

# Development of alkaline glycine processing technology & its evaluation within the circular hydrometallurgy context



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# The Circular Economy and Critical Minerals

- The dominant use of Critical Minerals in the Energy Transition requires that the minerals, and their associated metals and materials are extracted, converted and refined in sustainable ways to ensure that we don't pollute the earth under the banner of achieving clean energy.
- Sustainability in processing requires a circular approach to everything we do.
- Historically our metallurgical technological approaches have been linear value chains:
  - We used the cheapest extractants (sulfuric acid, cyanide, lime) irrespective of the carbon footprint of their production, or that their production were associated with fossil fuels (sulfur from oil refineries,  $\text{NH}_3$  from Haber-Bosch process).
  - The back end of the process often led to large waste/tailings heaps and toxic residues from leaching, still bearing some associated reactants e.g., red mud from bauxite, gold ore leach residues, etc., and neutralization products e.g. jarosite, gypsum and  $\text{Na}_2\text{SO}_4$ .
  - Water was seldom recovered, recycled and reused with loss of excess reactants.
  - Energy integration (in metallurgical processes) have been minimal
  - Toxicity and environmental impacts were often related to lower priority than economic benefit.

Natural Flake Graphite



Spodumene (Li)



HPA (Alumina)



Pentlandite (Ni)



Platinum

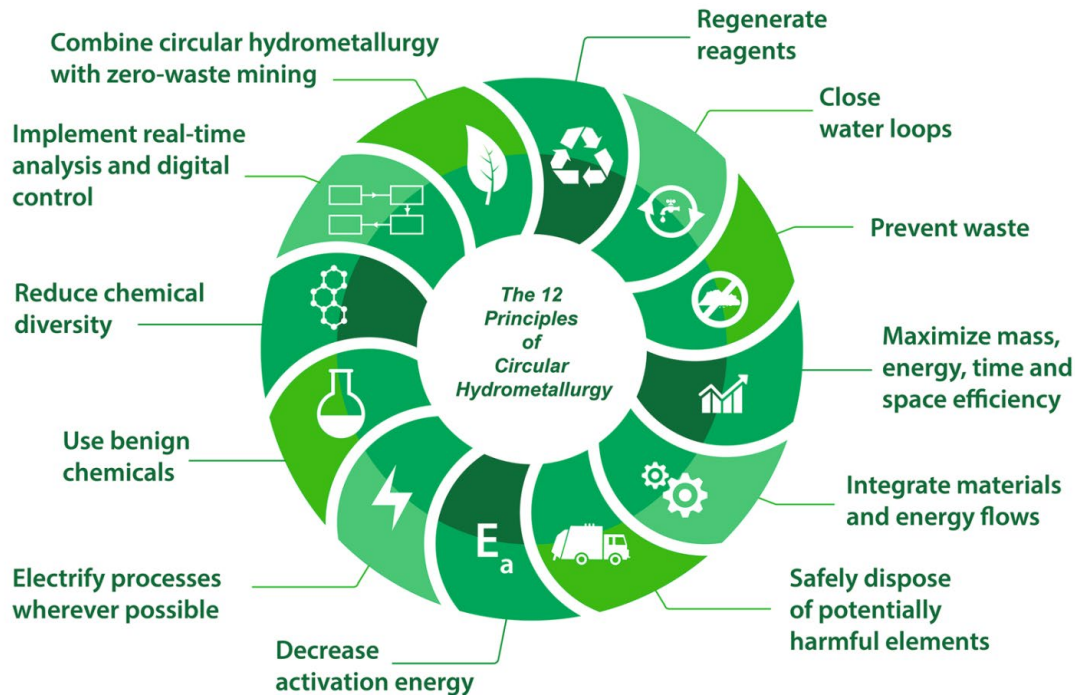


# The need for a new chemical-metallurgical approach

- Water scarcity (and water of the appropriate quality) has raised the value of water and has incentivized recovery of water (and water-soluble reagents). Conversely water rich areas cannot afford the pollution of their waterways.
- The reducing cost trend of renewable energy (with energy storage) has shifted the costs manufacturing bulk reagents (such as  $H_2$ ,  $O_2$ ,  $NaOH$ ,  $Cl_2$  and  $HCl$ , green ammonia) and has made them worthwhile to consider as alternative reagents.
- Conventional fossil fuels will not disappear, but there is a big driver to rather convert them into value-added products of higher complexity than burning them to  $CO_2$ . This includes the manufacture of benign organic reagents for the metallurgical industry.
- The recovery of effluent water implies that more expensive reagents can be considered as they themselves can be recovered (assuming they are stable and can be concentrated from water).
- Many organic acids are crystalline and allows easy reconcentration in cheap materials of construction. On the other hand, most inorganic acids ( $H_2SO_4$ ,  $HCl$ ,  $HNO_3$ ,  $H_2SO_3$ ,  $HF$ , and  $HCN$ ) are difficult to reconcentrate, either because of their extreme affinity for water or due to the formation of high boiling azeotropes, or extreme corrosivity or decomposition ( $HNO_3$ ). Conversely, the volatility of some ( $HCN$ ,  $HF$  decomposition of  $H_2SO_3$ ) creates challenges.



# The 12 Principles of Circular Hydrometallurgy: Process development towards circularity



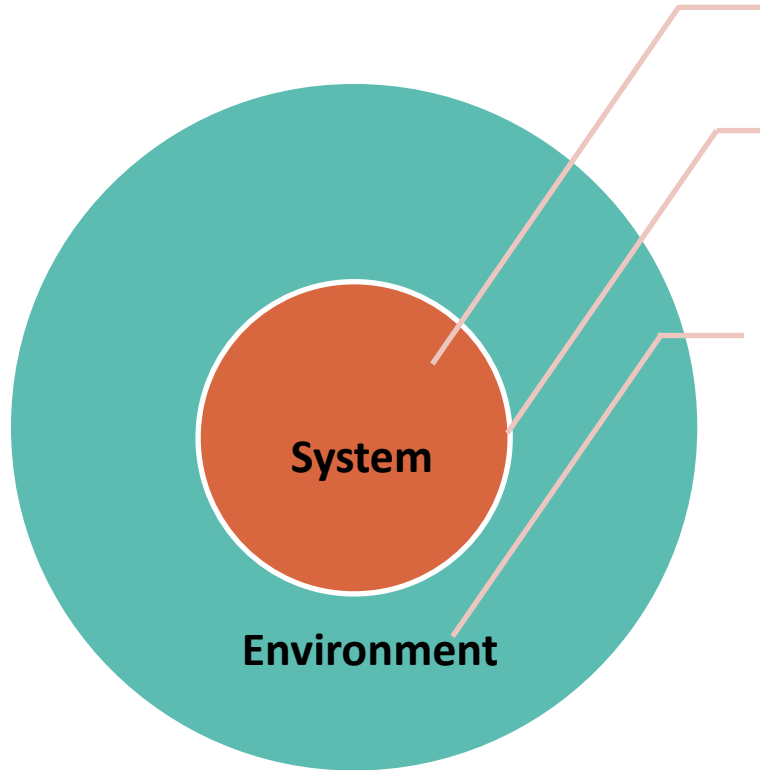
From: Binnemans, K., and Jones, P.T., 2022. The Twelve Principles of Circular Hydrometallurgy. Journal of Sustainable Metallurgy, p. 1-25 <https://doi.org/10.1007/s40831-022-00636-3>,

# The constraints created by the resources to be processed

- Our choice of reagents and processing options are typically highly constrained by the nature of the solid material we need to treat:
  - Rapidly deteriorating grade of metals of interest
  - Polymetallic nature of resources (complexity of separation without losses)
  - Difficulty in physical upgrading of oxide/silicate ores
  - Finely disseminated mineralization and emulsion mineral textures
  - Large amounts of acid-consuming gangue
  - Large amount of acid-leachable Mg & Fe & large uptake in leachates
  - Oxygen demand linked to reactive (but non-valuable) sulfides
  - Stability and leachate retention of the leach residues
  - The electrochemical, semiconductor and passivation characteristics of minerals
  - The sheer quantity of material to be treated (e.g. gold ore vs e-waste, iron ore vs. Rare-earth-ore)
- The attributes of the solid material to be leached often is the biggest constraint in our freedom to select reagents, and is often associated with the biggest cost, safety and environmental impacts.



# The Controlled System & its Uncontrolled Environment



## **The System:**

The process chemistry & development that we can influence through design, manufacture and control. Principles of Circular Hydrometallurgy essential

## **The Interface:**

Qualify & quantify as much as possible

## **The Environment:**

Disturbances we need to manage while minimising the impacts on it. We cannot control our environment, only adjust & adapt to it. Examples include:

Ore/raw materials / feed attributes

Water quality and quantity

Energy attributes (Renewable? / reliability? / Affordability? / CO2 Footprint)

Legal Frameworks

Community

Surrounding Industry

Customer Specifications

Waste / effluent /emissions constraints



# The challenges of polymetallic ores: Au-Cu example

- Many of the world's precious metal (Au, Ag, PGMs) ores are polymetallic. Thus, they co-occur with base metals such as Cu, Fe, Zn, Pb and Ni/Co in their oxide, silicate, sulfide or arsenide forms.
- A prime example is gold ores with nuisance copper (where Au grades may be 1 ppm and Cu grade at 0.1%). On its own the Cu grade often doesn't justify economic recovery.
- However, copper is a major consumer of cyanide reagent during gold leaching (and there is often >1000x more Cu than gold, but it's worth only 0.00011 of the value of gold).
- Also, Cu forms higher order complexes of cyanide than Au; Compare:  $[\text{Cu}(\text{CN})_4]^{3-}$  to  $[\text{Au}(\text{CN})_2]^-$ .
- While the Au-CN complex is very stable, the  $[\text{Cu}(\text{CN})_4]^{3-}$  complex releases cyanide with changing pH, making it dangerous (so called "weak-acid-dissociable cyanide" or WAD cyanide).
- $\text{CN}^-$  recovery and detoxification of the  $[\text{Cu}(\text{CN})_4]^{3-}$  is expensive and a "linear" (end-of-pipe) approach
- Cyanide costs are high and pH excursions may lead to dangerous and volatile HCN to form.
- To extract Cu before Au, often involves expensive and inefficient pretreatment with  $\text{H}_2\text{SO}_4$  and pH swings as the process progresses from base metal extraction to precious metal extraction.
- Many ores are located in dry/arid areas where water management and recovery is essential.



# In the Cu-Au example, cyanide-based processes fail the test of the 12 principles of circular hydrometallurgy

1. Regenerate reagents
2. Close water loops
3. Prevent waste
4. Maximize mass, energy, space, and time efficiency
5. Integrate materials and energy flows
6. Safely dispose of potentially harmful elements
7. Decrease activation energy
8. Electrify processes wherever possible
9. Use benign chemicals
10. Reduce chemical diversity
11. Implement real-time analysis and digital process control
12. Combine circular hydrometallurgy with zero-waste mining

1. Reagents consumed with poor or no recovery
2. Water is mostly not recovered
3. Significant cyanide bearing waste
4. Detoxification, pretreatment leads to plant complexity, excess reagent consumption
5. No integration
6. Problematic
7. No catalytic action by Cu, rather it can decrease overall Au recovery to CIP.
8. Little opportunity for electrification
9. Chemicals are highly toxic and used in large amounts
10. Diverse range of chemical by-products (Cu-CN complexes)
11. Measurement of free CN and complexes difficult
12. CN-Tailings hard to reintegrate back into mining





# Developing a new process achieving circularity for Cu-Au ores

1. During 2012-2013 J.J. Eksteen and E.A. Oraby investigated a process to extract, recover and refine precious metals and base metals that either eliminated or minimised the use of cyanide for precious metals and sulfuric acid for base metals.
2. Under optimised alkaline conditions precious metals such as Au, Ag and Pd could be leached in the absence of cyanide, or under cyanide starved conditions using amino acids.
3. While several amino acids were evaluated, it was found that the simplest one, glycine ( $\text{NH}_2\text{CH}_2\text{COOH}$ ), was the most suitable given kinetics, reagent cost and reagent consumption.
4. Under alkaline conditions, base metals could be leached from the sulfide minerals (with an oxidant) and oxide minerals. By raising the temperature and redox potential, Au, Ag and Pd could be leached in alkaline glycine in the absence of cyanide, or at room temperature in the presence of only a fraction of the cyanide used conventionally.
5. It didn't form higher order complexes with copper, as for cyanide.
6. The presence of copper glycinate catalysed the leaching of gold.
7. Silver could be leached as well.
8. The pH and leach conditions were similar to current industrial leaching.
9. The Au and Ag glycinates adsorbed well onto activated carbon, making CIP and CIL technology possible.
10. Cyanide detoxification could be minimised or eliminated.
11. pH changes between base metals and precious metal leaching could be averted.
12. Copper can be recovered by sulfide precipitation, IX and SX.
13. Reagent is easily recoverable and recyclable and follows recycled tailing water.
14. Direct electrowinning of copper possible from glycinate solutions.



# Glycine Chemistry versus Cyanide Chemistry

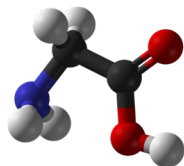
| Gold-copper-glycinate speciation | Gold-copper-cyanide speciation  |
|----------------------------------|---|
| $\text{Au}(\text{Gly})_2^-$      | $\text{Au}(\text{CN})_2^-$  |
| $\text{Cu}(\text{Gly})_2$        | $\text{Cu}(\text{CN})_2^-$ , $\text{Cu}(\text{CN})_3^{2-}$ , $\text{Cu}(\text{CN})_4^{3-}$  |
| Other:                           | Other   |
| $\text{GlyH}$ , $\text{Gly}^-$   | $\text{CuCN}$ (s), $\text{HCN}$ (aq), $\text{CNO}^-$ , $\text{CNS}^-$ , $\text{HCN}$ (g), $\text{CN}^-$ , $[\text{Fe}(\text{CN})_6]^{4-}$ . |
| # Species: 4                     | # Species: 11   |

Gly = Glycinate anion, i.e.  $\text{NH}_2\text{CH}_2\text{COO}^-$

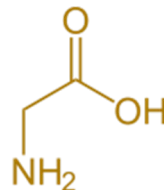
GlyH = Glycine, i.e.  $\text{NH}_2\text{CH}_2\text{COOH}$

# Why Glycine at Alkaline pH?

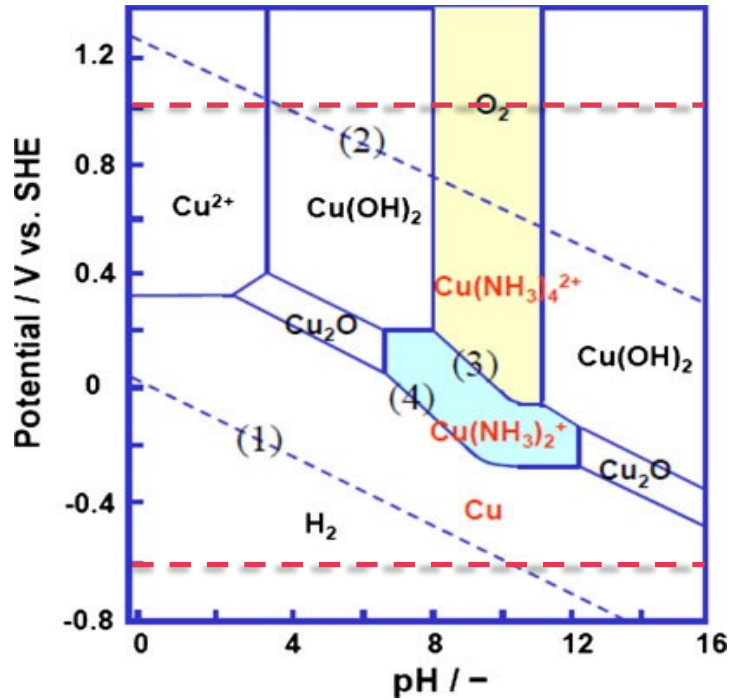
|  |   |   |
|--|---|---|
| Non-toxic (edible)                               | Crystalline, Non-volatile, High melting point (with decomposition): 233°C                     | Reagent Cost ~USD \$1.5 – \$1.7 /kg   |
| Non-flammable                                    | Non-oxidising/non-reducing  | Highly water soluble (250g/L)   |
| Stable over wide temperature, pH and Eh range    | Can be synergistic with cyanide, thiourea and ammonia: accelerated Au, Cu, Ni, Pd leach rates | High adsorption of Au, Ag onto activated carbon.<br>Ease of AARL-type elution |
| No interaction with acid consuming gangue        | Application to various leaching modes (ISL, Heap, vat, tank)                                  | Cheap materials of construction (mild steel)                                  |
| Selective over non-sulfide gangue minerals       | No transport, logistics, or trade restrictions  | Ease of base metals removal / recovery  |
| Operated under dilute and concentrated modes     | Easy reagent recovery, recycle and reuse  | High affinity for Au, Ag, Cu, Zn, Pb, Pd, Cd, Ni, Co                          |
| pK <sub>a</sub> : 2.35; and 9.78                 | Cu- glycinate good oxidant  | No pH swings, Simple chemistry  |
| Insignificant Fe, Mn, Cr, Mg, Al, Si dissolution | No elemental sulfur, no silica gels, no jarosites   | Pyrite not dissolved (unless mechano-chemically activated).                   |



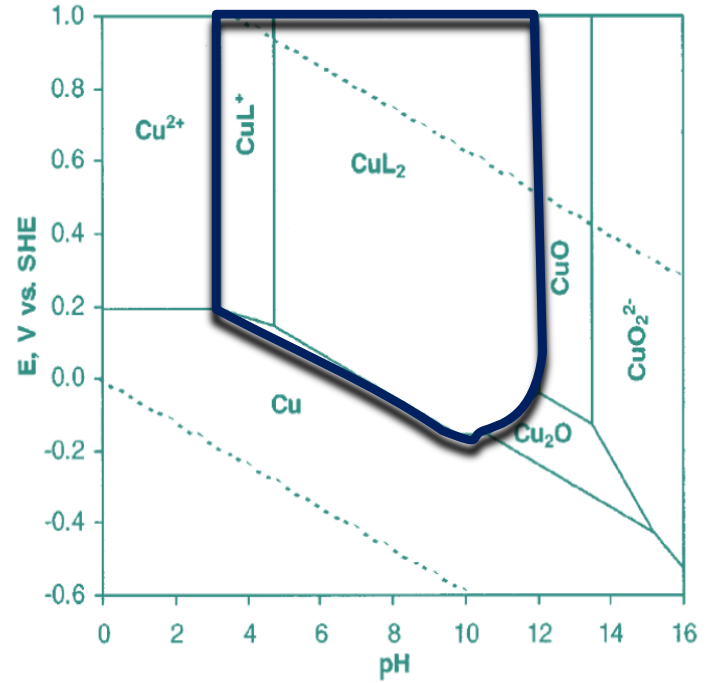
Black: Carbon  
White-grey:  
Hydrogen  
Blue: Nitrogen  
Red: Oxygen



# Cu-NH<sub>3</sub> vs Cu-Glycine



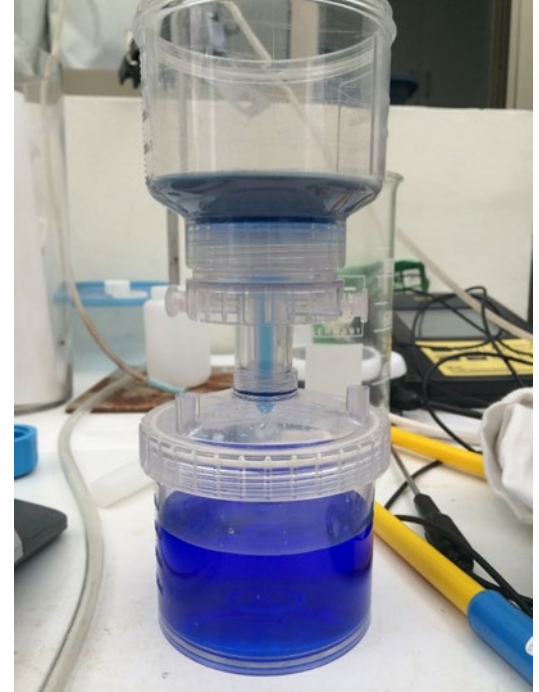
Cu-NH<sub>3</sub>



Cu- Glycine

Extending the stability zone for both pH and Eh

# A pilot plant example (heap leach of highly carbonaceous oxide ores with alkaline glycine using sea water in Atacama desert)





# Leaching of copper ores and concentrates



# Glycine Leaching of Metals and their Sulfide Minerals

The glycine leaching of chalcophile metals and their sulfide minerals and precious metals entails multiple chemical levers:

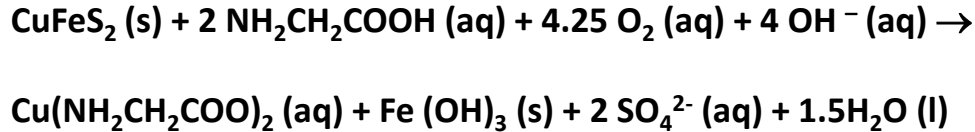
- Reduction-oxidation (of oxygen to water and metals to their divalent ions and sulfide sulfur to sulfates).
  - Raising the Dissolved Oxygen (DO), using  $\text{H}_2\text{O}_2$  or strong oxidants such as  $\text{KMnO}_4$
- Acid-base interactions.
  - Reactions typically in alkaline domain (pH 8-12)
  - Hydroxyl anions converted to water in combination with redox reaction
  - Form of speciation of glycine is pH dependent
- Complexation
  - Formation of glycinate complexes that can either be neutral (e.g. for copper) or anionic (e.g. gold, silver, nickel, cobalt).
  - Complex is moderately strong, but weak enough that cationic IX/SX can strip the metal cation from the complex, thereby releasing free glycine / glycinate
  - Formation of stereoisomers (*Cis*- and *Trans*- isomers) which have different solubilities (influence crystallisation) and hydrates.
- Temperature





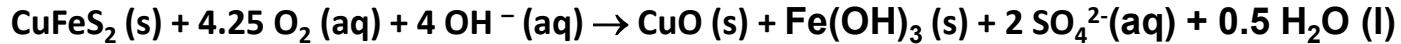
# Chalcopyrite Leaching in a Glycine Environment

## Direct Leach (without alkaline peroxidation):

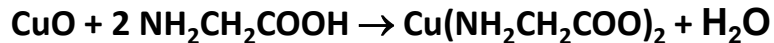


## Leaching following atmospheric alkaline preoxidation (2 step process)

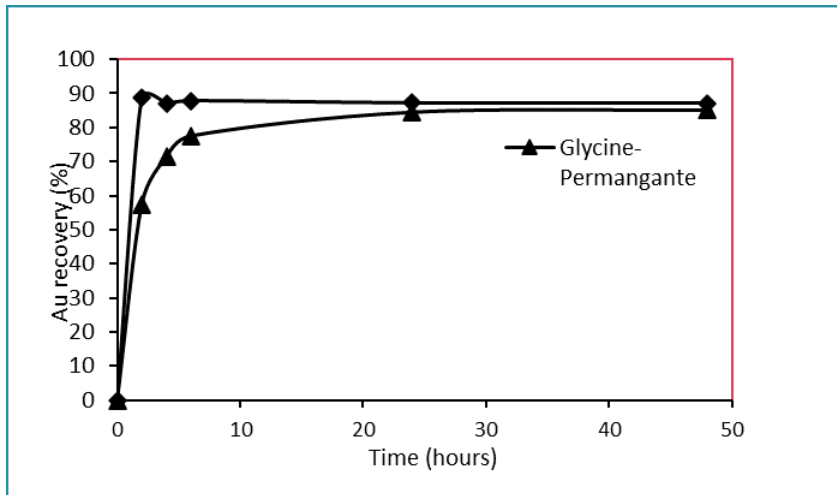
### Alkaline Preoxidation



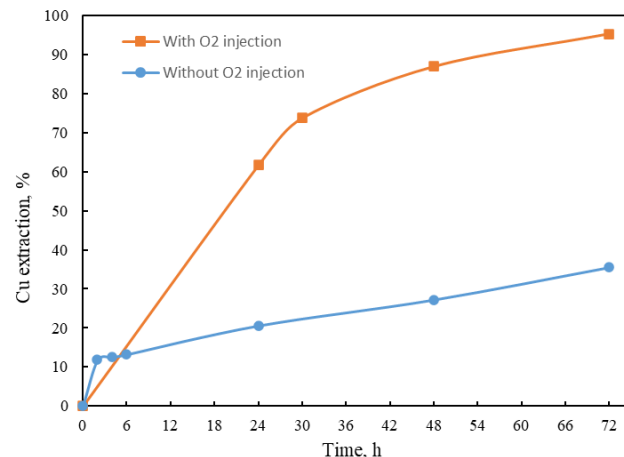
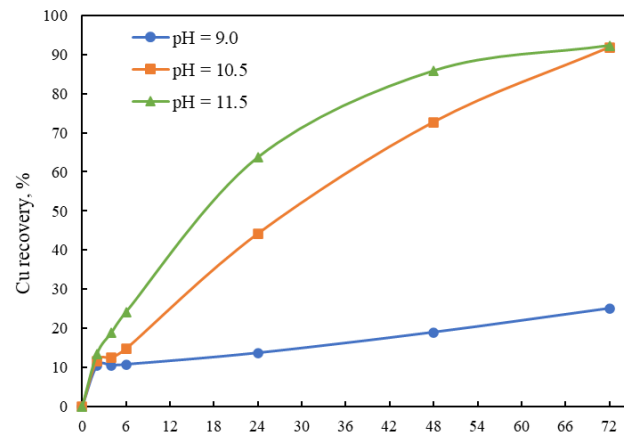
### Glycine Leaching



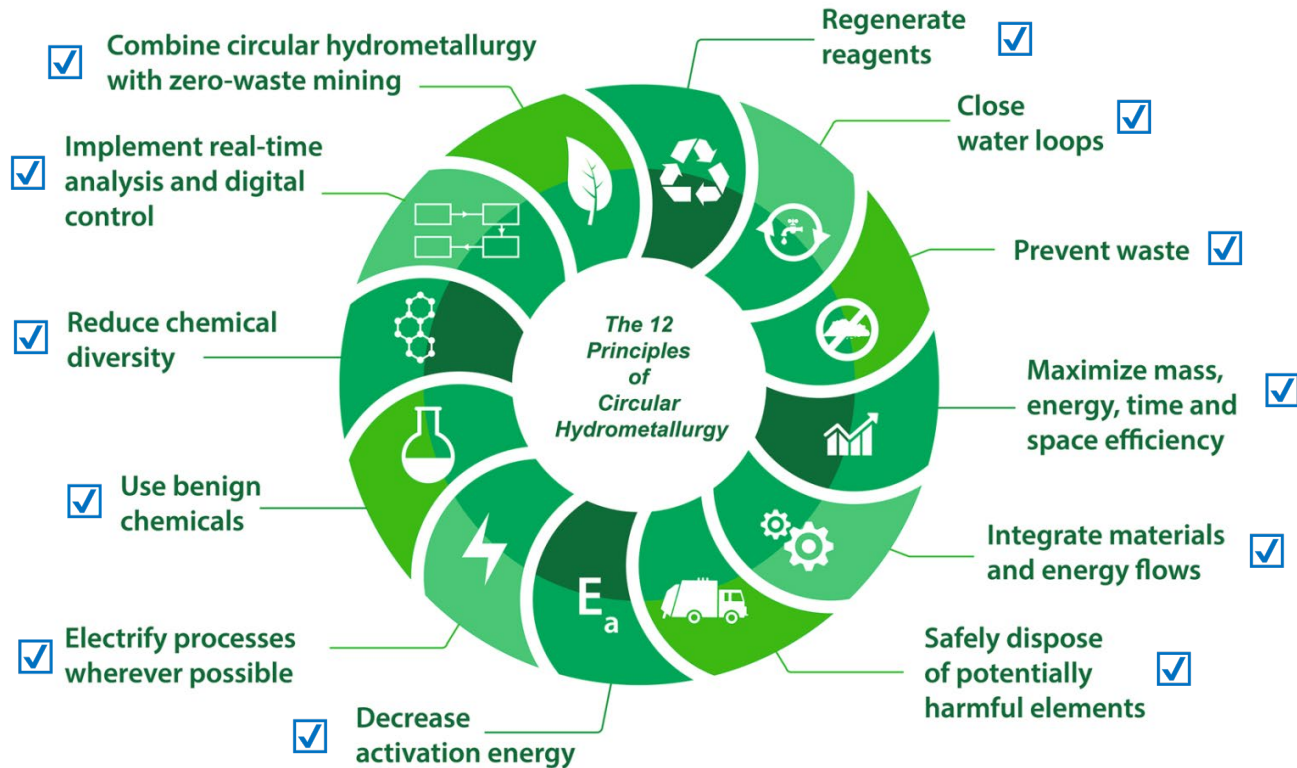
# Copper and gold leaching in cyanide-free alkaline conditions



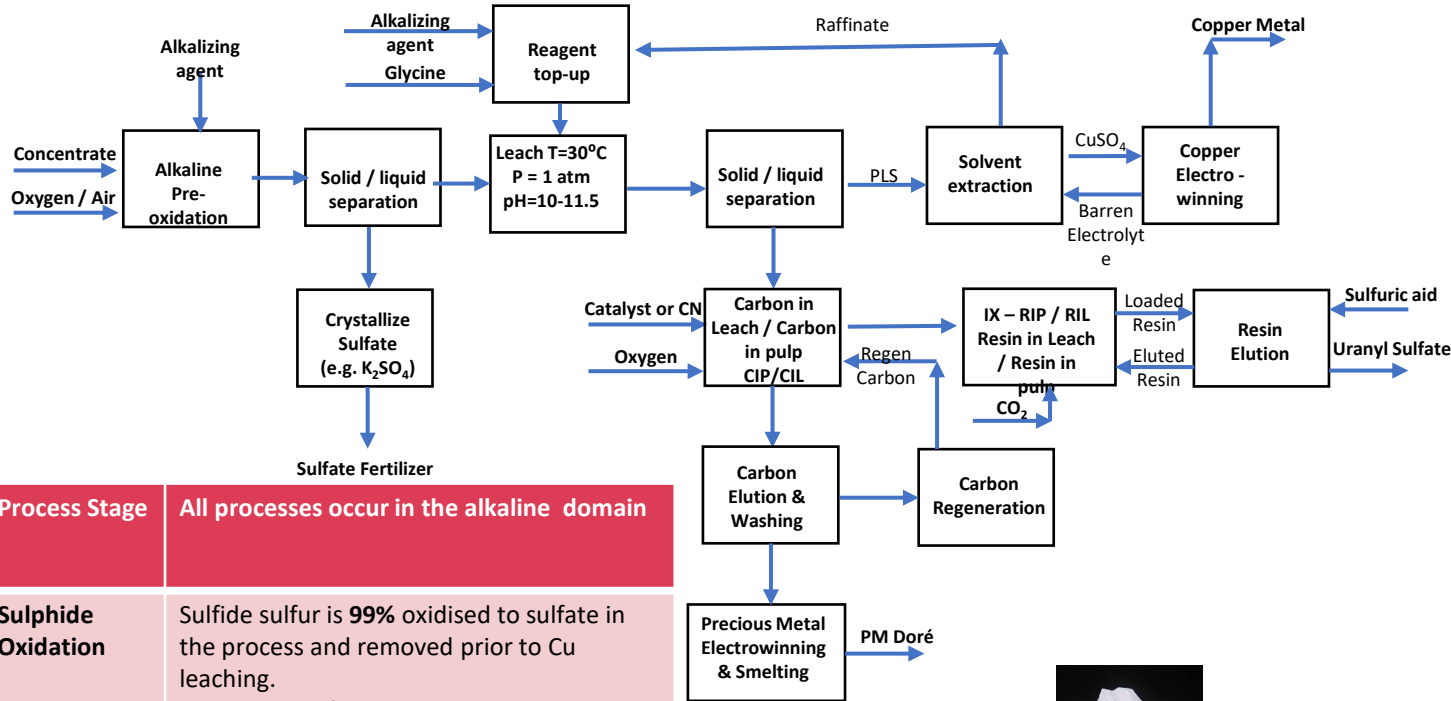
Gold extraction by cyanidation and glycine-permanganate from gold oxide ore at leach conditions of 2 g/L glycine, 30% solids content, 100% -75  $\mu\text{m}$ , pH 10.5, 2.0 g/L permanganate at room temperature



# Novel glycine systems satisfying the 12 Principles of Circular Hydrometallurgy



# Glycine leach to extract value from polymetallic (Au-Cu-U) concentrates



Alkaline Pre-oxidation (**99% S conversion**)  
Conditions: 75 °C, 2:1 K:S molar ratio, KOH, 16-24h



Copper leaching (**95% Cu extraction**)  
Conditions: glycine-Cu 4:1 molar ratio 30 °C, pH 10.5-11, 24-30 hours (**GlyLeach™**)



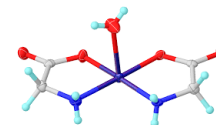
Gold leaching: Gold will be extracted by alkaline glycine in the presence of small amount of cyanide (**GlyCat™** Process)



Potassium Sulfate

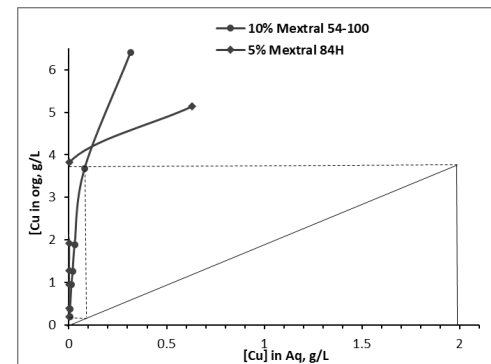
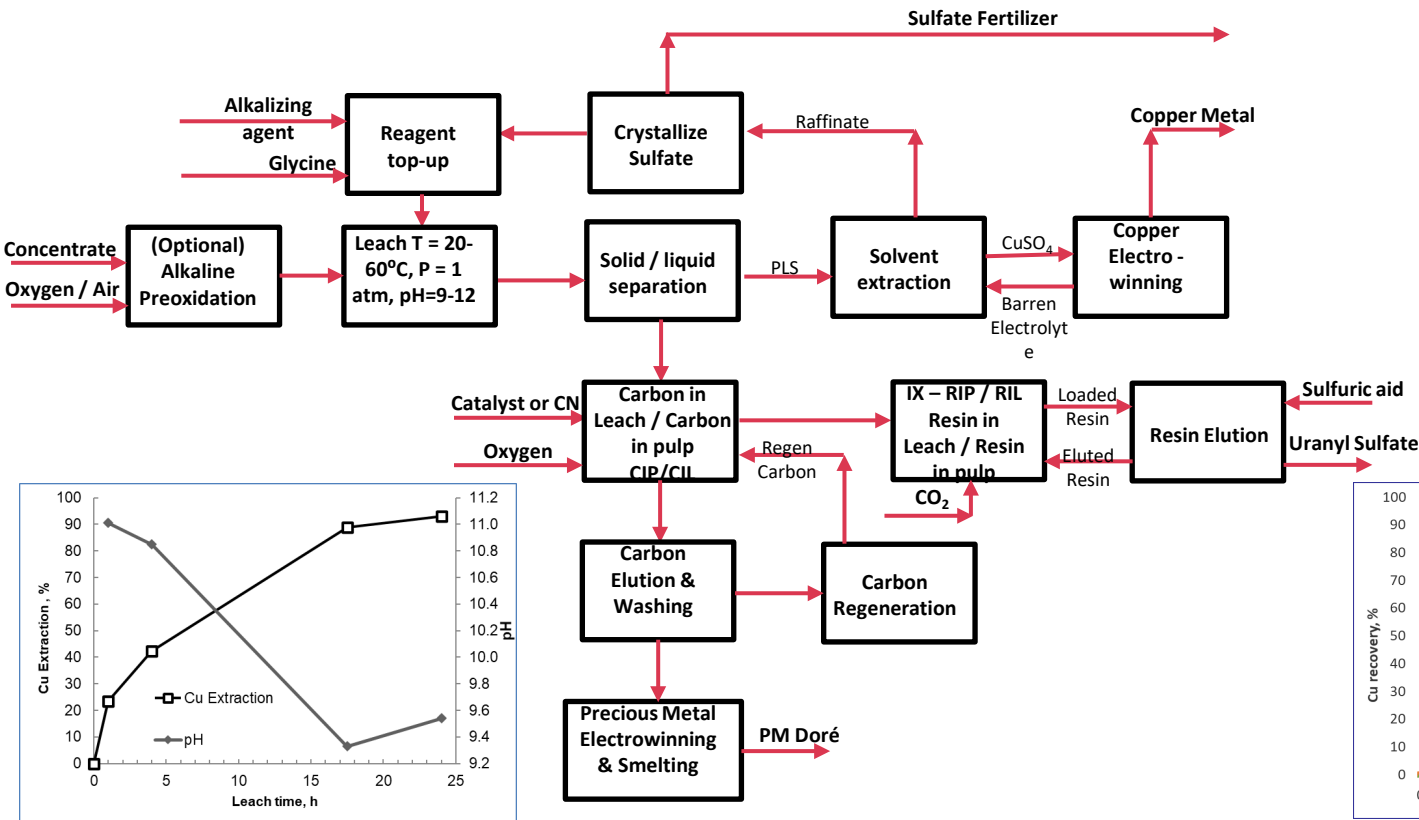


Copper Glycinate

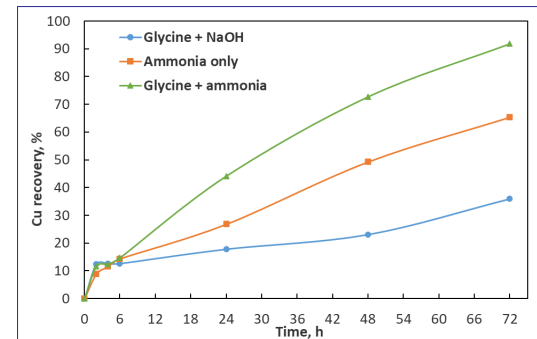


| Process Stage                       | All processes occur in the alkaline domain  |
|-------------------------------------|---|
| <b>Sulphide Oxidation</b>           | Sulfide sulfur is <b>99%</b> oxidised to sulfate in the process and removed prior to Cu leaching. Potassium sulfate can be produced as fertilizer |
| <b>Copper leaching and recovery</b> | Copper is extracted at <b>95%</b> by alkaline glycine (GlyLeach™) and it can be recovered by conventional SX-EW process.                          |
| <b>Gold leaching and recovery</b>   | Gold is extract by GlyGat™ Process and gold is recovered by conventional activated carbon adsorption.   |

## High level process block flow : Cu-Au-U polymetallic concentrate



**Extraction isotherm of copper with 5% Mextral 84H and 10% Mextral 54-100. Conditions operating A:O 2:1, 20 °C, for 10 minutes**



Cu recovery (batch bottle roll) leaching by: 1) Glycine + NaOH (Gly:Cu = 4:1); 2)  $\text{NH}_4\text{OH}$  only; 3) Glycine +  $\text{NH}_4\text{OH}$  (Gly:Cu = 4:1). T = 23°C, Rolling speed = 100 rpm, pH = 10.5.

Copper extraction and pH changes during leaching chalcopyrite concentrate  
Conditions: UFG (80% –10 µm), after alkaline pre-oxidation, 9% (w/w) solids, 40 g/L glycine, 60 °C 0.75 mL/min O<sub>2</sub>, 500 rpm

| Glycine leach extraction of Ni and Co from ores, tailings and concentrates   |                              |                       |                       |                       |       |                 |                    |                        |                        |
|--|------------------------------|-----------------------|-----------------------|-----------------------|-------|-----------------|--------------------|------------------------|------------------------|
| <div>Leach Conditions:</div> <ul style="list-style-type: none"><li>Room Temperature</li><li>Atmospheric Pressure</li><li>Controlled dissolved oxygen levels / Redox</li><li>Controlled (maintained) pH</li><li>Results reflect outcomes of batch tests</li><li>Resin-in-pulp / resin-in-leach and counter-current transfer can further improve results</li><li>Different alkalizing agents used, depending on nature of material treated</li></ul> | Sample                       | Rougher concentrate 1 | Rougher concentrate 2 | Ore 1                 | Ore2  | Cleaner Tails 1 | Cleaner Tails2     | High Pyrrhotite slimes |                        |
|  | Ni                           | 6.13                  | 6.02                  | 0.78                  | 1.67  | 0.886           | 0.79               | 4.075                  |                        |
|  | Fe                           | 9.12                  | 33.5                  | 5.89                  | 11.4  | 5.24            | 6.43               | 26.50                  |                        |
|  | Ca                           | 0.49                  | 0.33                  | 0.55                  | 1.49  | 0.39            | 0.20               | 2.975                  |                        |
|  | Mg                           | 16.29                 | 4.04                  | 22.9                  | 5.92  | 22.25           | 22.2               | 4.465                  |                        |
|  | S                            | 6.04                  | 27.6                  | 0.83                  | 7.04  | 1.15            | 1.70               | 15.30                  |                        |
|  | Mn                           | 0.08                  | 0.09                  | 0.05                  | 0.11  | 0.06            | 0.06               | 0.120                  |                        |
|  | Co                           | 0.11                  | 0.179                 | 0.014                 | 0.048 | 0.021           | 0.019              | 0.132                  |                        |
|  | Zn                           | 0.03                  | 0.012                 | 0.008                 | 0.011 | 0.001           | .023               | 0.021                  |                        |
|  | As                           | 0.03                  | 0.007                 | 0.007                 | 0.005 | 0.0045          | .007               | BDL                    |                        |
|  | Cu                           | 0.29                  | 0.301                 | 0.13                  | 0.10  | 0.0185          | 0.215              | 2.00                   |                        |
|  | Test ID                      |                       | Rougher Concentrate 1 | Rougher Concentrate 2 | Ore 1 | Ore 2           | Cleaner Tailings 1 | Cleaner Tailings 2     | High pyrrhotite Slimes |
|  | Solid, %                     |                       | 30                    | 10                    | 40    | 30              | 30                 | 30                     | 10                     |
|  | Initial pH                   |                       | 10.2                  | 10.2                  | 10.2  | 10.2            | 10.2               | 10.2                   | 10.2                   |
|  | Gly:Ni mole ratio            |                       | 4:1                   | 4:1                   | 4:1   | 4:1             | 4:1                | 4:1                    | 4:1                    |
|  | Residence time, hours        |                       | 72                    | 72                    | 48    | 72              | 48                 | 48                     | 72                     |
|  | Ni Extraction, % of total Ni |                       | 90.2                  | 81.9                  | 69.1  | 74.8            | 62.5               | 80.1                   | 81.5                   |
|  | Co Extraction, % of total Co |                       | 85.7                  | 16.5                  | 65.3  | 27.5            | 64.5               | 72.6                   | 71.9                   |

# Selectivity of Ni-Co-Cu leaching versus gangue co-leaching

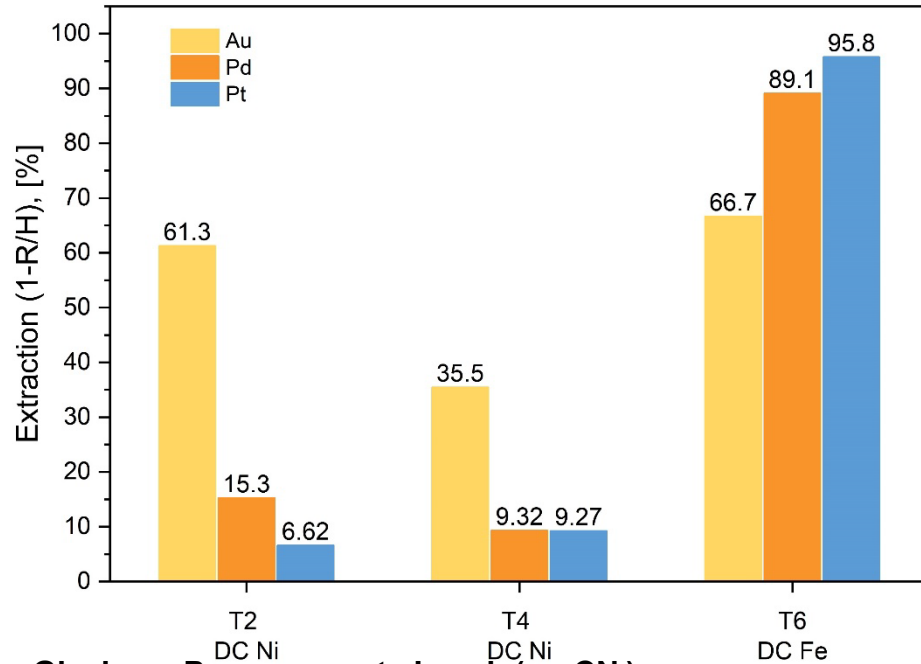
| Test ID                | Element                    | Ni   | Co   | Fe   | Ca   | Mg   | S    | Mn  | Zn   | As   | Cu   |
|------------------------|----------------------------|------|------|------|------|------|------|-----|------|------|------|
| Cleaner Tails 1        | Final solution assay, mg/L | 2070 | 52.8 | BDL  | 118  | 79.8 | 3200 | BDL | 0.8  | BDL  | 48.8 |
| Cleaner Tails 2        | Final solution assay, mg/L | 2805 | 63.8 | 1.5  | 30.5 | 25.3 | 3860 | BDL | 11.0 | BDL  | 118  |
| High pyrrhotite Slimes | Final solution assay, mg/L | 3500 | 100  | 19.6 | 12.8 | 7.4  | 3770 | BDL | BDL  | BDL  | 646  |
| Ore 1                  | Final solution assay, mg/L | 4100 | 80.5 | BDL  | 50.6 | 36.5 | 4820 | BDL | 2.5  | BDL  | 318  |
| Ore 2                  | Final solution assay, mg/L | 4020 | 27.2 | 11   | 78.6 | 78.4 | 7760 | BDL | 9.0  | 0.11 | 213  |
| Rougher Concentrate 1  | Final solution assay, mg/L | 7560 | 147  | 3.4  | 10.8 | 22.4 | 9860 | DBL | 15.8 | 0.07 | 316  |
| Rougher Concentrate 2  | Final solution assay, mg/L | 5080 | 30.8 | 115  | 5.5  | 2.6  | 9750 | BDL | 0.4  | 0.21 | 169  |





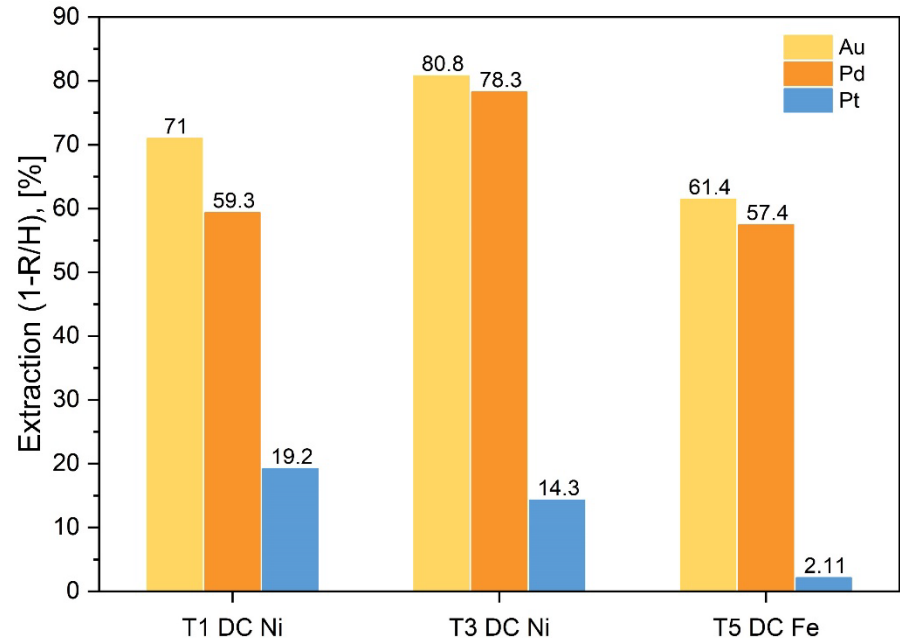
# PGM Leaching from low grade concentrates

| Sample (after BM leach) | Ni (%) | Cu (%) | Co (%) | S (%) | Fe (%) | Pd ppm | Pt ppm | Au (g/t) |
|-------------------------|--------|--------|--------|-------|--------|--------|--------|----------|
| DC Ni                   | 0.55   | 0.09   | 0.062  | 6.81  | 18.8   | 3.54   | 1.51   | 0.31     |
| DC Fe                   | 0.61   | 0.10   | 0.071  | 9.12  | 20.8   | 2.27   | 1.28   | 0.10     |



## Glycine – Permanganate Leach (no CN<sup>-</sup>)

Working conditions: pH = 11, glycine concentration = 45 g/L, solids content = 30% w/w, KMnO<sub>4</sub> = 5 g/L, T = 60°C, P = 1 atm, and DO = ~8 ppm.

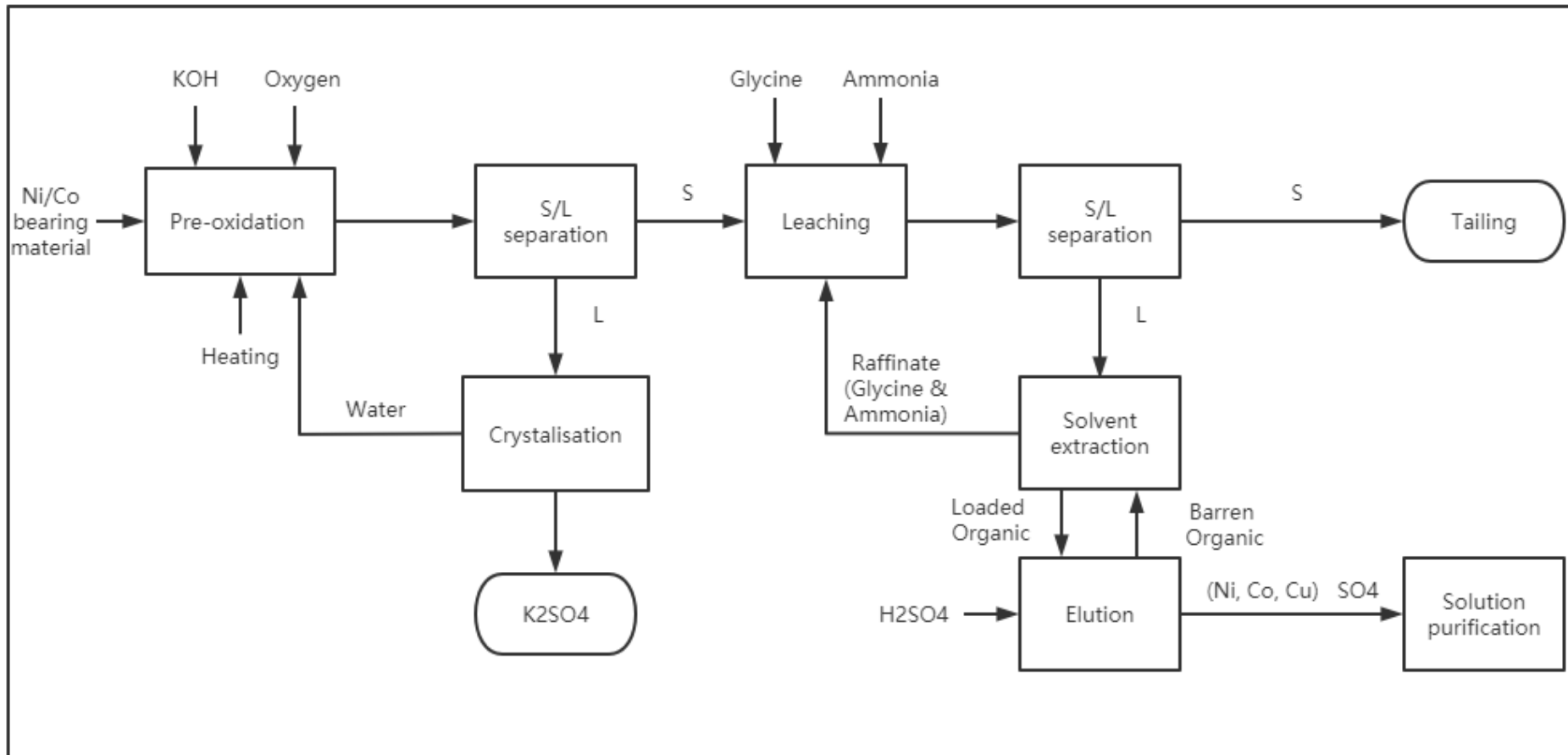


## GlyCat™ Leach (Starvation CN<sup>-</sup>, no free CN<sup>-</sup>)

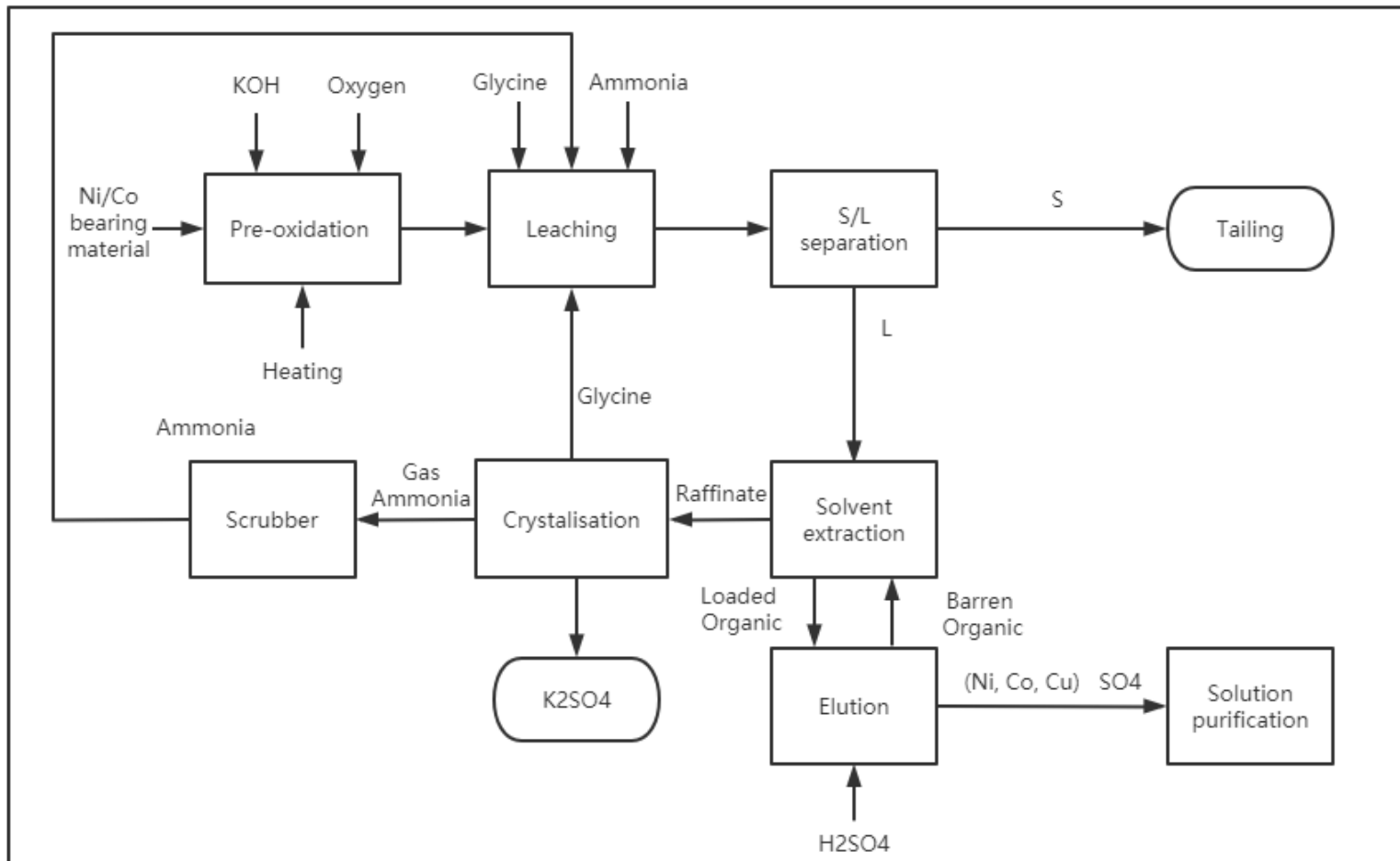
Working conditions: pH = 11, glycine concentration = 45 g/L, solids content = 30% w/w, cyanide = 1.5 g/L, T = 60°C, P = 1 atm and DO = 20 ppm.



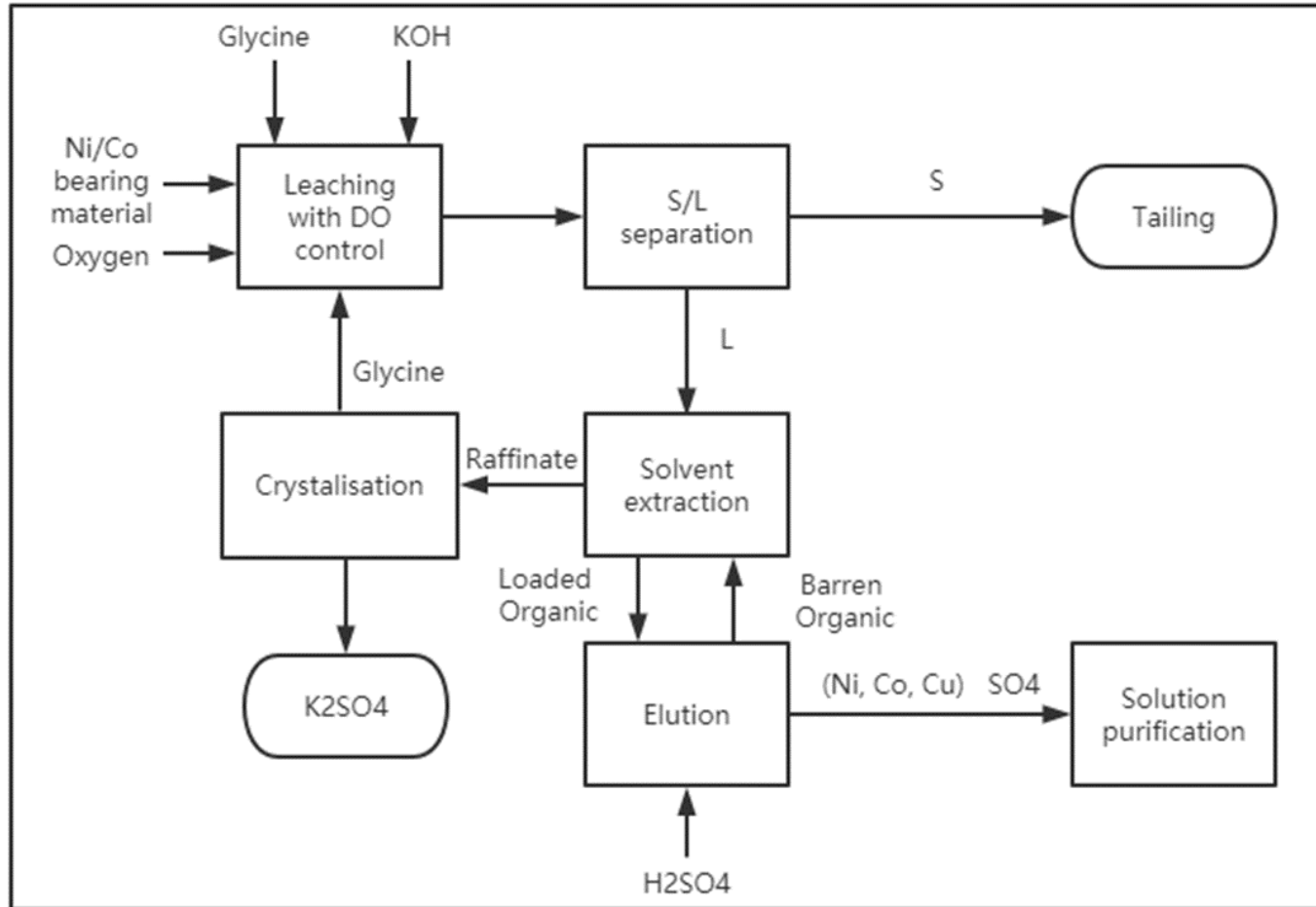
# High Level Process Options: Pre-oxidation (concentrates & high pyrrhotite materials)



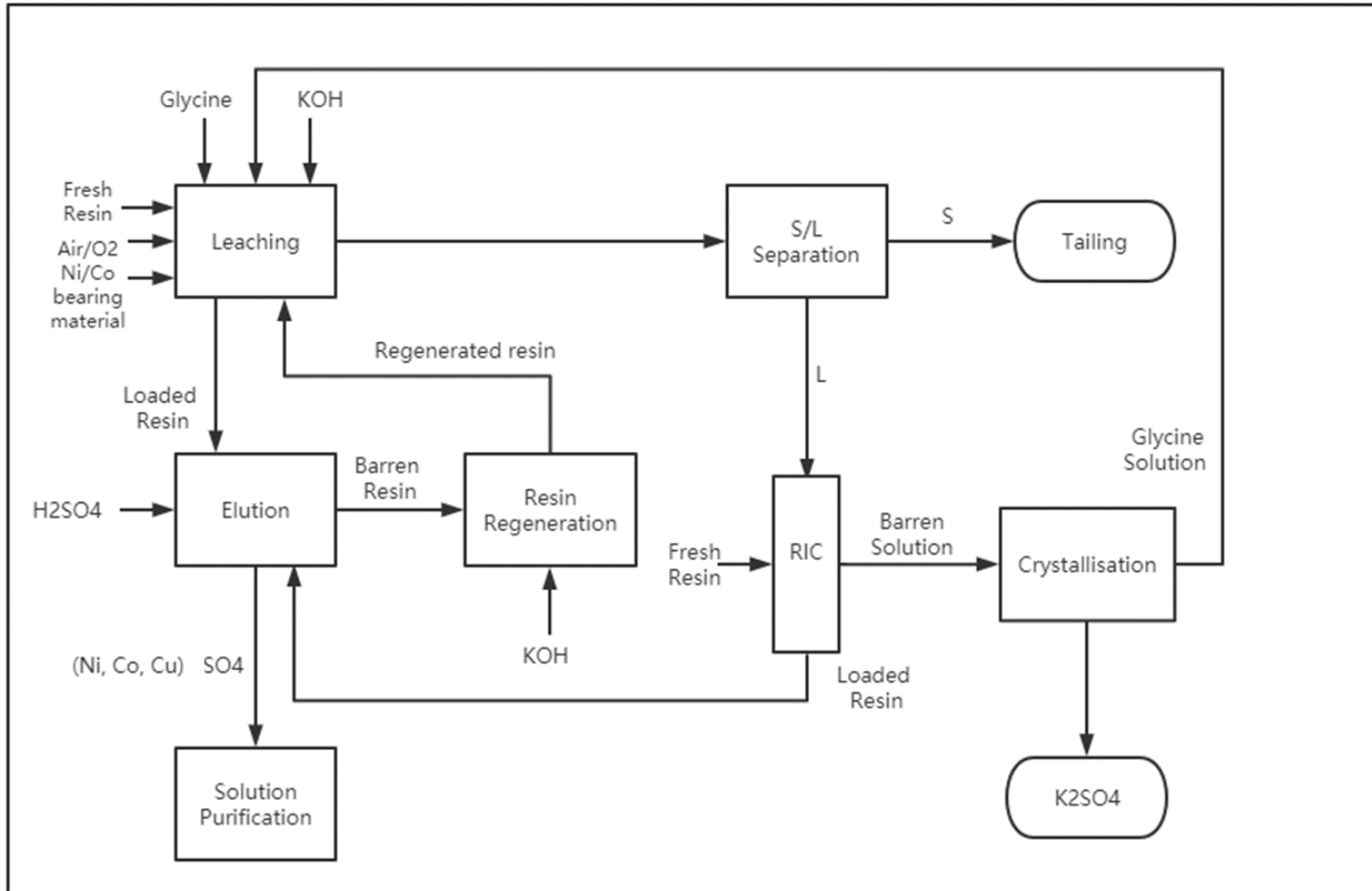
## Option 2 (for Concentrates and high sulfide materials): Low-Ammonia addition



### Option 3: High level conceptual flowsheet for rougher concentrate leach:



### Option 3: Ore / Tailings leach with ion-exchange recovery of Ni/Co/Cu from solution



## **Alkaline glycine technology provides an ideal pathway for the production of “Green” nickel and cobalt, particularly for lower grade and polymetallic resources.**

- It allows maximum recovery of Ni & Co with minimal co-extraction of impurities
- It allows pathways directly to Ni & Co sulfate without the need for smelting, converting, or pressure leaching
- It eliminates most of the typical problematic contaminants, such as Fe, Mg, Ca, Al, Si, Mn from the first extraction stage
- It operates under similar processing conditions, and with similar equipment to gold leaching circuits
- A detracting factor is leach residence time (around 24-48 hours) leading to more tankage
- Glycine recycle is simple, minimising reagent costs
- Processes can be used with saline / hypersaline water
- Applicable to various grades, but optimal for ores & concentrates with nickel grades of between 0.3% - 7.0% Ni
- Various alkalising agents can be considered (hydroxides/carbonates of K, Na,  $\text{NH}_4^+$ , Ca)
- Good Au & Pd recoveries can be obtained using GlyLeach™ or GlyCat™, when present in nickel.





## Piloting GlyLeach™ & GlyCat™ Processes

**CMET**



Curtin University



# Invention, innovation and commercialization

- The glycine and amino-acid based leach technologies has been invented by Jacques Eksteen and Elsayed Oraby with the original priority dates dating back to 2013.
- Since then, 5 patent families and more than 80 international national phase patents have been registered.
- The research to date has been published in more than 40 peer reviewed journal papers.
- Initially the technology was commercialised through Mining & Process Solutions Pty Ltd (MPS).
- MPS was acquired by the Czech multinational company Draslovka a.s. in 2022.
- Draslovka is currently deploying the GlyCat™ and GlyLeach™ technologies at an industrial scale globally.
- The process, in various modifications have been piloted for Au, Au-Cu, Cu, Ni/Co operations
- Many international operating licences have been issued and the process is being trialled at industrial scale at multiple sites in Africa, South and North America, Australia and Asia.
- The technology applies to the leaching, extraction, refining and recovery of metals from solutions for Au, Ag, Pd, Pt, Zn, Cu, Pb, Ni & Co.
- The challenge was to find holistic, integrated process solutions that covered the leaching, purification and recovery of metals from solution as well as reagent recycle and reuse.
- The development took a decade and is still ongoing.
- It is an example of a sustainable, “green” process that can be used for some key Critical Metals such as Ni, Co, Cu, Pd, Ag and Pt while satisfying the 12 criteria for “Circular Hydrometallurgy”.



## Barrick cuts cyanide by 80% by adding glycine leach for gold recovery

Staff Writer | March 4, 2024 | 11:16 am [Suppliers & Equipment](#) [Top Companies](#) [Africa Gold](#)



The Bulyanhulu gold mine, opened in 2001. (Archive image courtesy of [Acacia Mining](#).)

Barrick Gold (TSX: ABX: NYSE: GOLD) and Draslovka have achieved their goal – an 80% reduction in cyanide use by adding the GlyCat technology to the processing plant. Gold recovery remains comparable to traditional cyanidation.

Glycine leaching technology (GLT) uses glycine, a non-toxic, recyclable and biodegradable amino acid that is commonly used as a food additive, to recover gold, copper, nickel, and cobalt.

Draslovka

## Unlock tomorrow's battery metals

Achieve optimal recovery  
with GlyLeach™



# Thank you!

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