Emissivity retrieval from indoor hyperspectral imaging of mineral grains

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MIVIM
Multipolar Infrared Vision Infrarouge Multipolaire

PROJECT DESCRIPTION

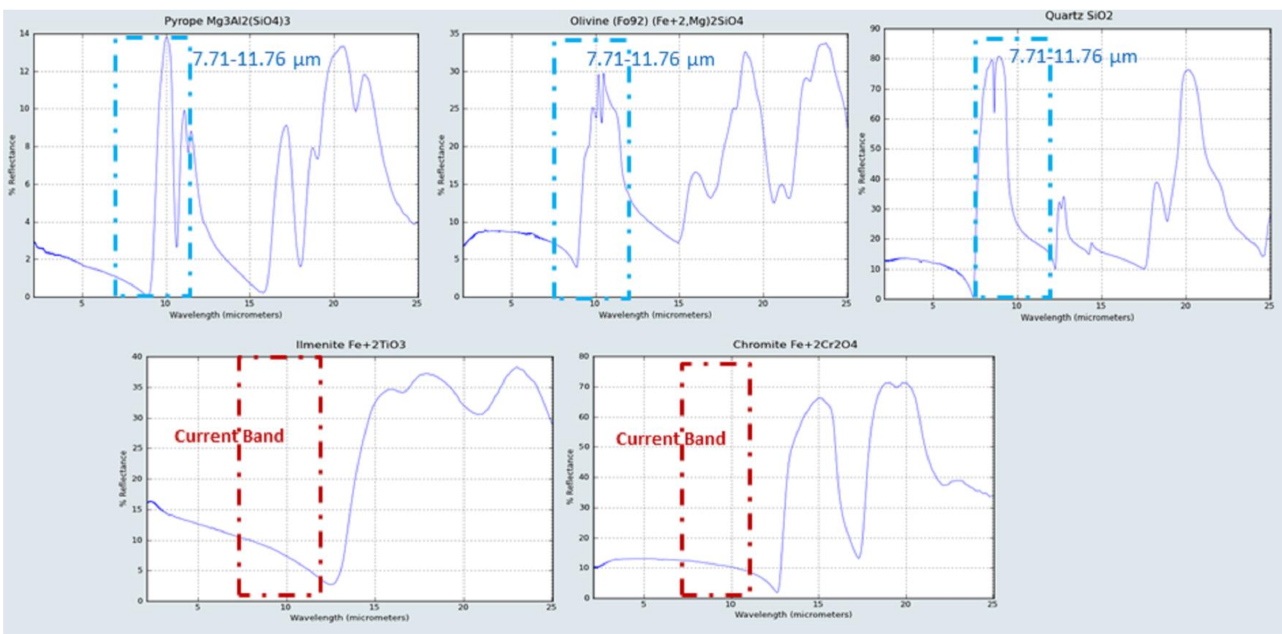
Our collaborative research on identification of the minerals using infrared thermography (LWIR 7.7-11.8μm) in the laboratory condition.

MINERALS

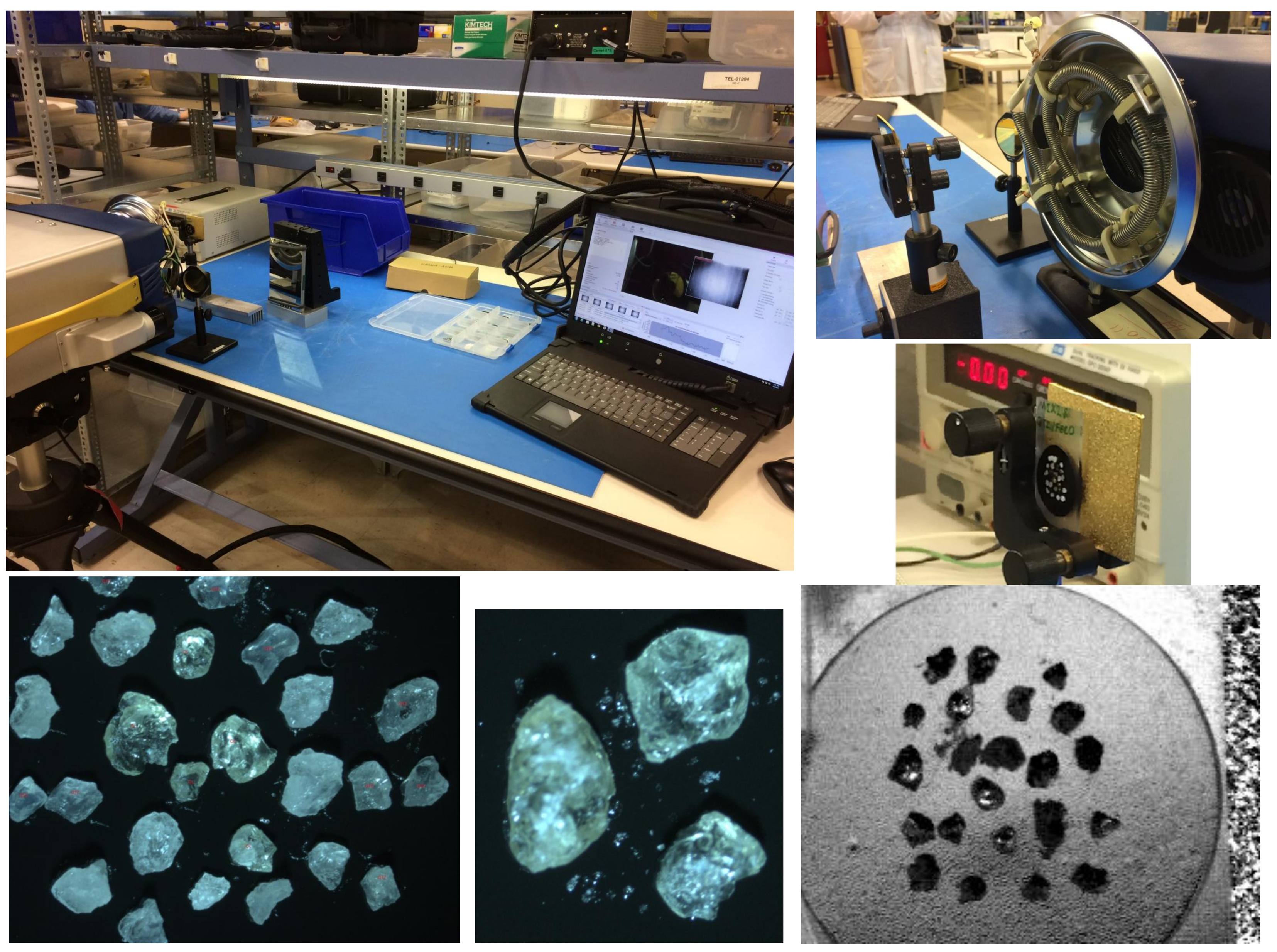
There are five different mineral grains which we wish to locate by automatic identification

Pyrope (PYR)
Olivine (OL)
Quartz (QTZ)
Ilmenite (ILM)
Chromite (CHR)

Spectra for all these minerals in ASTER/JPL NASA database for full spectrum. The band we are working is shown by blue. **Illuminate** and **Chromite** have **no signature** in this band.

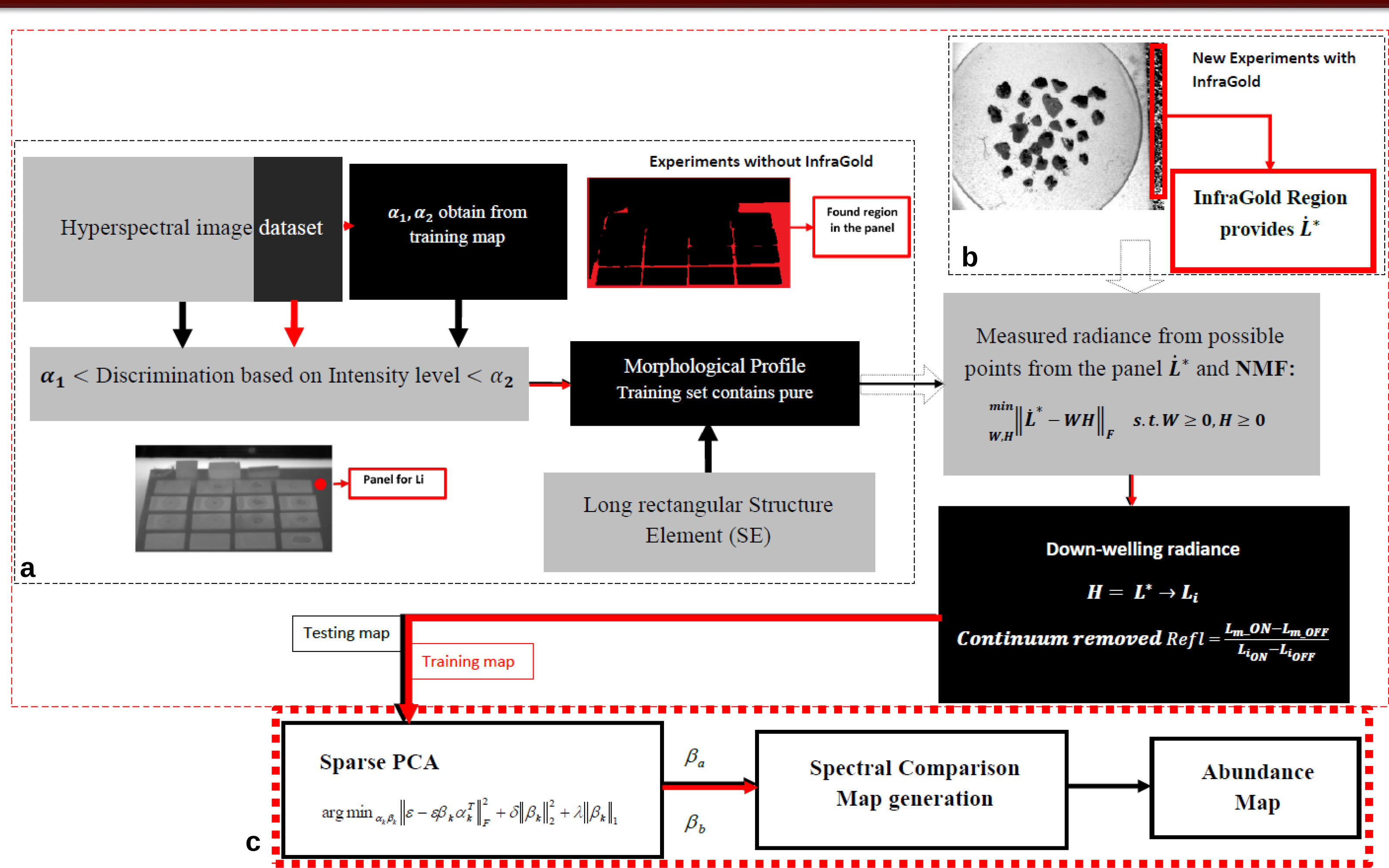


EXPERIMENTAL SETUP



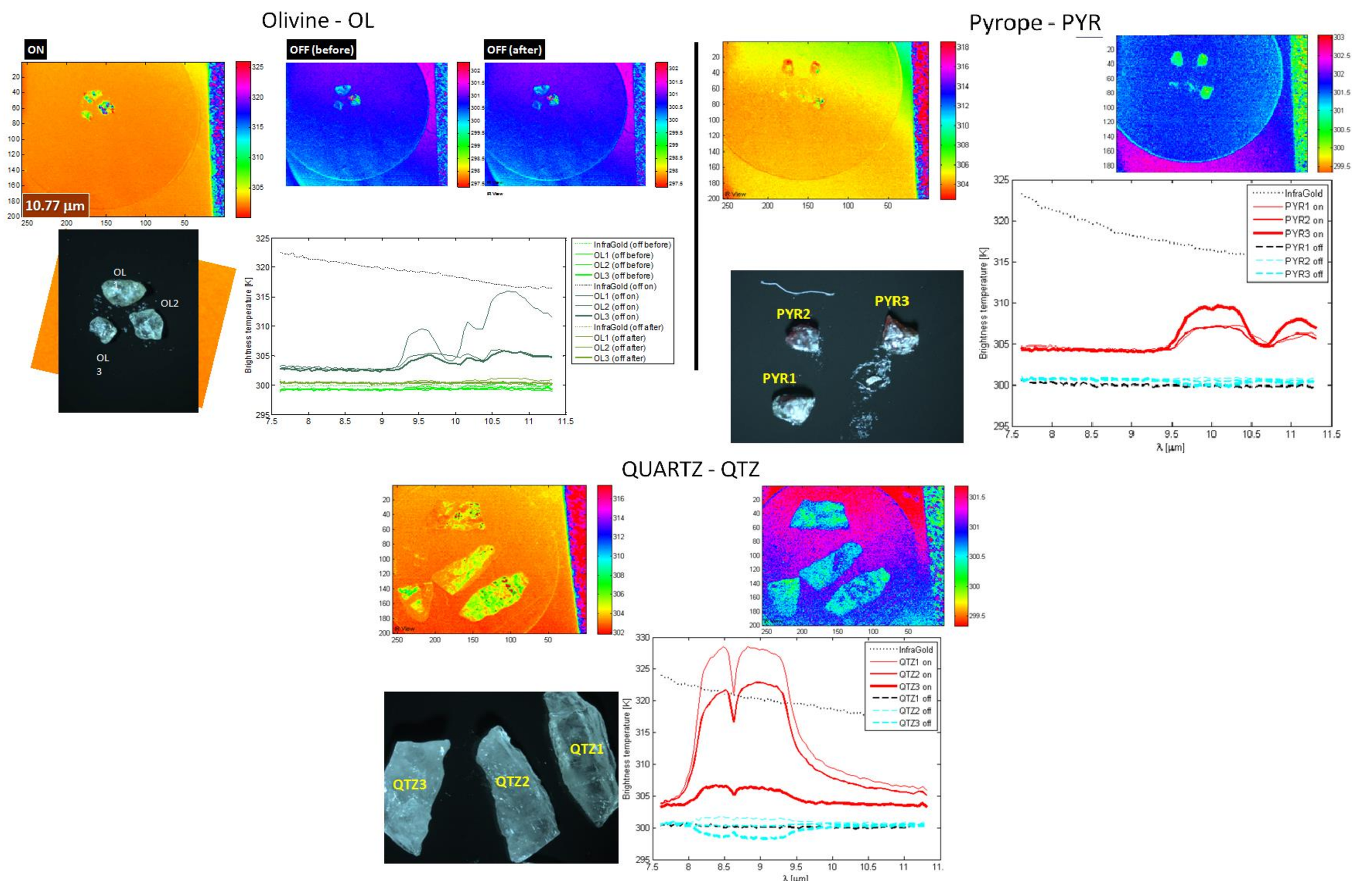
Experimental setup and mineral grains are shown in the figure. Two experiments were performed, in the first experiment a standard lens (for remote sensing) and non-uniform heating source were used. The second experiment was conducted using larger mineral grain, a more uniform heating source, an InfraGold plate in the background, and a suitable macro lens that was especially designed for the use of the hyperspectral camera in laboratory conditions.

METHODOLOGY



Flowchart reveals the proposed approach for estimation of down-welling radiance among all the possible points. Scheme presents general processes comprises three parts: **a)** represents the first experiment; **b)** depicts the second experiment having infra-gold plate; non-negative matrix factorization(NMF) [1] uses for selection of down-welling radiance for both experiments. **c)** presented the post-processing approach for estimating the mineral abundance map.

RESULTS



Selected results of the experiment in the LWIR. Hyperspectral images with and without heating source are presented. The hyperspectral profiles for three selected points on the surface of the grains are also shown with (ON) and without (OFF) stimulation. The binocular microscope images also illustrated the minerals grains for reference.

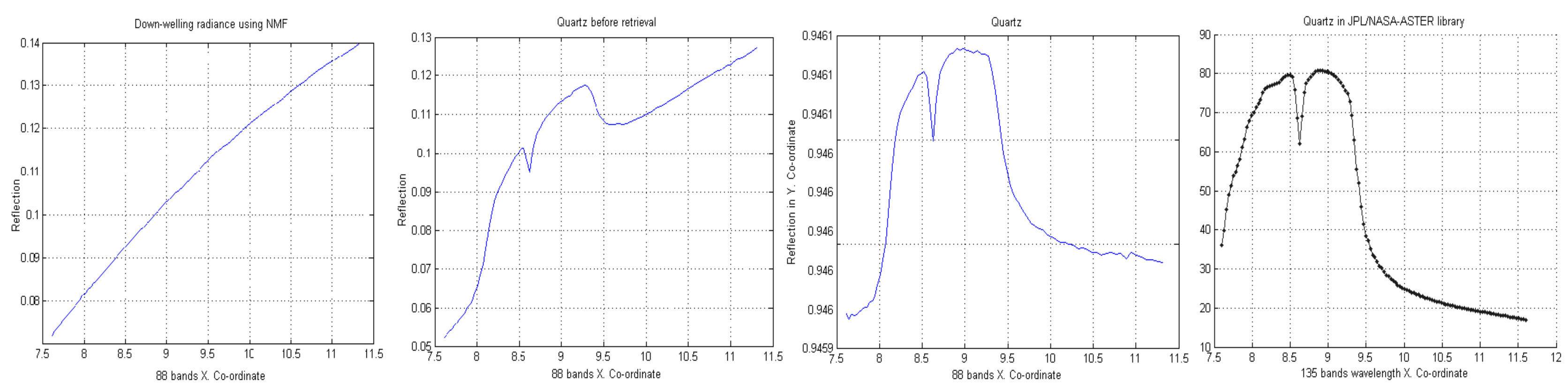
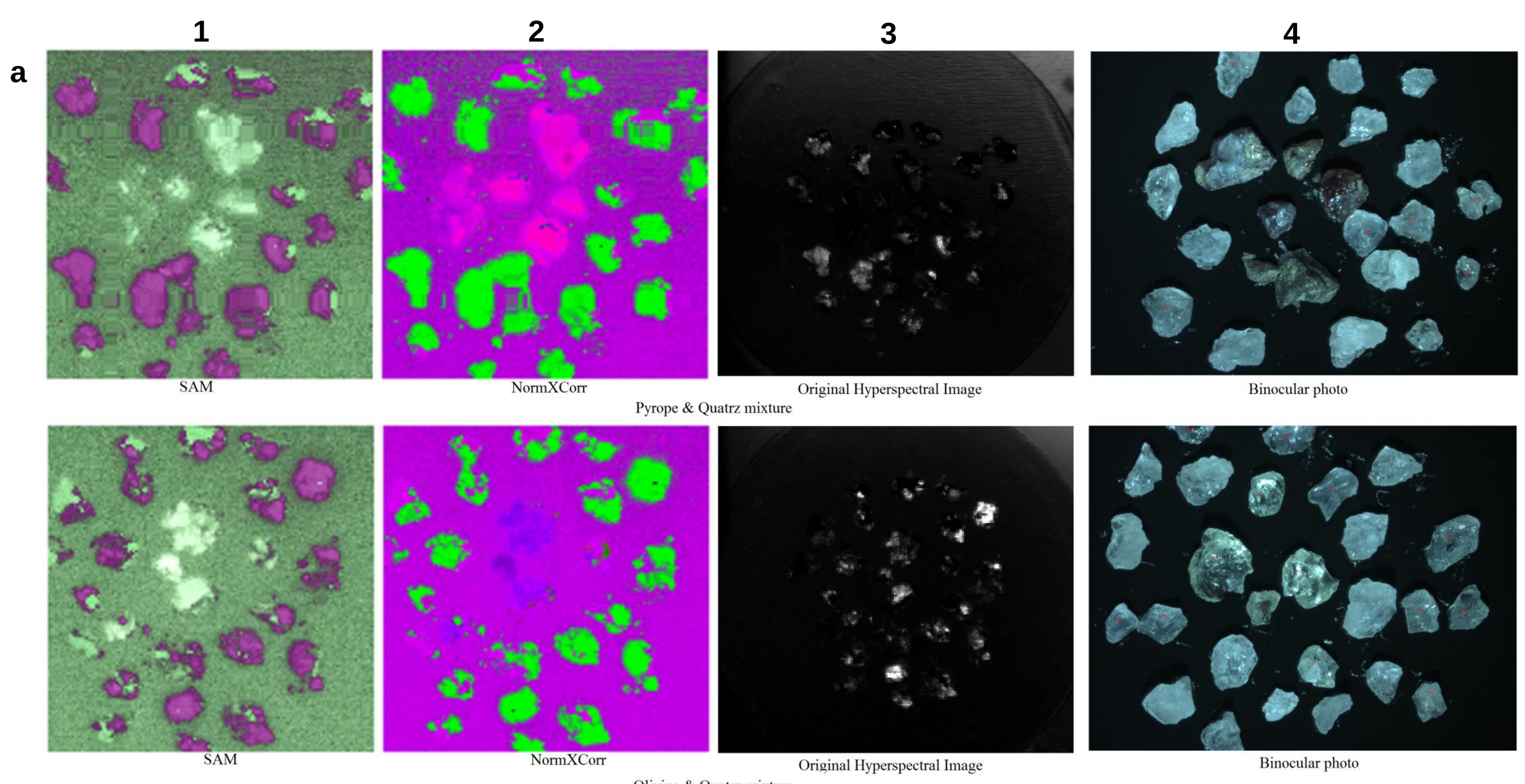


Illustration of the emissivity retrieval (Continuum Removal) procedure for the case of quartz grains and comparison to the ASTER/JPL-NASA library.



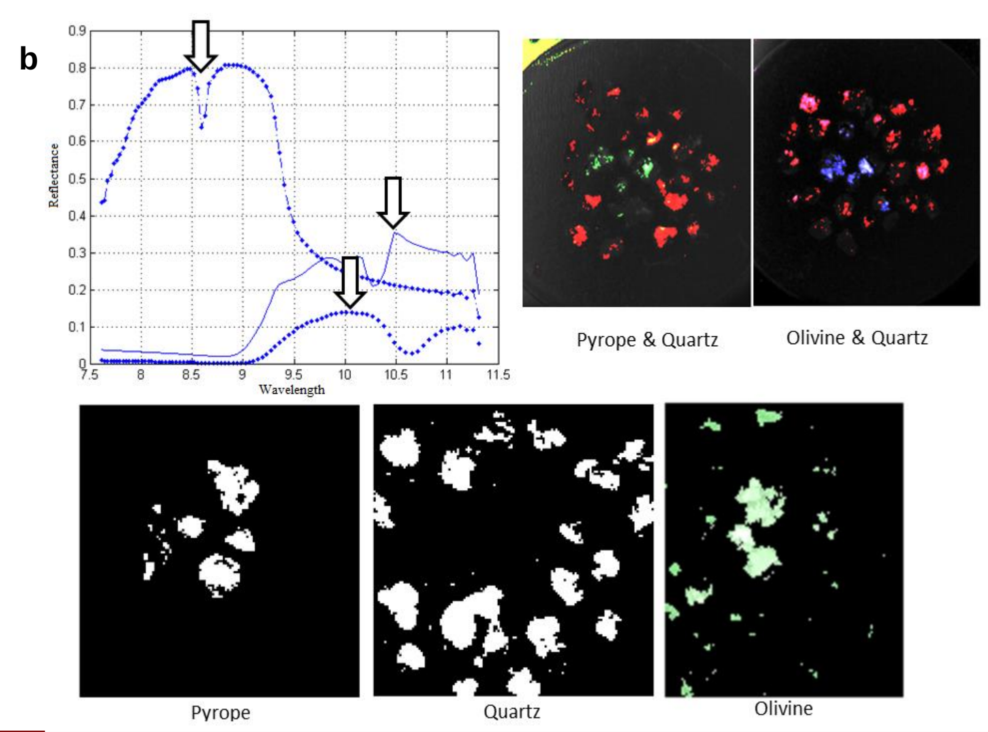


Illustration of the segmentation procedure:

a) results of spectral comparison map generation techniques for Pyrope-Quartz (top) and Olivine-quartz(bottom) mixed samples:

(1) spectral angle mapper (SAM),
(2) Normalized Cross Correlation (NormXCorr),
(3) Spectral image,
(4) binocular photograph.

b) results of segmentation using the wavelengths signature for each mineral [2].

SUMMARY

The presented approach concerned experimental hyperspectral data conducted in the LWIR spectrum. The continuum of the spectra has been removed using down-welling radiance from either an aluminum plate (first experiment) or an InfraGold plate (second experiment) using NMF analysis. Sparse principle component analysis has been applied to approximate the pixels associated with pure mineral grains from available databases (ASTER/JPL-NASA library). Several spectral comparison map generation techniques (i.e. spectral angle mapper, normalized cross correlation, spectral information divergence) were employed to generate mineral abundance maps, which were used for mineral identification though different classification\clustering techniques (i.e. Extreme Learning Machine, Kernelled K-Means clustering). Results are promising given that it was possible to clearly identify 3 of the 5 minerals in the LWIR (pyrope, olivine and quartz). The other two minerals (ilmenite and chromite) have a more distinctive spectral signature outside the LWIR" Hence, future work should consider a different hyperspectral bands, form 15 to 20 for ilmenite and from 12 to 16 for chromite.

References

[1] Lee, D. D., & Seung, H. S. (2001). Algorithms for non-negative matrix factorization. In *Advances in neural information processing systems (NIPS-* 2001), pp. 556-562).
[2] Feng, J., Rivard, B., Rogge, D., & Sanchez-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.

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