TU Clausthal

Investigating the reprocessing of mine tailings

- Experiences from the research project “REWITA”

Prof. Dr.-Ing. Tobias Elwert, M.Sc. Felix Römer

Johannesburg,
30 November 2017

Participating project partners

TU Clausthal
CUTEC
PPM PURE METALS
HMG
STÖBICH BRANDSCHUTZ
pdv software
BIG

Funded by

Bundesministerium für Bildung und Forschung

Innovative Technologien für Ressourceneffizienz
Bereitstellung wirtschafts-strategischer Rohstoffe

Presentation outline

- Project introduction
- Deposit & material characterization
- Motivation & potential benefits
- Consequences for the process development
- Mineral processing approach
- Conclusion & outlook

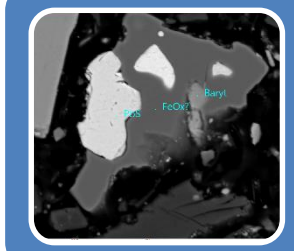
Drilling and sampling at the Bollrich, CUTEC, TUC

Project introduction - tailing Bollrich

- Massive sulfide SEDEX - ore
- Hercynian mountain range, North Germany
- > 1000 years of mining at Rammelsberg ⛏ 1988
- Flotation 1936 - 1988
- Content approx. 7 mio. t

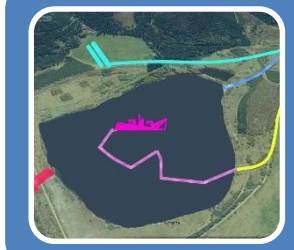
Tailing Bollrich, North Germany [1]

Project introduction - structure



Sampling and characterization

- Mineralogy
- Deposit and geomechanical aspects



Remining concept

- Adapted mining technology and techniques
- Optimized machinery

Reprocessing concept

- Investigation of mineral processing
- Metallurgy

Cooperation with local

- Companies (business model)
- Authorities (complience)

Project accompanied by

- Economic calculations
- Ecologic calculations

Overall concept development

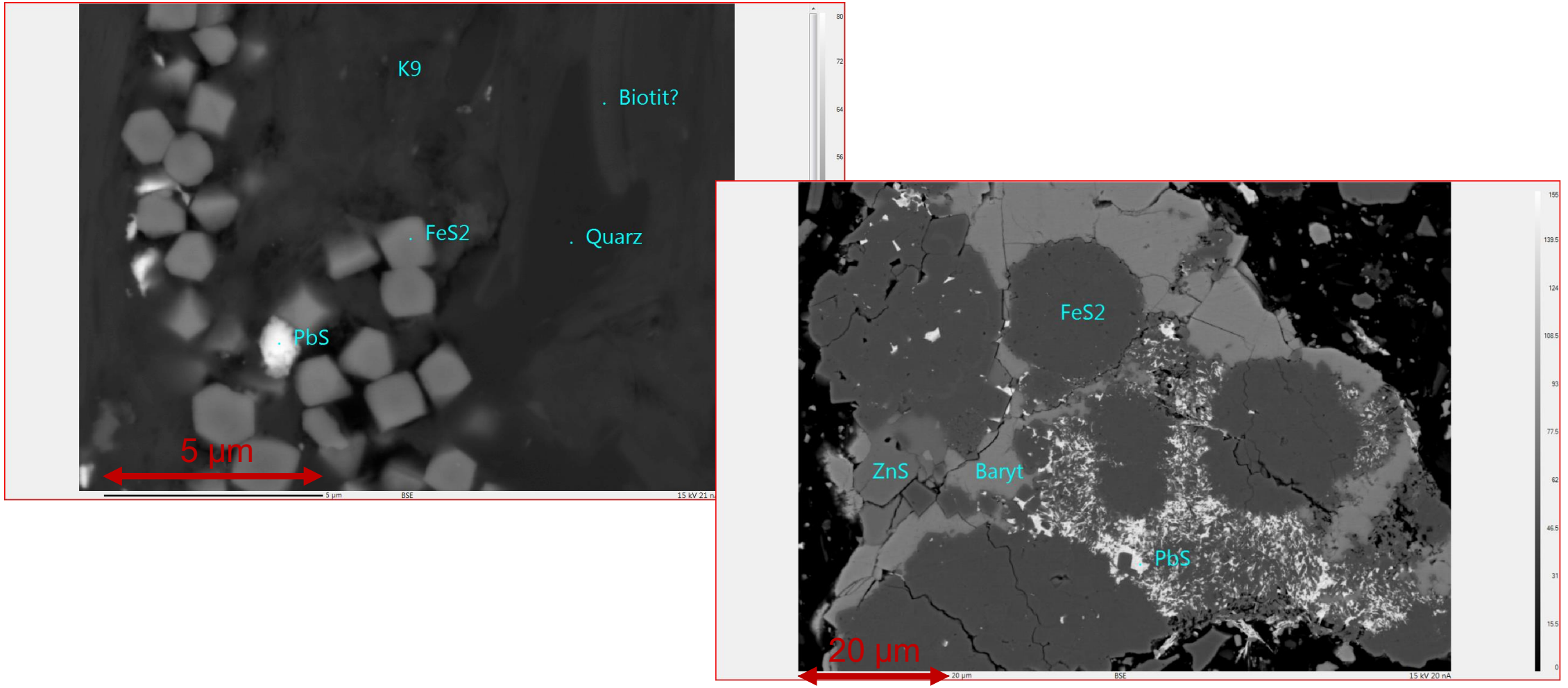
Images (IFAD, IBB) and adopted from [2]

Material characterization - chemical composition and mineralogy

Main compound groups	Metals of interest (metal content in tailing)	Trace metals of economic or strategic importance	Main [trace] elements with negative potential
Sulfates (24.6 %)	Ba (14.5 %)		
Sulfides (19.3 %)	Zn (1.39 %), Pb (1.21 %), Cu (0.15 %), Fe* (12.6 %)	Ag, Au, In, Co, Sb, Ga**	Pb, S, [As], [Cd], [Tl], [Sb]
Carbonates (22.7 %)			
Silicates (33.1 %)		Ga**	

Fe* = Due to AMD not value
Ga** = No clear correlation detected

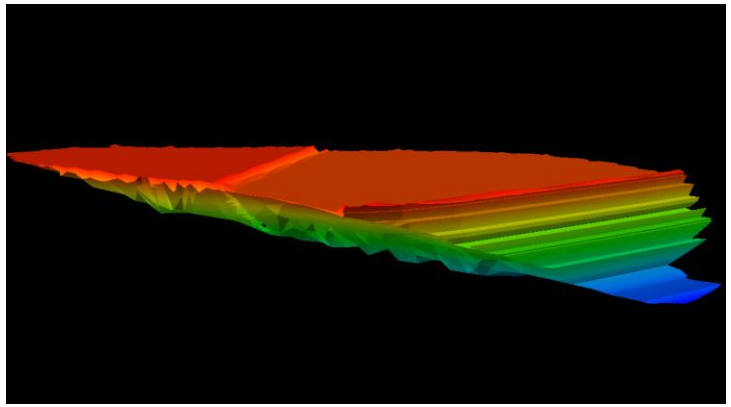
Material characterization - backscattered electrons images



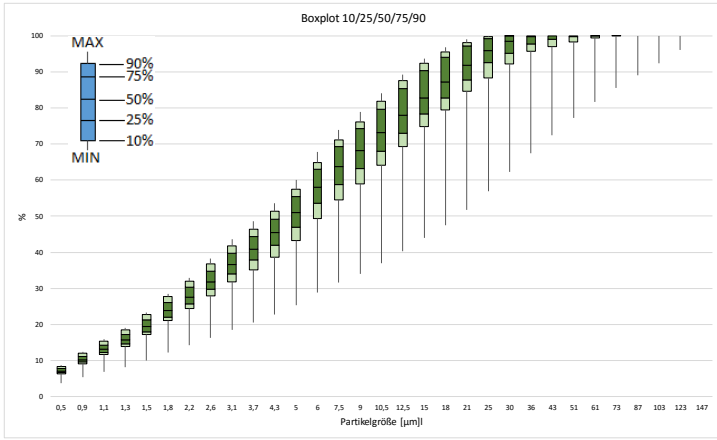
Backscattered electrons image (IELF)

Material characterization - deposit modelling

- Modelling of the deposit
  - Homogeneous material composition in general
  - Can be enhanced by old data
- Main deviations in chemical properties
  - Due to changes in the mineral processing chart
  - Observed for barite (increasing with depth)
- Main deviations in physical properties
  - changes of the inlet points (irregular) and comminution



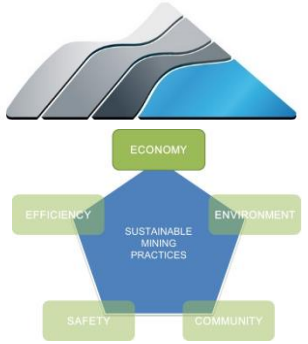
Modelled deposit (IBB)



Particle size distribution (IBB)

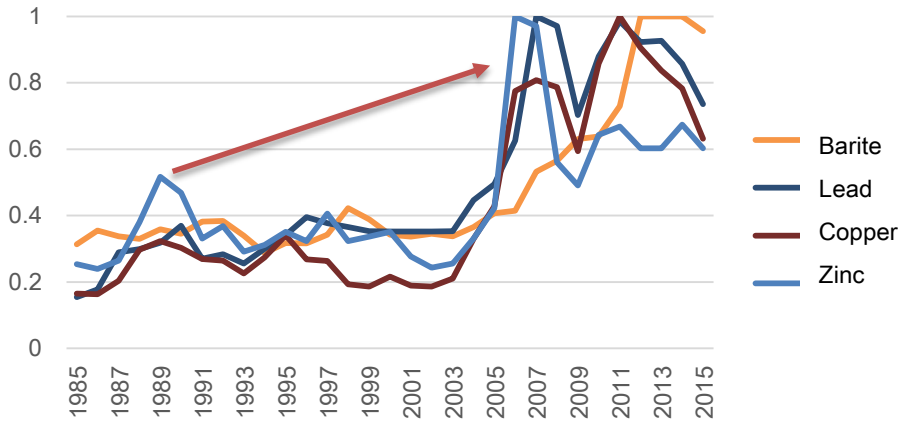
Motivation - overview

Community*: Not discussed in this presentation.
Sustainable Mining Practices adopted from [2]

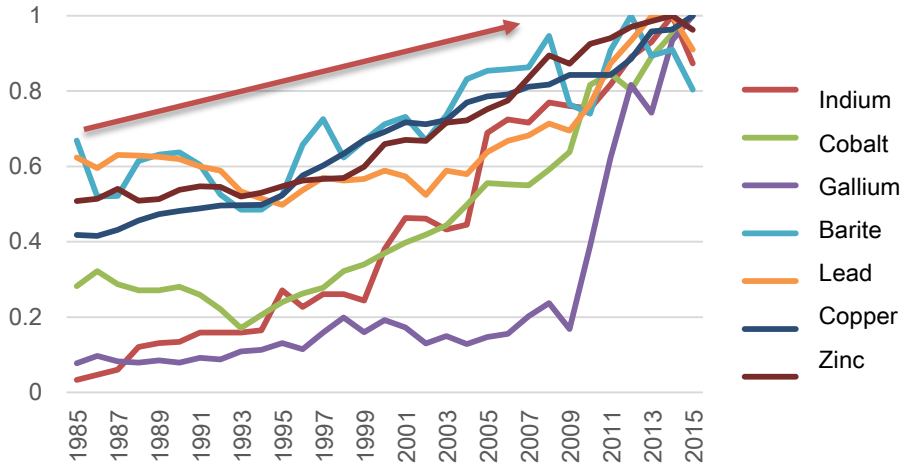


Motivation - economy

- Rise in demand and prices
- New metals of interest
- Sometimes less costs for mining and milling
- Cost avoidance for maintenance and aftercare



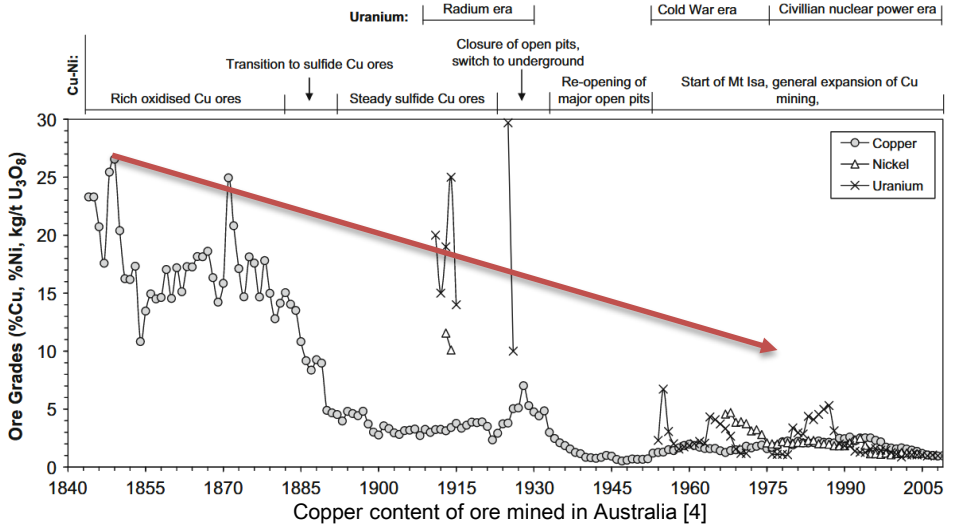
Visualization of prices for important metals in the tailing material (1=: max) based on [3]

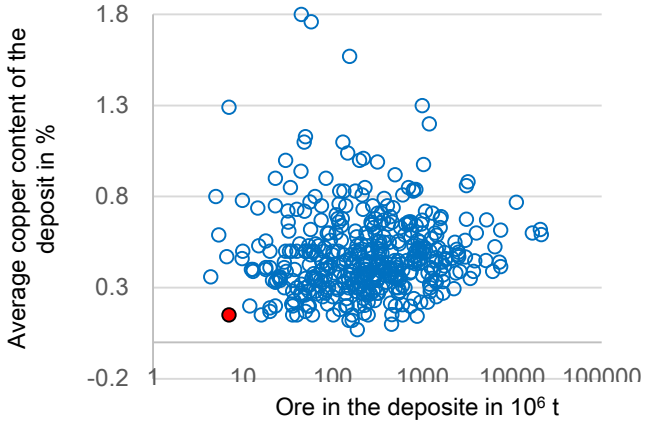


Visualization of global production for important metals in the tailing material (1=: max) based on [3]

Motivation - ressource efficiency

- Decreasing metal contents in deposits
- Partially decreasing reserves
- Unused anthropogenic deposit
- Import dependency
  - Many countries like Germany without primary resources
  - Critical raw materials defined by the EU, partially found in tailings
    - In, Co, Sb, Ga



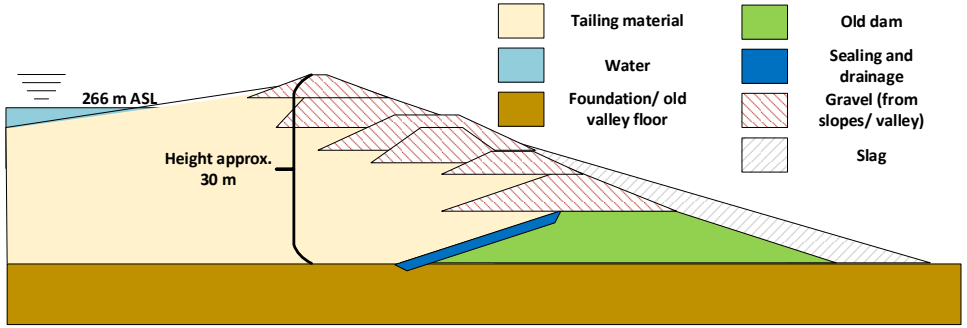


Average copper content in porphyric copper deposits in 2008 (blue) with tailing Bollrich (red). Figure on basis of data from [5].

Elwert, Römer
IFAD, TU Clausthal

Motivation - safety & environment

- Dam failures
  - Several smaller and larger dam failures every year
  - Up-stream dams sensible to failure
  - Underground stability
- Sulfidic tailings may lead to
  - Acidification
  - Mobilization of toxic elements
    - Tl, As, Co, Cd
- Follow-up cost may be very high

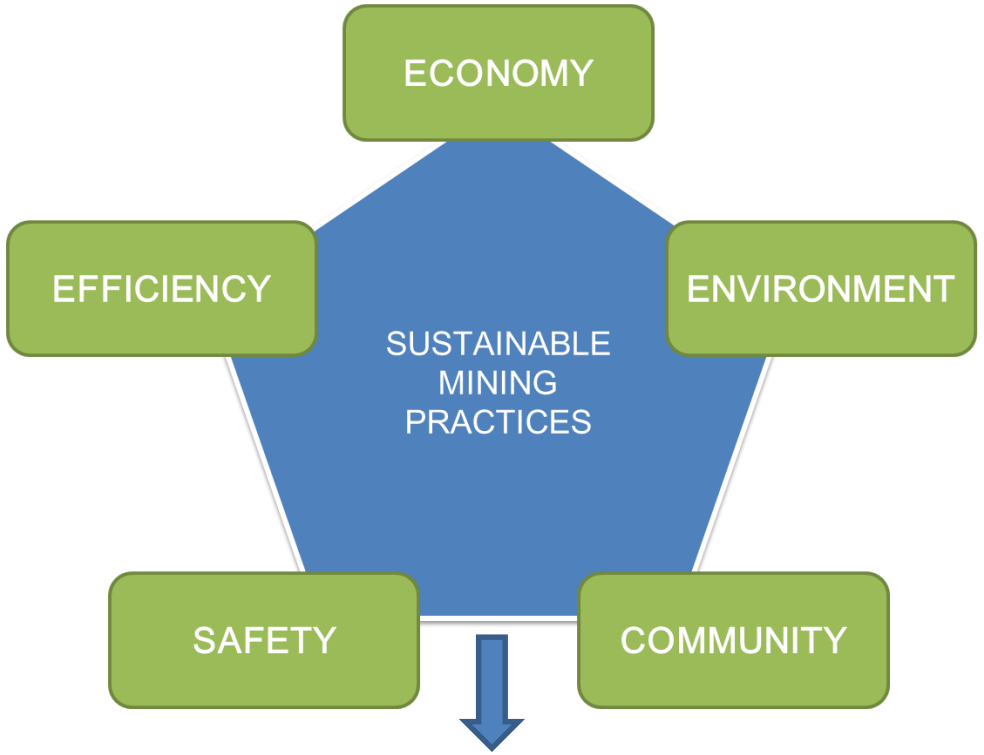


Scematic set-up of the main tailing dam (IGMC)

Precipitation from AMD [6]

Consequences for the process development at the tailing Bollrich

- Overall goals
  - Sanitation probably necessary (costly)
  - Residue reduction (costs for redepositing)
- Remining
  - Removal of the material and dam must be conducted vertically layer by layer
  - In-situ mining and deposition not possible
- Reprocessing
  - Barite winning (material reduction and value)
  - Concentration of harmful and valuable elements in sulfides
  - Generation of inert material

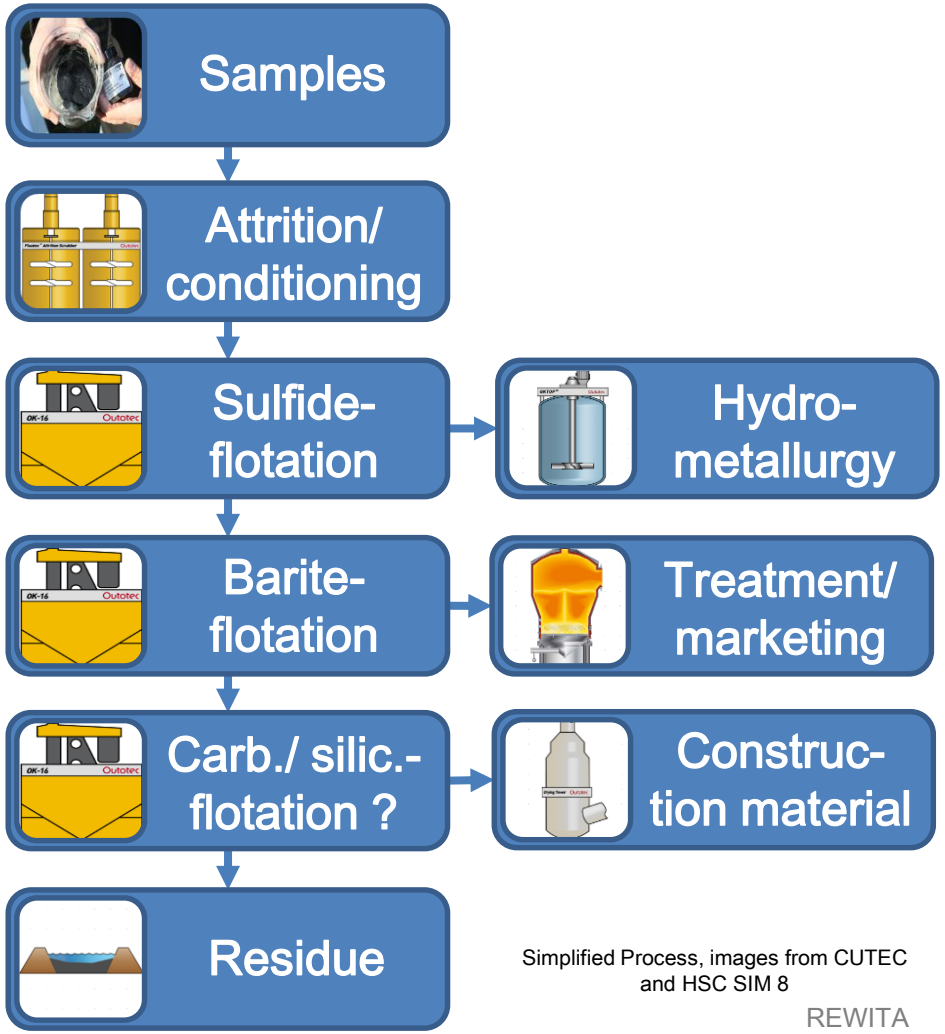


High complexity but potential costs through environmental and safety risks are very high

Elwert, Römer
IFAD, TU Clausthal

Mineral processing approach - overview

- Flotation
  - Mixed sulfide concentrate with dithiophosphinates /-carbamates
  - Barite with anionic alkysulfate
  - Silicates/ carbonates with amines
- Hydrometallurgy
  - Different processing routes investigated
  - Most feasable selective recovery of Cu, Zn with NH_3, containment/ bioleaching of residue
- Treatment of barite and inert material neccessary

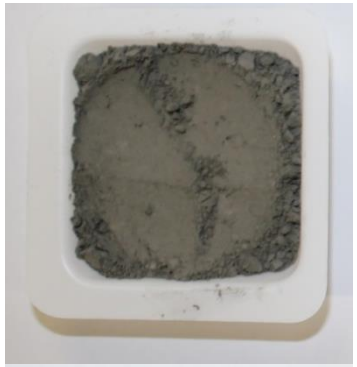


Simplified Process, images from CUTEC and HSC SIM 8

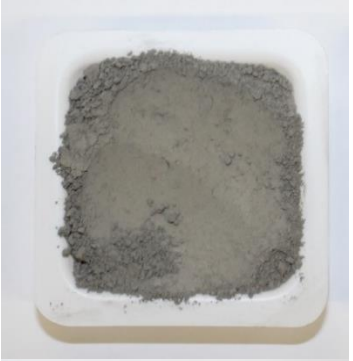
Mineral processing approach - example

- Barite flotation possible
- Low enrichment/ recovery/ product quality
  - ~ 3/80 % rougher, 85 - 90 % $BaSO_4$ in 2. cleaner float
  - 5 - 10 % sulfide losses to float
  - Intergrowth/ particle size
- High chemical input due to particle size
  - Consumption relatively high
  - Negative impacts for subsequent flotation steps
- Further treatment may be required
  - Requirement ~ 95 %
  - $BaSO_4$ usually roasted (destruction of chemicals)
  - Additional leaching may be necessary

1. rougher tailing
2 - 5 % $BaSO_4$



1. cleaner tailing
50 - 60 % $BaSO_4$



2. cleaner float
85 - 90 % $BaSO_4$

Tailings and barite float (IFAD)

Conclusions and outlook I - reprocessing

- Currently many investigations
- Reprocessing not solely value carrier driven, high complexities in decision making
- Value contents usually comparatively low, but might reach economic/ strategic relevance
- Main motivation for reprocessing is still profit and, to a lesser extend, avoided costs
- Business alternative for reprocessing may be sanitation or other follow-up costs/ compensations

Conclusions and outlook II - current tailing management

- Possible problems and value potentials should be monitored and anticipated
- Different residues should be separated to facilitate future separation efforts
- Externalization of follow-up costs must be prevented politically to enforce sustainable mining
  - Longlivity of structures must be considered
  - Consideration of possible long-term follow-up costs

Investigating dry tailings [7]

Oilsand tailing ponds, Alberta, Canada [8]

Thank you for your attention!

References

[1] https://commons.wikimedia.org/wiki/File:Europe_countries_map_2.png and https://www.google.de/maps/@51.9065485,10.4562992,14z.; 20.11.2017

[2] Laurence, D.C. ,2011, “Establishing a Sustainable Mining Operation—An Overview” Journal of Cleaner Production Vol. 19, Issue 2-3, Jan/Feb 2011 Elsevier Science Ltd

[3] Kelly TD, Grecia MR (2017) Historical Statistics for Mineral and Material Commodities in the United States. U.S. Geological Survey. https://minerals.usgs.gov/minerals/pubs/historical-statistics/; 27.07.2017

[4] Mudd, G.M., 2010, The Environmental sustainability of mining in Australia: Key mega- trends and looming constraints. Resources Policy, 35(2), 98–115.

[5] Singer DA, Berger VI, Moring BC (2008) Porphyry Copper Deposits of the World: Database and Grade and Tonnage Models, 2008. U.S. Geological Survey. https://pubs.usgs.gov/of/2008/1155/. 27.07.2017

[6] https://commons.wikimedia.org/wiki/File:Ohio_Valley_Mushroom_Farm,_Acid-Mine_Drainage_(AMD)_(13670996183).jpg (cc-by-sa-2.0.)

[7] http://www.westech-inc.com/blog-minerals/topic/paste-thickening; 20.11.2017

[8] https://www.desmog.ca/2017/06/28/no-sure-plans-funding-51-billion-cleanup-and-rehabilitation-oilsands-tailings-ponds; 20.11.2017