we
europlanet 2024
Research Infrastructure

Geology & Planetary Mapping
Winter School

Compositional data handling:
1st part: reflectance spectroscopy
brief introduction

Cristian Carli - IAPS-INAF

INAF
ISTITUTO NAZIONALE DI ASTROFISICA

IAPS ISTITUTO DI ASTROFISICA E PLANETOLOGIA SPAZIALI

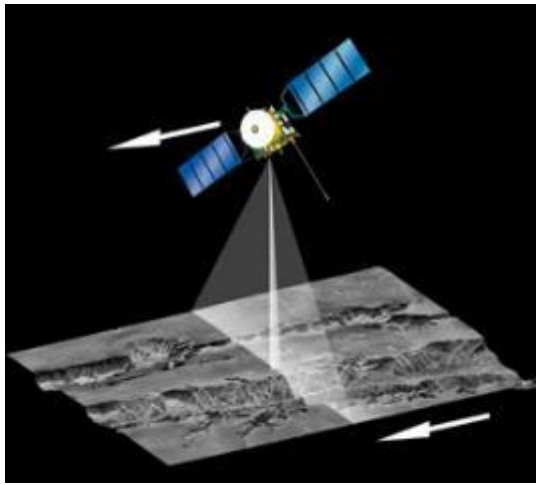
europlanet 2024 Research Infrastructure

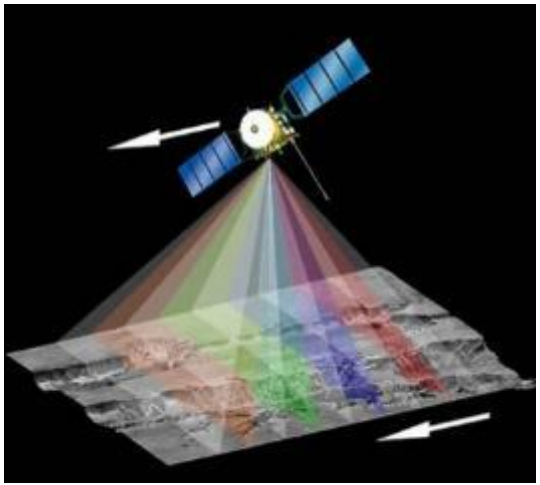
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871149.

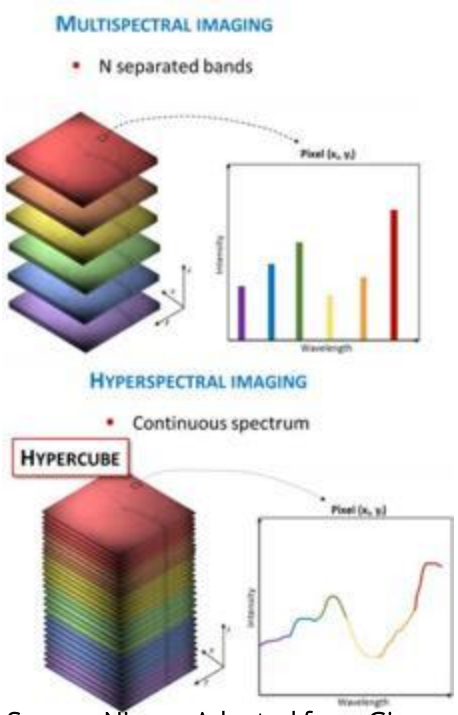
GMAP
Geological Mapping

Remote sensing composition:

Multi- or Hyper-spectral imaging



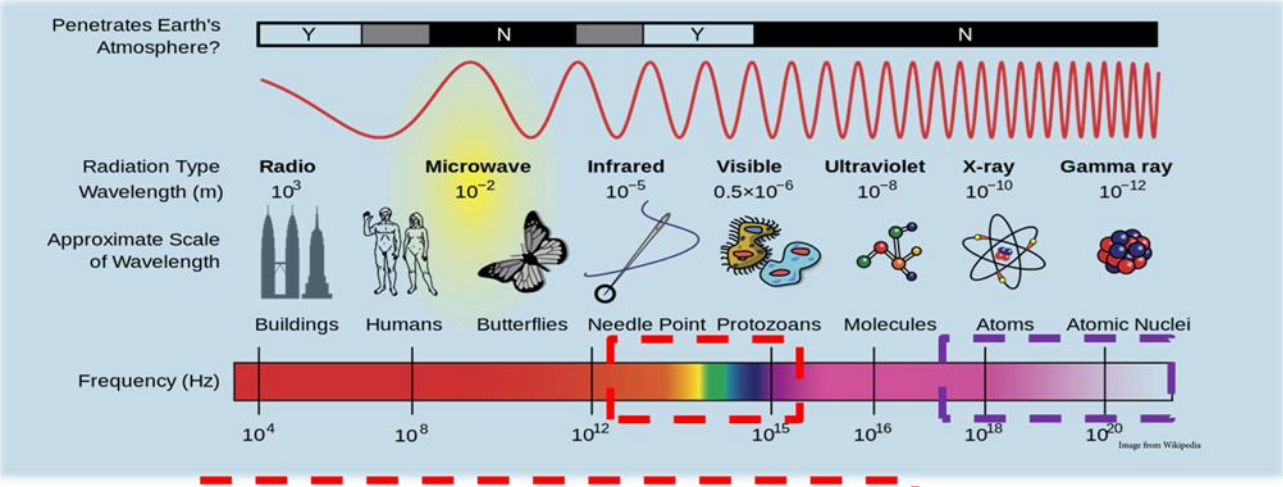




Source: Nireos, Adapted from Giannoni et al 2018 J. Opt. 20 044009

GMAP
Geological Mapping

Remote sensing composition:



increasing energy & wavenumber

Increasing wavelength

Composition of different minerals
electronic
molecular

Composition of different elements

GMAP
Geological Mapping

Spectroscopy:

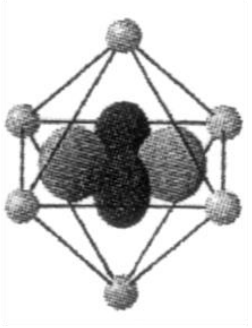
is a technique of investigation that exploits the interaction between *energy* and *matter*

Interaction

between electro magnetic radiation and surface

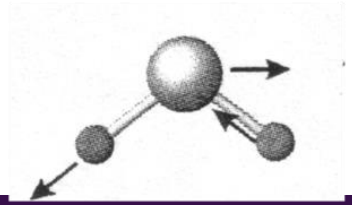
electronic transition

- electron excitation
- transitional metal → incomplete d/f orbital
- if enough energy an electron can jump to an higher quantum energetic level



molecular transition

- alteration of external electronic orbital – electronic energy states
- atoms vibration one respect to the other – vibrationa energy states
- atoms rotation one respect to the other – rotational energy states

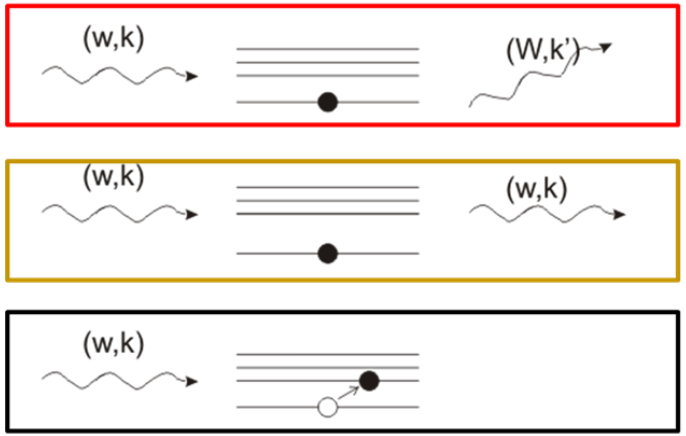


GMAP
Geological Mapping

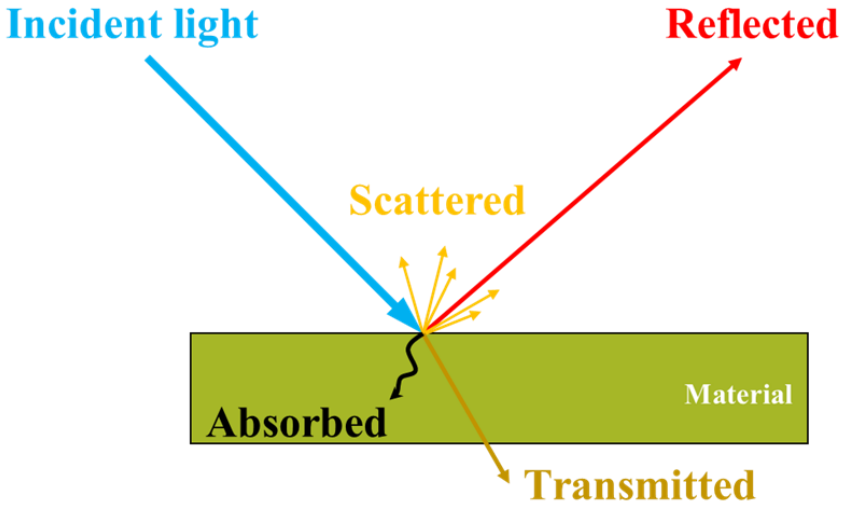
Spectroscopy:

The *reflectance-emittance* spectroscopy is a technique that exploit the interaction between E.M. radiation and matter

What happens when light hits a material?



Geiger 2004

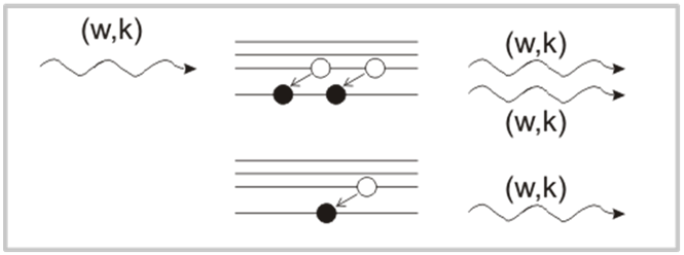


GMAP
Geological Mapping

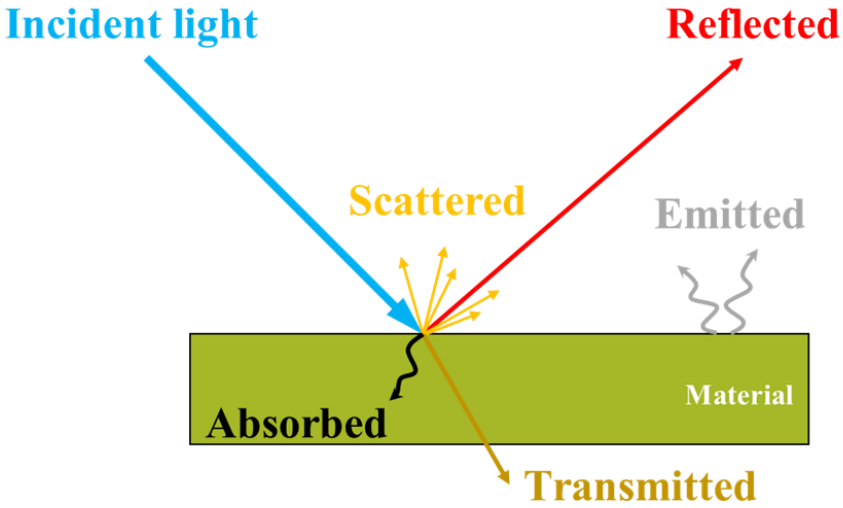
Spectroscopy:

The *reflectance-emittance* spectroscopy is a technique that exploit the interaction between E.M. radiation and matter

What happens when light hits a material?

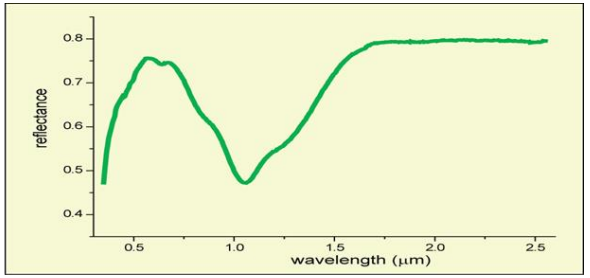


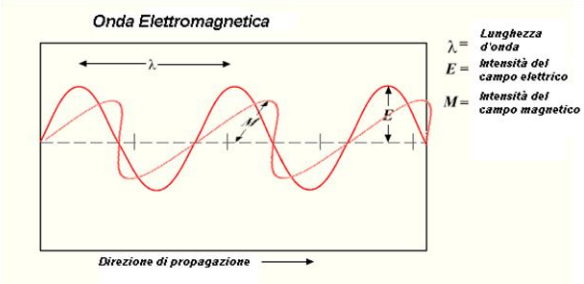
Geiger 2004

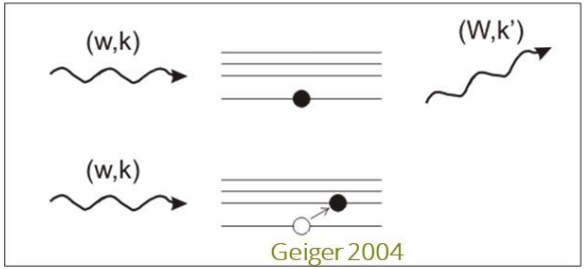


Reflectance

The *reflectance spectroscopy* is the study of the reflected or diffuse light, from a body, as a function of the wavelength

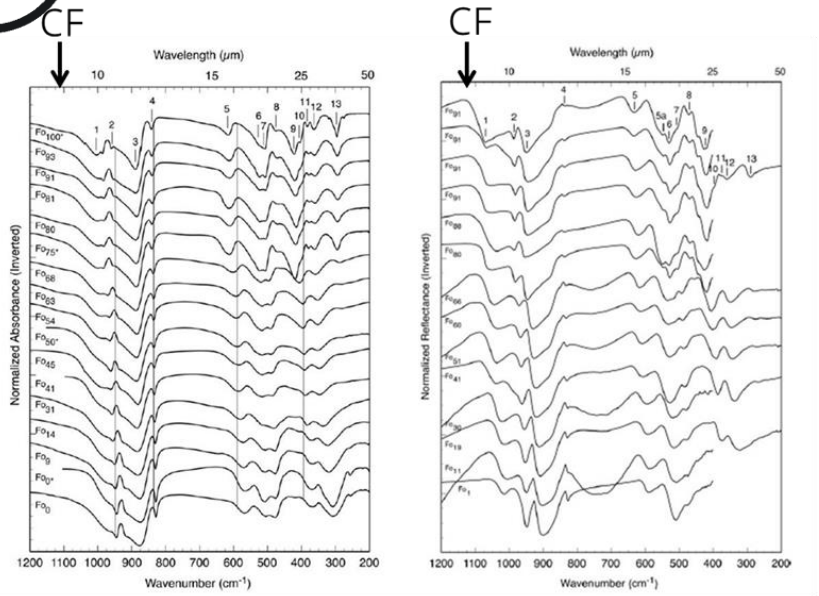






Emittance

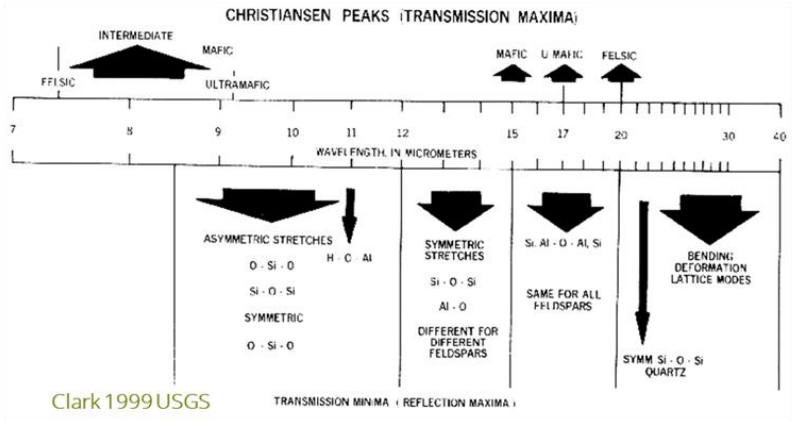
The *emittance* is the energy radiated by the surface of a body per second per unit area



Hamilton et al 2005 Chemie der Erde

Minimum of reflectance (Christiansen feature- CF)

Asymmetric and symmetric stretches



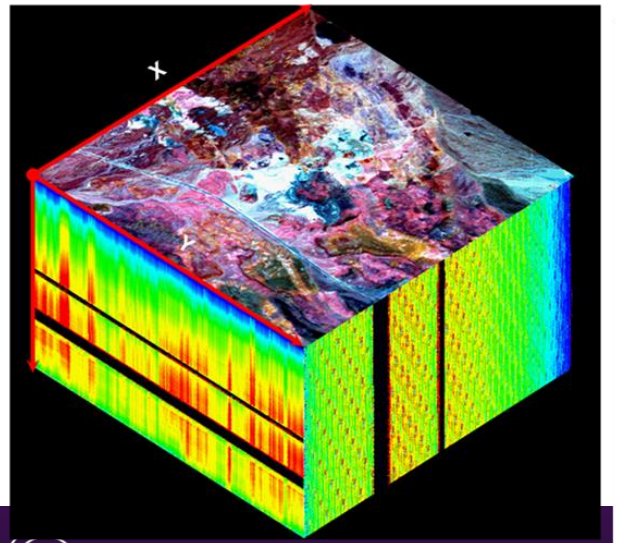
Clark 1999 USGS

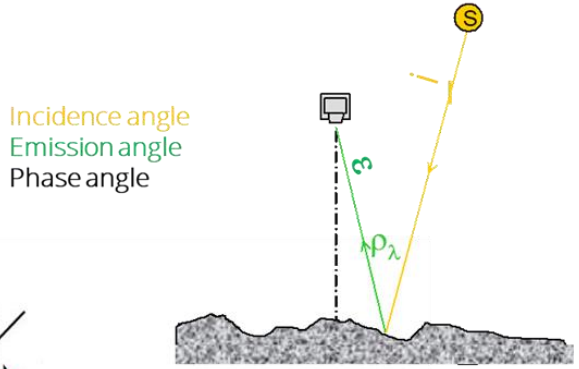
GMAP
Geological Mapping

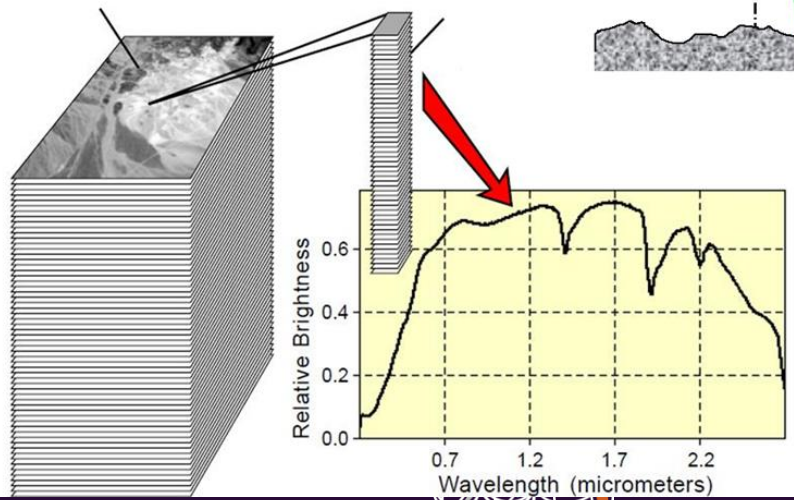
Data Set:

Often data are hyper- or multi-spectral images, we can consider them as a 3D data, called “cube”

Images / data cube:

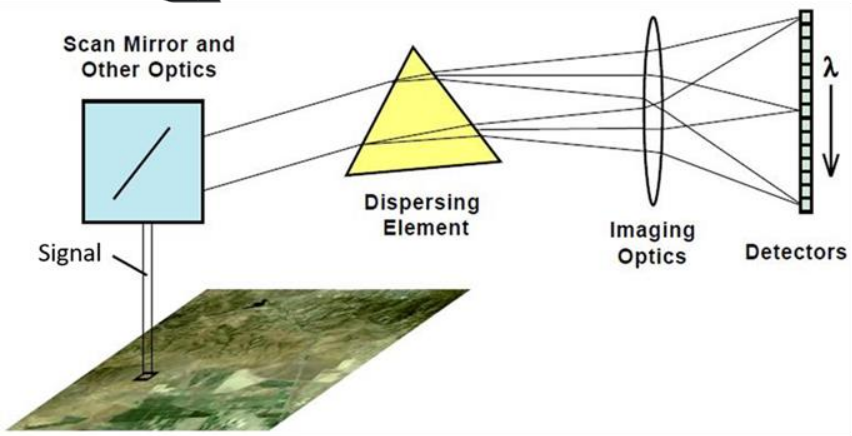




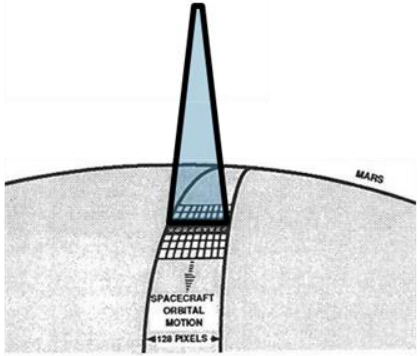


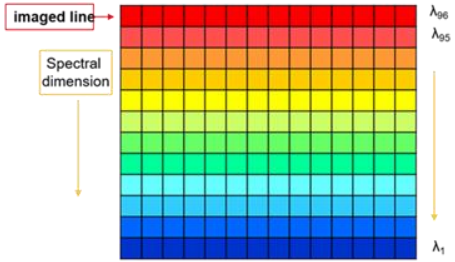
GMAP
Geological Mapping

Data Set:

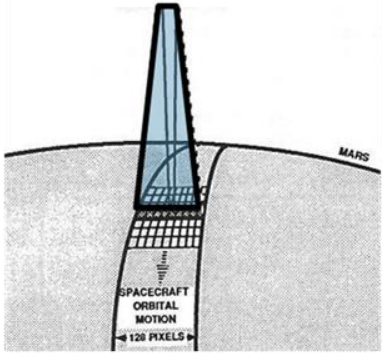


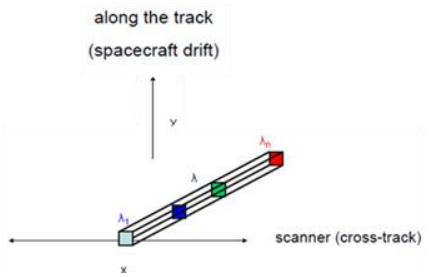
PUSH BROOM mode





WHISK BROOM mode

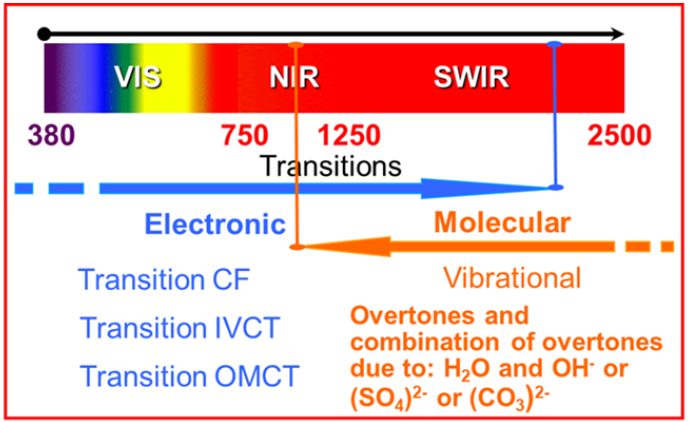




VNIR Reflectance spectra:

Often data are hyper- or multi-spectral images, we can consider them as a 3D data, called “cube”

The spectroscopy of reflectance is the study of the reflected or scattered light, from a body, as a function of the wavelength



Reflectance spectra are controlled by several factors

concentration of minerals,
dimension of crystals,
opacity,
type of surface

GMAP
Geological Mapping

VNIR Reflectance spectra:

Absorption parameters

Band minimum

energy

ions in selected site of coordination

Band depth

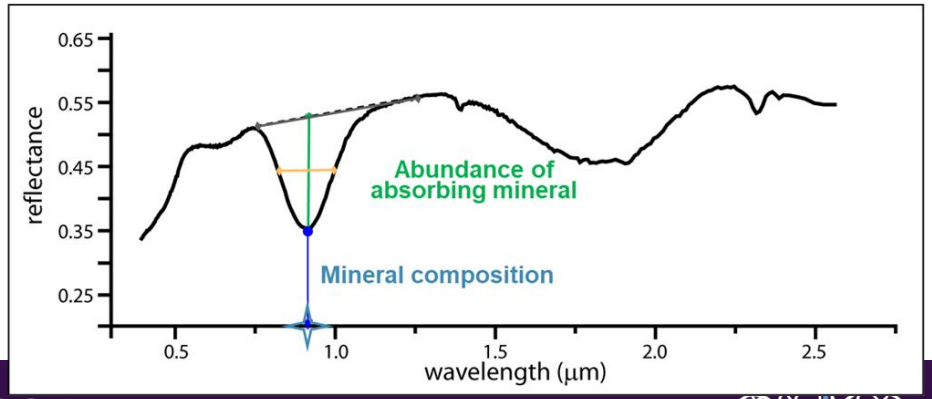
intensity of absorption

probability that transition occurs

Band width

vibronic process

geometry variation of site

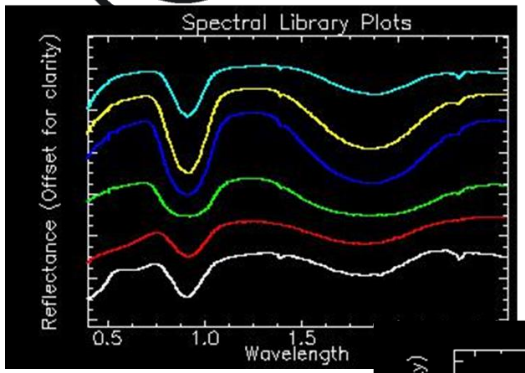


VNIR Reflectance spectra:

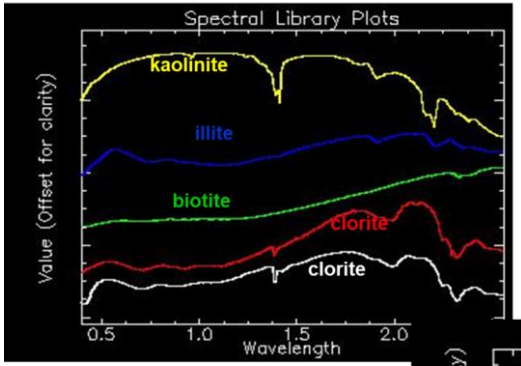
Absorption types:

electronic

molecular

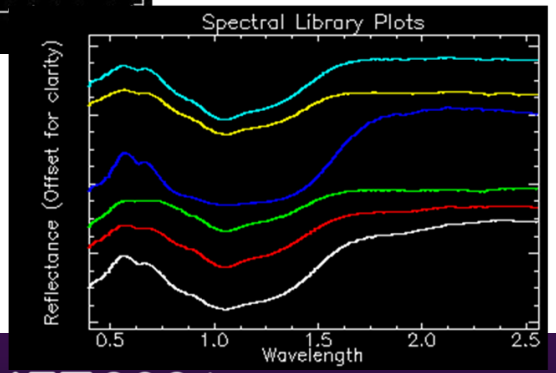


pyroxene

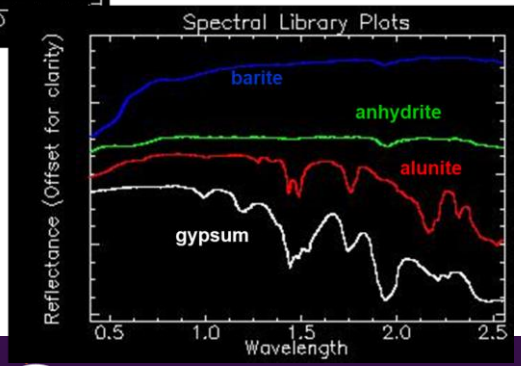


Hydrated silicates

olivine



Hydrated sulfates



GMAP
Geological Mapping

VNIR image analysis:

Different approaches:

Hyperspectral classification:

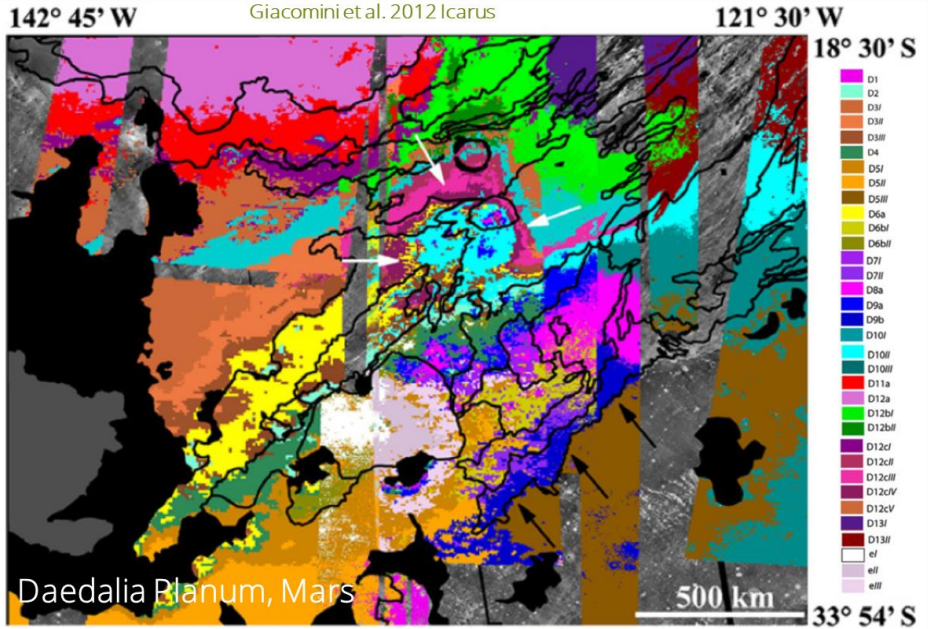
- Take into account all the spectra information;
- Permit to classify units directly;
- More complex classification level, and often require a supervision to select endmembers

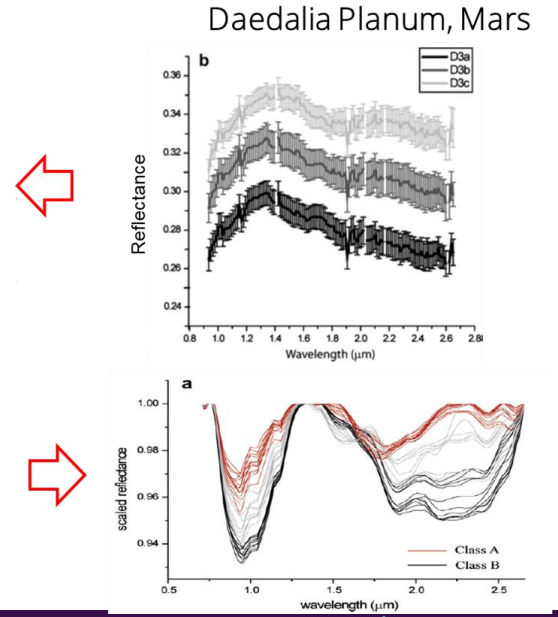
Spectral Parameters:

- Simplify the spectral analysis;
- Reduce the calculation-weight;
- Permit comparison between different portion of the spectral range (e.g. different absorption bands, different slopes)

VNIR image analysis:

Hyperspectral classification:





Supervised classifier

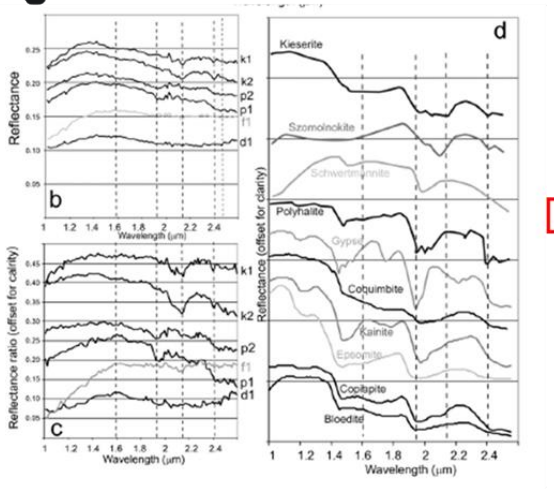
Spectral Angle Mapper

GMAP
Geological Mapping

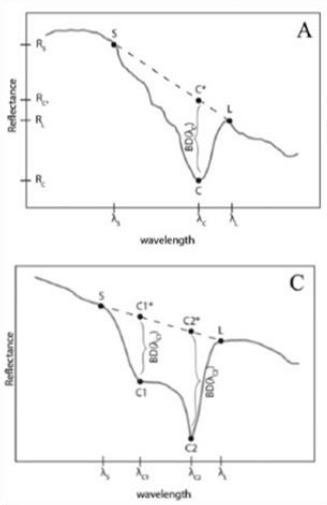
VNIR image analysis:

Spectral parameters:

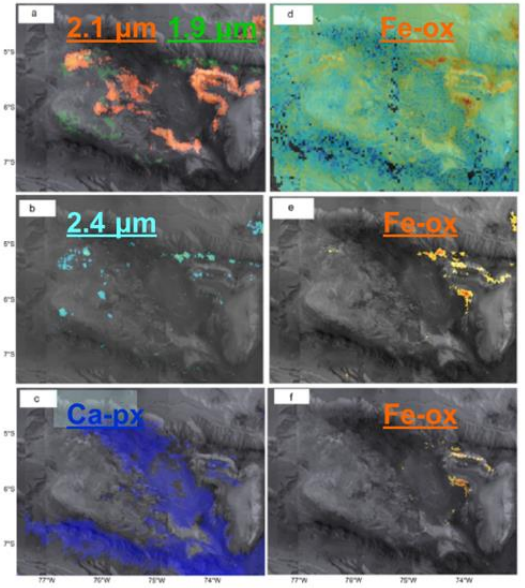
West Candor Chasma, Mars



Mangold et al. 2007 JGR



Viviano-Beck et al. 2014 JGR

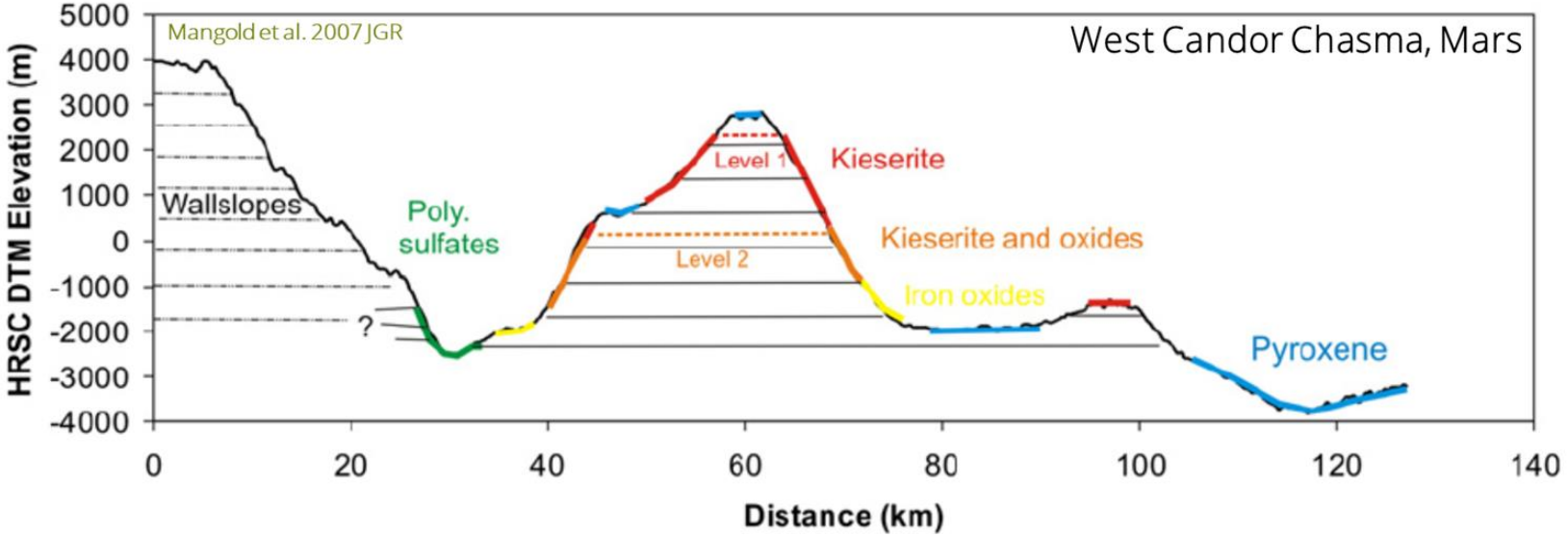


Mangold et al. 2007 JGR

GMAP
Geological Mapping

VNIR image analysis:

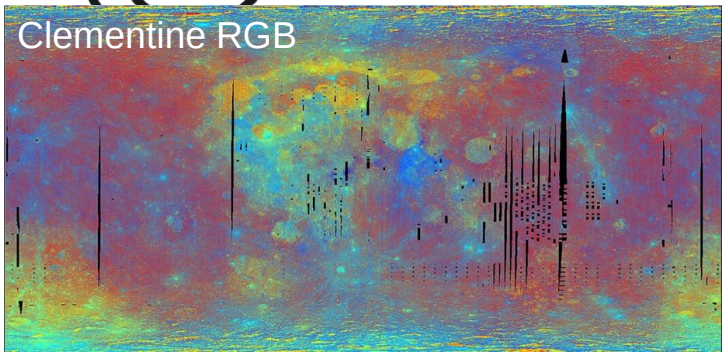
Spectral parameters:

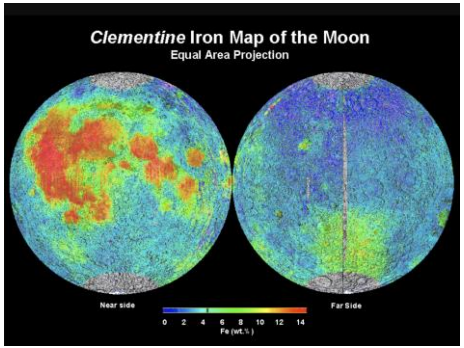


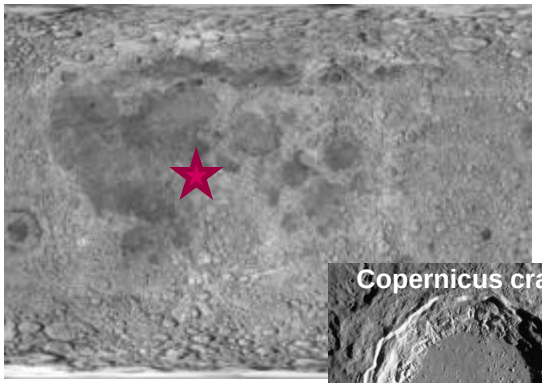
GMAP
Geological Mapping

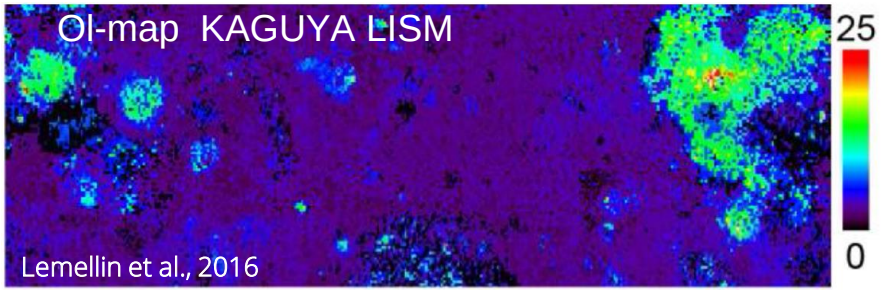
See following Zambon F. talk and Moon ex. tomorrow

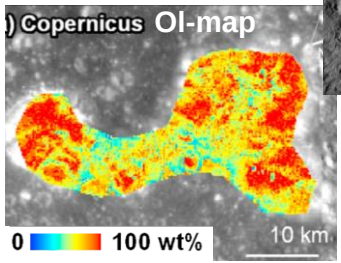
Moon











Lemellin et al., 2015

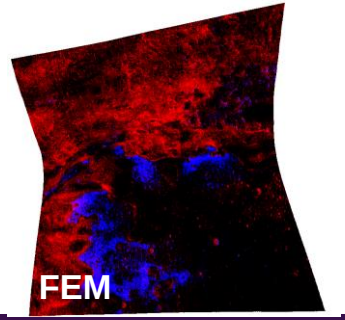
GMAP

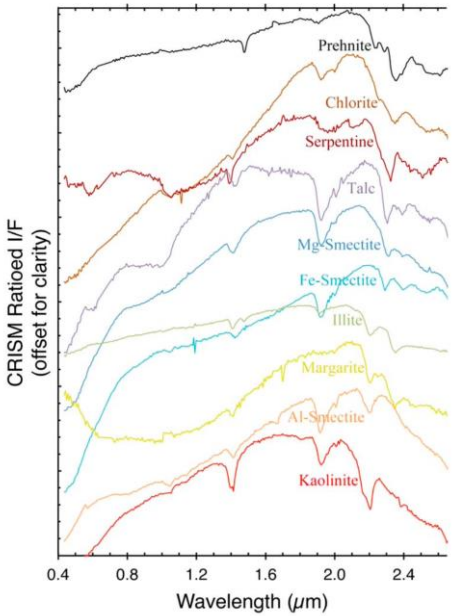
Geological Mapping

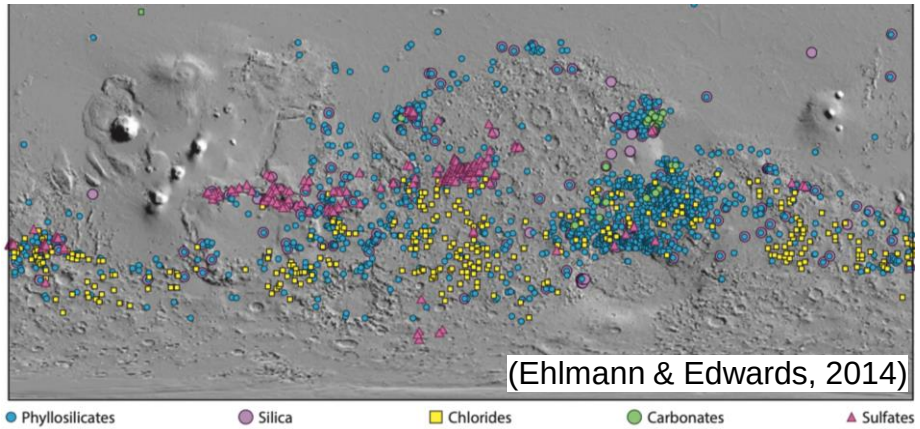
See following Baschetti B. talk and Mars ex. on Thursday

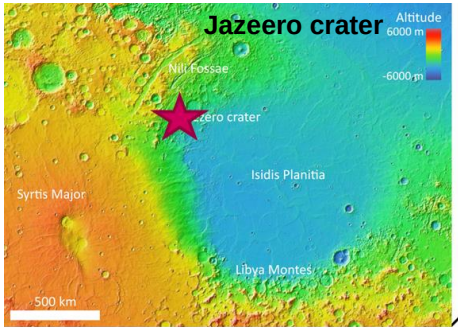
Mars

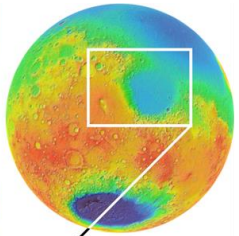
CRISM











Mandon et al., 2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871149.

Click to edit end text