

Mining the waste: prospecting valuable residues optimising processes with modern technology sustainably remediating legacy sites

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Mining waste and resources



Mining waste can be considered as a resource

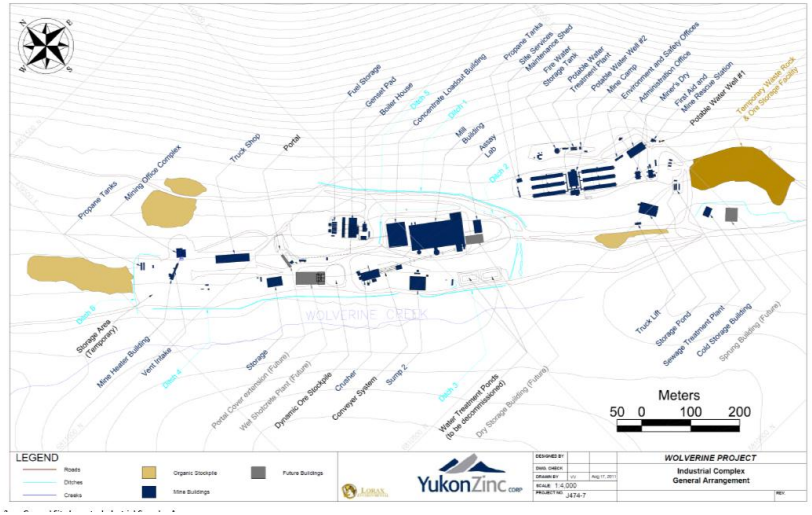
- by recovering commodities still present in waste stocks left by historic mining,
- by managing carefully waste stocks at active mine sites to be able to take profit of changing economic conditions,
- using new or improved technology for recovery,
- recovering elements of increasing interest (« priority substances »), previously left over with waste

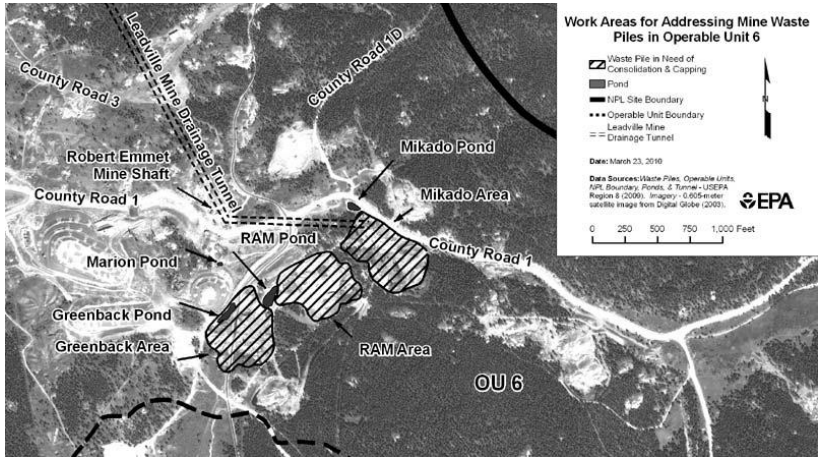


Historic mining and waste management

Modern mine waste management implies the following tasks

- organising waste rock storage according to future management (inert overburden, under grade ore, potentially hazardous mineralised rock and AMD sources, AMD buffers),
- organising ore processing waste (tailings, slag) for convenient and safe storage





Historic mining and waste management

Modern mine waste management implies the following tasks

- organising waste rock and tailings storage according to future mine closure plans (risk mitigation, site restoration)
- organising potentially valorizable waste (ore under cut-off grade) in order to facilitate later uptake
- never mix barren rock or hazardous material with low-grade ore

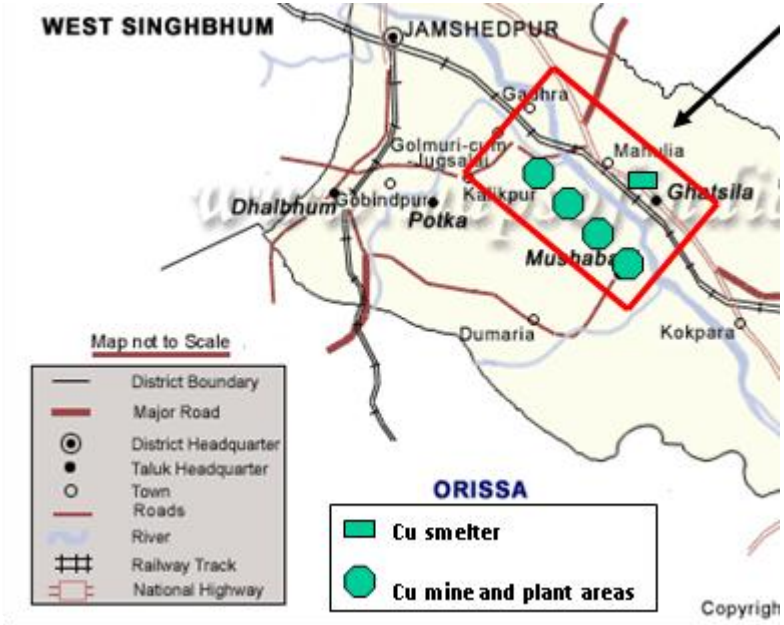


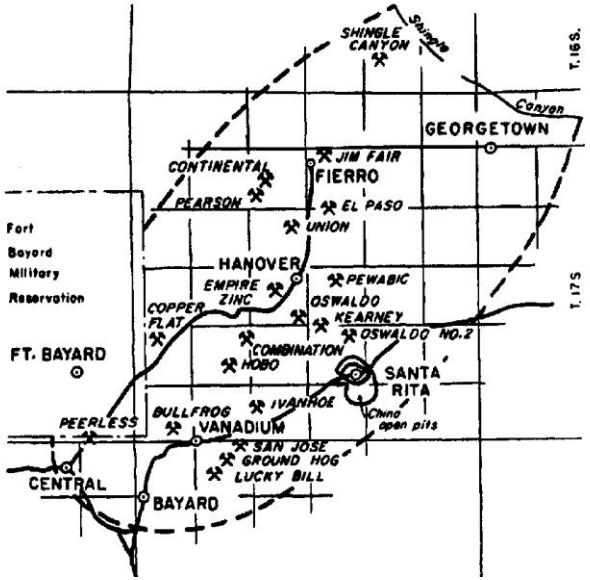
Historic mining and waste management

In the past, mine waste management implied the following tasks

- minimising waste handling costs,
- minimising land use and space requirements,
- avoiding as much as possible accidents (landslides, dam failure...)

and, as a general rule, minimising investment.





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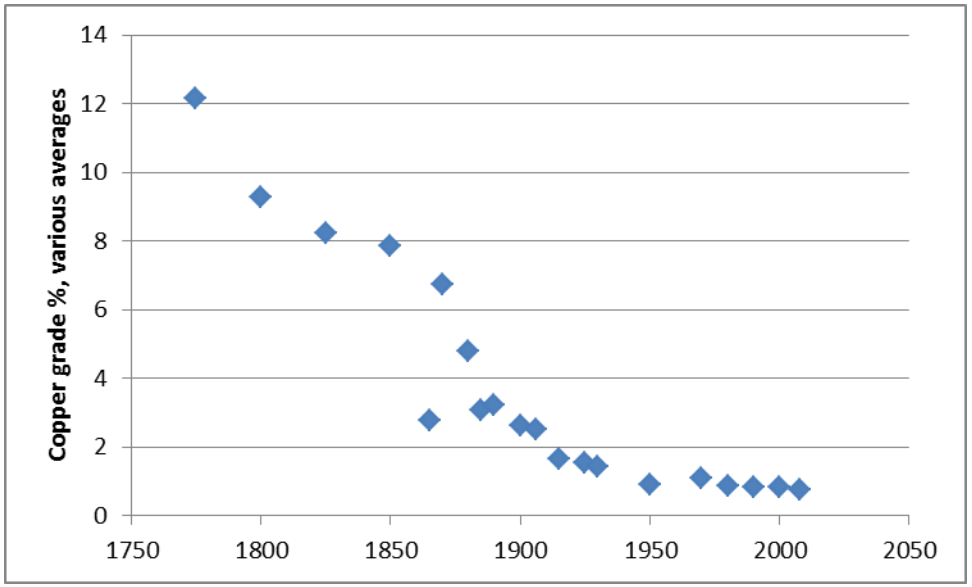
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Historic mining and waste management

The same rules applied to mining led to:

- careful and selective mining, hence higher ore grades, lower waste ratios and smaller operations,
- higher grades in waste rock,
- many small mines rather than a big one on a mineralised district,
- less advanced ore processing technology leaving higher grades in residues,
- more DSO mining than on-site processing.



Data source: Mining Journal 07 Oct 2011
Focus: Copper - Changing copper yields and grades

Prospecting valuable residues

Abandoned waste from closed mines or past operations may contain profitably recoverable commodities:

- when the market price of the commodity increased significantly since mine closure,
- when processing technology improved significantly since mine closure,
- when another commodity present in the ore was not recovered and thus sent to waste, because it was not of commercial value.
- especially relevant for high-tech elements.

Mined in 1950

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
			Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

Strategic in 2012

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
			Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

Prospecting valuable residues

- Abandoned waste rock heaps (halda) and processing waste (tailings) can be prospected and re-evaluated with modern on-site analysis and sampling equipment..





Mining valuable residues : examples

Pinto Valley, AZ - Commodity: Copper - Stock: 38 Mt - Grade: 0.33%

Mining method: hydraulic + leaching by solvent extraction/electrowinning





Mining valuable residues : examples

Disputada Mine, Chile

Commodity: Copper - Stock: 76 million tonnes

Mining method: hydraulic

Environmental constraints on existing tailing dams







Images: www.tailings.info, Anglo-American

Mining valuable residues : examples

Kaltails Project, Kalgoorlie, Western Australia

Commodity: Gold

Stock: 60 million tonnes

Grade: 0.3 g/t

Mining method:

hydraulic + CIC + CIP





Photos Newmont

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Prospecting valuable residues : examples

Somewhere in Turkey, 2012...

An abandoned lead-zinc mine

with > 1 Mt tailings and slag





Prospecting valuable residues : examples

Somewhere in Turkey, 2012...

An abandoned lead-zinc mine

with > 1 Mt tailings and slag



TYPE		Sb	Cd	As	Pb	Zn	Cu	Fe
ALL	Max	0.090	0.055	1.133	**10.655**	**10.413**	23.710	36.085
ALL	Average	0.027	0.014	0.264	**1.668**	**2.363**	0.743	8.350
ORE		0.013	0.003	0.256	**0.698**	**0.338**	0.013	2.821
OXYD		0.009	0.006	0.194	**0.873**	**2.253**	0.139	7.706
SEDI	MaxSe	0.017	0.005	0.216	**1.418**	**1.051**	0.053	4.912
SEDI	Average	0.011	0.004	0.216	**0.540**	**0.653**	0.026	2.277
SLAG	MaxSla	0.017	0.006	0.216	**1.418**	**2.253**	0.139	7.706
SLAG	Average	0.012	0.005	0.205	**0.793**	**1.181**	0.057	3.781
TAIL	MaxTail	0.090	0.055	1.133	**10.655**	**10.413**	0.983	22.144
TAIL	Average	0.037	0.019	0.303	**2.094**	**2.918**	0.171	7.052

Examples of field measurements by pXRF, in mg/kg

Optimising processes with modern technology

Why reprocessing mine waste ?

Reprocessing mine waste is attractive because it skips most of the mining and crushing costs. The operator can therefore focus on investment in processing technology and in site management.



It allows also earlier profit generation, with lesser site development. This allows keeping funds for proper site closure.

Optimising processes with modern technology

Reprocessing mine waste: how ?

- former mines were smaller than modern ones.
- mining districts comprised often many mines, leaving many waste deposits.
- each deposit is smaller than a modern mine. Often too small for profitable mining, due to the investment costs.

Centralised reprocessing plant for several deposits:

- amortization of the plant with several waste deposits
- addressing the needs of district remediation

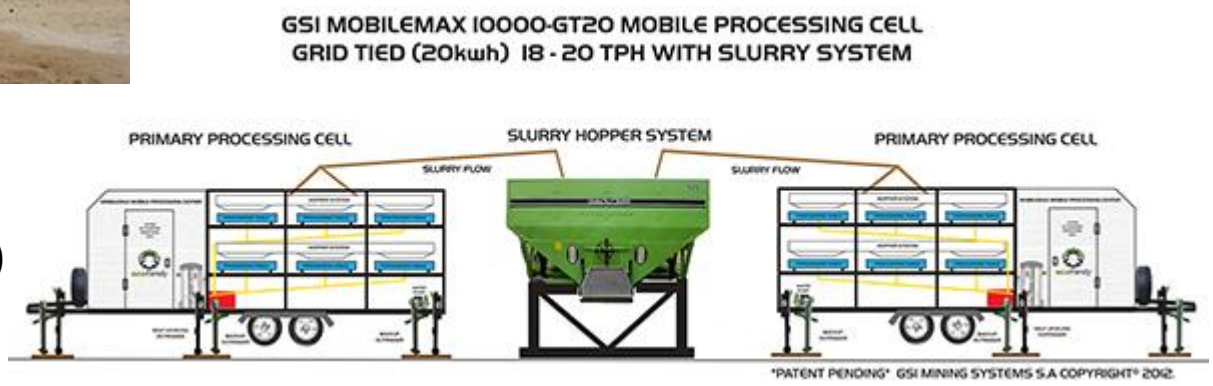
Optimising processes with modern technology

Reprocessing mine waste: how ?

- Mobile processing plants :
  amortization of the plant with several waste deposits
- moving the plant between distant small deposits



mobile unit
(GSI Mining Systems)

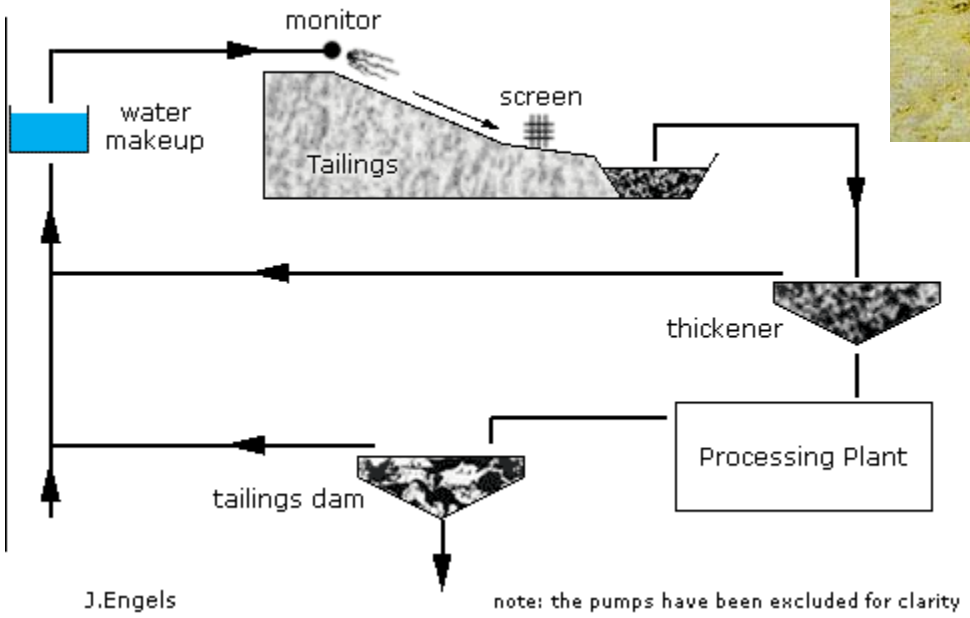


Optimising processes with modern technology

Reprocessing mine waste: how ?

> Hydraulic mining :
most of the handling is done without mechanical equipment





images: www.tailings.info

Optimising processes with modern technology

Kasese, Uganda

Commodity: Cobalt (out of pyritic waste from past copper mining)

Stock: 5.5 million tonnes Grade: 0.114 g/t Mining method: Bioleaching





Sustainably remediating legacy sites

Existing mine waste where a new mine is planned: how to deal with acceptability ?





Sustainably remediating legacy sites

Reprocessing mine waste: what's left afterwards?

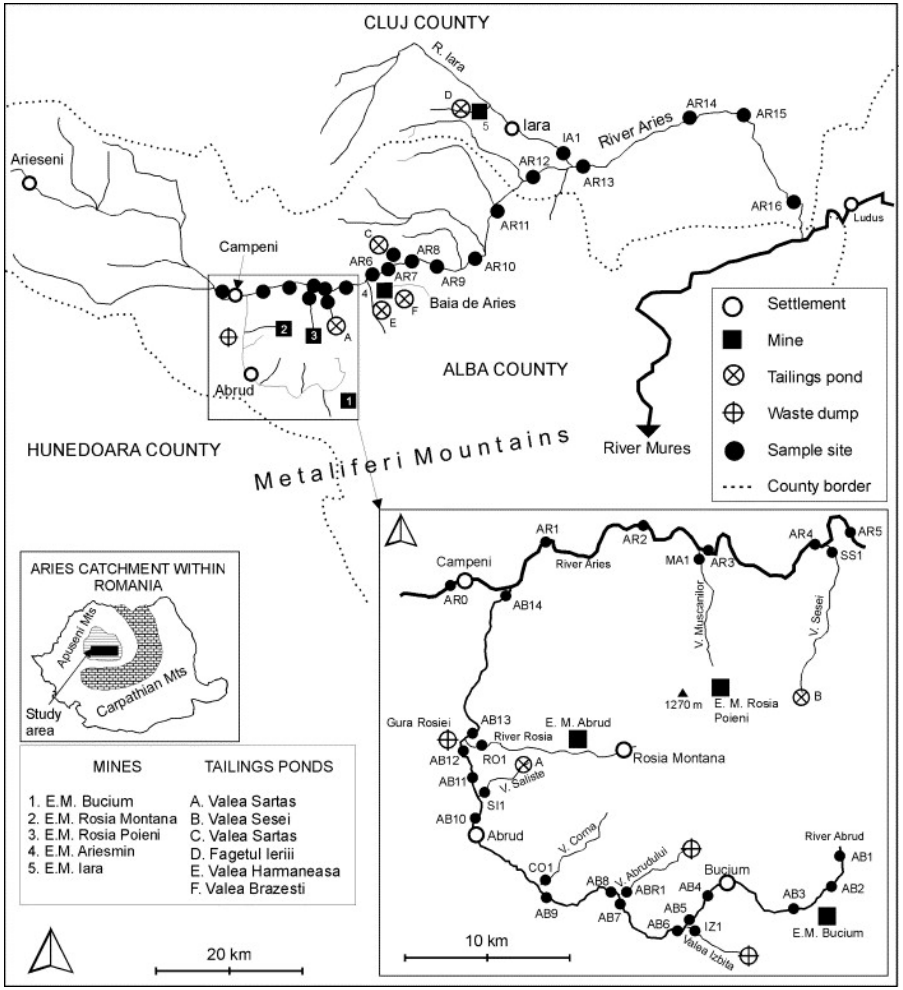
- Reprocessing waste will leave a similar amount of residual waste, generally more reactive and with potential environmental impacts.
- A sustainable management of this residual waste is therefore a mandatory part of waste mining.



Sustainably remediating legacy sites

Reprocessing mine waste: what's left ?

- Many abandoned mines are potential environmental hazards.
- In most cases, there is no economical option for remediation.
- Mining again abandoned waste can provide the required funds for sustainable waste management and site remediation.



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Sustainably remediating legacy sites

Somewhere in Turkey, 2012.

An abandoned lead-zinc mine...





Tailings dam failure and tailings escaping towards the river

Sustainably remediating legacy sites

Somewhere in Turkey, 2012.

An abandoned lead-zinc mine...





Valuable resources lost with every rain

Metallic contamination of the river

Sustainably remediating legacy sites

Somewhere in Turkey, 2012.

An abandoned lead-zinc mine...





Acid drainage

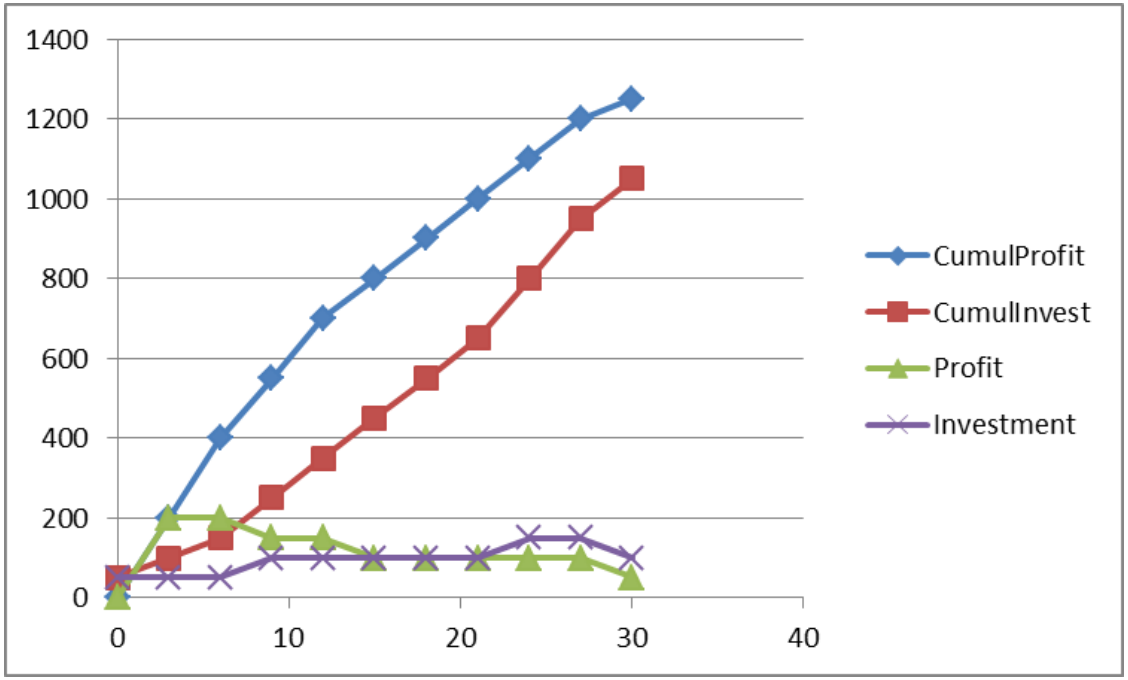
Metalliferous sediments

=> Mining with profit while remediating the site ?

Mining the waste: economics

At closed mine sites without identified risk issues:

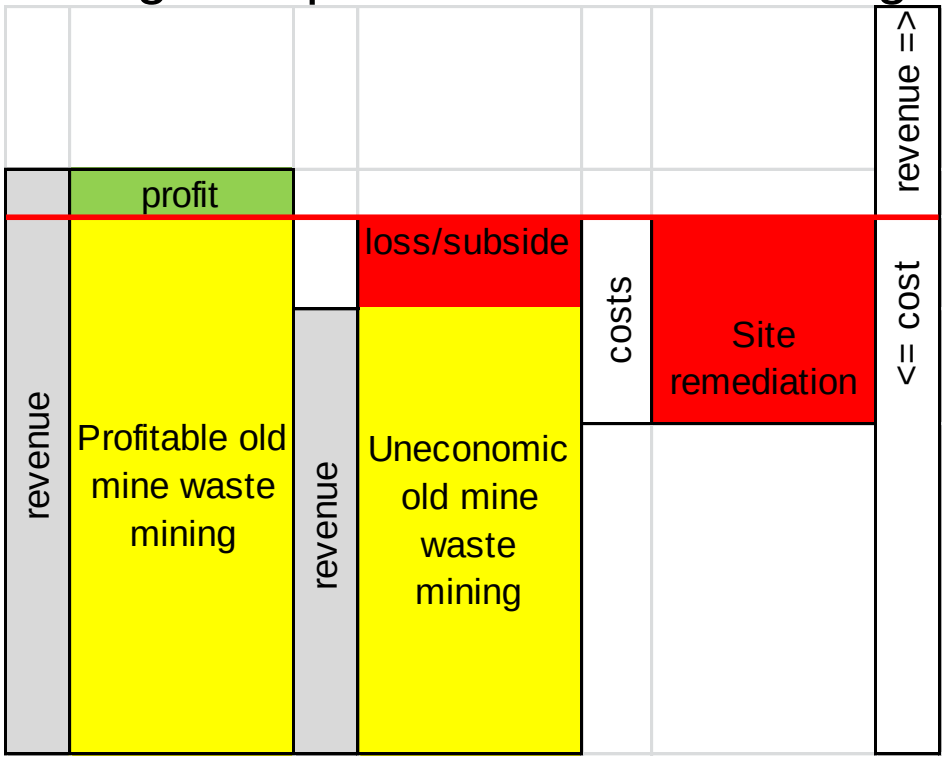
- mining first the best available waste to fund investment on site and final remediation,
- using the bulk of waste as a normal mine,



Mining the waste: economics

At closed mine sites without identified risk issues:

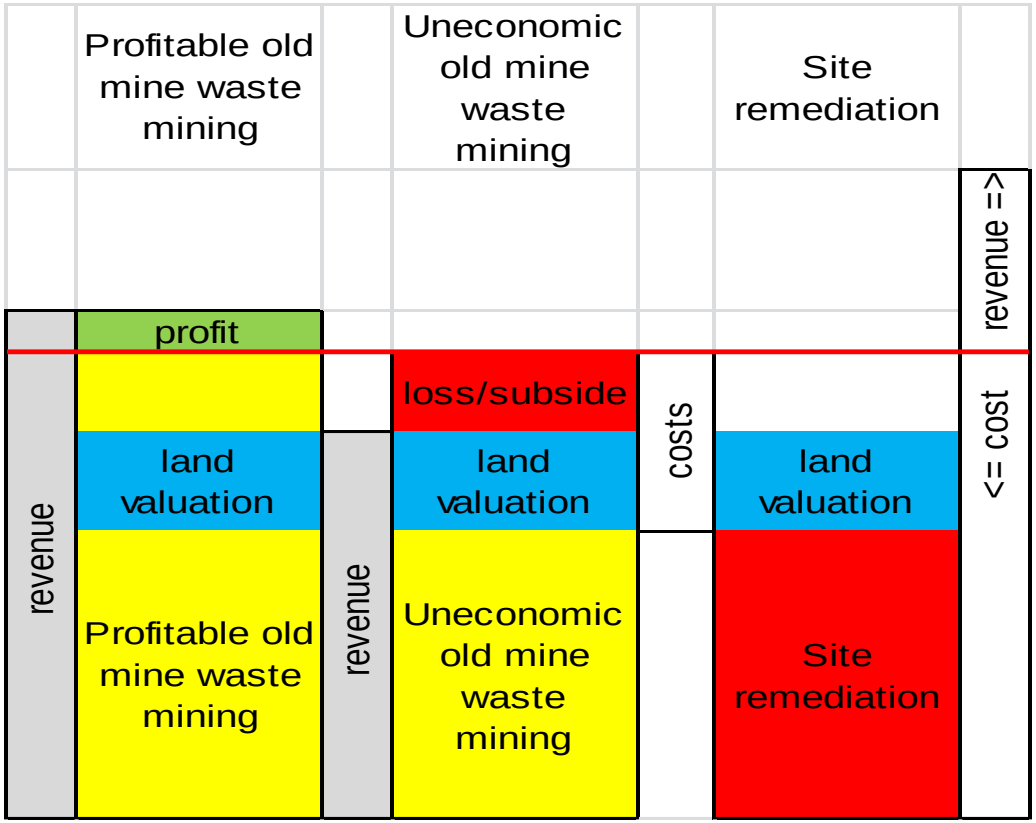
- use public clean-up funding or guarantee bonds, if any, to complete profitably site clean-up
- Mining with profit while remediating the site ?



Mining the waste: economics

At abandoned sites with potential land reuses:

- use land valuation, subsides and waste mining profits to complete profitably site clean-up



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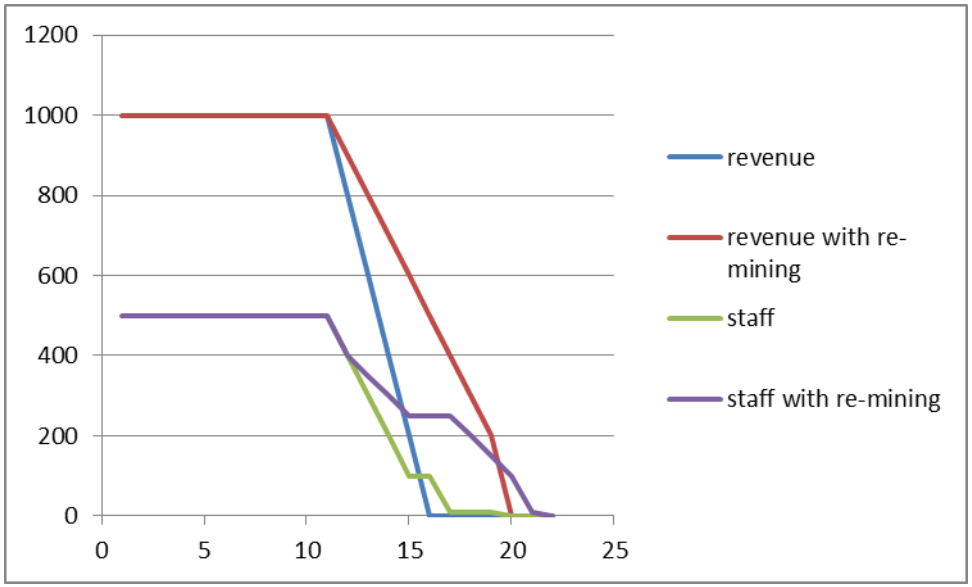
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Mining the waste: social issues

While closing a mine, waste re-mining and site clean-up activities may extend the mine activity before closure.

Shortly after the closure of several mines in an historic district, a coordinated waste mining and site clean-up program may provide employment in the district. Public support may be applied for.



Mining the waste: perspectives

At active mine sites with a long history:

- detailed evaluation of the economic potential and hazards of each existing waste facility, in order to improve the mine's value and to optimise future remediation and closure costs,

- include future remediation costs and social benefits in any waste reprocessing option.



Mining the waste: perspectives

At abandoned mine sites:

- assessment of the economic potential of the main waste facilities,
- careful evaluation of the potential hazards of each existing waste facility, in a risk perspective,
- comparative evaluation of two site remediation options: **confinement or reprocessing**, both in terms of economic and environmental efficiency.



Mining the waste: perspectives

These strategies require expert work:

- detection, sampling and quantitative evaluation of valuable resources in existing waste facilities,
- identification and evaluation of potential hazards at existing waste facilities, and closure options,
- identification, design and quantitative evaluation of innovative recovery processes and mining strategies,
- social benefits and acceptability evaluation.

