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Subsurface Mining Methods: Advanced In-Situ Bioleaching

Northern Mined Operations
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MDEC Mandate

To control and reduce diesel emissions in the mining workplace environment

MINED 2018 Case Review:

- 5% annual increase in mining costs
- Point of Reference - Long hole open stope mining method
- Improve efficiency by 3x through innovation

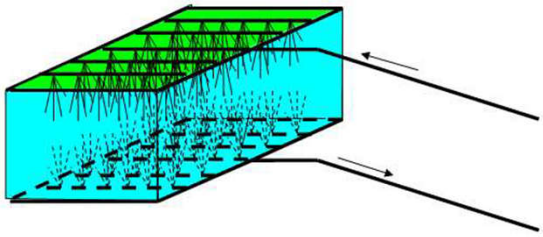
The Question:

How would your solution to the MINED challenge also bring about benefits to a mine in reducing diesel particulate matter and/or reliance on diesel equipment?

- MDEC 2018

Drilling, Development & Ore Body Preparation

- Similar to open stoping development
- 10% void space excavation
- Small stope size
- Fan drilling
- Electrode assembly for SelFrag system
- Pumps and piping for leachate solution (temporary set-ups)

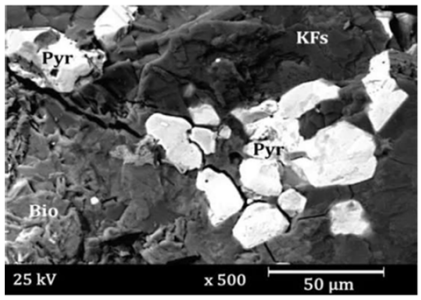


[1]

SelFrag (Selective Fracturing Method)

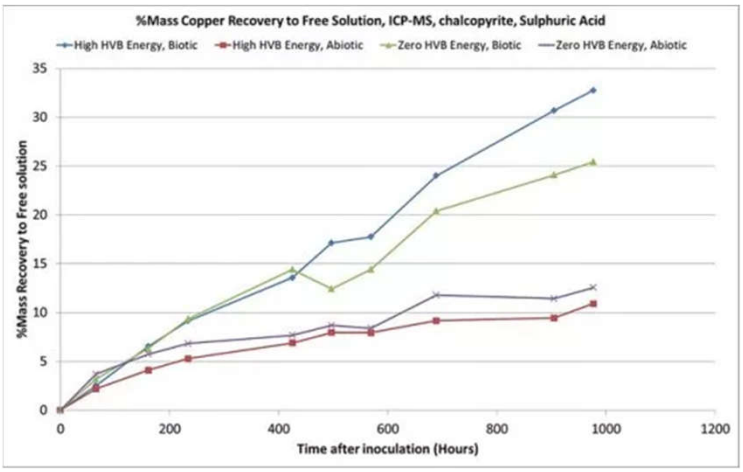
- High voltage pulses (90k-200kV)
  - 2-3x higher initial energy demand, but 24% energy savings overall (Green Tech.)
- Fractures along grain boundaries of minerals due to electrical potential differences
- Microfractures pre-weaken ore and channel permeation for easier metal separation
- No blast gases or dust due to water insulation

[2]



[3]

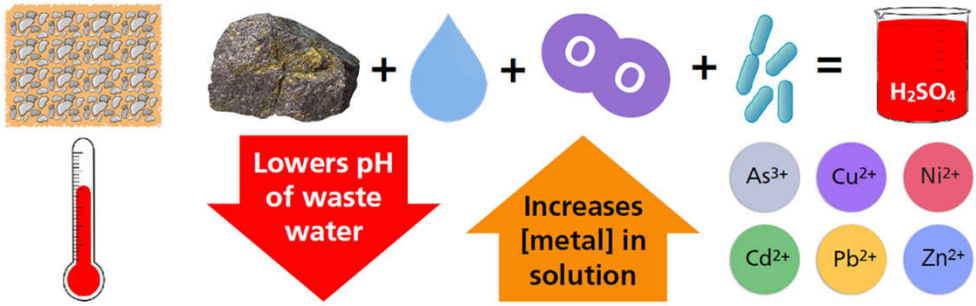
Comparison of %Mass Copper Recovery to Free Solution using HVB and Biotic Methods



[3]

Bioleaching (Subsurface Extraction)

- Continuous biomining method
- Minimal materials handling
- Environmentally friendlier
- 5x faster than chemical leaching
- 50-75% lower operating costs
- 80-90% recovery in 101 days

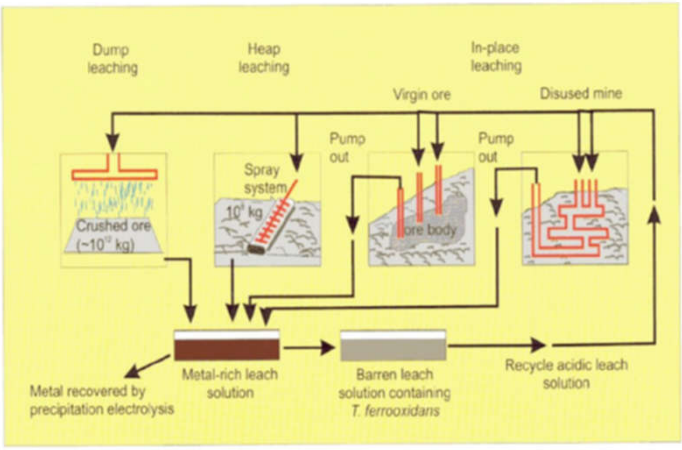


[4]

Situational Benefits to In-Situ Bioleaching

- 30% less CO2 and SO4 emissions from primary and secondary sources
- 5x less energy and water consumption
- Closed loop system with minimal acidic makeup and electronic plating for recovery
- Controlled steady state conditions due to self -containing “deep hard-rock ore body” pseudo underground reactor (i.e. Temperature, pH, and Flow)

Illustration of In-Situ Biomining Methods



[4]

Key Assumptions

- ~25k tonnes/stope (25m x 20m x 15m)
- 33% reduction in mine life
- Constant drill time
- Constant prep time for leaching or backfill
- Constant blasting or Selfrag time
- No mucking
- 80% recovery from bioleaching v. 90% recovery from longhole mining

Mining Methods Comparison

Parameters	Longhole Mining	3x Mucking Rate	Bioleaching
Mine Life	10 years	7.8 years	6.7 years
Processing Rate	1.1M tonnes/year	1.41M tonnes/year	1.64M tonnes/year
Mucking Rate	1000 tonnes/day/stope	3000 tonnes/day/stope	-
Mucking Time	24.75 days	8.25 days	-
Stope Life	74.25 days	57.75 days	49.5 days
Stope Turnover	44.24 stopes/year	56.88 stopes/year	66.36 stopes/year
Production Ratio	100%	128.6%	150%

Financial Comparison

*Non-Encompassing

M$ (CAD) per Annum	Longhole Method (10 yr.)	Longhole Method [3x] (7.8 yr.)	Bioleach Method (6.7 yr.)
Revenue	534.6	685.4	709.3
Cost	-164.3	-210.5	-175.8
Annual Balance	370.3	474.9	533.5
NPV (B$, CAD)	2.09	2.32	2.36

Potential Considerations

- Surface oxidation of minerals by electrical pulse of Selfrag
- Contamination by accidental release into ground water table
- Anoxic conditions of the u/g reactor reducing recovery (52-73%)
- Further oxidation of exposed minerals u/g or at surface (i.e. AMD)

Suggested operating procedure for best practice:

- Pretreatment: prime the fractured stope under pressure at the interface with a biofriendly reducing agent containing detectable agents to test vessel integrity
- Reaction: Aerate the leachate with supplemental O2 injection to increase DO and provide necessary oxygen for higher reaction efficiency
- Purge: Chase acidic bio-leachate with alkaline liquor containing a structural adhesive reagent, if necessary, to neutralize the stope and precipitate and oxy-hydroxide minerals and seal the pores of the metal-depleted ore body

EU Horizon 2020 Research and Innovation Program - BioMOre

www.biomore.info/home/

Northern Advantages

- Metals within orebody extracted without mucking (No backfill needed)
- Strong synergy between SelFrag and in-situ leach method
- Minimal use of mucking equipment
- Only development blasting required
- Increased extraction efficiency and reduced CO2 and SO4 emissions when using bio-leachate
- Production increased without limitation of material handling (i.e. equipment fleet or shaft)
- 50% Increase in production results in a 13% increase in NPV
- Overall, improves productivity, EHS and economic feasibility while reducing air pollutants such as diesel emissions, dust and blasting fumes

References

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