ACID MINE WATERS AND CASE STUDIES FROM SPAIN

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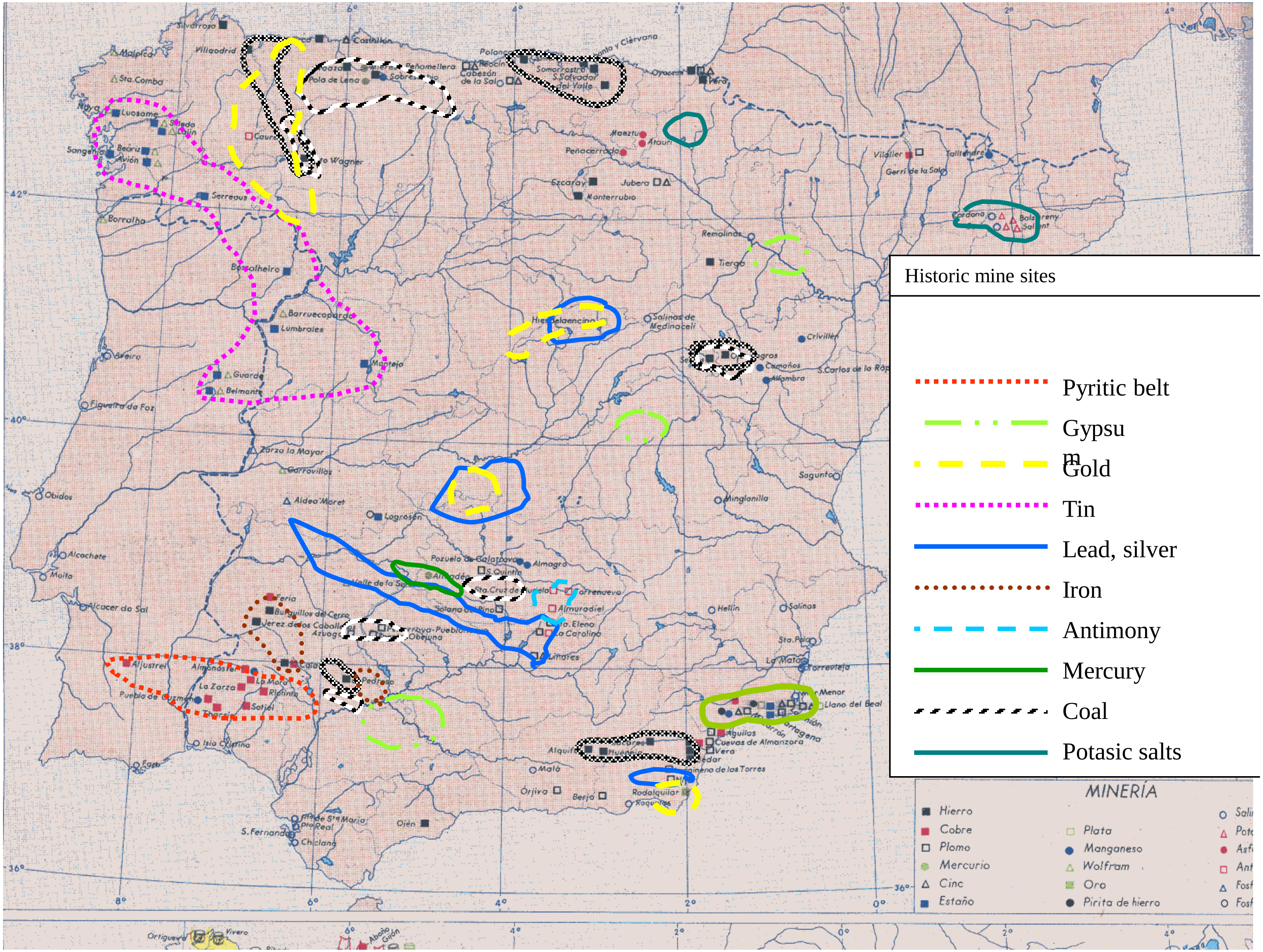
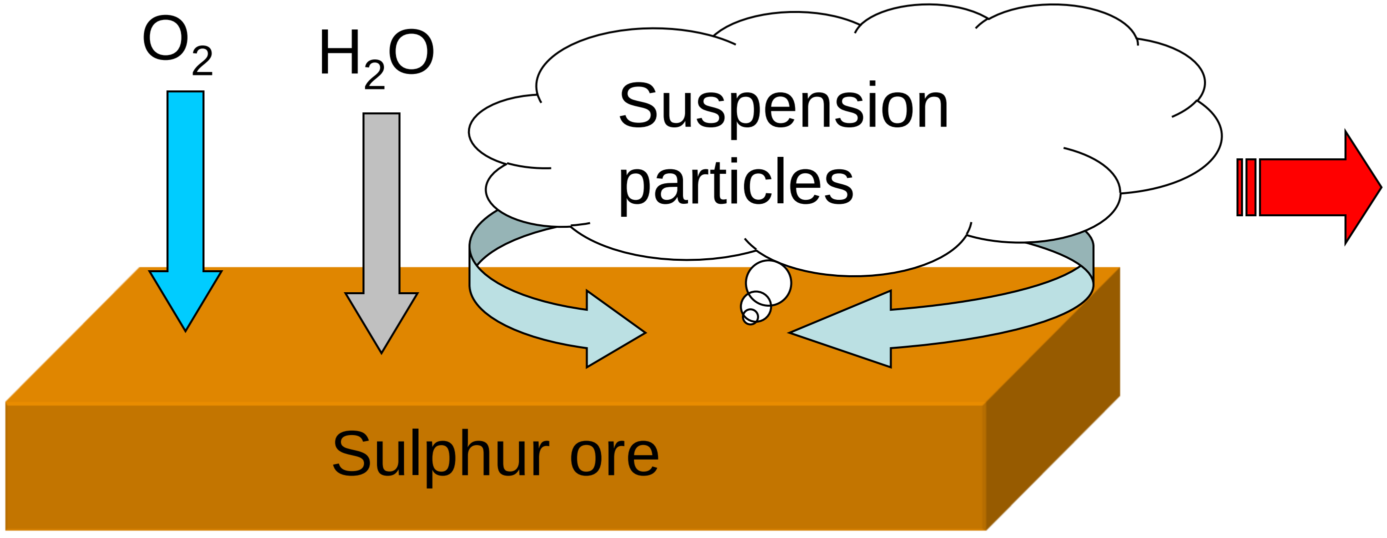
International Conference on Outbursts of Water from the Abandoned Mines. Causes, Consequences, Remediation and Responsability

18-19 March 2010, Litija - Slovenia


Historic mine sites
Pyritic belt
Gypsu m
Gold
Tin
Lead, silver
Iron
Antimony
Mercury
Coal
Potasic salts
MINERÍA
Hierro
Cobre
Plomo
Mercurio
Cinc
Estaño
Plata
Manganeso
Wolfram
Oro
Pirita de hierro

ACIDIC MINE DRAINAGE (A.M.D.)



Atmospheric pollution by heavy metals in suspension

Acid transference to fluvial system

- Acidity
- High content in sulphates and heavy metals
- Sediments with high metals content
- Damage to ecosystems
- Lose of hydric resources

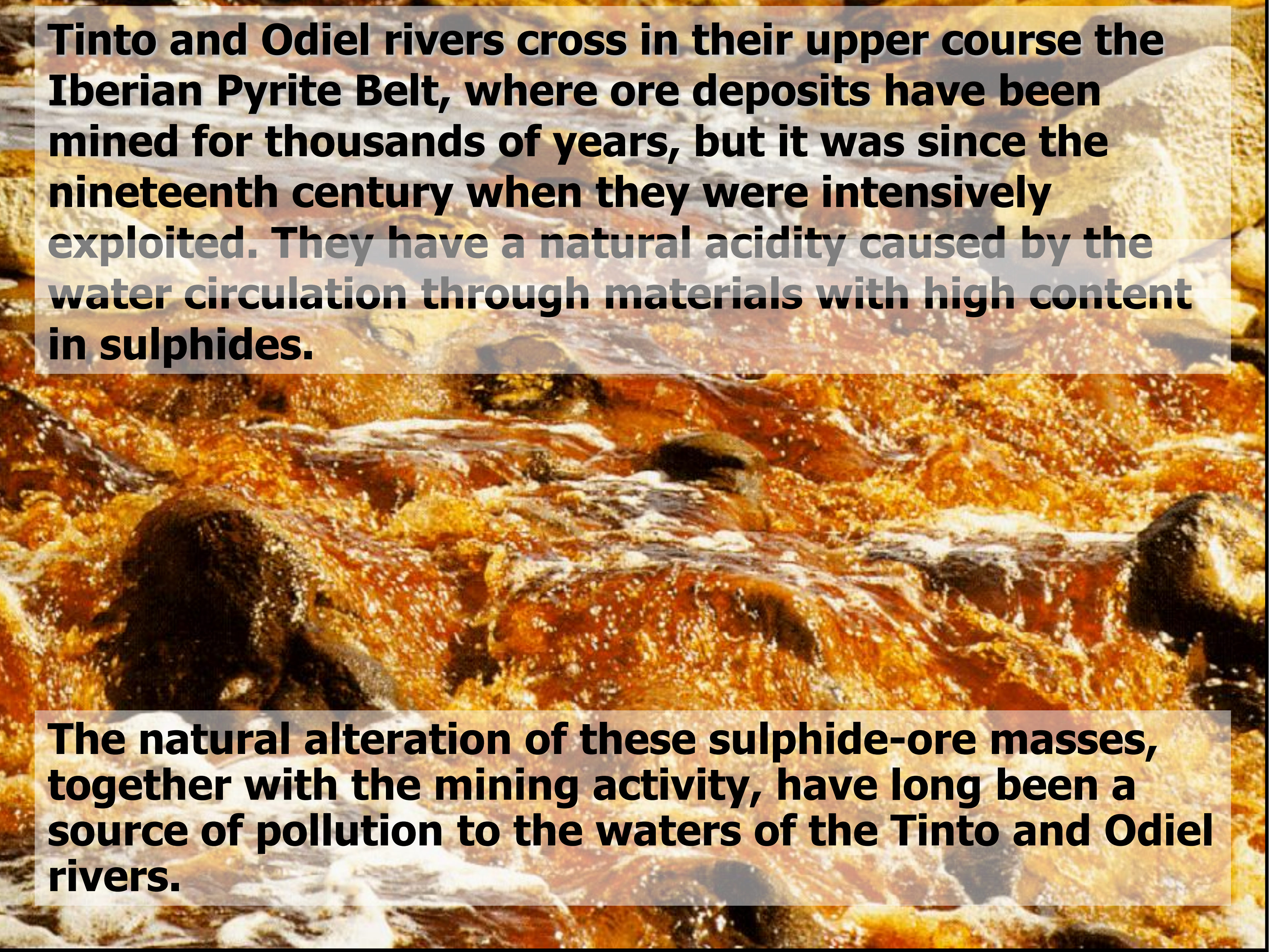
Unreclaimed spoil heaps are capable of generating highly polluting runoff during storm events.

There are abundant examples of waste rock piles releasing acidic leachates, which are polluting surface and groundwater.

There are many entire rivers (and substantial reaches of others) which have effectively been removed from the inventory of fresh water resources due to mine water pollution.

CASE STUDIES

TINTO AND ODIEL RIVERS BASIN (HUELVA, SOUTH SPAIN)


Tinto and Odiel rivers cross in their upper course the Iberian Pyrite Belt, where ore deposits have been mined for thousands of years, but it was since the nineteenth century when they were intensively exploited. They have a natural acidity caused by the water circulation through materials with high content in sulphides.
The natural alteration of these sulphide-ore masses, together with the mining activity, have long been a source of pollution to the waters of the Tinto and Odiel rivers.

A.M.D. AND IBERIAN PYRITE BELT

- **A.M.D. POLLUTION SOURCES**

1. **Drainages**
2. **Spoil heaps: Ash, slags**
3. **Ore deposits: Pyrite, azufrones....**
4. **Ponds and flotation and cementation effluents**
5. **Irrigation of concentration areas**
6. **Polluted areas**

More than 130 mining exploitations

Thousand of ha affected and polluted water courses

Water courses: SO4: 20,000 mg/L

Fe: 1,000 mg/L,

Cu/Zn: 50/100 mg/L

As/Cd: 4/8 mg/L

Estuary >80 Kg/day As

TINTO AND ODIEL RIVERS BASIN

	As	Cd	Cu	Fe	Mn	Pb	Zn
Tinto	53.4	21.7	955.6	8927	1041		44.03
Odiel	4.56	6.19	771.6	1390	869.5	339.7	1660

Heavy metals mean contributions (ton yr^{-1}) from fluvial discharges of Odiel and Tinto rivers. (Source: Confederación Hidrográfica del Guadiana)

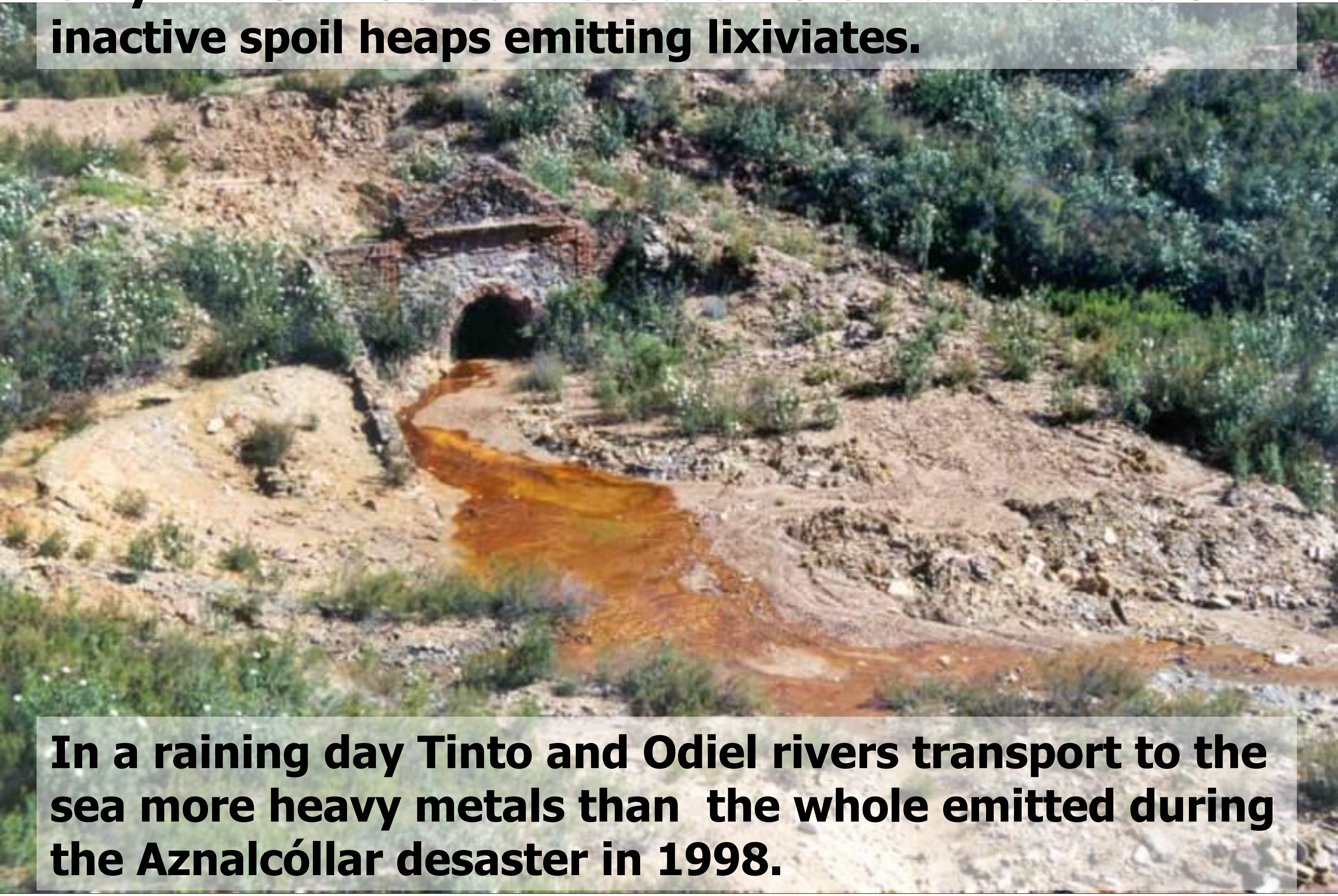
TINTO AND ODIEL RIVERS BASIN

	pH	Sulphates	Fe	Cu	Zn	Mn	Pb	Cd
Odiel (1)	7.4	44	0.01	0.03	0.44	0.04	0.00	0.00
Odiel (2)	2.2	23,464	306	185	358	350	0.9	1.9
Tinto (3)	1.9	11,590	3800	216	476	54	1.0	2.0

Concentration values (mg/l) and pH during a dry period. (1: Odiel before pollution takes place; 2: Odiel after pollution occurs; 3. Tinto after Rio Tinto mines) (Sainz et al, 2000).

Recent large-scale contamination events in Europe have shown the potential risks of water pollution by mine waste and discharges from abandoned and active mines.

Only in Riotinto area there are more than 4000 ha of inactive spoil heaps emitting lixiviates.



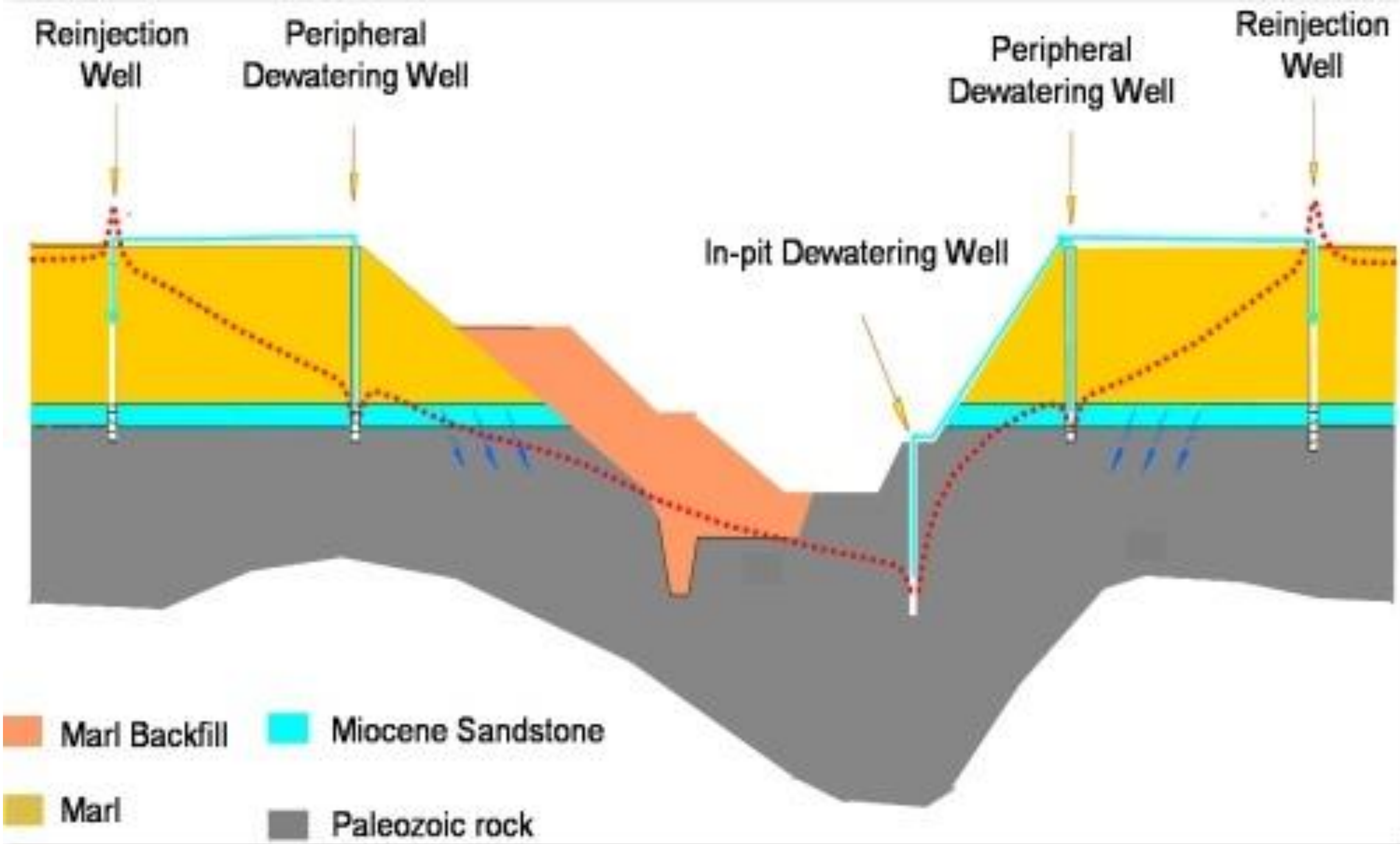
In a raining day Tinto and Odiel rivers transport to the sea more heavy metals than the whole emitted during the Aznalcóllar desaster in 1998.

AMD AS A GLOBAL PROBLEM

- **Tinto and Odiel rivers flow 20,000 tons/year of heavy metals and 1200000 tons/year of sulphates (Sáinz, Grande, de la Torre, 2000)**

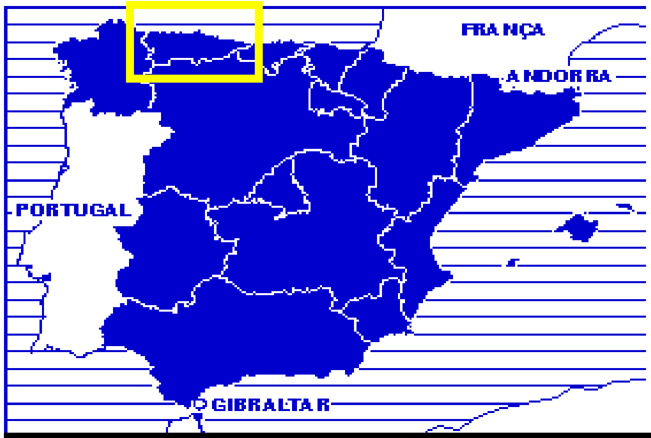
Cobica Stram in Herrerías Mine

LAS CRUCES MINE

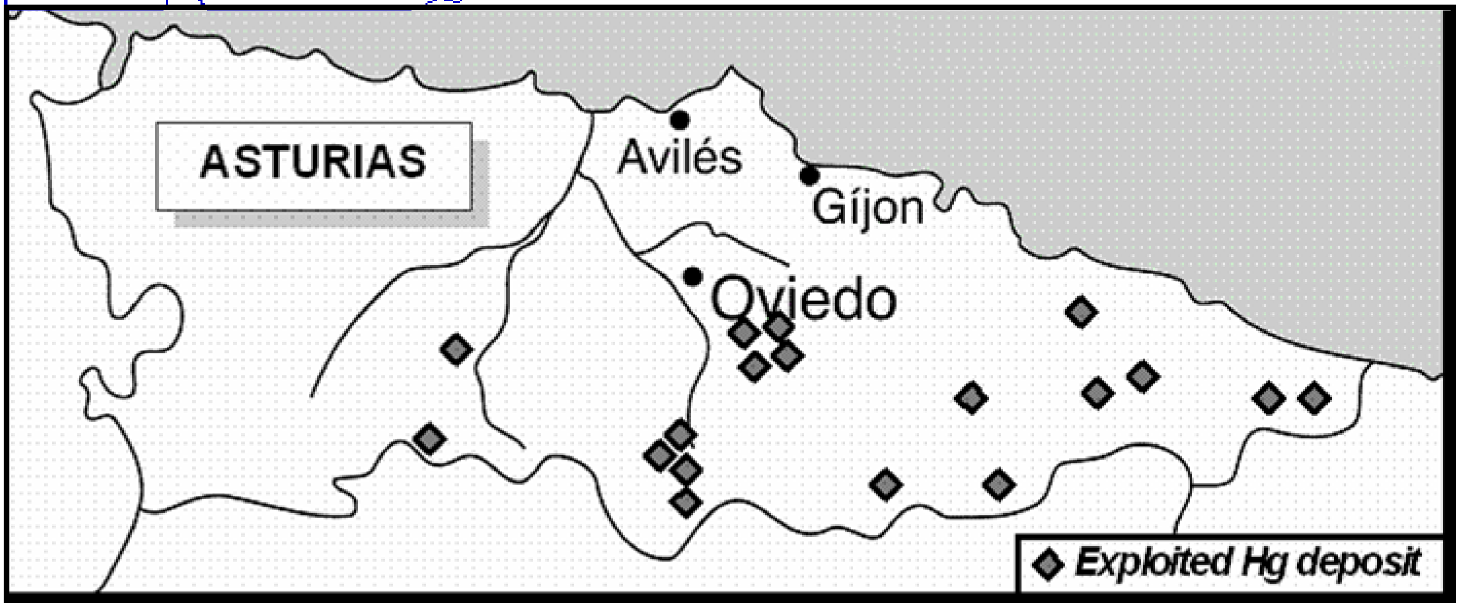


Reinjection Well
Peripheral Dewatering Well
Peripheral Dewatering Well
Reinjection Well
In-pit Dewatering Well
Marl Backfill
Miocene Sandstone
Marl
Paleozoic rock

CASE STUDIES

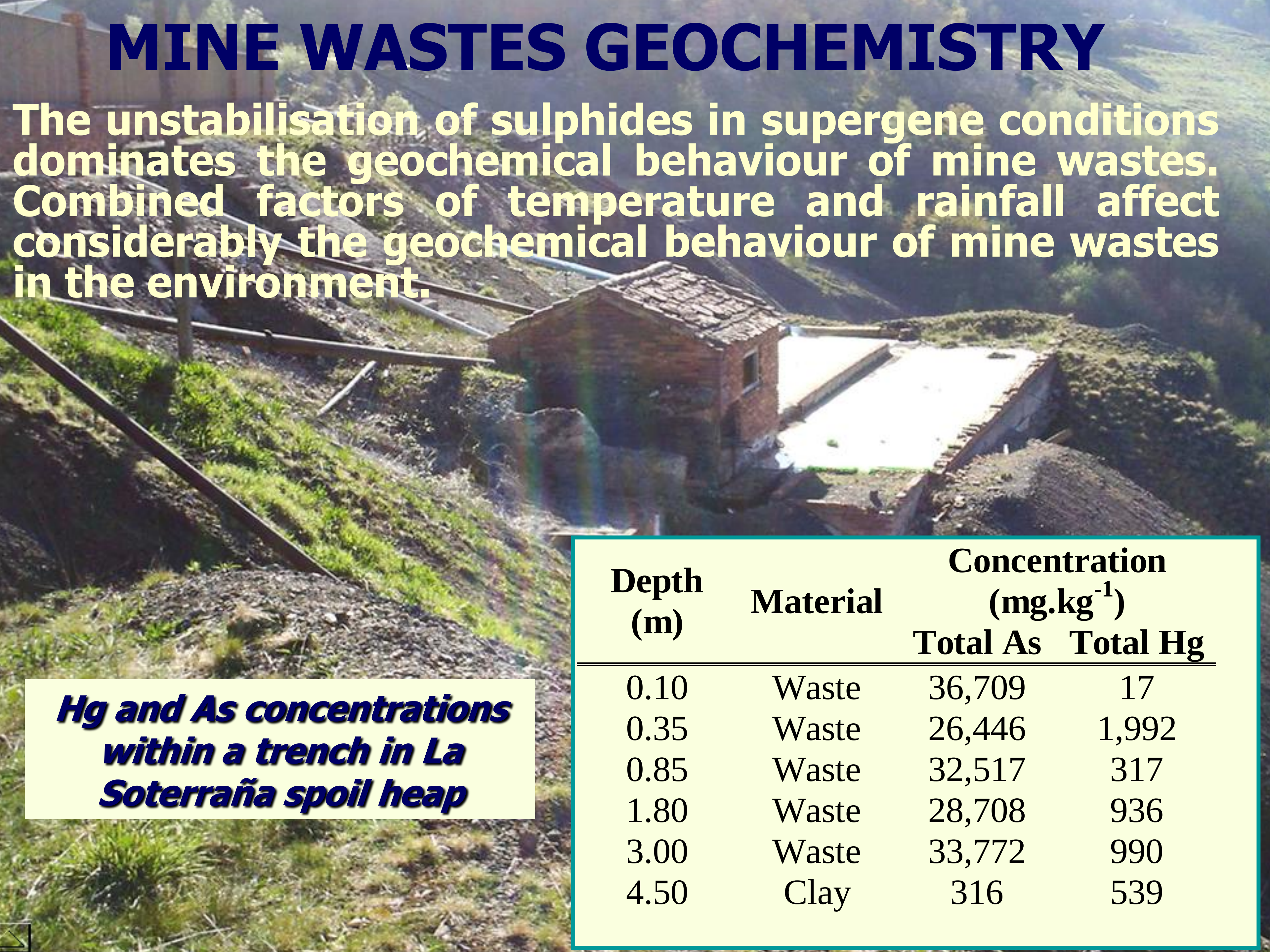


ASTURIAS MERCURY MINING DISTRICT (NORTHERN SPAIN)



The potential of this abandoned mine site to pollute the environment is enhanced by climatic characteristics, mineralogy of ore and proximity to urban areas.

MINE WASTES GEOCHEMISTRY



The unstabilisation of sulphides in supergene conditions dominates the geochemical behaviour of mine wastes. Combined factors of temperature and rainfall affect considerably the geochemical behaviour of mine wastes in the environment.

Hg and As concentrations within a trench in La Soterraña spoil heap

Depth (m)	Material	Concentration ($mg.kg^{-1}$) Total As	Total Hg
0.10	Waste	36,709	17
0.35	Waste	26,446	1,992
0.85	Waste	32,517	317
1.80	Waste	28,708	936
3.00	Waste	33,772	990
4.50	Clay	316	539


Santirso River, upstream El Terronal mine
Santirso River, downstream El Terronal mine
Entrance to the gallery under Morgao spoil heap
Mouth of Morgao stream
San Juan River
Morgao stream downstream Los Rueldos mine
Morgao stream downstream Los Rueldos mine
San Juan River (channeled)

MINE DRAINAGE GEOCHEMISTRY

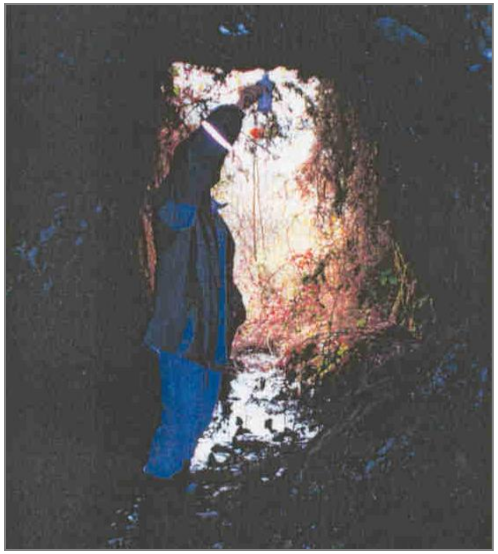
pH: 1.84 - 2.11

Sulphates: 5,000 mg/l

Total As: 9.1–17.7 mg/l

Total Pb: 0.33 mg/l

Total Hg: 3.7 μg/l



SPOIL HEAP LEACHATES GEOCHEMISTRY

pH: 2.15 - 2.63

Sulphates: 2,900-4,600mg/l

Total As: 1.4-9.2 mg/l

Total Pb: 0.03-0.48 mg/l

Total Hg: 3.6-14 μg/l

MORGAO STREAM

Upstream mine works (Sampling point 7A)	Date	Flow (l/s)	Conductivity (µS/cm)	pH	As (mg/l)	Hg (µg/l)
	27-April	-	-	-	-	-
	26-May	0.1	168	6.11	< 0.2	< 1
	23-June	-	-	-	-	-
	28-July	-	-	-	-	-

Los Rueldos Mine drainage (Sampling point 9)	Date	Flow (l/s)	Conductivity (µS/cm)	pH	As (mg/l)	Hg (µg/l)
	27-April	-	4543	2.49	12	< 1
	26-May	-	6355	2.55	6.3	< 1
	23-June	-	6115	2.50	7.9	< 1
	28-July	-	5065	2.28	8.5	< 1

Downstream mine works (Sampling point 10)	Date	Flow (l/s)	Conductivity (µS/cm)	pH	As (mg/l)	Hg (µg/l)
	27-April	4.7	1008	8.6	0.34	< 1
	26-May	4	1080	7.41	0.44	< 1
	23-June	1.2	1256	6.45	0.52	< 1
	28-July	0.4	1200	7.50	0.61	< 1

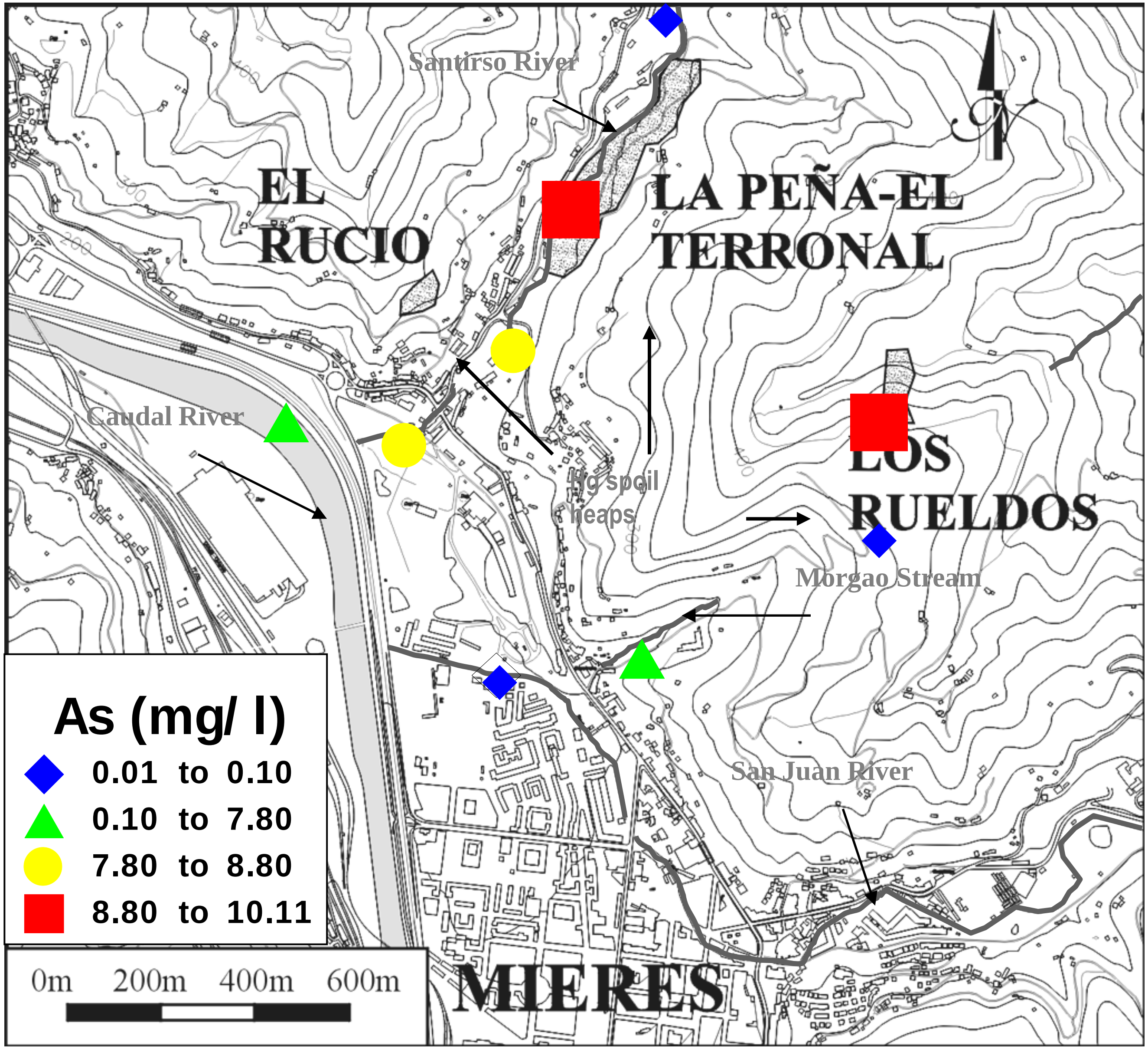
LA SOTERRAÑA

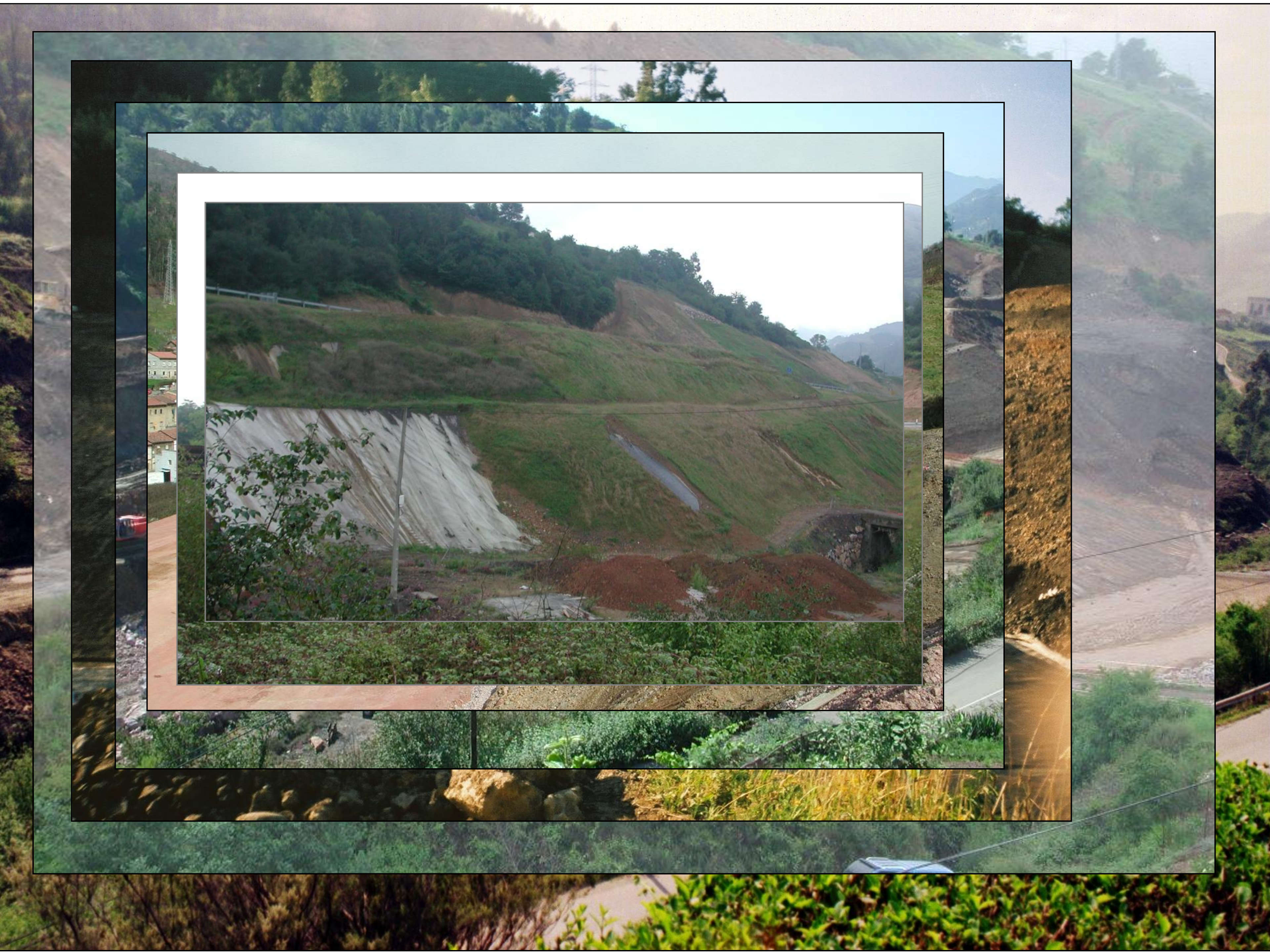
Upstream mine works (Sampling point 1)	Date	Flow (l/s)	Conductivity (µS/cm)	pH	As (mg/l)	Hg (µg/l)
	27-April	0.09	415	7.88	<0.2	<1
	26-May	0.08	397	7.99	<0.2	<1
	23-June	0.03	432	6.63	<0.2	<1
	28-July	0.02	289	6.72	<0.2	<1

Downstram mine works (Sampling point 3)	Date	Flow (l/s)	Conductivity (µS/cm)	pH	As (mg/l)	Hg (µg/l)
	27-April	0.2	809	8.2	26	<1
	26-May	0.3	882	8.16	29	<1
	23-June	0.01	1397	7.70	41	<1
	28-July	0.03	1753	7.75	44	<1

Muñón Cimero village (Sampling point 4A)	Date	Flow (l/s)	Conductivity (µS/cm)	pH	As (mg/l)	Hg (µg/l)
	27-April	-	-	-	-	<1
	26-May	0.8	951	8.26	43	<1
	23-June	0.18	1185	8.03	52	<1
	28-July	0.17	1278	7.98	46	<1

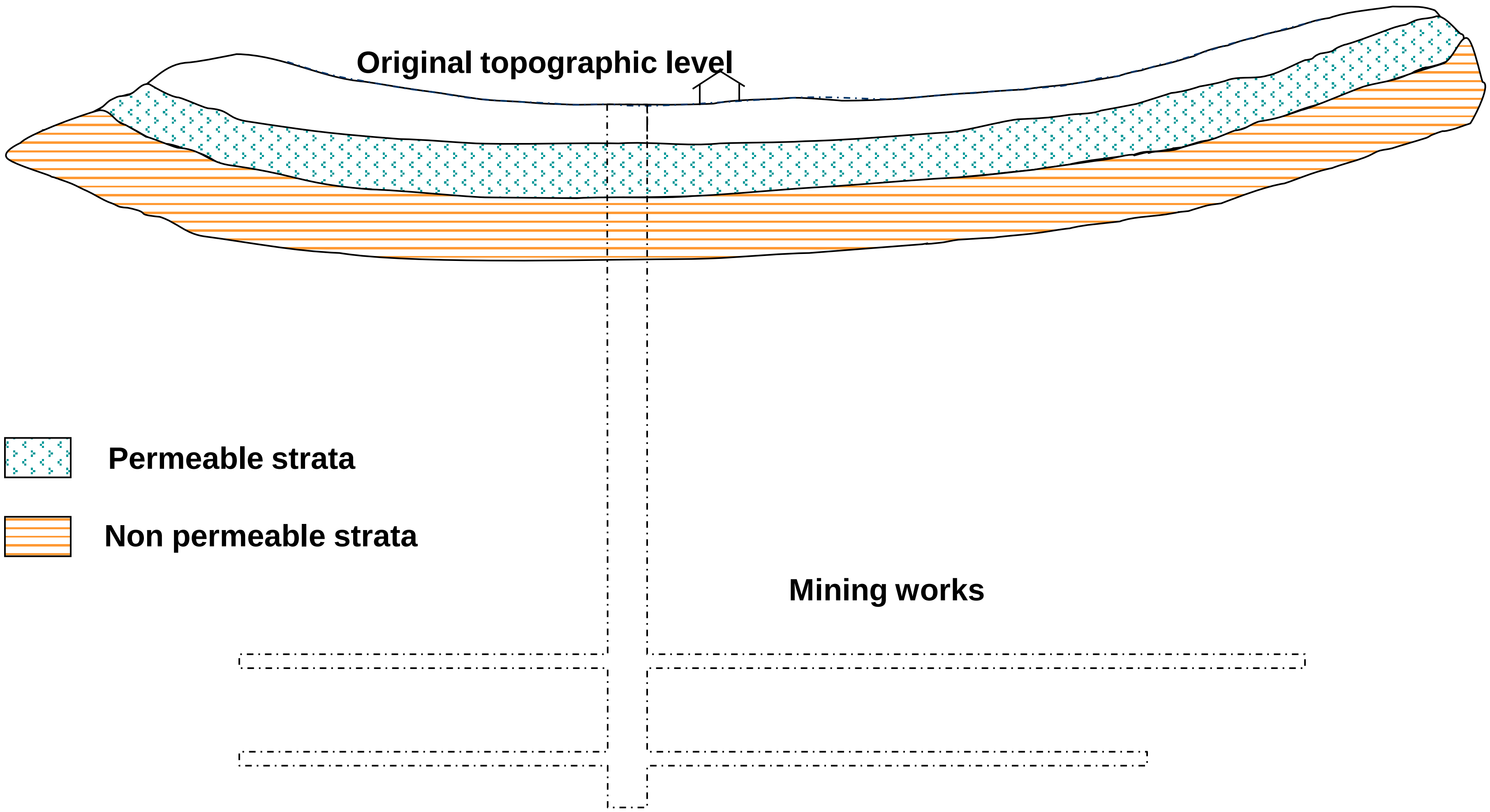
As CONTENT IN SURFACE WATER IN A PART OF THE CATCHMENT

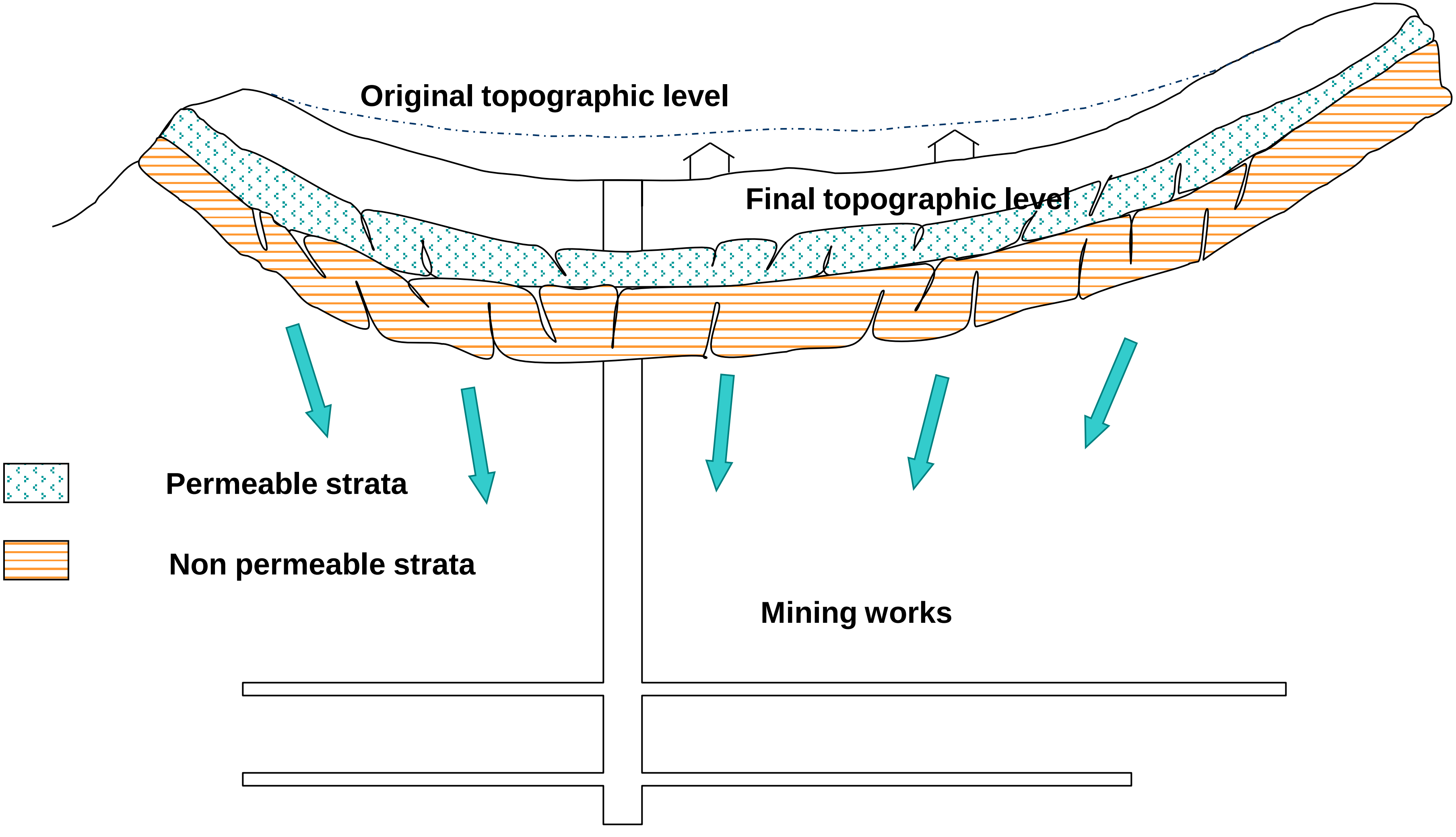


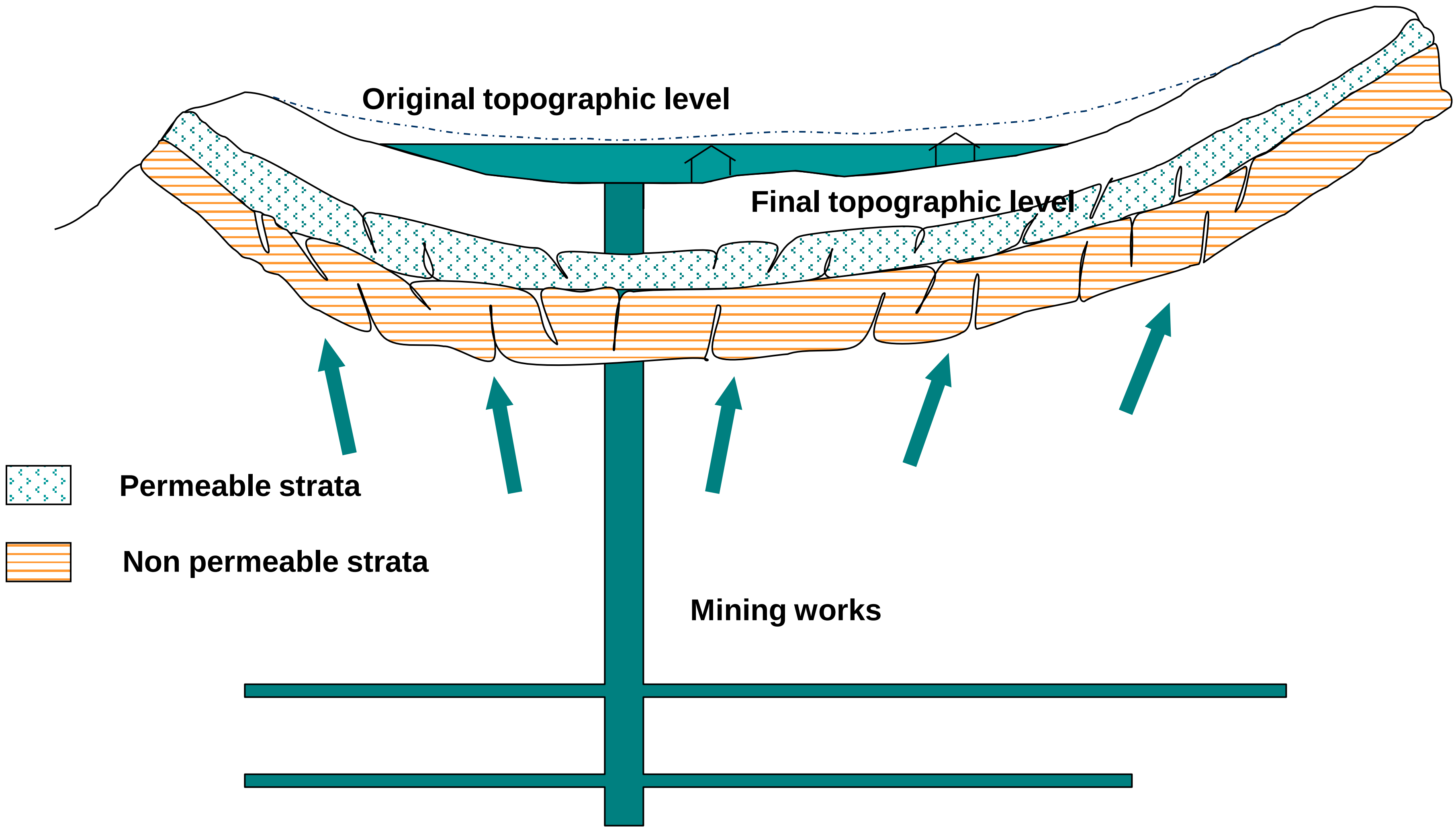


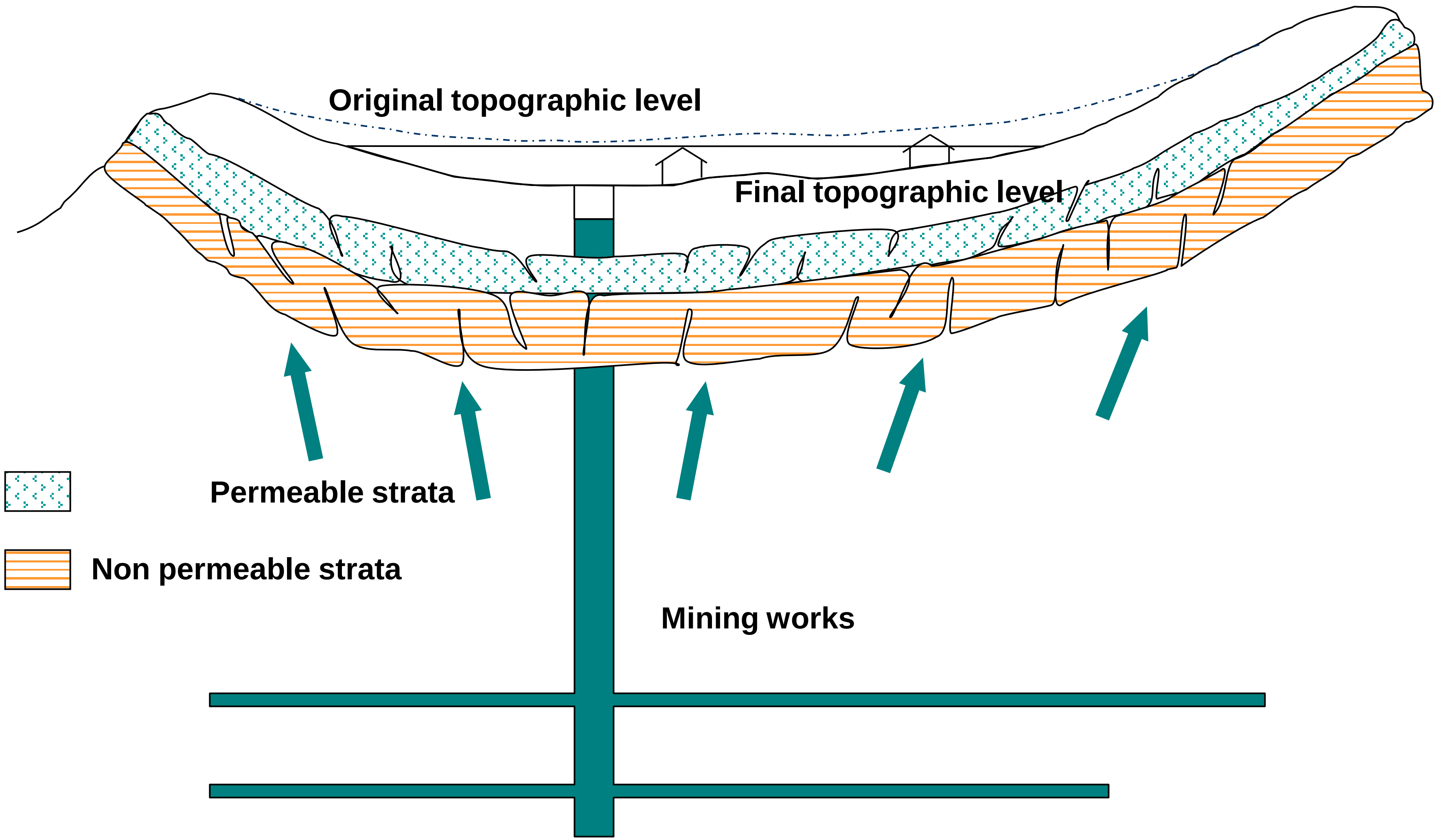
Flooding of mine works by pumping cessation can impacts the water environment as water levels recover ("rebound") to pre-mining levels.

The process of rebound in deep mines commonly leads to a marked deterioration in the quality of mine water. The flooding of open-pit mines to form pit lakes can also cause water quality to deteriorate.


Original topographic level
Permeable strata
Non permeable strata
Mining works

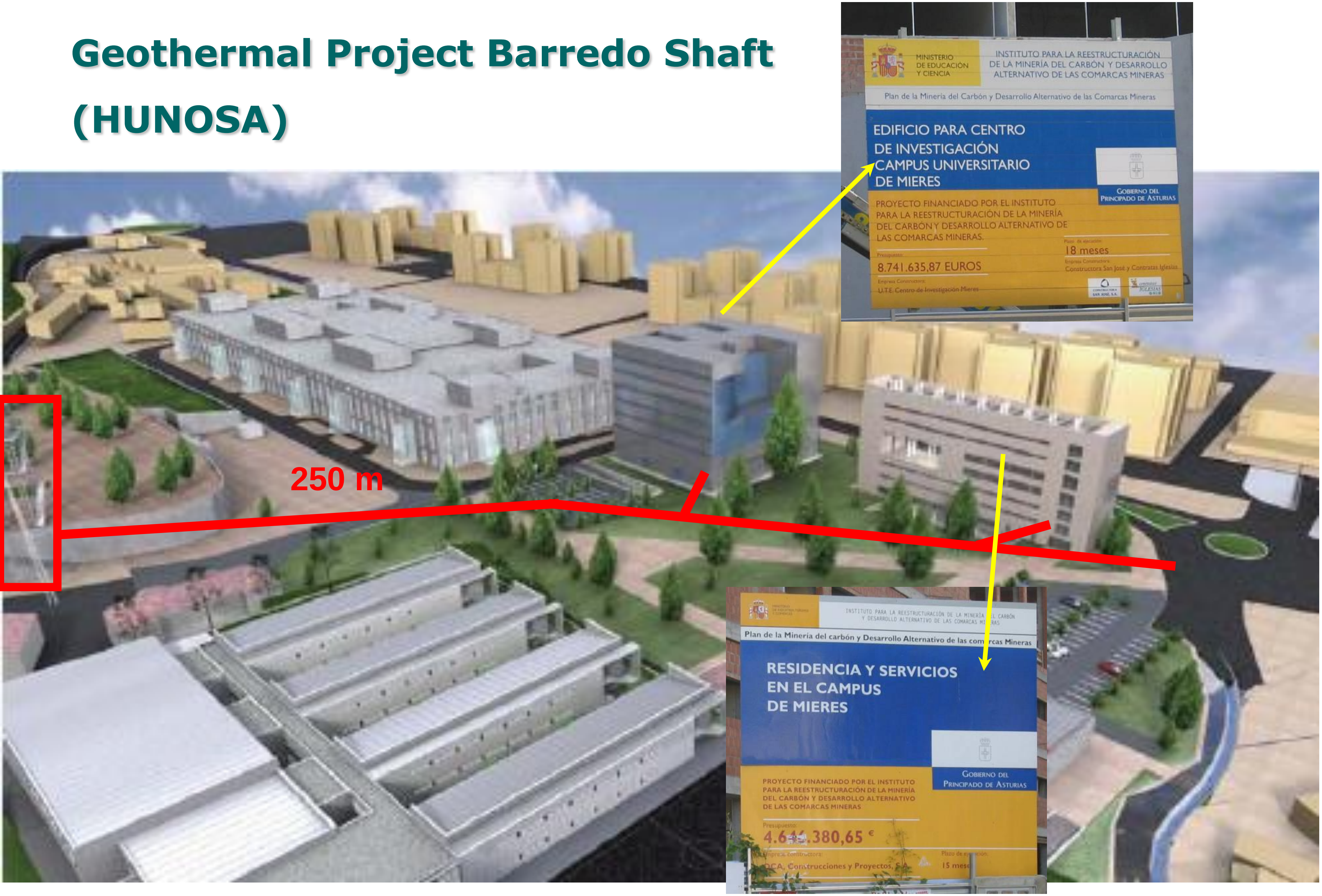

Original topographic level
Final topographic level
Permeable strata
Non permeable strata
Mining works


Original topographic level
Final topographic level
Permeable strata
Non permeable strata
Mining works



Original topographic level
Final topographic level
Permeable strata
Non permeable strata
Mining works

Geothermal Project Barredo Shaft (HUNOSA)



Acidic drainage from mines and associated drainage is a major cause of ground and surface water pollution. Given the longevity of these problems, the most sustainable solutions to ecological and socio-economic damage wrought by such discharges will be those which require a minimum of operating expenditure such as the passive treatments.

PASSIVE TECHNOLOGIES OPTIONS

- Aeration units
- Settlement lagoons
- Aerobic wetlands
- Anoxic Limestone Drains (ALDs) and Oxic Limestone Drains (OLDs)
- Compost wetlands
- Reducing and Alkalinity Producing Systems (RAPS)
- Permeable Reactive Barriers (PRBs)

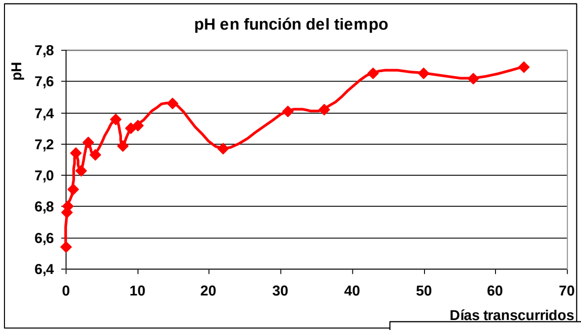
Flow: 10 l/min Retention time: 24 h

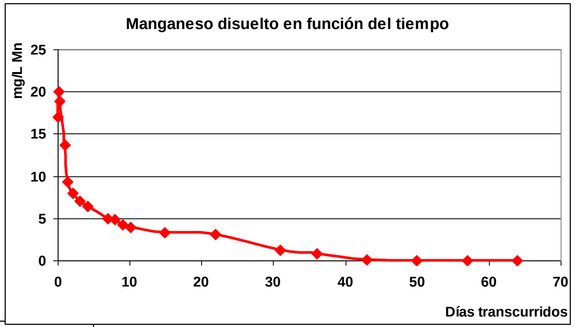


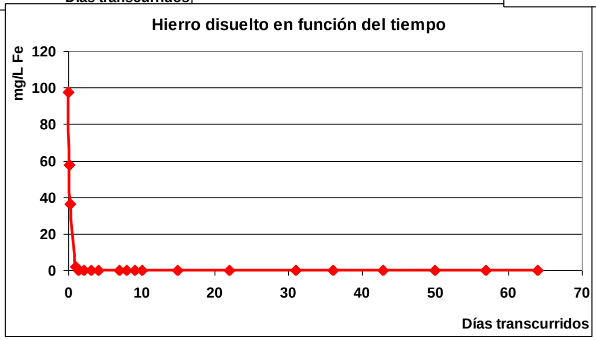
Passive treatment system in an active gold mine in Asturias

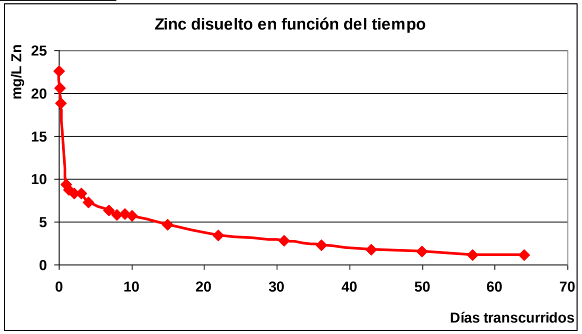

31/3/2006


8/5/2007


pH en función del tiempo
pH
7,8
7,6
7,4
7,2
7,0
6,8
6,6
6,4
0
10
20
30
40
50
60
70
Días transcurridos

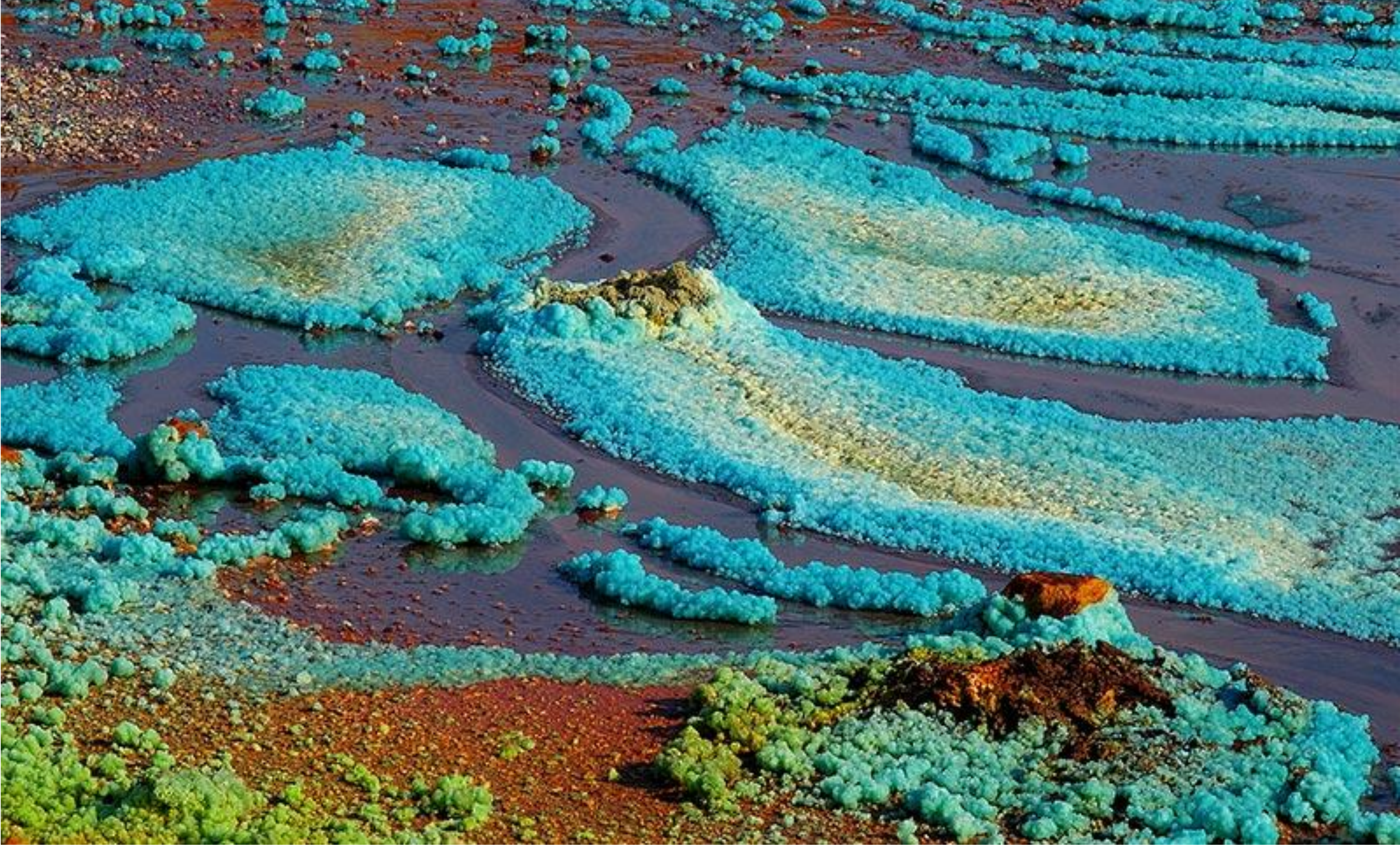

Manganeso disuelto en función del tiempo
mg/L Mn
25
20
15
10
5
0
0
10
20
30
40
50
60
70
Días transcurridos


Hierro disuelto en función del tiempo
mg/L Fe
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
Días transcurridos


Zinc disuelto en función del tiempo
mg/L Zn
25
20
15
10
5
0
0
10
20
30
40
50
60
70
Días transcurridos

REHABILITATION OF AS PONTES OPEN PIT (Northern Spain)

Areas where extensive grazing was the pre-mining land use suitability should be returned to that status after mining. Mine works corresponding to open pit have been restored with very well results.



Thanks for your attention