Hyperspectral assessment of polluted sites

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Introduction

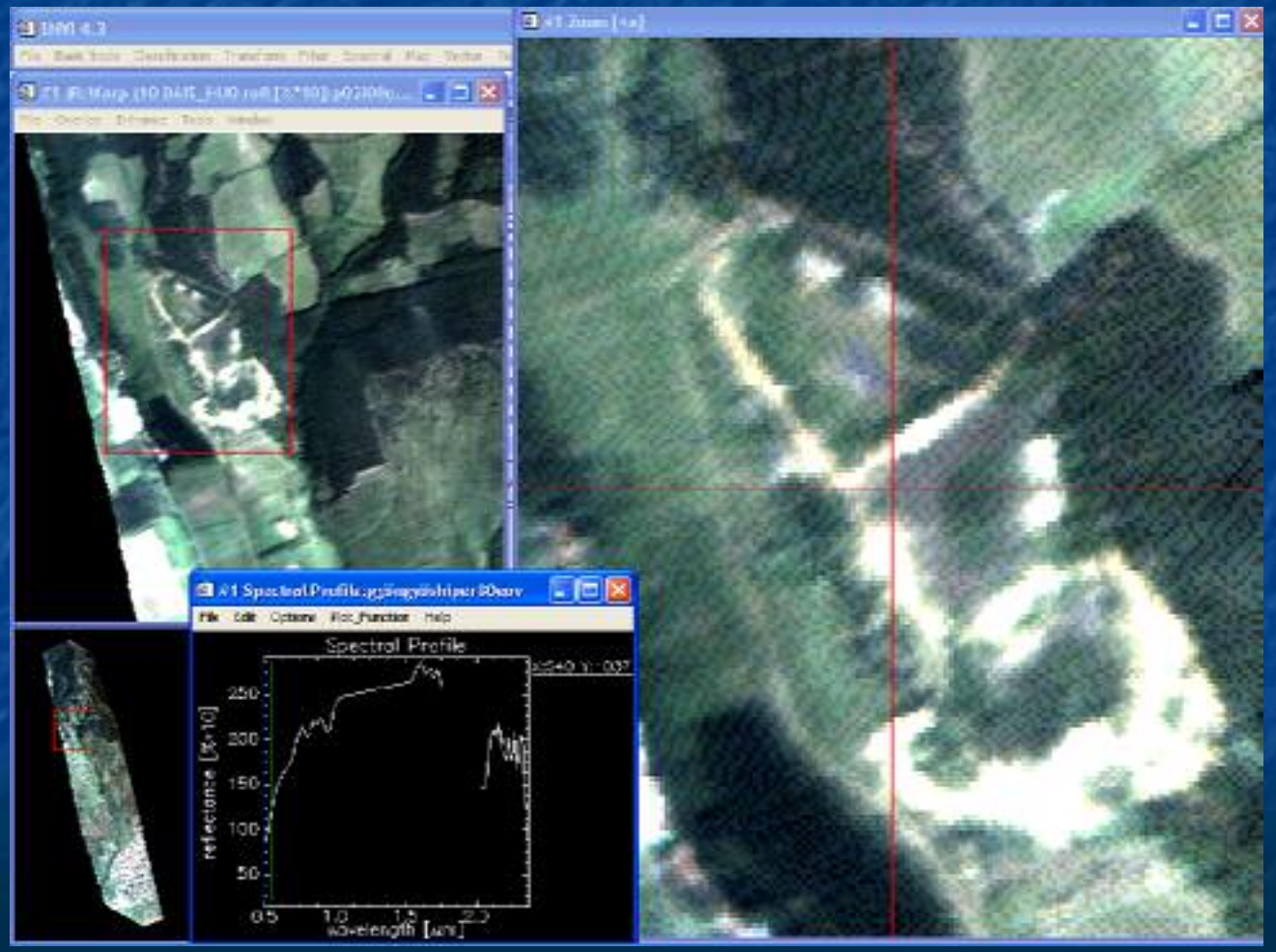
Mines and related mining activities, mine tailings, and wastes of ore smelters cause severe local environmental impact all over the world.

After leaving off, the recultivation of abandoned mining sites are often omitted, which could lead the contamination of soil, surface and underground water in long term, so these sites possess potential risk for the environment.

One of the most important achievement in remote sensing was the development of hyprespectral sensors and software to analyzed the obtained hyperspectral data. On hyperspectral images the reflectance of every pixel is measured in many narrow, but neighbouring wavelengths interval. The spectral profiles/properties of each pixels provide appropriate information for the identification of materials in pixels.

Materials and methods

- The examined area is flotation sludge reservoir of abandoned Pb-Zn mining site located in Gyöngyösoroszi, Northern Hungary



Materials and methods

- The hyperspectral image of the flotation sludge is obtained by using a Digital Airborne Imaging Spectrometer DAIS 7915, in the frame of DLR HySens first Hungarian hyperspectral flight campaign (21/08/2002).
- Technical parameter of DAIS 7915 sensor:
  - It has 80 spectral channels from visible to infrared interval;
  - 450 - 2450 nm: 72 narrowband channel for surface examination with special regard to soil and plant interactions;
  - 8000 - 12000 nm: 8 channel for determination of temperature.
- Parallel to the flight campaign heavy metal content of soil samples were examined from the area of the flotation sludge.

Materials and methods

Examined minerals:

- The oxidative acidic weathering of pyrirtic materials on mine tailings and flotation sludge significantly contribute to the acidification processes as well as the solubility of heavy metals (Pb, Zn, Cu, etc.) in water. Therefore, mapping of these acidic and heavy metal containing minerals is important in environmantal state assesment of the examined area:
  - jarosite ($KFe_3(SO_4)_2(OH)_6$),
  - sphalerit ((Zn, Fe)S),
  - pyrite (FeS_2),
  - galena (PbS),
  - goethite (FeO(OH)).

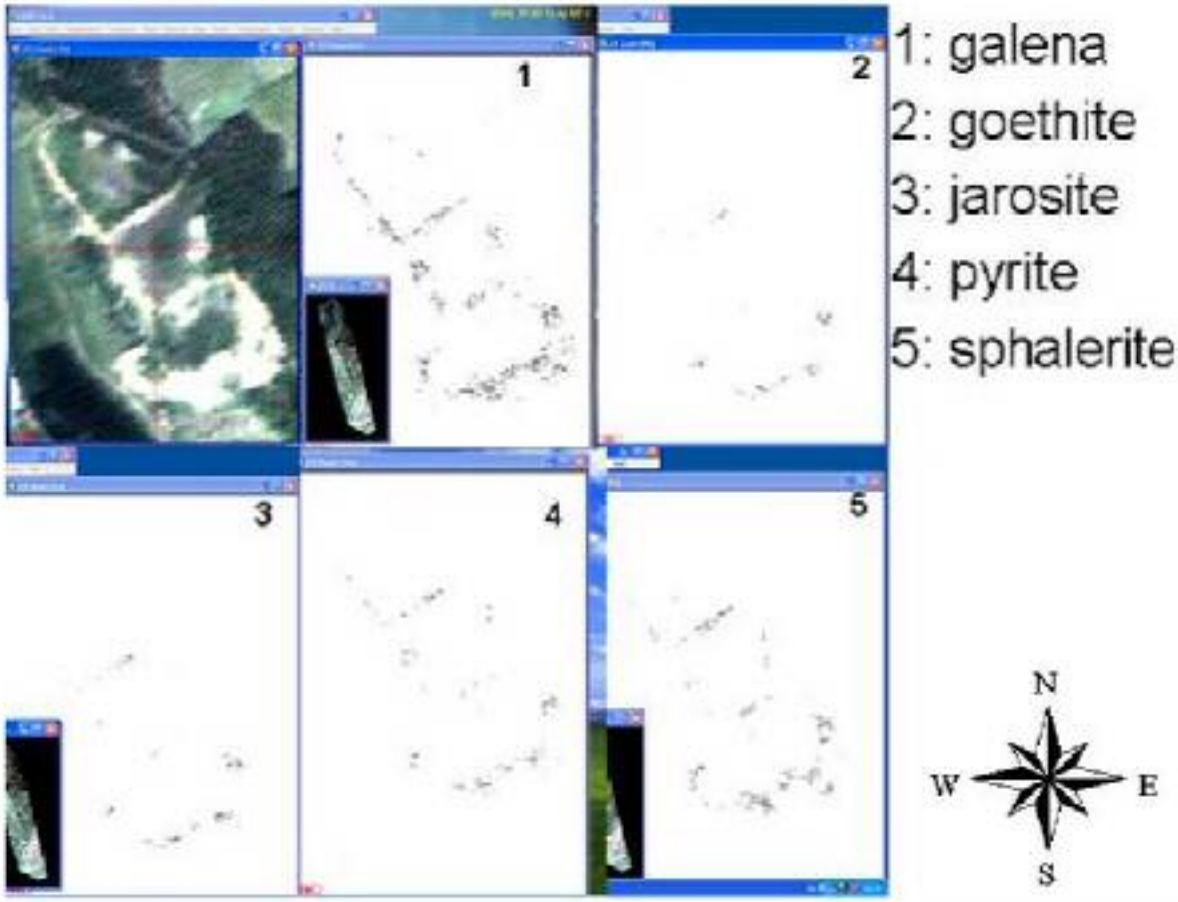
Materials and methods

- Applying the Spectral Angle Mapper with BandMax classification in ENVI 4.3 software the distribution of minerals (galena, pyrite, sphalerite, goethite, jarosit) in the area was defined based on the USGIS standard spectral profiles of the minerals.
- The DAIS sensor recorded spectra at SWIR I,II (1,5-1,8; 2,0-2,5 μm) as well, which can be used for the determination of heavy-metal containing minerals.
- Principal component analysis and correlation coefficient were counted within heavy metals based on the measured heavy metal content of samples.

Results

According to the results, all of the mineral formations (containing Pb/Zn) have the same spatial distribution in flotation sludge reservoir.

Figure1.: Spatial distribution of different minerals



Results

The highest correlations were found between Pb-Zn, Fe-Zn and between Fe-Pb (Table 1). This result are also supported by the results of the principal component analysis, where usually Pb, Zn, Fe introduce the main component.

Table 1. Correlations between heavy metals

	Whole	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Pb-Zn	**0.902***	**0.935***	**0.797***	**0.655***	**0.948***
Pb-Fe	**0.828***	**0.674***	0.412*	**0.604***	0.418
Pb-As	0.225*	**0.730***	**0.843***	**0.815***	**0.815***
Pb-Cu	0.414	**0.929***	-	0.211	**0.853***
Zn-Fe	**0.877***	0.535*	0.206	0.256	0.347
Zn-Cu	0.171*	**0.985***	-	0.188	**0.679***
As-Fe	0.181*	**0.825***	0,529*	**0.684***	0.495
As-Zn	0.210	0.553*	**0.660***	0.257	**0.800***
Ni-Cr	0.329*	**0.864***	0.089	**0.947***	0.332
Ni-Cu	0.115	-0.072	-	**0.857***	-0.050
Cu-Cr	0.060	-0.084	-	**0.928***	-0.091

* Significant at p<0,01

- Cu is not detetected

Results

At the examined site, in the frame of hyperspectral information, the spatial distribution of Pb, Zn, Fe containing minerals are similar, which was verified by the analysis of heavy metal content of the soil samles. This result suggests, that hyperspectral remote sensing is an effective tool for the characterization and modeling the distribution of Pb, Zn and Fe containing minerals at the examined heavy metal polluted sites.

- It provides wide range of information in no time.
- Validation (field measurements, soil samples) is necessary to carry out in order to obtain more precise and reliable results.
- Nevertheless, the effect of the vegetation and other objects should also be assessed during mineral mapping.

Thank you for the attention!