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Introduction of Remote Sensing Methods for Monitoring the Under Restoration Amiantos Mine, Cyprus

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Presentation Outline

- **Who we are: EuroGeoSurveys**
- **GEO-CRADLE Overview**
- **Pilot: The Amiantos abandoned Asbestos Mine**
- **Feasibility study – the methodology**
- **Results from selected remote sensing techniques**
- **Discussion**

EuroGeoSurveys (EGS) – Geological Surveys of Europe

37 Geological Surveys

Earth Observation and Geohazards Expert Group

Chair: Gerardo Herrera (IGME SPAIN)

Deputy chairs:

- Eleftheria Poyiadji (IGME GR): responsible for Geohazards
- Maria Przyłucka (PGI): responsible for Geohazards EO
- Veronika Kopackova (CZH): responsible for Raw materials EO

Mission and vision:

- Assessment of geohazards
- Application of Earth Observation tools to geohazards and raw materials

Members: 28 Geological Surveys and 80 scientists

ISPRA · Instituto Geológico y Minero de España · GeoZS · SGUDS · NGU Norges geologiske undersøkelse · LNEG · GSD · ICGC Institut Cartogràfic i Geològic de Catalunya · TNO · brgm Geoscience for a sustainable Earth · BGS 1835 · 1919 Geološka služba Slovenije · SGU Sveriges geologiska undersökning Geological Survey of Sweden · HGI-CGS HGI · GSI · MCK · Geological Survey of Belgium · RZGRS - GSRS · EGK · VSEGEI · BGR · Lietuvos Geologijos Tarnyba Lithuanian Geological Survey

GEO-CRADLE – Objectives

GEO-CRADLE brings together key players fully representing the Region of Interest (Balkans, N. Africa and M. East) and the complete EO value chain therein, with the **overarching objective of establishing a multi-regional coordination network** that will:

i. Support the **effective integration of existing EO capacities** (space/air-borne/in-situ monitoring networks, modelling and data exploitation skills, and past project experience),

ii. Provide the interface for the **engagement of the complete ecosystem of EO stakeholders** (scientists, service/data providers, end-users, governmental organisations, and decision makers),

iii. Promote the **concrete uptake of EO services and data in response to regional needs**, relevant to four thematic priorities: **adaptation to climate change, improved food security, access to raw materials and energy**

iv. Contribute to the **improved implementation of and participation in GEO, GEOSS, and Copernicus in the region**.

More information can be found online at http://www.geocradle.eu/

GEO-CRADLE - Pillars

Visit: http://195.251.203.238/surveygeocradle/index.php/inventories/capacities/gc-survey1

GEO-CRADLE – Thematic Areas (Pilot areas)

EGS

Adaptation to Climate Change

(ACC)

Improved Food Security – Water Extremes Management

(IFS)

Access to Raw Materials

(ARM)

Access to Energy

(SENSE)

GEO-CRADLE – Access to Raw Materials (ARM) WP4

Objective: Establishing a roadmap for long-term monitoring, mapping, and management of mineral deposits in a severely under-explored ROI.

Use of existing regional capacities and skills

Development of protocol for evaluating the level of impact

Mapping of waste materials in abandoned mines

Monitoring of ground deformation during/after mining

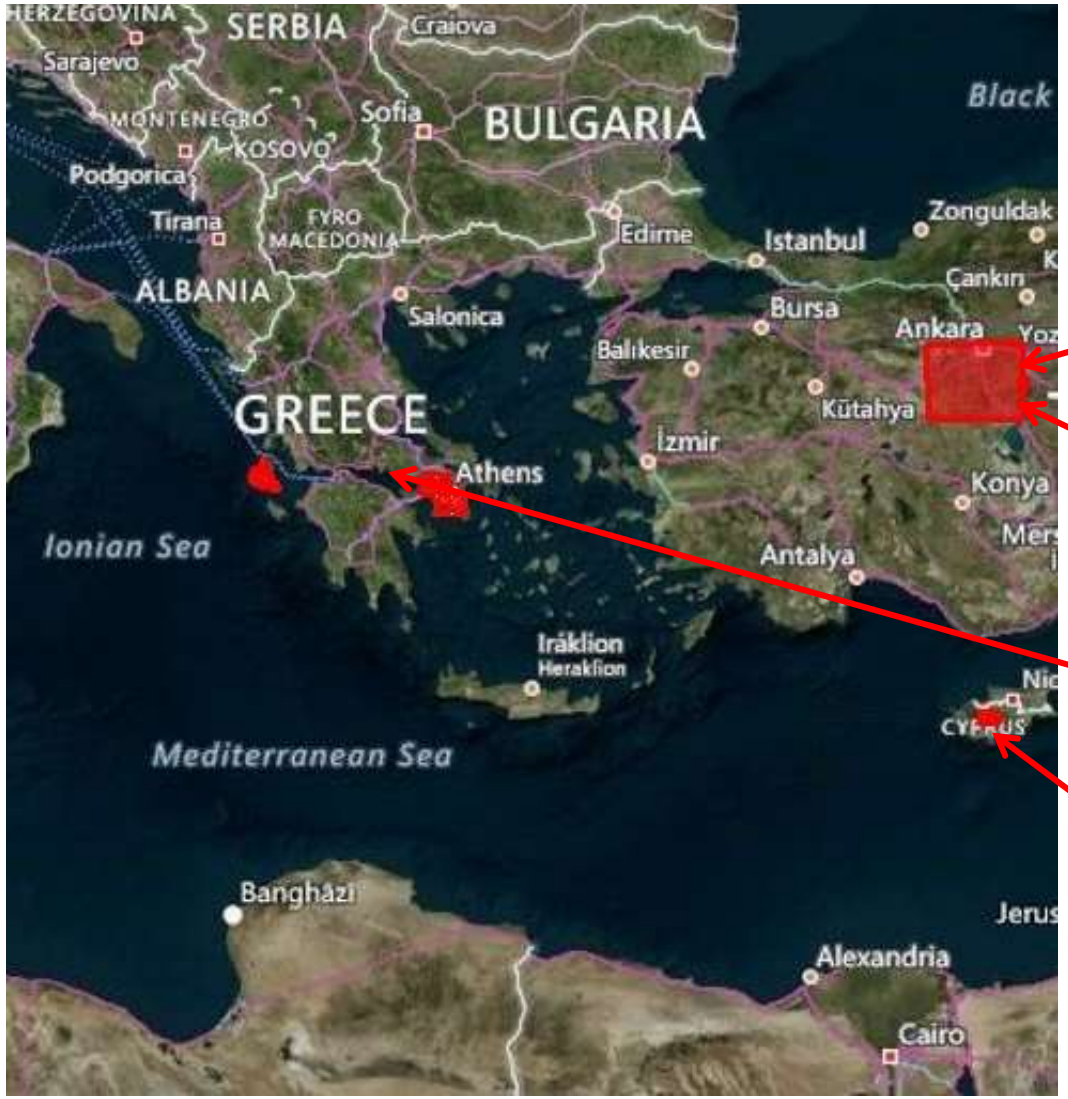
Identification, collection, assessment and use of EO based and in-situ data

Enrichment of the information content of the Regional Data Hub

WP 2 & WP 3
Find examples of end-users with specific problems in the mining and post-mining areas

WP 5
Identification of EO based data for the chosen example problems and enrichment of the Regional Data Hub

GEO-CRADLE – Access to Raw Materials (ARM)



Several mining and post-mining areas from Balkans, North Africa and Middle East were selected that meet the users' needs according to the output of WP 2 and WP 3 and were chosen based on the short questionnaire sent to the end-users of various regions

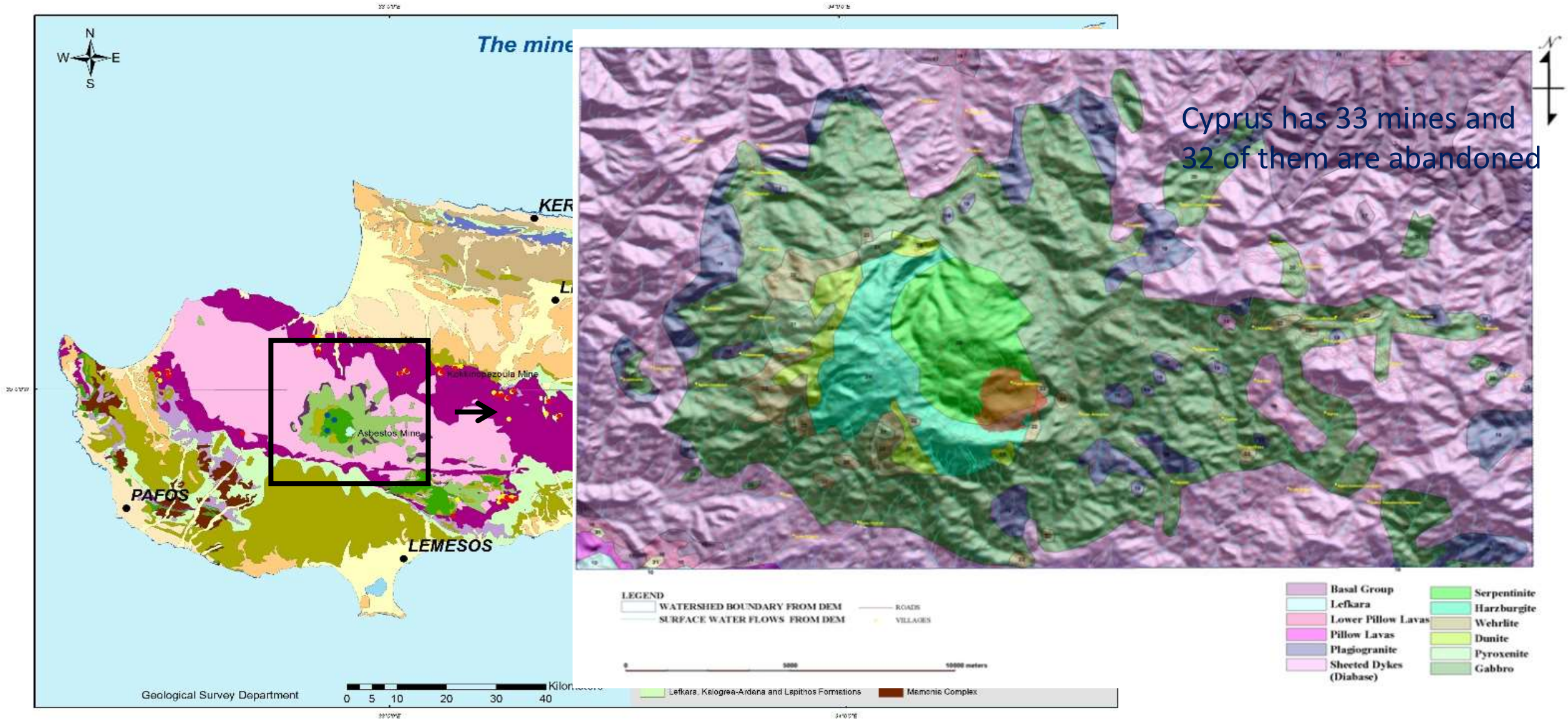
Turkey: Central Anatolian Lignite Basin
Determining of orientation of coal outcrops in a selected volcano-sedimentary basin

Turkey: Çelebi-Kesiköprü **iron**-oxide mineralization district
environmental monitoring of mining activities

Greece: Attica Region and Cephalonia Island
Monitoring of Illegal Quarrying

Cyprus: Abandoned Asbestos mine
Improved environmental monitoring

Amiantos Mine, Cyprus



Amiantos Mine – The Problem

Geographic and geological characteristics of the site (Asbestos Mine)

- It is located in the central part of Troodos Ophiolite and it is an outcrop of serpentine.
- The Asbestos Mine operated between 1904 and 1988
- It is estimated that 130 million tones of rock have been excavated
- One (1) million tones of asbestos fibers (chrysotile) were produced

Consequences

- adverse effects on the environment
- the enormous open pit
- the extensive waste tips
- pollution of the soil/water
- stability of the waste tips
- the barren nature of the tips

Amiantos Mine – User Needs

- The Geological Survey Department does not have any Earth Observation data for the asbestos mine.
- The mine is under restoration since 1995 and it will need 15 to 20 additional years to complete the restoration.
- The waste dumps cover an area of about 3,2 km^2.
- A detailed geotechnical investigation was carried out in order to design the reprofiling of the waste dumps before the initiation of the restoration works.
- Based on field observations there are locations on the reprofiled berms with indications of subsidence and possibly other instabilities.
- It is an area that gets high rainfall during the winter.

Amiantos Mine, Cyprus

The waste tips before restoration (from: http://www.amiandos.eu/en/)

The waste tips after restoration (from: http://www.amiandos.eu/en/)

- Near the foothills of the reprofiled heap dumps is located the community of Amiantos.
- Due to this the stability of the waste dumps is very crucial.
- There are field observations for instabilities but never the site was checked for instabilities or environmental pollution using Earth Observation systems.
- The waste dumps contain an average content of 0,2% of Ni.
- In a small area within the mine the endemic plant Alyssum Cypricum was planted directly on the waste material in order to collect data for the amount of Ni that Alyssum Cypricum collects.
- The information that will be collected will be used for the development of a pilot project for phytoming for the recovery of Ni.

Project “Biodiversity Conservation in Restoration and Management of the Amiantos Asbestos Mine, in Troodos National Forest Park (2013-2015). Department of Forests of the Ministry of Agriculture, Natural Resources & Environment of Cyprus

Feasibility Study - The methodology

The main objectives of the Asbestos Mine pilot - feasibility study are as follow:

- Determination of ground stability of the former mining area, taking under special consideration the slope mass movements and vertical ground motions.
- Determination of ground stability of the former mining area, taking under special consideration the slope mass movements and vertical ground motions.
- Identification of the local pollution (if possible) related to former mining activities.

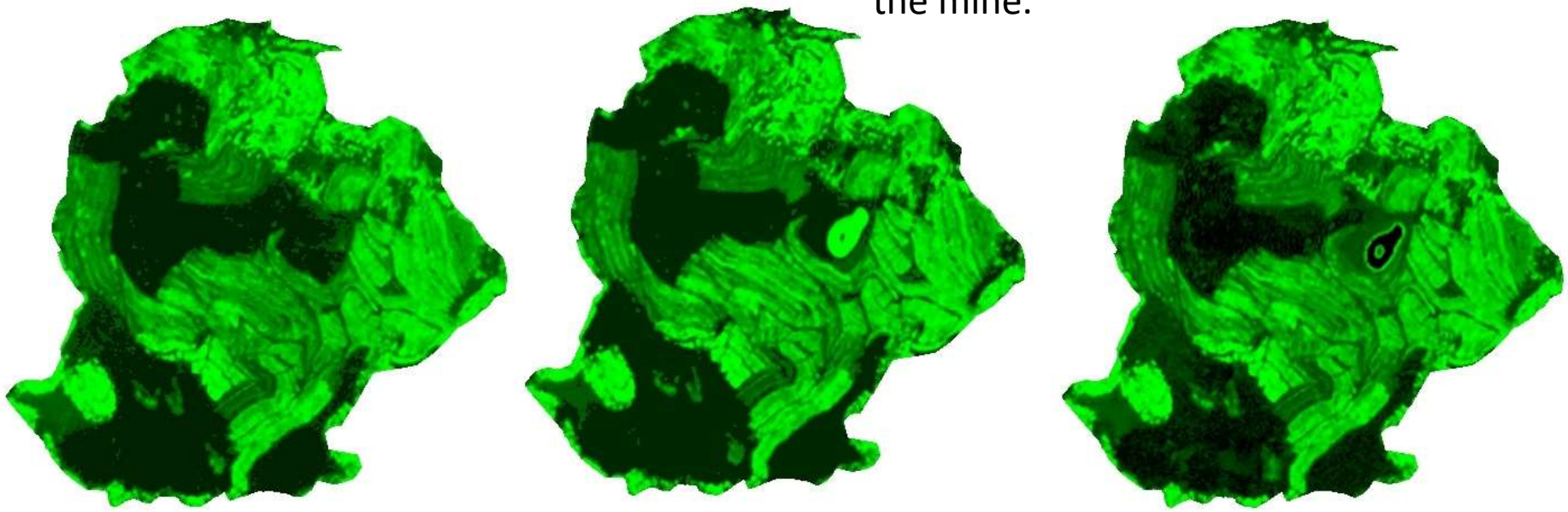
The feasibility study has taken into account all available information (geological maps, geotechnical investigations, stability analysis, etc), and

contains all needed exploration and monitoring works needed for a complete study of the area including ground, airborn, UAVs, satellites

Results from selected remote sensing techniques

Determination of the land use changes

NDVI Bright green colors healthy vegetation
NDVI index analysis for different dates based on Sentinel-2 data. The analysis can support the monitoring of reforestation process carried out in the mine.

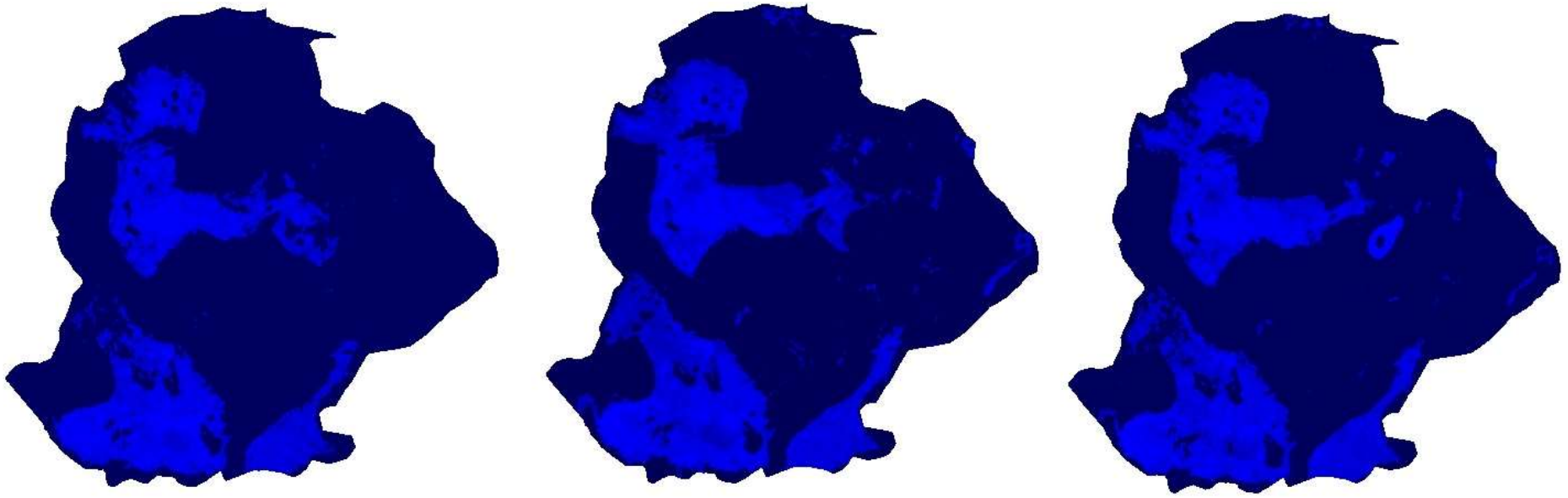


2015 2016 2017

Results from selected remote sensing techniques

Determination of the land use changes

NDWI Bright blue colors increased soil moisture / water
NDWI index analysis for different dates based on Sentinel-2 data. The analysis can support the monitoring parameters related to surface waters and soil moisture



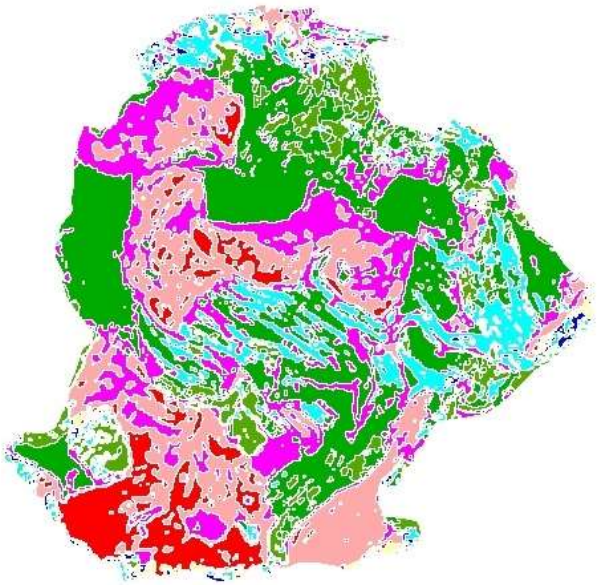
2015 2016 2017

Results from selected remote sensing techniques

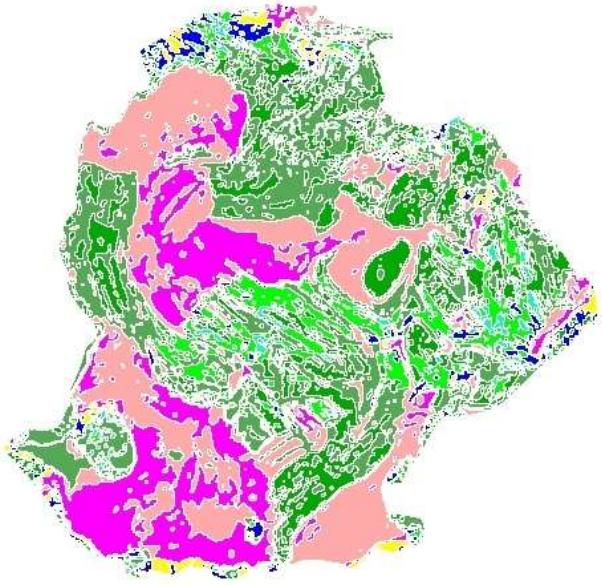
Determination of the land use changes

Results of classification: Green colors show vegetation Increase of fragmentation of the different land cover types can be mapped during the period of 2015 to 2017

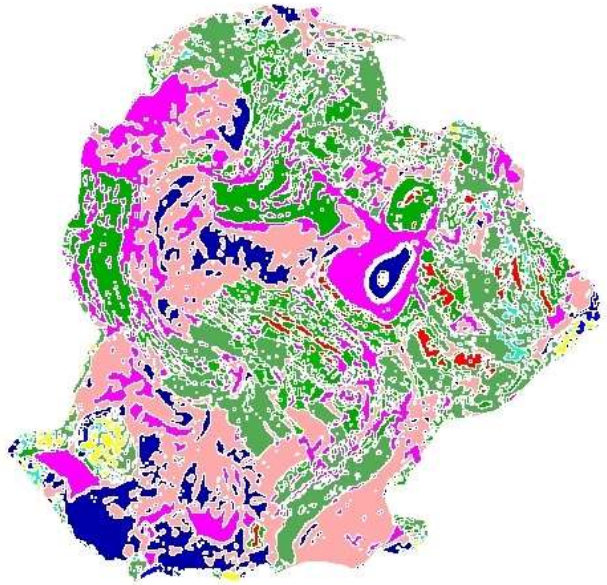
Sentinel-2 multitemporal analysis for determination of the land use changes and monitoring progress of restoration works.



2015



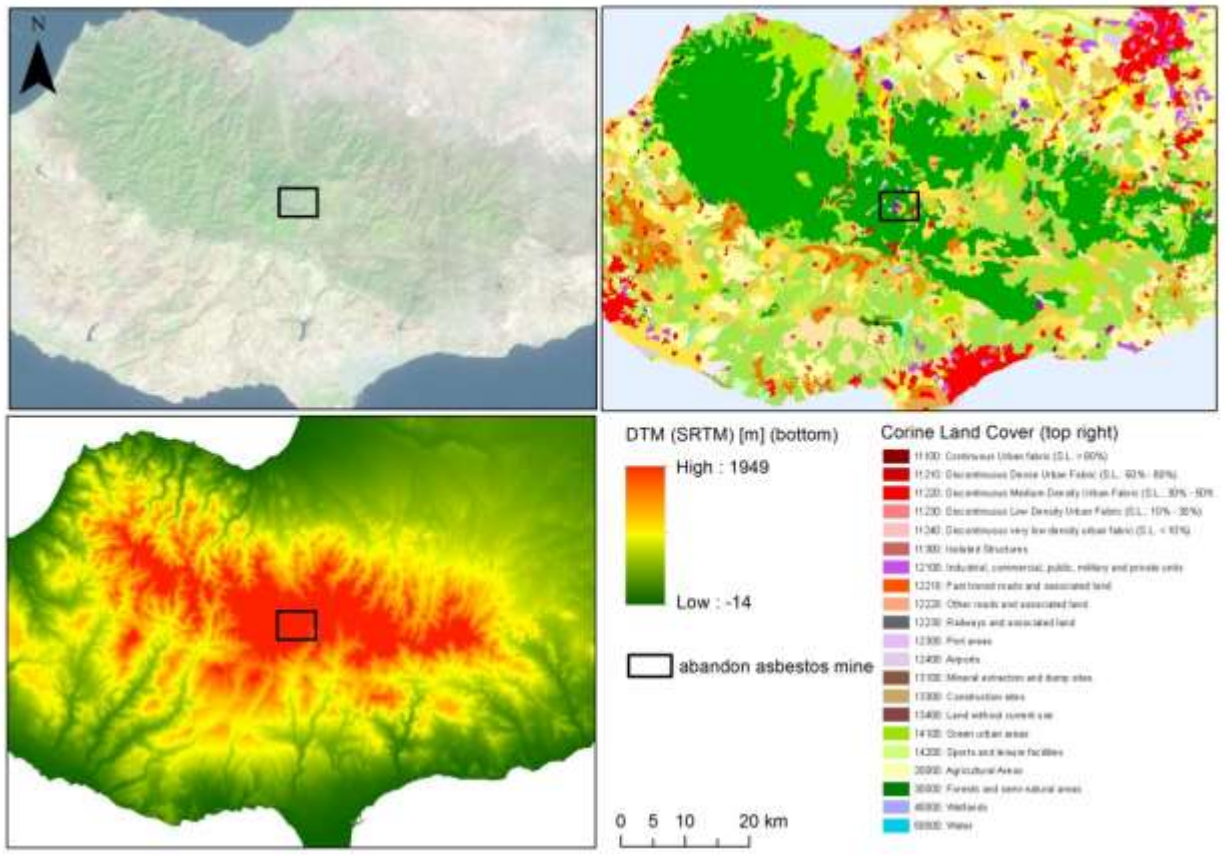
2016



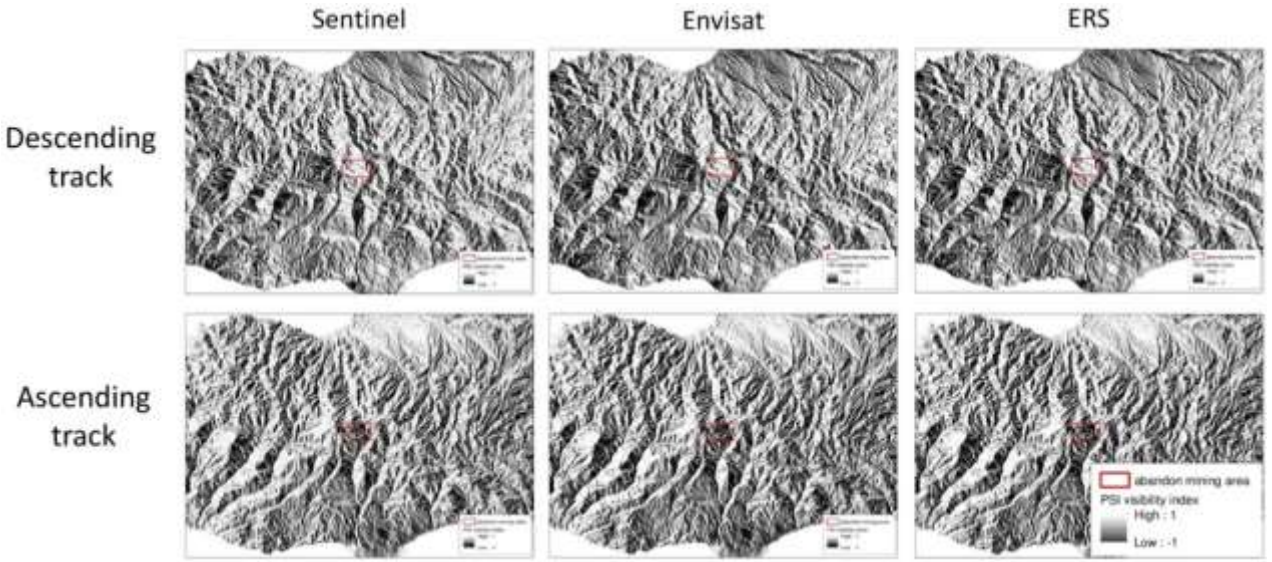
2017

Results from selected remote sensing techniques

Determination of ground stability



(top left) natural color satellite image. (top right) Corine Land cover GIS layer. (bottom) SRTM DTM. In black square the abandon asbestos mine area.

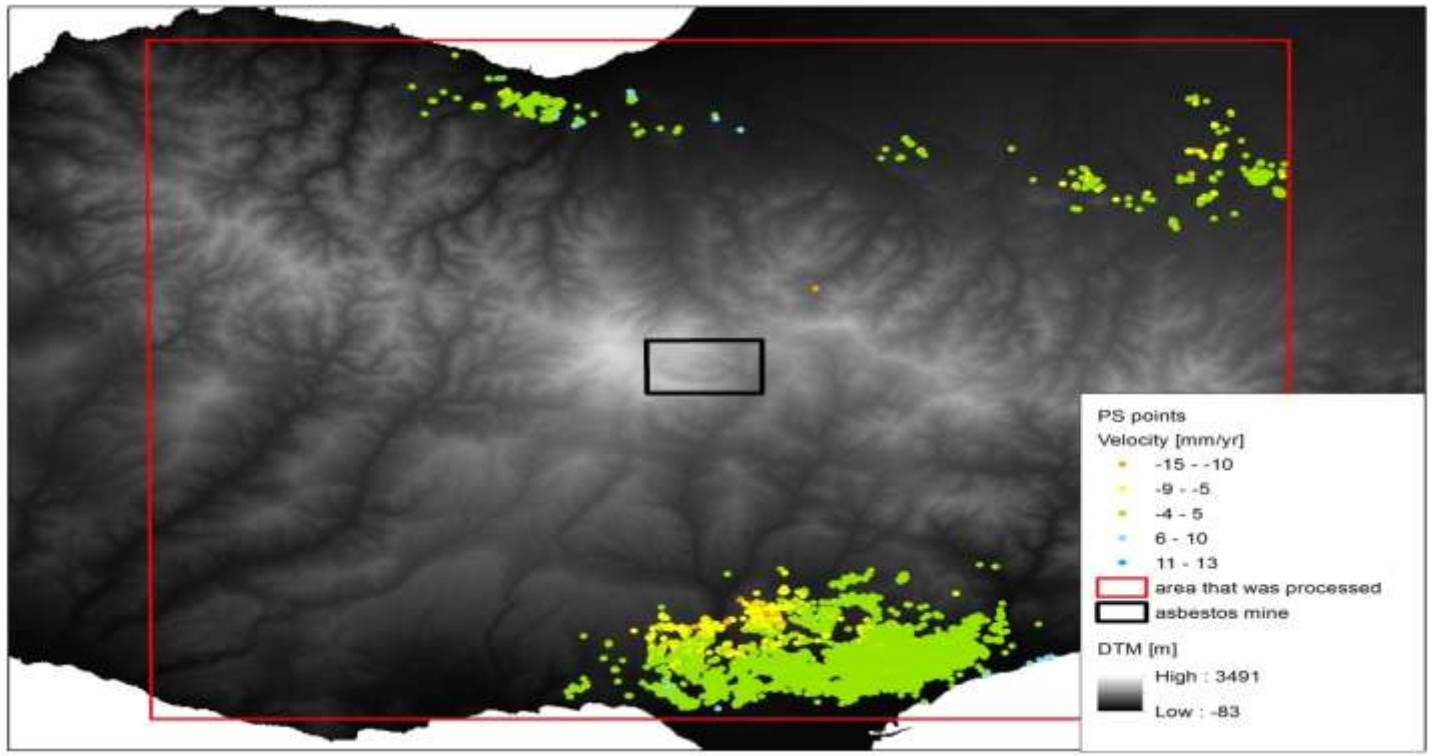


PS potential visibility was analyzed on the example radar scenes from Seninel-1, ERS and Envisat satellites. The results are similar for all three satellites and reveal that Descending geometry should give more PS points.

Land cover has a significant impact on the results of the processing. PS points are created in pixels with objects strongly and stable in time reflecting the radar wave. These are mainly buildings, roofs, railways, roads, bridges and other metal objects, but also outcrops of rocks.

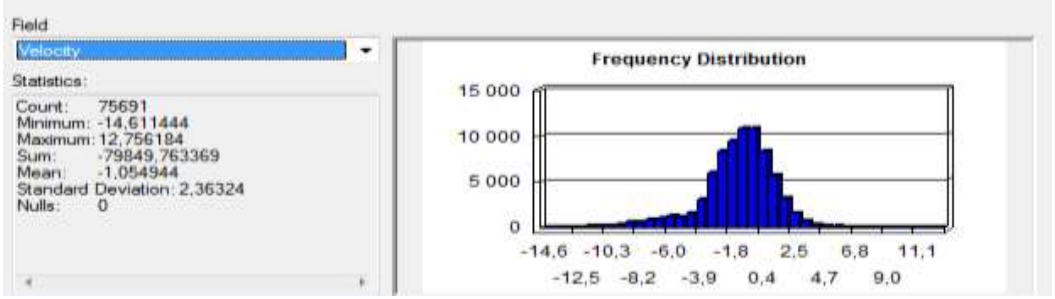
Results from selected remote sensing techniques

Determination of ground stability



Results of the test Seninel-1 processing for period 2016/07/26-2017/07/09

PSInSAR results



Summary statistics of PS points

The test processing included 30 Sentinel-1 scenes from 2016/07/26 - 2017/07/09. the processing was done using SBAS algorithm in ENVI SARScape software. It resulted in acquiring 75 691 PS points. Unfortunately none of the points intersects the area of the asbestos mine. High vegetation in the area prevented the software to find pixels for PS points.

Processing can be improved by larger set of data (e.g. 40-50 scenes) or data from L-band satellite

Discussion

The aim of the ARM pilots were to develop a methodology and to offer a feasibility study to form a basis for future funding. Only selected remote sensing techniques were elaborated, focusing on free Copernicus data.

The activity on the mining area can be monitored, while a general evaluation and quantitative aspects of certain parameters can be accomplished, but there are restrictions in using Sentinel-2 data, due to its medium resolution and key features, related to inspections, cannot be recognized easily, while misinterpretations can also occur.

Using Sentinel-1 data in InSAR processing has limitations, as the area in covered by vegetation and is characterised by high altitude changes.

Acquisition of 3D data may also be required to be obtained using satellite or UAV airborne photogrammetric methods in order to get the third dimension of the depth of excavations and / or restoration.


Thank You
Ευχαριστώ
Manos Botrini