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27-28 NOVEMBER I KULTURENS HUS, LULEÅ I SWEDEN

ImpactMin
Romanian case study

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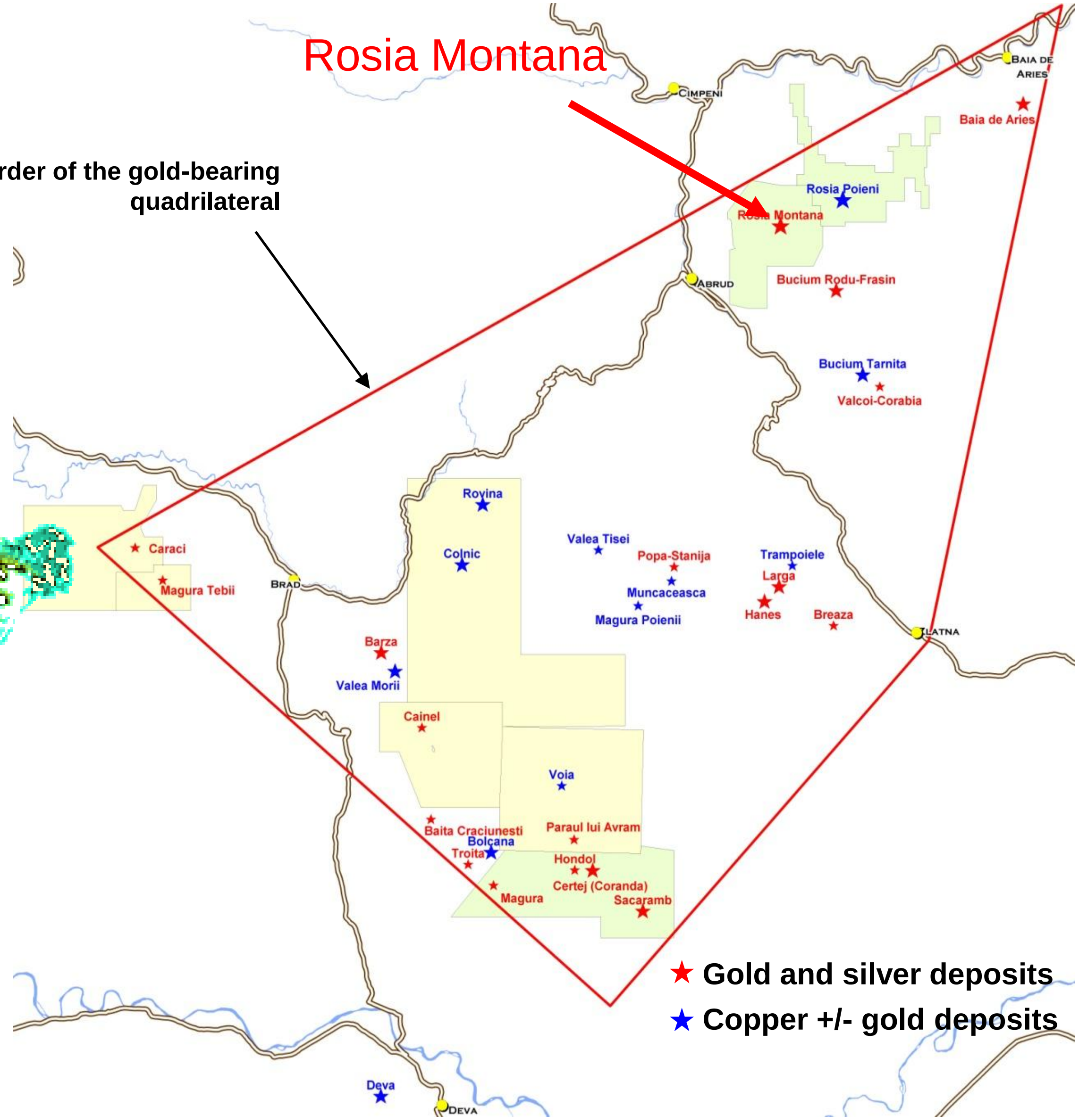
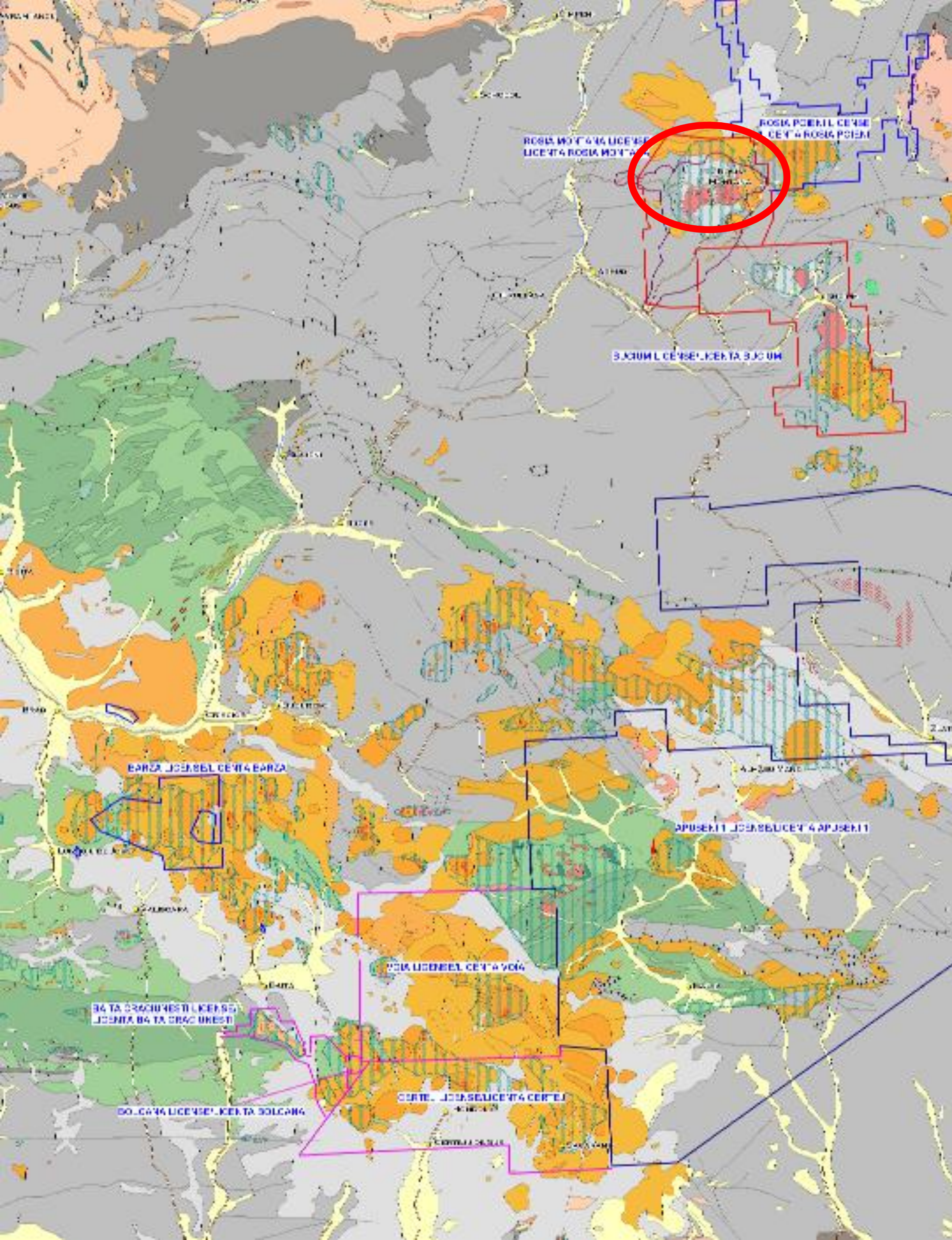
Apuseni Mountains (W Romania)

Gold-bearing Quadrilateral (~900 km²)



Neogene mesothermal porphyry

-Gold/silver,
-Copper/gold
-Copper



1. Geological context

Basement
-Precambrian and Paleozoic rocks (metamorphic and sedimentary)

Cretaceous
-mainly flysch

Miocene volcanism
-3 stages – the 2nd (Upper Badenian) of interest for the mineralization – Au, Ag, Cu, Pb, Zn.

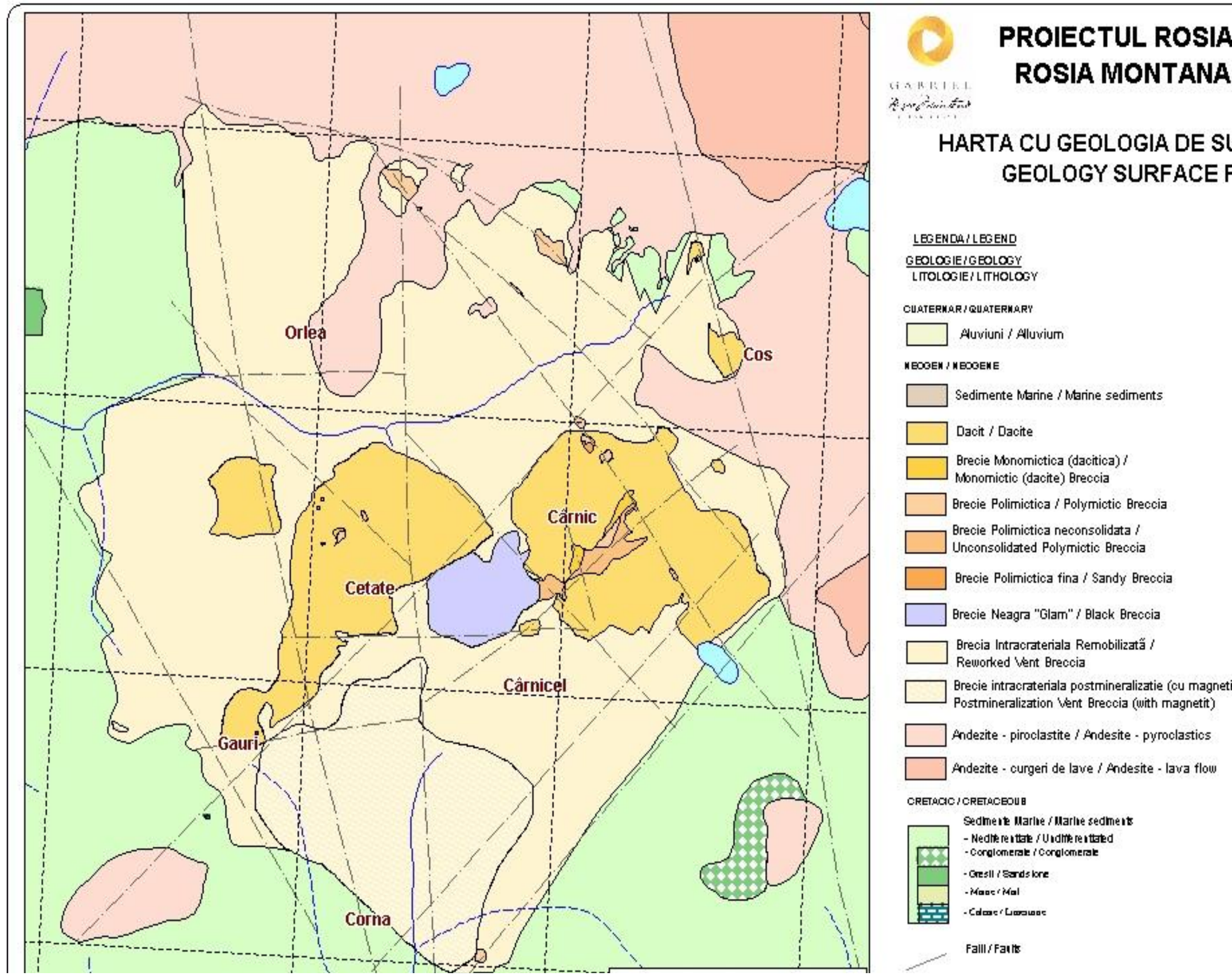
- Neogene maar-diatreme complex inserted into Cretaceous sediments

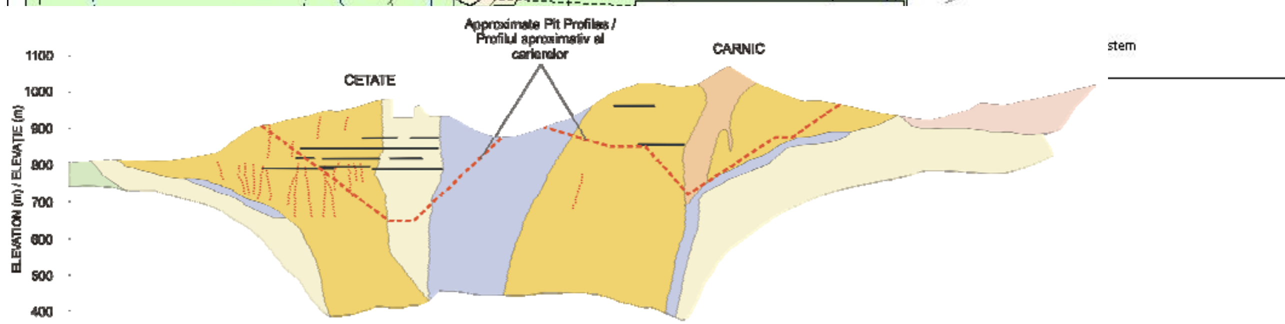
Rock texture and evolution:

-volcaniclastics & breccias (phreatomagmatic and subaqueous breccias), intruded by a series of porphyritic dacitic sub-volcanic bodies, dacitic dykes and later phreatomagmatic breccias

-hydrothermal processes have led to pervasive alteration

-epithermal Au-Ag deposit (one of the largest gold deposits in Europe)





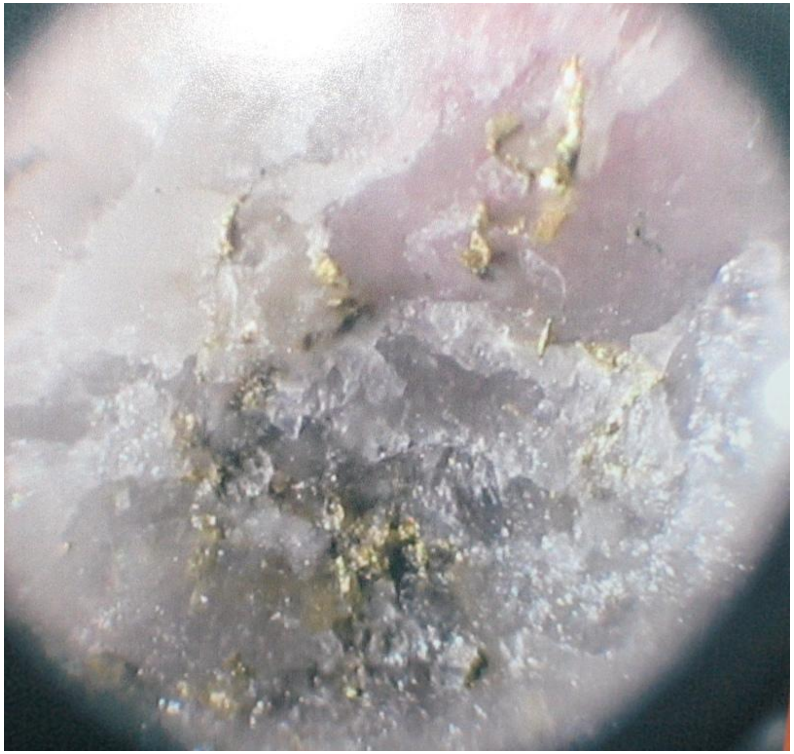
Piatra despicata (Split rock) nature monument – an andesite fragment different from the surrounding rock (volcanic bomb?)

2. Mineralization:

- ore bodies: veins, breccia structures (breccia pipes and breccia dykes), stockworks, and impregnations

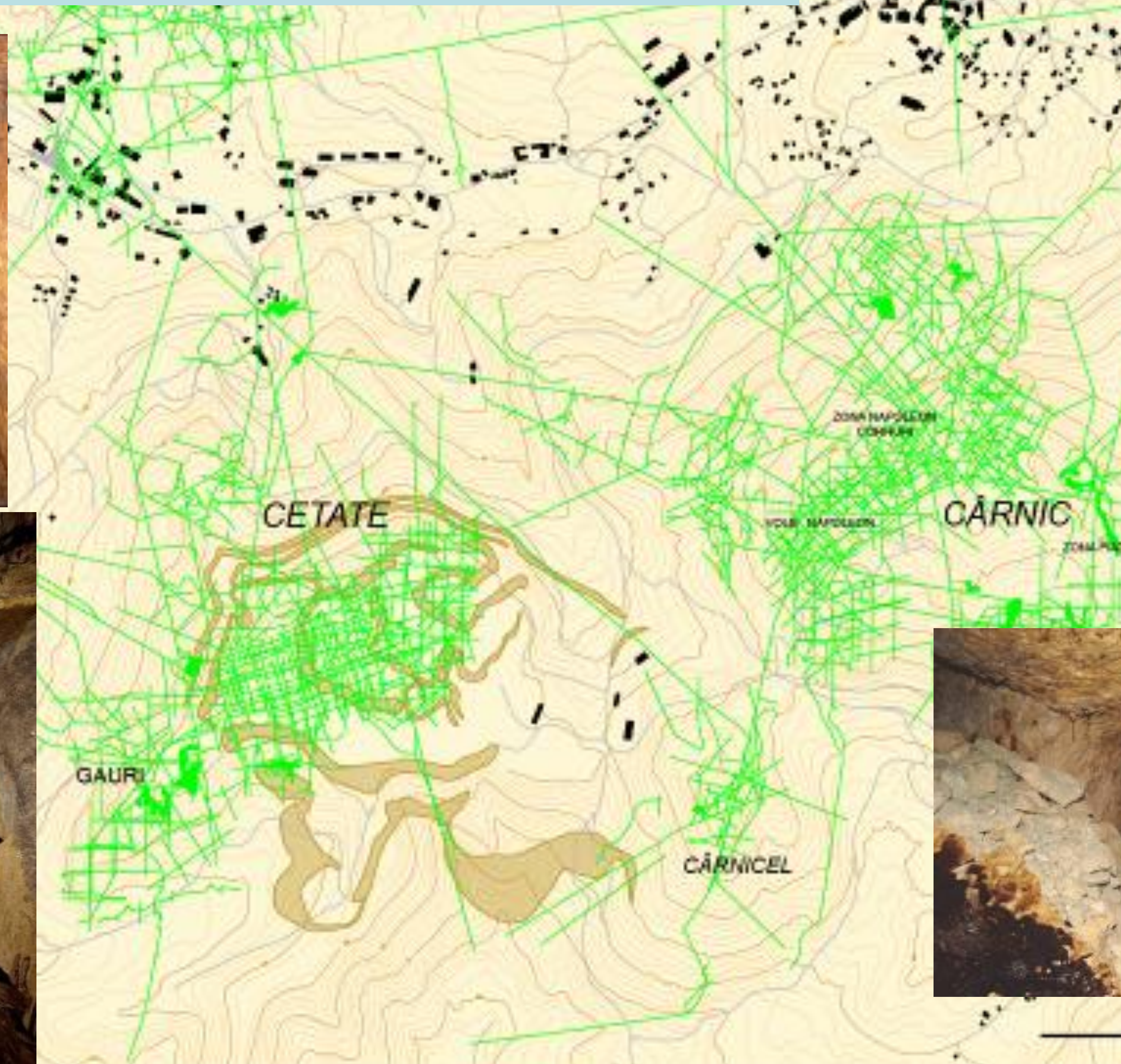
- precious metals minerals are electrum and free gold

- other minerals (small amounts): common sulphides (pyrite, chalcopyrite, sphalerite, galena, marcasite, arsenopyrite, etc.), Ag-minerals (argentite, proustite, pearceite, polybasite, etc.) and tellurides (hessite, sylvanite, petzite, altaite)



3. Mining

- Ore (Au+Ag) extracted in underground works until 1970
- About 140 km of galleries from different periods (Roman times to recent)



Roman gallery
Orlea mine

Roman hydraulic wheel
Paru Carpeni mine

Cătălina Monuleşti
gallery

ARCHAEOLOGICAL & INDUSTRIAL HERITAGE

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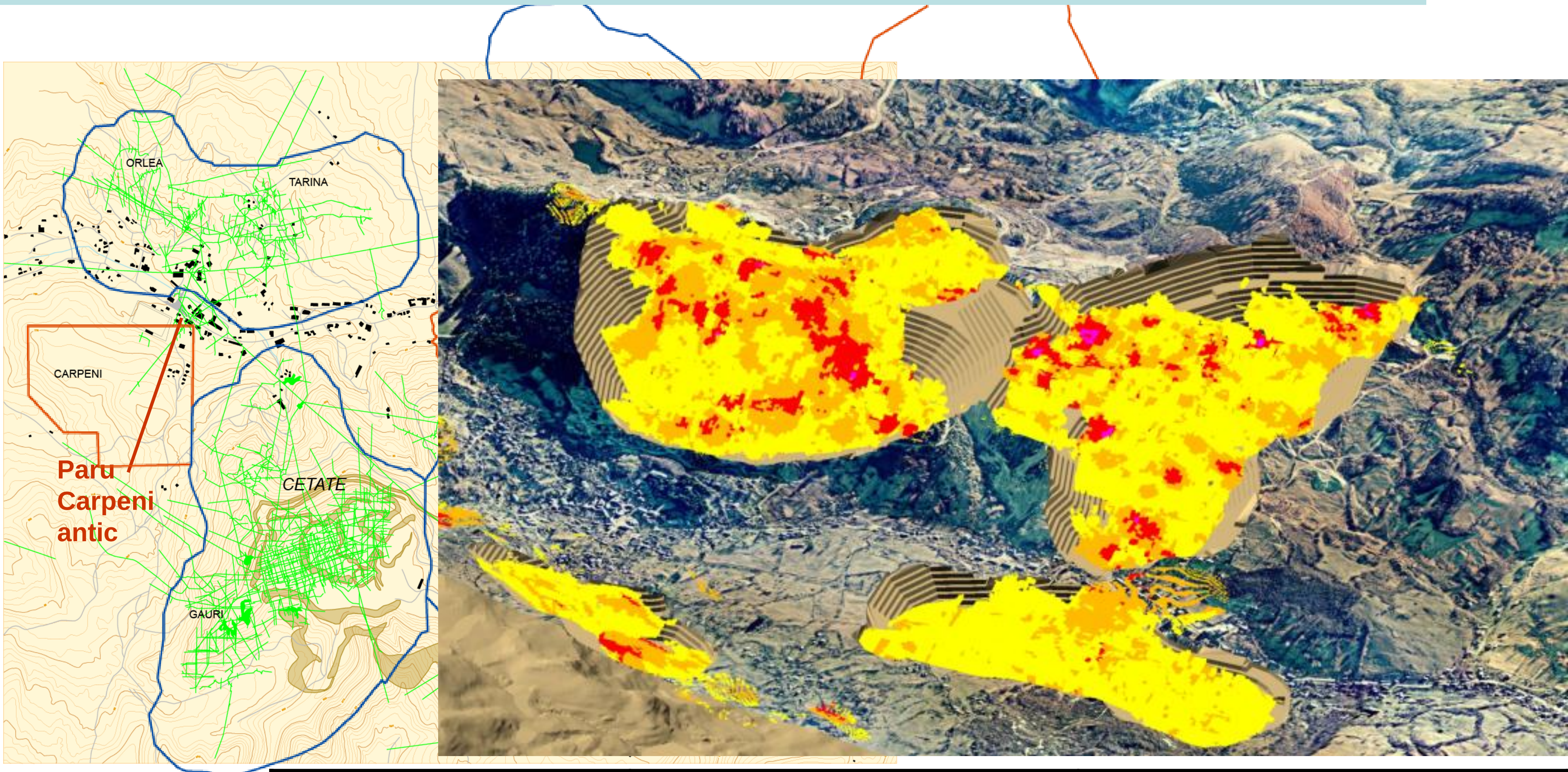
- Open pit operations were developed between 1970-2006 in two adjacent areas (Cetate, Carnic)
- Mining was stopped in 2006 due to the low economic efficiency and need for subsidies

– A new mining project proposed by RMGC awaits for the permits to start operations
– large scale open pit mining in 4 fields (Cetate, Carnic, Orlea, Jig)



Category	Gold "in situ"		Silver "in situ"	
	Million ounces	Tons	Million ounces	Tons
Exploitable resources	**10.10**	**314**	**47.6**	**1.480**

4. Acid mine drainage

Acid mine drainage (AMD) – very active on exposed surfaces and in underground works.

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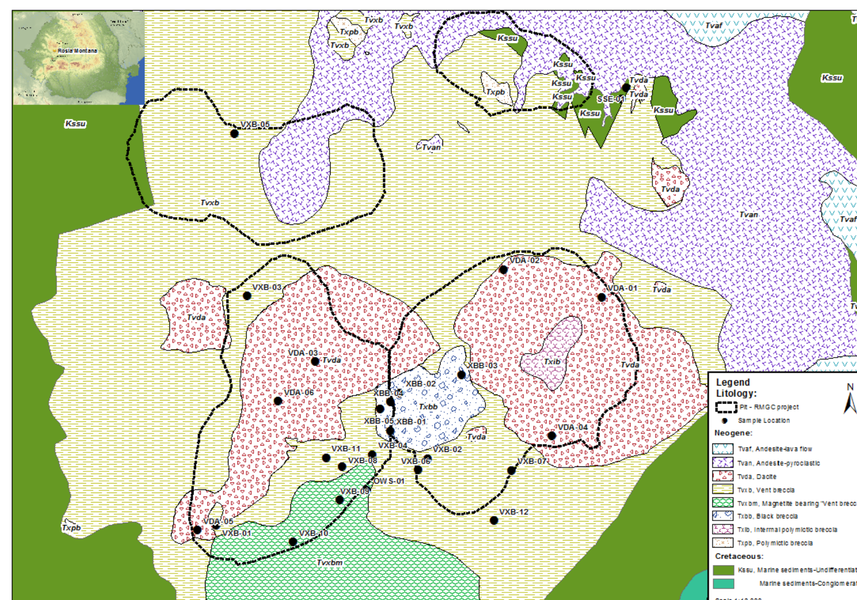
Field-based leaching test

- 26 plastic barrels of 200-litre; sample weight – 300 kg
- non-weathered (fresh) rocks, < 10 cm fragments
- field parameter measurements and laboratory analysis on collected leachate



Results

- Sulphate – the most concentrated ion from the leachate
- ARD samples – the highest values of various elements concentration

Maximum values (minimum values for pH)

Chemical parameter (measurement unit)	Dacite	Vent Breccia	Black Breccia	Chemical parameter (measurement unit)	Dacite	Vent Breccia	Black Breccia
pH	1.8	1.6	1.6	Cd (μg/L)	2386	414	23100
TDS (mg/L)	17660	42152	59356	Ni (μg/L)	3150	11560	24980
Sulphate (mg/L)	12268	33954	42531	Cr (μg/L)	6380	7025	75210
Fe (mg/L)	6622	15643	19956	Co (μg/L)	6180	3035	30800
Mn (mg/L)	85.1	9619	11363	Sb (μg/L)	582	5278	1608
Cu (μg/L)	37510	151250	145780	Ba (μg/L)	161	158.8	266
Pb (μg/L)	615	134000	298	Hg (μg/L)	0.96	13.2	4.3
Zn (μg/L)	5214600	22030	370000	Mo (μg/L)	254	2000	3480
As (μg/L)	91210	21200	210000	Se (μg/L)	3162	516.2	2670

- Black breccia – some of the highest ARD concentrations
- All the silicified samples of the waste rocks generated ARD
- 4 of 13 argilic alterated samples generated ARD

5. Major land-use modifications

•Two open pits: Cetate (19.75ha) and Carnic (5.2 ha)

•Several waste dumps

•Two tailings management facilities : Saliste (12.5 ha) and Gura Rosiei (21.25 ha)

•The new mining project RMP proposes an Industrial Zone on 1257.31 ha, including all mining areas, waste dumps, facilities for milling and processing the ore, a tailings management facility, water treatment facilities etc

6. Landscape scarring

Important landscape modifications, mainly due to open pit mining operations

Large areas of land were used for disposing of the rock waste and tailings resulted during the mining excavations and ore processing.

7. Mining waste

Large areas of land were used for disposing of the rock waste and tailings resulted during the mining excavations and ore processing.

All the operations were stopped in 2006 due to economic reasons, but very few significant attempts of rehabilitation were done afterwards.

Example: Gura Rosiei TMF restoration

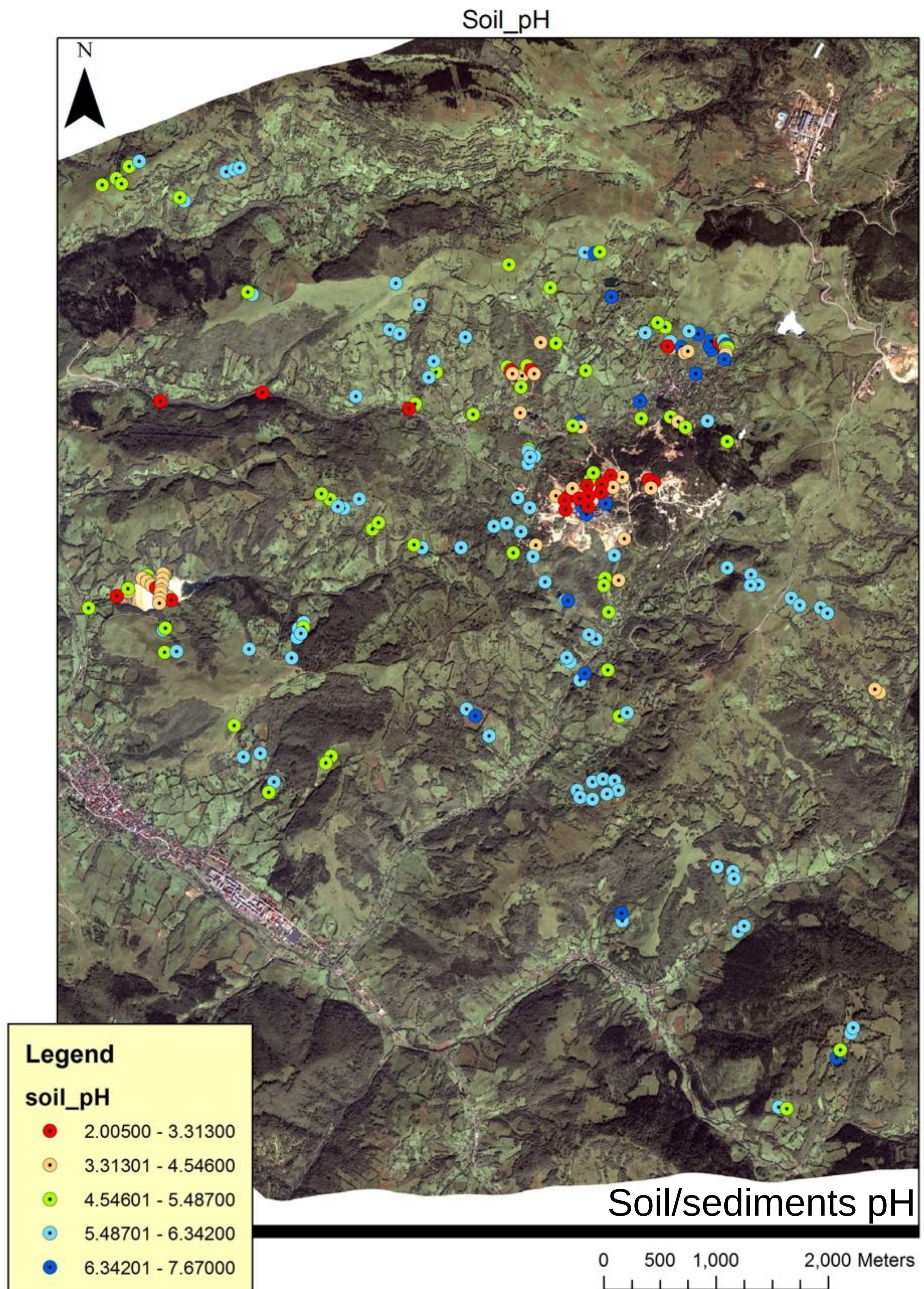
Gura Rosiei TMF

Tailings dams issues

- *Dust*
- *Physical instability*
- *AMD*

Soil/sediments survey

The degree of contamination of soils is generally low, but very variable, depending on their position by respect to the mining area, the geological background, the proximity of waste deposits, etc.



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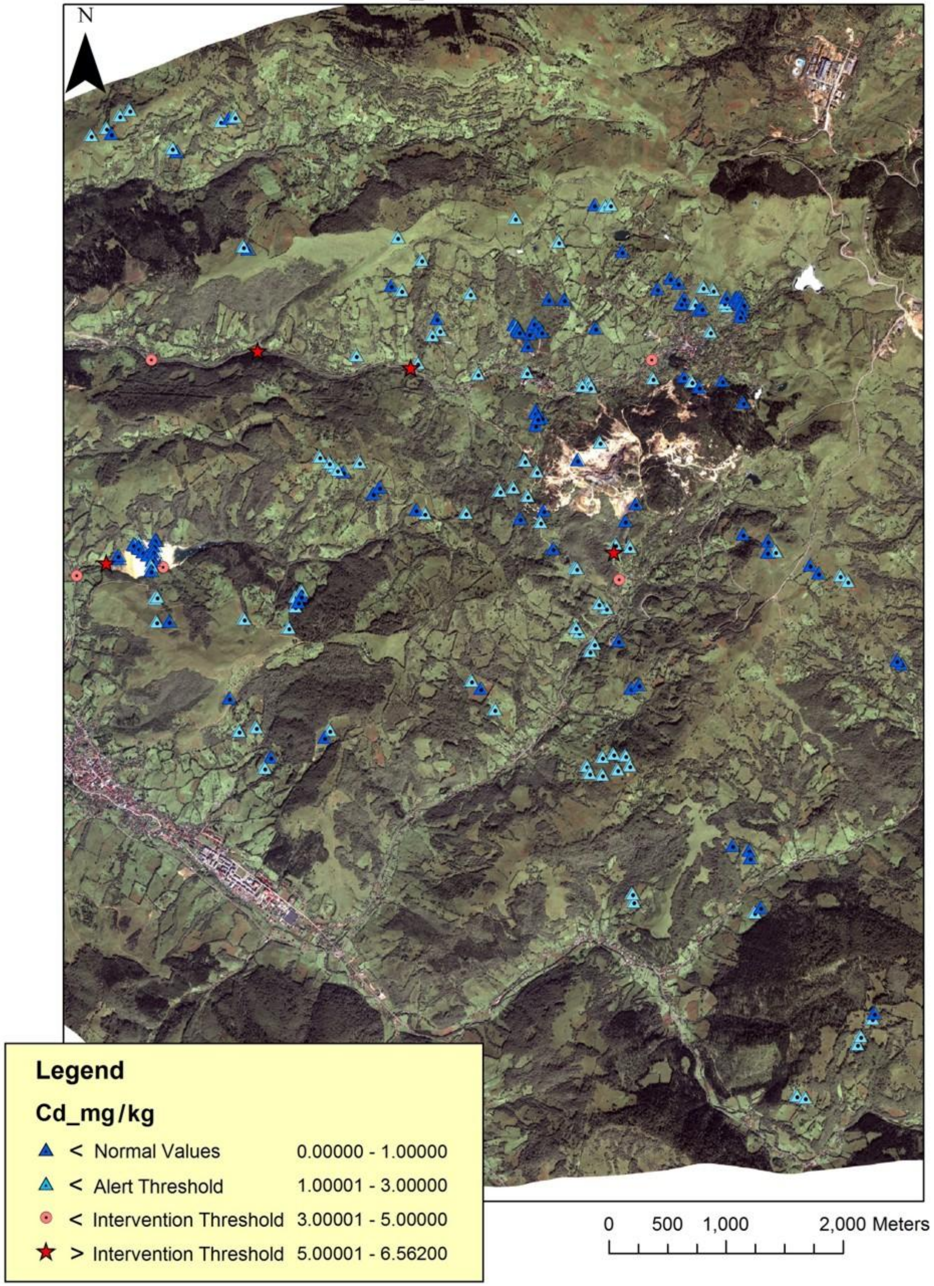
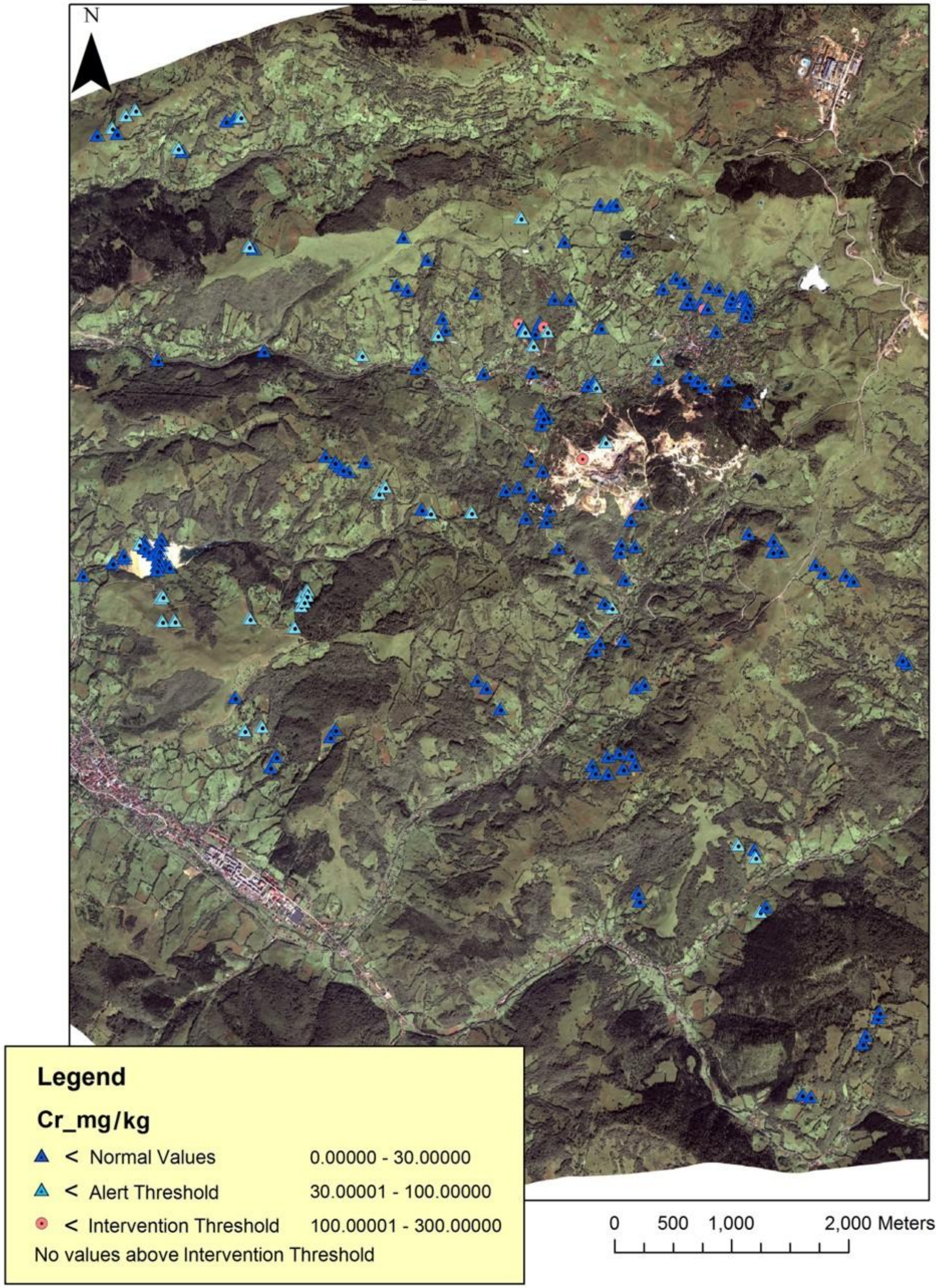
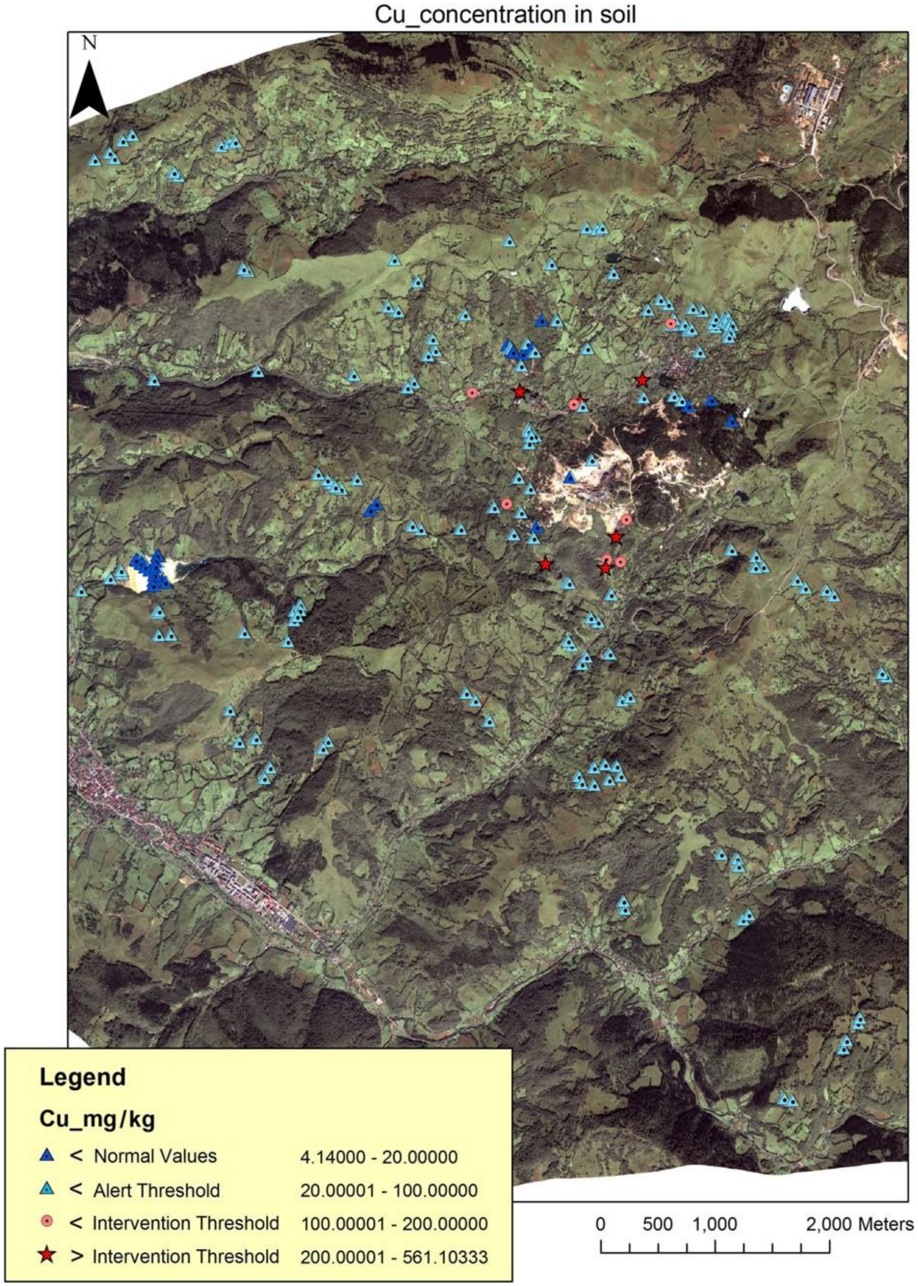
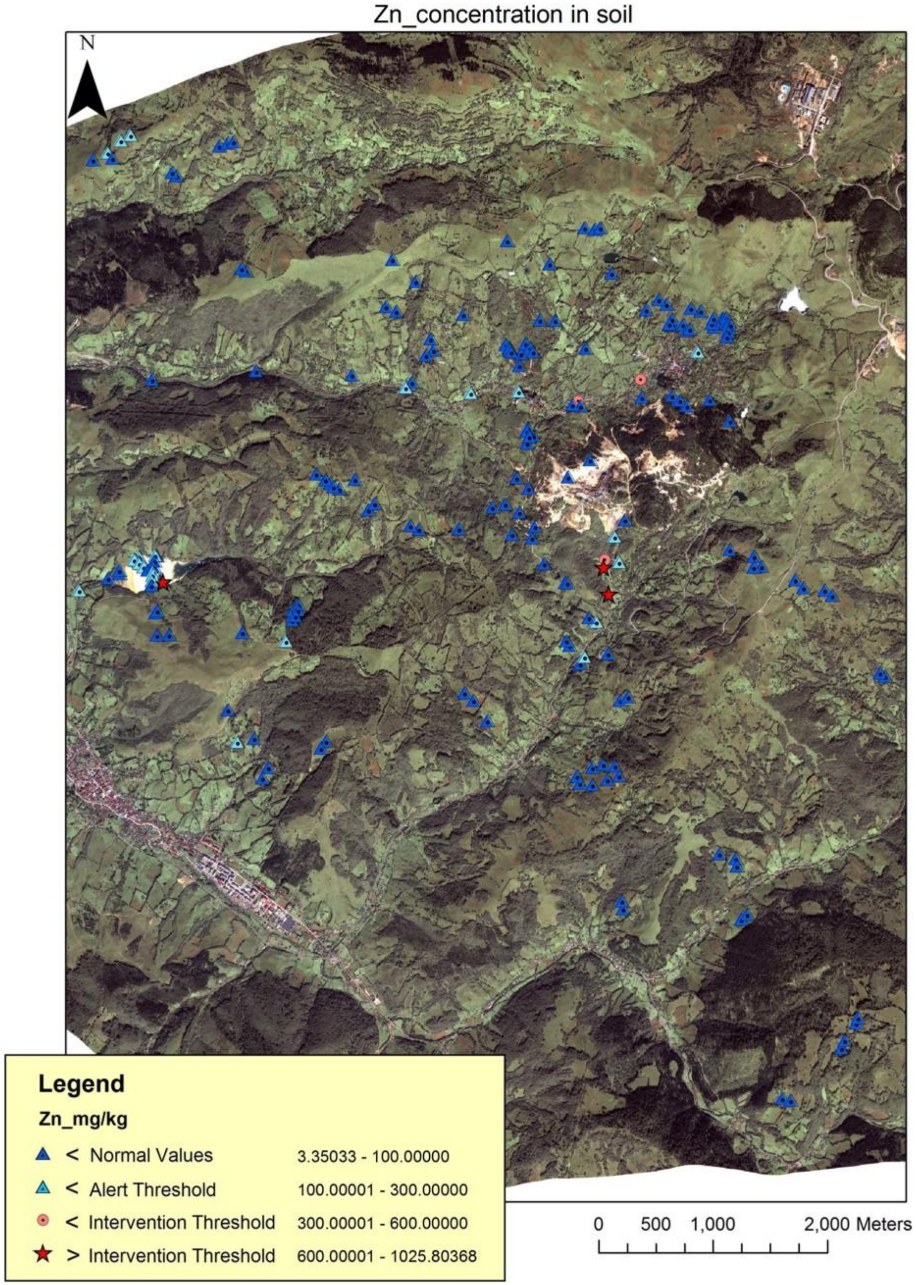
Cd_concentration in soil



Cr_concentration in soil







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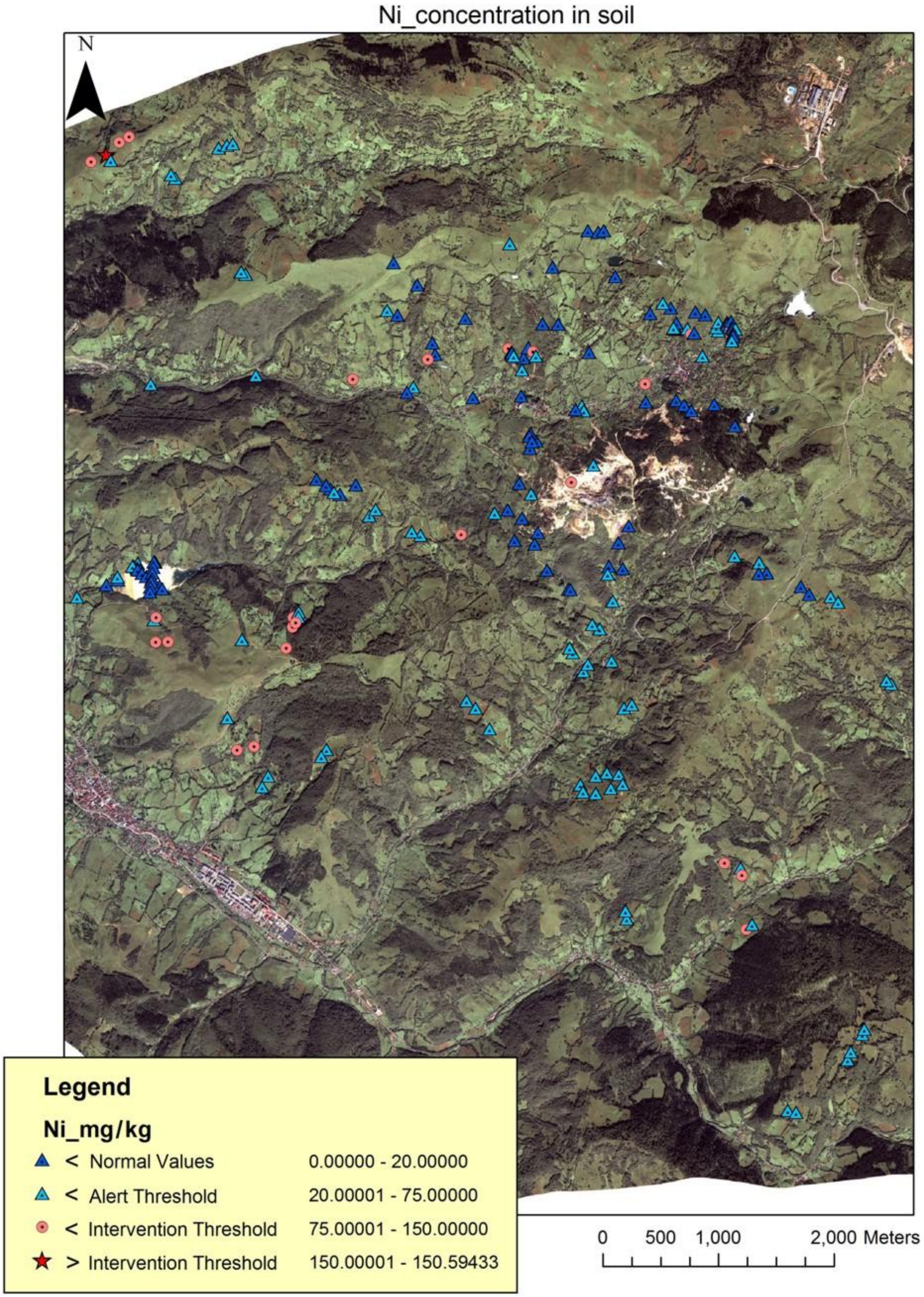
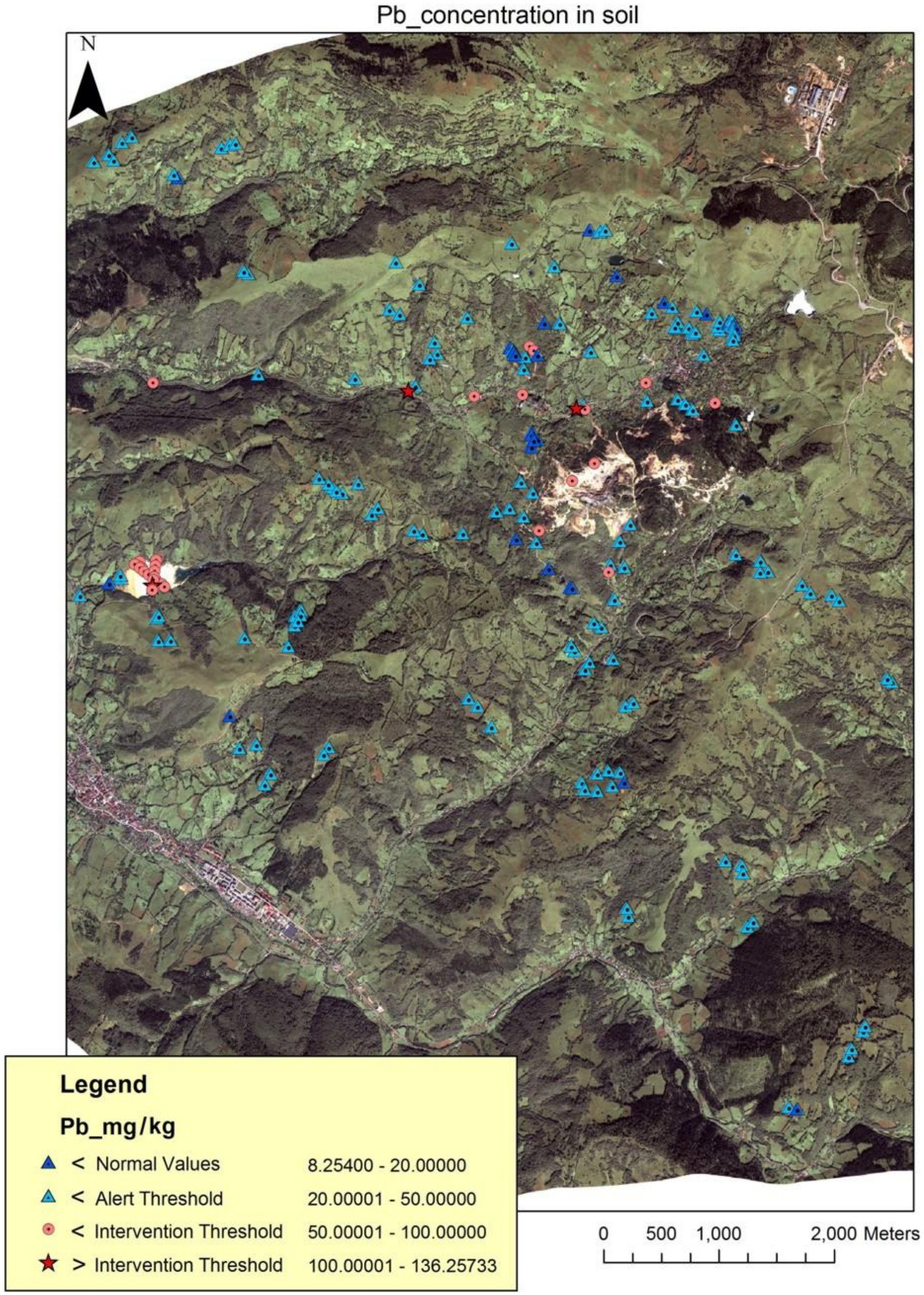
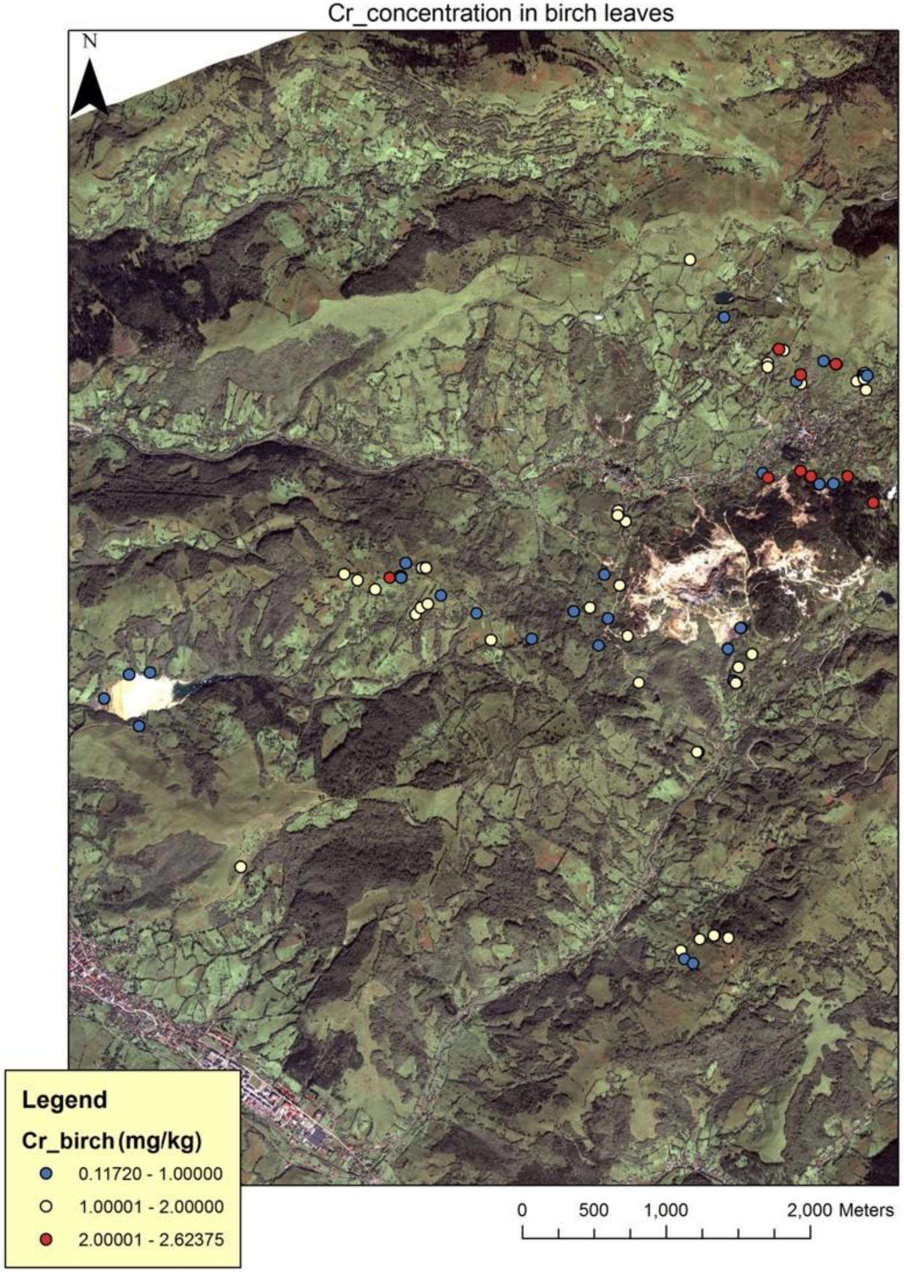

Ni_concentration in soil
N
Legend
Ni_mg/kg
< Normal Values 0.00000 - 20.00000
< Alert Threshold 20.00001 - 75.00000
< Intervention Threshold 75.00001 - 150.00000
> Intervention Threshold 150.00001 - 150.59433
0 500 1,000 2,000 Meters

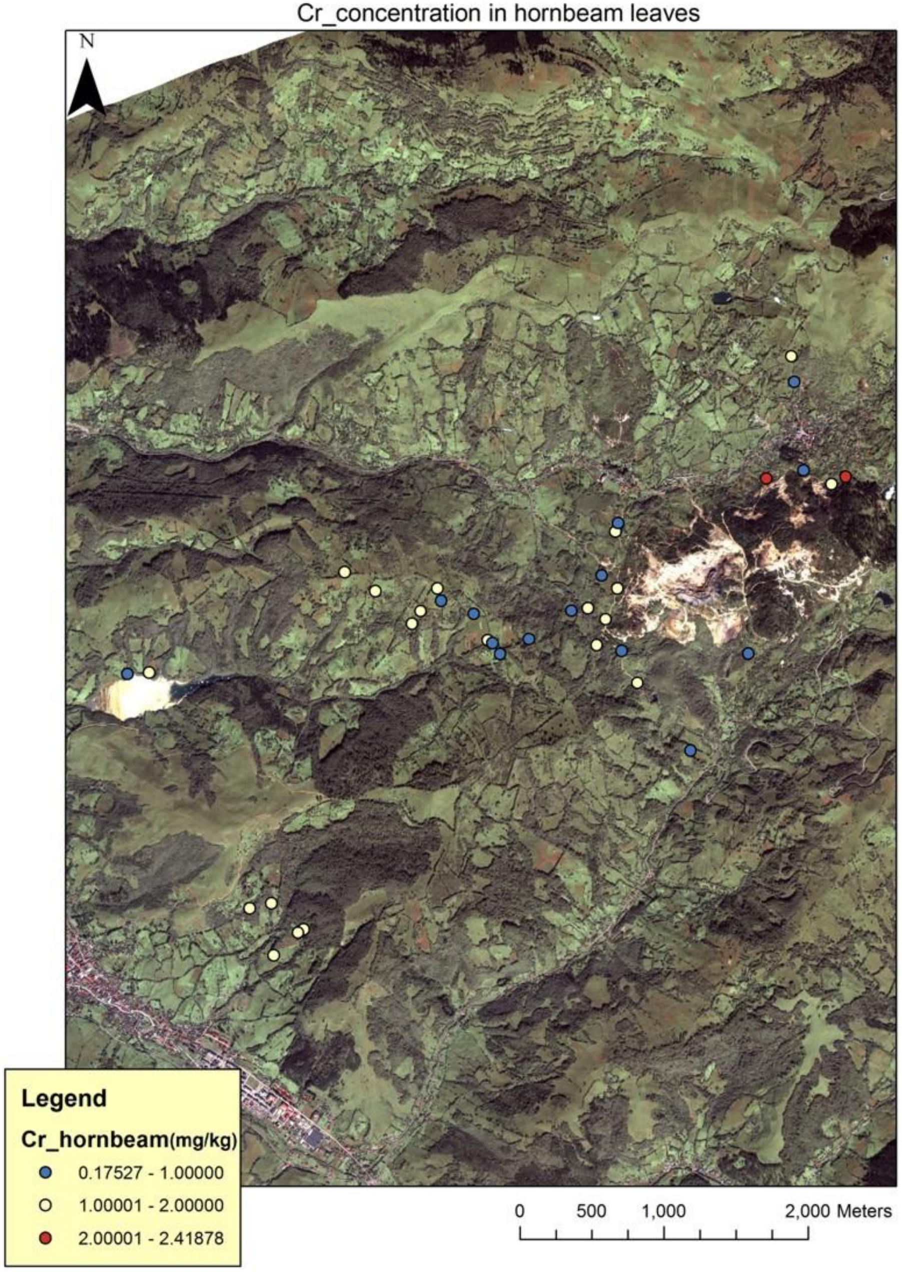

Pb_concentration in soil
N
Legend
Pb_mg/kg
< Normal Values 8.25400 - 20.00000
< Alert Threshold 20.00001 - 50.00000
< Intervention Threshold 50.00001 - 100.00000
> Intervention Threshold 100.00001 - 136.25733
0 500 1,000 2,000 Meters

Vegetation

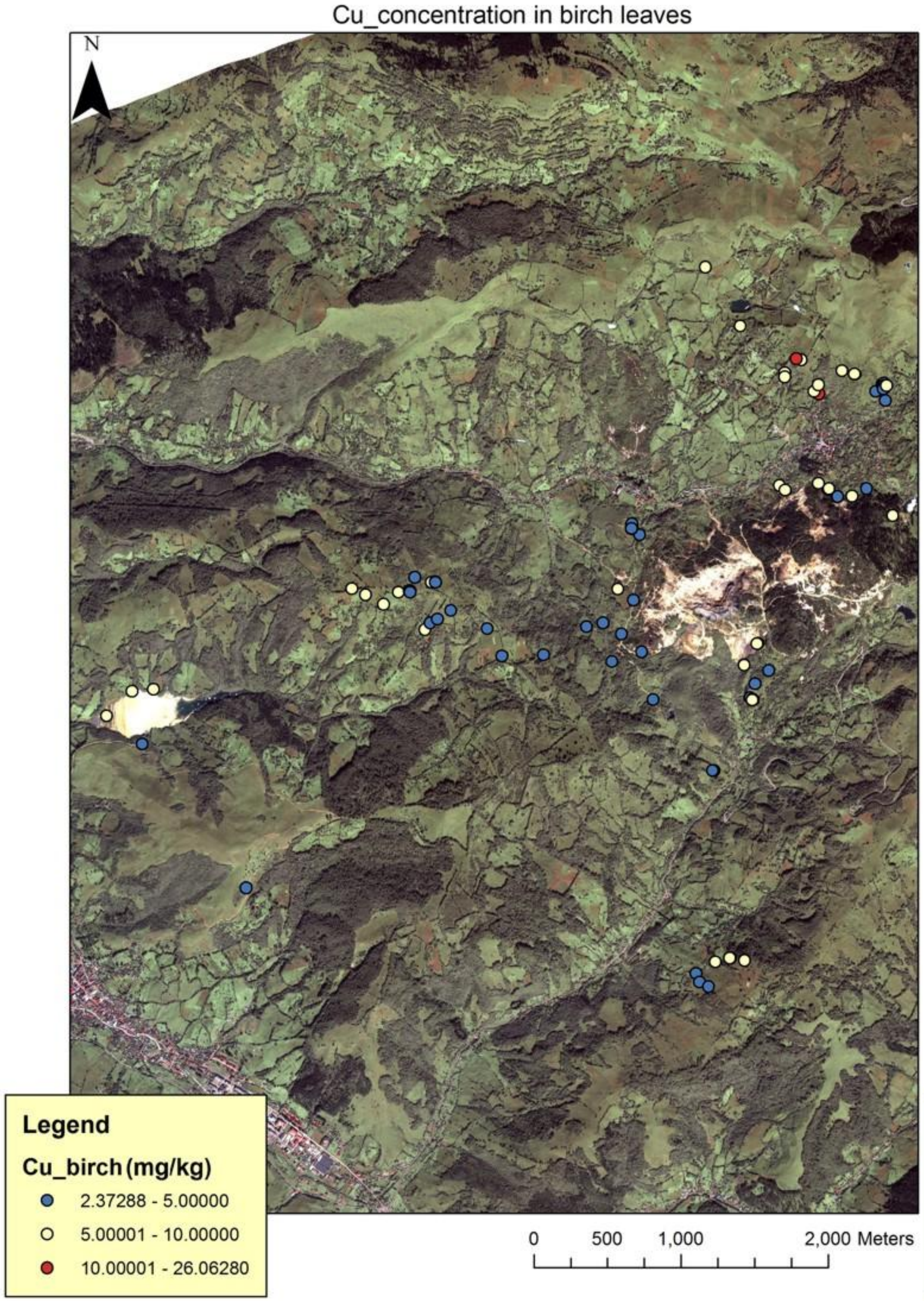
- The state of the vegetation was assessed by hyperspectral measurements in the field, and laboratory analyses.
- Investigations on birch (*Betula pendula)* and hornbeam (*Carpinus betulus*) trees. Samples of leaves (144) have been analysed in the laboratory for heavy metals content (ICP-MS) and chlorophyll content and fluorescence.

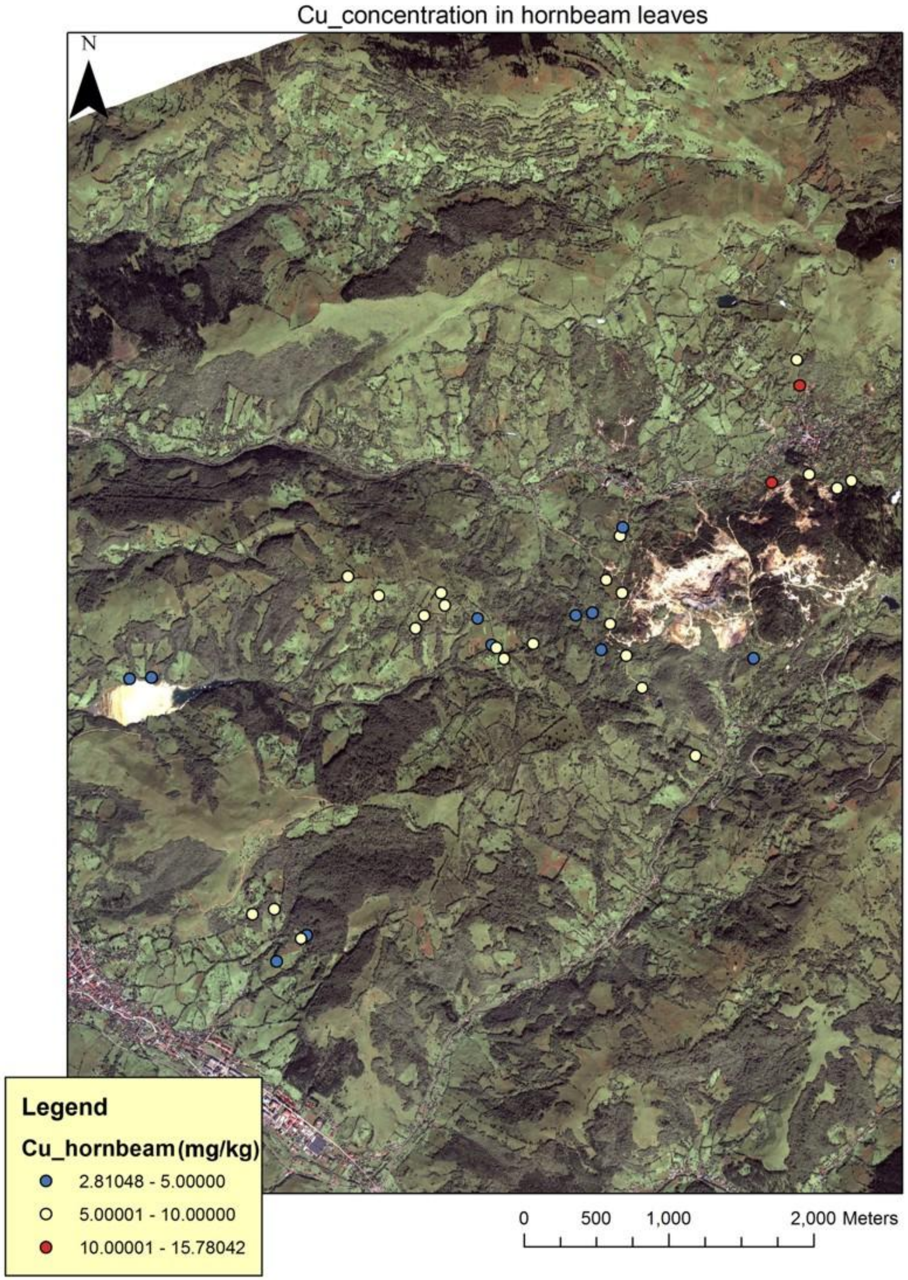


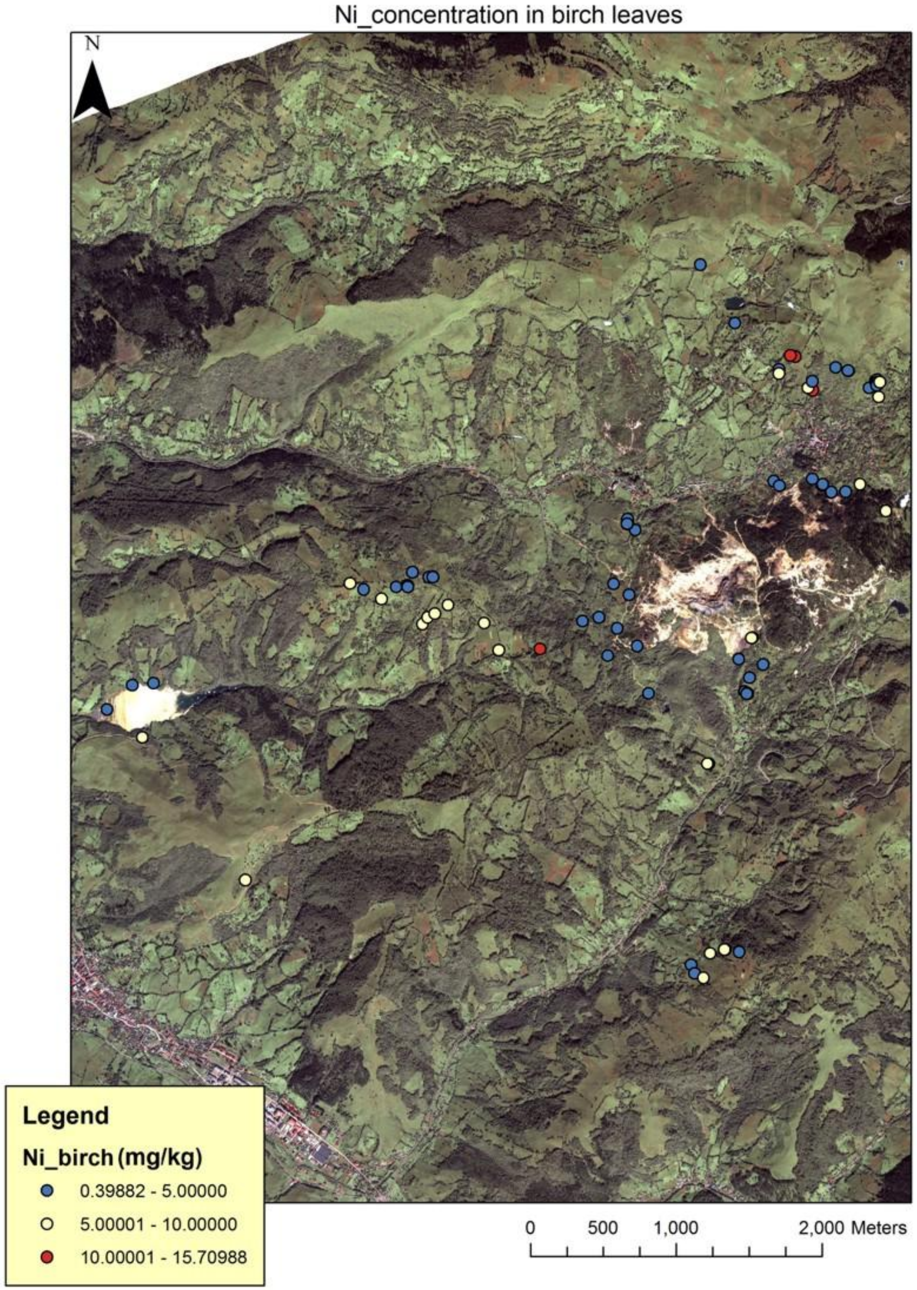
Cr_concentration in birch leaves
N
Legend
Cr_birch (mg/kg)
0.11720 - 1.00000
1.00001 - 2.00000
2.00001 - 2.62375
0
500
1,000
2,000 Meters

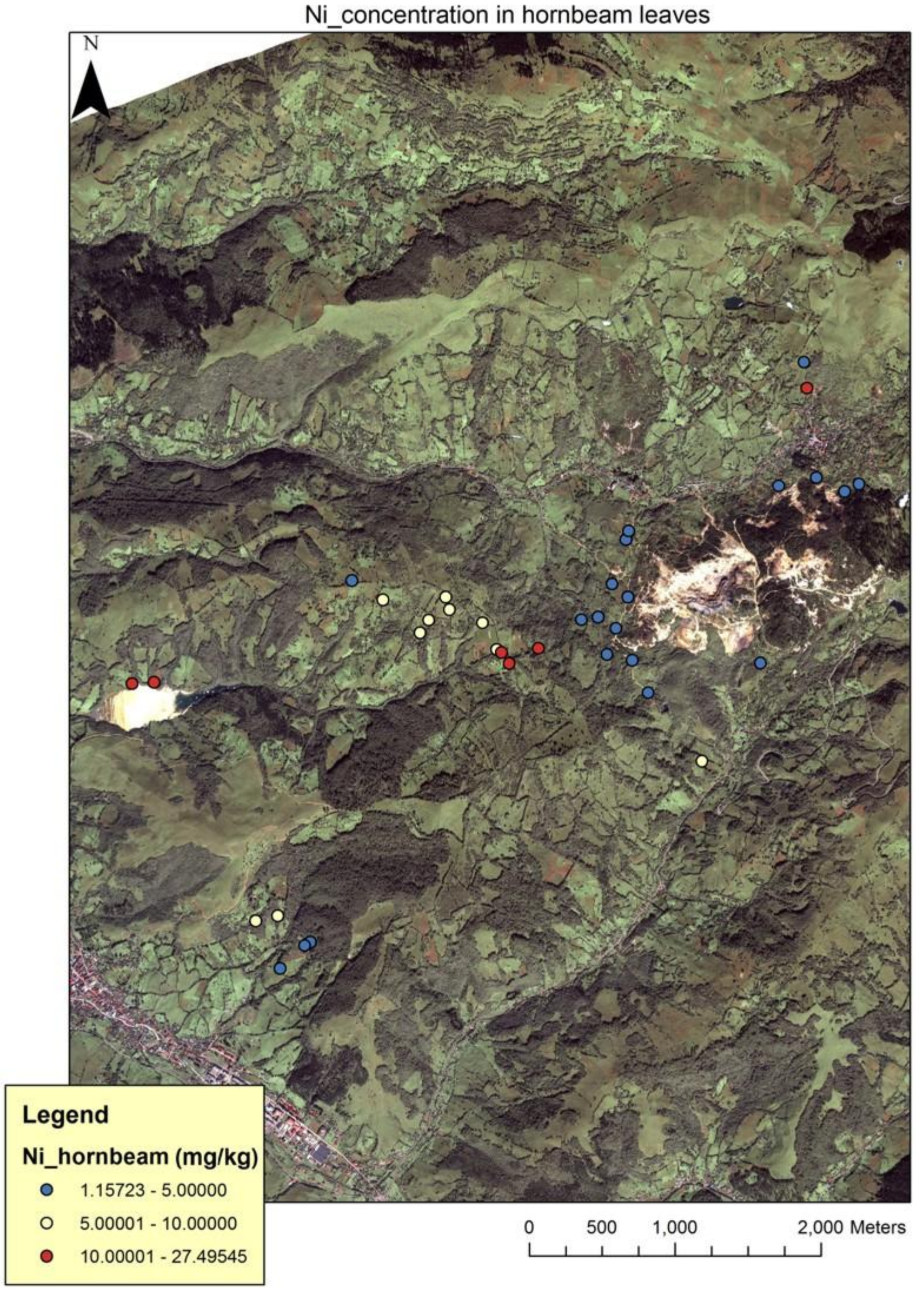


Cr_concentration in hornbeam leaves
N
Legend
Cr_hornbeam (mg/kg)
0.17527 - 1.00000
1.00001 - 2.00000
2.00001 - 2.41878
0
500
1,000
2,000 Meters

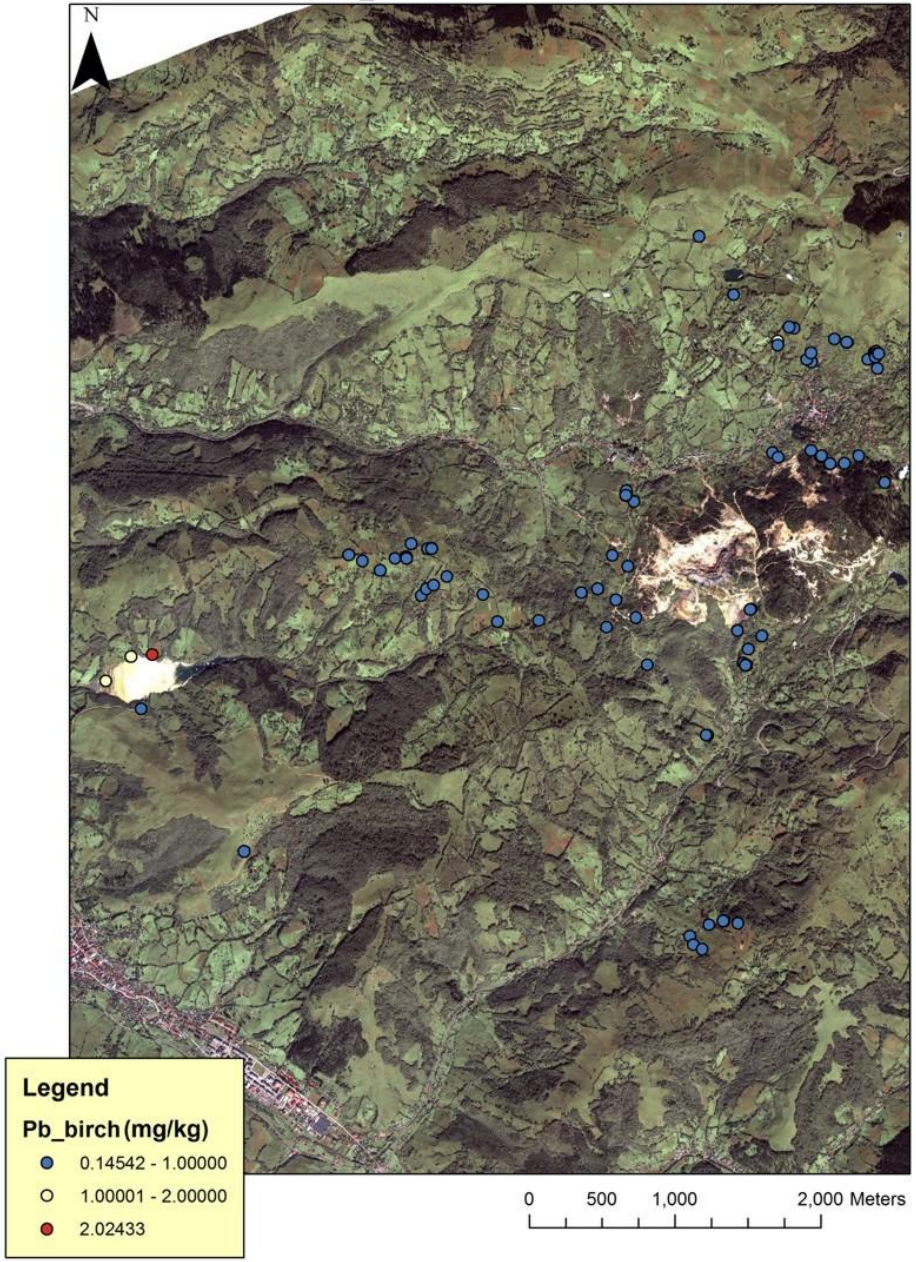

Cu_concentration in birch leaves
N
Legend
Cu_birch (mg/kg)
2.37288 - 5.00000
5.00001 - 10.00000
10.00001 - 26.06280
0 500 1,000 2,000 Meters


Cu_concentration in hornbeam leaves
N
Legend
Cu_hornbeam (mg/kg)
2.81048 - 5.00000
5.00001 - 10.00000
10.00001 - 15.78042
0 500 1,000 2,000 Meters

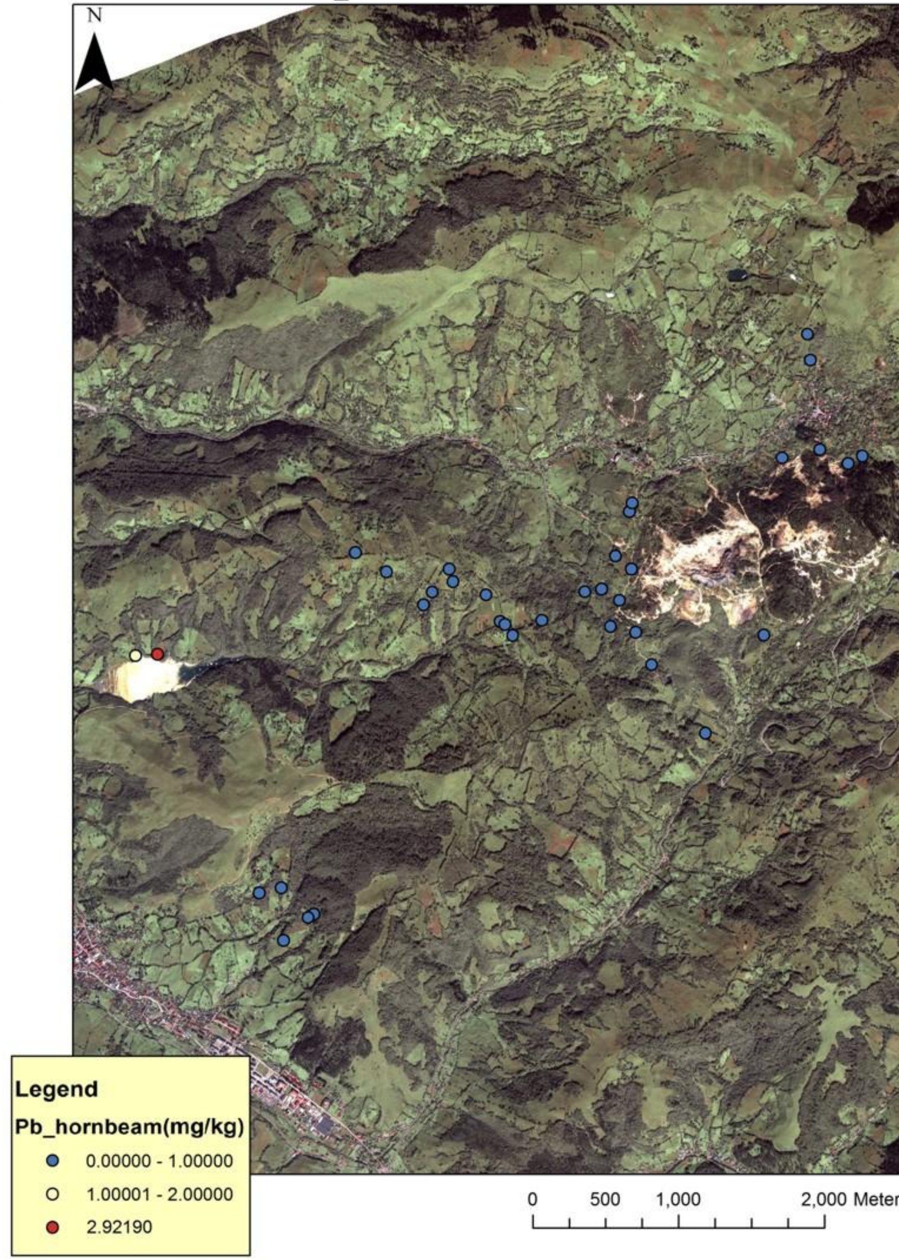

Ni_concentration in birch leaves
N
Legend
Ni_birch (mg/kg)
0.39882 - 5.00000
5.00001 - 10.00000
10.00001 - 15.70988
0
500
1,000
2,000 Meters

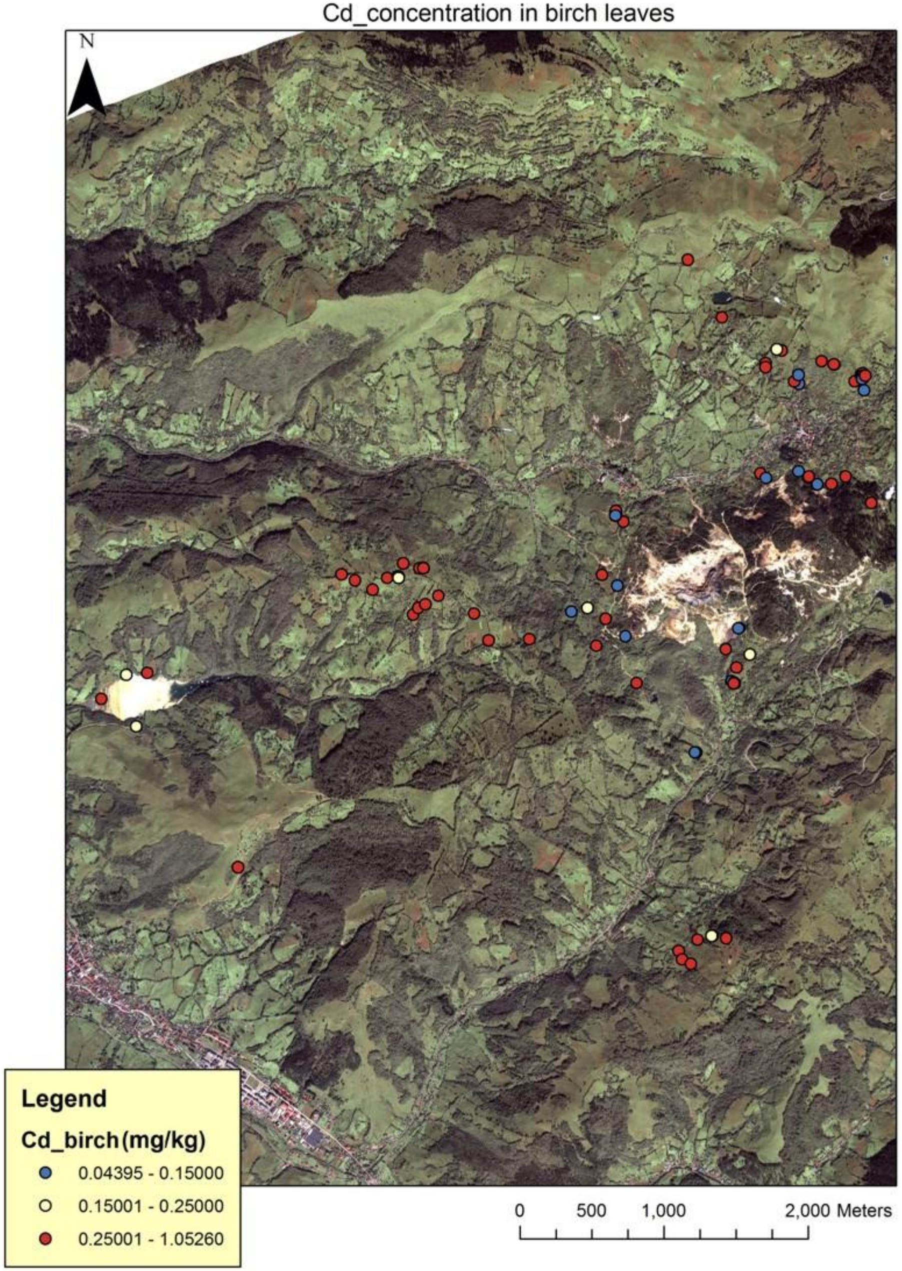

Ni_concentration in hornbeam leaves
N
Legend
Ni_hornbeam (mg/kg)
1.15723 - 5.00000
5.00001 - 10.00000
10.00001 - 27.49545
0
500
1,000
2,000 Meters

Pb_concentration in birch leaves

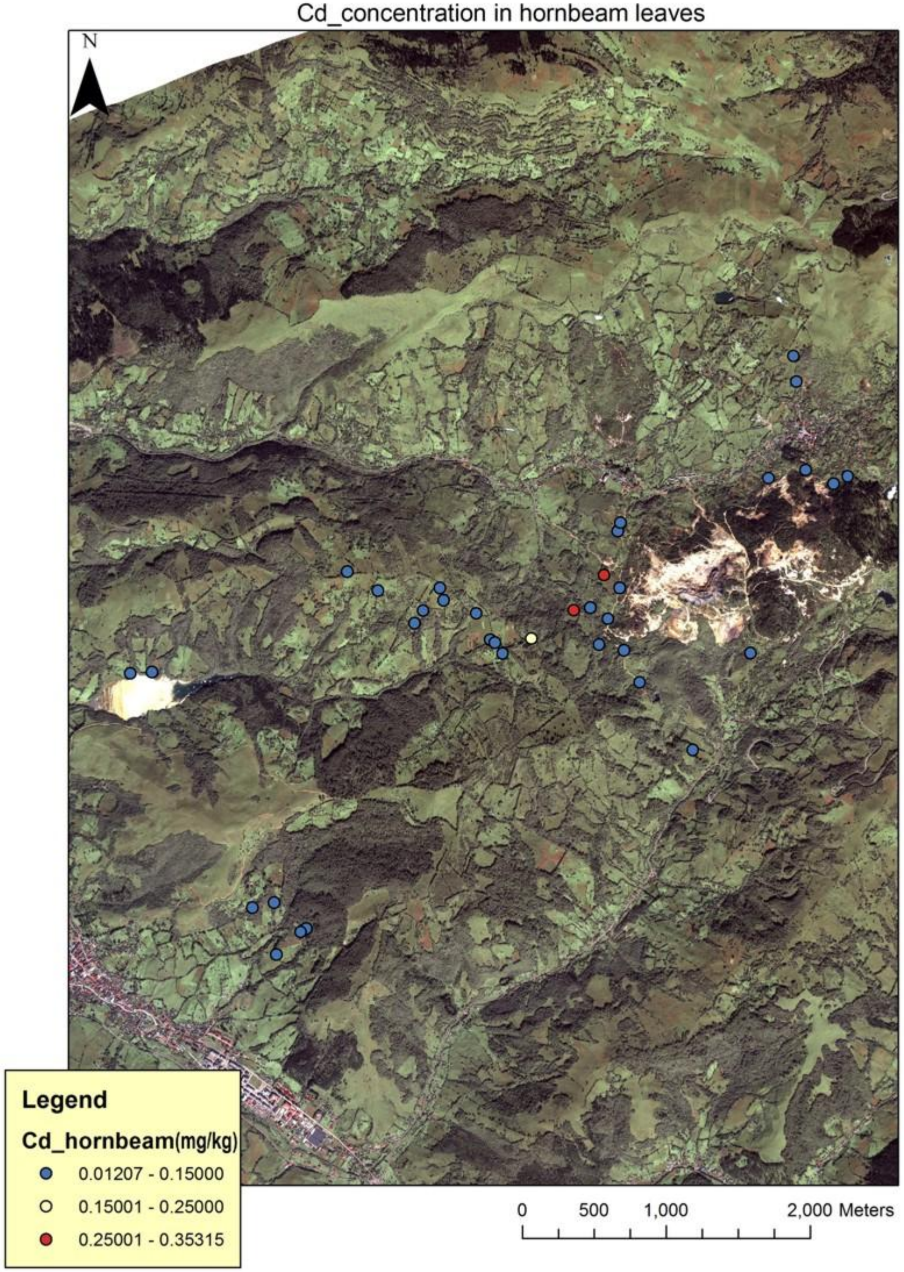


Pb_concentration in hornbeam leaves

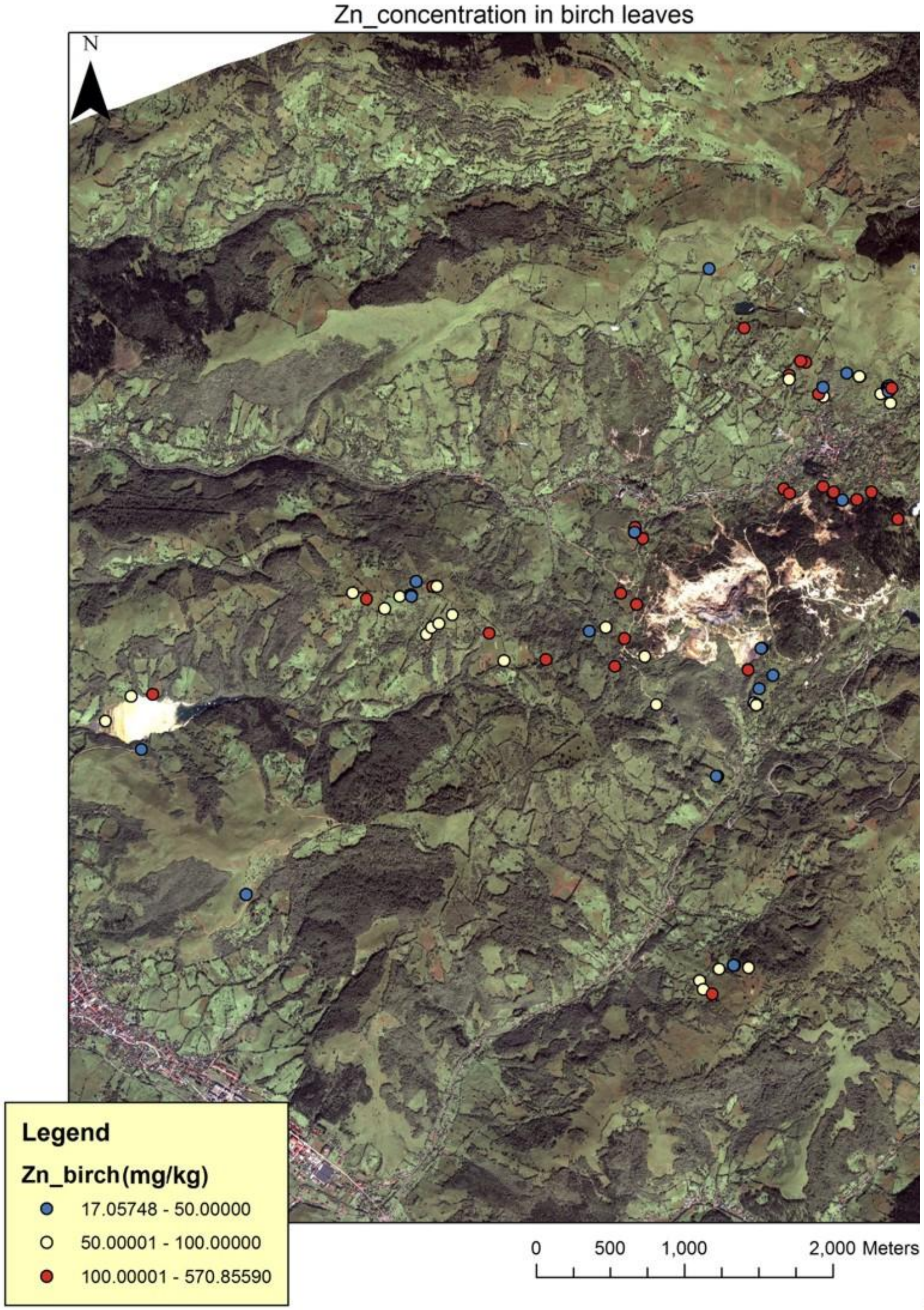


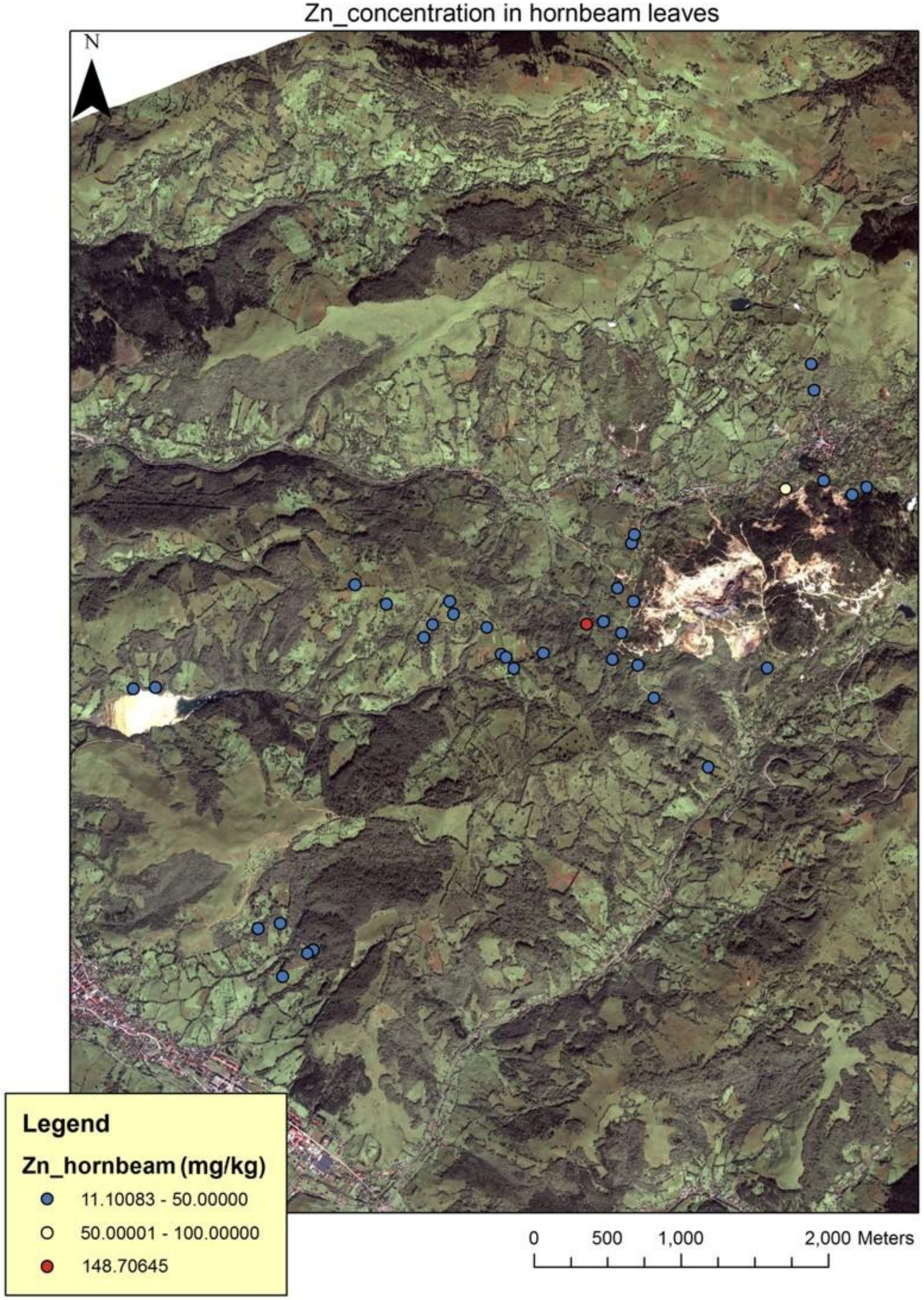


Cd_concentration in birch leaves
N
Legend
Cd_birch (mg/kg)
0.04395 - 0.15000
0.15001 - 0.25000
0.25001 - 1.05260
0
500
1,000
2,000 Meters



Cd_concentration in hornbeam leaves
N
Legend
Cd_hornbeam (mg/kg)
0.01207 - 0.15000
0.15001 - 0.25000
0.25001 - 0.35315
0
500
1,000
2,000 Meters





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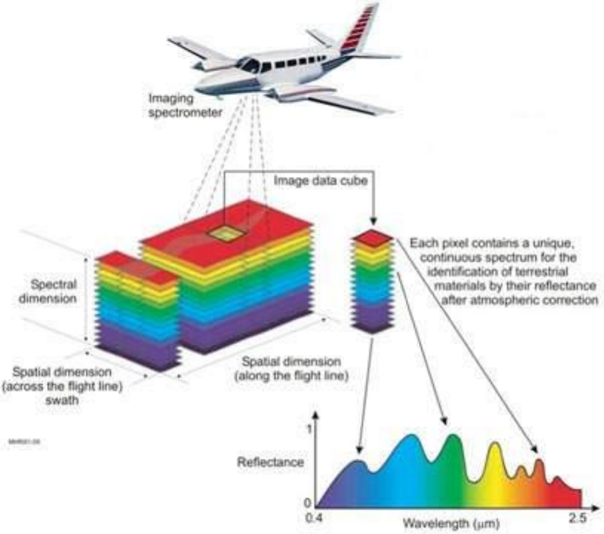
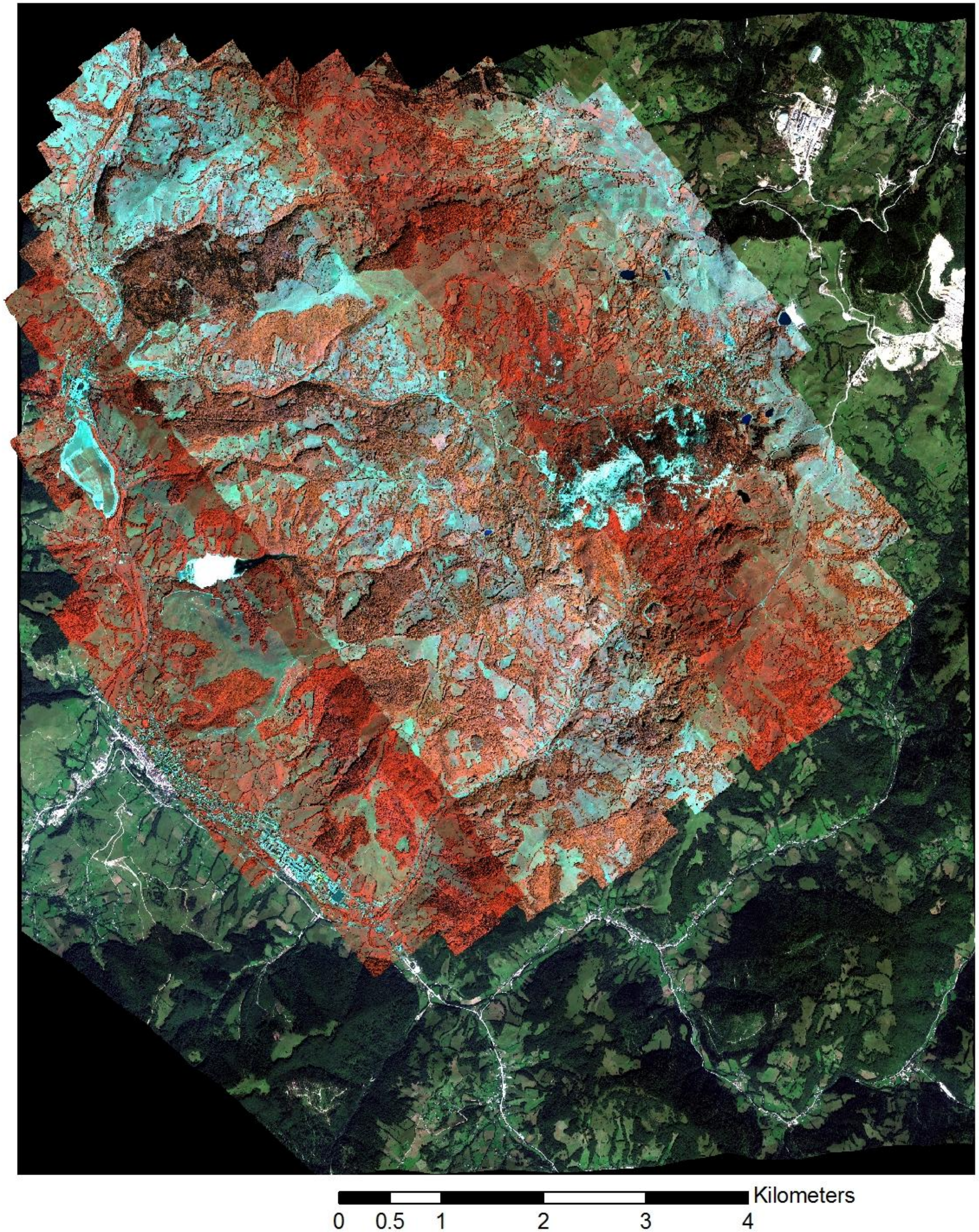
Airborne survey for hyperspectral imaging



First 2 attempts in June-July 2011 (EUFAR project, INTA crew and aircraft)

Failed due to bad weather!



A successful survey was performed in August 2012.

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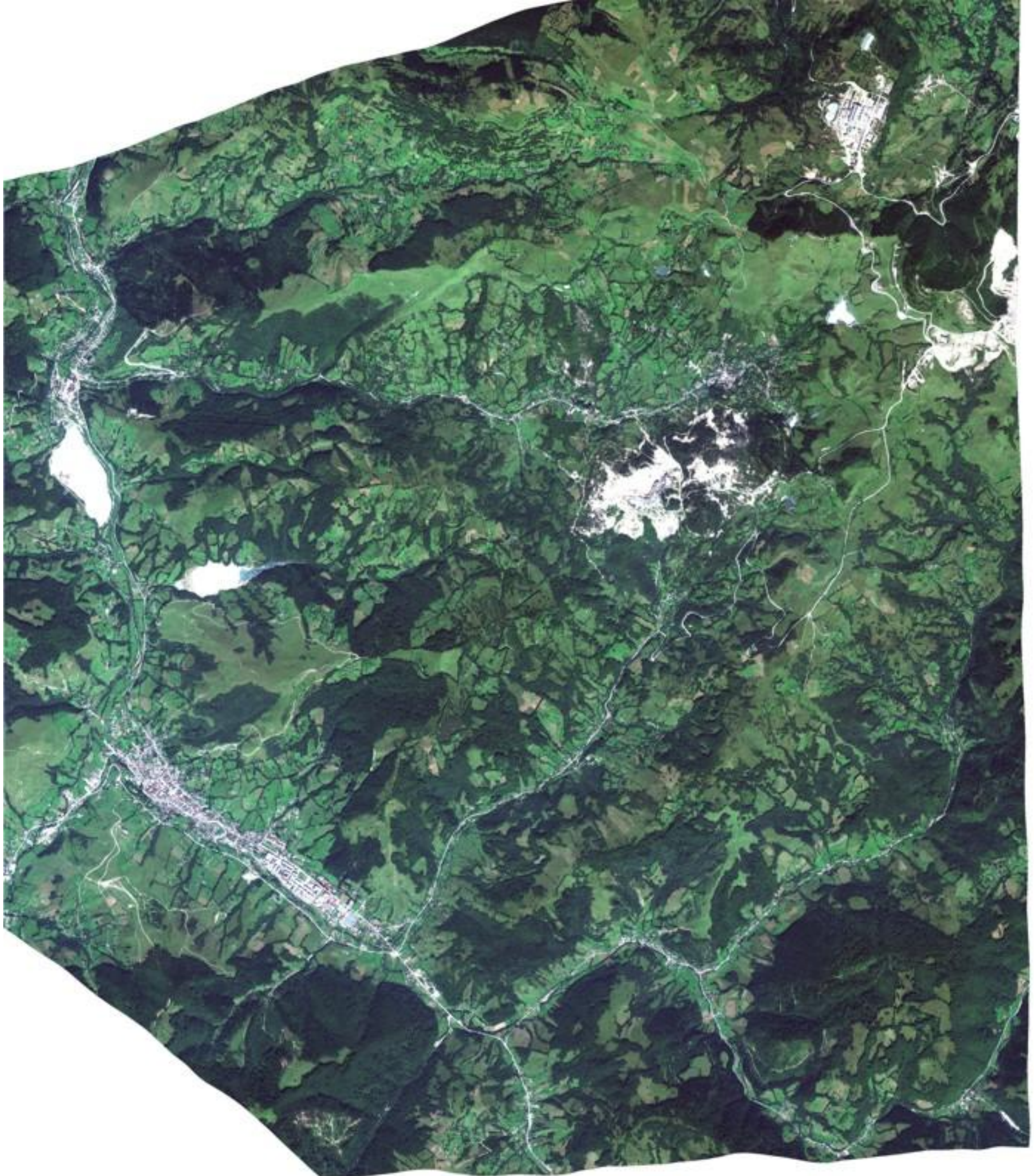
Satellite imagery

Worldview II time series

- 2010
- 2011
- 2012



Conclusions

- Integration of information from in-situ, airborne, and satellite observations through data assimilation and models
- Environmental monitoring – from discrete to continuous in spatial terms
- Accurate definition of the environmental baseline conditions
- Real- or near-real time monitoring
- Reliable long term environmental monitoring of the mining areas
- Time-series of the evolution of the state of the environment
- Prediction of the future developments;
- Identify vulnerabilities; reducing probability of loss by natural/technological disasters;
- Improve the management of energy resources
- Identify risks against human/ecosystems health

Thanks to the ImpactMin partners for their contribution

Thank You!

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