TECHNISCHE UNIVERSITÄT
BERGAKADEMIE FREIBERG
Die Ressourcenuniversität. Seit 1765.

KRÜGER-STIFTUNG
FREIBERGER BIOHYDROMETALLURGISCHES ZENTRUM

Setup of an Underground in-situ Bioleaching for Sulphide Ores in Crystalline Hard Rock Formations – Challenges and Opportunities



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Outline

1. Current problems in mining
2. Experimental and Educational Mine “Reiche Zeche”
3. Research Site at “Reiche Zeche”
4. In-situ Bioleaching
5. Results
6. Summary

1 Current problems in mining

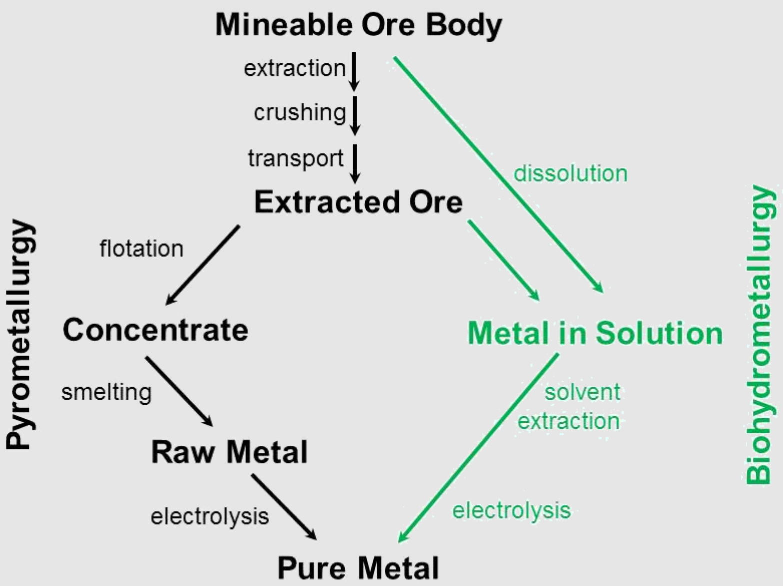
- Deposits with dropping qualities and quantities
- Decreasing ore grades
- More complex mineralization
- Increasing depths
- Narrow veins
- Irregular deposit shapes

<u>Consequences</u>

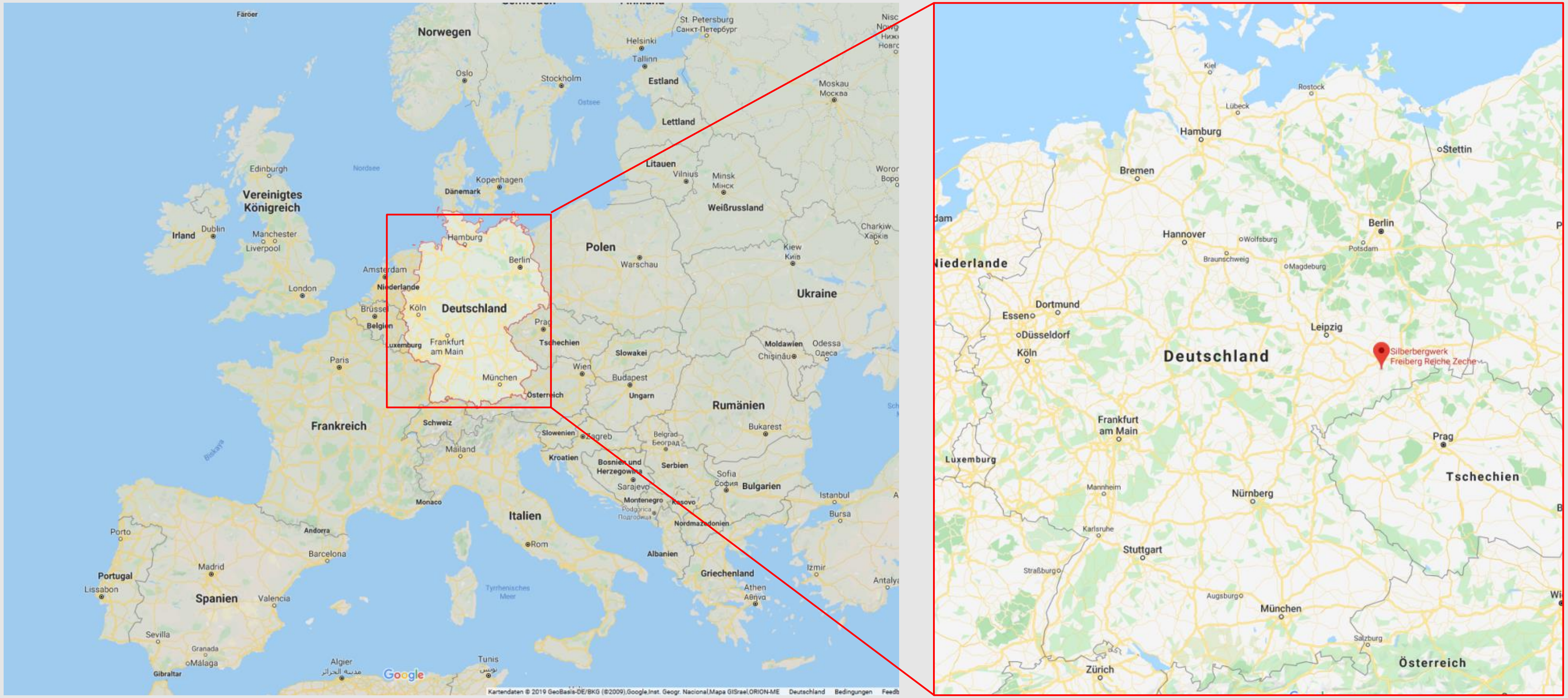
- Increasing costs
- Complex processing
- Fluctuating raw material prices

<u>Solution Approaches</u>

- Economy of Scales
- Automation
- Efficiency enhancement
- New mining technologies



2 Experimental and Educational Mine “Reiche Zeche”



www.maps.google.de

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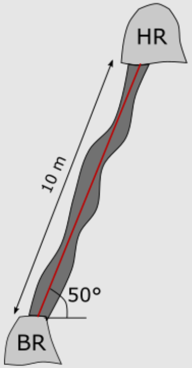
- Mining started on silver in 1168 and production stopped in 1969
- Founding of the Bergakademie in 1765
- Mine was given to the university in 1919
- Dewatering adit 230 m below surface
- Main level 150 m below surface

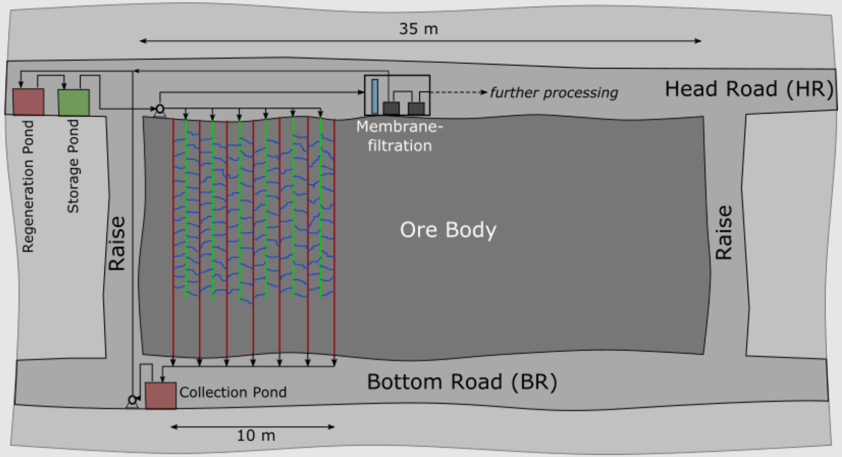
- Sulfide lead-zinc deposit (mainly Galena, Sphalerite, Pyrite)

3 Research Site at Reiche Zeche

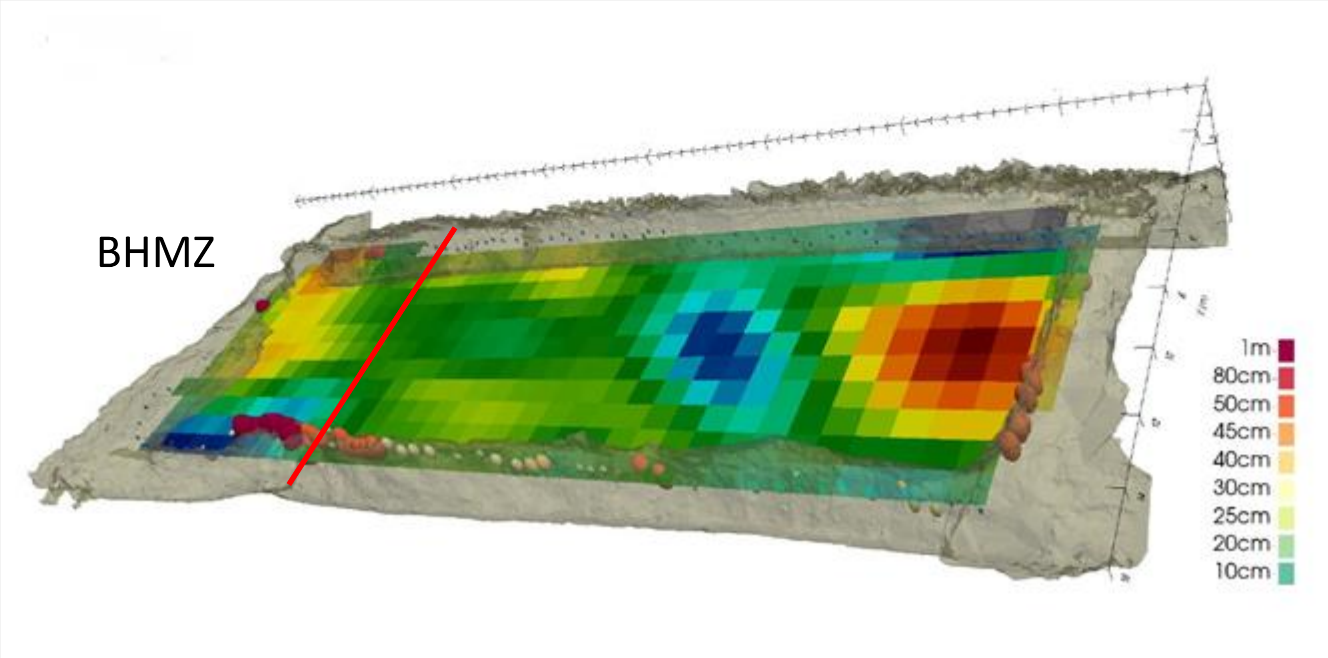
- Borehole distance: 0.2 – 0.5 m
- Borehole diameter: 53 mm
- Drilled from upper level

- Vein thickness: 0.1 – 1 m
- Dipping angle: ~ 50°
- Temperature ~ 8 - 12 °C
- pH of mine seepage 2 – 3



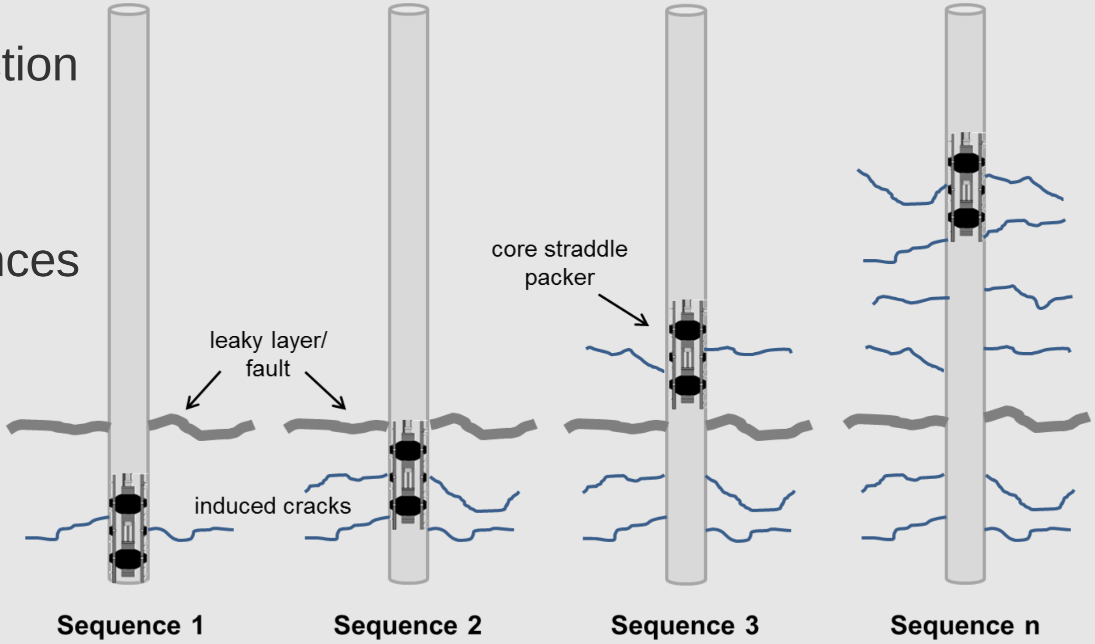


Thickness of the ore vein



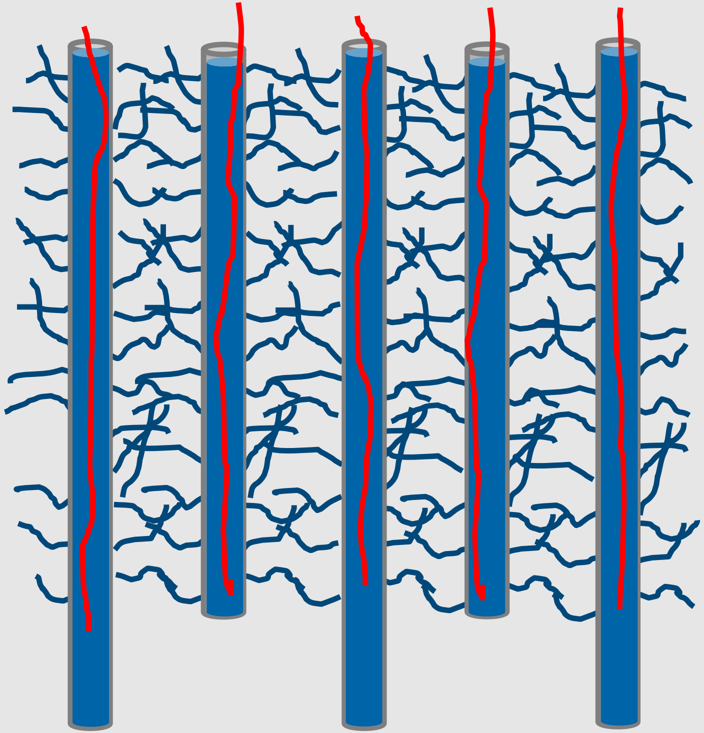
- Sealing of a small bore hole section
- Pumping until fracture occurs
- Fractures can be positioned in different horizons due to sequences

- One big fracture perpendicular to perimeter of bore hole
- No even fracturing of the vein



4 In-situ Bioleaching – Hydraulic fracturing by blasting

- Combination of water and detonation cord
- Generating interlinked fractures between neighboring holes
- Different load of detonation cord
  100 g/m – 300 g/m
- Best results
  (many small fractures, high increase in faces)



Borehole monitoring – March 2017

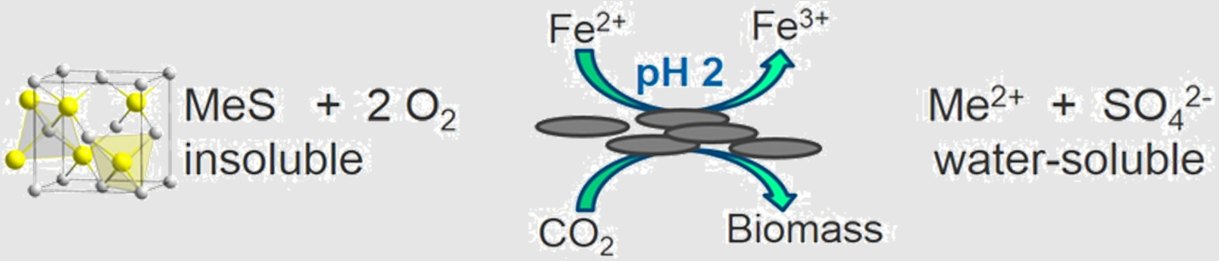
Borehole monitoring – August 2019

Comparison of Conditioning Methods

Hydraulic fracturing	Hydraulic fracturing by blasting
low specific surface	sufficient specific surface
few fractures	multiple main fractures
one fracture perpendicular to direction of minimum principal stress in each sequence	circumferential and radial blasting fractures, fan-shaped propagation of hydraulic fractures
→ **insufficient**	→ **promising**

4 In-situ Bioleaching

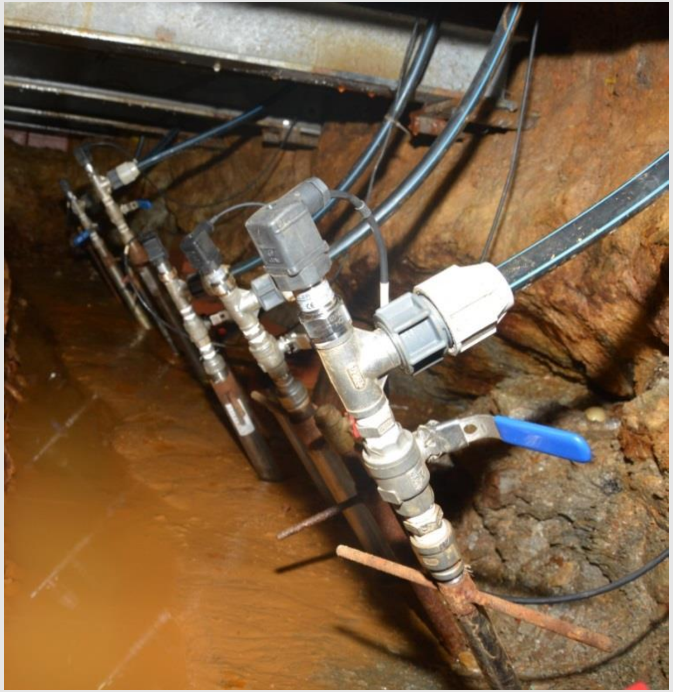
- Technology used since the 1980‘s for tailings
- A. Ferrooxidans, A. Thiooxidans, L. Ferrooxidans
- pH: 1.6 – 1.9
- Cultivated in a storage pond



- Brass: Pressure regulators and valves
- Iron, low quality steel: Packer
- Leakages occur every few days → no continuous testing was possible
- Underestimation of the influence of the solution (sulfur acid + bacteria)
- Corruption of the values ("mining of brass")

4 In-situ Bioleaching - Sensors

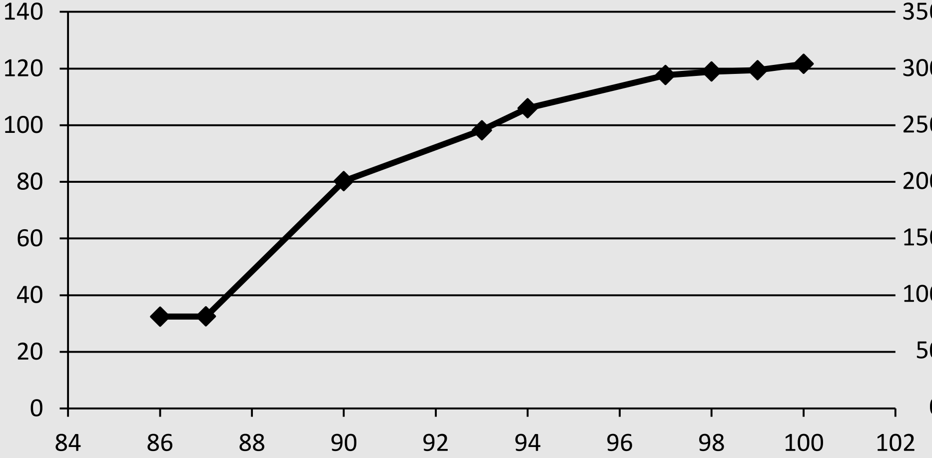
- Rebuilding of all installations after 6 months
- V4A stainless steel and HD-PE
- Replacement of sensors
  Custom product out of a special alloy
  (Hastelloy C276)



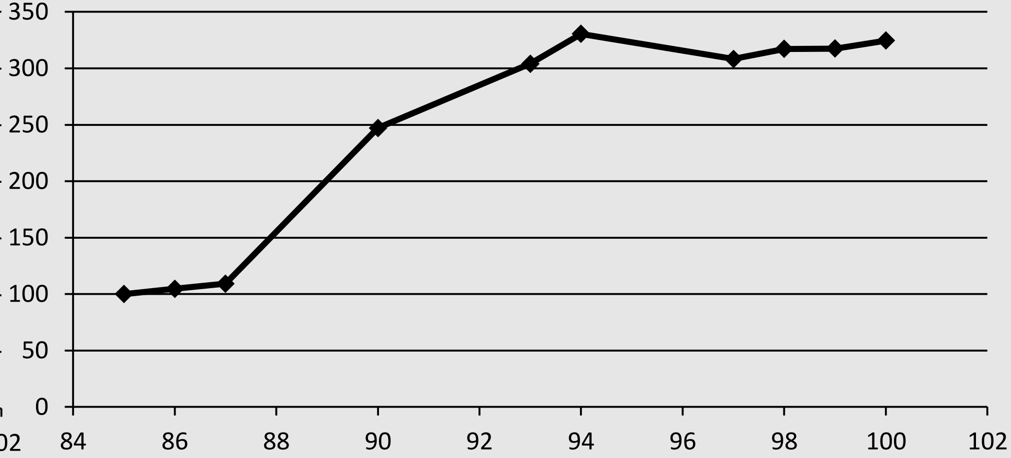
- Production of a concentrate
  Reduction of transported material
- 2 step processing:
  - Separating bacteria - Microfiltration
  - Separating polyvalent ions - Nanofiltration

5 Results - Examples

Manganese



Zink



6 Summary

- Research is still in beginning
- Influences of circumstances are not well researched
- First problems are fixed → long-term tests started
- Further research:
    - Passivating oxide layers (Limonite) (now managed by hydrochloric acid)
    - Strengthen the production rate
    - Influence of fractures compared to borehole distance
    - Possibilities for different sulfide ore deposits

Thank you for your attention and Glück Auf!