection – 430-1000 nm

Case 2



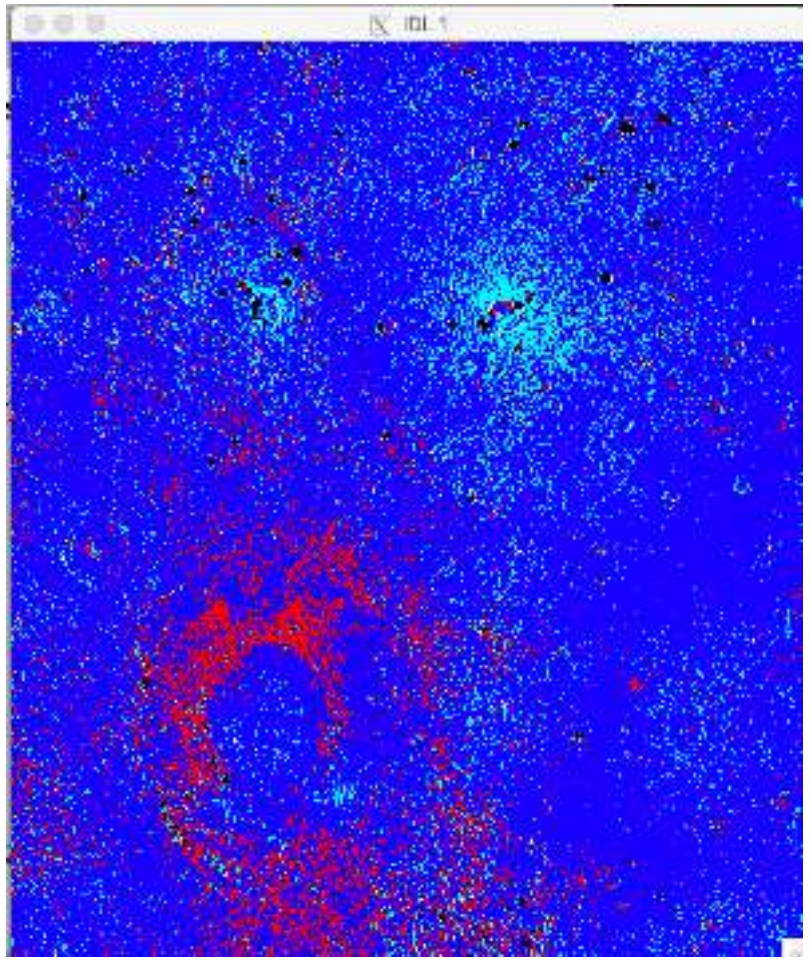


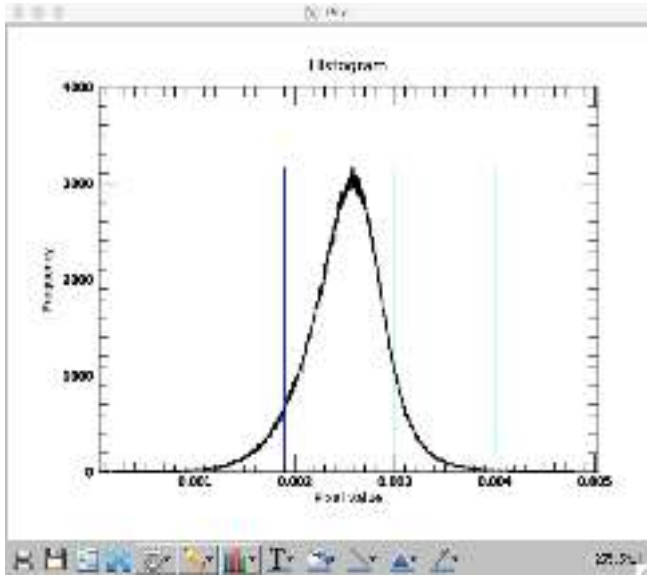


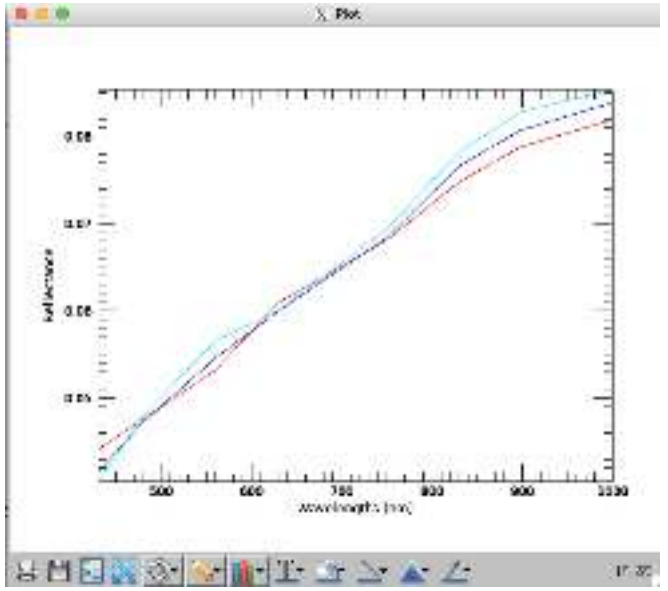
THRESHOLD 1	0	THRESHOLD 2	0.0016	Plot_1
THRESHOLD 3	0.0016	THRESHOLD 4	0.0022	Plot_2
THRESHOLD 5	0.0022	THRESHOLD 6	0.003	

Threshold intervals selection – 430-560 nm

Case 1



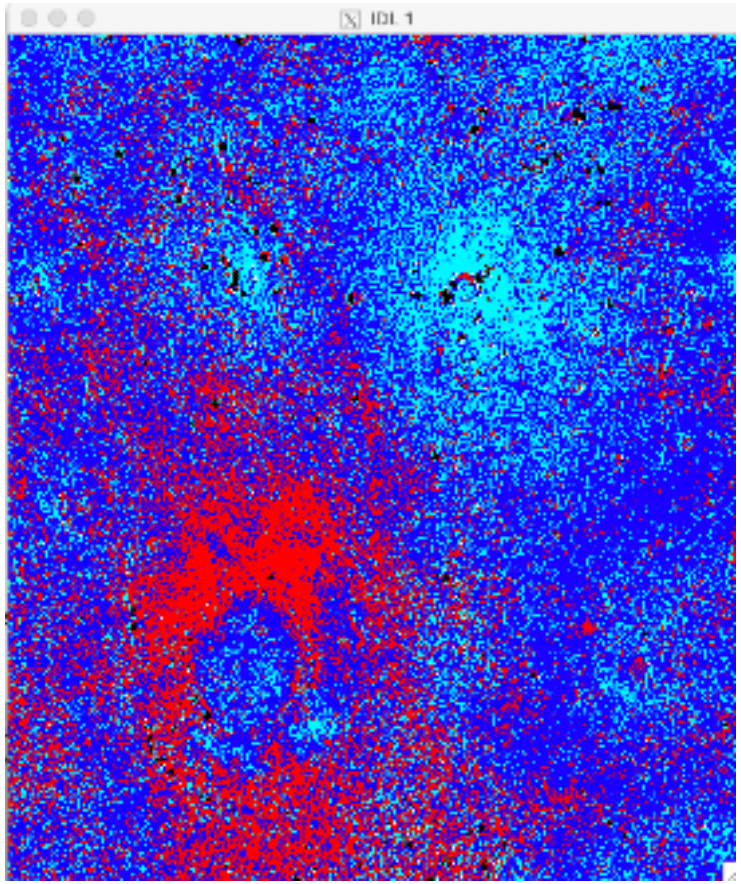


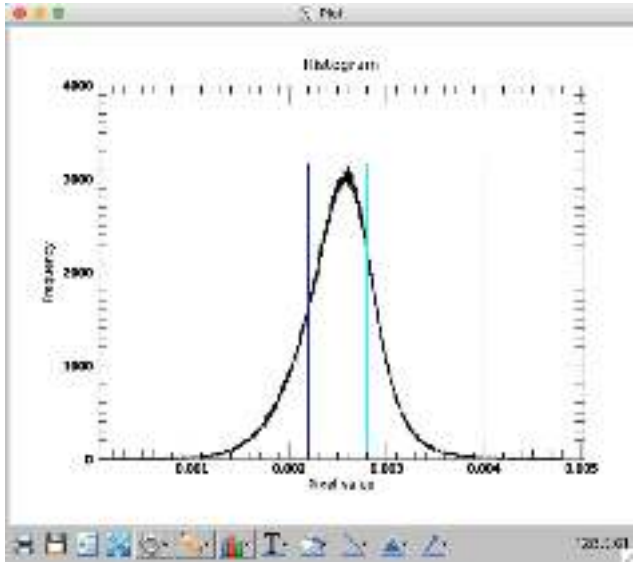


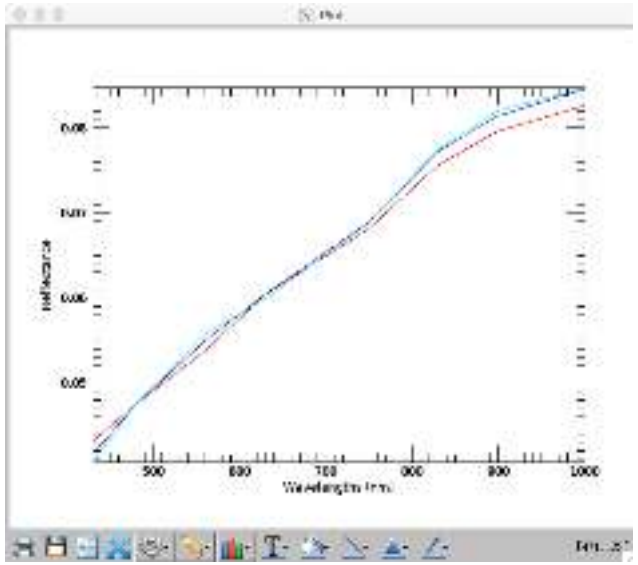
THRESHOLD 1	0	THRESHOLD 2	0.0019	Plot_1
THRESHOLD 3	0.0019	THRESHOLD 4	0.003	Plot_2
THRESHOLD 5	0.003	THRESHOLD 6	0.004	

Threshold intervals selection – 430-560 nm

Case 2



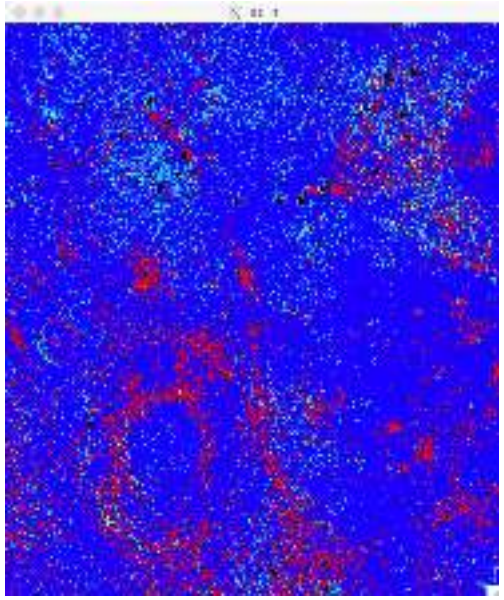


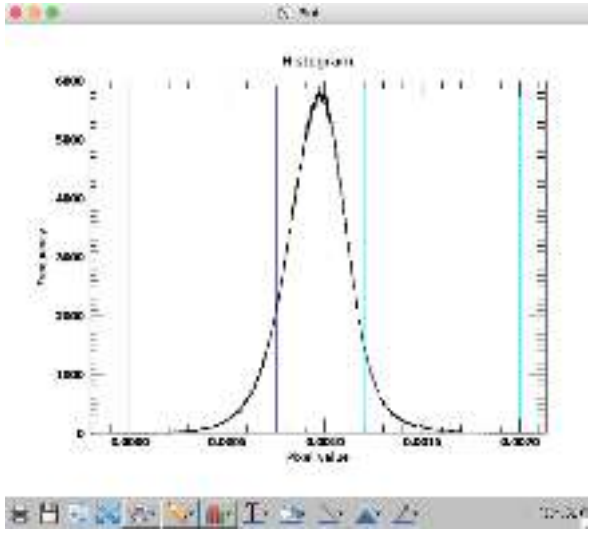


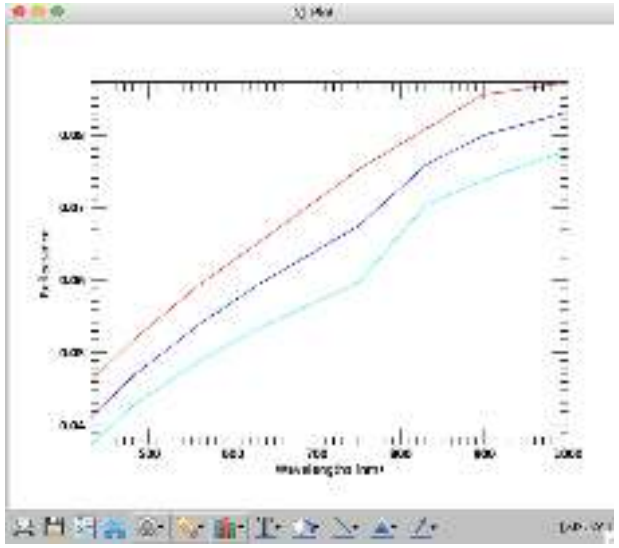
THRESHOLD 1	0	THRESHOLD 2	0.0022	Plot_1
THRESHOLD 3	0.0022	THRESHOLD 4	0.0028	Plot_2
THRESHOLD 5	0.0028	THRESHOLD 6	0.004	

Threshold intervals selection – 750-1000 nm

Case 1



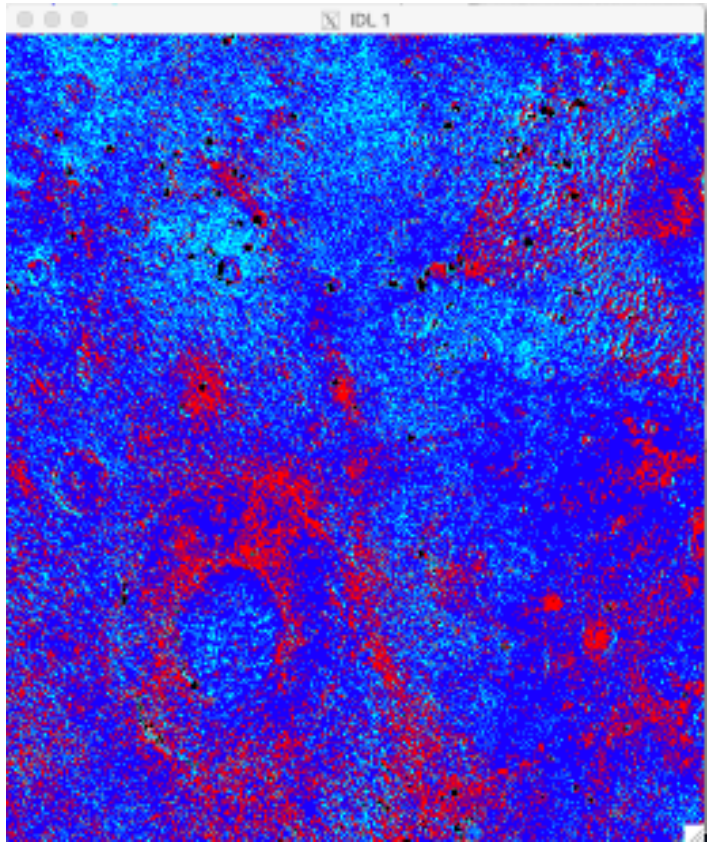


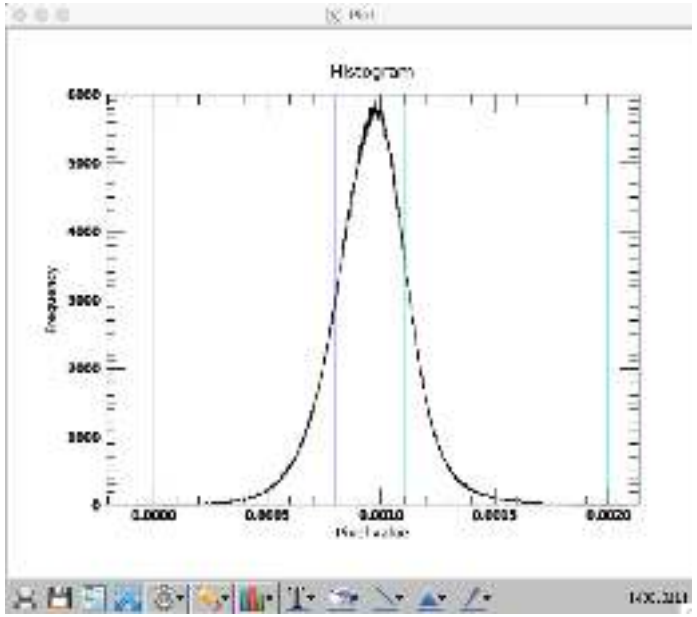


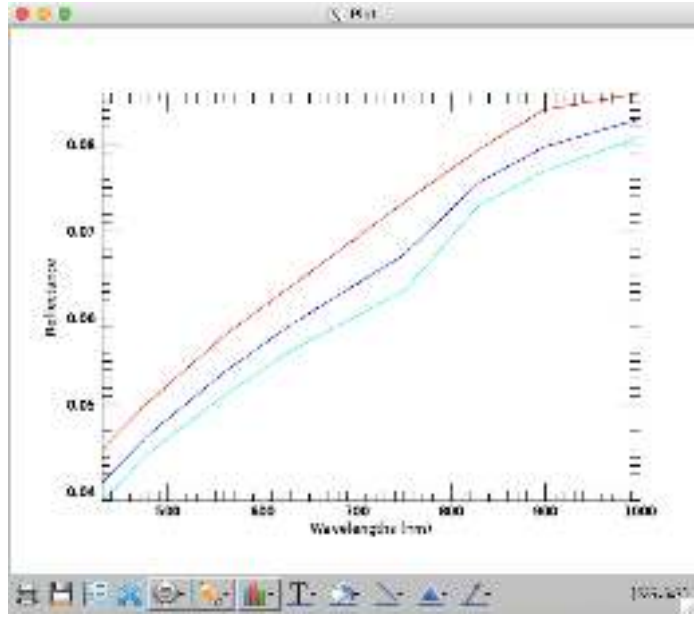
THRESHOLD 1	0	THRESHOLD 2	0.00075
THRESHOLD 3	0.00075	THRESHOLD 4	0.0012
THRESHOLD 5	0.0012	THRESHOLD 6	0.002

Threshold intervals selection – 750-1000 nm

Case 2







THRESHOLD 1	0	THRESHOLD 2	0.0008
THRESHOLD 3	0.0008	THRESHOLD 4	0.0011
THRESHOLD 5	0.0011	THRESHOLD 6	0.002