OPHIOLITES MAPPING IN THE TARO VALLEY (CENTRAL ITALY) BY USING AN LWIR AIRBORNE TASI-600 SURVEY: PRELIMINARY RESULTS ON THE ROCCAMURATA COMPLEX

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Introduction

The Italian "*Istituto Nazionale Assicurazione contro gli Infortuni sul Lavoro*" has funded the research contract ASBESTOP (ID57/2016), which deals with the exploitation of different sensing technologies from proximal to remote (from airborne to satellite) and processing methodologies to detect both asbestos natural (NOA) and manmade materials.

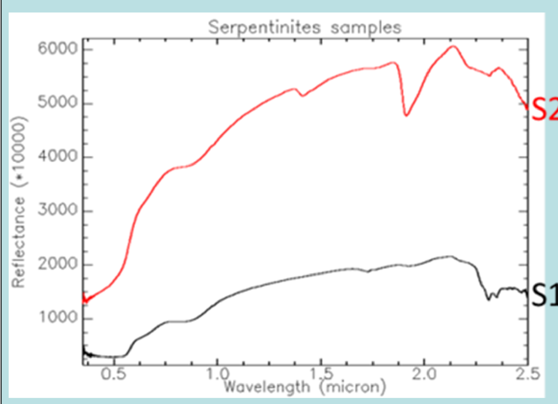
The accurate mapping and monitoring of asbestos-bearing rock formations (mainly serpentinites) is of great interest for the public Authorities as the presence of asbestos fibers in the form of inclusions within the rock matrix is a possible public health problem (asbestosis, mesothelioma and lung cancer), which determines the need to identify the existence or not of risk for the workers and resident population nearby and to assess its extent

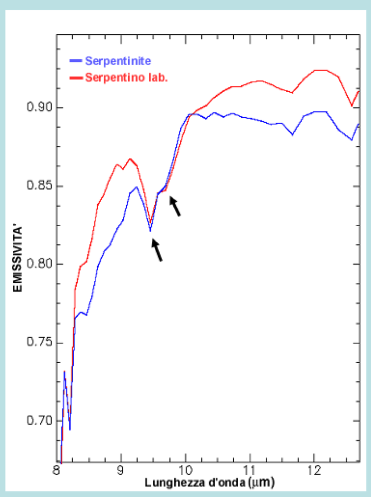
In Italy, serpentinites and ultramafic rocks are common in the Alps and Apennines Mountains and in particular in the Liguria, Toscana, Piemonte, Calabria and Basilicata regions.

Asbestos VNIR-SWIR-LWIR spectral characteristics

The asbestos distinctive absorption spectral features are centered at 1.385µm (NIR), 2.323µm (SWIR) and 9.6µm (LWIR) [1].

Serpentinization is responsible for a decrease in contrast of olivine-pyroxene iron absorption features and an appearance and increase in OH– absorption features near 1.385 µm and 2.323 µm associated with serpentine minerals.





Scientific Objectives

1. Assess the potential of VNIR-SWIR satellite and LWIR airborne multispectral data to detect and identify Natural Occurring Asbestos outcrops
2. Test the suitability of TES algorithm applied to TASI LWIR radiance data to retrieve surface emissivity
3. Identify the best performing algorithm for mapping NOA using reflectance and emissivity images
4. Quality assessment of the different maps (i.e. validation using ground truth)

EXPECTED RESULTS: ongoing activity

1. On airborne TASI emissivity and PRISMA satellite reflectances imagery acquired over the Parma test site, hard classification algorithms (e.g., ML, SVM, RF etc.) and spectral features analyses will be tested to produce the asbestos bearing rocks (NOA) outcrops maps with the relative accuracies.
2. A comparison of the performances in mapping NOA minerals using different sensors and platforms at different spatial (1-30 m) and spectral resolutions (multi/hyperspectral) will be carried out also with their pros and cons.

References

1) Bassani, C., Cavalli, R. M., Cavalcante, F., Cuomo, V., Palombo, A., Pascucci, S., & Pignatti, S. (2007). Deterioration status of asbestos-cement roofing sheets assessed by analyzing hyperspectral data. Remote Sensing of Environment, 109(3), 361-378.
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TASI AIRBORNE CASE STUDY: Taro River Valley, Parma, Italy

STUDY AREA: located in the Emilia-Romagna Region side of the Northern Apennines, a fold and thrust belt that resulted from the Cenozoic post-collisional processes between Europe and Adria plates. It is included in the SIC (Site of Community Importance) with its Peridotitic ophiolite (Ligurian Units derived from the Ligurian-Piedimont oceanic basin) that is of great thickness and extension, with remarkable landscape prominence. The rocky slopes reach the Taro river bed and the Roccamurata cave is located in the lower part of a slope which evidences an height difference of about 700 m.

TASI-600 sensor

Spectral channels (800-11444 nm)	32
FHWM	110nm
Across track pixels	600
FPA pitch	30x30 micron
FOV	≥40°
IFOV	≤2 mrad
Foreoptics	≤ f/2.5

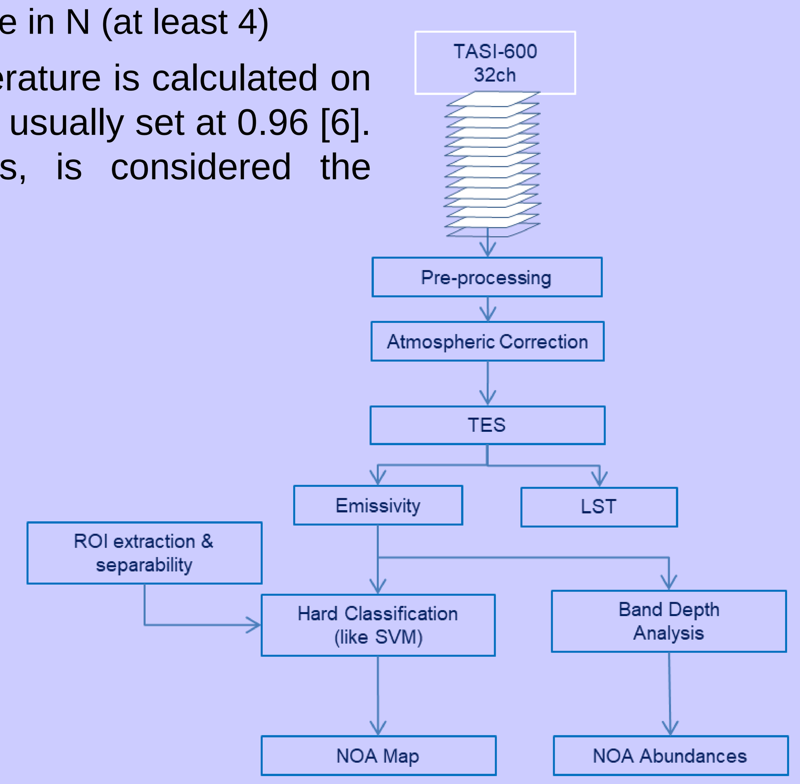
Italian ASBESTOP Project (2016-2019)	
Test Area	Parma (PR), Italy
Objective	LWIR spectral data acquisition on NOA surfaces
Flight date	December, 04, 2019
Acquisition time	Between 12:00-14:00 local time
Meteo conditions	Sunny day to assure a good dynamic range
Flight height	830metres ~2700 ft above ground level
Spatial Coverage	Stripes length about 10.000m Entire survey 50 Km^2 Flightlines # 12
GSD	1.0-1.5 m
Bands	32
Swath	600m
Overlapping	320m; 45%
Frame time	15 msec
Ground Speed	<130 Kn (240 Km/h);

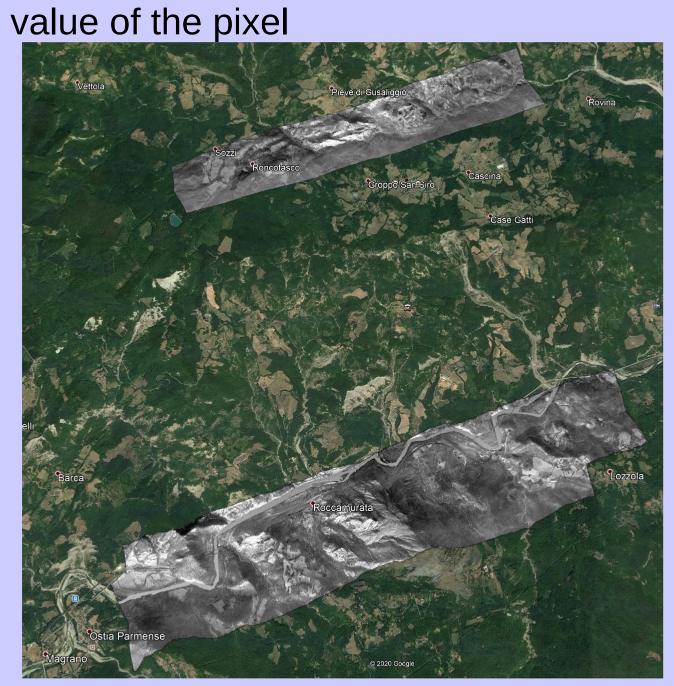
TASI flight plan

Taro River Valley (Parma) campaign

METHODS: The compensation of diffusion, and emission phenomena effects is an important issue to quantitatively retrieve parameters as brightness and kinetic T and emissivity. Literature studies [2-5] show how atmospheric compensation algorithms, based exclusively on the data acquired on the scene by the thermal sensor such as the *ISAC* method, offer an accurate method to compensate for atmospheric effects in the 8–12 µm spectral range.

The *ISAC algorithm* assumes that some of the pixels in the scene behave like a black body without the need of knowing the exact position or T values. The *TES method* (ENVI 5.1 software) allows to determine the absolute value of the spectral emissivity using the measurements made in N (at least 4) spectral bands in the TIR range. For each pixel, the temperature is calculated on all the spectral channels using a constant emissivity value, usually set at 0.96 [6]. The highest temperature value, among all the bands, is considered the temperature value of the pixel





LST images of the TASI-600 flightlines on Roccamurata and Pieve di Gusaleggio (PR) on Google Earth

TASI Band Depth analysis

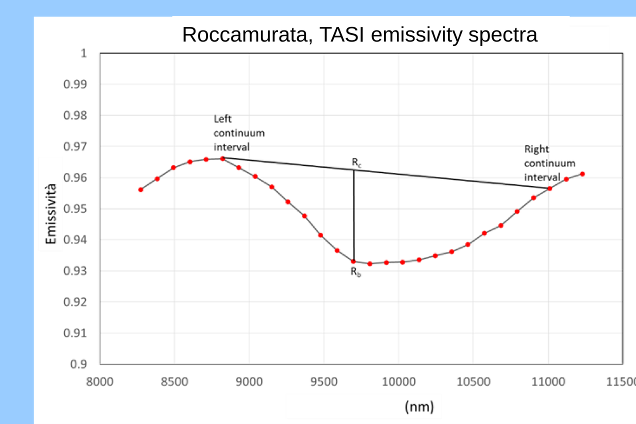
Based on the experience gained (Bassani et al., 2007) the spectral type algorithm "Continuum Removed Band Depth" has been tested and optimized to the characteristics of the sensor TASI-600.

The "continuum removal" is a numerical method commonly used in the laboratory in infrared spectroscopy to estimate the absorption of specific bands or spectral features. This approach is based on the identification of a reference curve, i.e. the continuum (Kokaly & Clark, 1999) whose removal allows to enhance the absorption bands and clean them from any contaminating factors. The continuum is the envelope of the emissivity curve in the spectral neighborhood of the absorption band. It represents the curve that joins the two "shoulders" of the absorption feature (see Figure 68).

$$BD_{Serp} = 1 - \frac{R_b}{R_c}$$

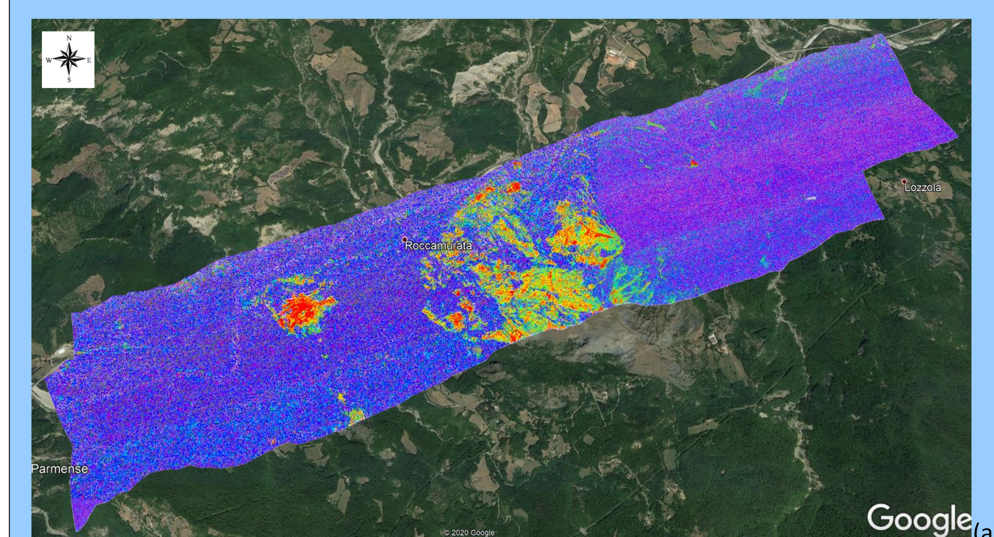
Where, Rc is the value of the emissivity continum at the center of the band (chosen for the absorption peak of the serpentine on the spectral characteristics TASI) and Rb is the value of the emissivity at the center of the band. In the case of the spectral signature in emissivity (8-12 µm) of the TASI for the mapping of serpentinites, the BD was centered at 9.697 µm, while the left shoulder (left continuum interval) at 8.821 µm and the right shoulder (right continuum interval) at 11.011 µm

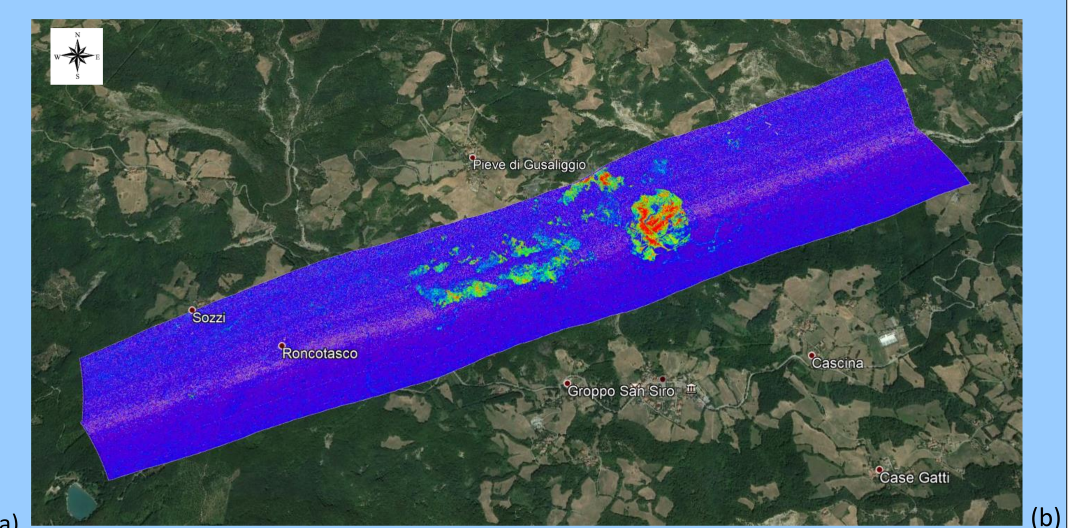
Emissivity spectrum of the Roccamurata serpentine quarry, the red dots indicate the TASI bands. Rc is the value of the continuum of the emissivity at the center band and Rb is the value of the emissivity at the center band.



The Figure below shows the maps of the Roccamurata (a) and Pieve di Gusaleggio (b) areas , on Google Earth. Images are obtained by the TASI emissivity Band Depth analysis (BD centered at 9.697 microns).

- red and orange represent high BD values, corresponding to a high concentration of serpentinitic outcrops,
- yellow medium concentration,
- green low concentration
- light blue and blue low BD values or absence of serpentinitc outcrops.



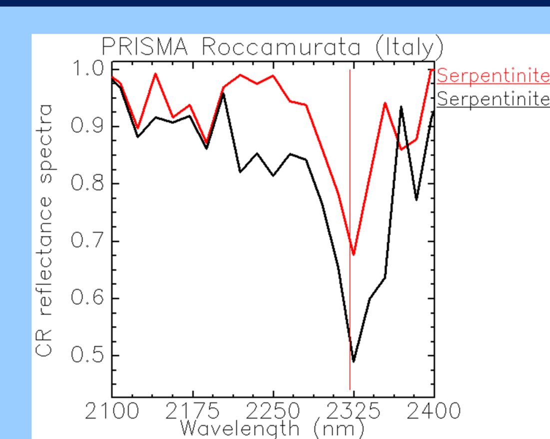


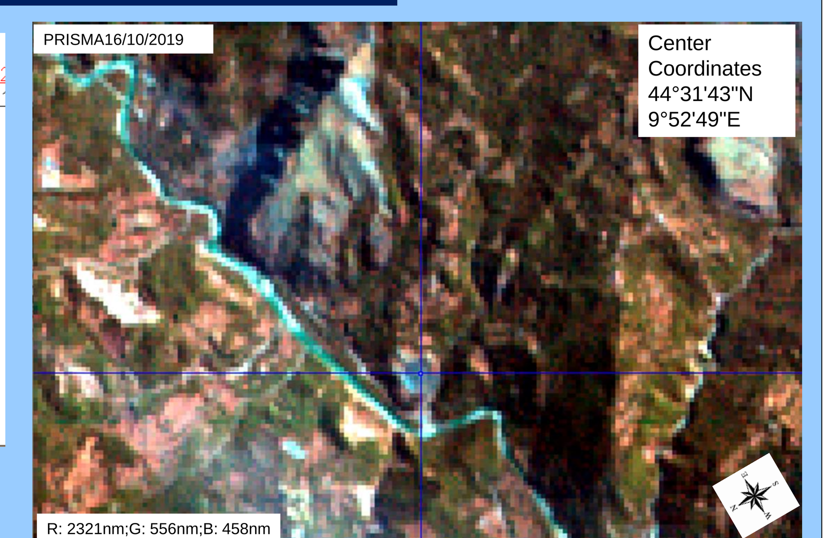
(Band Depth analysis centered at 9,697 µm; left shoulder at 8,821 µm, right shoulder at 11,011 µm)

PRISMA (VSWIR) image on Roccamurata, Parma, Italy

PRISMA characteristics

- **Swath**
  - 30Km / 27.7° / 48microrad
- **Spatial GSD**
  - PAN: <5 m (2x6000 pixels)
  - HYP: <30 m (1000x256 pixels)
- **Spectral ranges:**
  - PAN camera: 400-700 nm
  - Hyperspectral
    - VNIR: 400-1010 nm (66ch)
    - SWIR: 920-2500 nm (174 ch)
- **Spectral width**
  - <14nm
- **Aperture diameter**
  - 210mm
- SNR
  - PAN: 240:1
  - VNIR: > 160:1 (450:1 @650nm)
  - SWIR: > 100:1 (>360 @1550nm)
- Thermal Control System
  - Double stage passive radiator + stabilization heater





On PRISMA hyperspectral imagery acquired over the Roccamurata site (Parma) on 16/10/2019, the following steps will be performed to produce the NOA outcrops map:

- Hard classification algorithms & Spectral features analyses
- Map validation using ground truths