Deep UV Penetration Depth in Astrobiologically Relevant Rocks & Minerals

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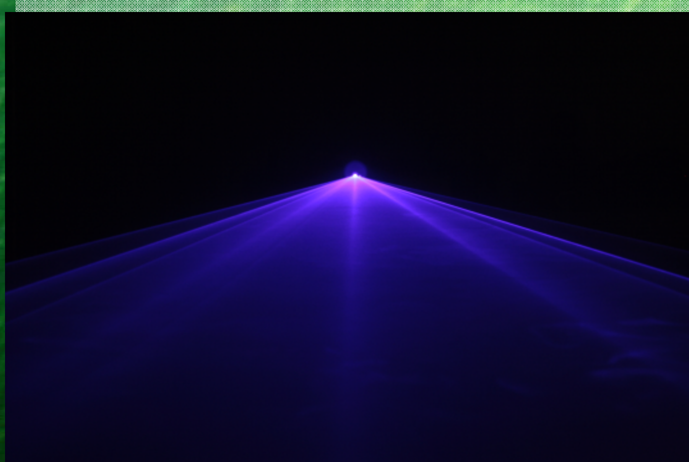
CSU STAR Program

The Ultimate Question

What is the attenuation rate (gradual loss of intensity) of ultra-violet light as it transmits through rock or mineral samples (such as basaltic rocks)?

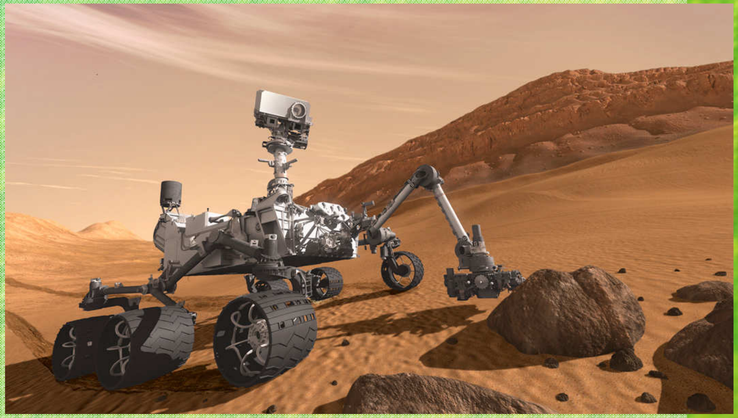


Why does this matter?

We hope that this study will eventually…

Prove that using Deep UV fluorescence is

- **non-invasive**
- **appropriate**
- **effective** means **to identify**
  - mineral content
  - organics



Someday be an In-situ technique to use on Earth or Mars?

What is Deep UV Fluorescence?

Using laser light that has a wavelength less than ≈250nm (also known as Deep Ultraviolet).

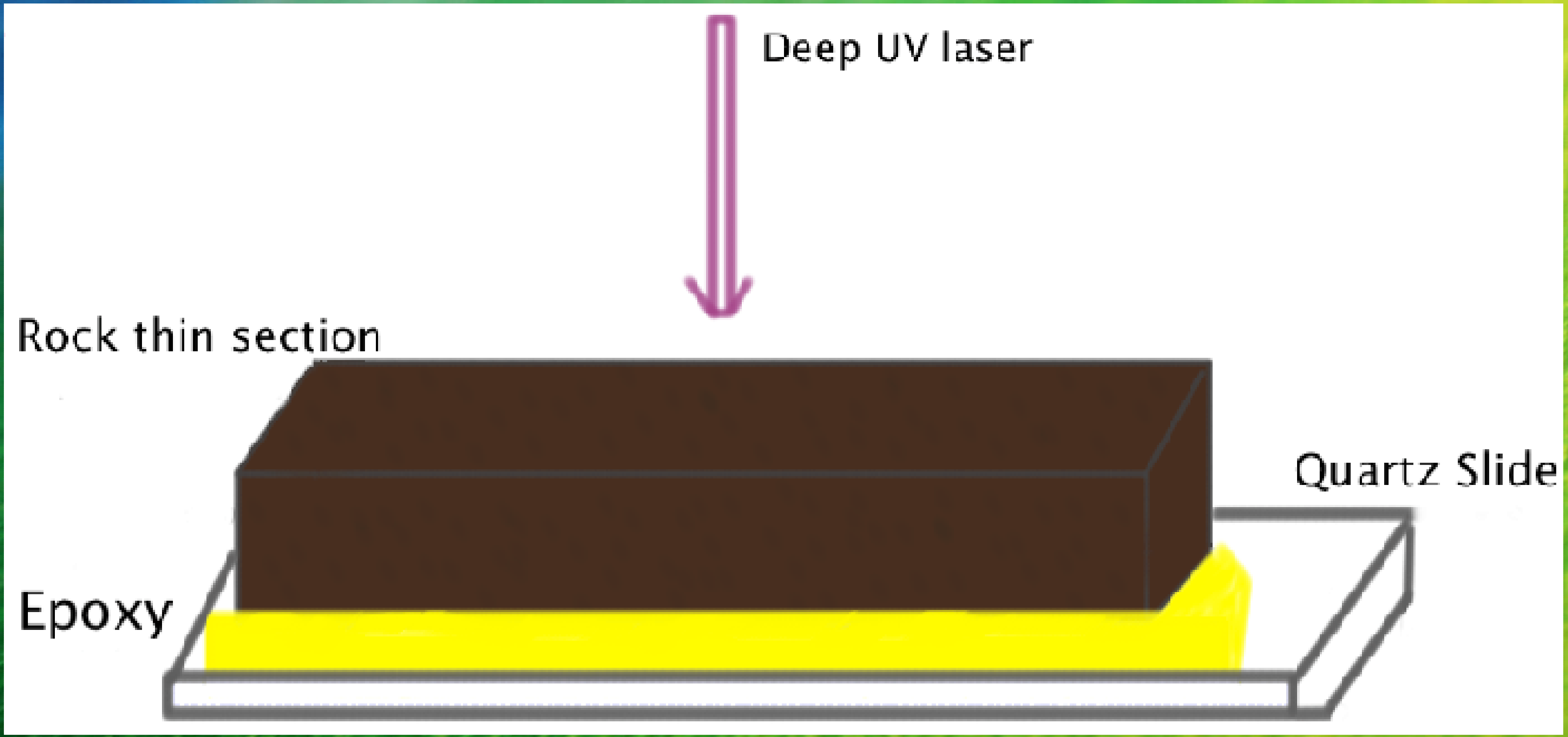
The laser ‘excites’ the sample,

The light is absorbed, and

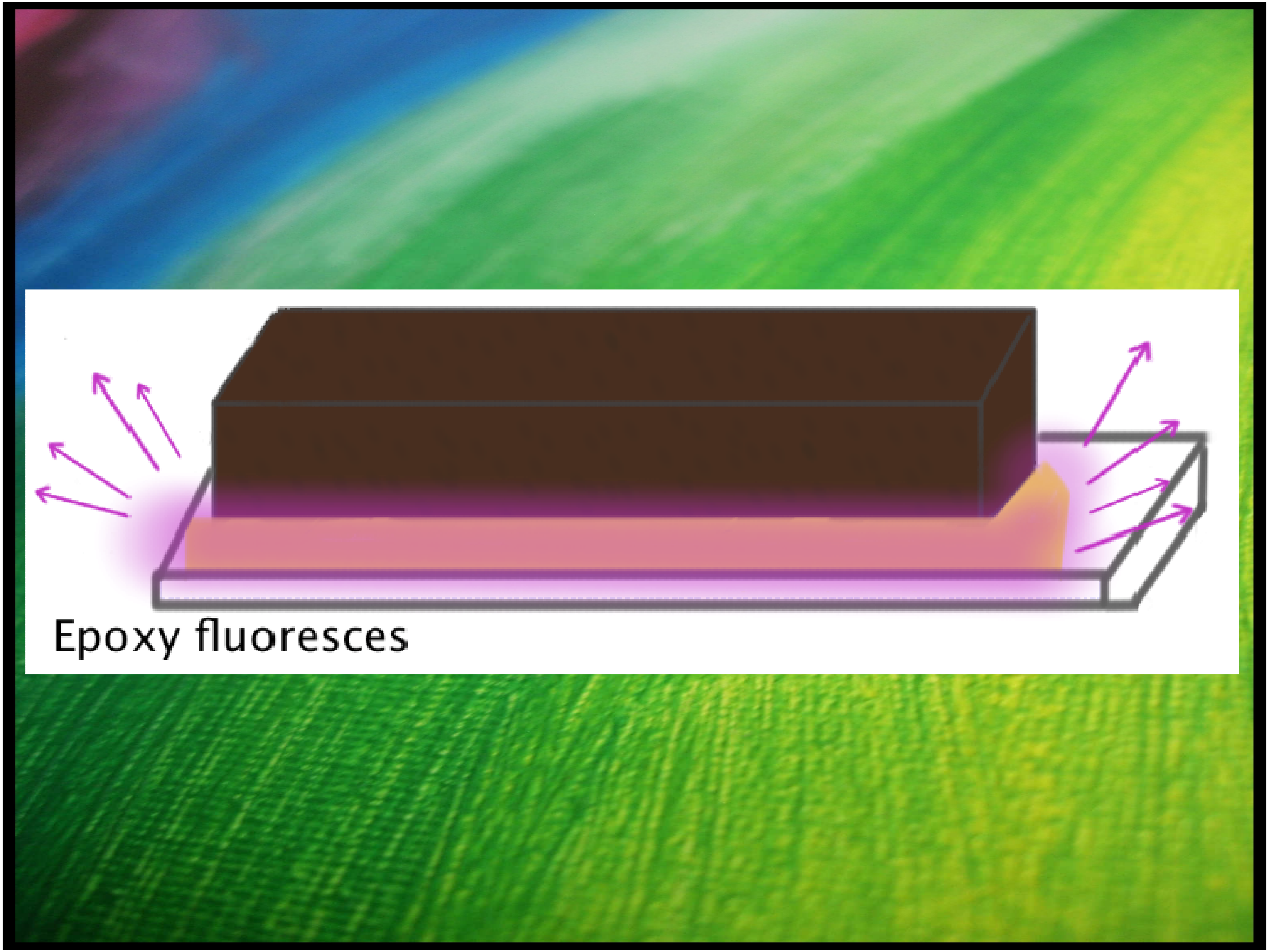
Some of the light is emitted or fluoresced.

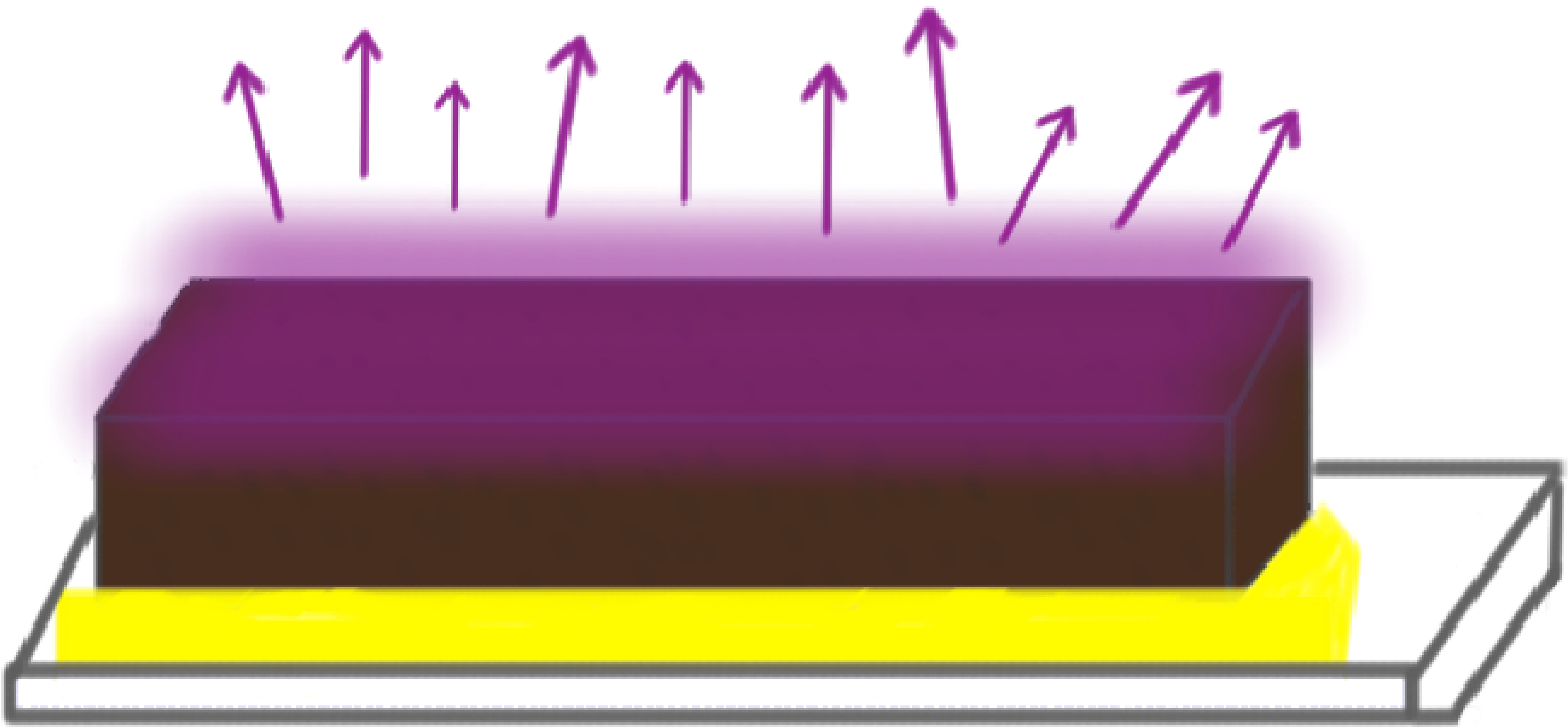
Fluorescence: emission of light by a substance that has absorbed light

How DUV fluorescence works…

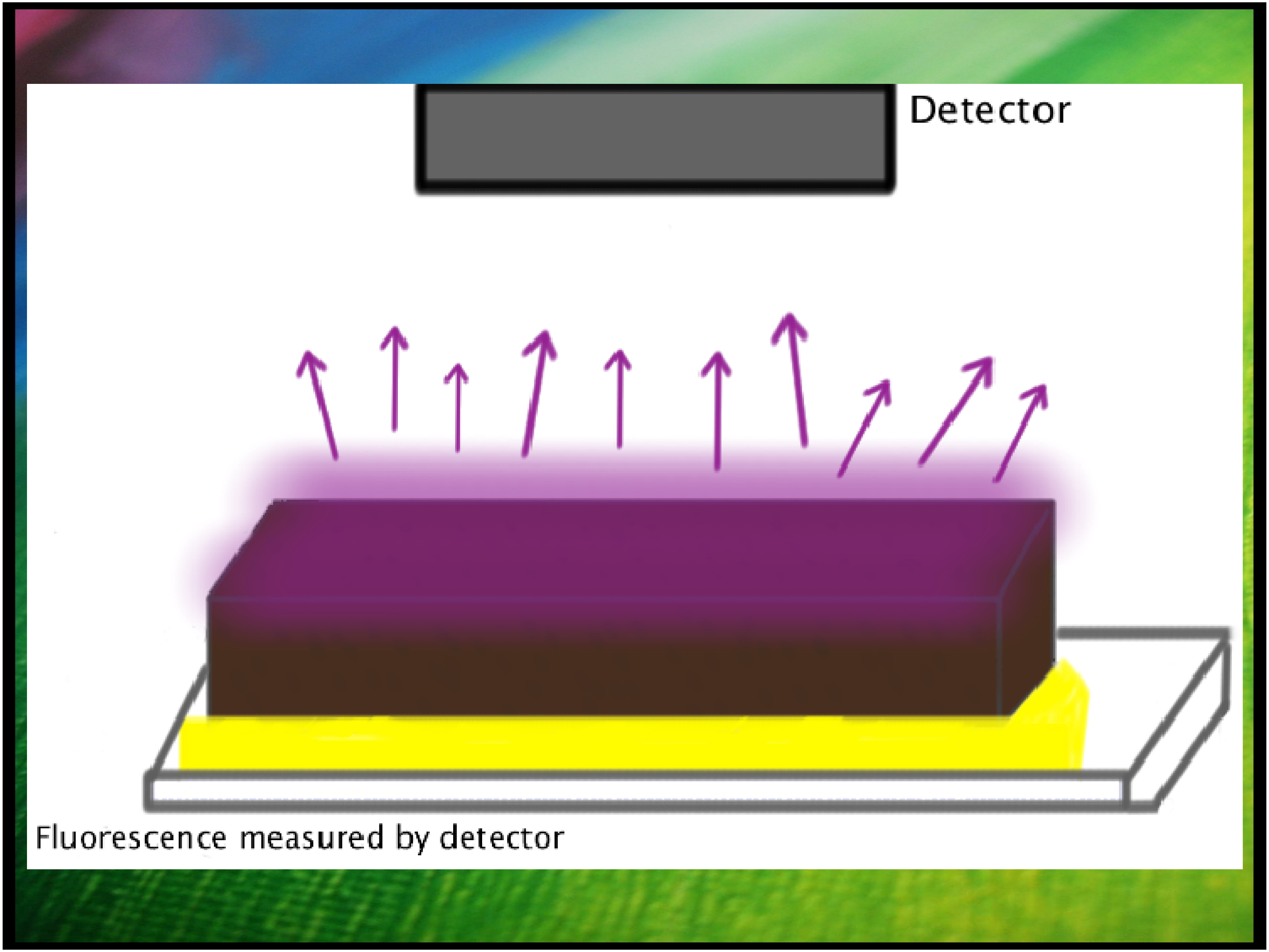


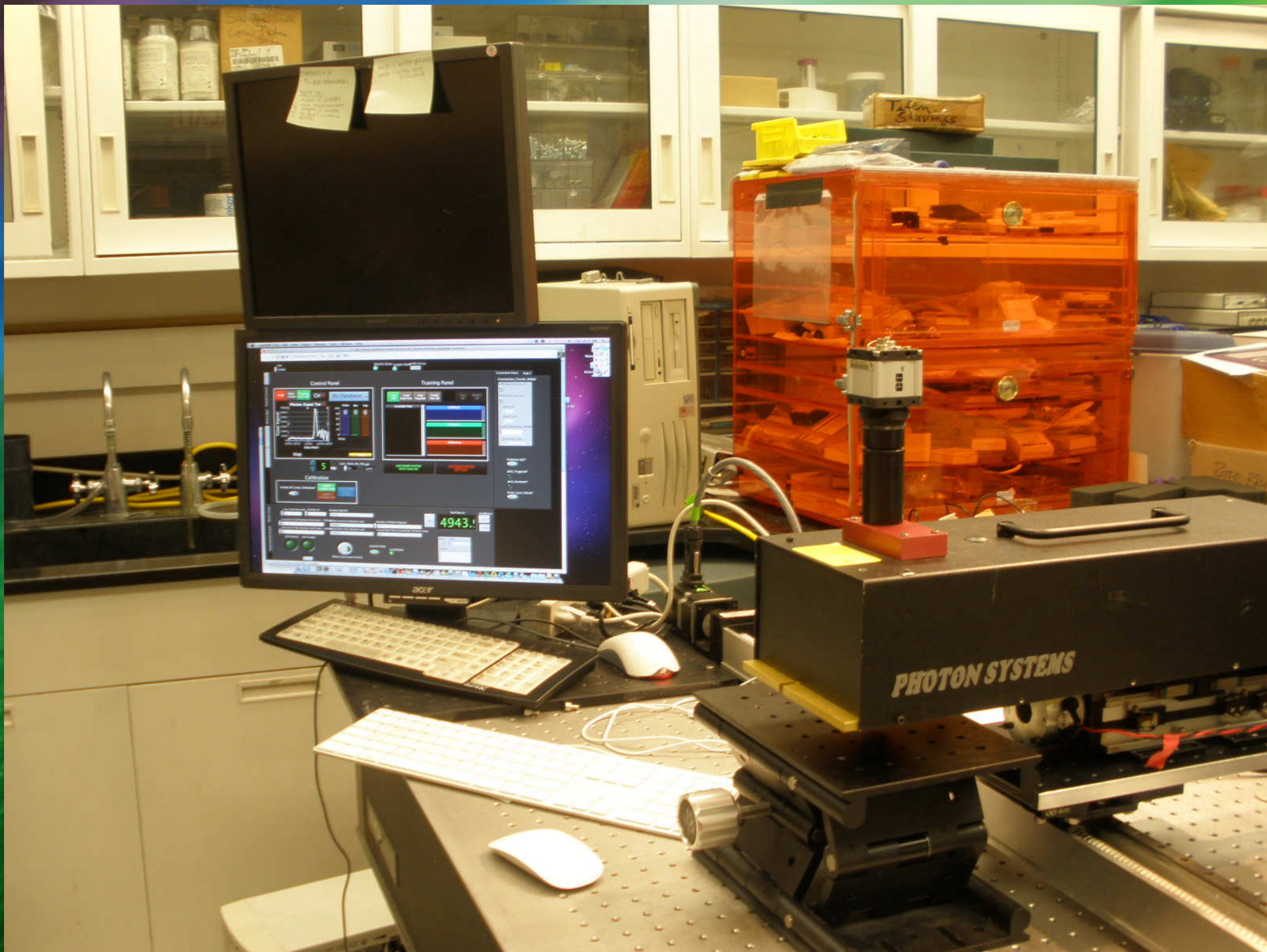
** Illustration not to scale


Epoxy fluoresces



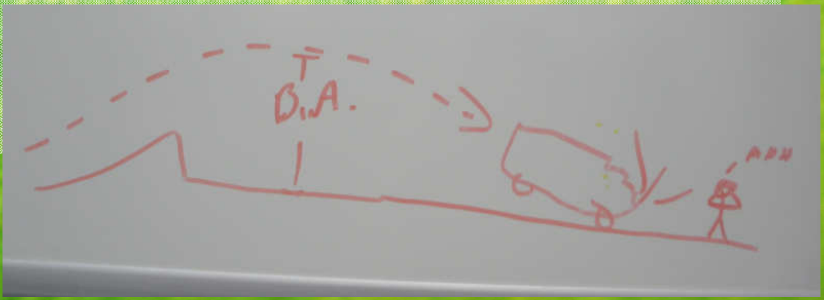
Thin section fluoresces


Detector
Fluorescence measured by detector


PHOTON SYSTEMS
4943.

Methodology

- Read about rock samples (Saddleback and Belleville Basalts)
- Create rock slabs to study the mineral composition of the rock samples
- Create thin section samples.
- Use Raman spectrometer
- Measure fluorescence of rock thin sections with Deep UV Laser instrument
- Use Petrographic microscope
- Field Research



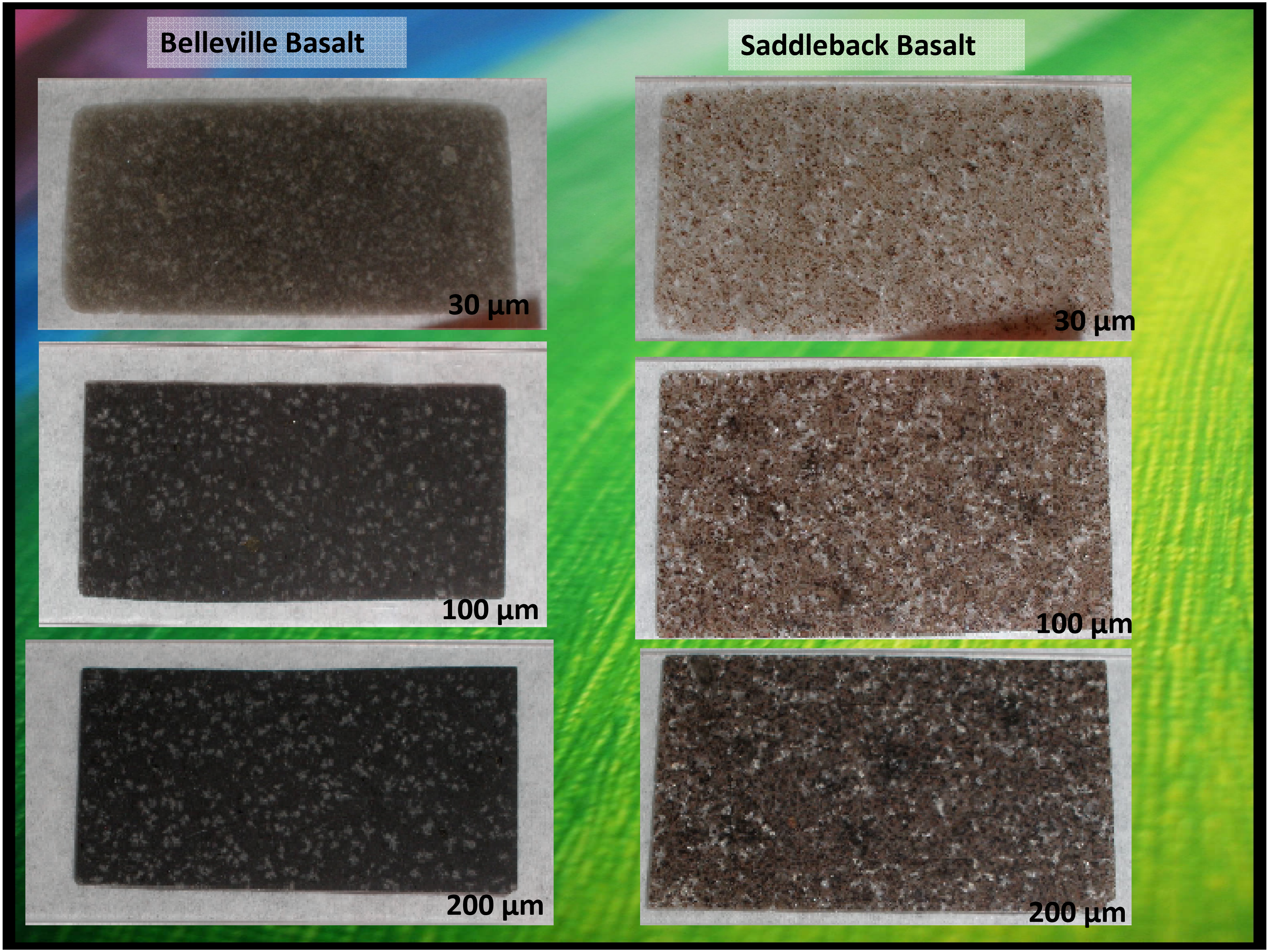
Thin section prep

Belleville Slab (Ready for thin section!)

40mm x 24mm x 1.5cm

Rock sample ready for cutting!

Standard issue Tile Saw



Belleville Basalt
Saddleback Basalt
30 µm
30 µm
100 µm
100 µm
200 µm
200 µm

Raman Spectroscopy

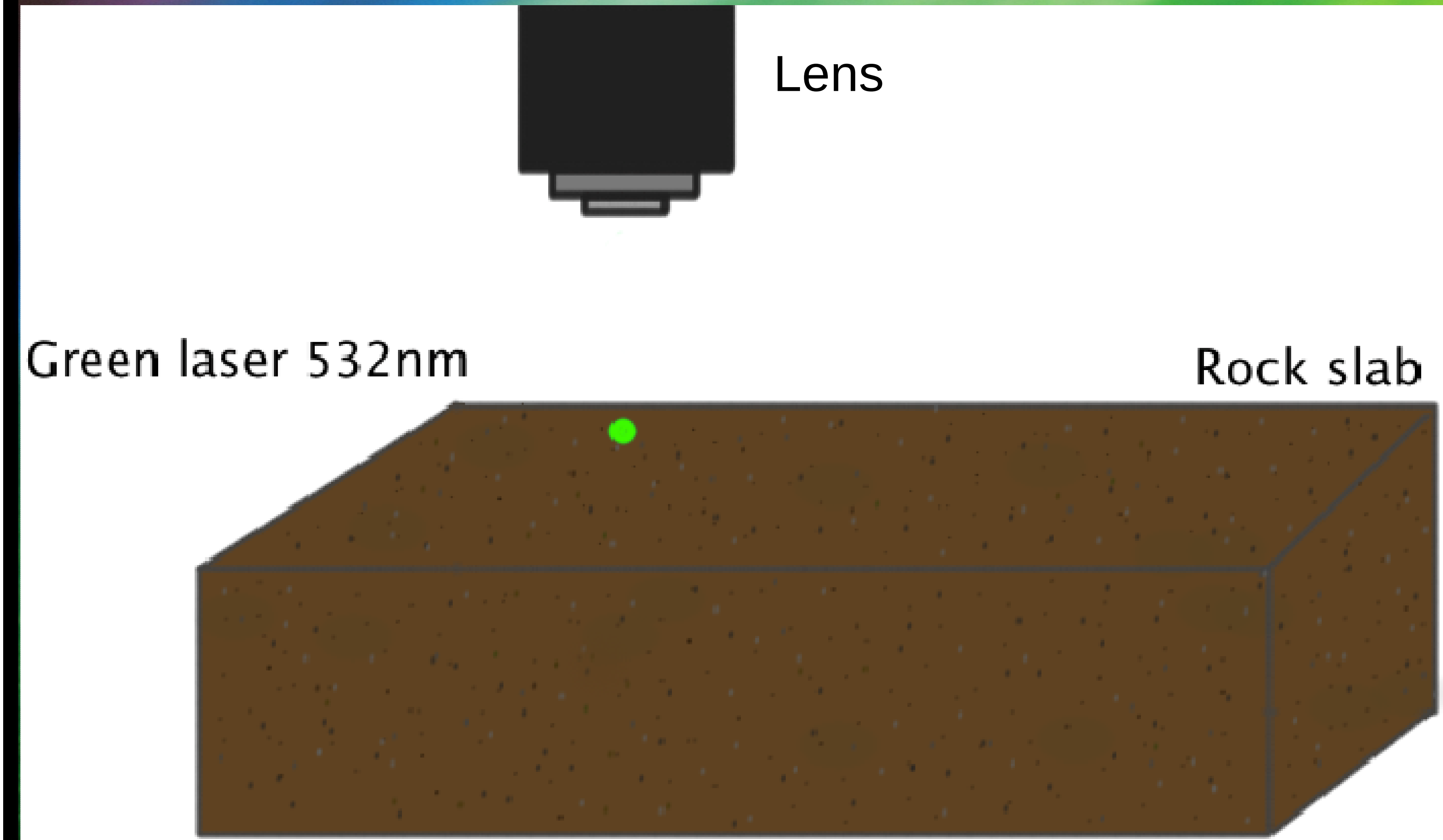
After learning about the minerals typically found in the basalt samples (plagioclase feldspars and pyroxenes) my research team and I used the **Raman** Spectrometer to take **point spectra to identify** what **minerals** are **present** in the rock slabs.

*Each **mineral** has a **unique spectrum** with peaks at certain wavelengths.

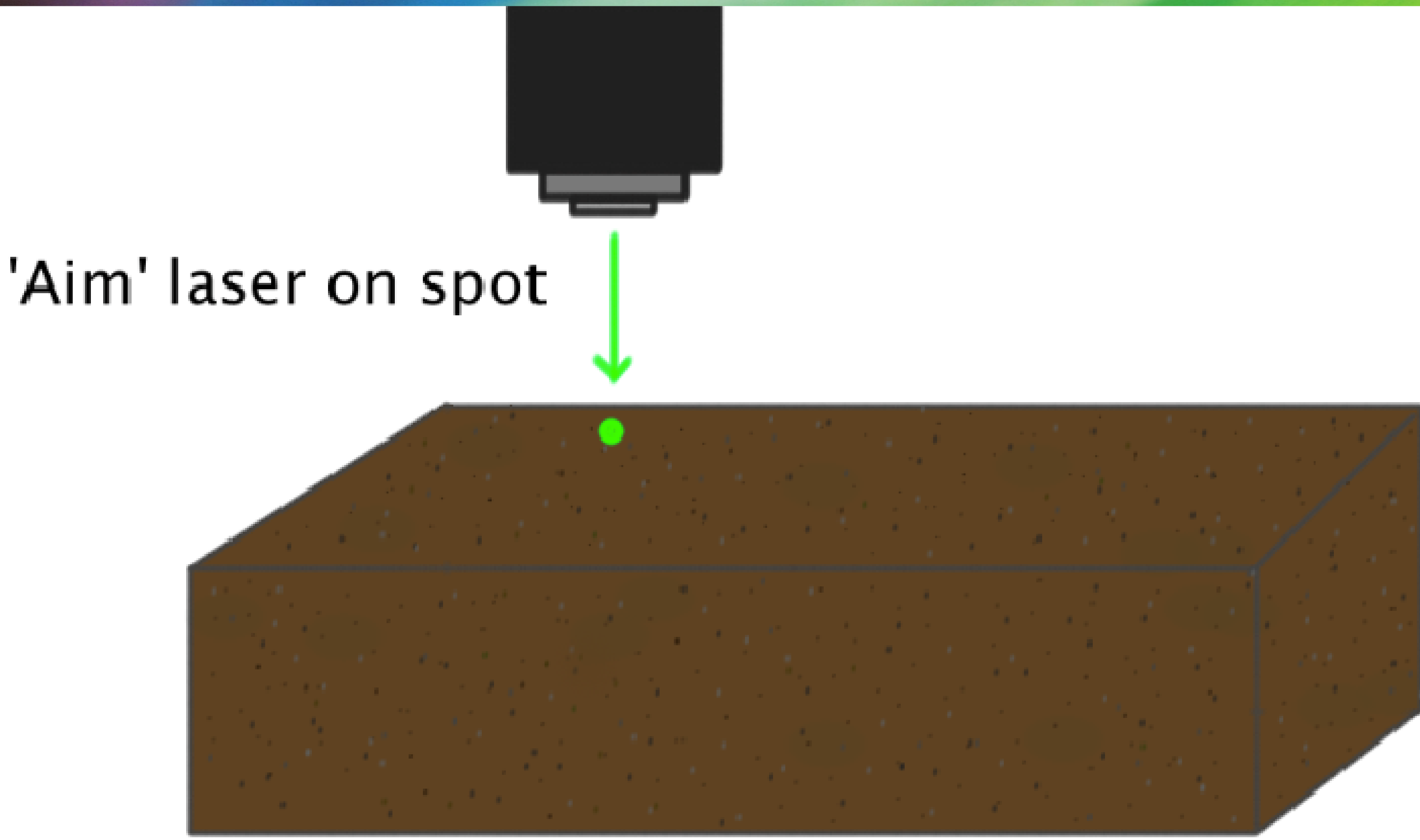
By examining the spectrum and making note of where significant peaks are located, we can **identify** what **mineral** is present.

We do this over and over again at different locations on the rock slab to get a grasp of what minerals are present.

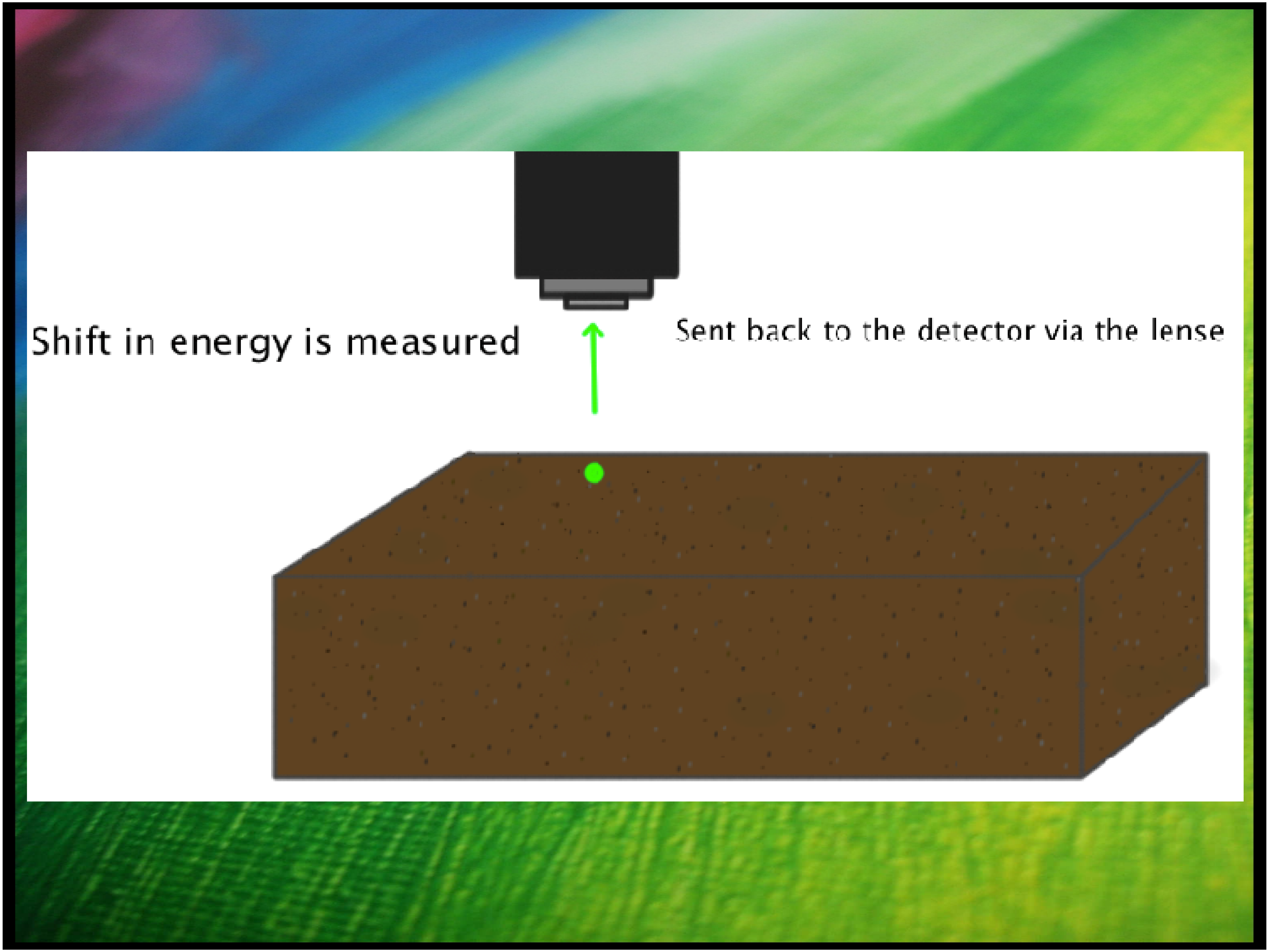
How the Raman works…



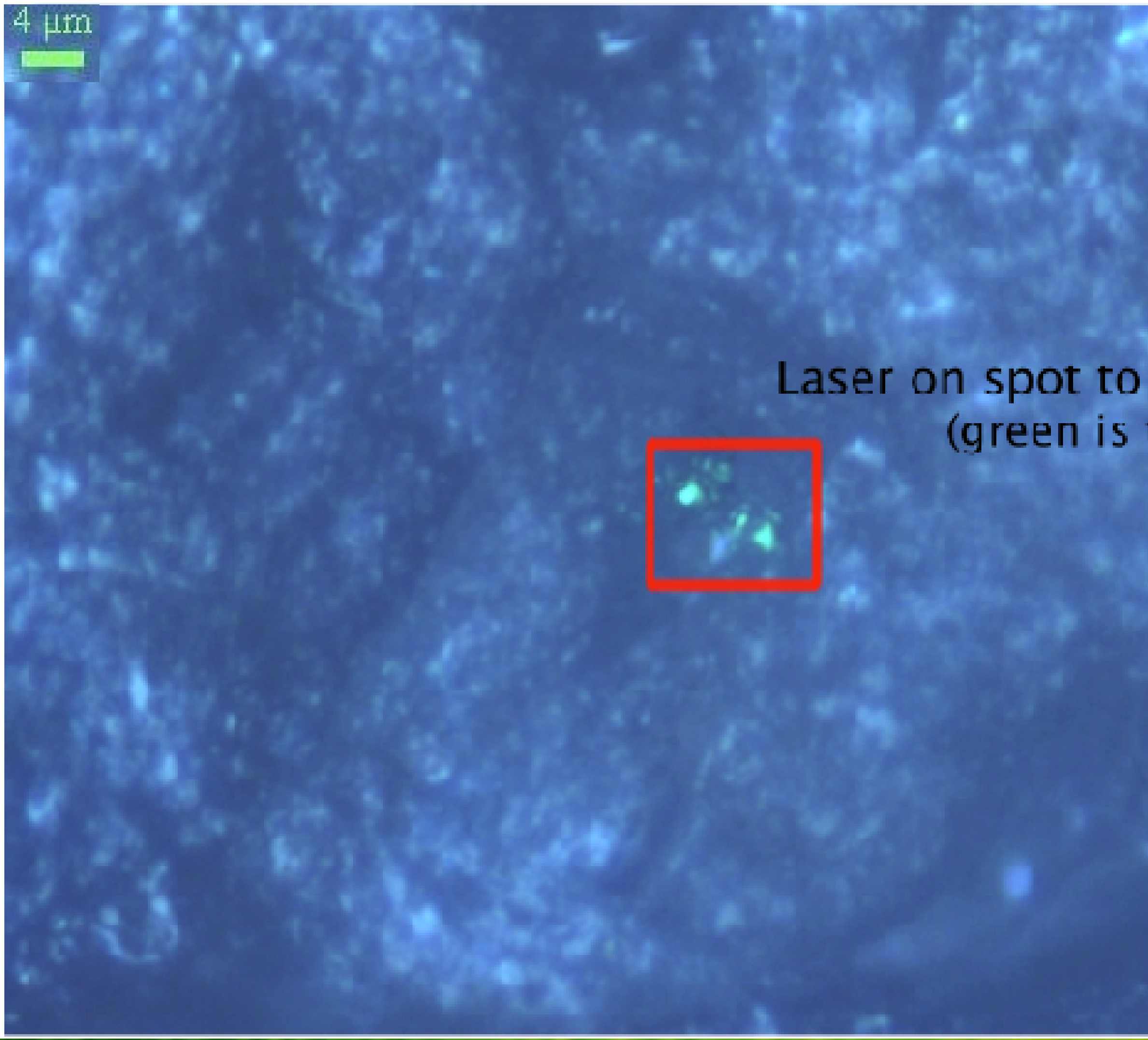
Select a spot to take a point spectra



Sample area is 'excited' by the laser.

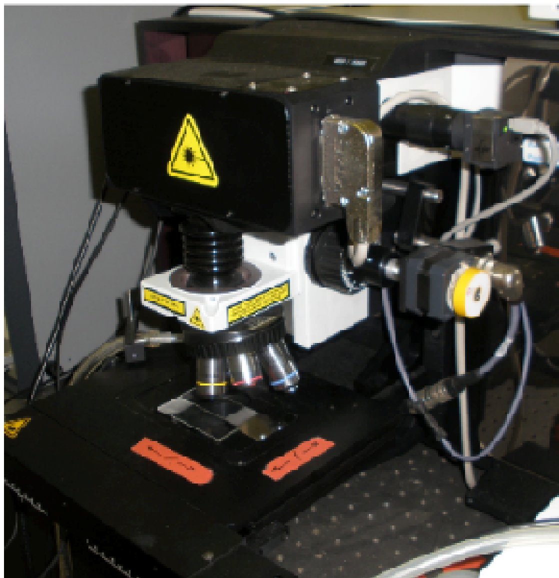

Shift in energy is measured
Sent back to the detector via the lense

Saddleback Basalt Slab



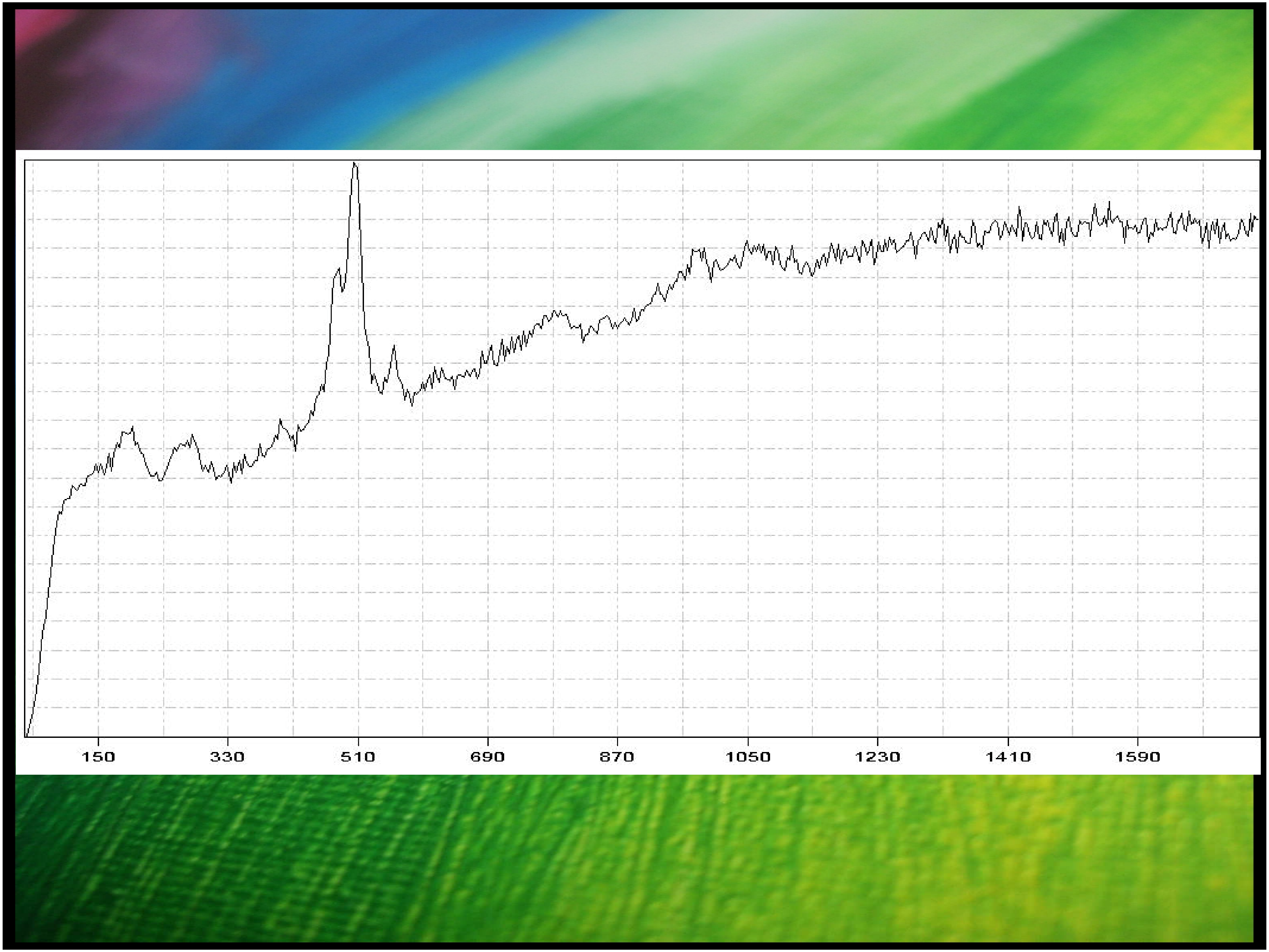
Laser on spot to take spectra
(green is the laser)

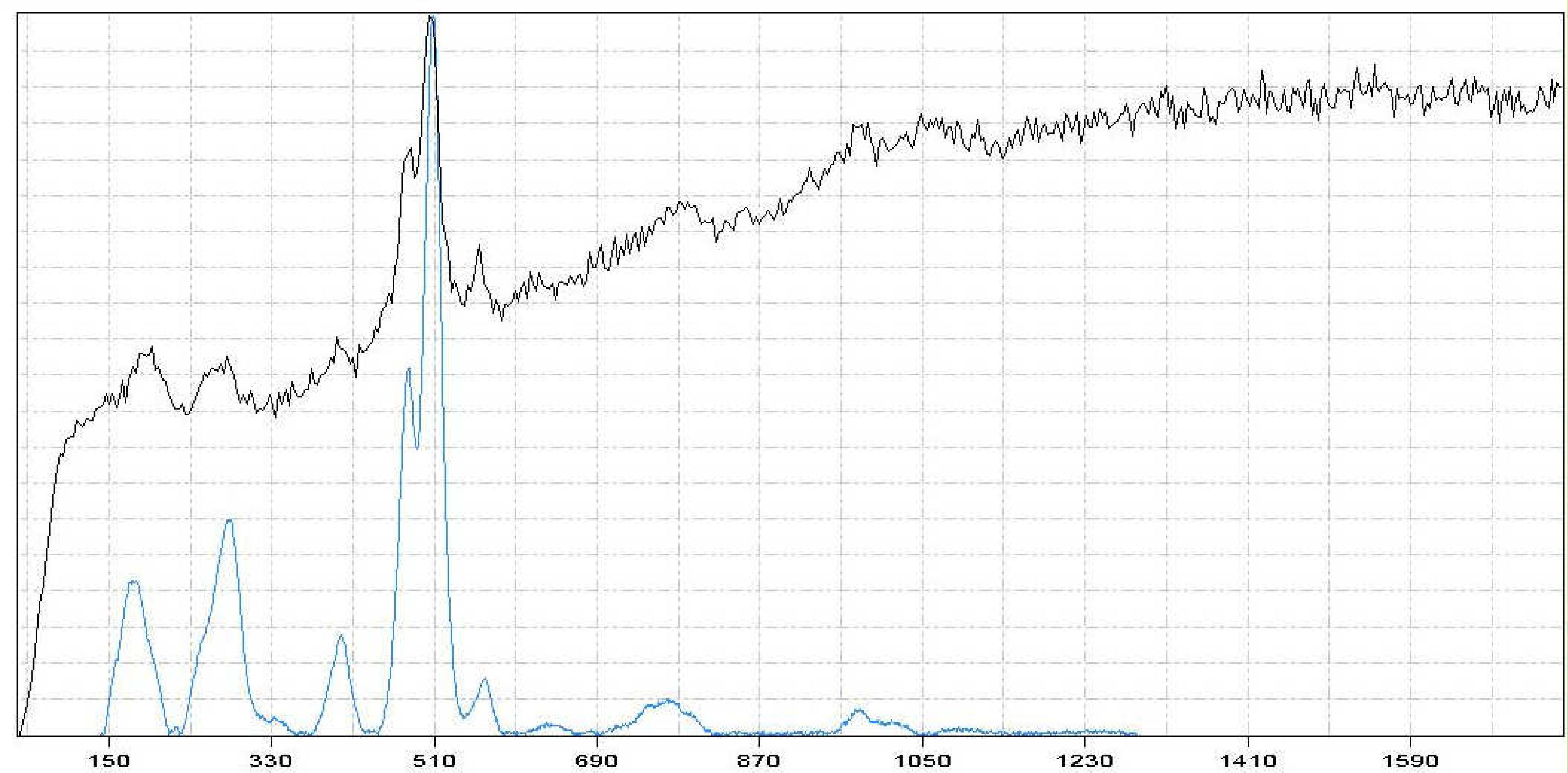
Spot size ≈ 12µm



Camera, Lenses, and Laser apertures

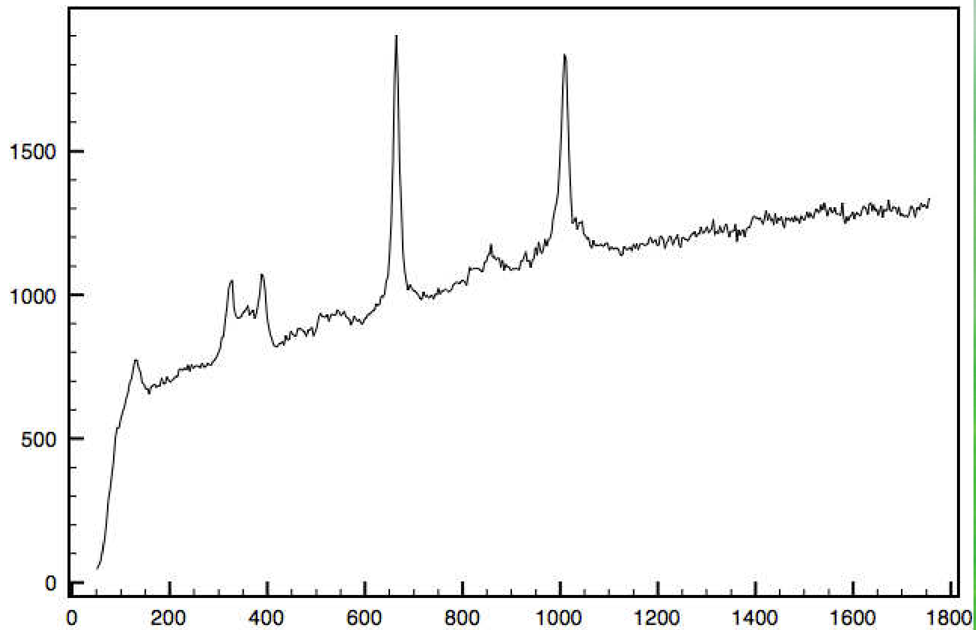
Detector and Chiller

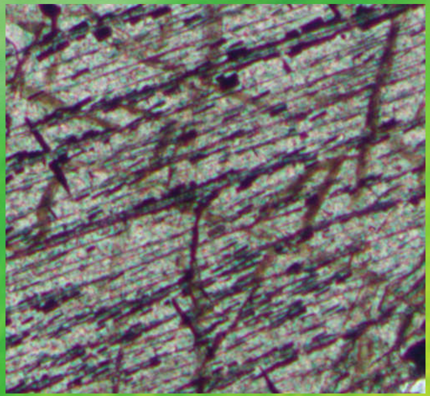

150
330
510
690
870
1050
1230
1410
1590



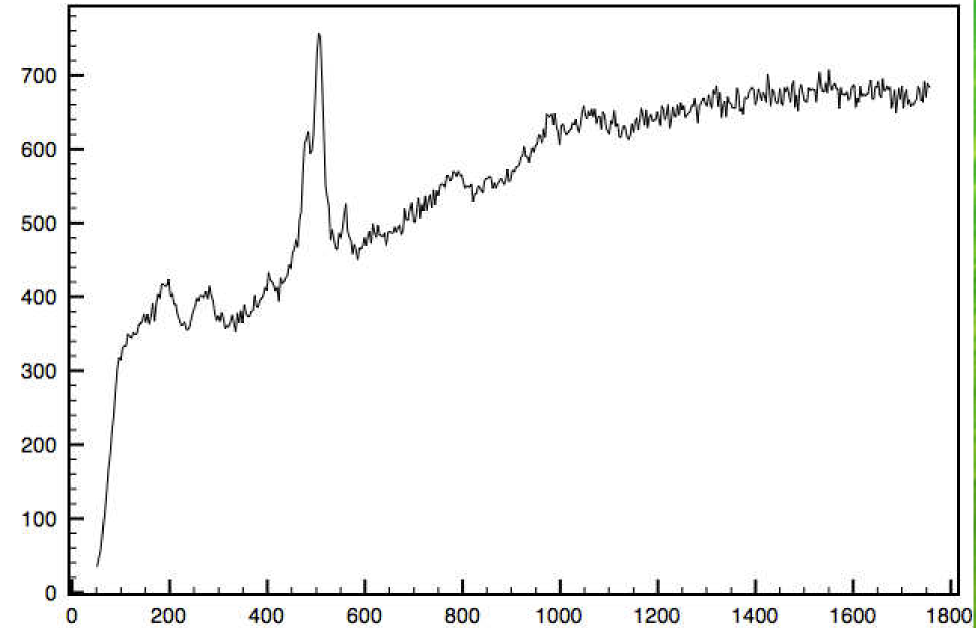
Labradorite

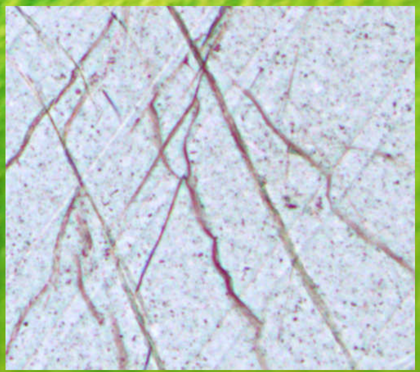
Augite (Pyroxene)



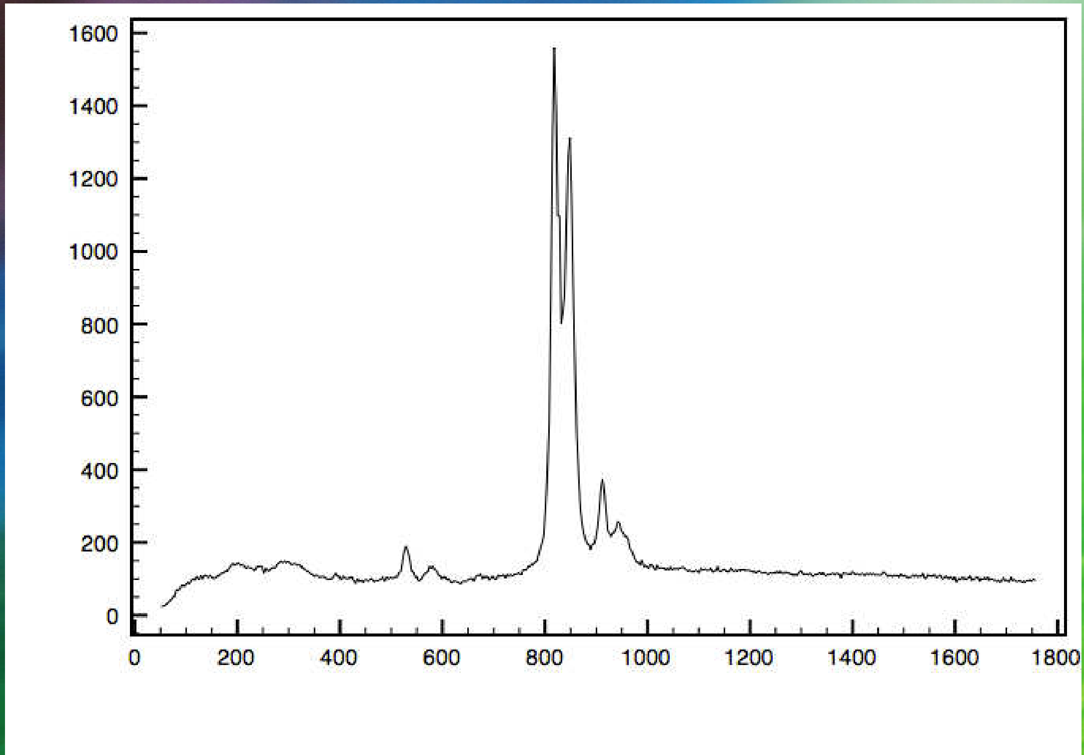


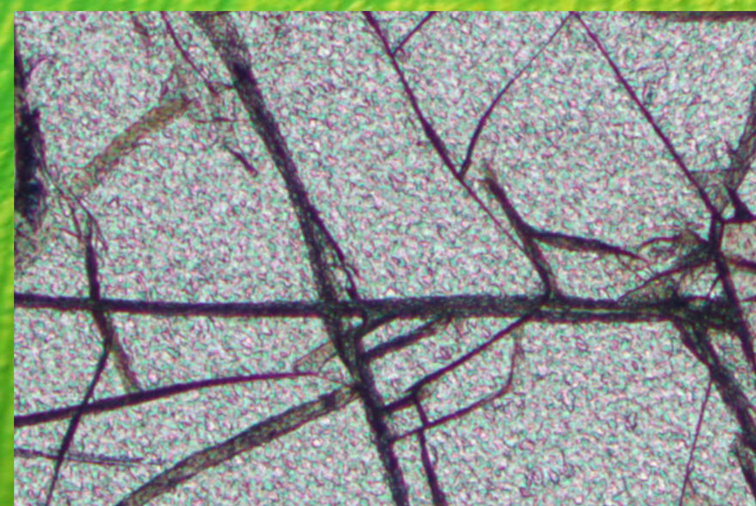
Labradorite (Plagioclase Felspar)





Fayalite (Olivine)





Raman Findings

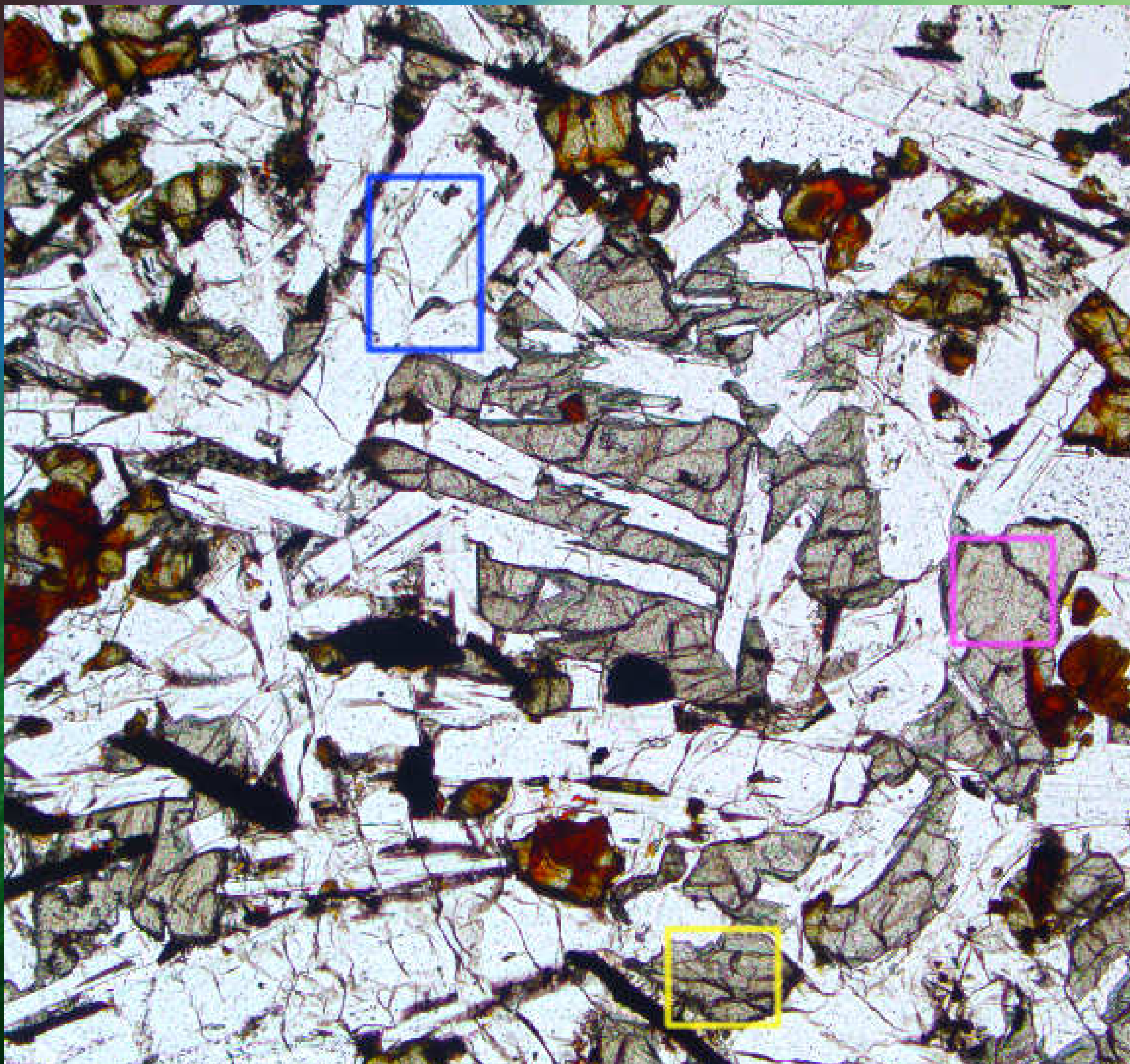
Minerals found:

In Saddleback Basalt: Plagioclase Feldspars, Pyroxenes, and Olivines.

In Belleville Basalt: Plagioclase Feldspars, Pyroxenes, and Olivines.

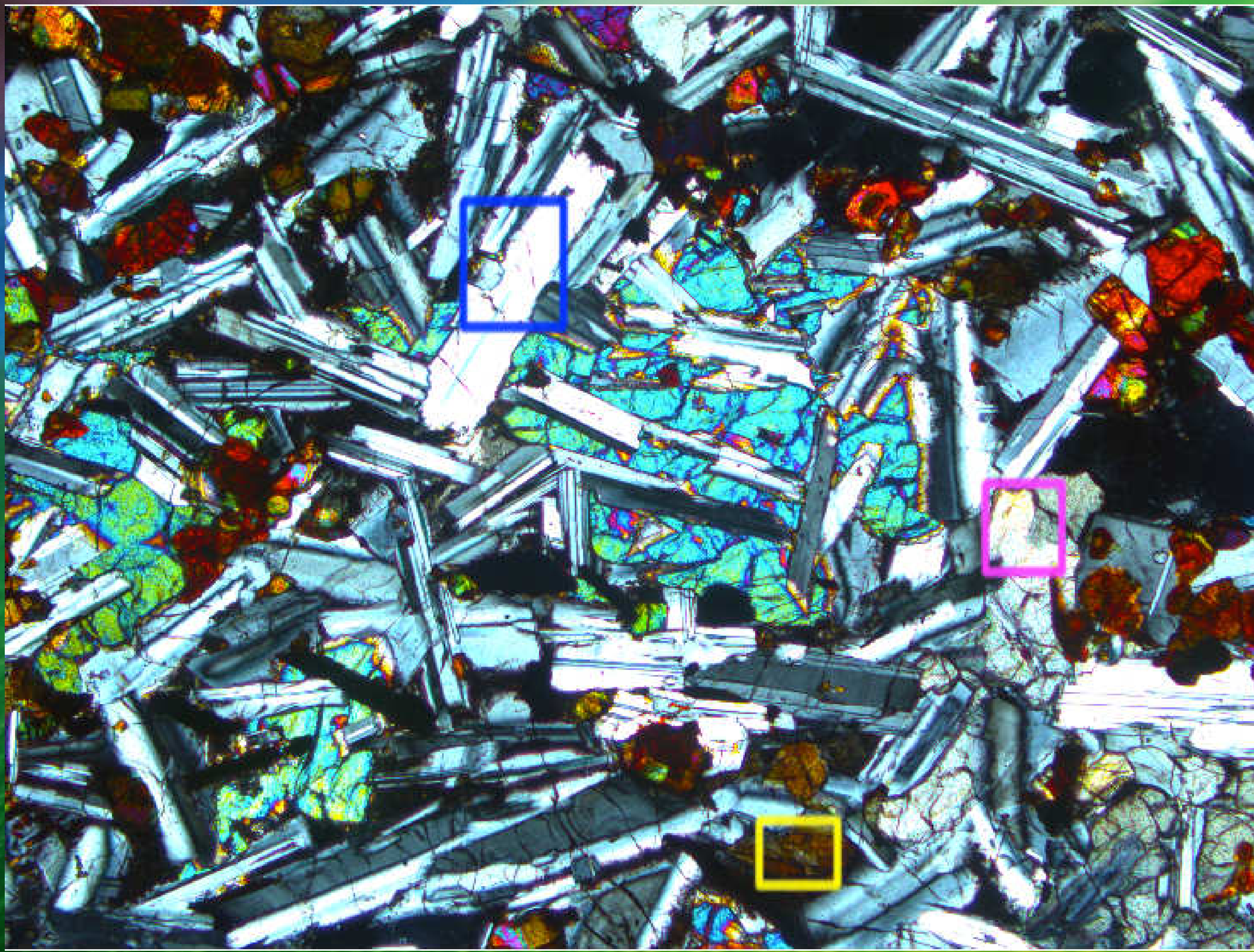
Plagioclase Feldspars were the most common/ prevalent mineral type found in both samples.

Plagioclase Feldspar Olivine Pyroxene

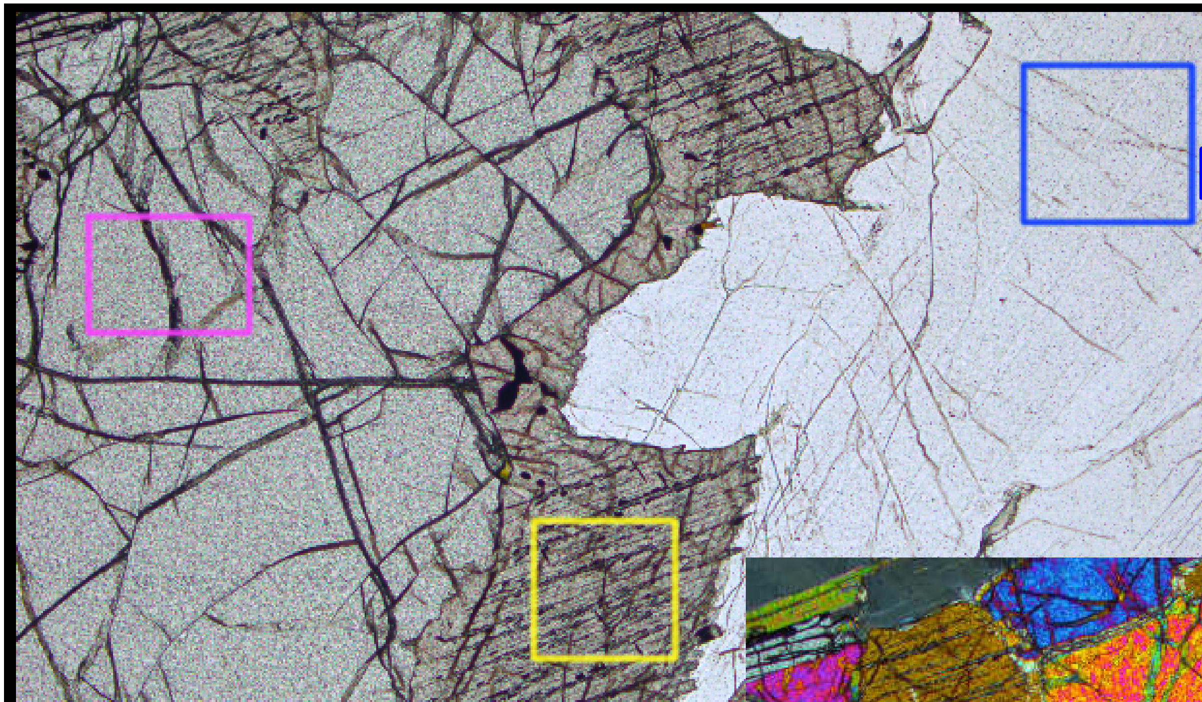


Magnification of
1,763 X 1,322 microns

Plagioclase Feldspar Olivine Pyroxene

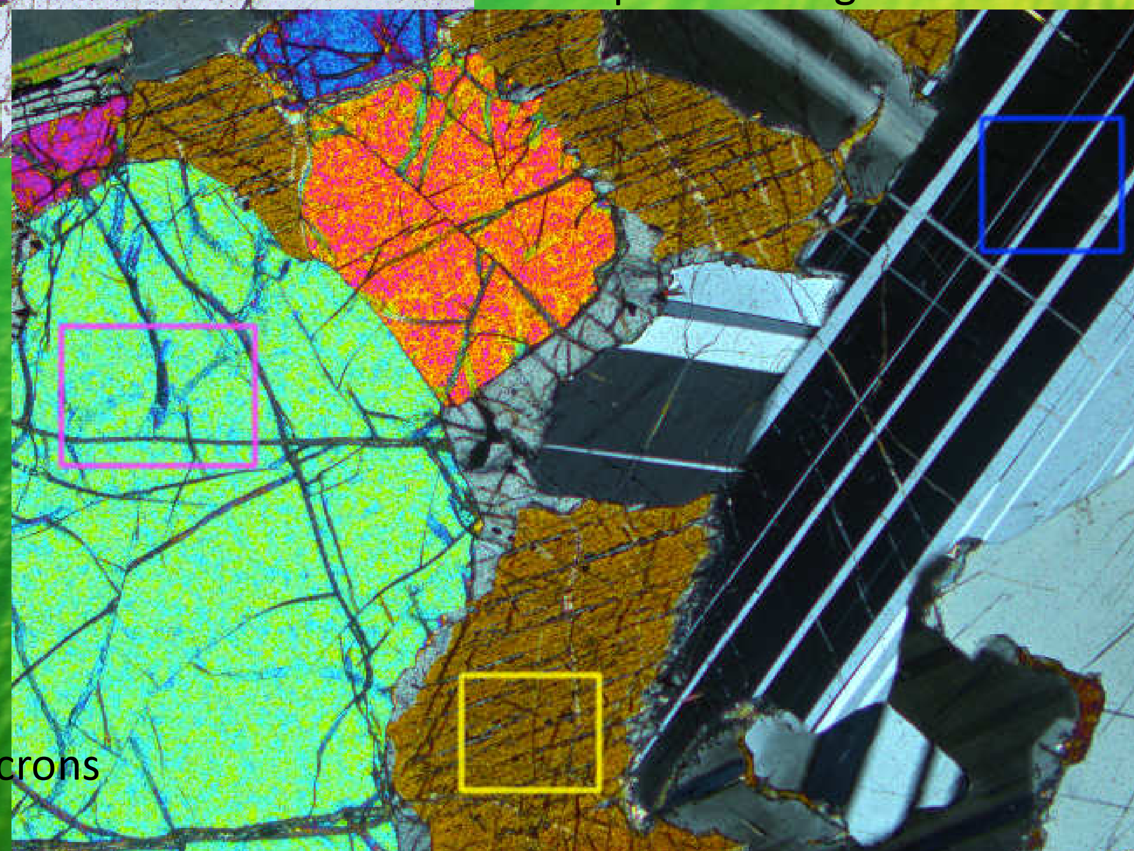


Cross-polarized Light   Magnification of 1,763 X 1,322 microns



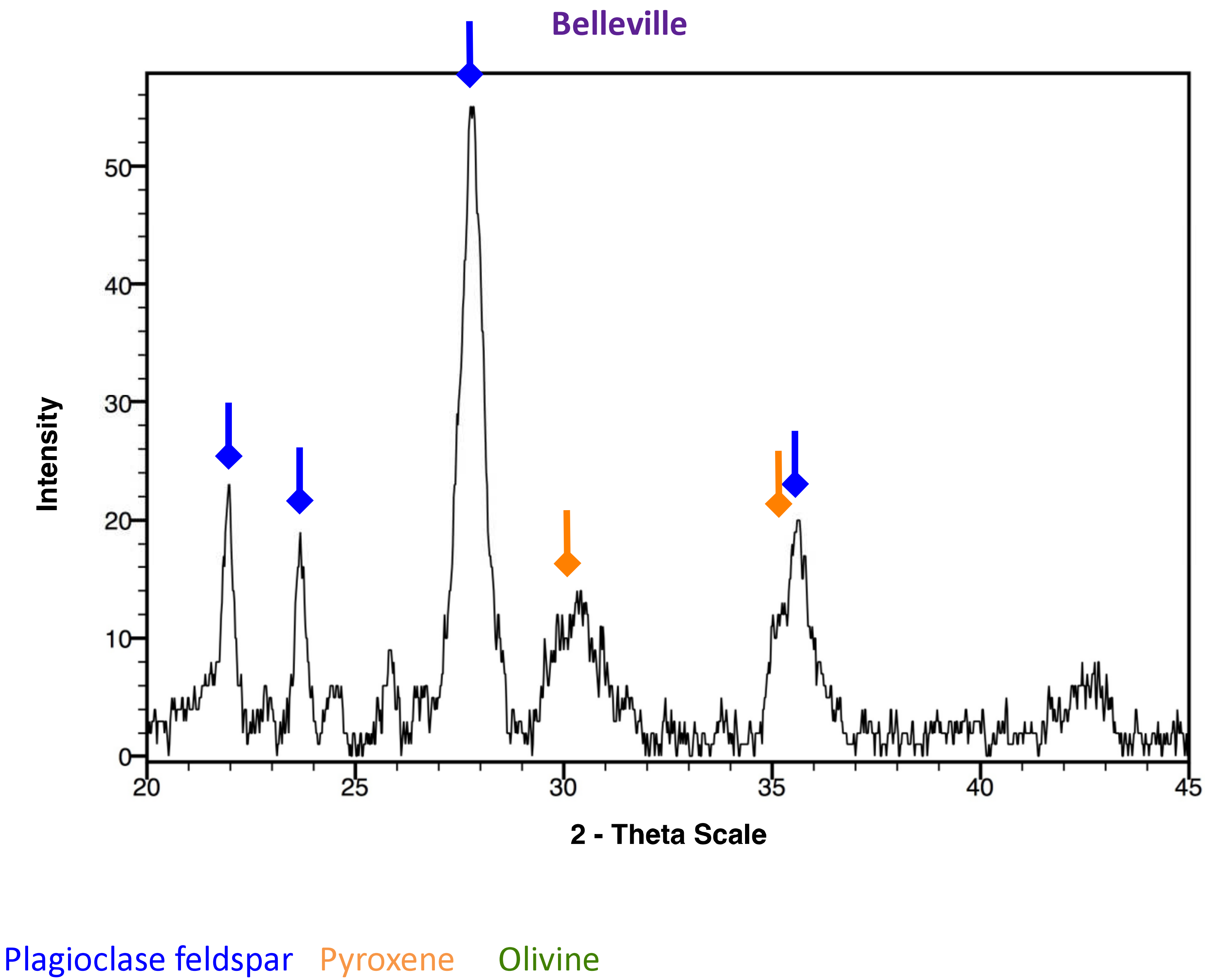
Plagioclase Feldspar
Olivine
Pyroxene

Cross-polarized Light

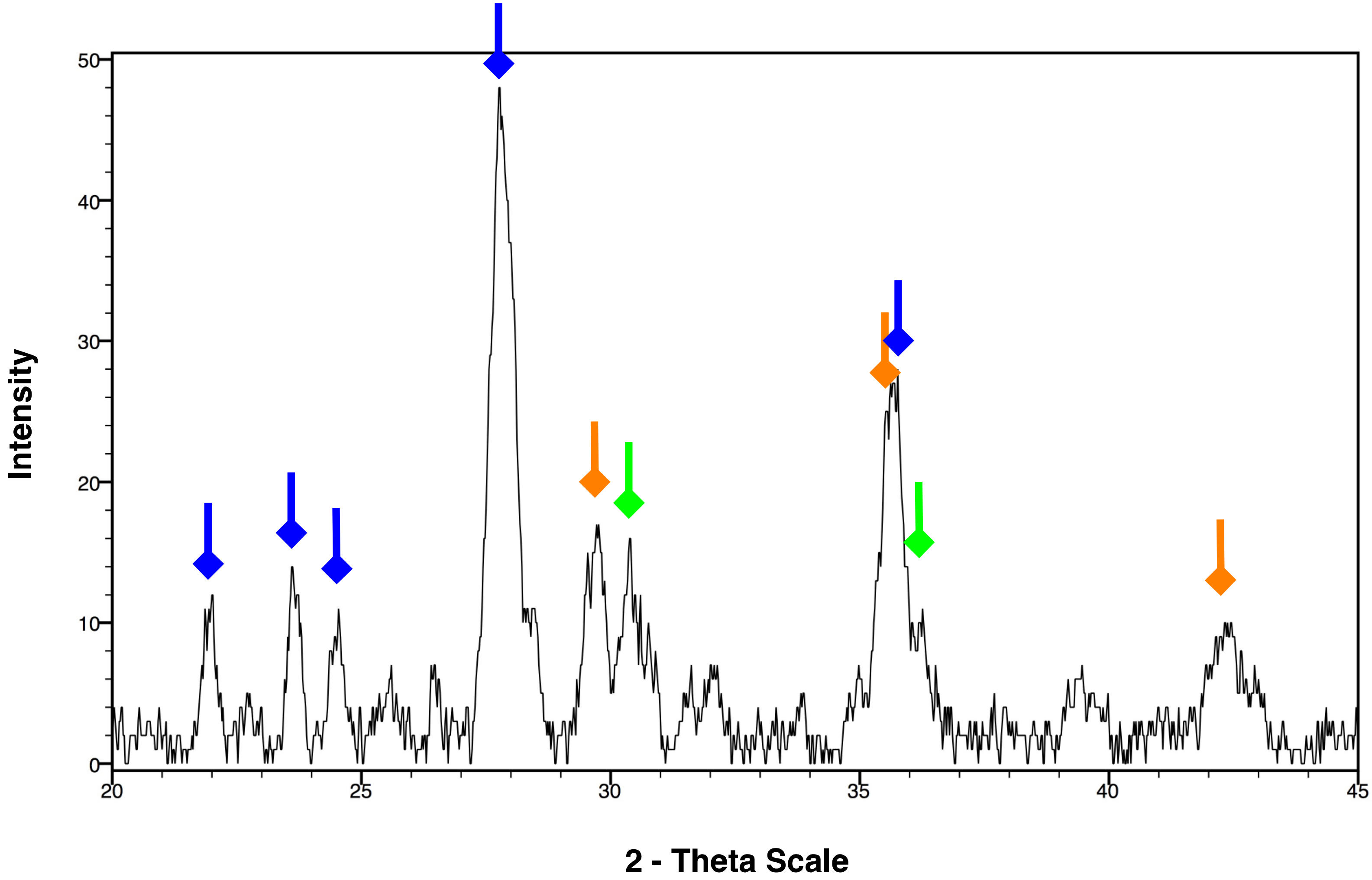


Polarized Light

Magnification of 1,763 X 1,322 microns


Belleville
50
40
30
20
10
0
Intensity
20
25
30
35
40
45
2 - Theta Scale
Plagioclase feldspar
Pyroxene
Olivine

Saddleback

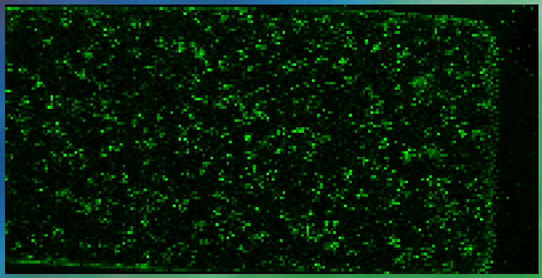


Plagioclase feldspar Pyroxene Olivine

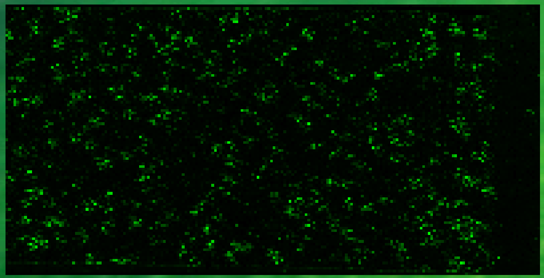
Challenges

- Raman calibration
- Cleaning the samples properly
- Finding the right equipment for the plasma cleaner
- Making sure the DUV instrument is working
- Instrument availability
- Time it takes to run scans and to clean the samples

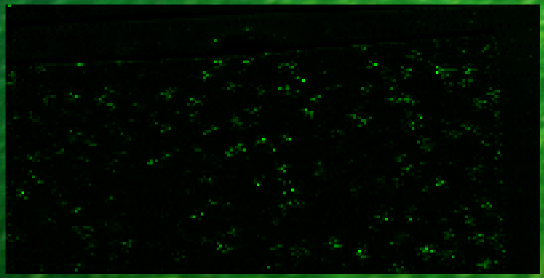
Belleville (Basalt)



30 MICRONS



100 MICRONS

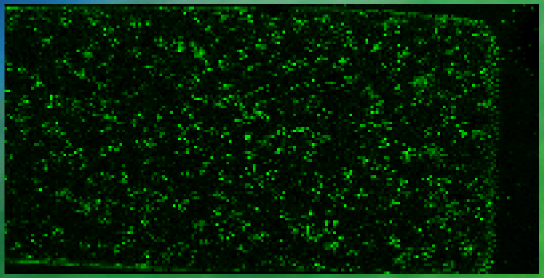


200 MICRONS

- Images show epoxy fluorescence through thinsection
- Epoxy fluorescence decreases with thickness = attenuated
- *30 microns*: fluorescence attenuated by 90%
- *100 microns*: fluorescence attenuated by 99.8%
- *200 microns*: fluorescence mostly attenuated.
- Areas of fluorescence in 100 and 200 microns thinsections are due to large crystals of feldspars (light conduits?)

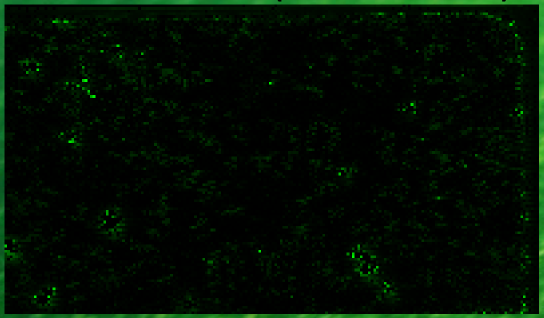
Belleville vs. Saddleback (fresh vs rusty)

Belleville (30 microns)



Attenuation: 90%

Saddleback (30 microns)



Attenuation: 99.8%

- Belleville attenuates less than Saddleback at the same thickness
- Belleville is not as "rusty" (ie oxidized) as Saddleback
- Saddleback has more iron which is an excellent UV absorber
- However, areas of fluorescence in the Saddleback are due to large crystals of feldspars (more light conduits?)

Findings

Based off of what has been observed so far from the data collected by the DUV it is evident that…

The DUV laser is able to penetrate the surfaces of the Basalt thin sections at 30 and 100 microns thick.

We know this is true because the epoxy that holds the rock thin section to the slide fluoresces and the laser attenuates and the minerals in the rock thin sections fluoresces.

Maximum attenuation value 1-3%/micron (for Belleville)

Field Deployment!

References

Bhartia et al (2008) Appl Spec 62(10), 1070-1077

Frosch et al (2007) Analy Chem 79)3), 1101-1108

Cloutis et al (2008) Icarus 197, 321-347

Peters et al (2008) Icarus 10.1016

Pictures:

http://www.jpl.nasa.gov/spaceimages/details.php?id=PIA14156

http://www.gocomics.com/fminus/2011/08/01

http://www.gocomics.com/fminus/2011/07/27

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