

# *High Nickel Slimes at a Copper Refinery: Rejecting or Recovering?”*

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# Agenda

- Safety
- Introduction
- Case Study Definition
- Case Study: High Nickel Feed
- Summary
- Questions

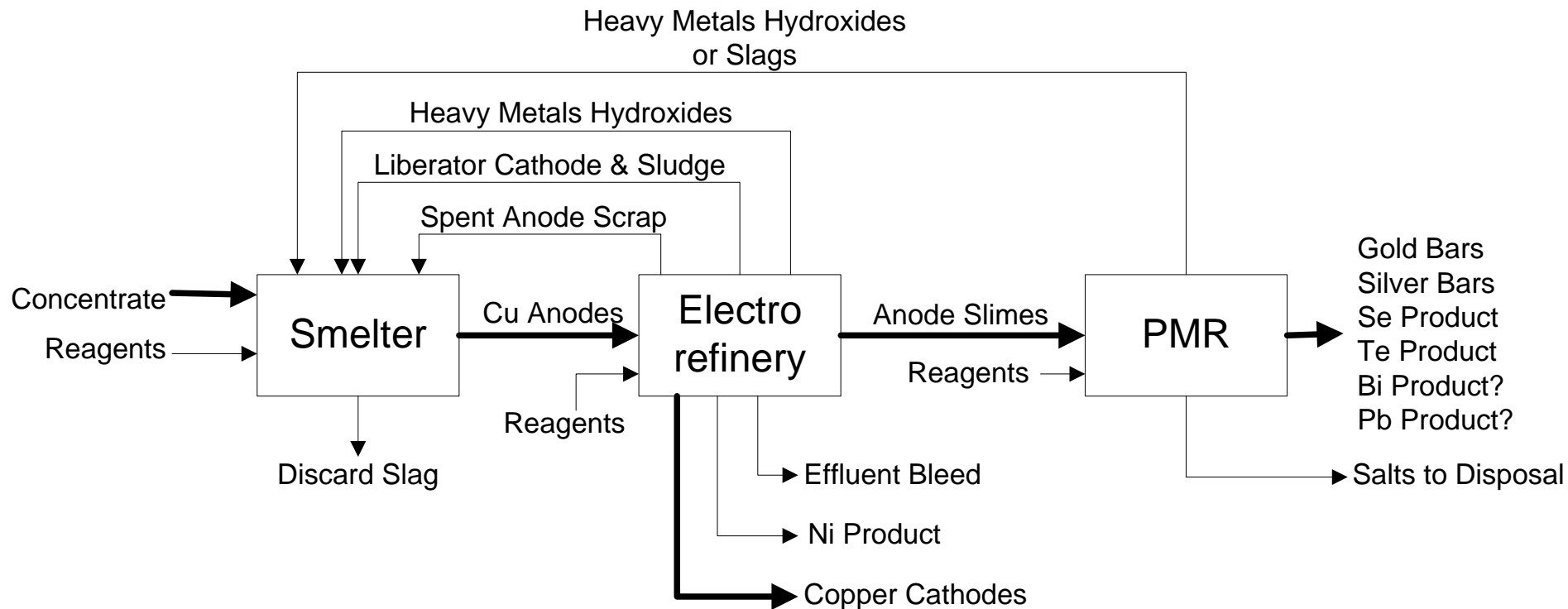
# Safety

- HAZAN for a Copper Electrorefinery Identifies a Long List of Hazards:
  - Electrocution, Falling Objects, High Temperatures & Pressures, Pinch Points, Dangerous Solutions and Gases, Moving Equipment, Mobile Equipment, etc.
- Even though these are all well known from over 100 years of copper electrorefining, this is an important stage in engineering design to make all stakeholders aware of hazards and many of the reasons for design decisions

# Introduction

- Electrorefineries need to adapt to more complex, higher impurity feeds
- Impurity deportment is extremely complex in an integrated smelter-electrorefinery-precious metals refinery
- As, Bi, Ni, Pb, Sb, Se, Te
- Some impurities have value but can cause operational problems as well as increase the costs of refining
- Refiners main concerns are to maintain health & safety maintain environmental compliance, maintain metal recovery & production and maintain product quality
- Case study of nickel follows

# Introduction



# Case Study Definition

- Integrated Smelter-ER-PMR producing 225 kt/a copper with 200 ppm Ni, 300 ppm Ag, 25 ppm Au in anode
- Electrorefinery bleeds to a conventional liberator circuit followed by an existing wastewater treatment plant (no nickel recovery)
- Decopperization is existing and is a traditional moderate temperature leach circuit
- PMR could be hydrometallurgical or pyrometallurgical
- Feed change is proposed that increases nickel in feed by 2x or 10x (to 400 ppm in anode or to 2,000 ppm)
- What are the cost implications?

# Case Study: Base Case

## (200 ppm Ni in Anode)

- 45 tpa Ni in concentrate (value assumed to be \$5/lb) = value approx. \$500,000 /a
- 7-8 gpl Ni in electrolyte
- Order of Magnitude Capital Cost of adding Ni recovery through either NiSO<sub>4</sub> (evaporation) or Acid Purification Unit (APU)-basic nickel carbonate (BNC) in the electrorefinery approximately \$4-6M dollars
- Order of Magnitude Operating Cost approximately \$0.8/a excluding credits (credits would be for reducing acid and lime consumption – could be half of the operating cost)
- Poor economic return

# Case Study: Alternate Case 1

## (400 ppm Ni in Anode)

- 90 tpa Ni in concentrate (value assumed to be \$5/lb) = value approx. \$1,00,000 /a
- 15 gpl Ni in electrolyte
- Order of Magnitude Capital Cost of adding Ni recovery through either NiSO<sub>4</sub> (evaporation) or Acid Purification Unit (APU)-basic nickel carbonate (BNC) in the electrorefinery approximately \$6-8M dollars
- Order of Magnitude Operating Cost approximately \$1.0M/a excluding credits (credits would be for reducing acid and lime consumption – could be half of the operating cost depending on acid value)
- Poor economic return



# Case Study: Alternate Case 2

## (2,000 ppm Ni in Anode)

- 450 tpa Ni in concentrate (value assumed to be \$5/lb)  
= value approx. \$5,000,000 /a
- >60 gpl Ni in electrolyte
- Additional bleed (liberator capacity, possibly copper crystallization) required
- Order of Magnitude Capital Cost of adding Ni recovery, including doubling liberation, approximately \$15-20M dollars
- Order of Magnitude Operating Cost approximately \$2-\$2.5 M/a excluding credits
- Still poor economic return...BUT!

# Case Study: Alternate Case 2

## (2,000 ppm Ni in Anode)

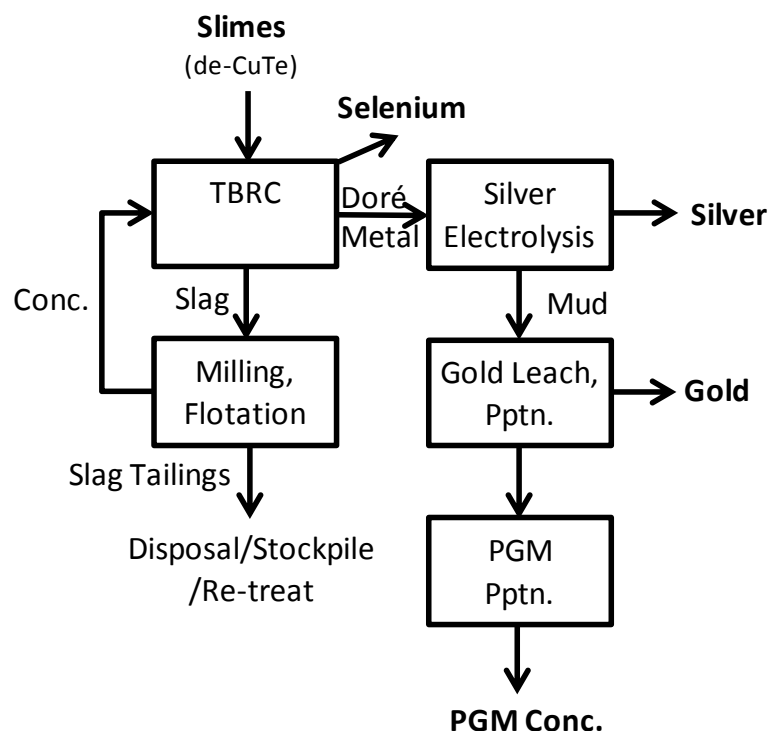
- Not all of the nickel dissolves from the anode
- Portion of nickel that ends up in anode slimes could be as high as 10-25% giving 3-5% nickel in the anode slime
- With a traditional, moderate temperature autoclave this nickel may not leach in decopperization representing a nickel loss of up to 25% of nickel revenue, lowering the economic return on nickel recovery
- Also, that nickel will increase costs in downstream precious metals refinery (PMR)

# Conventional (Pyrometallurgical) or Hydrometallurgical PMR

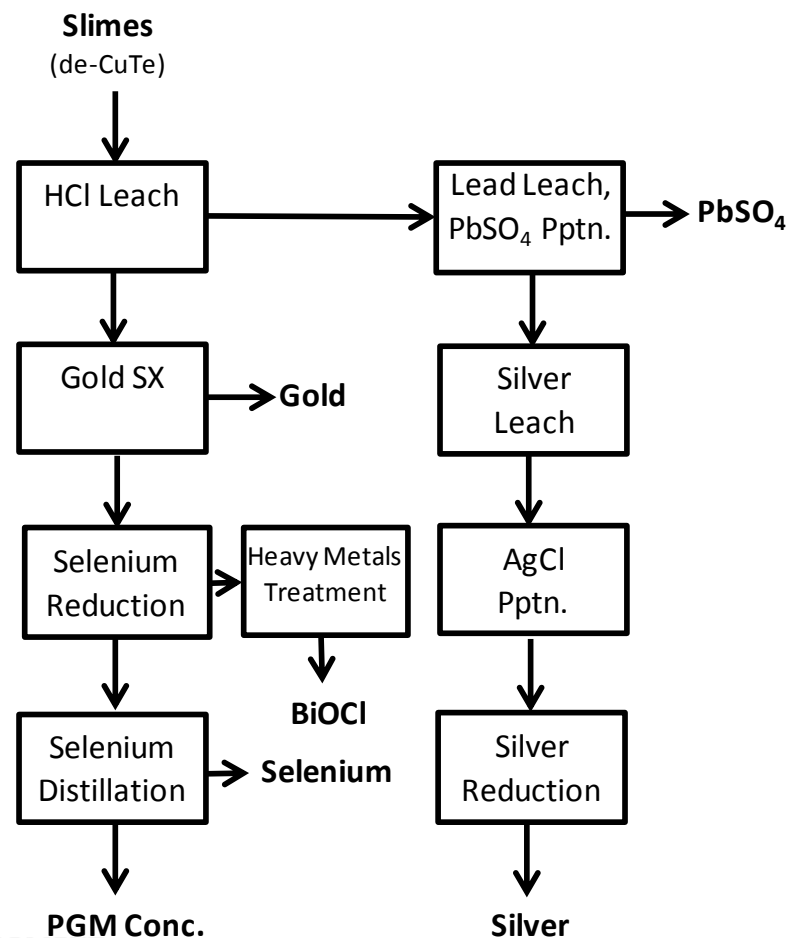
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## Conventional



## Hydrometallurgical



# Conventional (Pyrometallurgical) or Hydrometallurgical PMR

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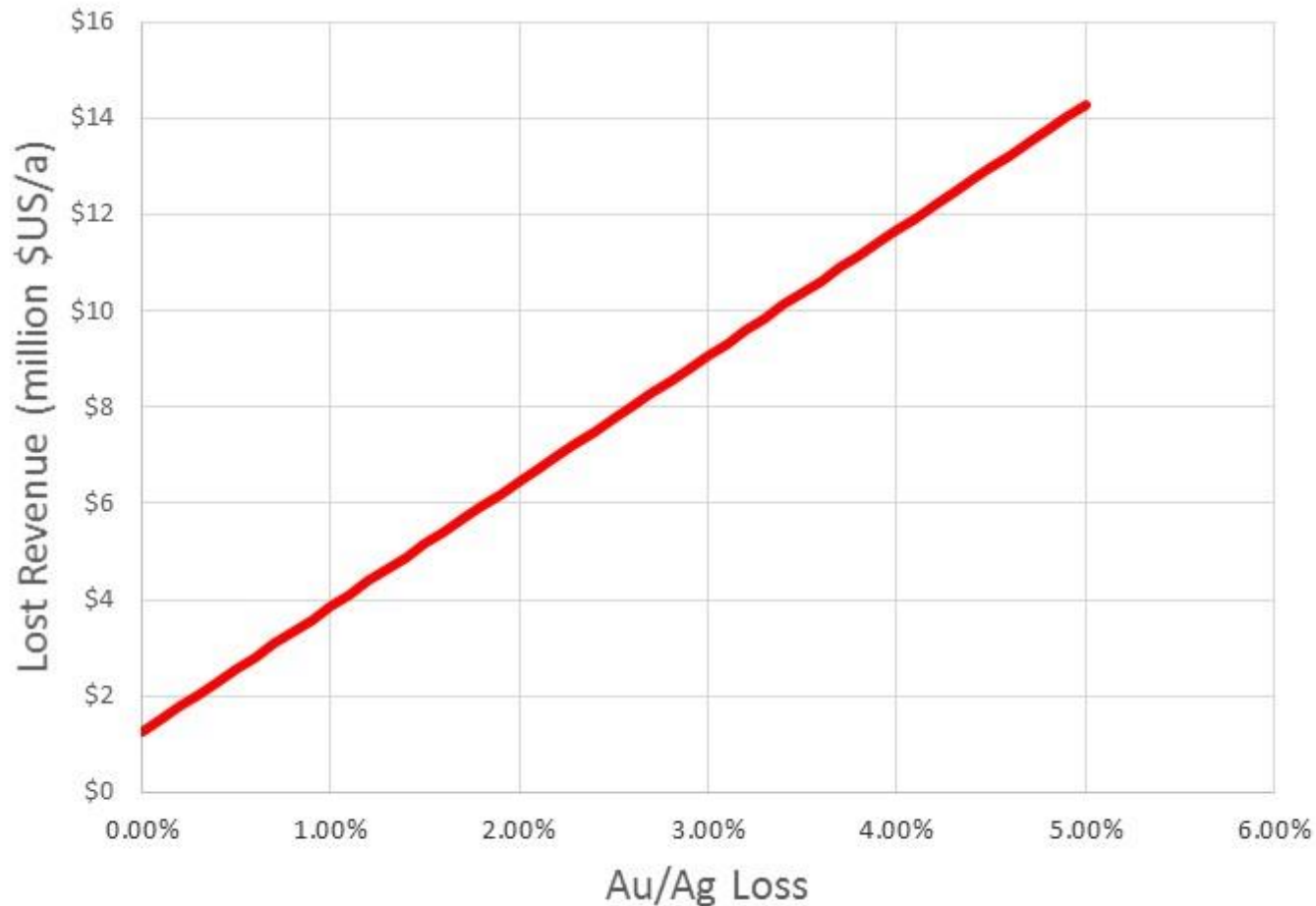
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- In a conventional PMR, nickel in slimes causes slag to become viscous in the top blown rotary converter (TBRC), making it difficult to separate and leading to PM losses to slag.
- Some of the PM can be recovered by flotation – recycle to TBRC, some by returning slag to copper smelter.
- Latter option increases PM and impurity recirculating loads in facility which are a significant cost. Also, eliminates bleed of impurities from the entire smelter-ER-PMR complex. Antimony and bismuth especially significant.
- For this example, a 1% loss of gold and silver would be approximately \$4.0M/a (incl. nickel loss)
- In a hydrometallurgical PMR, nickel would leach in HCl and then precipitate with heavy metals or wastewater, depending on configuration. Recycling these high-impurity precipitates would recover the nickel but, similar to the conventional PMR, would reduce impurity bleed (esp. arsenic & antimony).

# Case Study: Alternate Case 2 (2,000 ppm Ni in Anode)

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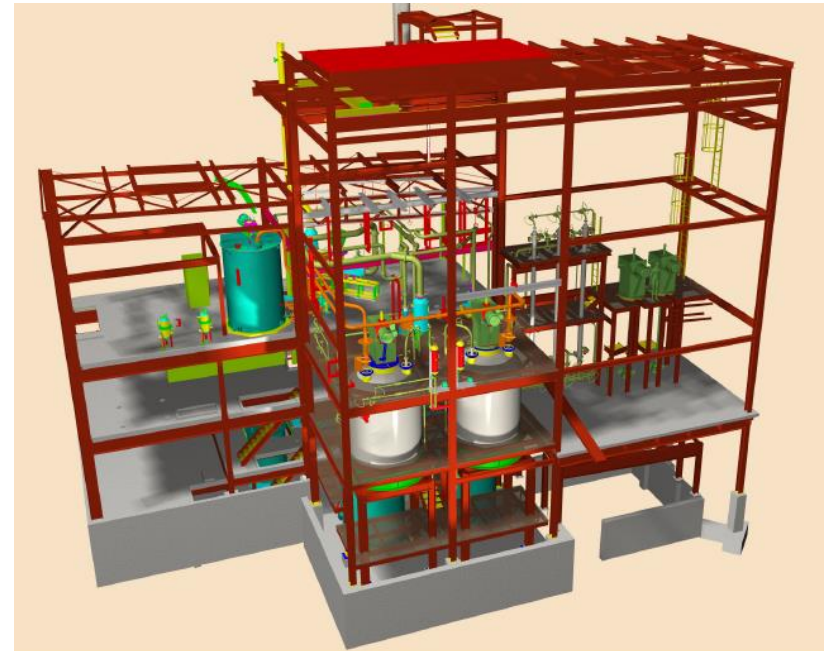
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# Case Study: Alternate Case 2

## (2,000 ppm Ni in Anode)

- Upgrading the decopperization leach circuit from base case to autoclave leaching at 150°C might cost \$30M above nickel circuit costs
- Operating cost will increase due to higher labour and maintenance costs for autoclave circuit
- As high as +\$1M/a above non-autoclave circuits



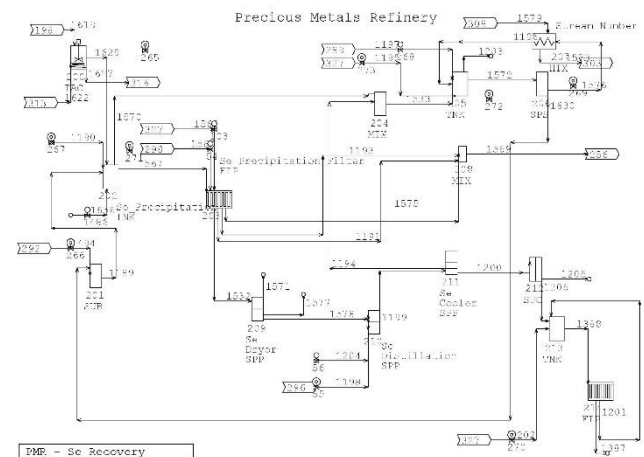
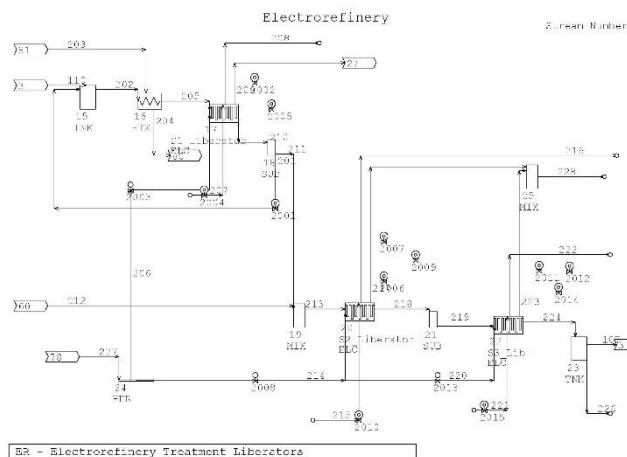
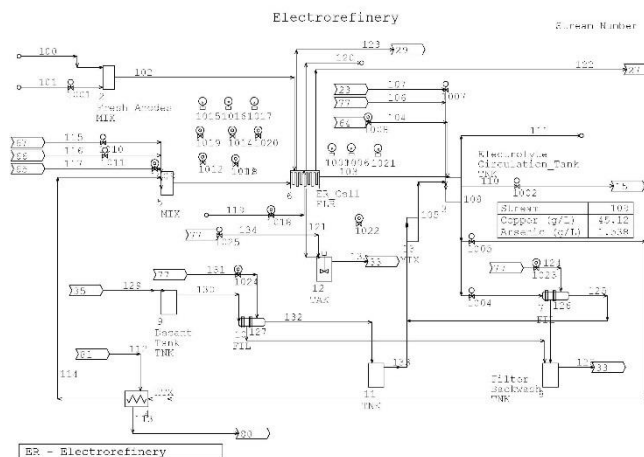
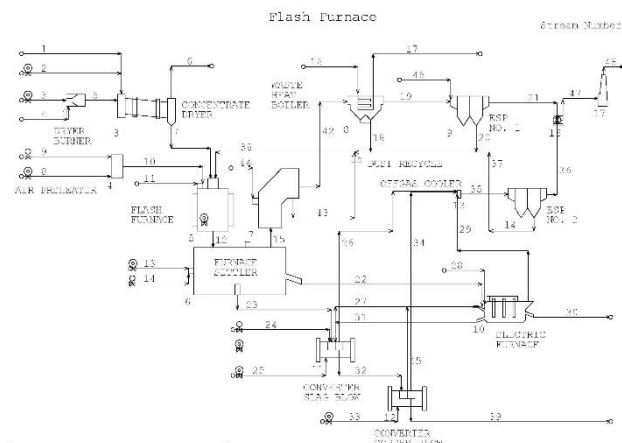
# Discussion of Cases

- Economics of Alternate Case depend more on PM losses rather than nickel.
- Other factors that will determine whether upgrading the decopperization leach circuit to process high nickel feeds through PMR is economical:
  - Availability of “clean” smelter feed (may mean difference between producing 175,000 tpa Cu vs 225,000 tpa Cu)
  - Deportment of impurities through entire smelter-ER-PMR complex when recycles required. Need bleeds.
  - Amount of PMs in inventory. Pyro PMR higher than Hydro PMR.
  - Greenfield vs brownfield: Greenfield will have best payback.
  - Other cost benefits related to water balance, current efficiency, acid/sulphate balance

# Discussion of Cases

- Further thoughts:
  - Cases where anodes are purchased and/or decopperized slimes are sold will depend on refining terms and customer specifications
  - Modelling of integrated smelter-ER-PMR complex a very useful tool for determining elemental deportments and identifying potential impurity problems
  - If not fully identified, costs can increase in unexpected ways due to requirement to add on impurity removal circuits
  - Sometimes better to avoid impurity recycles or break them (e.g. by selective leaching of smelter dusts, impounding or selling value by-products, etc.) then trying to target removing them from slimes or electrolyte





# Summary

- The question of whether to treat high nickel anode slimes produced from high nickel feed is a complex one
- Highly dependent on feed availability, value of precious metals, impurity deportments, configuration of smelter-ER-PMR complex
- Costs are very site or operation-specific so analysis must be done on a case-by-case basis

# Questions?

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