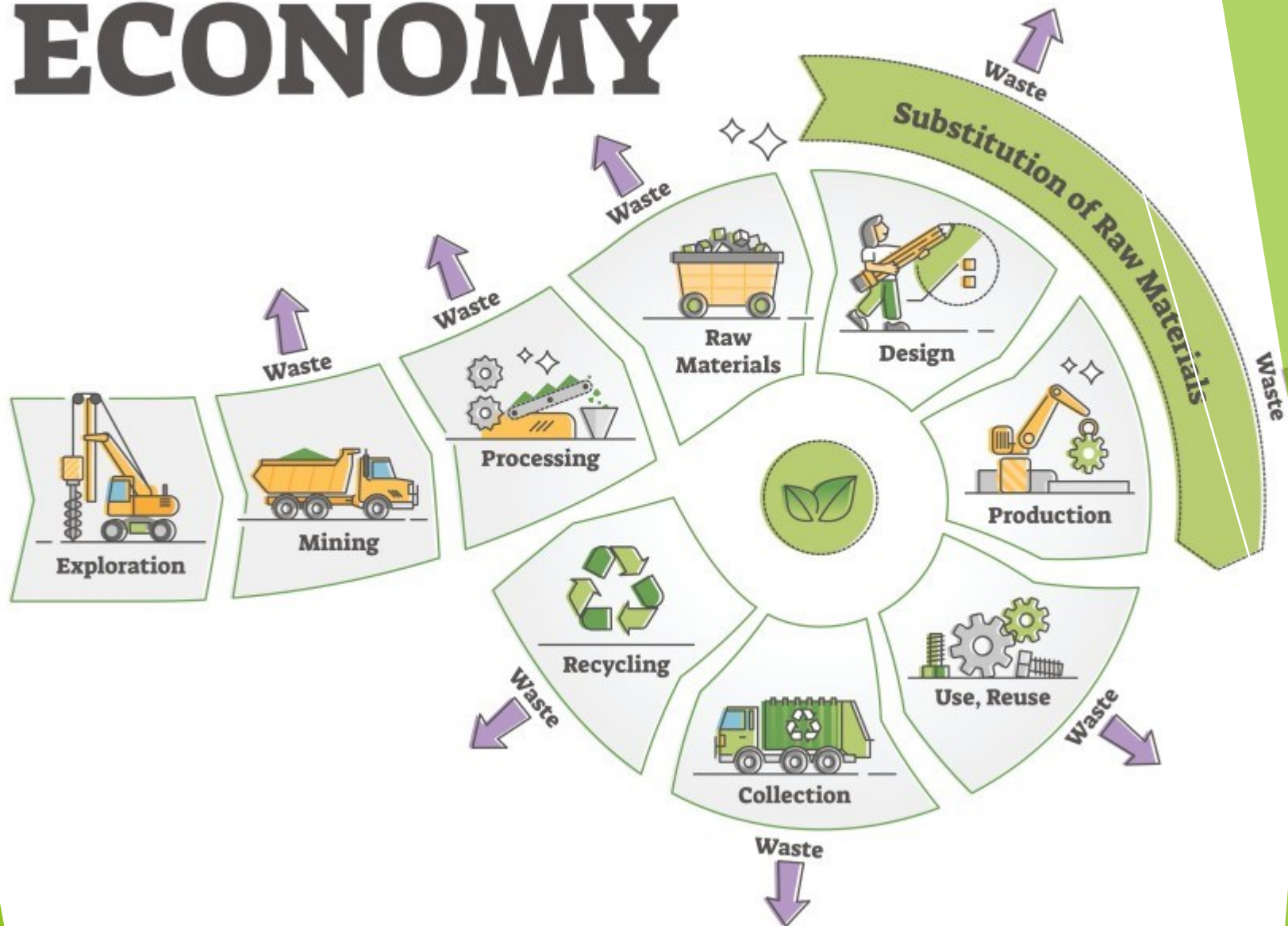


Waste to Riches: Abandoned Mines in a Circular Economy

Oct 24, 2024

One Person's Waste is Another Person's Treasure

CIRCULAR ECONOMY



The Opportunity Challenge

Pyrrhotite tailings contain significant value of nickel, iron, sulfur and other elements

Rethink
Pyrrhotite
Tailings



Ideal State:
No Tailings

Primary Level: Sulphur Management

- Safely manage sulphur generated in the proposed solution
- Opportunities for co-location usage of different sulphur products

Primary Level: Iron Management

- Dissolution of Nickel and Copper with significant iron

Primary Level: Nickel Management

- Ni / Fe selectivity can be poor and economically challenging

Key Considerations:

- Best Environmental Practices
- Financial Feasibility
- Circular Economy Principles Employed

Secondary Level: Additional by-products

- Additional By products include Cu, Co, PGMs, rock, silica

Secondary Level: Energy Management

- Potential for energy recovery from exothermic reactions
- Local usage supports lower CO₂ emissions

Underlying Theme: Effluent Generation and Water Treatment

- Minimize emissions and waste streams from the process



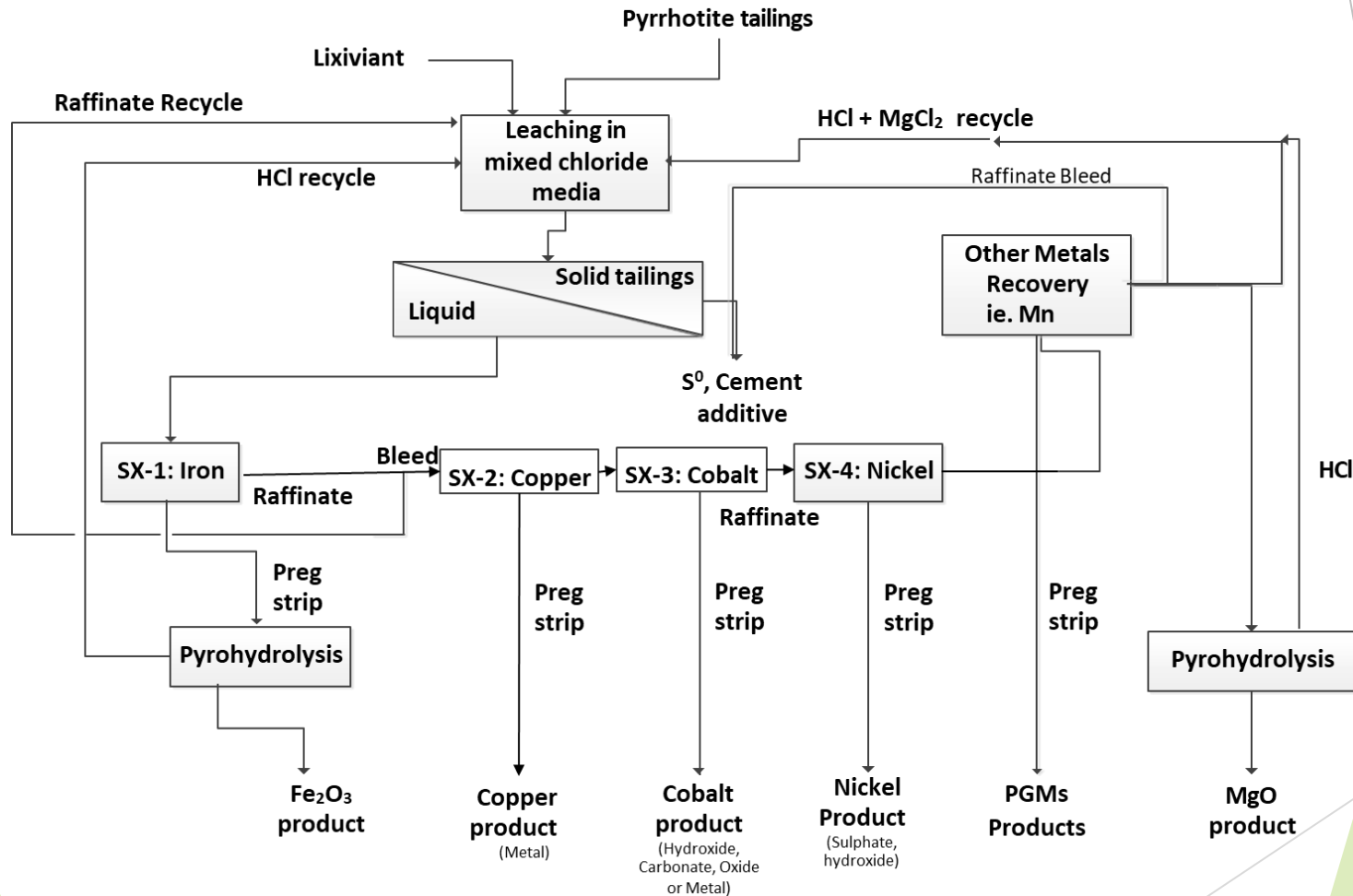
Circular Economy and Environmental Impact

A perennial mining waste of pyrrhotite tailings can be transformed into valuable products for the new EV technology, while reducing the waste into usable materials. Iron is transformed into iron oxide for specialized applications (LFP batteries, pigments), while the remaining silicate and oxide residue can be used as a construction material in cement and road construction.

Vale Base Metals: Pyrrhotite Resource Recovery Innovation Challenge - A Summary

- ▶ The Open Innovation Challenge facilitates Vale Base Metals capabilities to leverage new, state-of-the-art technologies into their mining & metals operations to build a cleaner, greener, more prosperous world. Vale Base Metals is looking for innovative solutions to unlock sustainable and financially viable solutions to recover the valuable metals and minerals contained in pyrrhotite.
- ▶ Canadian Minerals Technologies (CMT) Inc. is a startup company focusing on mining technology solutions, process development and commercialization.
- ▶ CMT Inc. proposes the use of the PRO nickel process, employing the following innovative steps:
 - Atmospheric leaching in mixed chloride media to bring Ni, Cu and other metals into solution.
 - Innovative low pH solvent extraction steps for successive extraction and stripping of Fe, Cu, Co and Ni ions to obtain high purity concentrated preg strip solutions of Fe, Cu, Co and Ni, respectively.
 - Production of final high-grade products.
 - Leach residues transformed into products (S⁰, cement additive).
 - Historic opportunity to deliver final products from tailings to the new EV economy.

Proposed Process Flowsheet



PRO Technology for Nickel

Uses the HCl + MgCl₂ leaching system:

- ▶ Regeneration of the acid and recycling

Mixed chloride leach is combined with innovative solvent extraction (SX) to derive value

- ▶ SX in chloride media provides high separation factors for value metals
- ▶ Provides opportunities for high purity products with tailored morphology



Technology has been applied to Ni lateritic ores and Cu/Ni sulphide concentrates and it is applicable to other intermediates

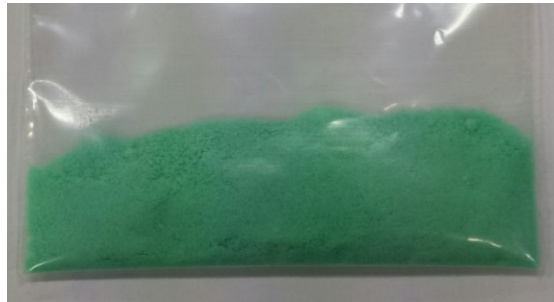
Nickel Sulphate Product

- ▶ A high purity $\text{NiSO}_4 \cdot x\text{H}_2\text{O}$ product has been generated from the process
- ▶ Ni:Co ratio of >20,000:1

Analysis $\text{NiSO}_4 \cdot x\text{H}_2\text{O}$

	Ni	Co	Ni:Co Ratio	Al	As	Ca	Cr	Cu	Fe	Mg	Mn	Ti	V	Zn
	%			mg/L										
$\text{NiSO}_4 \cdot x\text{H}_2\text{O}$ Crystal	22.38	0.001	21,000	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL

DL < 5 mg/L



BIOSOLIDS

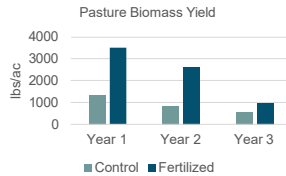
Yield Improvement

Biosolids are the organic material generated from the municipal wastewater treatment plants. They are a nutrient-rich fertilizer with high organic matter that contain essential plant macro and micronutrients that are used as a soil amendment.



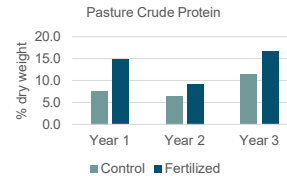
PRODUCT BENEFITS (from one application)

Enhance growth and increase crop yield



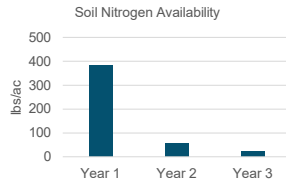
160% higher yield on average

Improve crop quality



Average 60% higher crude protein

Multi-year N release following application



464 lbs/acre available over 3 years

Additional benefits

Free fertilizer with a fertilizer replacement value of \$116 per dry ton

Longer grazing season for cattle's due to early and late season green-up

Improved percent cover assists in reducing soil erosion

Heavier cattle due to higher crude protein and increased yield

PRODUCT INFORMATION

Application rates of biosolids are determined by the nitrogen requirements of the crop being grown. The following key nutrients are provided by a typical application of 10 dry tons per acre.

MACRONUTRIENTS		MICRONUTRIENTS	
Nitrogen - Plant Available Year 1	383 lbs/ac	Boron	0.11 lbs/ac
Available Phosphorus (P ₂ O ₅)	707 lbs/ac	Copper	1.20 lbs/ac
Available Potassium (K ₂ O)	62 lbs/ac	Iron	26.6 lbs/ac
Available Sulfate	18 lbs/ac	Manganese	0.98 lbs/ac
		Molybdenum	0.14 lbs/ac
		Selenium	0.09 lbs/ac
		Zinc	1.67 lbs/ac

*Total value per dry ton \$116 *not including Organic Matter*

Total value per acre at 10 dry tons per acre = \$1,160

CASE STUDY

SYLVIS has established a long-term grassland restoration program at the OK Ranch in Clinton, BC. Areas fertilized with biosolids experience **250% increase in biomass** and **48% increase in crude protein**.



The effect of the first test application was "immediate." The steers that grazed on test plots were up to 150 lbs heavier than their range-fed cousins.

Lawrence Joiner, OK Ranch Landowner
Country Life in BC – November 2016



Vegetation comparison near the end of the first growing season after biosolids fertilization.



**PRODUCERS PIT
AGGREGATE PIT RECLAMATION**



**SECHELT SAND AND GRAVEL MINE
MINE RECLAMATION**

Thoughts, questions?