

**»ad hoc« international conference on the theme:
Outbursts of Water from the Abandoned Mines:
Causes, Consequences, Remediations, and Responsibility
Litija 18.-19. marec 2010**

Environmental impacts of metal mining and some case studies from Slovenia

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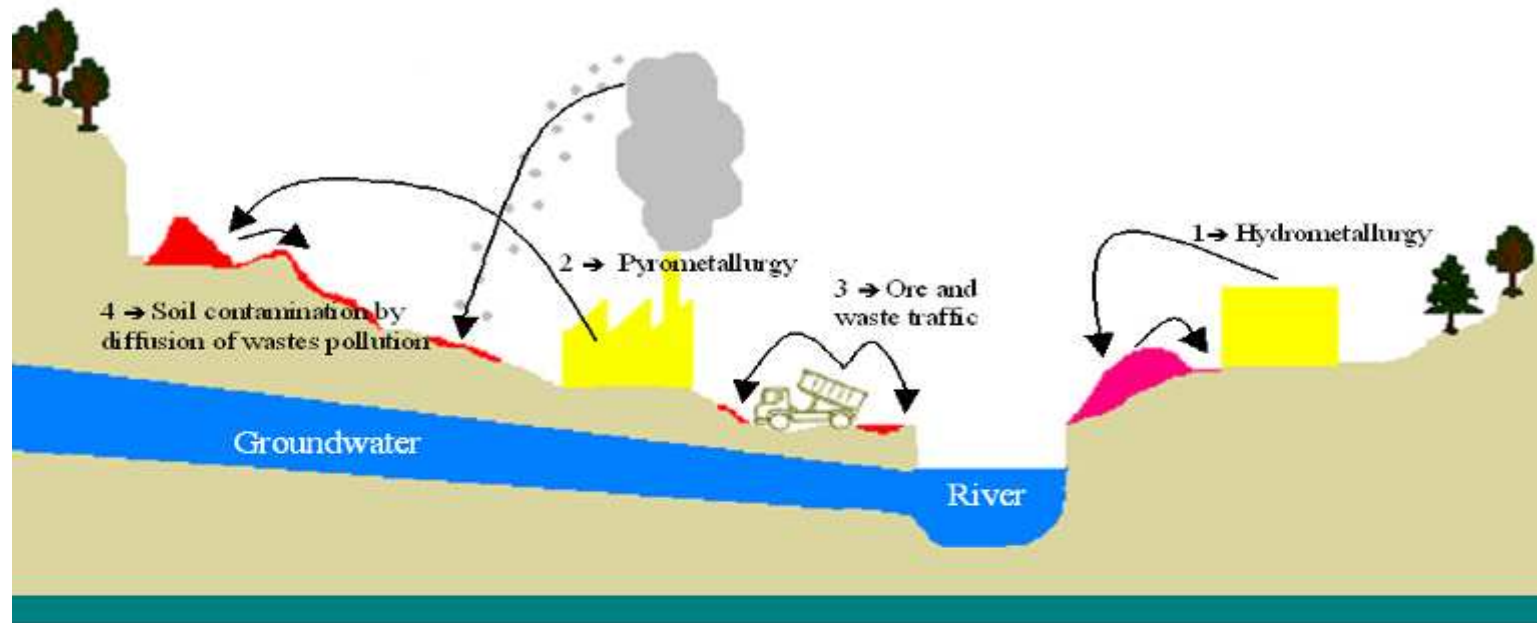


Geological Survey of Slovenia

Outline

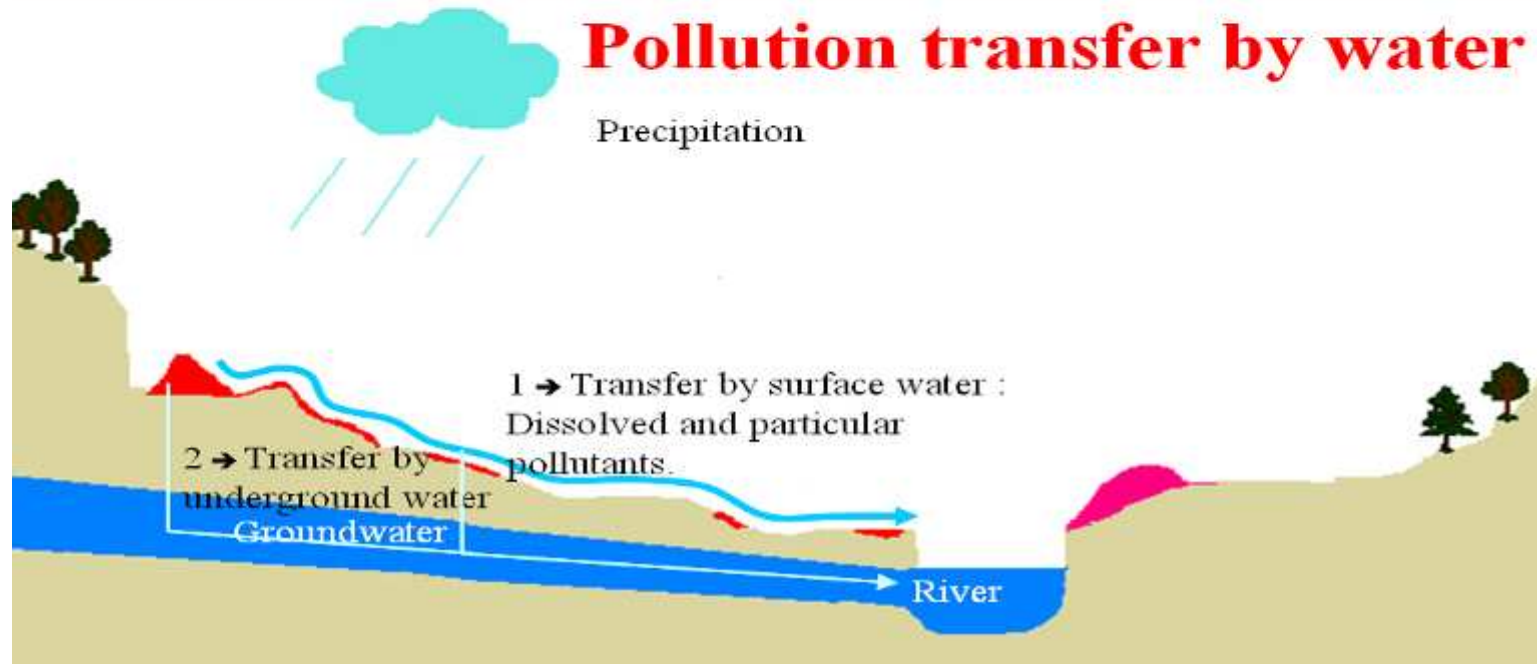
- Potential environmental impacts of mining
- Pollution impacts of metal mines
- Abandoned mines and mining waste dumps
- Legal basis (MWD) and legal questions
- Closed and abandoned metal mines in Slovenia
- Case studies from Slovenia:
 - Idrija
 - St. Ana – Podljubelj
 - Mežica

Sources of diffuse pollution on mining sites



Pollution transfer by water

Precipitation



Potential Environmental Impacts of mining

Physical Impacts

- Destruction of natural habitat
- Changes in river regime and ecology due to flow modification
- Changes in landforms
- Land instability
- Abandoned equipment, plant and buildings
- Land subsidence

Pollution Impacts

- Drainage from mining site (AMD)
- Sediment run-off-pollution in riverbed
- Effluent from mineral processing operation
- Soil contamination
- Air emissions
- Dust emissions and vegetation destruction
- Contaminated mining waste dumps (active and historical - often abandoned)

Occupation Health Impacts:

- Dust inhalation
- Handling of chemicals, residues, products
- Exposure to toxic materials used on-site
- Air emissions
- Exposure to heat, noise, vibration, radiation.



Pollution impacts of metal mines

- **Air pollution:**

dust, smelting (SO₂, HM)

- **Water pollution:**

sulphides+air+water=acidic and M bearing solution; toxic chemicals; suspended solids; influence on hydrogeology)

- **Solid waste:**

source of dust and Water pollution if sulphides - AD

- **Tailings**

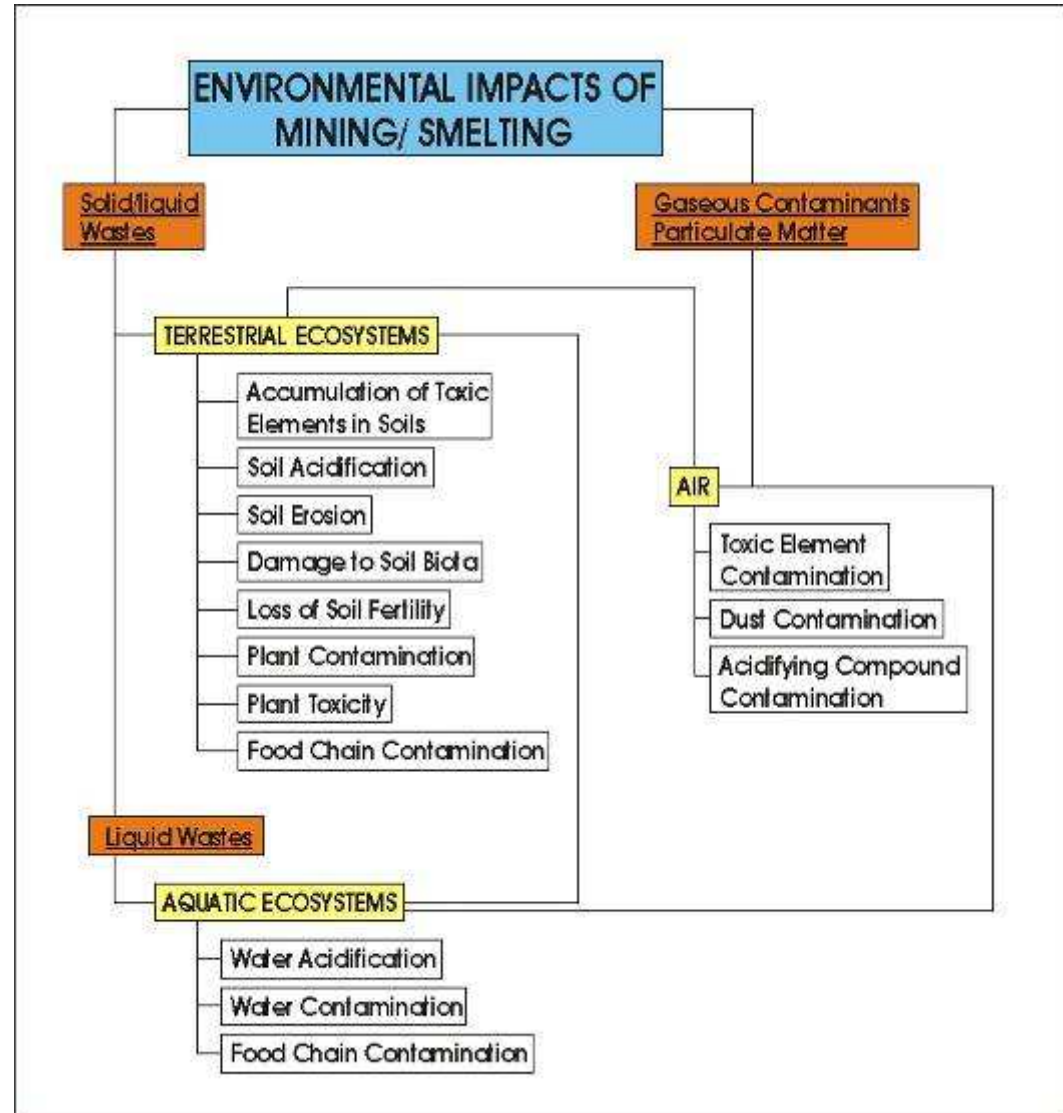
tailings dams represent potentially serious environmental hazard

- **Abandoned Mine Sites – abandoned mine waste dumps**

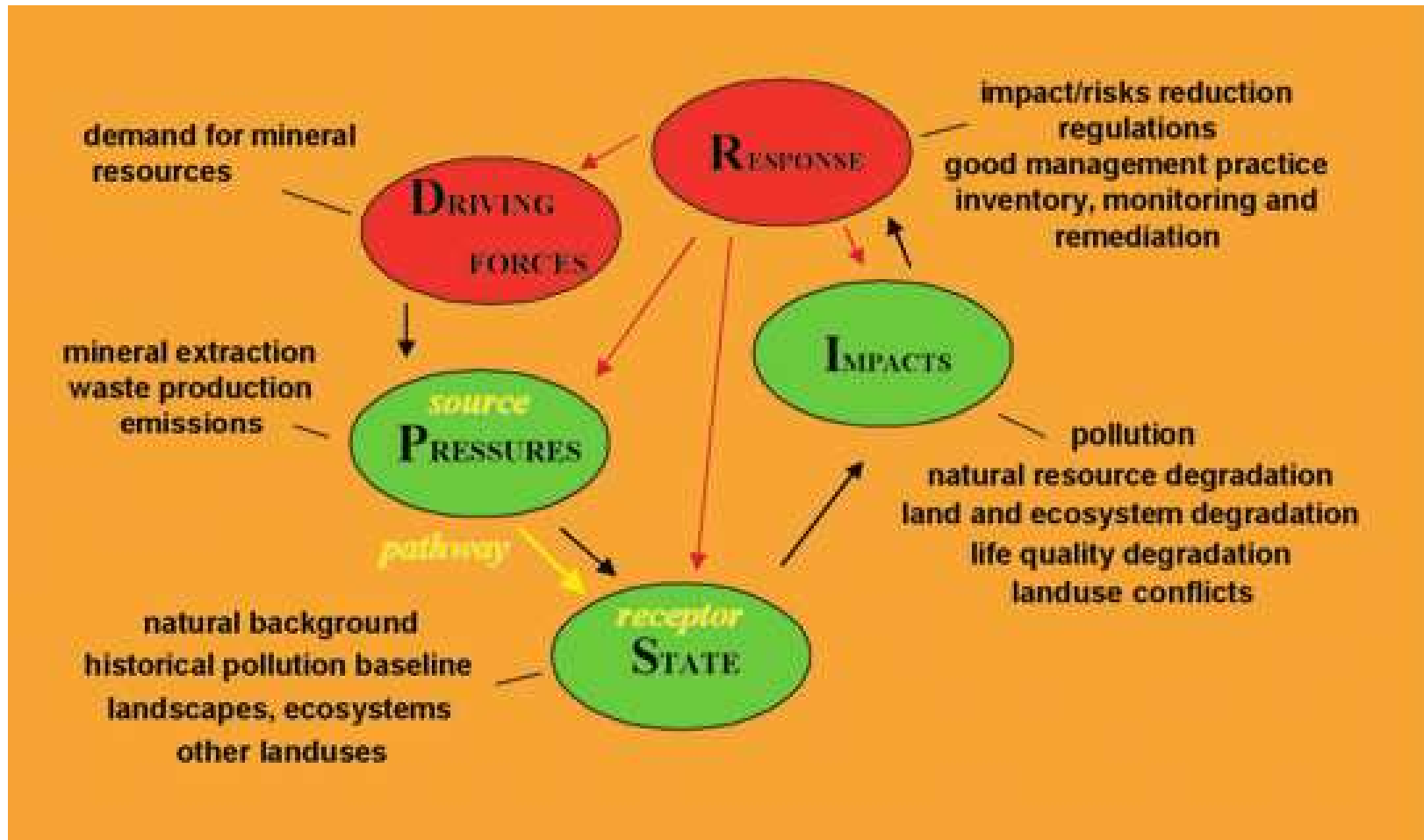
? magnitude of impacts from past mining

? what are their major hazards and ???

? where are the sites generating the greatest hazards located



DPSIR framework for mining waste



Schematic EEA DPSIR framework for mining waste.

Traditional pollution relationship **source - pathway- receptor** is also shown.

Red boxes are related to socio-economic and green to environmental systems (after Jordan, 2004)

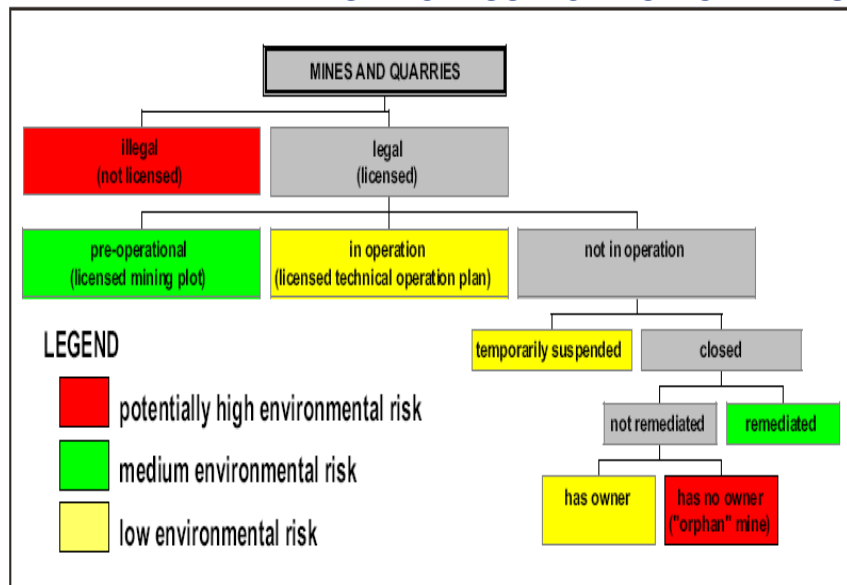
Abandoned mines and mining waste dumps

Abandoned mines are a wide-spread problem in Europe where mining has a long history. A lot of metal mines and small coal-mines were abandoned more than 30 years ago, without proper closure and rehabilitation actions and plans. Historical mining activities contributed important part of existing accumulations of mining waste material. For abandoned mines that were closed before environmental legislation became common, there is a lack of clearly defined responsibility and remediation has often high cost.

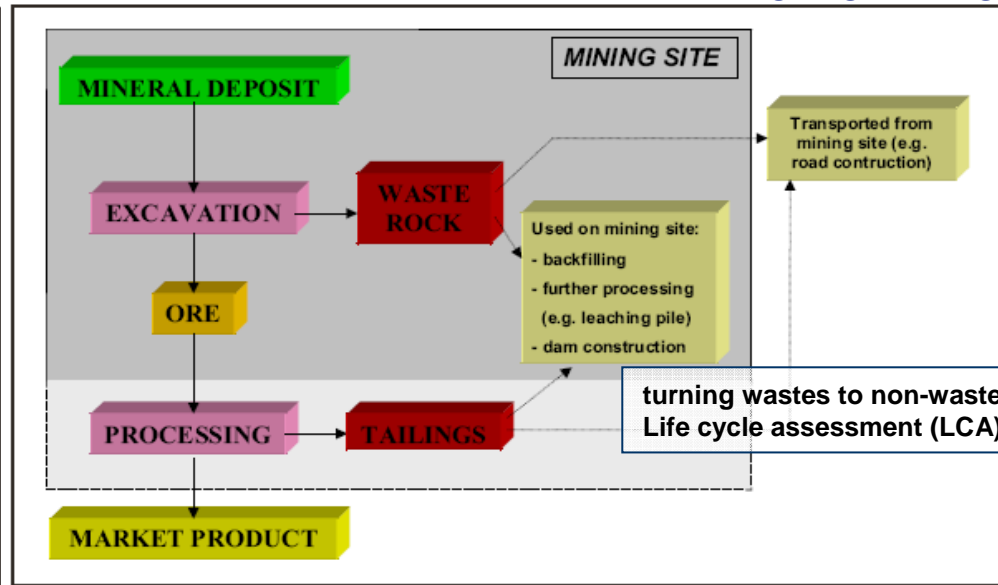
The wastes of base metals mining are probably the most critical hazards for the environment and human health (because of their physical and geo-chemical characteristics).

The EU Directive (MWD) prescribes an inventory of abandoned mine waste dumps that should reduce the uncertainty due to a lack of this type of information.

LEGAL CLASSIFICATION OF MINES



MINE WASTE STREAMS



Legal basis - MWD

EN

Official Journal of the European Union

DIRECTIVE 2006/21/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

SL

Uradni list Evropske unije

Direktiva 2006/21/ES Evropskega parlamenta in Sveta

z dne 15. marca 2006

**o ravnanju z odpadki iz rudarskih in drugih ekstraktivnih dejavnosti ter o spremembi Direktive
2004/35/ES**

člen 20

Popis zaprtih objektov za ravnanje z odpadki

Države članice zagotovijo pripravo in redno posodabljanje popisa zaprtih objektov za ravnanje z odpadki (vključno z opuščeni objekti za ravnanje z odpadki), ki se nahajajo na njihovem ozemlju in povzročajo resne negativne vplive na okolje ali utegnejo srednjeročno ali kratkoročno postati resna grožnja za zdravje ljudi ali okolje. Takšen popis, ki bo dosegljiv javnosti, se pripravi v roku štirih let od 1. maja 2012, upoštevajoč metodologije iz člena 21, če so na voljo.



Legal questions

Closed waste facilities:

Art.12 (3):

A waste facility may be considered as finally closed only after the competent authority has, without undue delay, carried out a final on-site inspection, assessed all the reports submitted by the operator, certified that the land affected by a waste facility as been rehabilitated and communicated to the operatorist approval of the closure.

“Objekt za ravnanje z odpadki se šteje za dokončno zaprtega šele takrat, ko pristojni organ brez nepotrebnega odlašanja izvede zadnji inšpekcijski pregled lokacije, oceni vsa poročila, ki jih je predložil upravljavec, potrdi, da je zemljišče, na katerega vpliva objekt za ravnanje z odpadki, sanirano, ter upravljavcu sporoči, da je zaprtje odobreno.“

Abandoned waste facilities:

no operator in charge, land owner responsibility ?

Definition of serious negative environmental impacts ?

Serious threat to human health or the environment ?

Smelter waste do not fall into the scope of MWD and are not to be considered with the inventory item.



History of mining activities in Slovenia

Bronze age – Roman Empire - Medieval times:

Archaeologists found evidence of primitive mining and metalurgic activities
polimetalic sulphide vein occurrences were mined in small mines
and smelters were situated on outcrops
in Roman times excellent steel for weapons (noric steel)
After collapse of the R.E. mining/smelting activities ceased for longer period.

Industrial revolution (19. century)

Increased mining/smelting activities and increased production in coalmines, production rate was variable and depended on the price.

After WW2

Socialist system supported industrialization; mines were nationalized
increased production in existing big mines (Idrija, Mezica) and coalmines
intensive prospecting of ore outcrops but success was very limited
the only new mine opened (and closed) in this period was uranium mine Žirovski vrh.



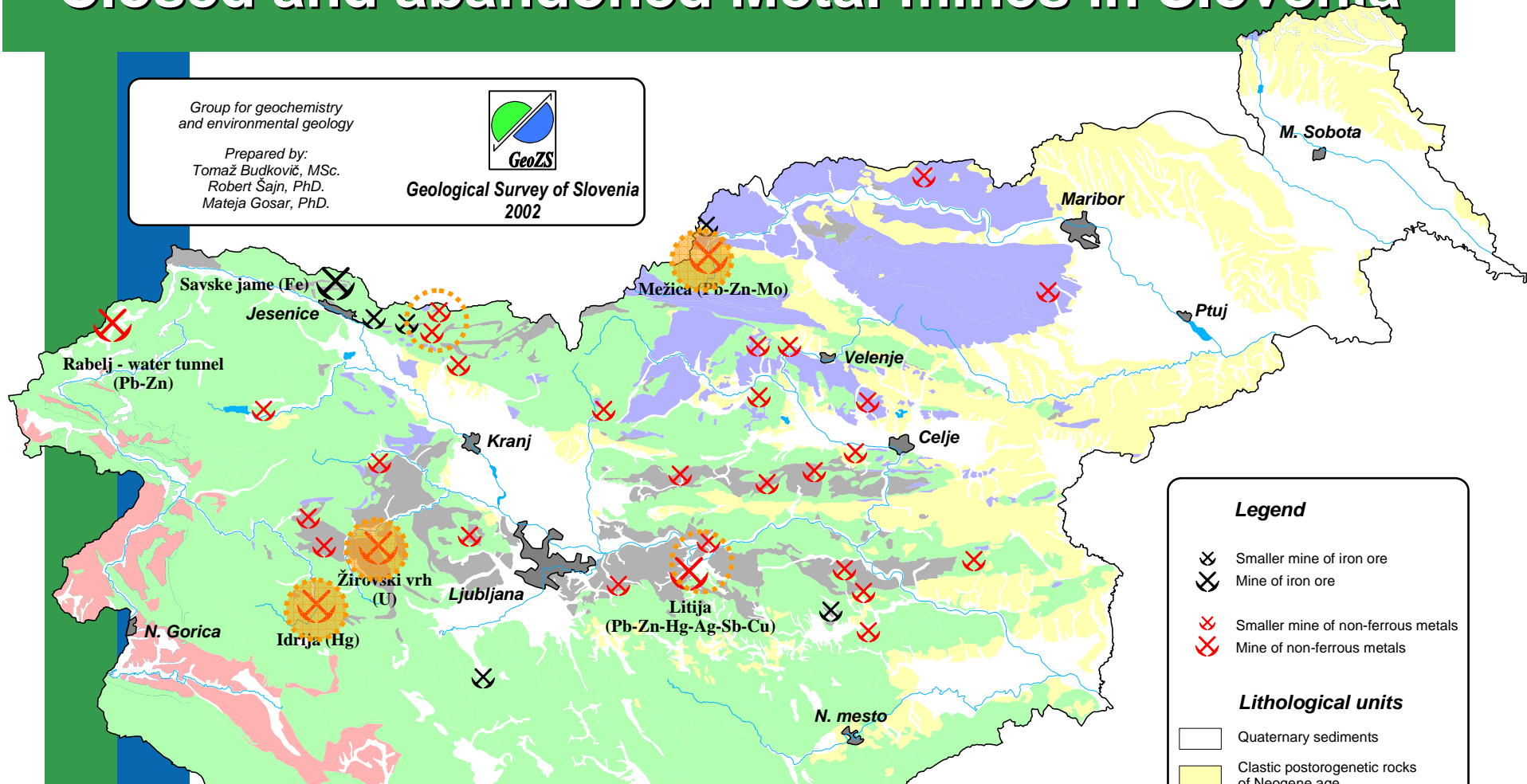
Closed and abandoned Metal mines in Slovenia

Group for geochemistry
and environmental geology

Prepared by:
Tomaž Budkovič, MSc.
Robert Šajn, PhD.
Mateja Gosar, PhD.



Geological Survey of Slovenia
2002



Legend

- Smaller mine of iron ore
- Mine of iron ore
- Smaller mine of non-ferrous metals
- Mine of non-ferrous metals

Lithological units

- Quaternary sediments
- Clastic postorogentic rocks of Neogene age
- Clastic flysch rocks of Paleogene age
- Carbonate rocks mostly of Mesozoic age
- Clastic rocks of Paleozoic age
- Igneous and metamorphic rocks

GeoZS carried out in 2002 inventory of metal mines which contains information on the following elements of 49 closed and abandoned mines.

- the geo-referenced location of the site
- the type of mineral or minerals extracted
- the brief history of the site
- reserves and perspectivity of the site (Budkovič et al., 2003)

Around 200 sites of metallic mineral resources (mining sites and finds) are known in Slo.

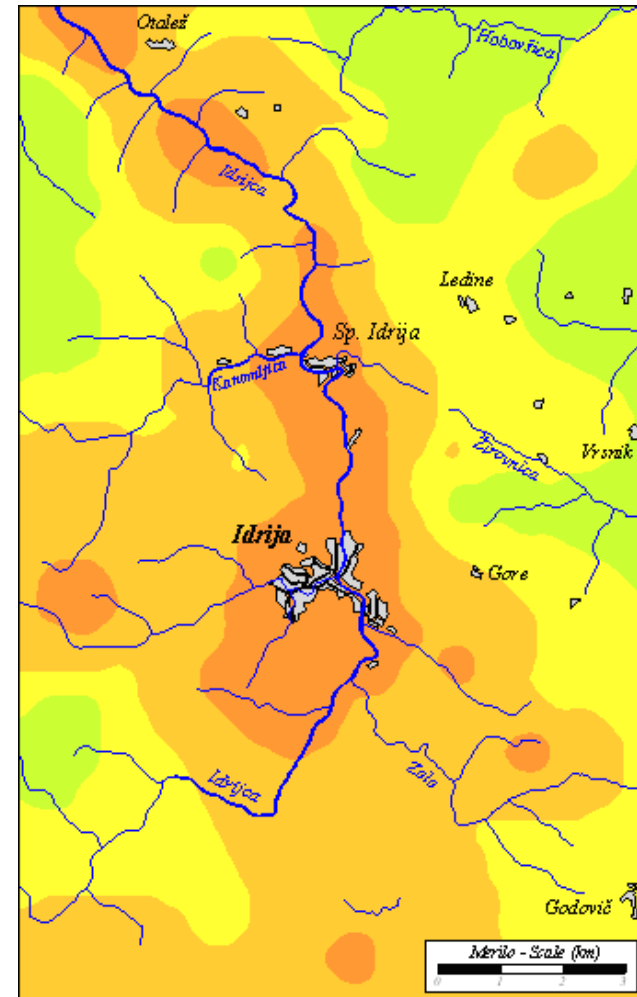
Environmental impacts of Idrija mine (1)

Mercury mine in Idrija:

- more than 500 years of operation
- 12.760.700 t of ore excavated
- contained 145.000 t Hg
- 107.500 t Hg produced
- 37.500 t of Hg lost into the environment

Environmental impacts:

- increased Hg contents in all environmental compartments
- geomechanical instability
- ionization radiation



Onesnaženost tal - Soil pollution (Uč. list RS 68/96)



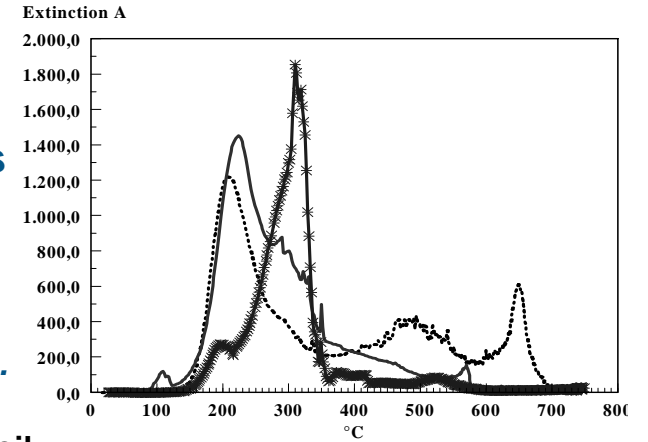
Soil pollution in Idrija area (Šajn & Gosar, 2004)

Environmental impacts of Idrija mine (2)

Researches of Hg speciation in soil and attic dust

- determination of Hg distribution in soil/attic dust
- qualitative and quantitative determination of Hg species
- study of the mechanism of Hg dispersion
- investigations of transformations and transport processes

- GOSAR, M, ŠAJN, R. 2004: *Geochemical soil and attic dust survey in Idrija, Slovenia. J. phys., IV.*
- GOSAR, ŠAJN & BIESTER, 2006: *Binding of mercury in soils and attic dust in the Idrija mercury mine area (Slovenia). Sci. total environ.*



Attic dust

Soil

researched area
160 km²



average 1.3 mg/kg
min 0.6 mg/kg
max 1055 mg/kg

BESEDILO

>10 mg/kg on 19 km²
average 1.3 mg/kg
min 0.26 mg/kg
max 973 mg/kg

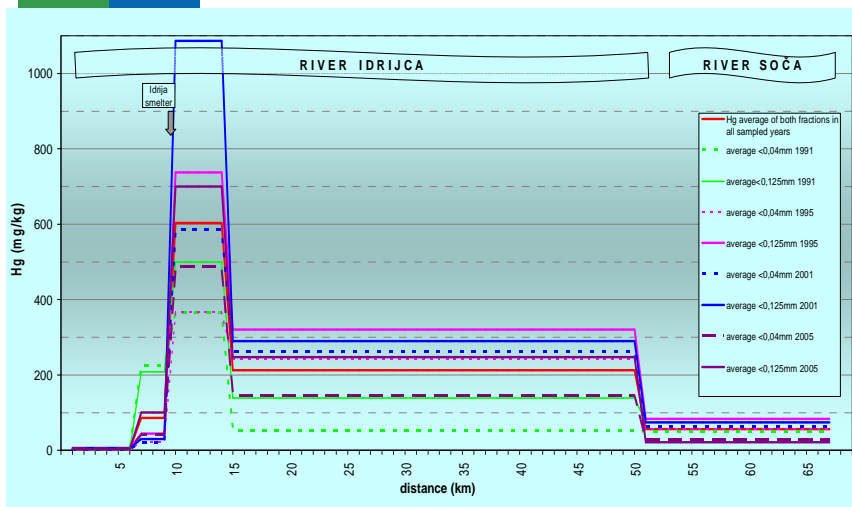
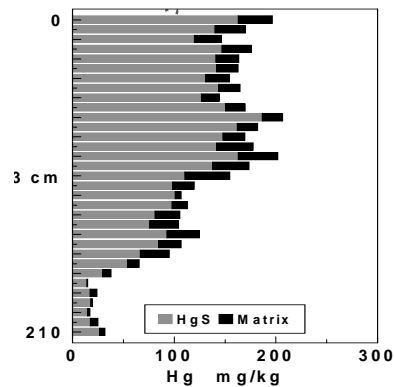
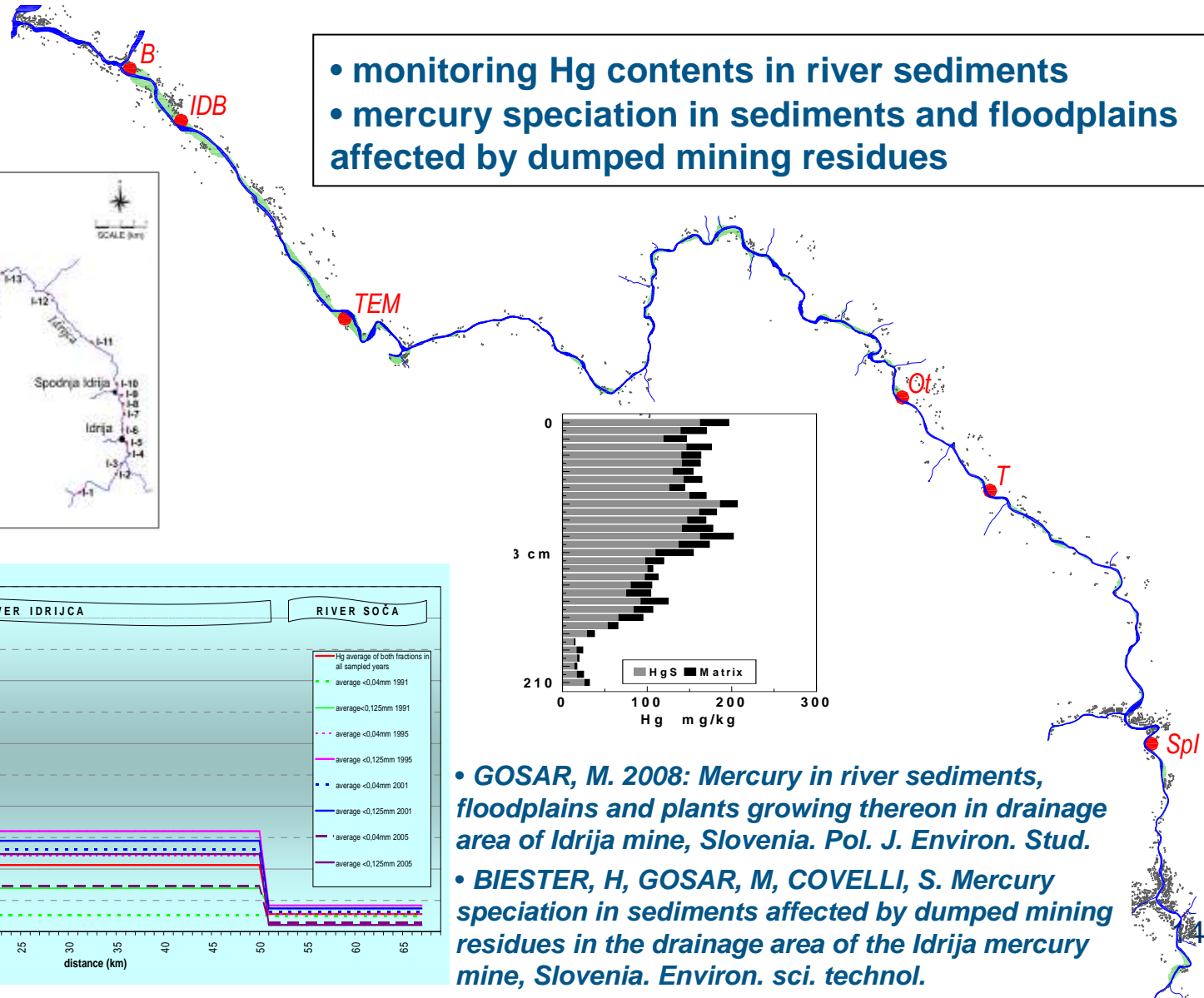
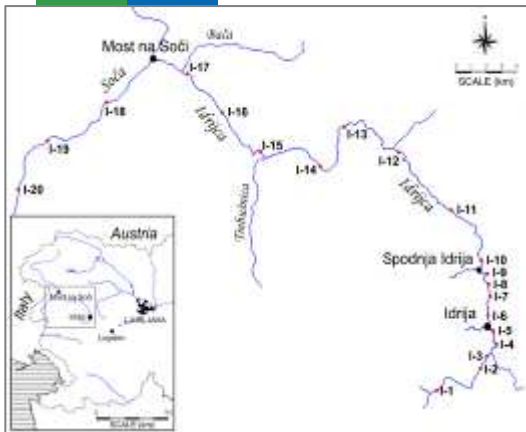
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Environmental impacts of Idrija mine (3)

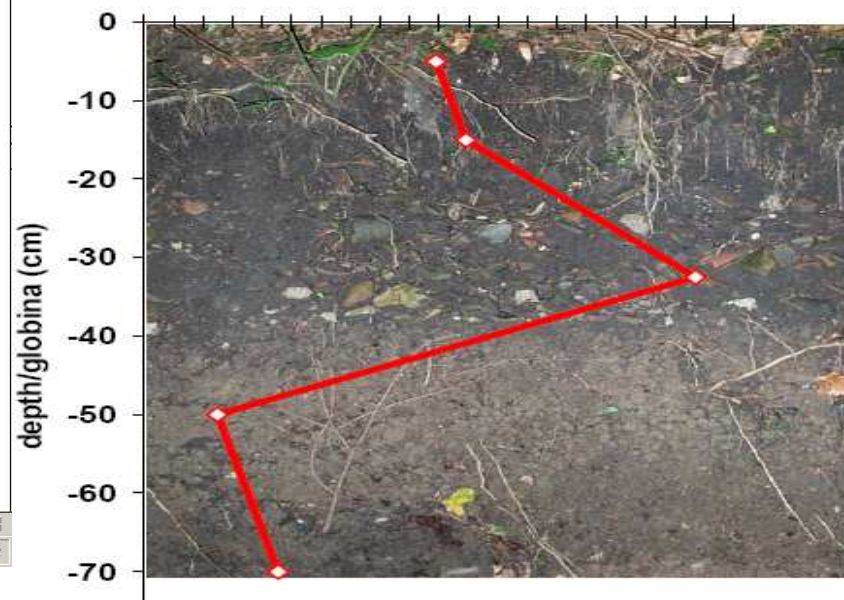
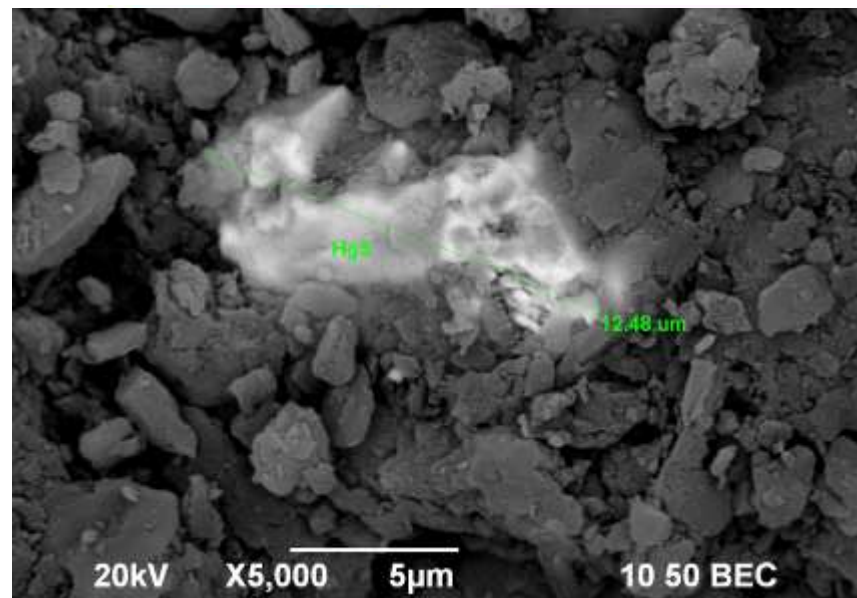
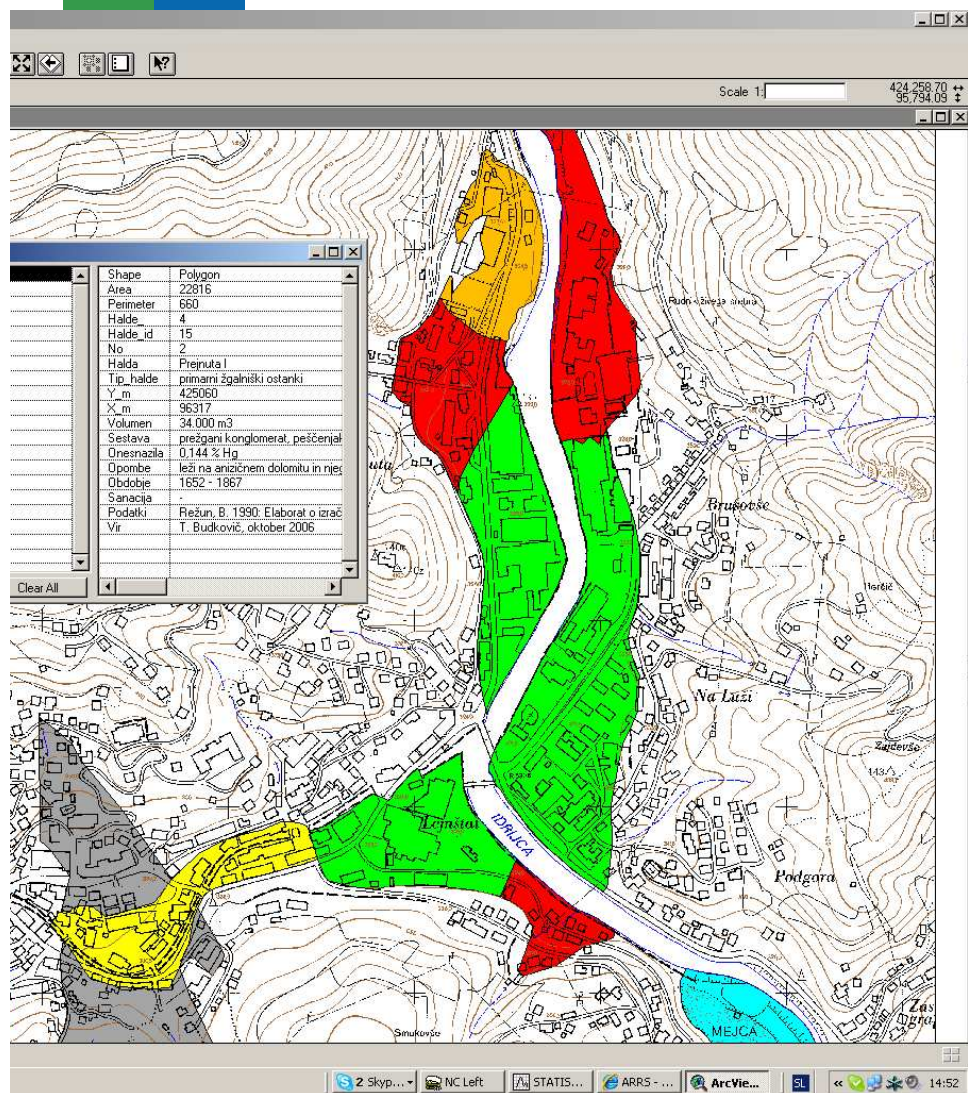
Hg distribution and binding forms in the sediments

- monitoring Hg contents in river sediments
- mercury speciation in sediments and floodplains affected by dumped mining residues



- **GOSAR, M. 2008: Mercury in river sediments, floodplains and plants growing thereon in drainage area of Idrija mine, Slovenia. Pol. J. Environ. Stud.**
- **BIESTER, H, GOSAR, M, COVELLI, S. Mercury speciation in sediments affected by dumped mining residues in the drainage area of the Idrija mercury mine, Slovenia. Environ. sci. technol.**

Environmental impacts of Idrija mine (4) mining waste

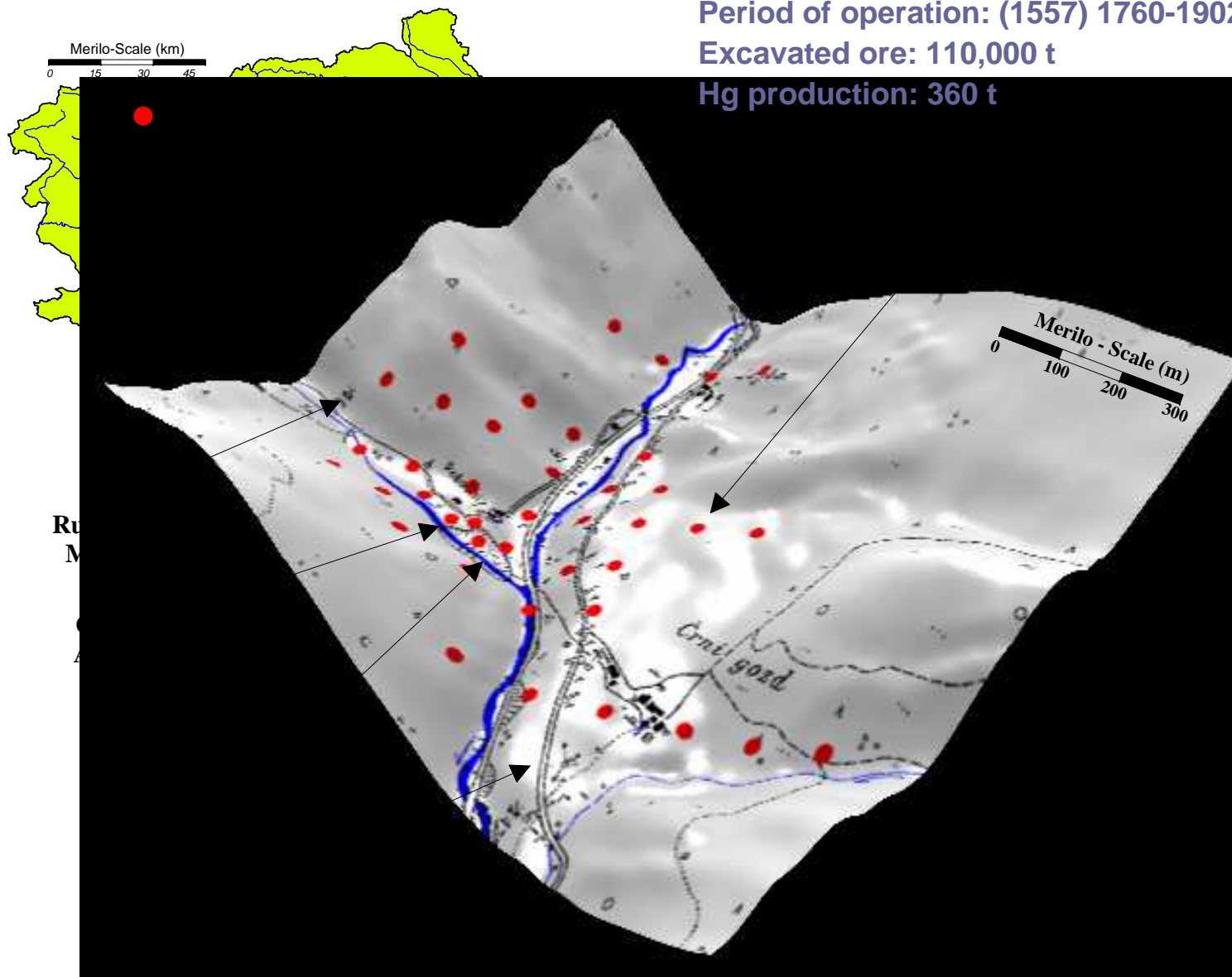


Environmental impacts of Podljubelj Hg mine (1)

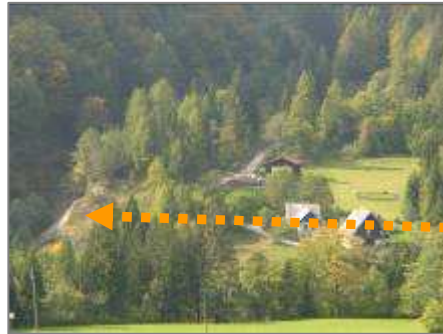
Period of operation: (1557) 1760-1902

Excavated ore: 110,000 t

Hg production: 360 t

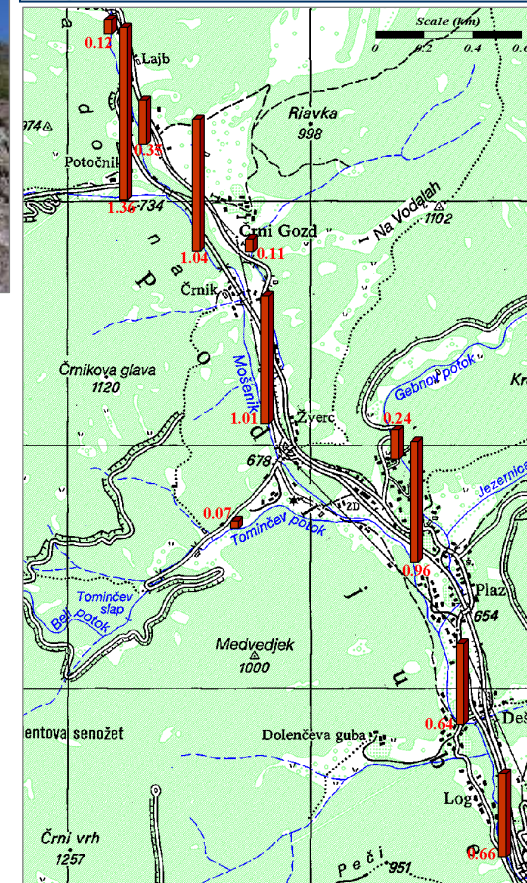


Environmental impacts of Podljubelj Hg mine (2)



170,000 t waste material

Hg in sediments of Mošenik



Aerial distribution of Hg in soil

Critically polluted: 9 ha

	<u>Podljubelj</u> Md (min-max)	<u>Idrija</u> Md (min-max)
Hg in soil (mg/kg)	3 (0.17–719)	20 (0.68–973)
Hg in sediments (mg/kg)	0.64 (0.065-1.36)	112 (0.9-4,121)
Critically polluted area (km ²)	0.3	20



•Teršič, T., Gosar, M., Šajn, R., 2006. Environmental impacts of abandoned mercury mine in Podljubelj. Geological Survey of Slovenia, Ljubljana.

•Teršič, T., Gosar, M., Šajn, R., 2008. Impact of mining activities on soils and sediments at the historical mining area in Podljubelj, NW Slovenia. Journal of geochemical exploration.

Environmental impacts of Mežica mine (1) soil pollution

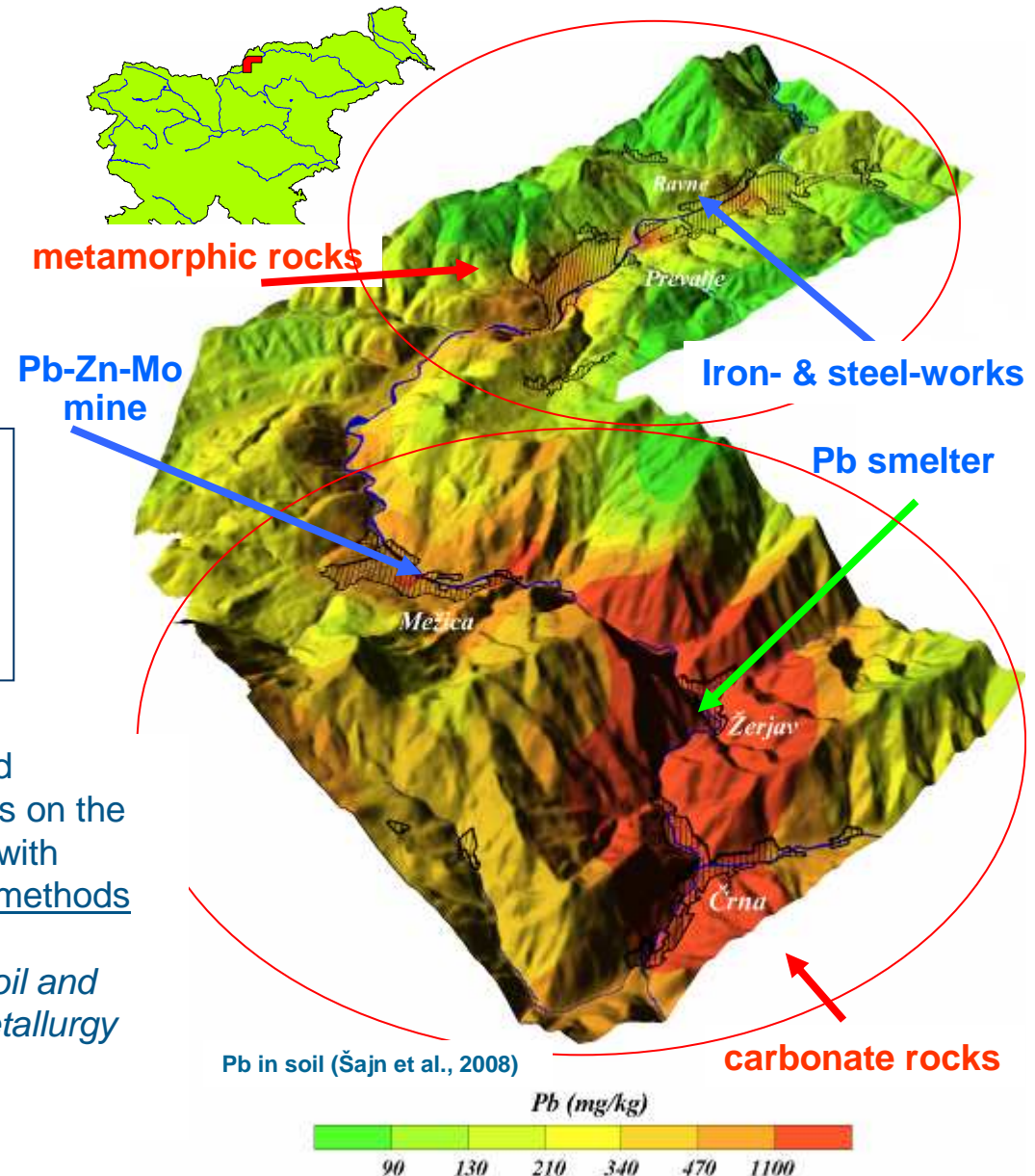
Mežica mine (Pb-Zn-Mo)
operation: 1665 -1994
ore excavation: 19.000.000 t
Žerjav (Pb smelter)
operation: 1746 - >
produced: ~ 500.000 t Pb
Ironworks Ravne
operation: 1835 - >

Soil degradation:

- 24 km² metal contaminated soil
- mine waste, flotation tailings
- destroyed vegetation cover
- water erosion at barren slopes

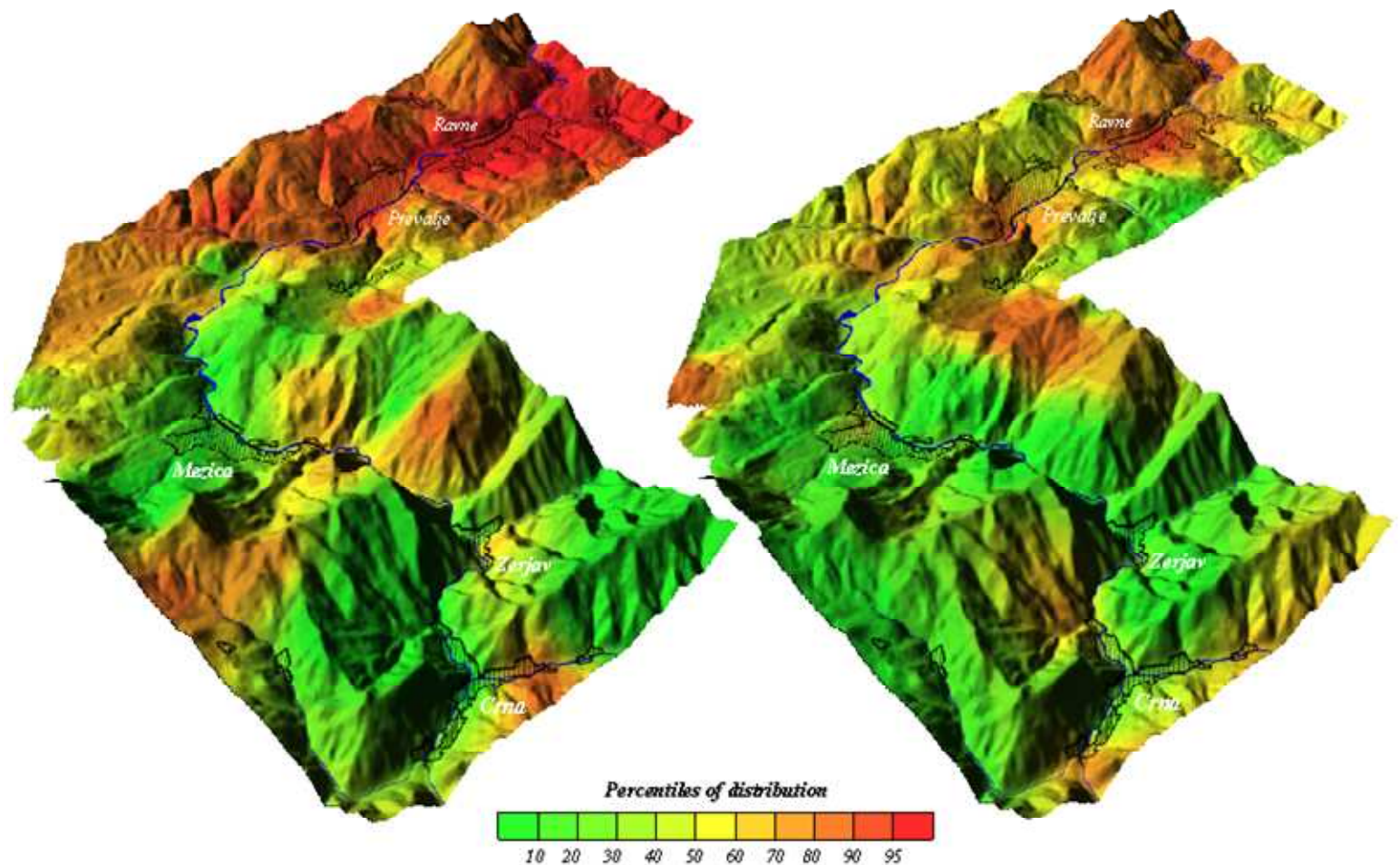
Differentiation between geogenic and anthropogenic environmental impacts on the basis of soil and attic dust sampling with application of multivariate statistical methods (factor analysis)

• Šajn, R., 2006: *Factor analysis of soil and attic-dust to separate mining and metallurgy influence, Meža Valley, Slovenia. Mathematical Geology 38/6*



Environmental impacts of Mežica mine (2) soil pollution

Distribution of factor 4:
accumulation of elements which are influenced of ironworks in Ravne
(Mo, Cu, Mn, Co, Cr, Ni, W, Fe)



Environmental impacts of Mežica mine (3) contaminated sediments

- Increased contents of **Pb, Zn, Cd, Mo** in **As** in the area of Mežica (source: mining and smelting)

Hot points:

Meža: - Mežica (Polena), surroundings of Poljane and Prevalje

Meža tributaries: - Helenski potok, Mušenik, Junčarjev potok

Important input from mining waste dumps!

Increased contents of **Cr, Cu, Co, Fe** in **Ni** in Ravne area because of iron and steel industry in Ravne)

- More HM in coarser fraction (< 0.125 mm) in upper Meža Valley; from Ravne downstream and in Drava more HM in finer fraction

Drava:

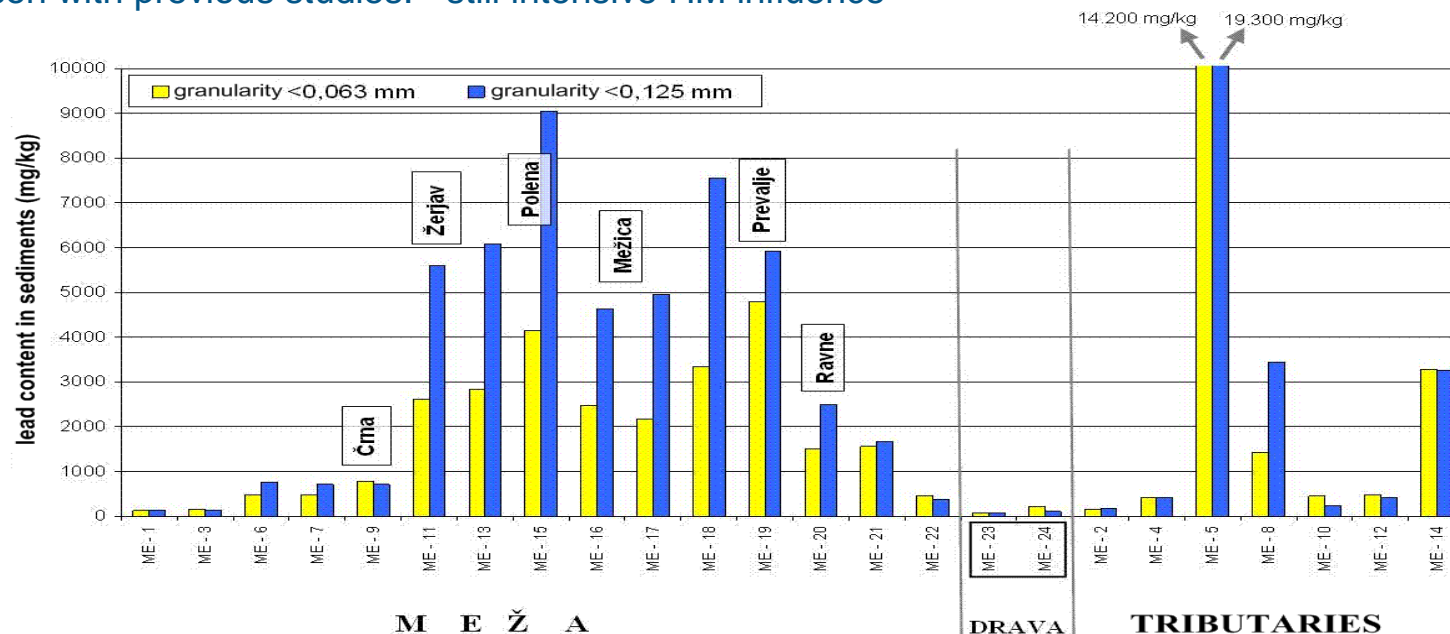
-influence of Meža is evident;

increased Pb & Zn and Cd, Mo, downstream from Meža confluence

-more As in Drava then in Meža

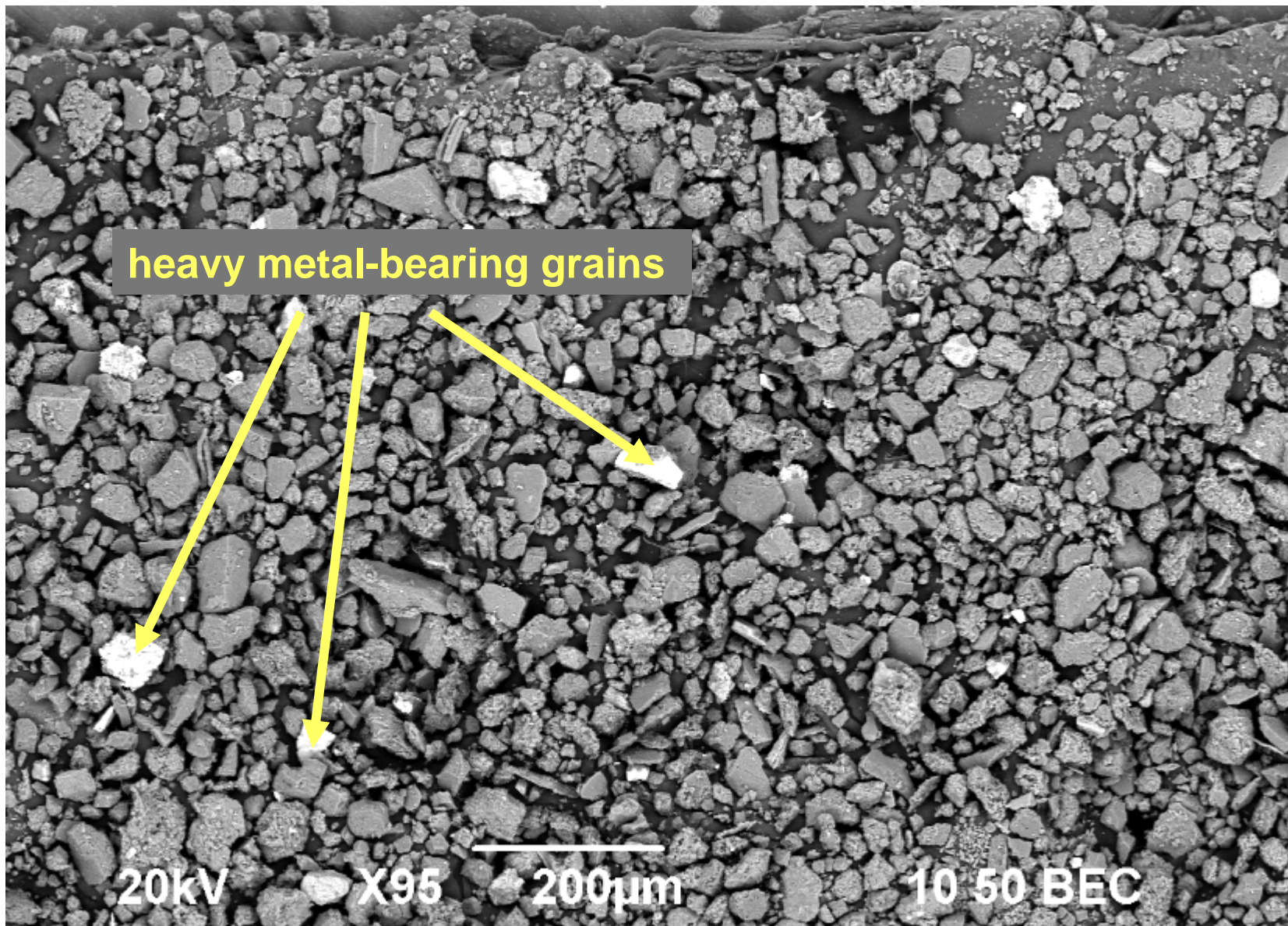
-higher As

- Comparison with previous studies: - still intensive HM influence



Environmental impacts of Mežica mine (4)

Individual particle analysis



Thank you!

