Mineral identification using indoor hyperspectral imaging

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NSERC CRSNG

Photon etc

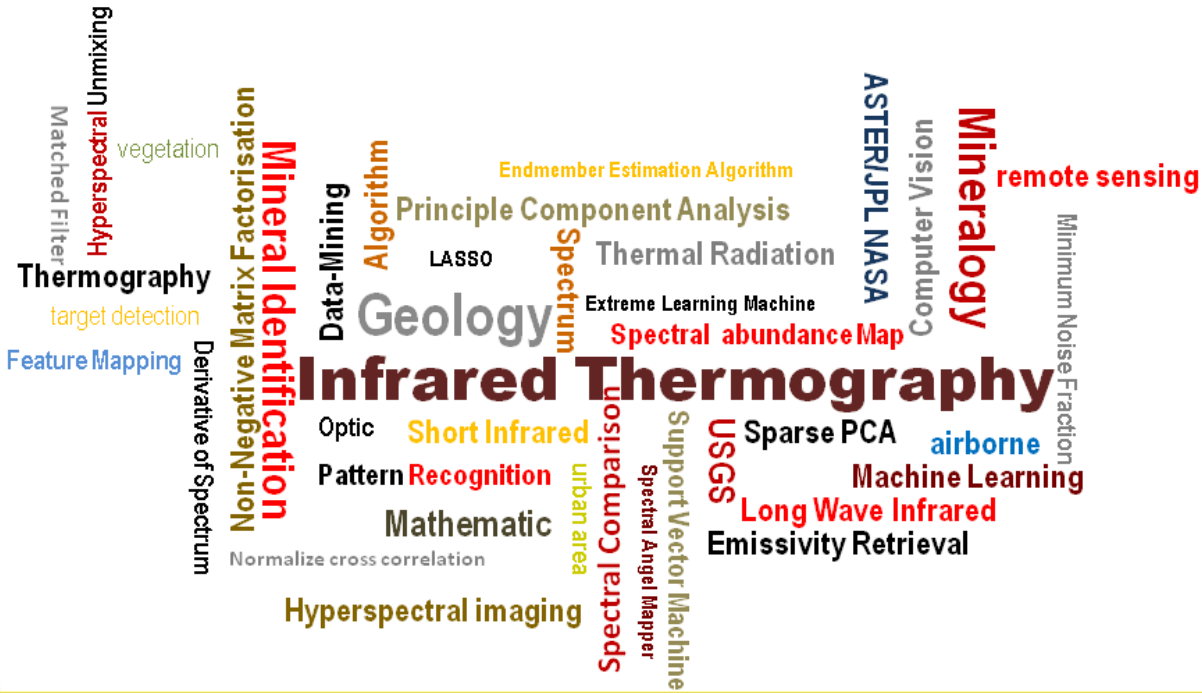
TELOPS

MIVIM Multipolar Infrared Vision Infrarouge Multipolaire

PHOTONIC KNOWLEDGE

Outline

- Introduction
  - Hyperspectral Imaging
  - Problem Statement
  - What we are doing
- Experimental Results
  - Measurement
- Method
  - HYMID
- conclusion



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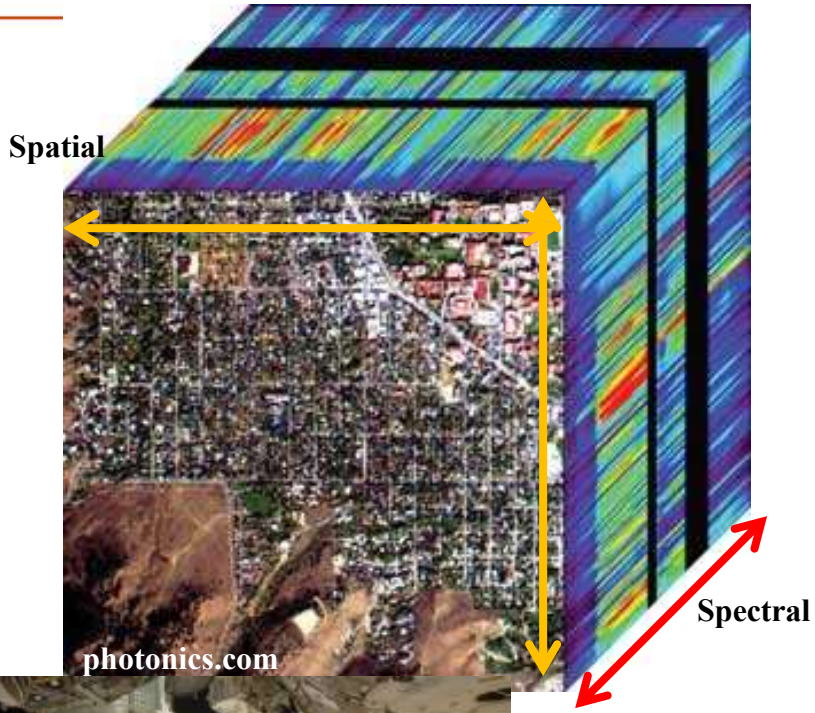
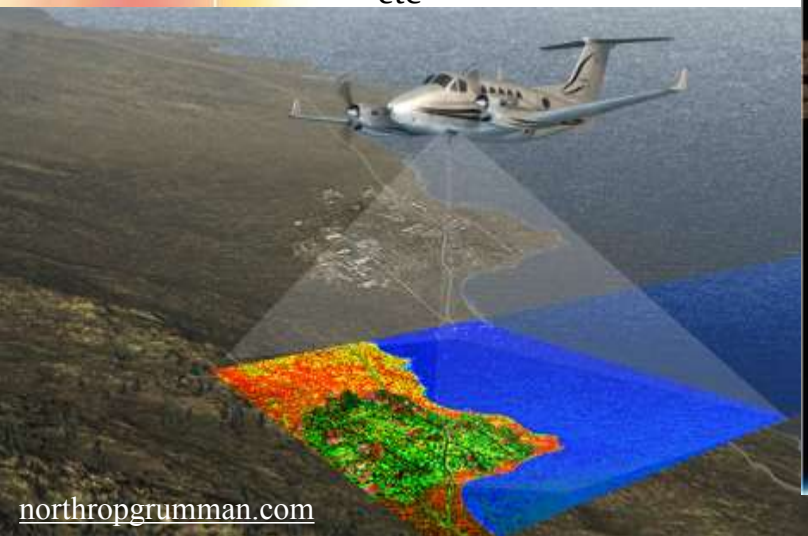
HYPERSPECTRAL IMAGING

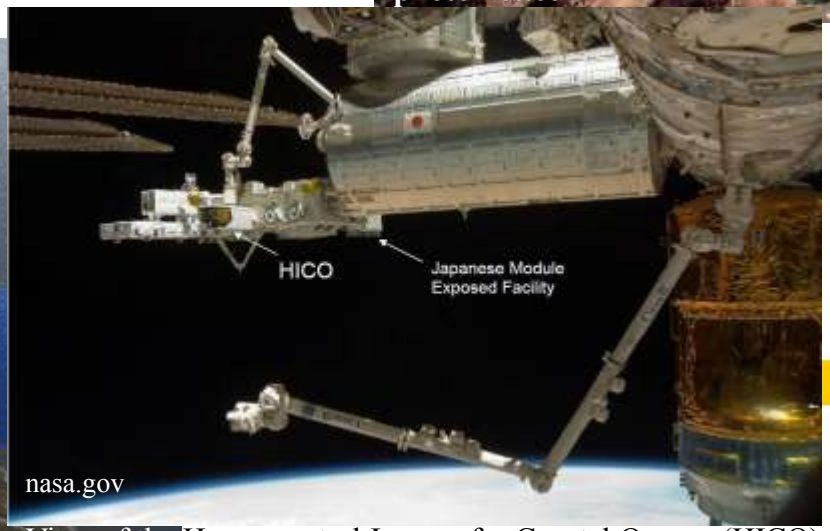
- **Hyperspectral imaging**, like other spectral **imaging**, collects and processes information from across the electromagnetic spectrum. The goal of **hyperspectral imaging** is to obtain the spectrum for each pixel in the **image** of a scene, with the purpose of finding objects, identifying materials, or detecting processes.

Applications

- vegetation
- urban area
- geology
- target detection
- medical
- etc



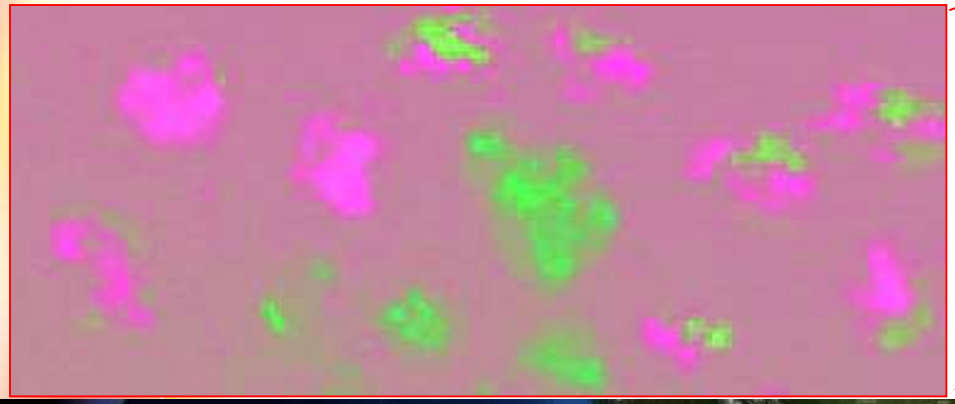


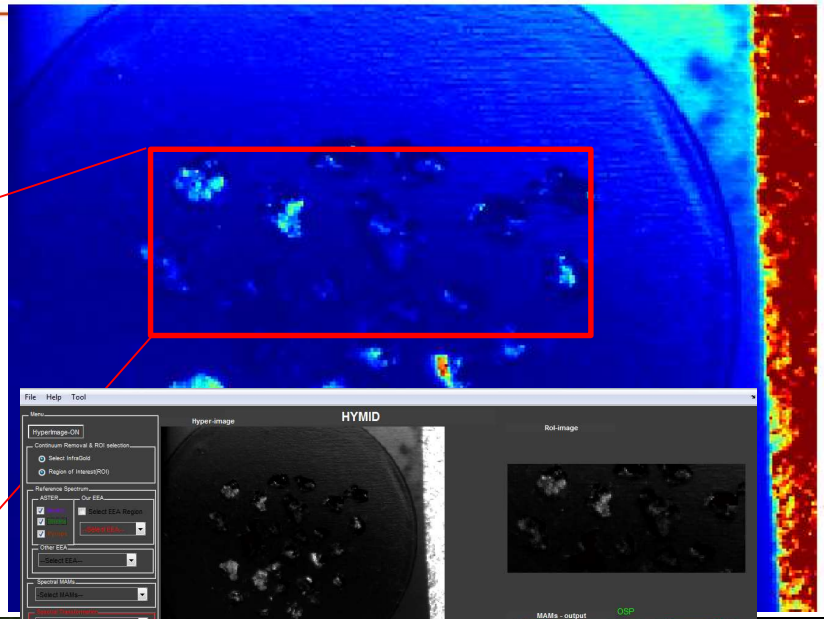


View of the Hyperspectral Imager for Coastal Oceans (HICO)

WHAT WE ARE DOING

Hyperspectral in Laboratory

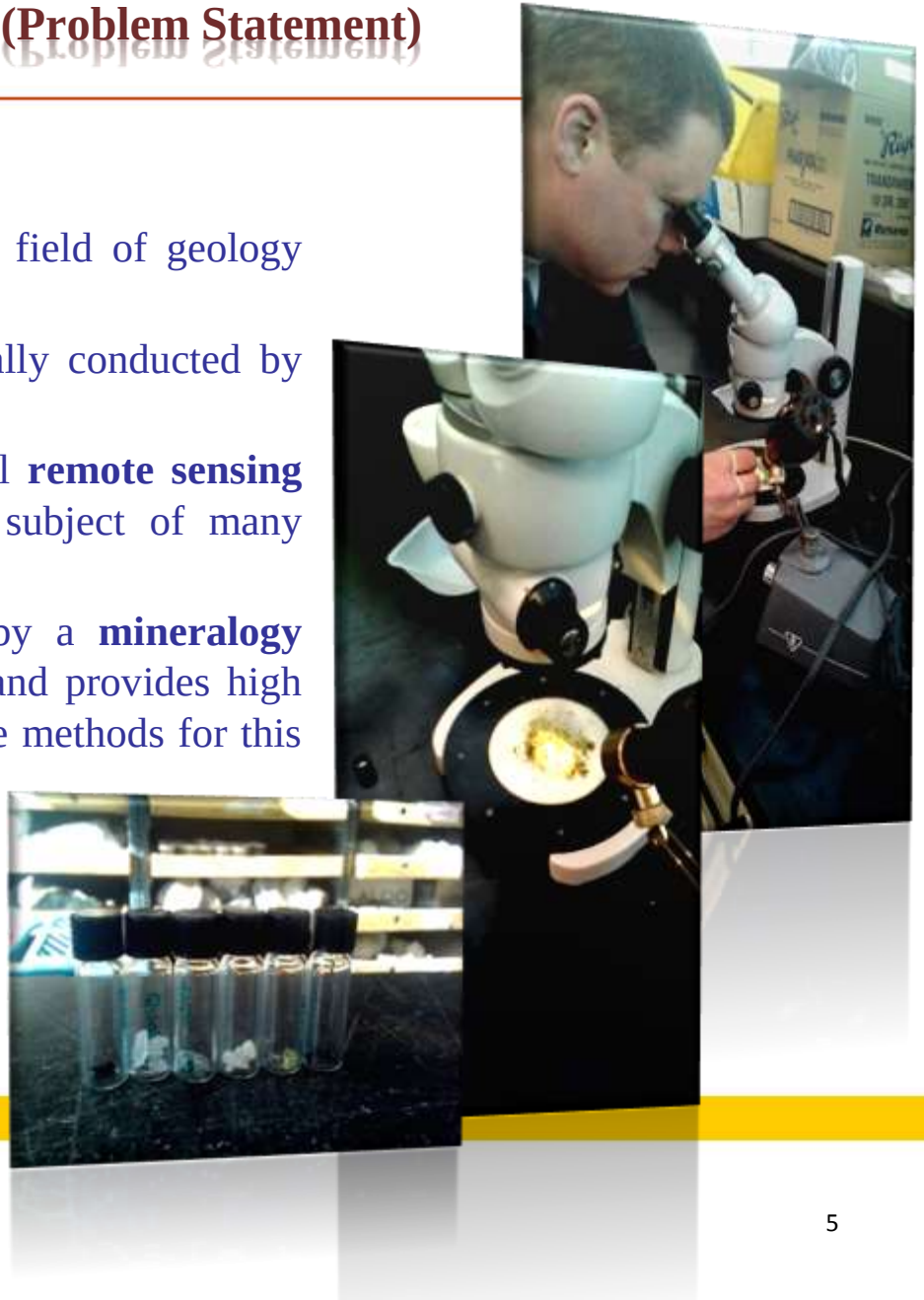




Hyperspectral in Satellite

INTRODUCTION(Problem Statement)

- **Mineral identification** is challenging in the field of geology and mineralogy.
- It relates to **geological research** and is usually conducted by geologists (mineralogy experts).
- It is extensively investigated by hyperspectral **remote sensing (and airborne) sensing** and has been the subject of many research studies.
- **Manual** identification of mineral samples by a **mineralogy expert** which is a **time consuming** process and provides high level of **disparity** due to fatigue or inadequate methods for this specific application.



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INTRODUCTION

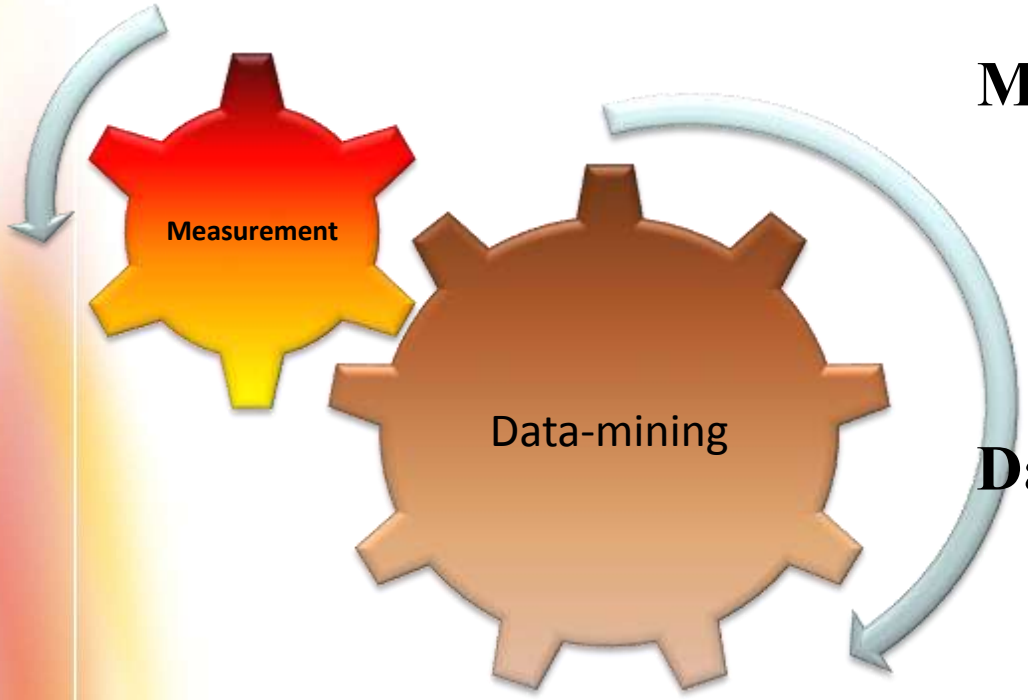
- The **main objective** of this research lies under the **automatic mineral identification** which is considered as **hyperspectral unmixing**.

What: Making automated system for mineral identification

- Hyperspectral **unmixing** in the **hyperspectral infrared image**.
- It use(d/s) for long time and **most** of the HSI researches are basically for **remote sensing(and airborne) research**. (***e.g.*** Only in 2015 the geological based hyperspectral infrared imagery (contributions) papers were more 100>)

Photograph showing measurements being made with the PIMA II field spectrometer. Picture from: Kruse, F. A. (1996). Identification and mapping of minerals in drill core using hyperspectral image analysis of infrared reflectance spectra. International journal of remote sensing, 17(9), 1623-1632.

Mineral identification



Measurement

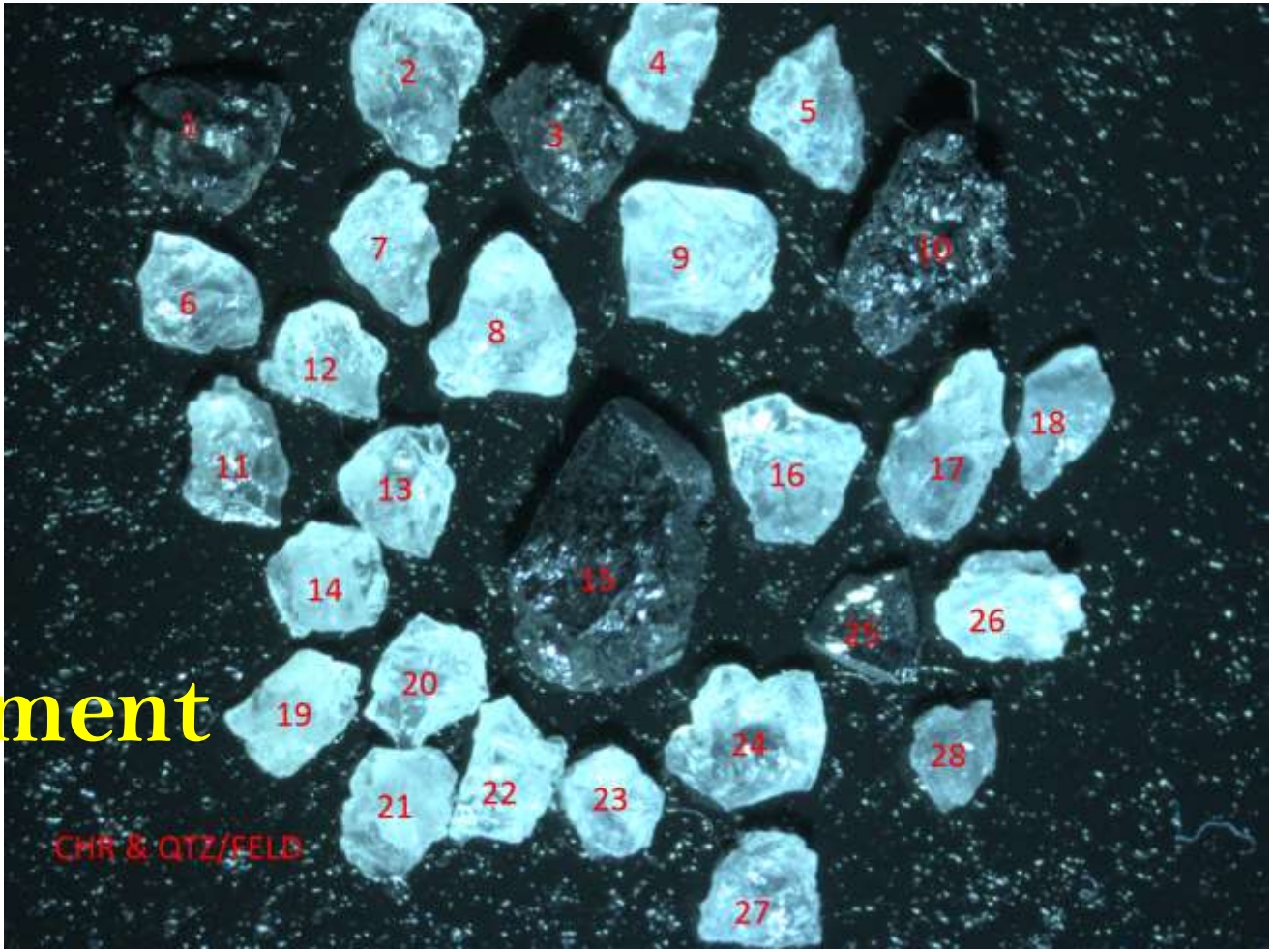
- Mineral preparation
- Conducting the experiments
- Producing the clean data
- Finding the reference datasets
- Data retrieval

Data-mining

- Data retrieval
- Creating a system for automatic mineral identification:
  - Feature extraction /Selection
  - Classification- Pattern recognition task & machine learning

Measurement

- Mineral preparation
- Conducting the experiments
- Producing the clean data
- Finding the reference datasets



Measurement

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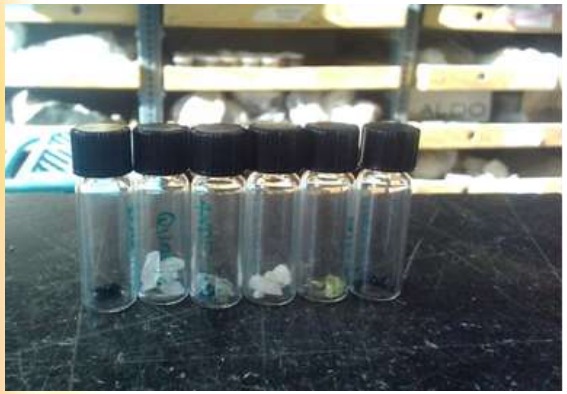
Measurement

- **Mineral preparation**
- Conducting the experiments
- Producing the clean data
- Finding the reference datasets



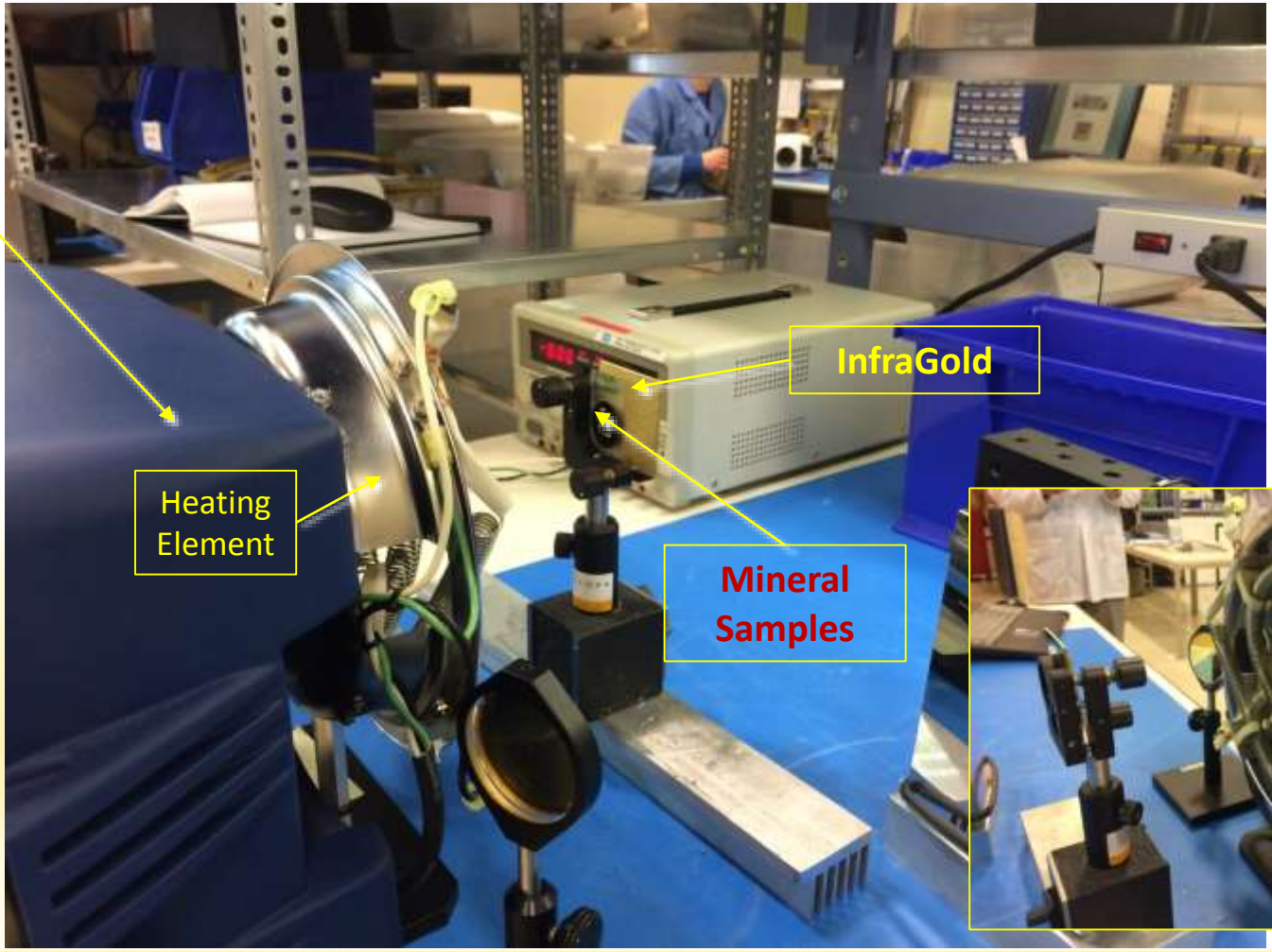




New mineral grains have been prepared for the new experiment

Hyperspectral imaging

Measurement

- Mineral preparation
- **Conducting the experiments**
- Producing the clean data
- Finding the reference datasets



Imaging are done at Telops Inc. 02 April 2015

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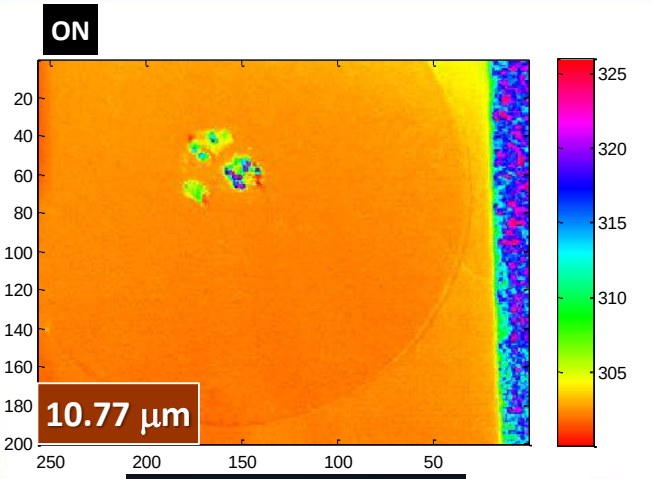
List of all samples

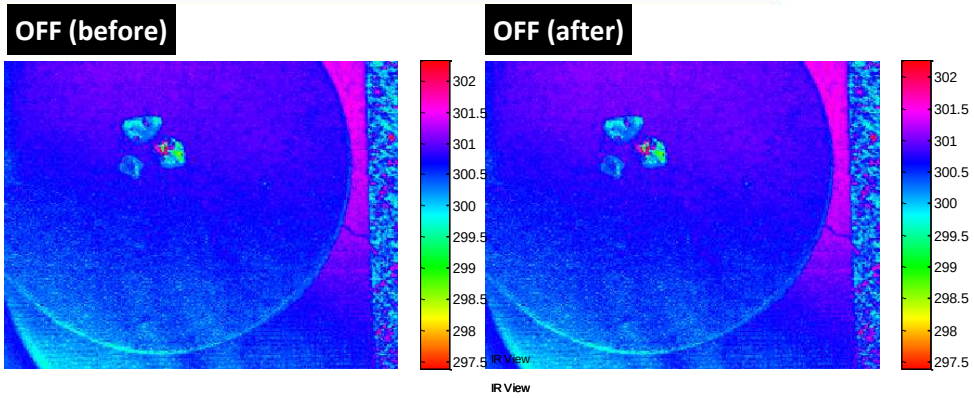
1. ILM
2. ILM – NEW
3. OL
4. OL – NEW
5. CHR
6. CHR – NEW
7. PYR
8. QTZ 1&2
9. QTZ-NEW
10. QTZ- FELD
11. MIX 1
12. MIX 2

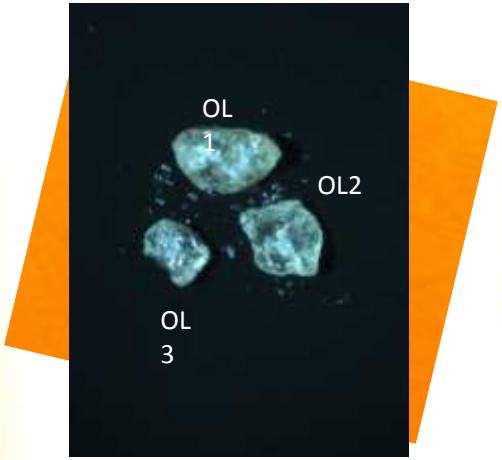
Olivine - OL

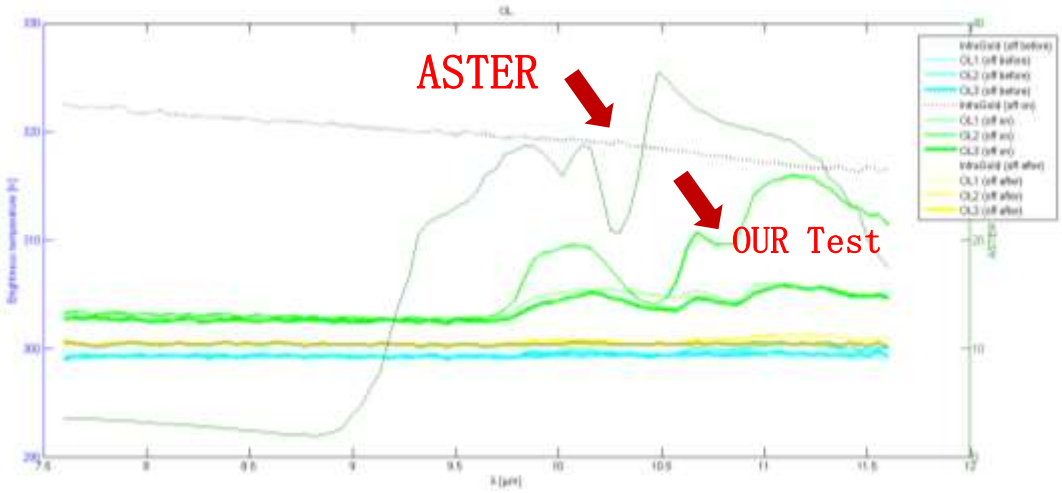
Measurement

- Mineral preparation
- Conducting the experiments
- **Producing the clean data**
- **Finding the reference datasets**









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Chromite - NEW- CHR

Measurement

- Mineral preparation
- Conducting the experiments
- **Producing the clean data**
- **Finding the reference datasets**

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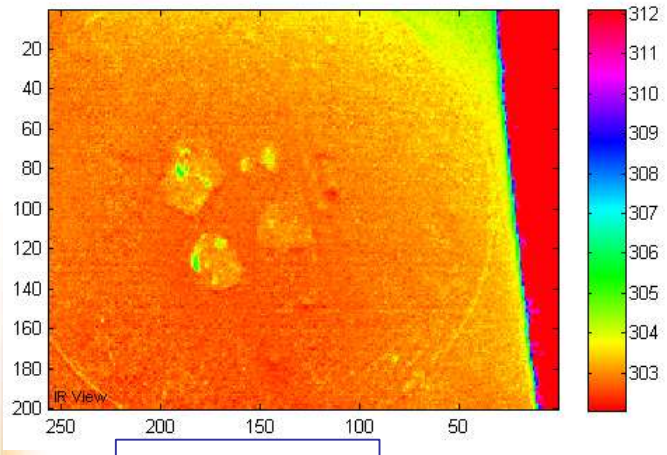

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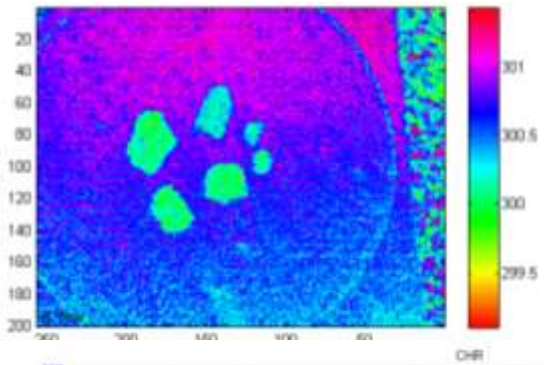
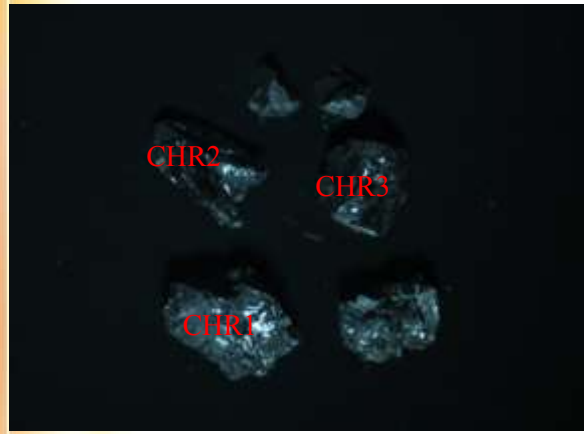
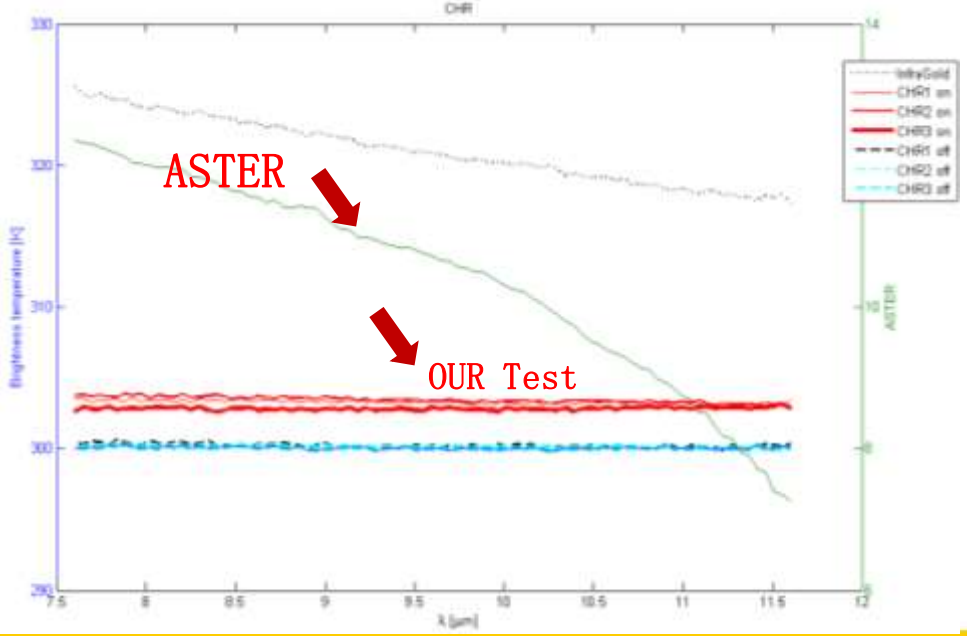


Binocular

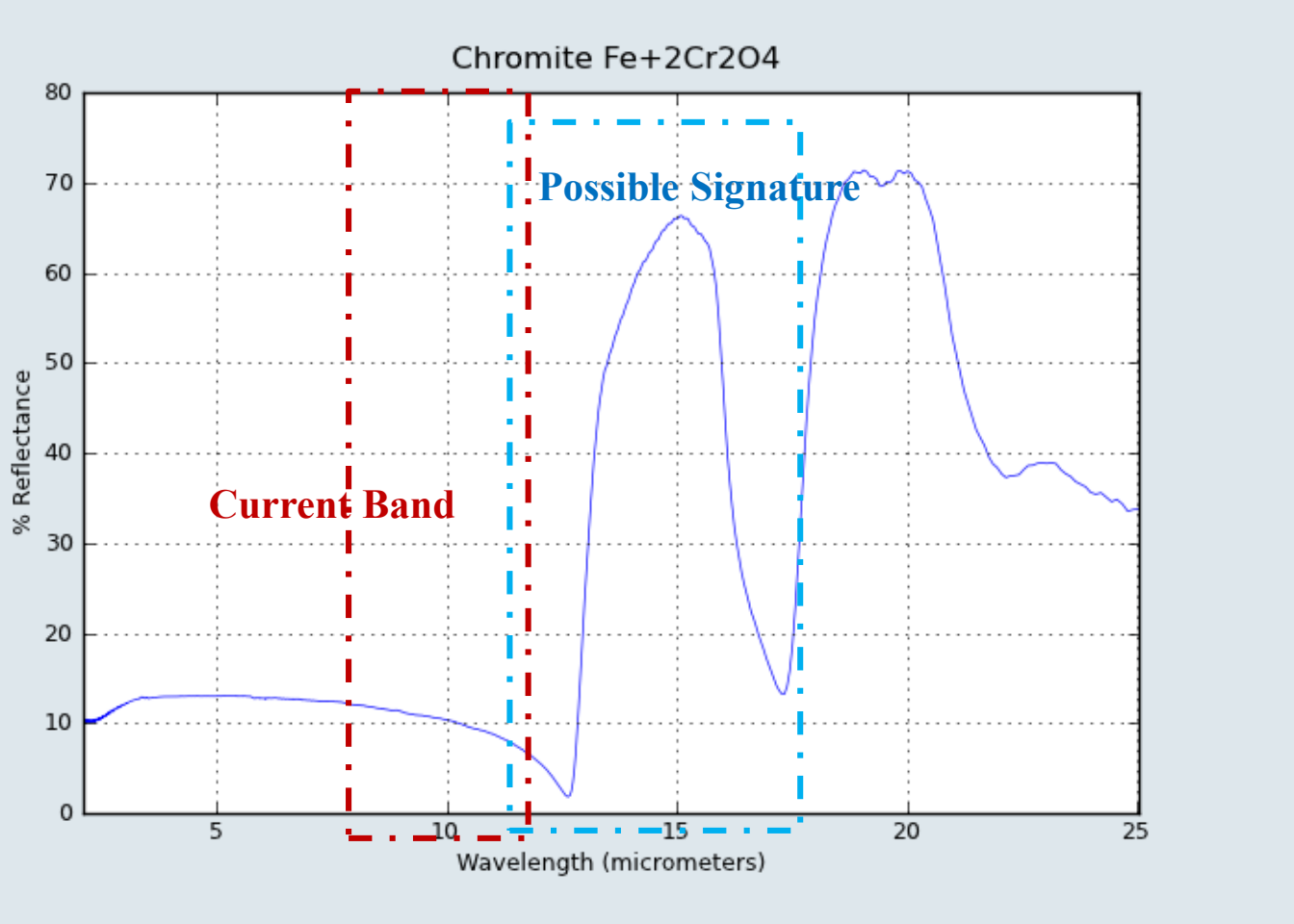




ASTER - Chromite

Measurement

- Mineral preparation
- Conducting the experiments
- Producing the clean data
- **Finding the reference datasets**

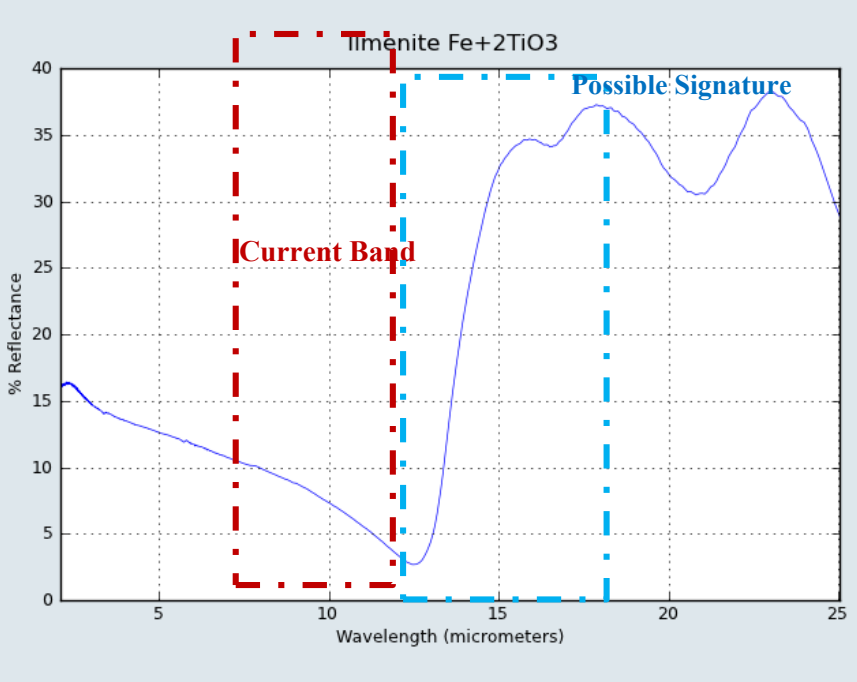


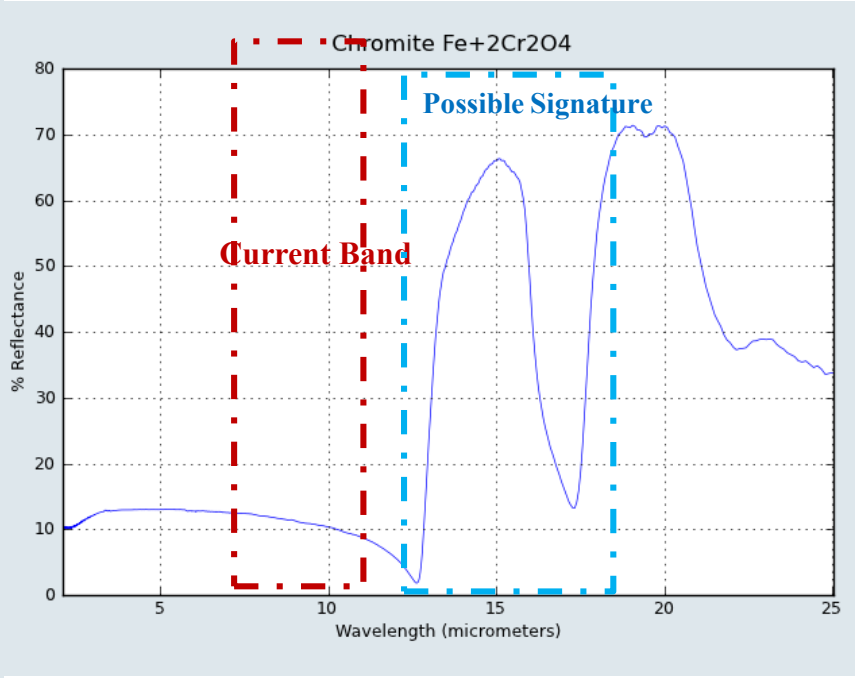
Picture adopted from ASTER

ASTER – Ilmenite & Chromite

Measurement

- Mineral preparation
- Conducting the experiments
- Producing the clean data
- **Finding the reference datasets**





Pictures are adopted from ASTER

There is no signature for Ilmenite and Chromite in LWIR

Ilmenite – ILM- NEW

Measurement

- Mineral preparation
- Conducting the experiments
- **Producing the clean data**
- **Finding the reference datasets**

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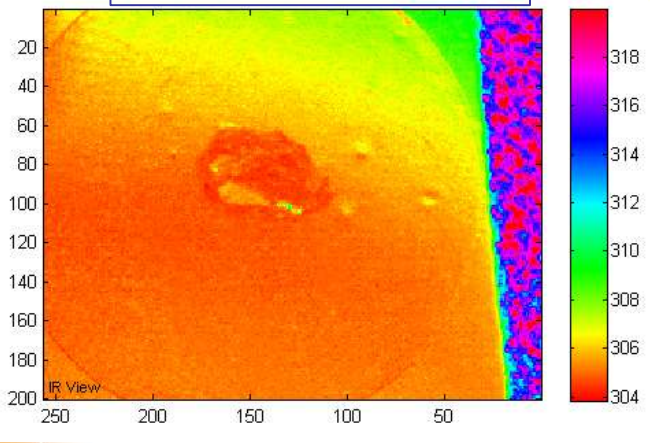

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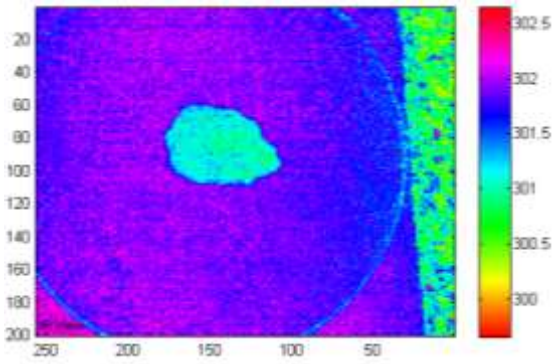

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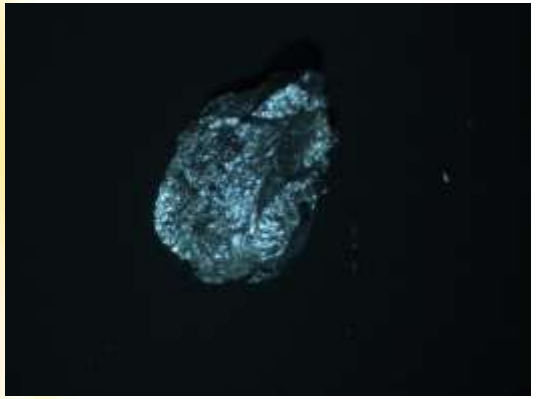

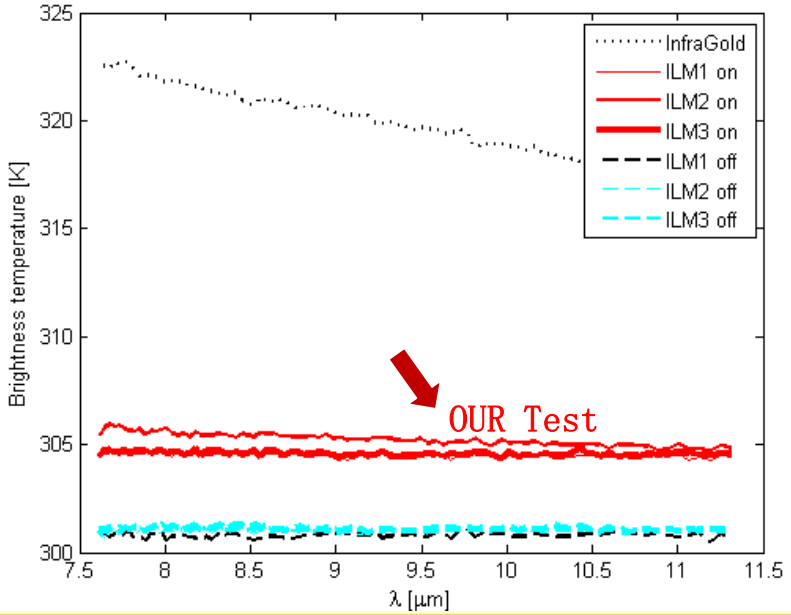

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Measurement

- Mineral preparation
- Conducting the experiments
- **Producing the clean data**
- **Finding the reference datasets**

Pyrope - PYR

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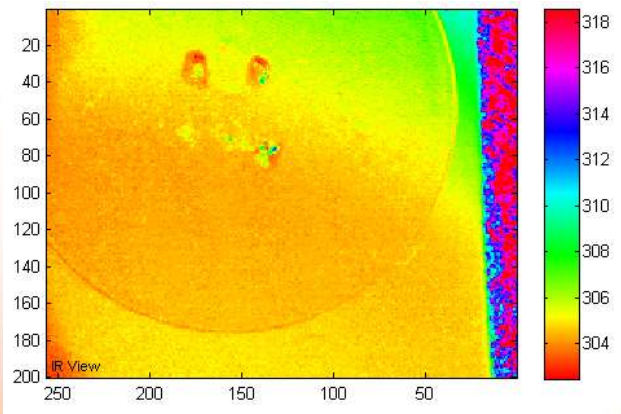

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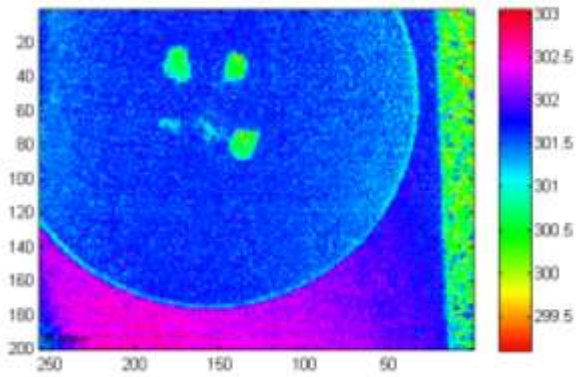

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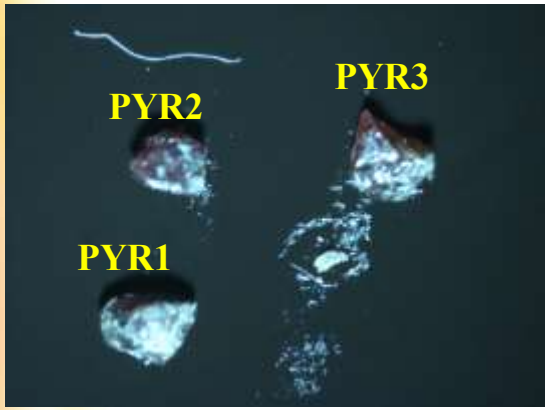

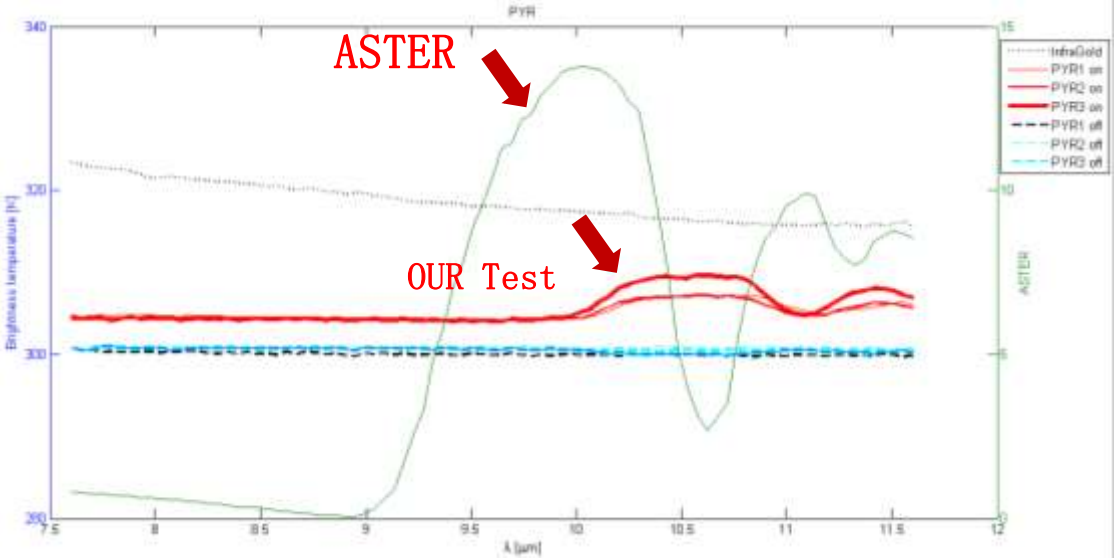

Measurement

- Mineral preparation
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- **Finding the reference datasets**

QUARTZ –NEW - QTZ

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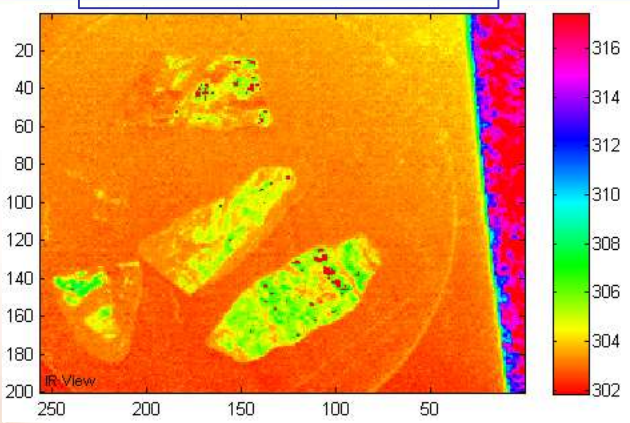

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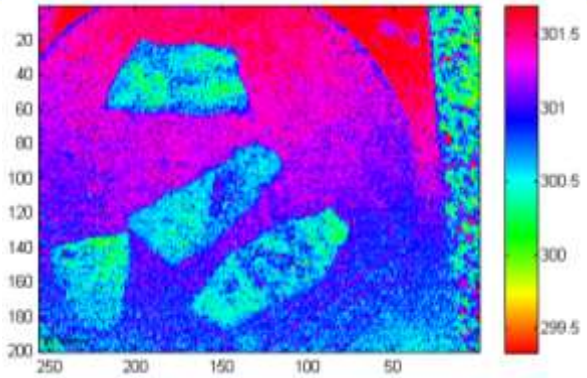

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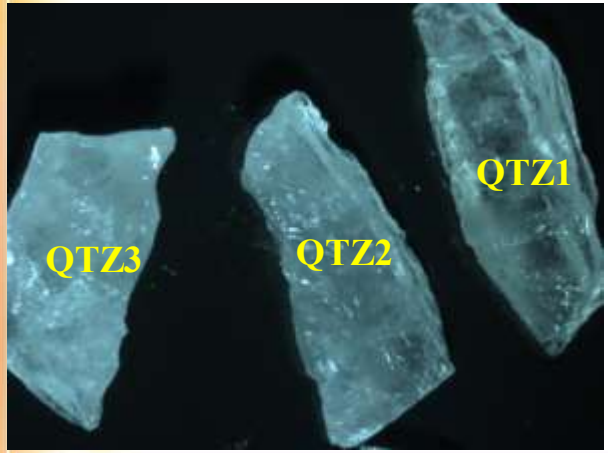
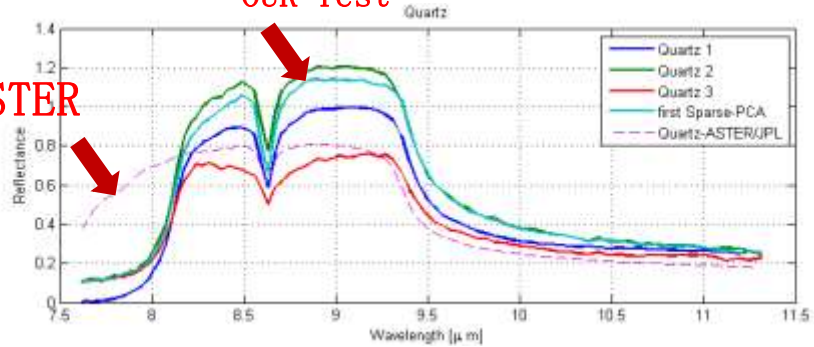


OUR Test

ASTER



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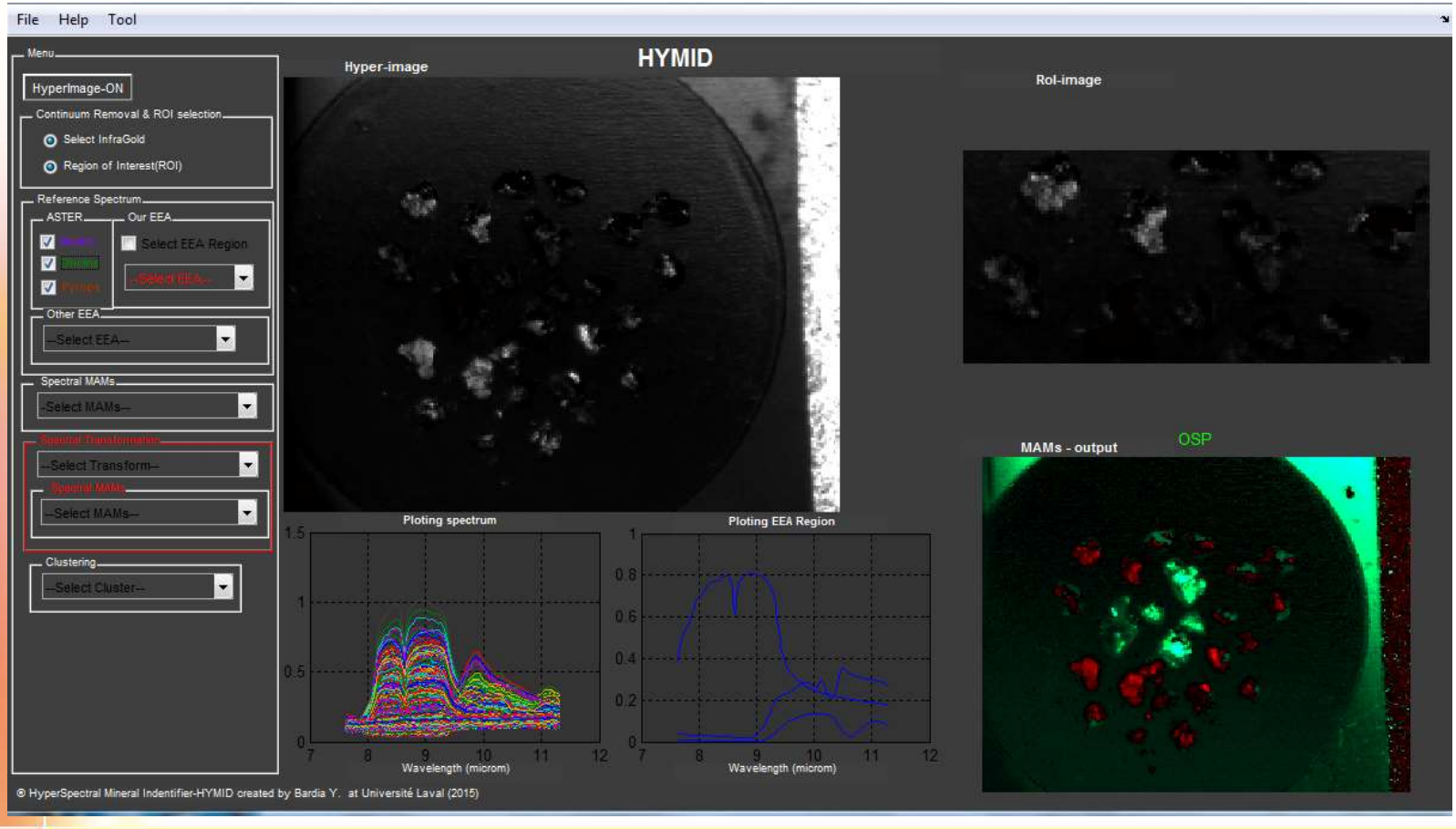
HYMID

Hyperspectral Mineral Identifier (HYMID): a tool for applying spectral analysis



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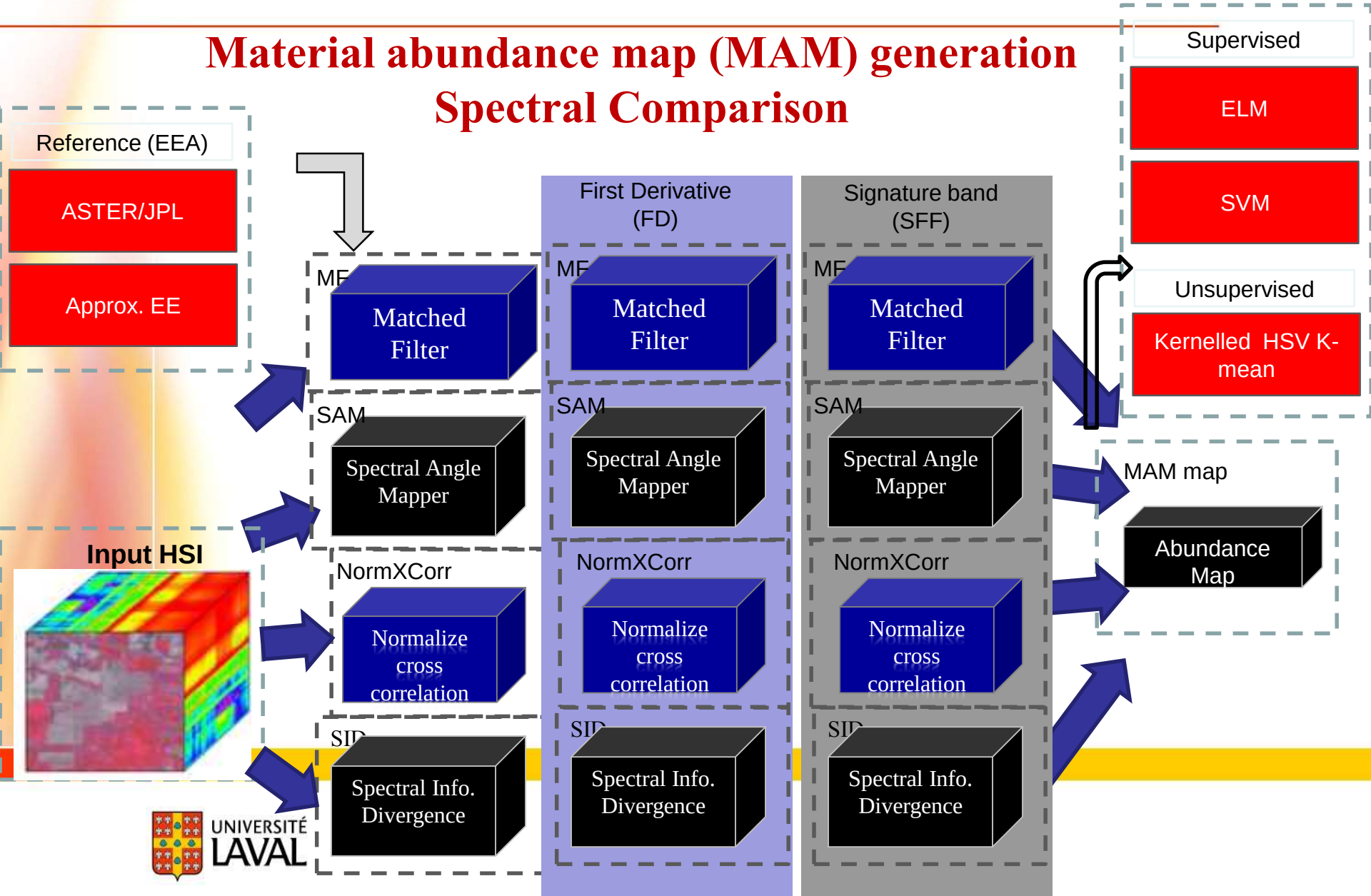
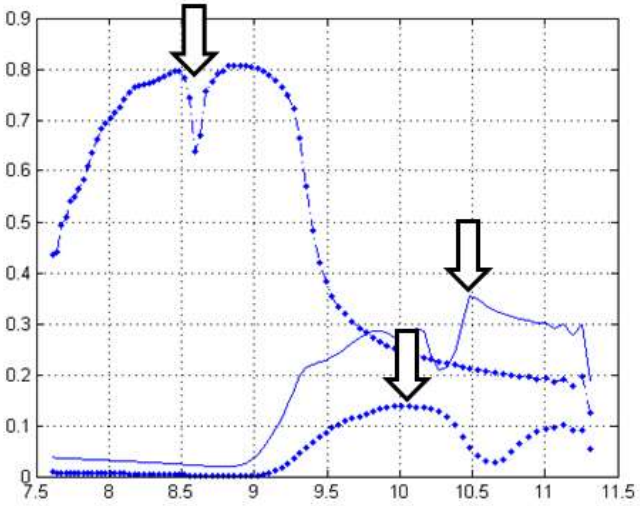
METHODOLOGY

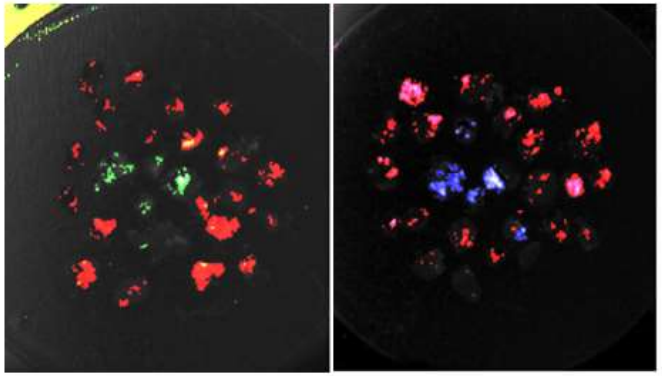
Material abundance map (MAM) generation
Spectral Comparison



RESULTS

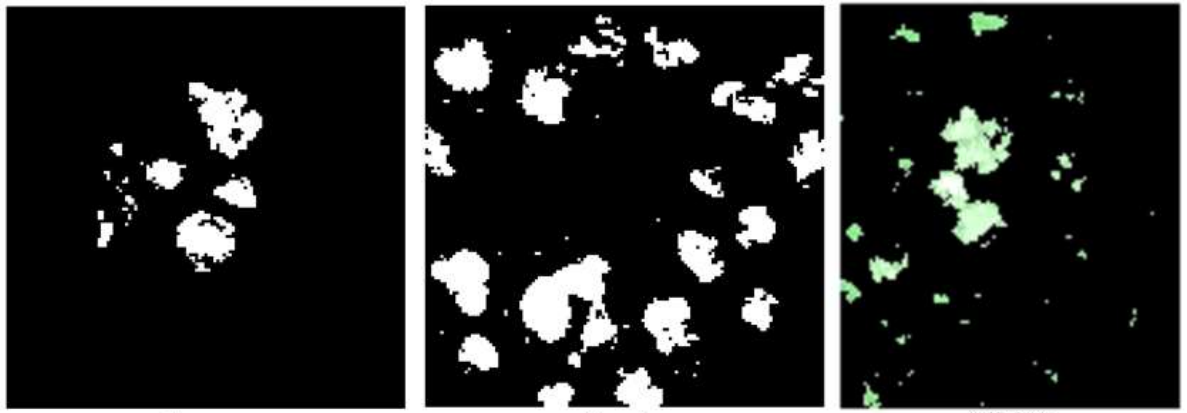
Simple looking at the problem, applying a simple threshold in the certain wavelength.





Pyrope & Quartz

Olivine & Quartz



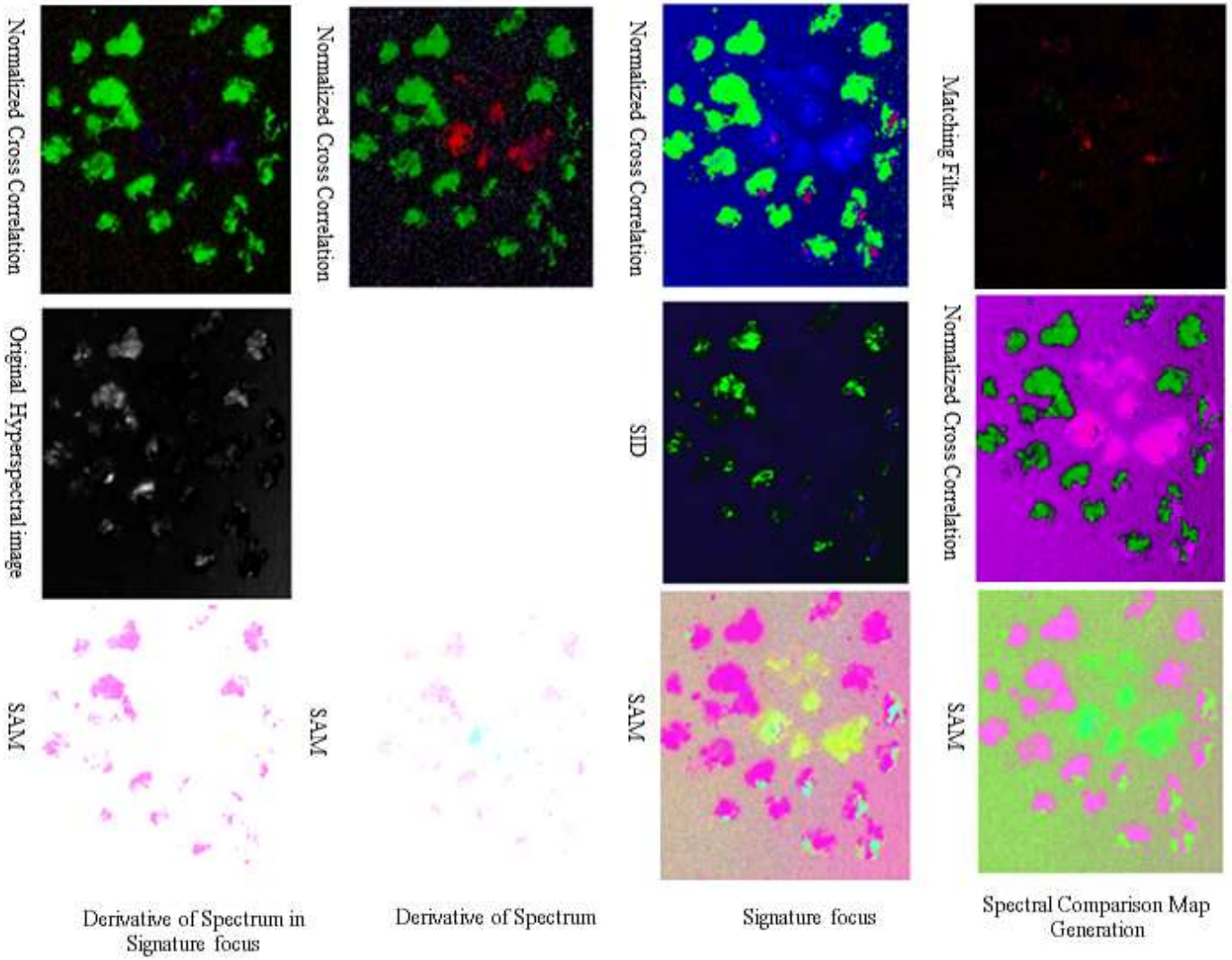
Pyrope

Quartz

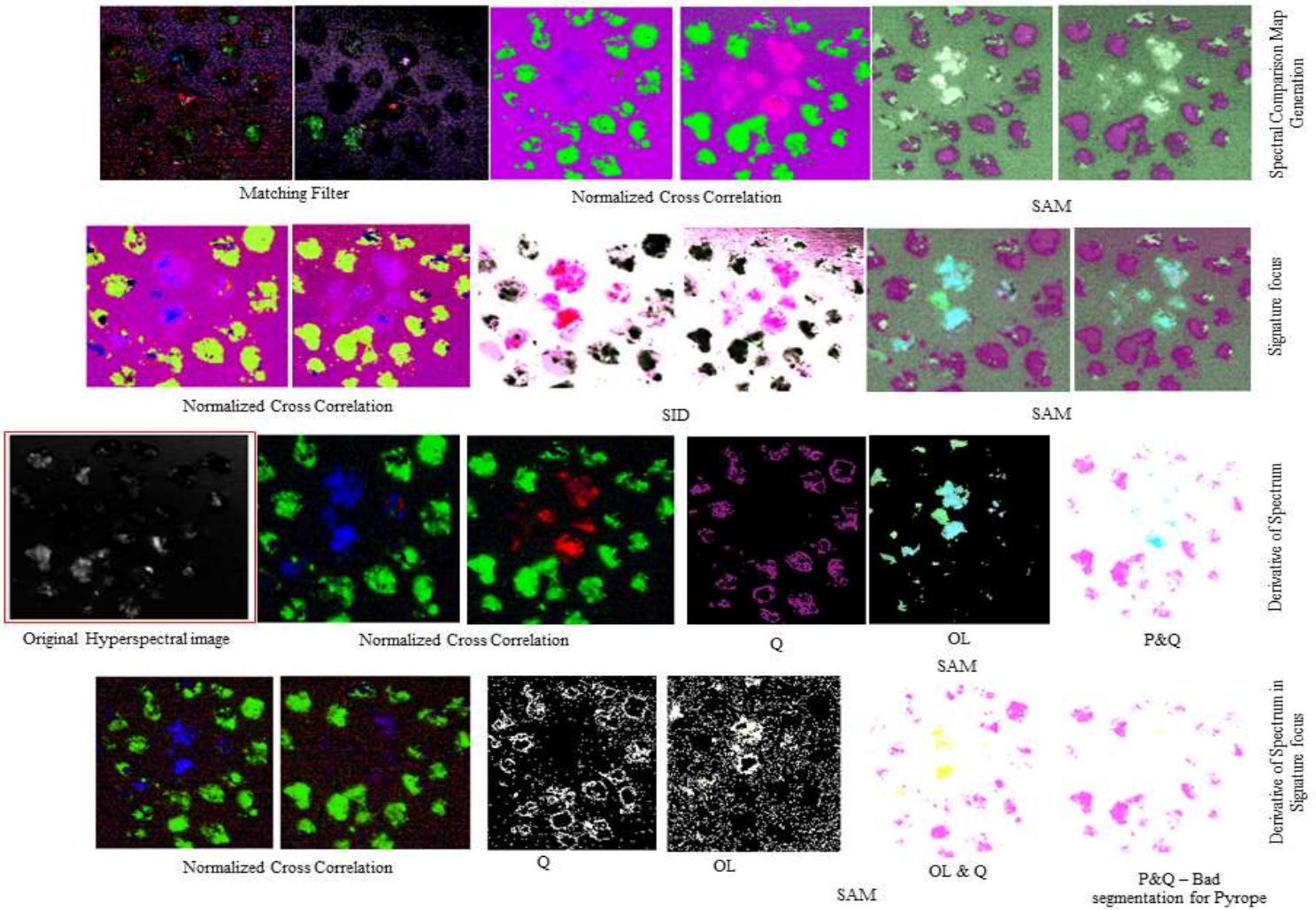
Olivine

Feng, J., Rivard, B., Sánchez, D. & Sánchez-Azofeifa, A. (2013). The longwave infrared (3–14μm) spectral properties of rock encrusting lichens based on laboratory spectra and airborne SEBASS imagery. *Remote Sensing of Environment*, *131*, 173-181.

RESULTS

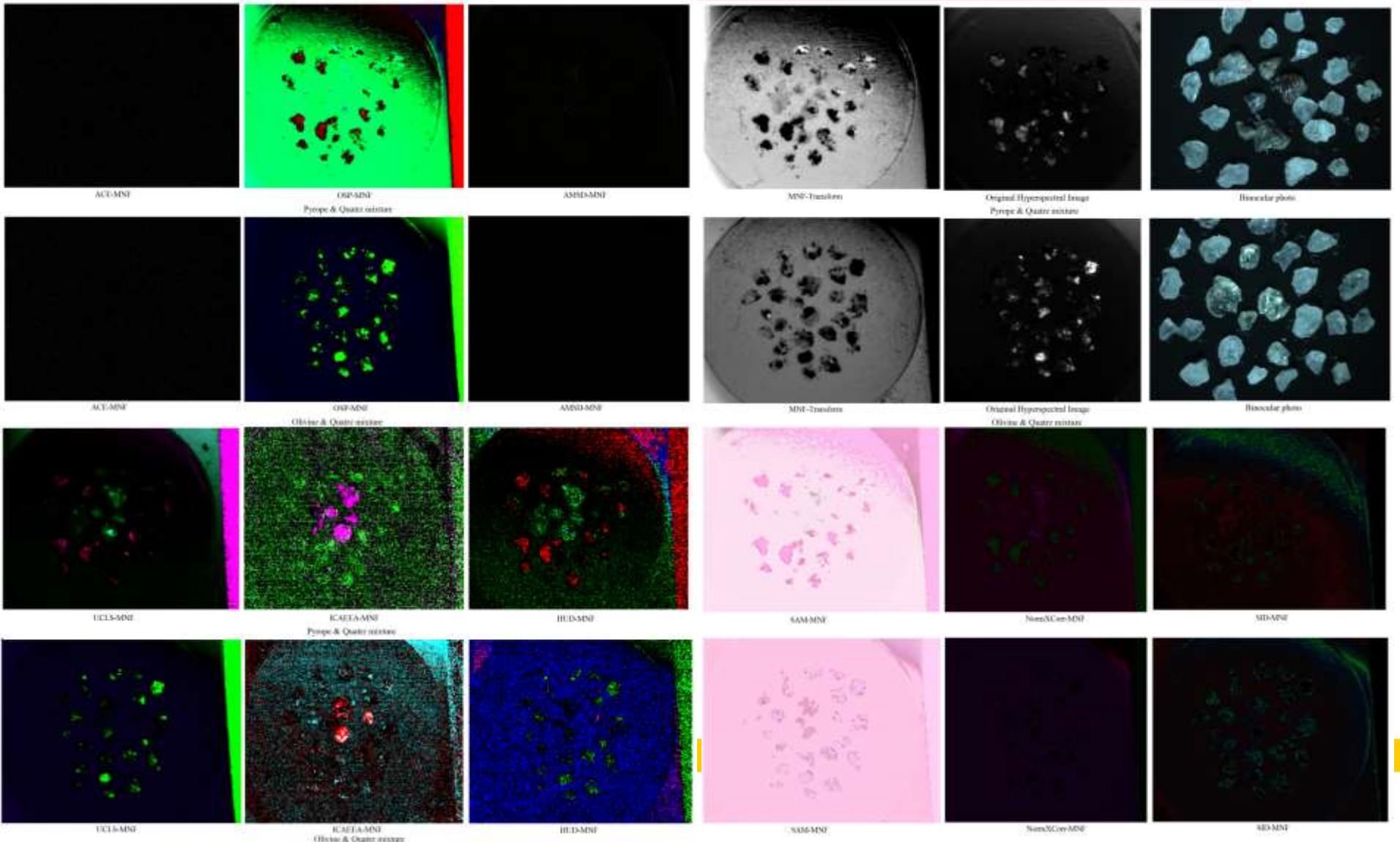

Matching Filter
Normalized Cross Correlation
SAM
Spectral Comparison Map Generation
Normalized Cross Correlation
SID
SAM
Signature focus
Normalized Cross Correlation
SAM
Derivative of Spectrum
Normalized Cross Correlation
Original Hyperspectral image
SAM
Derivative of Spectrum in Signature focus

RESULTS


Matching Filter
Normalized Cross Correlation
SAM
Spectral Comparison Map Generation
Normalized Cross Correlation
SID
SAM
Signature focus
Original Hyperspectral image
Normalized Cross Correlation
Q
OL
SAM
P&Q
Derivative of Spectrum
Normalized Cross Correlation
Q
OL
SAM
OL & Q
P&Q – Bad segmentation for Pyrope
Derivative of Spectrum in Signature focus

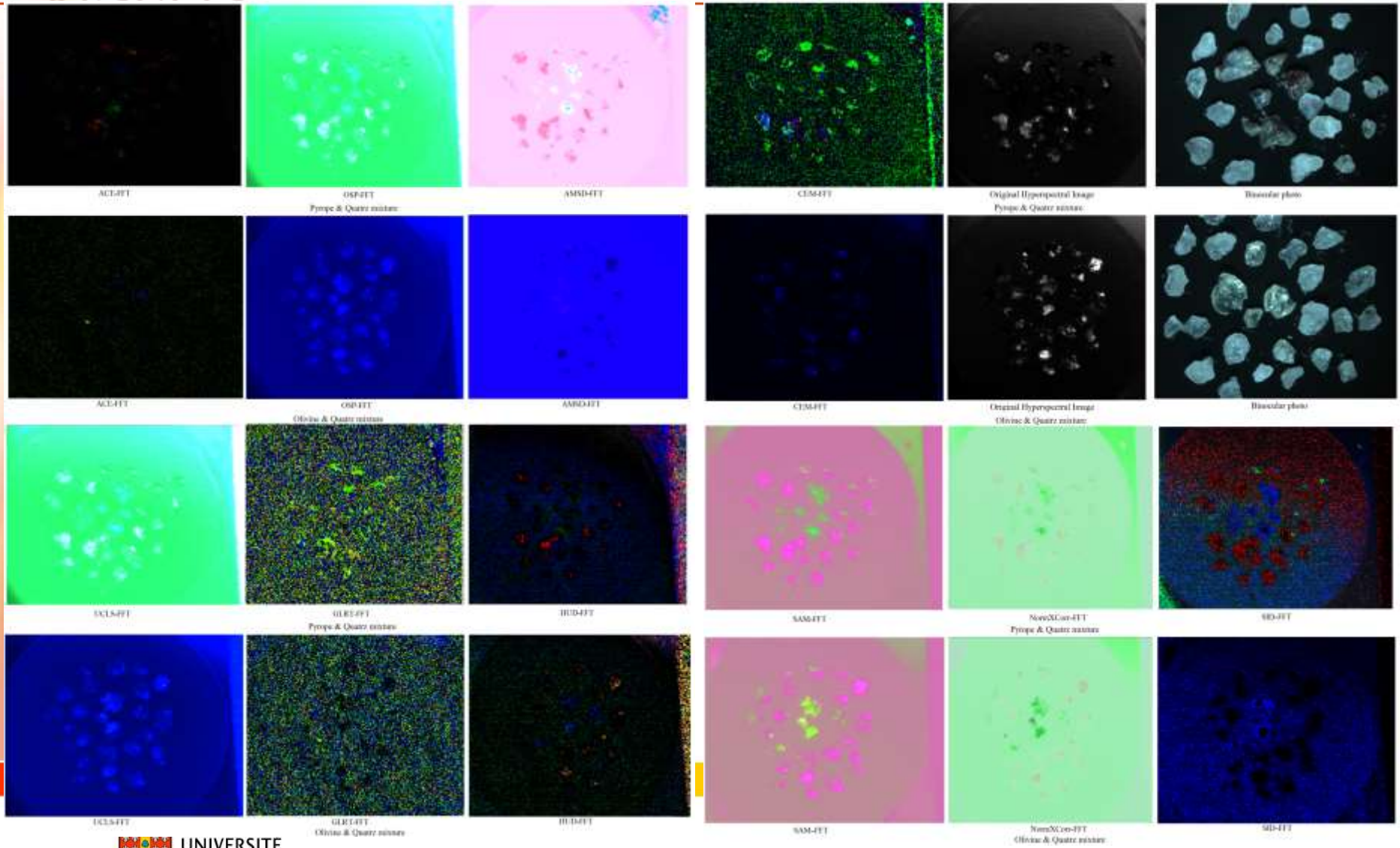
RESULTS

Minimum Noise Fraction (MNF)



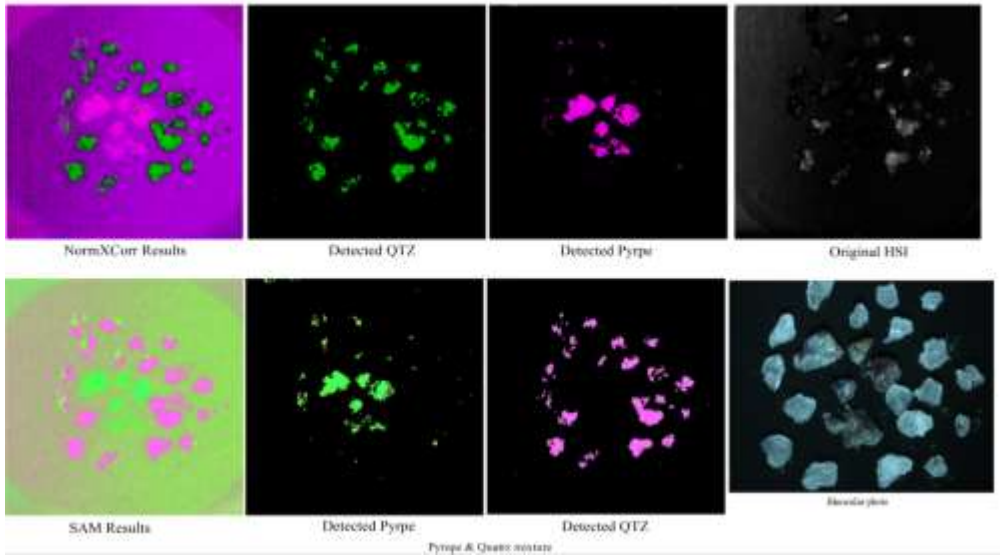
LAVAL

RESULTS



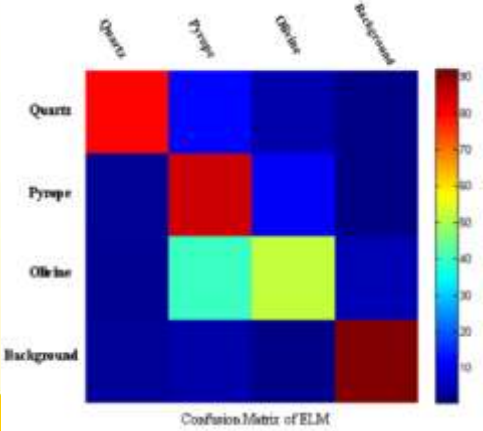
CLUSTERING/CLASSIFICATION

K-MEANS



MAM	HSV-Kernelled K-means clustering	Quartz (%)	Pyrope (%)	Olivine (%)
NormXCorr	Accuracy of mineral detection	77.95	94.59	85.39
	Misclassification	22.06	5.41	14.61
	Total accuracy	55.89	89.19	70.78
SAM	Accuracy of mineral detection	75.82	91.40	99.75
	Misclassification	29.56	29.34	4.03
	Total accuracy	46.25	62.06	95.72
SID	Accuracy of mineral detection	68.52	72.01	92.19
	Misclassification	31.48	27.99	7.81
	Total accuracy	37.04	44.01	84.38

ELM



Confusion Matrix of ELM

Linear Kernel ELM	Pyrope-Carbon	Olivine-Carbon	Quartz-carbon
Training Time	0.6025	0.5944	0.7262
Testing Time	0.3711	0.3928	0.4453
Training Accuracy	0.9810	0.9810	0.9816
Testing Accuracy	0.9299	0.9505	0.9497

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CONCLUSION

- The problem of mineral identification has been discussed.
- Systems for automated identification of the minerals have been introduced using the hyperspectral infrared imaging system. Clustering and classification of the mineral has been analyzed.
- Hyperspectral infrared in the wavelength (7.7-11.8 µm) provides distinctive signatures of **Quartz, Pyrope** ,and **Olivine**.
- On the contrary, the hyperspectral profiles for **Ilmenite** and **Chromite** are difficult to identify in this spectral band.
- Using ELM is not a good option as its training is hard for overcoming this issue unsupervised approaches are recommended.

Future Work:

- Further investigate clustering techniques to improve performance,
- Investigate the application of spectral transformation techniques such as the S-transform


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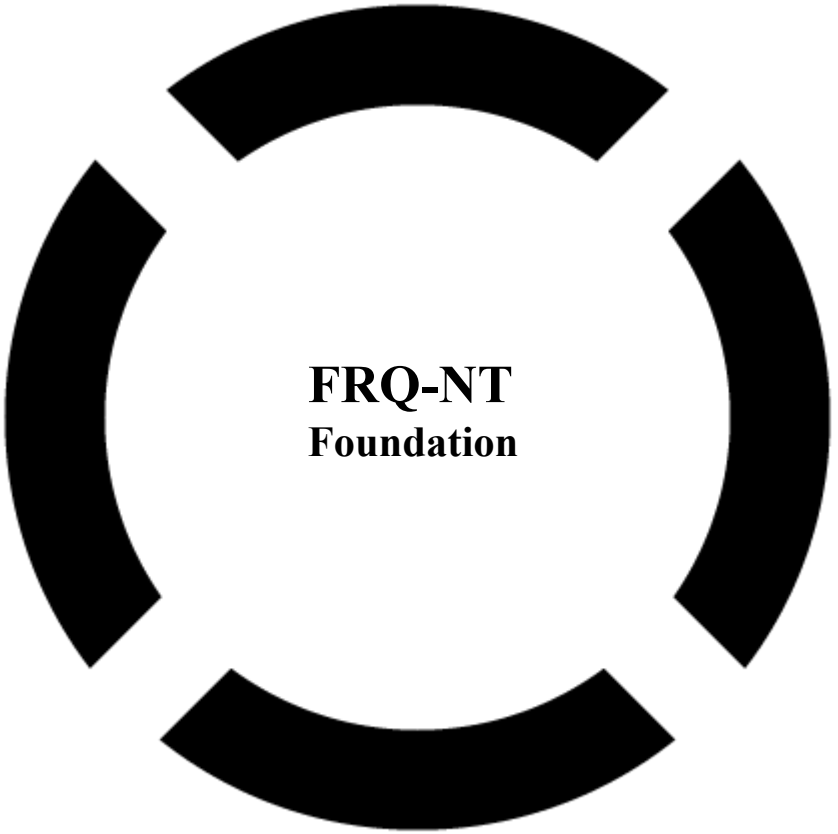
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Multipolar Infrared Vision Infrarouge Multipolaire

THANK YOU


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GROUND TRUTH

Orthogonal subspace projection (OSP) & Adaptive matched subspace detector (AMSD) algorithm