Sicherung, Rückbau und Aufbereitung zur vollständigen Verwertung der Tailings aus der Erzaufbereitung am Rammelsberg

Securing, reclaiming, and processing for complete recycling of tailings from ore processing at Rammelsberg

REWIMET Symposium 2025

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Rammelsberg – The History

1,500 B.C - 300 A.D. | 300 A.D. – 968 | 968 – 1935

Earliest traces of Mining at Rammelsberg had been detected 3,500 year ago

Mining has been reported/detected but continuous production has not been reported

More or less continuous mining is reported with some phases of paramount importance

11th and 12th century: the Rammelsberg was THE silver mine of Europe.

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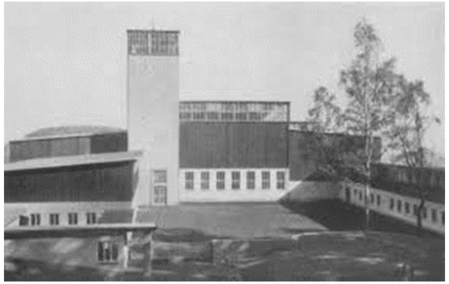
Rammelsberg – The History

1,500 B.C - 300 A.D. → 300 A.D. – 968 → 968 – 1935 → 1935 – 1988 / 1953 - 1988 → 1988 - now

The so called "Reicherz" (rich ore) has been processed in the newly set up processing plant at the eastern shoulder of the Rammelsberg mountain

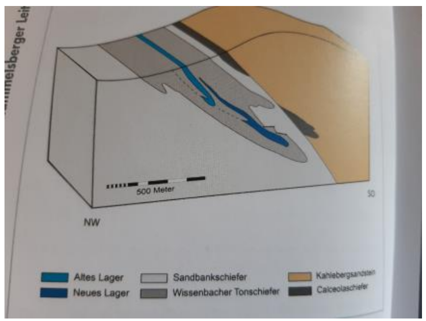
The so called "Banderz" (banded ore) has been processed in an additionally set up processing plant at the western shoulder of the Rammelsberg mountain

Evaluation and tests for the recovery of the tailing pond materials



Rammelsberg – The Geology

- The Rammelsberg orebody was a SEDEX type deposit (black smoker)
  of Devonian age, folded and compressed during development of the Harz



- The ore was very rich in Cu, Pb, Zn and especially Ag (largest silver mine in Europe)

- Additionally large amounts of pyrite and barite are dominating the composition
  plus some carbonatic material

- The host rock is Wissenbach shist (mild metamorphic rock, based on deep sea sediments)

Rammelsberg – Mining and Processing since 1935

The main process steps

- Crushing (cone crusher) and grinding (ball mills)
- Desliming (hydrocyclones)
- Flotation (mechanical cells)
- Dewatering (thickeners and drum filters)

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Aerial view of the ponds

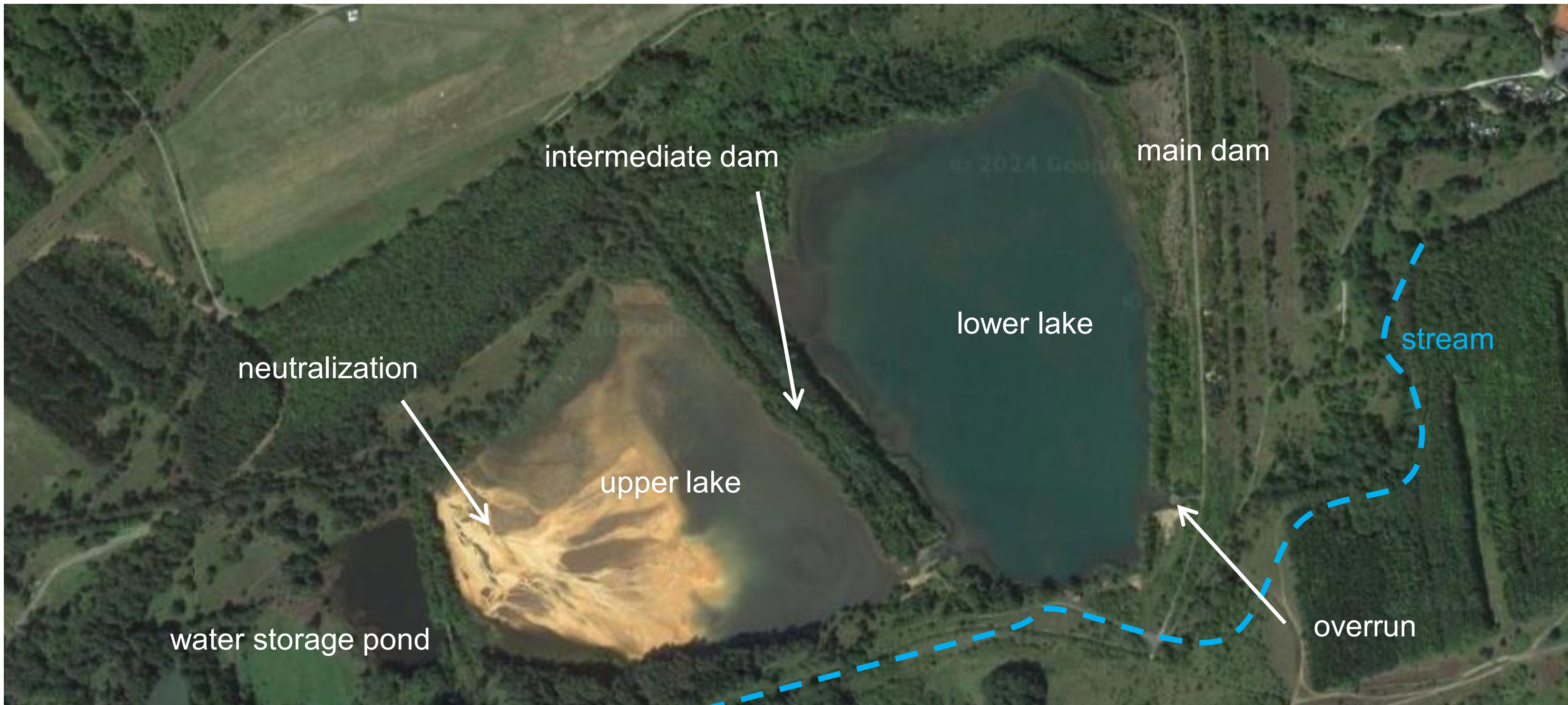

Figure: close-up of the tailing ponds at Bollrich near Goslar (Google Maps, 2024)

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Plans and Projects

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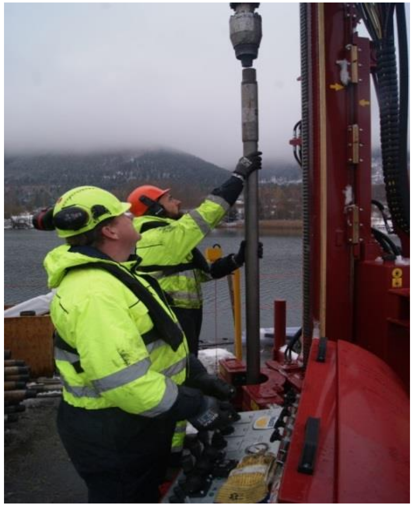
RETAIL

2025 – (2028)

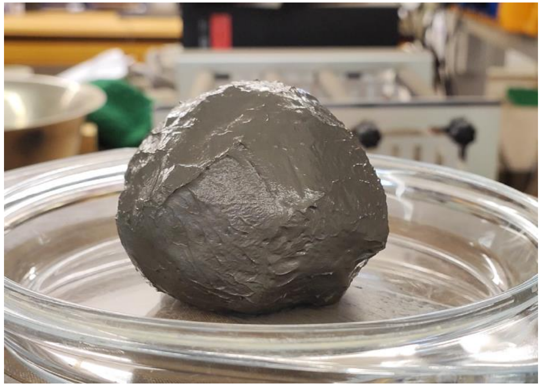
- Focus on industrial implementation
- Monitoring of deposits
- Green hydrogen and green steel from sulfide mining waste

Exploration Drilling

November 2015



The Rammelsberg Tailings



Mineral, Intergrowth and Grainsize Characterization

Main mineral phases

Quartz, Illite, Chlorite

Ankerite, Dolomite

Pyrite, Sphalerite, Galena, Chalcopyrite

Barite

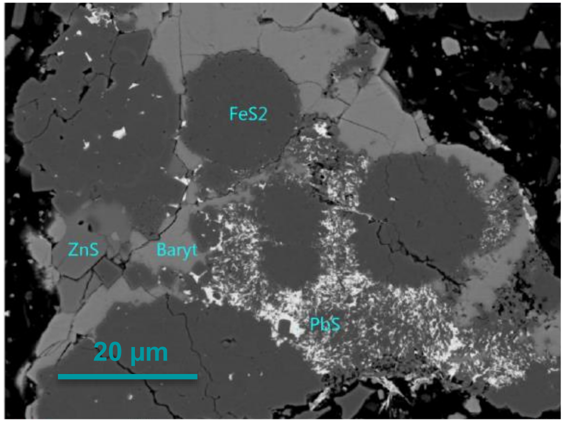
Elements mainly bound to

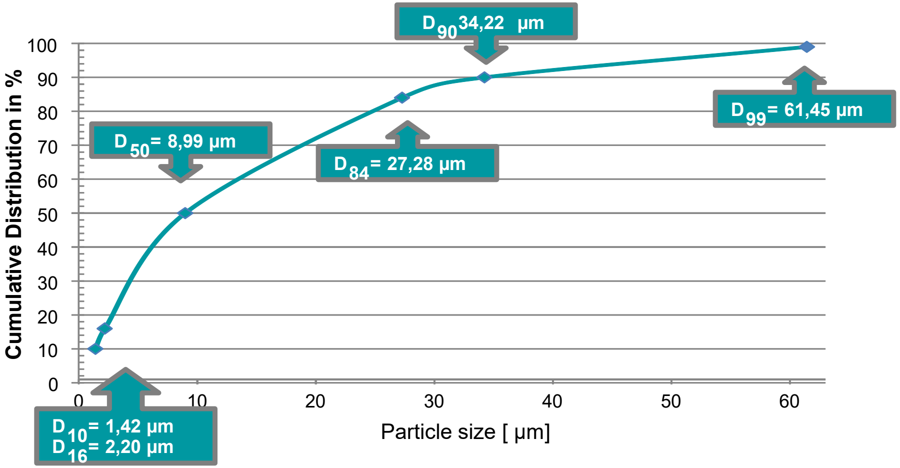
Silicates: Si, Al, K, Ga (=> no recovery potential for Ga)

Carbonates: Ca, Mg, Mn

Sulfides: Cu, Pb, Zn, Fe, Co, In

Sulfates: Ba





source: T. Zeller

The Rammelsberg Tailing Ponds and its Resources

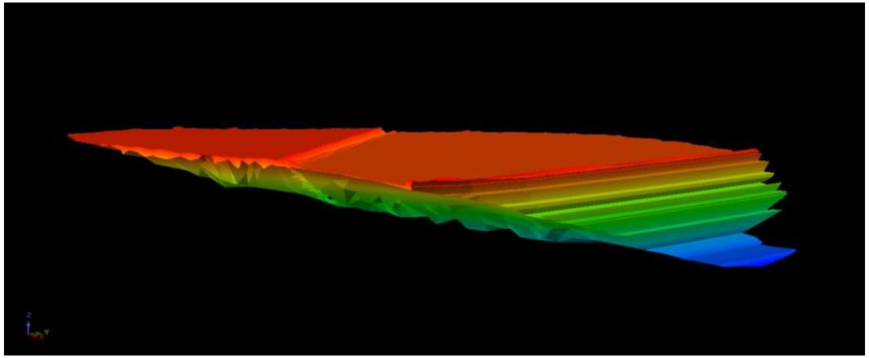
7 Mio. t

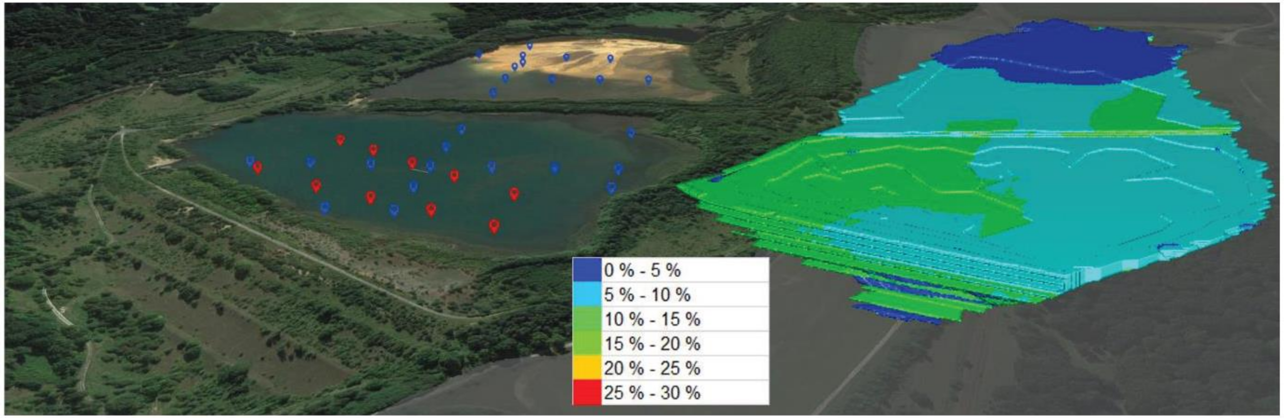
Gold	1,5 t
Indium	44 t
Gallium	170 t
Cobalt	1.220 t
Silver	234 t
Copper	10.650 t
Lead	85.200 t
Zink	120.700 t
Barite	1.356.000 t
Pyrite	1.330.000 t
Silicates a.o.	3.920.000 t

* critical raw materials

Analysis and Modelling

of the dam, the underground and the tailings





Stability and Safety

- For the geotechnical analysis and assesments of the „construction“

In particular:

- Geometric structure and mechanical properties of the tailings, the dam, and the subsoil
- Water management
- Consideration of impacts during reclaiming and from infrastructure to be installed

(1) Mining sludge/ - material
(2) Protective layer, clay sealing and seepage layer
(3) Valley bottom
(4) Old dam
(5) Tailing-slag
(6) Slope gravel

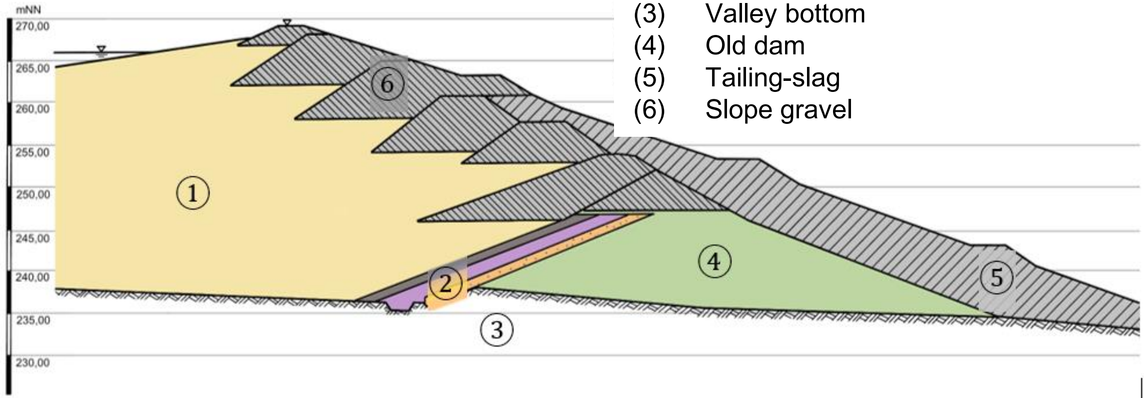


Figure: schematic profil of the Gemketalsperre's main dam (based on Schmidt and Stoewahse, 2003)

Stability Calculation

Slope failure investigations on the main dam in 2003

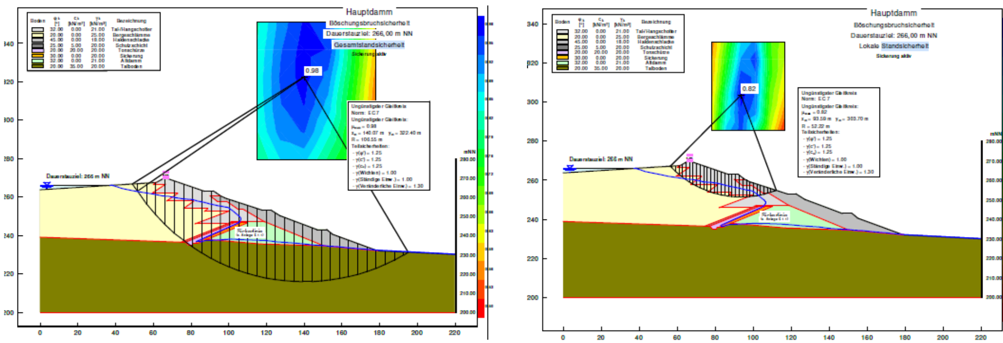


Figure: schematic profil of the Gemketalsperre's main dam (based on Schmidt and Stoewahse, 2003)

				Safety DIN 4084 : 1981	
Load case	Water level	drainage	stability	required	achieved
Normal planned operating conditions	Permanent 266 m NN	active	total	1,3	1,35
			local		1,92
Special unscheduled operating conditions	Permanent 266 m NN	not active	total	1,2	1,21
			local		1,71
	Permanent 267 m NN	active	total	1,2	1,31
			local		1,73
Exceptional e.g. damage	maximum	active	total	1,1	1,31
			local		1,75

Geotechnical Analysis

- Generally stable according to current regulations
  → Stability increases over the years due to sedimentation and higher storage density

but …

- The pollutant emissions from the contaminated site have not been thoroughly investigated.
- Changing climatic conditions will make it necessary to recover the deposited residues in order to eliminate or at least minimize the risks posed by tailing ponds

therefore …

- Monitoring of the tailings body is planned

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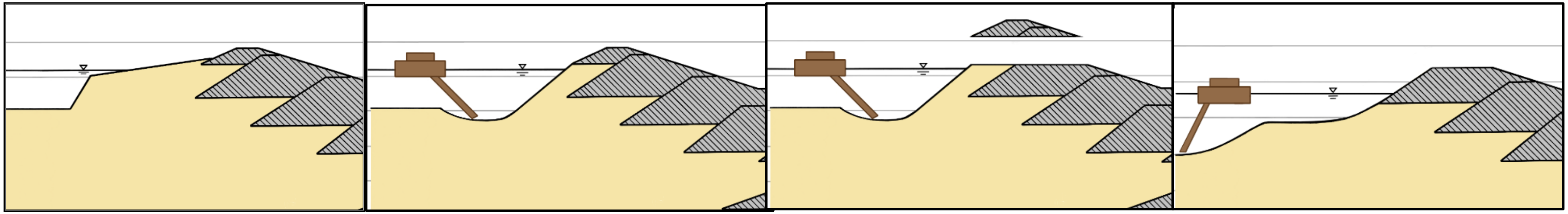
Excavation Planning

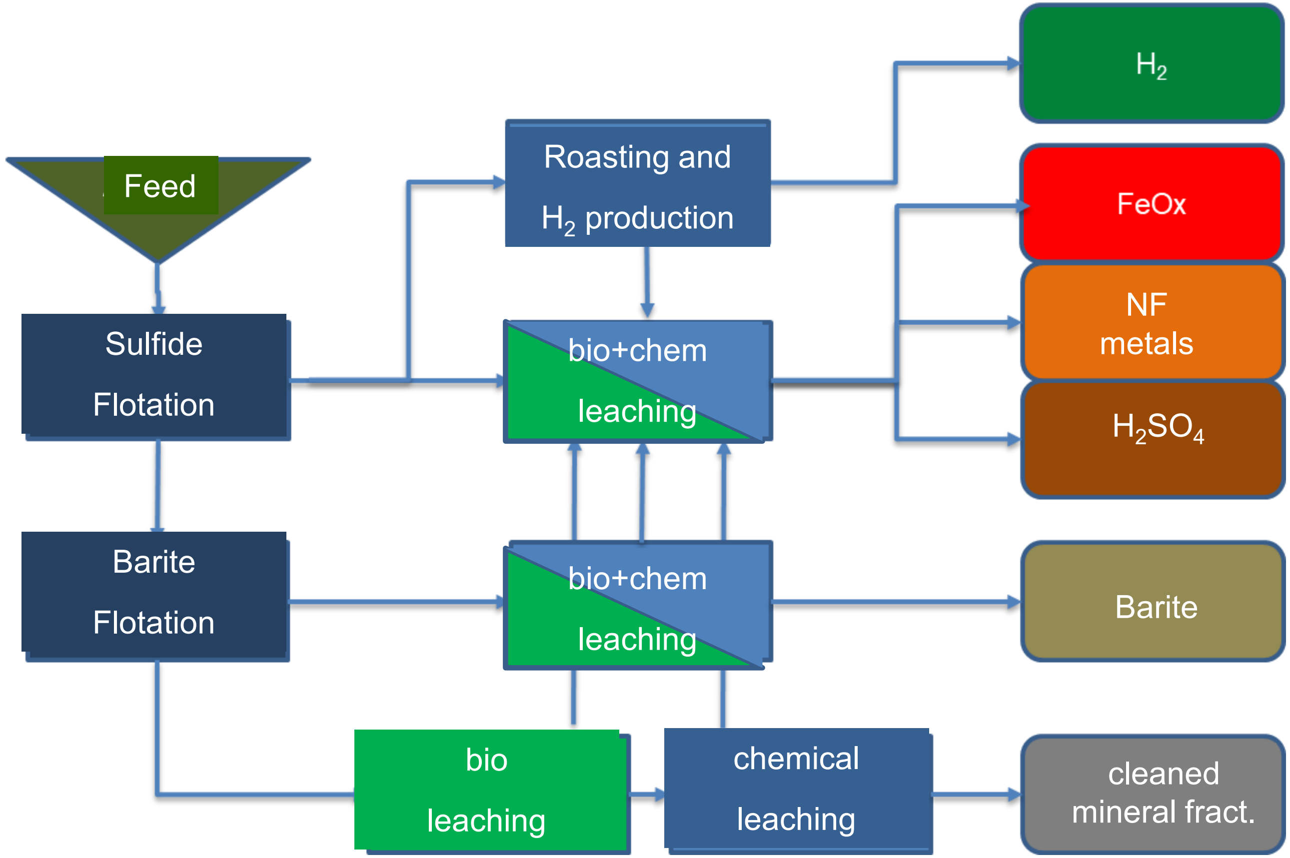
- Use of a pontoon and dredger
- Water level must be maintained above the salvaged material
- The deconstruction has to take place in layers while simultaneously reclaim the dam gradually – and not segment by segment as customarily
- The contaminated water from the ponds is used to transport the material in the pipelines.
- After reclaiming the tailing ponds the renaturation of the valley is an adequate solution, furthermore the construction of rainwater retention basins should be considered. These basins serve as buffer in the event of heavy rainfall
- The tailings shows change in their mechanical behavior while in dynamic movements, thus limiting the dam stability when the tailings pond contents are removed
- Due to weakened underground conditions (karst areas), the entire tailing pond must be reclaimed and the subsoil renaturalized



Mine Tailings Processing and Valorization

Valorization rate: 50 % → 80 % → 95 %

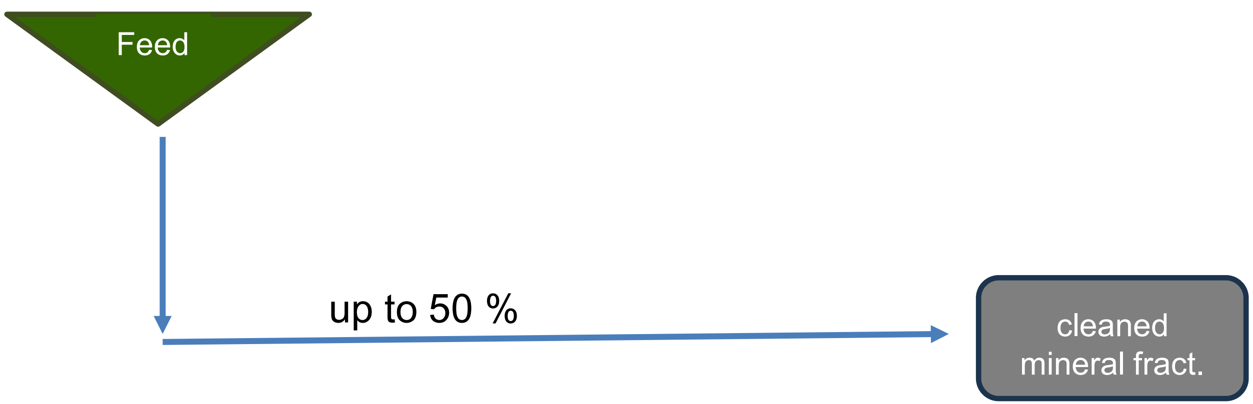
REWITA | REMINTA | ReTail



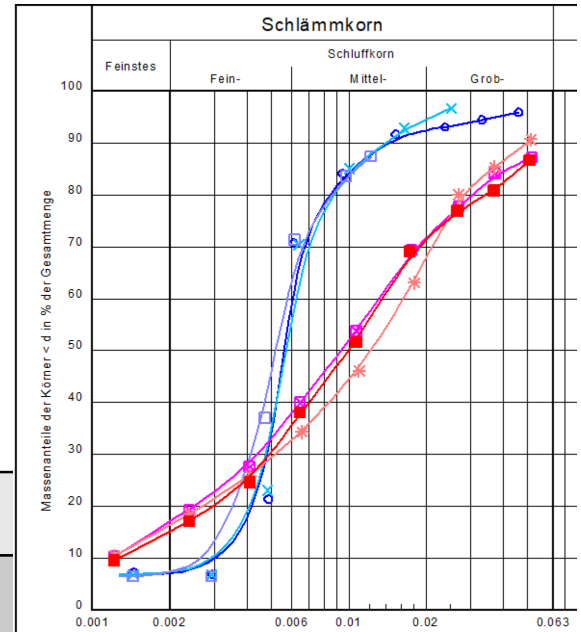
The remaining Material

- The REWITA found that about 50% of the tailings material consist of finely ground waste rock and gangue from the ore body and must be recycled.

- Restorage on site is not an option and landfill is hardly justifiable from an economic and ecological point of view



Ways of Recycling the remaining Material



Parameter	Input Material OMM + OML	Mineral Fraction (GV4)
water content w	7 – 44,5% mean ca. 20 – 30% w decreases with depth	Based on settings
dry density ρ_d	1,8 – 2,6 g/cm³	1,6 – 1,7 g/cm³
grain density ρ_s	3,0 – 3,9 g/cm³	3,11 - 3,13 g/cm³
permeability k_f	1,4 • 10^{-7} – 4,6 • 10^{-9} m/s	1,8 • 10^{-10} – 8,7 • 10^{-10} m/s

Processed minerals
upper figure: $w \approx$ 40 – 45 %
lower figure: $w \approx$ 25 – 30%

Possible Applications for the remaining Material (1)

- Mineral based substitute material as per EBV (Substitute Building Materials Ordinance)
  - Dam structures
  - Paved surfaces
  - Fillings
  - Transport infrastructure construction

- Specialized building materials
  - Additives in lightweight building materials and anthropogenic aggregates
  - Special geotechnical building materials
  - Backfilling of mining cavities
  - Use in non-construction industries

- Landfill construction
  - Levelling layer
  - Mineral-based waterproofing

- Cements

Possible Applications for the remaining Material (2)

- in cement

IBU-Mix I (mineral content 13.8 %)

- Very good reactivity during calcination
- good reactivity during firing
- CaO too high

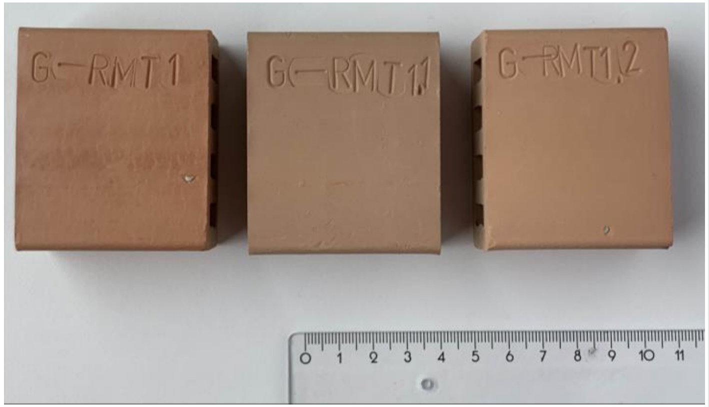
IBU-Mix II (mineral content 5 %)

- Very good reactivity during calcination and firing

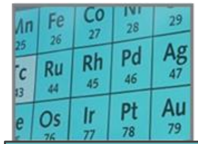
1‘450°C

- in coarse ceramics

- Is technically suitable for use in coarse ceramics
- Firing tests with an admixtures of 15% of the mineral from large-scale tests showed no impairment of ceramic properties, including compressive strenght, color, thermal conductivity and shrinkage



Implementation? Multi-criteria decision!



Motivation

- More efficient process technologies
- Additional or other target components
- Preventing pollutant emissions
- Long-term rise in commodity prices
- Subsequent use of land
- Improving the status quo (Enviroment, pollutant removal)
- Social aspects

Source modified: T. Zeller

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Thank you
for your attention

Treasure in the mud:
this lake contains gold
worth €150 million

Bild

STARTSEITE NEWS POLITIK REGIO UNTERHALTUNG KAUFBERATER SPORT FUSSBALL RATGEBER GESUNDHEIT SEX & LIEBE AUTO SPIELE

Schatz im Schlamm

In diesem See liegt Gold für 150 Millionen Euro

Foto: Marcus Prell

Stefan Sievering

10.08.2025 - 09:47 Uhr