Mining and post mining Earth Observation applied research and technology from EuroGeoSurveys

Gerardo Herrera

Earth Observation and Geohazards Expert Group

Outline

1. Earth Observation and Geohazards Expert Group
2. Mining EO activities
3. Post mining EO activities
4. Future perspectives

Earth Observation and Geohazards Expert Group

Mission and vision

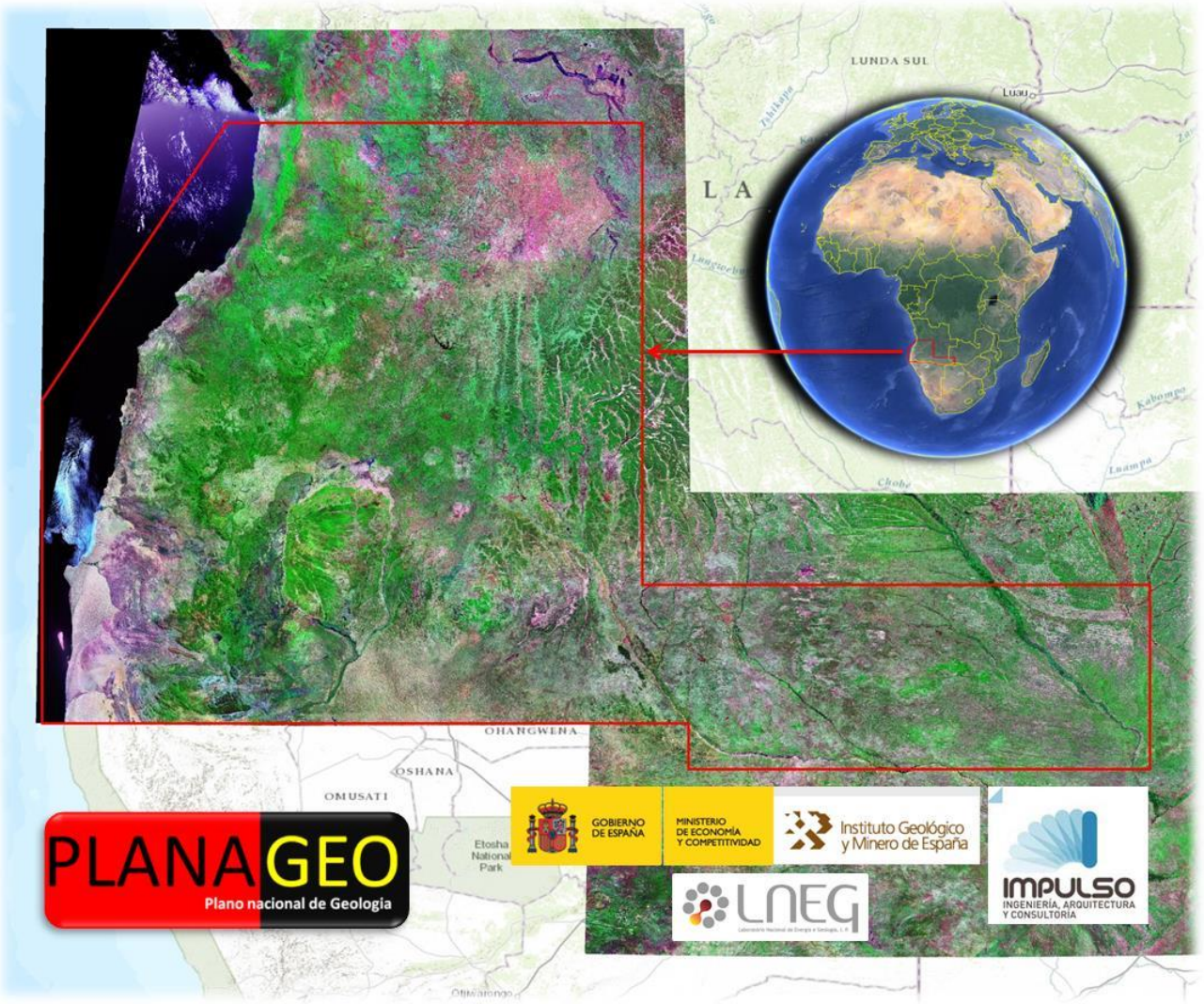
- **Apply Earth Observation technology to improve geoscience delivery** on minerals, mining, environment, geohazards
- **Deliver harmonized pan-european geo-information** improving the operational capacity and economic capabilities of governments, institutions, organizations, businesses and individuals.

Mining EO activities

- Geological mapping – regional scale
- Mineral classification in mining areas
- Mapping and monitoring mining activities
- Mining risk assessment: simulation of mine spills

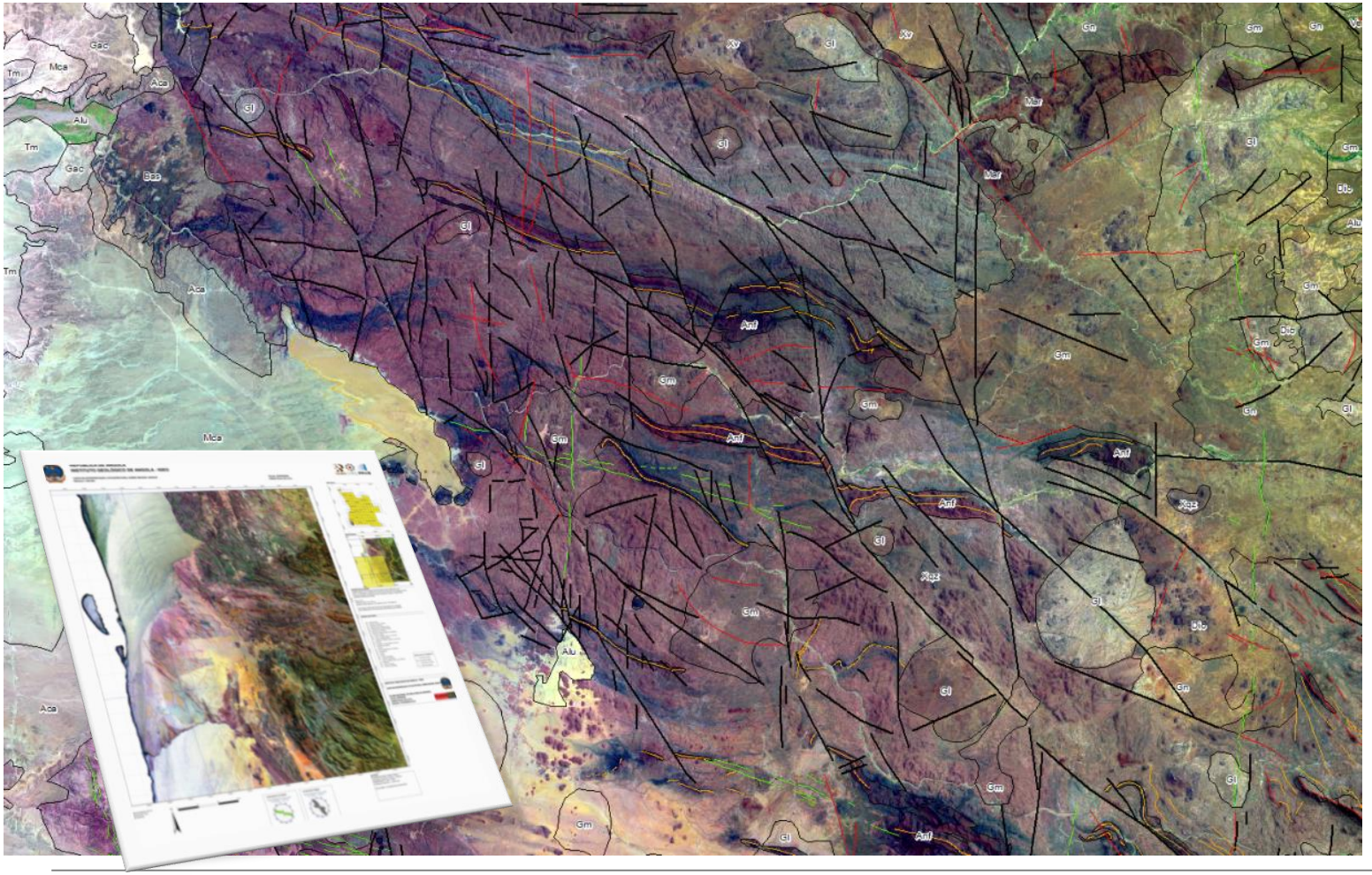
Geological mapping

Angola Geology map



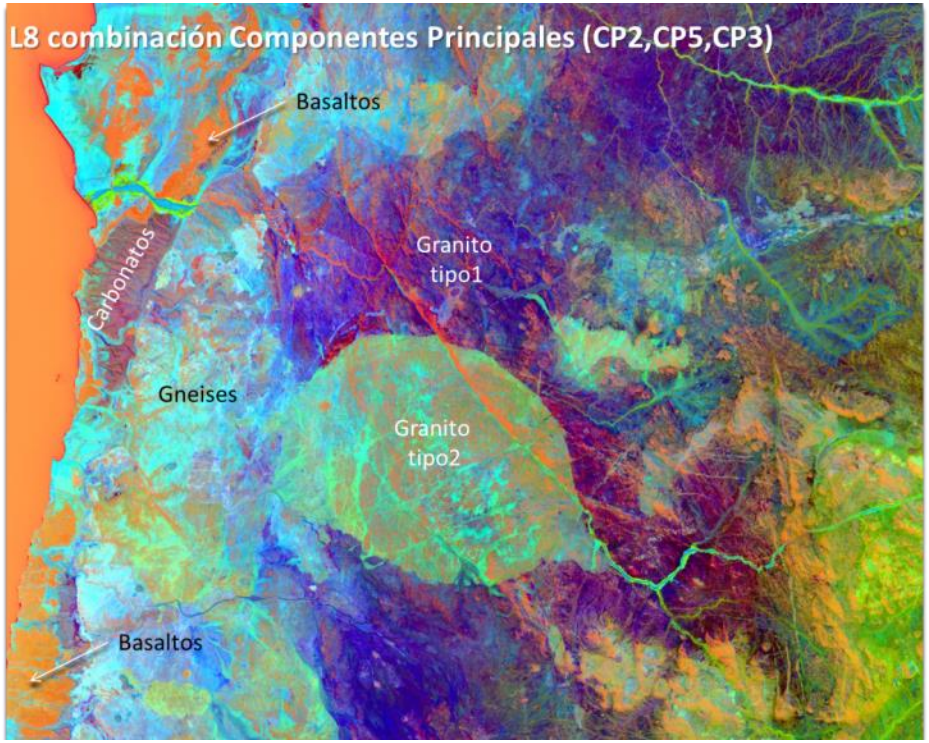
Geological mapping

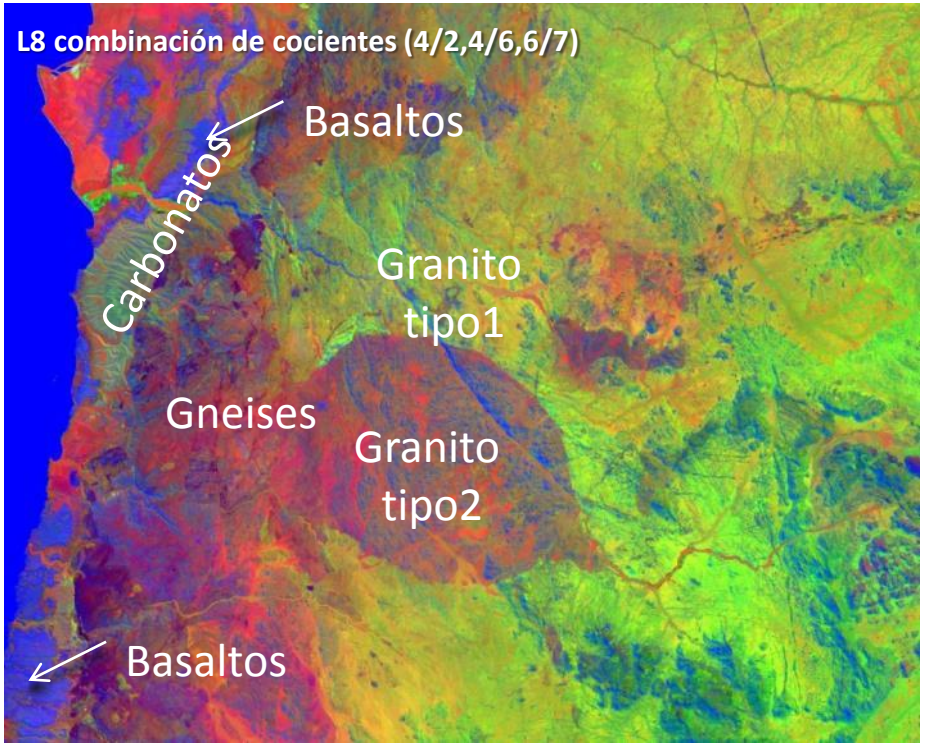
Lito-structural mapping in Angola



Geological mapping

Lito-structural mapping in Angola





Mineral mapping in mining areas

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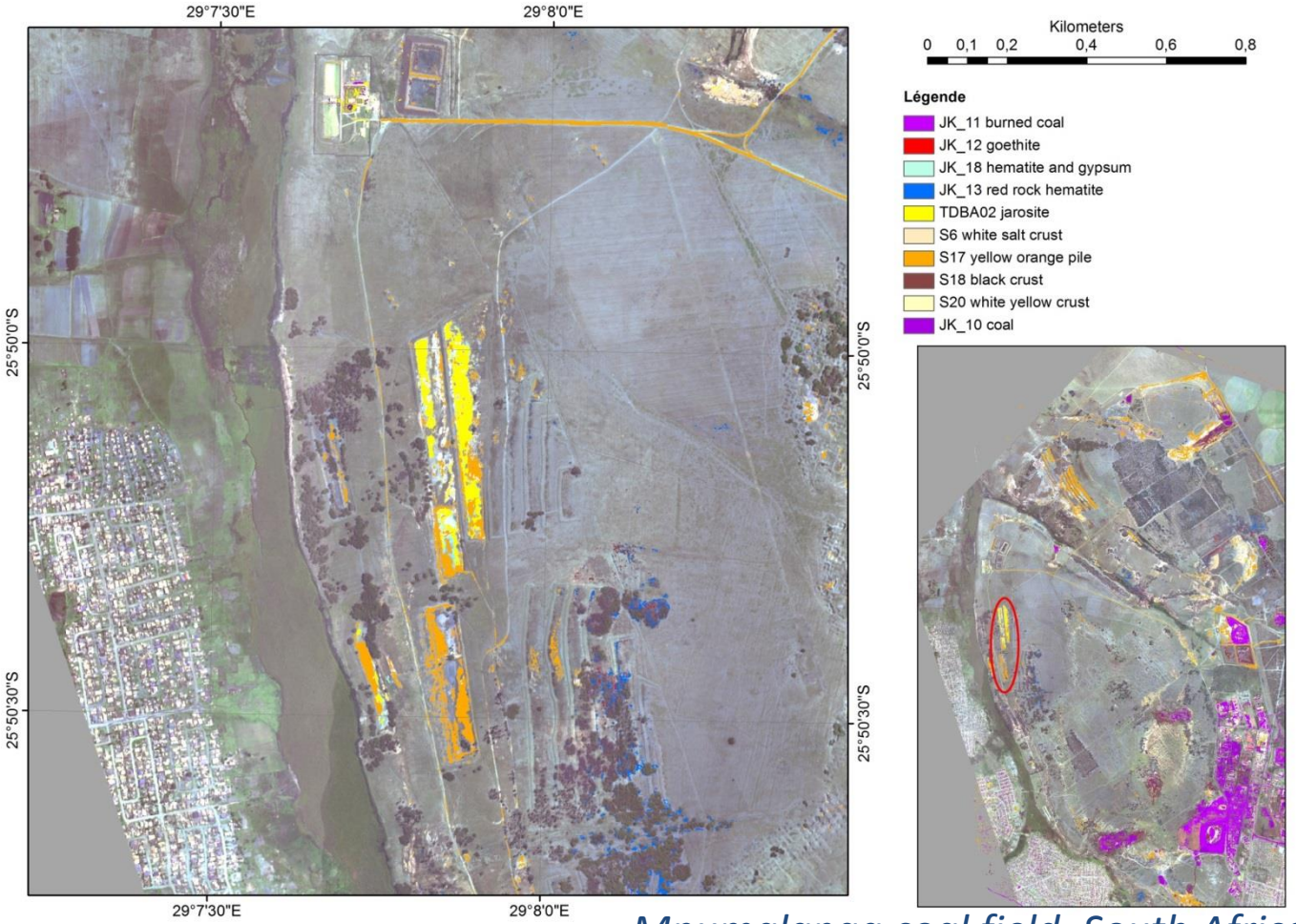
Mapping Acid Mine Drainage minerals from hyperspectral imagery

In mining areas hyperspectral imagery is analysed to map Acid Mine Drainage minerals and residues. In this example we can see Jarosite in yellow, goethite and mining related surface workings in orange and dumped coal in violet and purple



Mpumalanga coal field, South Africa

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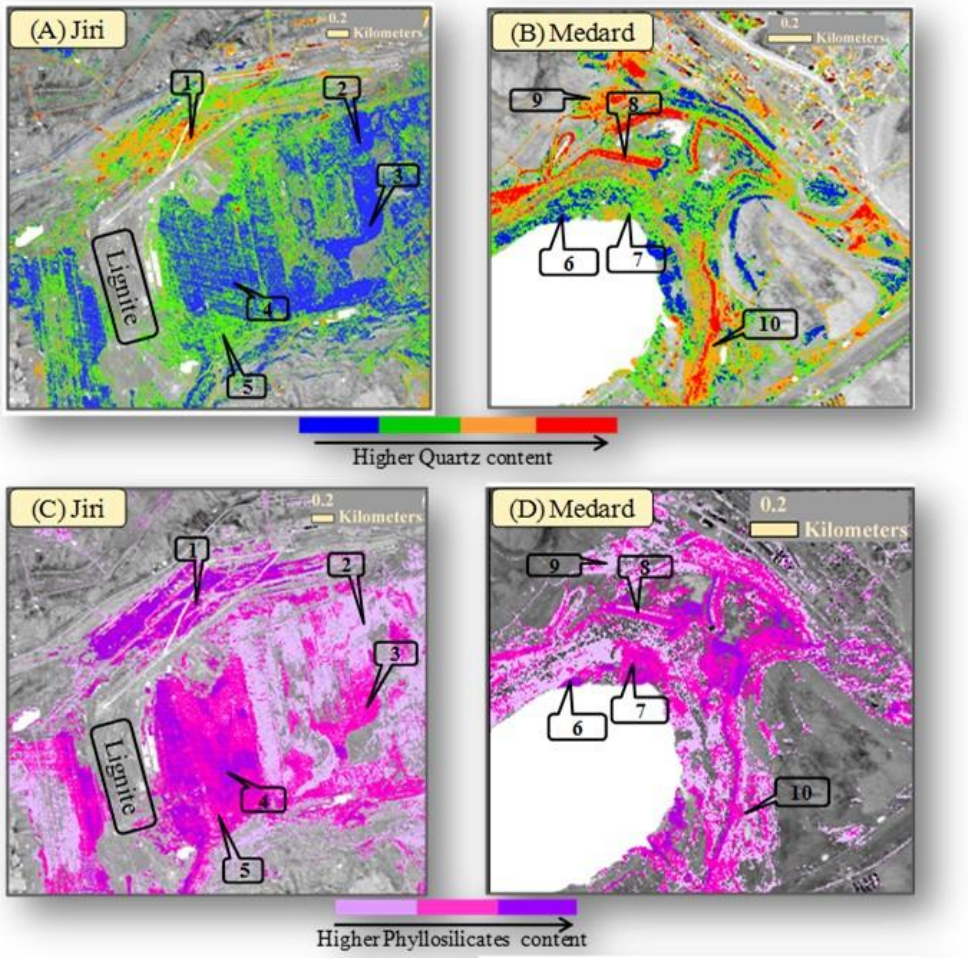
Mineral mapping in mining areas

Airborne multispectral data in the thermal region (LWIR) and hyperspectral data in the optical region (VNIR-SWIR), acquired with the Airborne Hyperspectral Scanner (AHS) sensor were analyzed to map quartz (LWIR), phyllosilicates and kaolinite (SWIR) content in the exposed surface

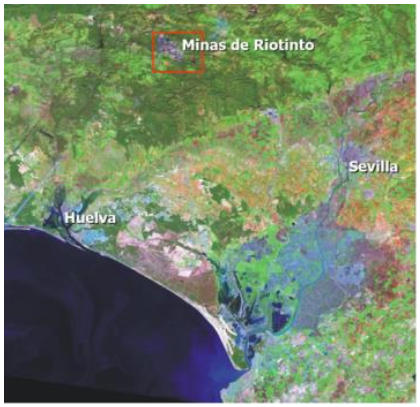


Sokolov Lignite Open-Pit Mines, Czech Republic

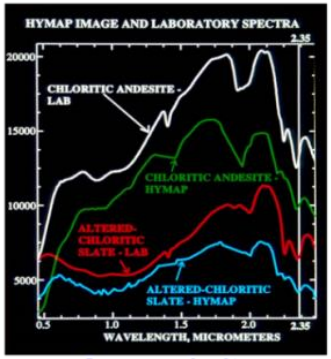
Notesco, G. – Kopačková V. – Rojík, P. – Schwartz, G. – Livne, I. – Ben-Dor, E. (2014): Mineral Classification of Land Surface Using Multispectral LWIR and Hyperspectral SWIR Remote-Sensing Data. A Case Study over the Sokolov Lignite Open-Pit Mines, the Czech Republic. – Remote Sensing 6, 8, 7005-7025. ISSN 2072-4292 (on line). DOI 10.3390/rs6087005.

Mineral mapping in mining areas

Iberian Pyrite Belt mineral mapping from hyperspectral analysis of HyMap images in Rio Tinto mines (Huelva, Spain) to map clorite and moscovite minerals



Landsat TM5 Feb. 99



Curvas clorita

- Rocas con clorita hidrotermal
- Rocas con clorita metamórfica
- Clorita & moscovita en rocas básicas

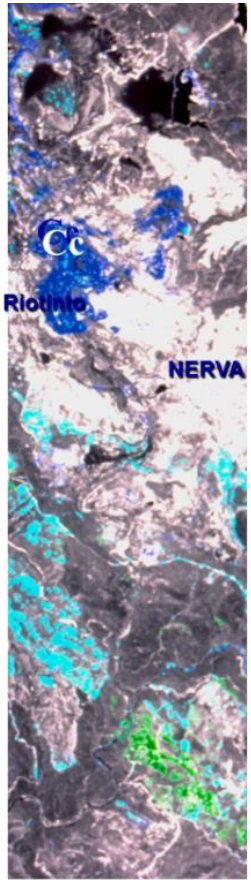
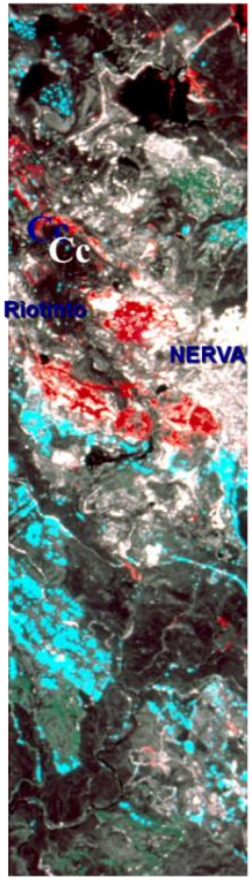
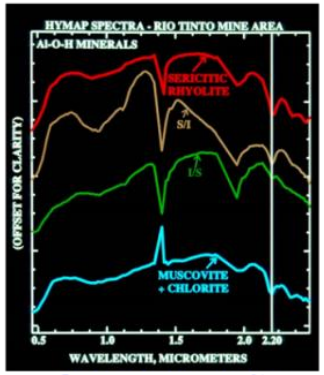


Imagen de fracciones clorita





Curvas moscovita

- Rocas volcánicas ácidas con moscovita hidrotermal
- Clorita & moscovita en rocas básicas

Imagen de fracciones minerales AlOH

Mining subsidence monitoring

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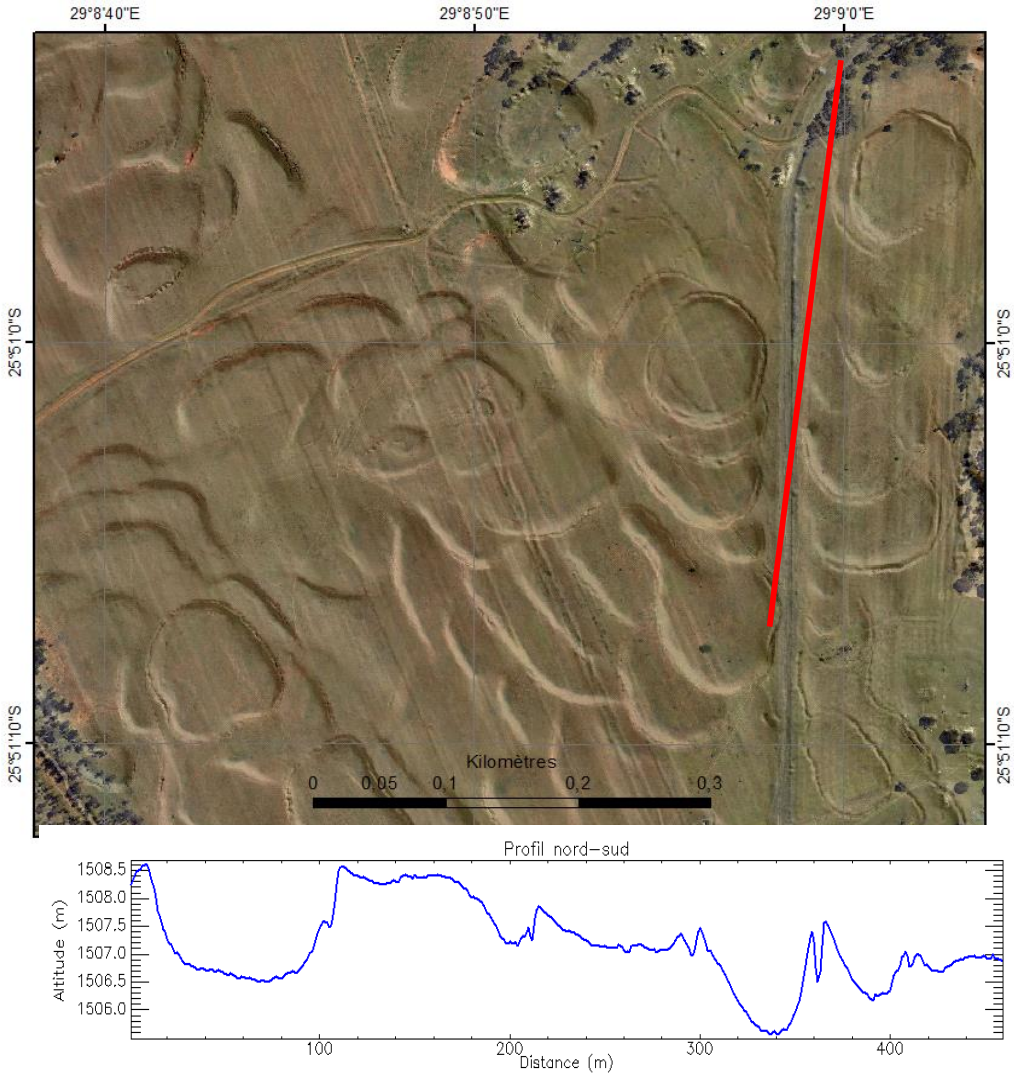
Measuring metric subsidence due to underground “chamber and pillar” exploitation of coal seams from LiDAR DSM

Mpumalanga coal field, South Africa



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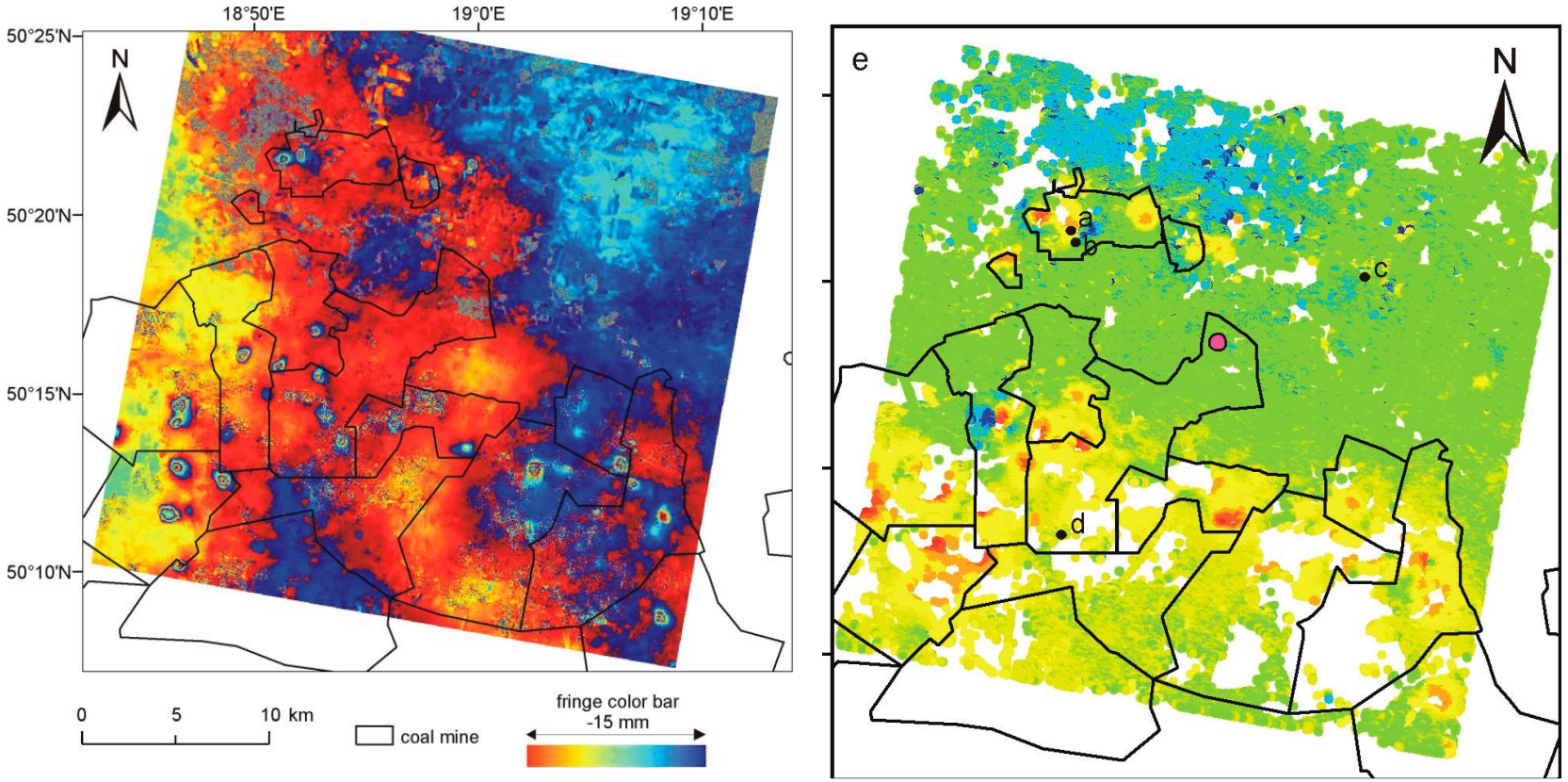
Mining subsidence monitoring

Detection of underground coal mining subsidence in urban areas using Radar Interferometry: USCB (Poland)



Przyłucka, M.; Herrera, G.; Graniczny, M.; Colombo, D.; Béjar-Pizarro, M. Combination of Conventional and Advanced DInSAR to Monitor Very Fast Mining Subsidence with TerraSAR-X Data: Bytom City (Poland). Remote Sens. 2015, 7, 5300-5328.

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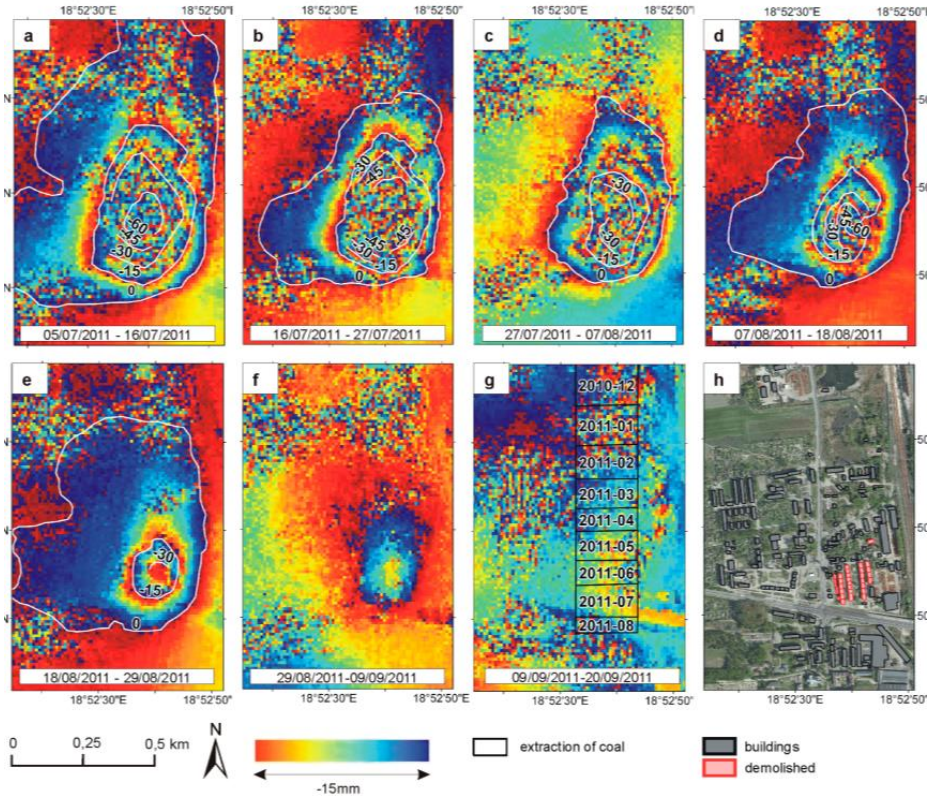

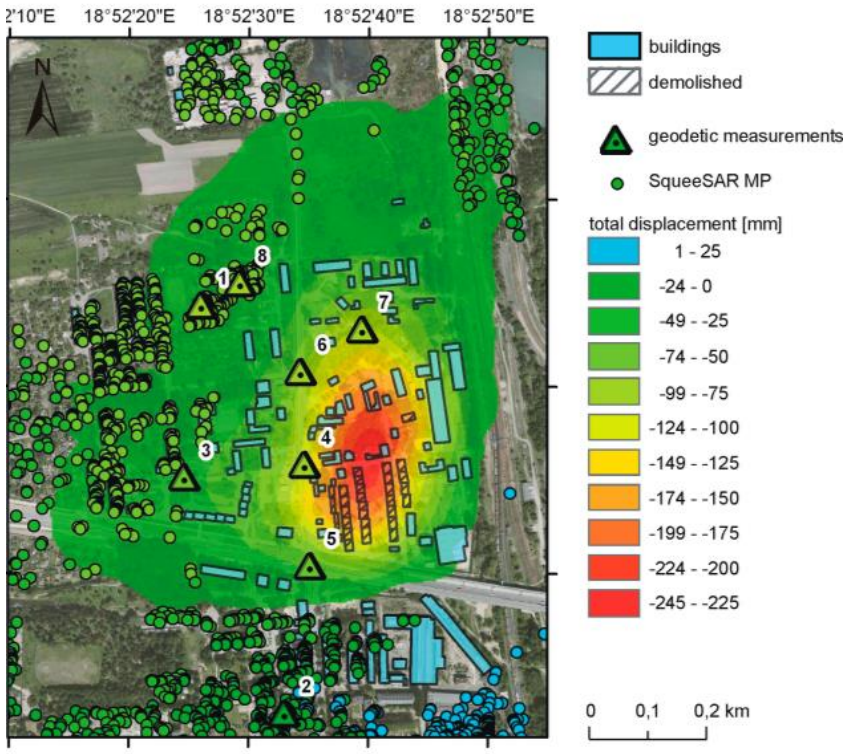

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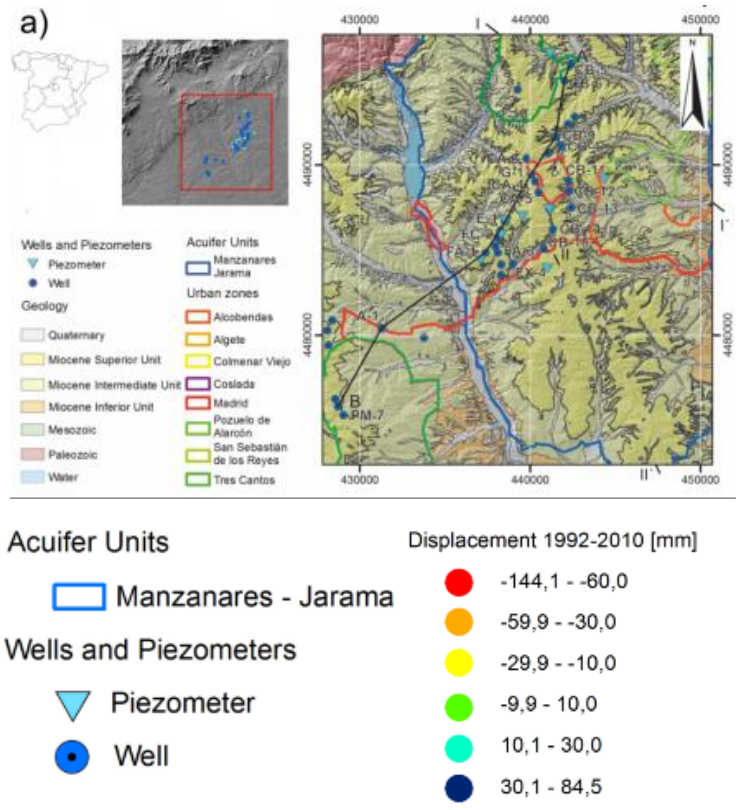
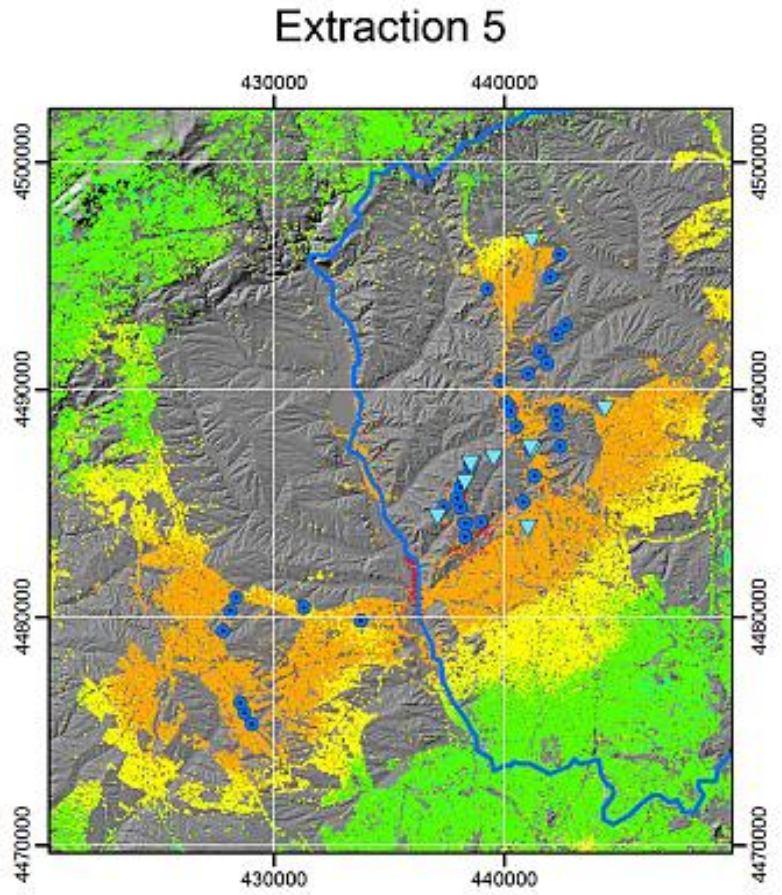
Groundwater mining monitoring & modelling

InSAR based estimation of groundwater variations in exploited aquifers: Madrid case study (Spain)





Béjar et al. 2015. Evaluation of the potential of InSAR time series to study the spatio-temporal evolution of piezometric levels in the Madrid aquifer

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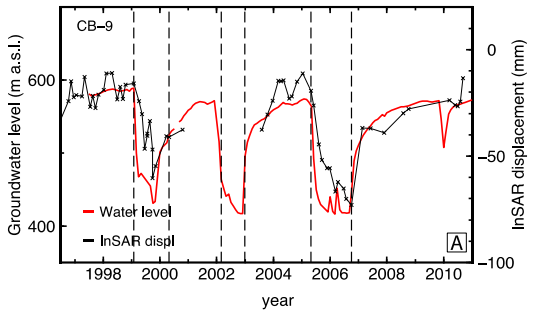
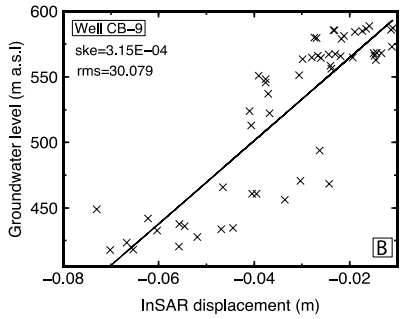
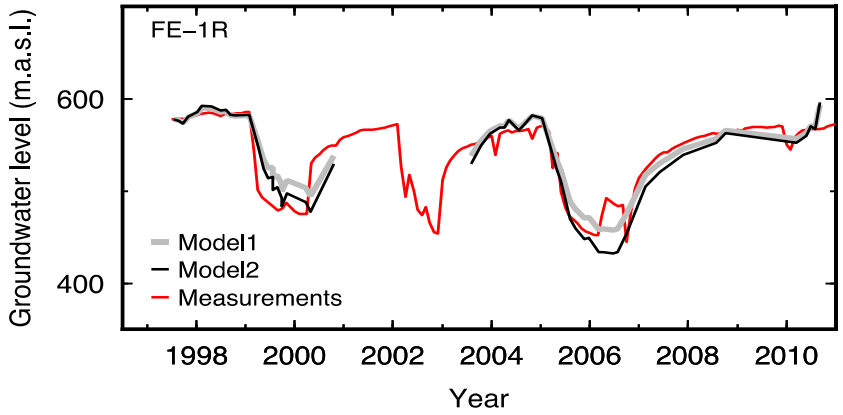
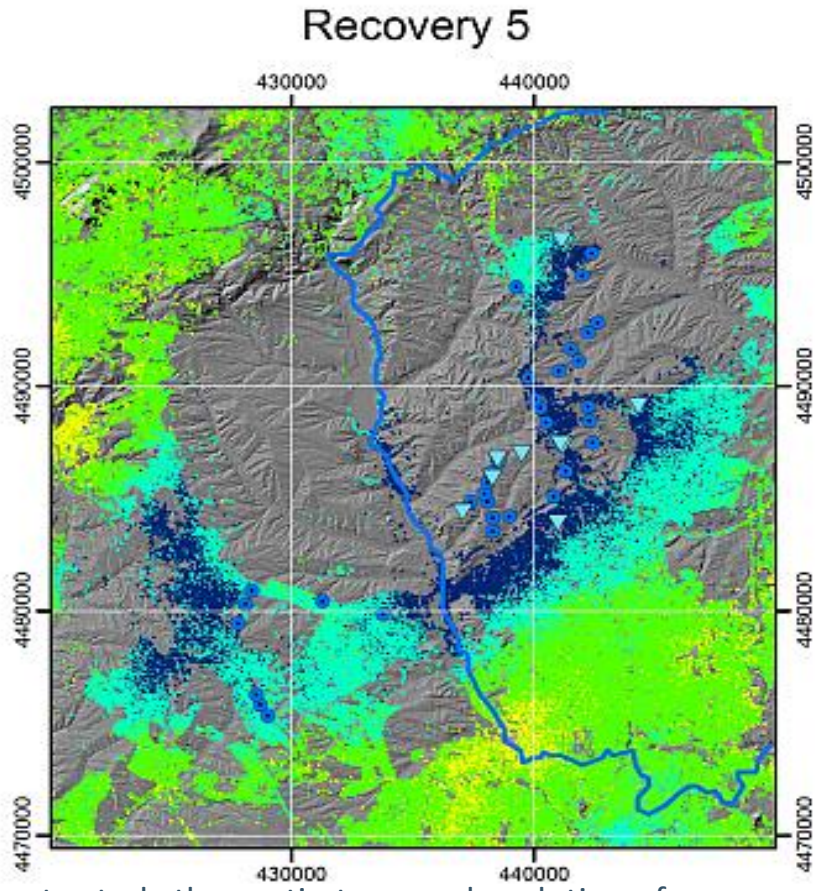




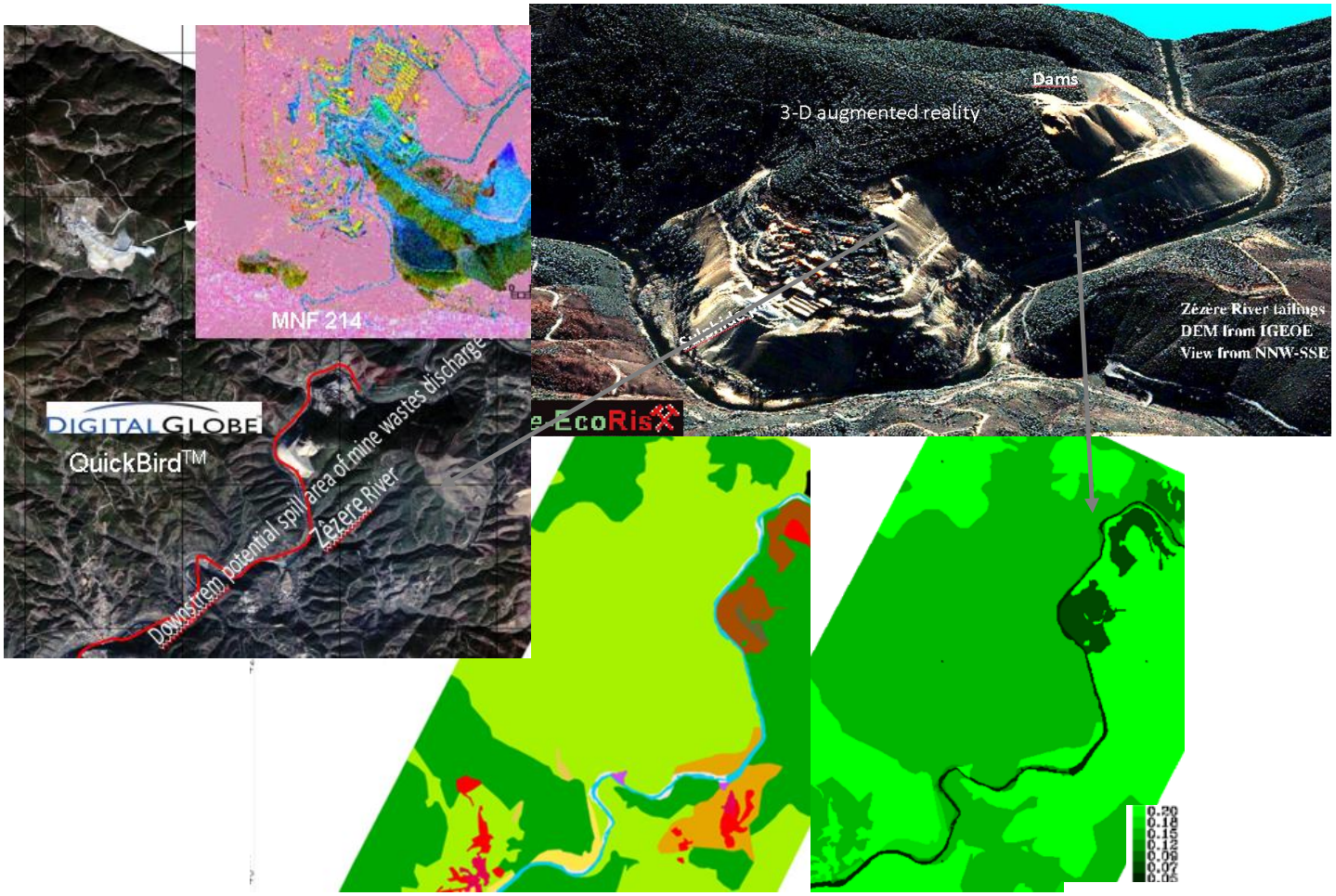




Béjar et al. 2015. Evaluation of the potential of InSAR time series to study the spatio-temporal evolution of piezometric levels in the Madrid aquifer

Mining risk assessment: simulation of mine spills

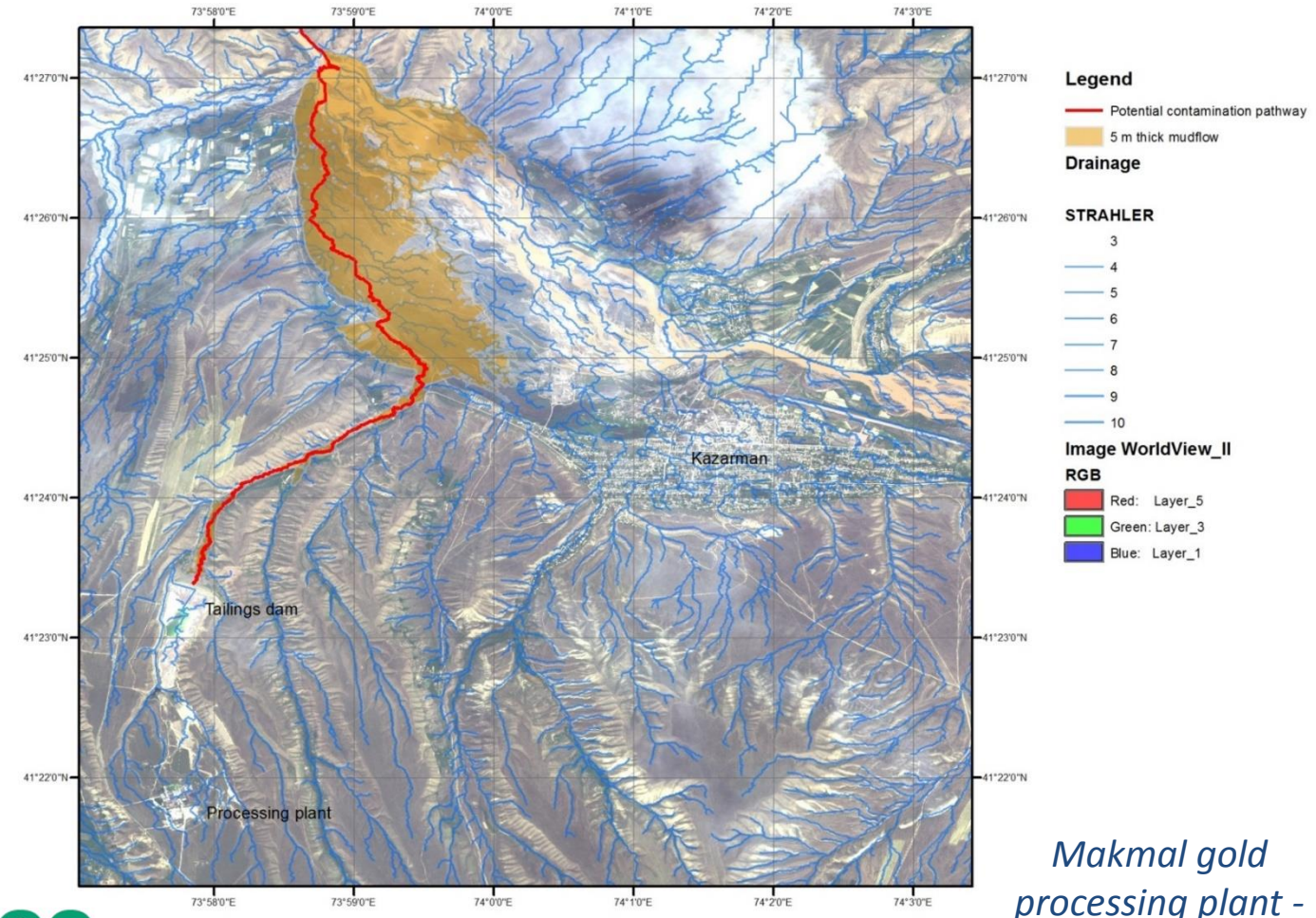
Land cover mapping of high spatial resolution (Corine legend) and derived roughness Mannings coefficient as knowledge components for simulation of mine spills



e-EcoRisk – A Regional Enterprise Network Decision-Support System for environmental Risk and Disaster Management of Large-Scale Industrial Spills (EVG1-CT-2002-00068) 2004-2007

Modelling tailings dam failure from very high resolution satellite imagery

Modelling tailings dam failure from very high resolution satellite imaginery show that the maximum possible extension of a 5-meter thick mud flow (in light brown) will affect only the most western part of the town of Kazarman and the Naryn river floodplain, potentially leading to grassland contamination



Makmal gold processing plant - Kyrgyzstan

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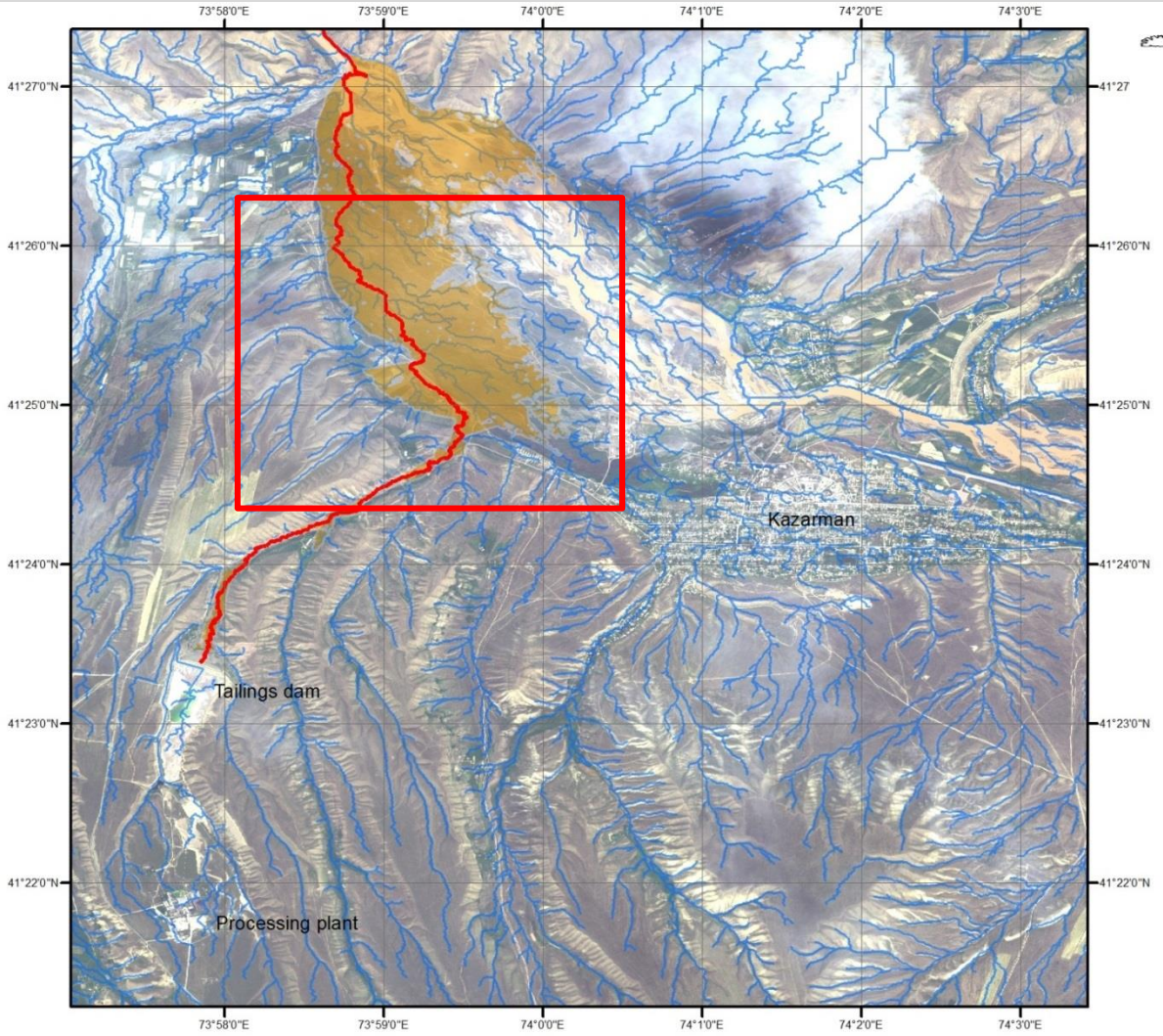
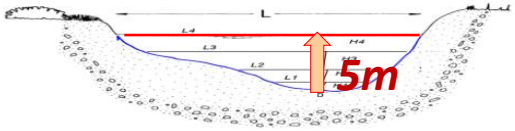
Modelling tailings dam failure from very high resolution satellite imagery





Drainage

STRAHLER

3
4
5
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10

Image WorldView_II

RGB

Red: Layer_5
Green: Layer_3
Blue: Layer_1

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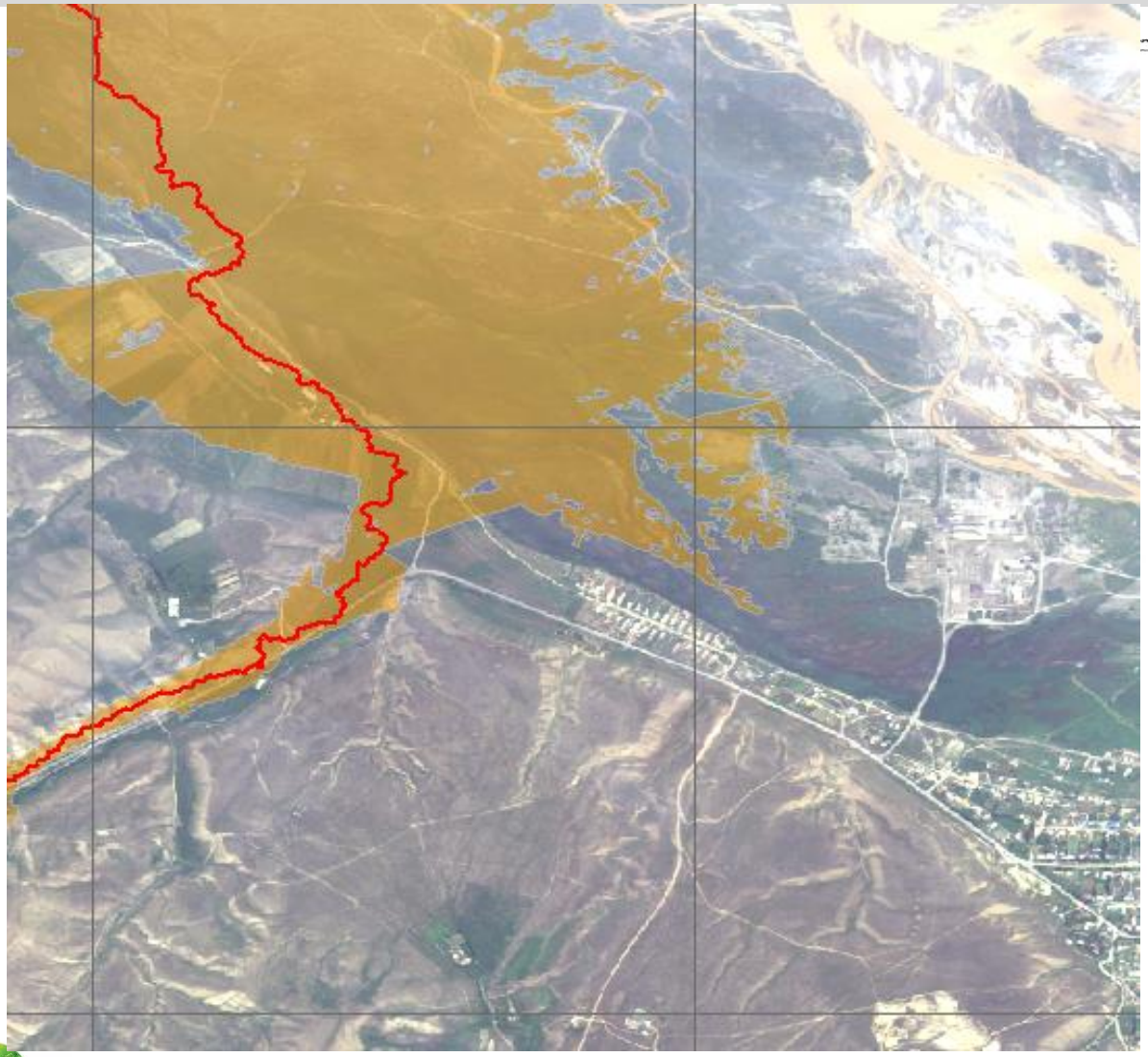

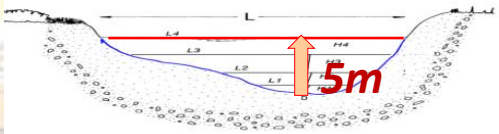

Drainage

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Makmal gold processing plant - Kyrgyzstan

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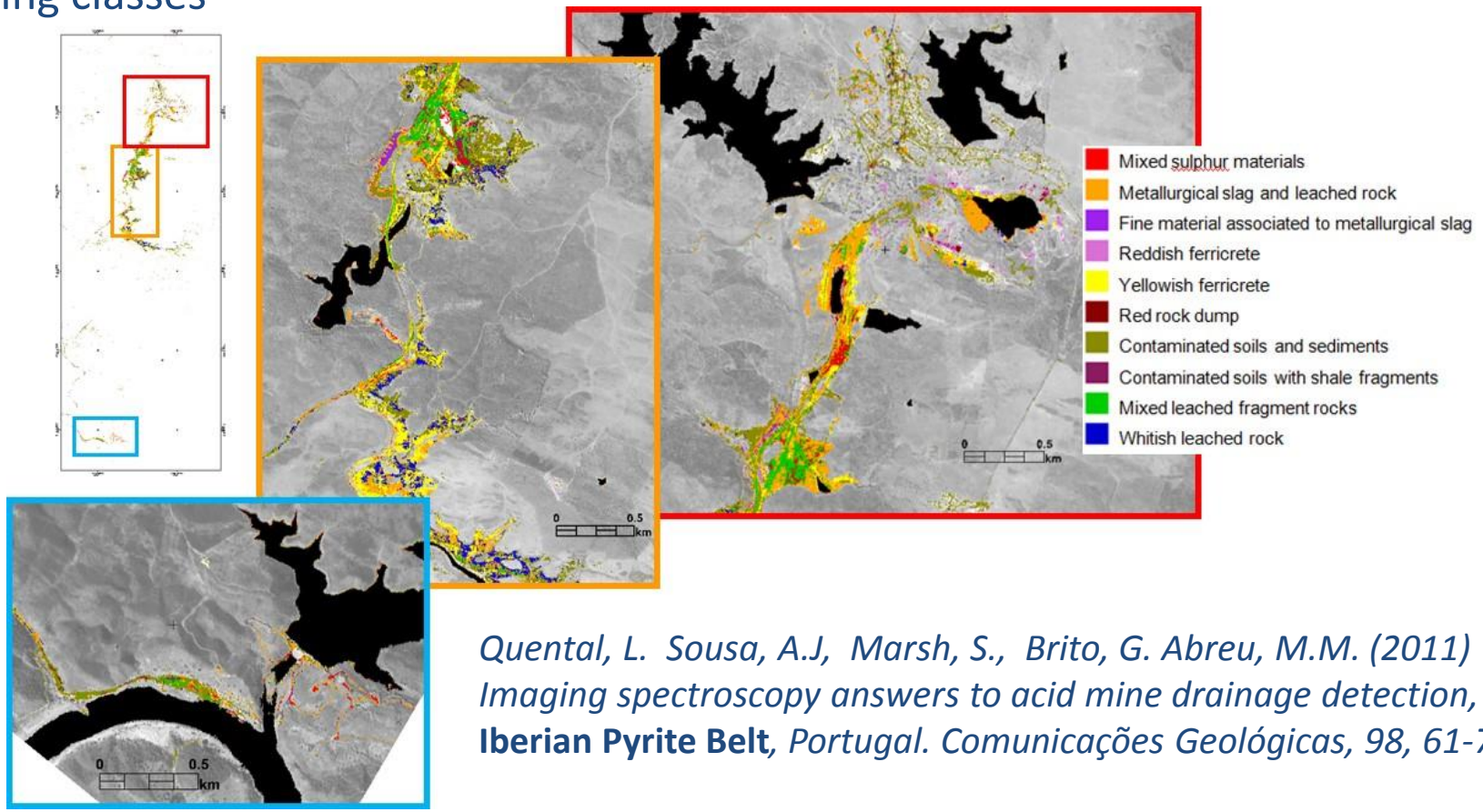
Post-mining EO activities

- Mining waste & spill mapping
- Acid Mine Drainage/pH mapping in open-pit mines using image spectroscopy
- Mapping components of mining waters
- Forest health assessment

Mining waste mapping

Iberian Pyrite belt mining waste mapping using hyperspectral HyMap sensor and field meaurements in order to associate chemical charcateristics to the spectral mapping classes

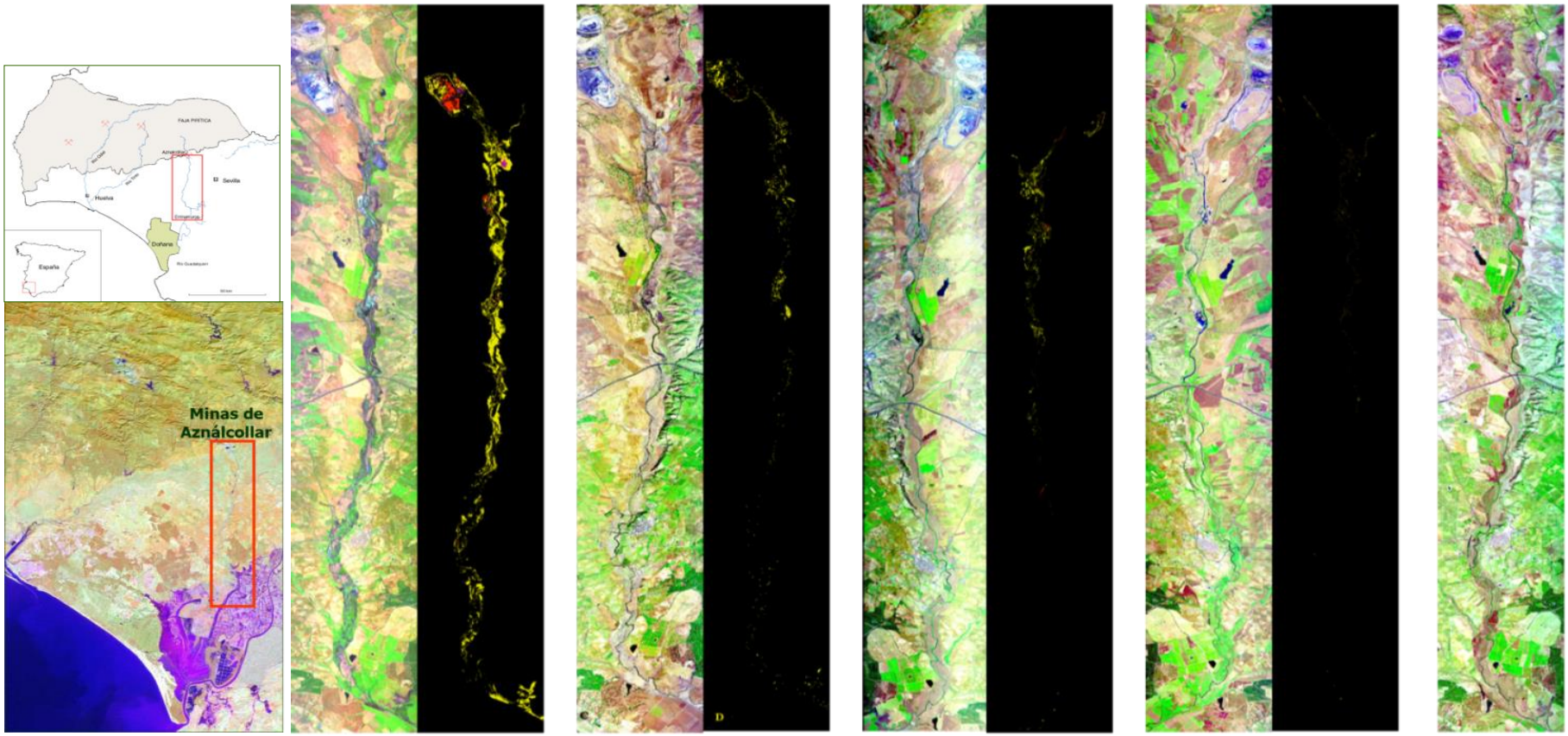


Quental, L. Sousa, A.J, Marsh, S., Brito, G. Abreu, M.M. (2011) Imaging spectroscopy answers to acid mine drainage detection, **Iberian Pyrite Belt**, *Portugal. Comunicações Geológicas, 98, 61-71.*

Mining spill mapping

Instituto Geológico y Minero de España

Multispectral monitoring (1998-2001) of pyrite mud and sulfates during the remediation works of a tailing dam spill in the Iberian Pyrite belt



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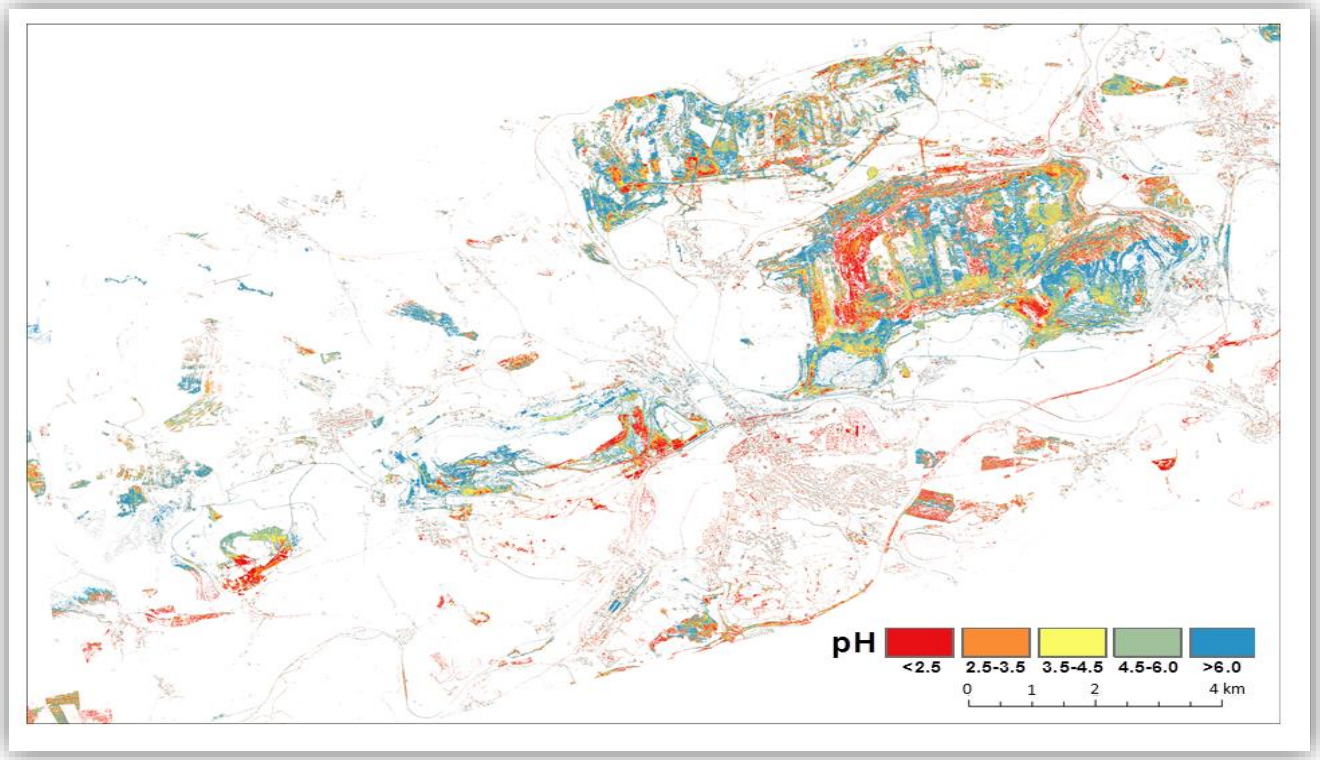
Acid Mine Drainage/pH mapping

Aiborne hyperspectral HyMap & field data was used to propose a geochemical model of this open pit mining area and estimate surface pH



- Pyrite, jarosite or lignite (<3.0)
- Jarosite & goethite (3.0–6.5)
- Goethite (>6.5)

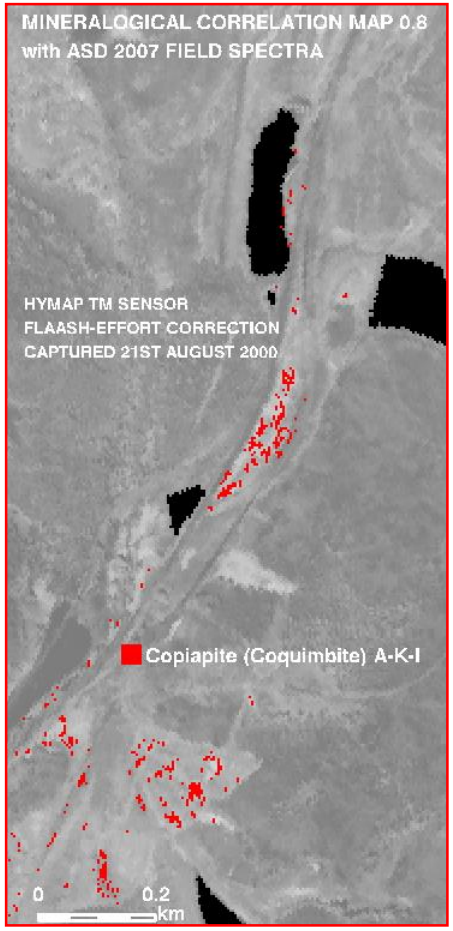
Sokolov Lignite Open-Pit Mines, Czech Republic

Kopačková, V. (2014). *Using multiple spectral feature analysis for quantitative pH mapping in a mining environment*. International Journal of Applied Earth Observation and Geoinformation, 28, 28-42. http://dx.doi.org/10.1016/j.jag.2013.10.008

Acid Mine Drainage/pH mapping

Mineralogical mapping for pH monitoring with hyperspectral multi-sensor image and field spectra in the Iberian Pyrite belt

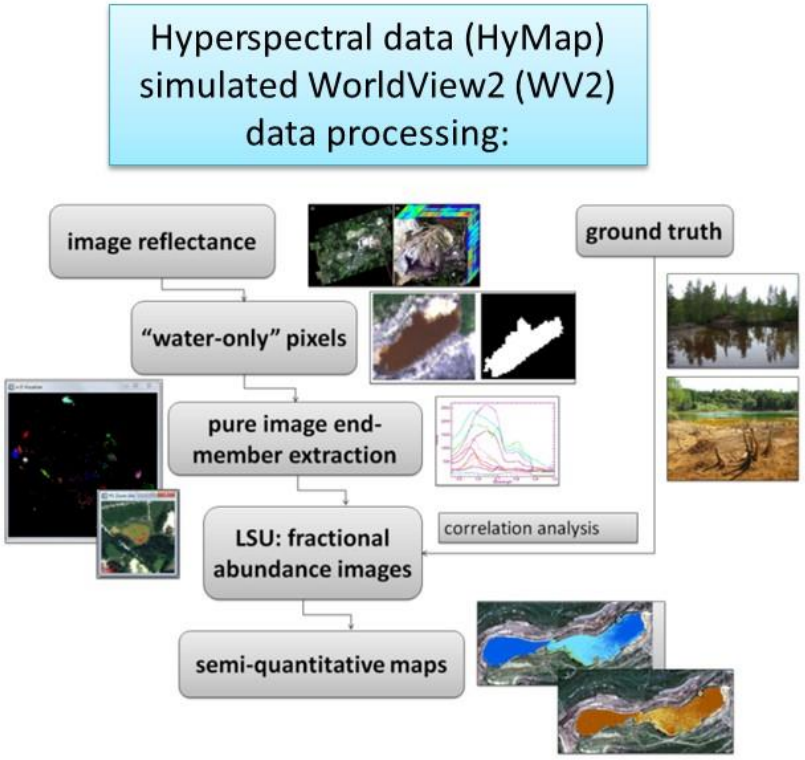
COPIAPITE-COQUIMBITE-ALUNITE
pH < 3
exclusive signature based on correlation with mineralogical spectral libraries

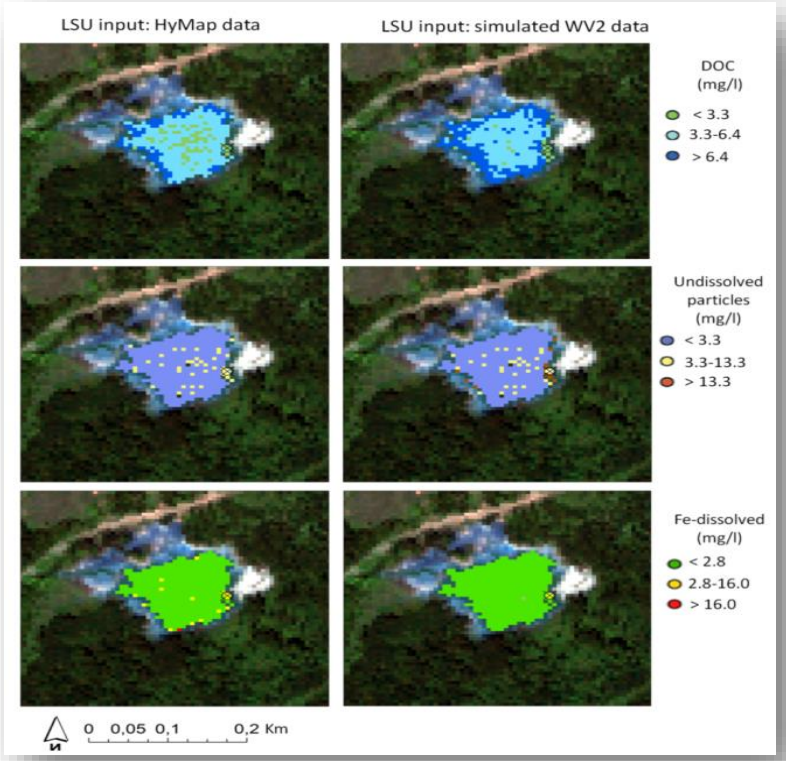


HYPMINGEO - Hyperspectral images applied to environmental monitoring of mining areas, optimised using geostatistics- http://www.eufar.net/experiment/rprojects/specproj.php?num=346 (EUFAR, 6PQ) March 2007

Mapping components of mining waters

Linear Spectral Unmixing (LSU) method for the analysis of HyMap and WV2 data to map mine water components: dissolved Fe_s, dissolved organic carbon—DOC, undissolved particles

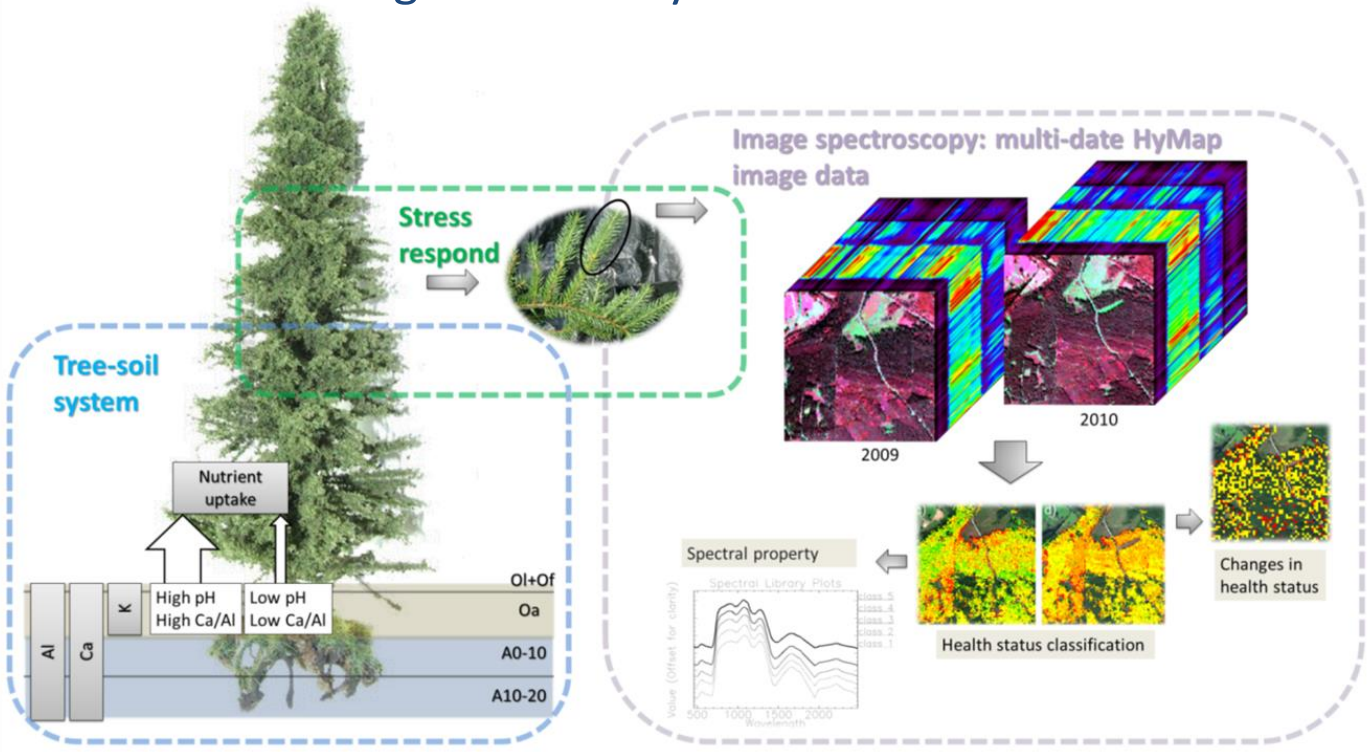




Kopačková V. – Hladíková, L. (2014): Applying Spectral Unmixing to Determine Surface Water Parameters in a Mining Environment. – Remote Sensing 6, 11, 11204-11224. ISSN 2072-4292. DOI 10.3390/rs61111204.

Forest health assessment

Using multi-date high spectral resolution data to assess the physiological status of macroscopically undamaged foliage on a regional scale, demonstrate the potential application of RS for monitoring forest ecosystems.



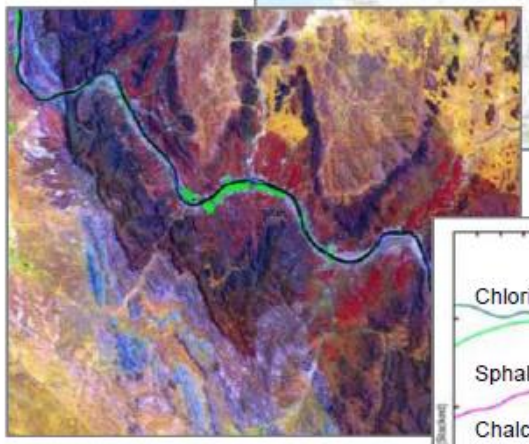
Kopačková, V., Mišurec, J., Lhotáková, Z., Oulehle, F., & Albrechtová, J. (2014). *Using multi-date high spectral resolution data to assess the physiological status of macroscopically undamaged foliage on a regional scale*. International Journal of Applied Earth Observation and Geoinformation, 27, 169-186. http://dx.doi.org/10.1016/j.jag.2013.09.009

Hyperspectral remote sensing

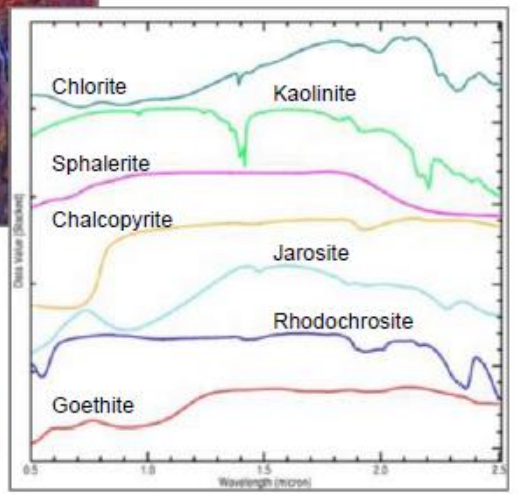
Environmental Mapping and Analysis Program (EnMAP) is a hyperspectral satellite mission for geology and exploration, to be launched in 2018.

Currently, a pilot study is being carried out in South Africa for the spectral characterization of ore deposits and their geological settings using hyperspectral flight campaigns.

Topographic map of South Africa



BIF's near Prieska, South Africa
LandSat 8, color composite
(7, 5, 2 (RGB))



Reflectance spectra of exploration relevant minerals

Future perspectives

- Training capacities in Mining and Post-mining Earth Observation
  - Multispectral, hyperspectral, Radar Interferometry, Geohazards related to mining, environmental impact, GIS & Geostatistics
- Exchange of researchers & technicians in these topics
- Elaboration of joint project proposals, e.g. H2020 calls

Thank you!

This presentation was made by:

- Gerardo Herrera – IGME (Spain): g.herrera@igme.es
- Juan Carlos Gumiel – IGME (Spain): jc.gumiel@igme.es
- Lidia Quental – LNEG (Portugal): lidia.quental@lneg.pt
- Stephane Chevrel – BRGM (France): s.chevrel@brgm.fr
- Veronika Kopacková – CGS (Czech Republic): Veronika.Kopackova@seznam.cz
- Maria Przylucka – PGI (Poland): Maria.Przylucka@pgi.gov.pl
- Marta Bejar – IGME (Spain): m.bejar@igme.es
- Michaela Frei –BGR (Germany): Michaela.Frei@bgr.de
- Eleftheria Poyiadji –IGME GR (Greece): kynpo@igme.gr
- Valerio Comerci – ISPRA (Italy): valerio.comerci@isprambiente.it


Muchas gracias!
Gerardo Herrera
g.herrera@igme.es