



Enabling Innovation → Innovating to zero Roadmap to the Future

COM 2017 with World Gold Conference
Vancouver August 28-30, 2017

Process & Energy Chair ~ Simon Hille, Goldcorp
Co-author Rob Stevens, Teck

Who is the Canadian Mining Innovation Council (CMIC)?

- The Canada Mining Innovation Council (CMIC) is an umbrella organization to coordinate innovation in the mining industry.
- Our Vision is to ***Fundamentally Transform Mining to a Zero Waste Industry***
- By ***Connecting innovators to catalyze transformation across the industry***
- Our members include mineral exploration and mining companies and their service providers, working together towards common solutions to common challenges.
- CMIC technical groups are led by Canadian company executives and supported by leading industry experts in the fields of mineral exploration, extraction, processing, mine waste management and energy.

CMIC 10 year VISION ~ Mineral Processing

- **50%** reduction of **Energy**
- **50%** reduction in **Water** and
- **50%** reduction in **Footprint**

→ All of this by 2027

- Footprint= Mineral Processing + Mining inclusive of tailings being +50% of the overall footprint

CMIC 10 year Vision ~ Mineral Processing

How can this be accomplished?

By unlocking the intellectual power of the metallurgical industry, through open collaboration, developing a vibrant innovative ecosystem which believes in transformation change for the Mineral Processing

CMIC 10 year Vision ~ Mineral Processing

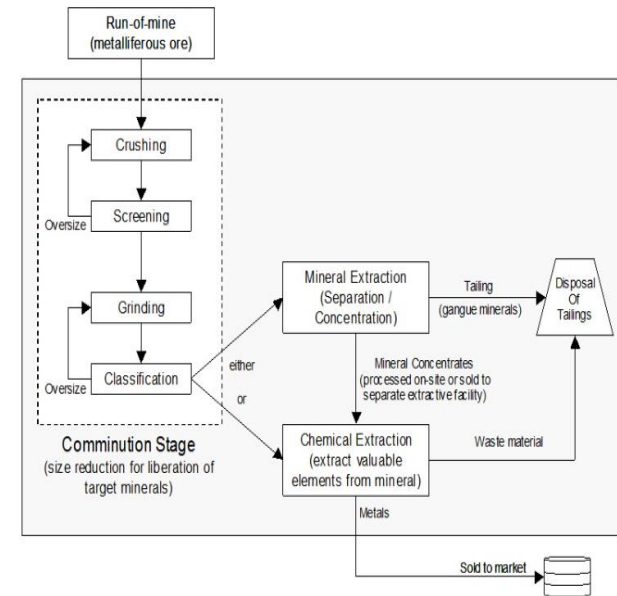
CMIC Role

- Facilitate Canadian Innovation in the mining sector
- Articulate mining sector innovation gaps
- Initiate thought leadership
- Champion industry wide collaboration
- Secure government and corporate support
- Develop lasting industry & research partnerships

Mineral Processing – Current Paradigms

Our current practice of “what works well” holds us where we are. To move forward we must continuously challenge what could be possible.

- Focus on maximising production capacity and throughput to drive value.
- You must accept variability that the mine sends you:
 - Flexible Processing
 - Reliant on quality upfront characterization
 - Throughput trumps energy, recovery and efficiency
 - Water is necessary
 - Tailings are inevitable



Current Paradigms

Current Paradigms

- **Waste rock is a reality**, lower grades means more rock to the mill
- **Blending enables consistency**: You must accept what the mine sends you. Mines are unpredictable, getting accurate “tons & grade” is hard enough so geochemical and geophysical properties all in real-time is not realistic.
- **Water is necessary**
- **Energy is required to liberate**
- **Throughput maximizes value**: maximum value is achieved by maximising throughout. 2nd consequence – large capital & footprint.
- **Infrastructure costs** drive project economics
- **Tailings** are inevitable
- We must continuously challenge what we believe to be true

Another Way?

- **Always reject Waste Rock**, through design, differentiation, sorting = pre-concentration
- **Accept that Orebodies are variable**, orebody knowledge is king, leverage variability into an asset = Real-time digital/TRUE model (Geo-Mine-Met)
- **Always reduce Fresh Water**, water is not the answer
- **Always seek Energy efficiency**; effective liberation particle liberation maximizes value
- **Always scale from margin**: flexible, modular plants both decrease capital and footprint.
- **Shared Infrastructure**
- **Water scarce/less Tailings**, ensuring sustainability

New Design Principles

SMART SIZE REDUCTION

Use drill and blast and newer methods to reduce the size of the conventional crushing and grind circuits.

TARGETED ECO LIBERATION

Use energy & water efficient comminution technology.

GEO-MINE-MILL INTEGRATION

The mine and mill are now one integrated flow sheet. We have high fidelity on orebody characteristics, transparency and integration.

CONCENTRATION ALONG THE PATH

Mass rock(waste) rejection from mine face and along the path to the mill.
We are using all available sorting technology before the conventional mill.

DRY (SEPARATION) CONCENTRATION

Increasingly reduce the use of water to extract to final product.
Engage other technologies to separate valuable mineral

SMART PROCESSES

Design SMART processes (Plants) that are **modular**, **flexible**, and **scalable**.

BRIGHT MINDS ECOSYSTEM

Recruit bright minds and build new intellectual ecosystem around the mining industry to deliver fast innovation that transforms the industry.

Mineral Processing Technology Development Roadmap

Pillars	Geo-Mine-Met Integration	Intelligent Selectivity	Eco-Liberation Concentration	Sustainable Metal Extraction	Bright Minds Collaboration
Ready Now Technology	Forward Looking <ul style="list-style-type: none"> Analytics Modeling 	Particle Sorting <ul style="list-style-type: none"> Speed of analysis Accuracy Sort criteria Size sorting 	Grade-Recovery-Mineralogy <ul style="list-style-type: none"> Dry comminution (from cement industry) Coarse float 	Metal Extraction <ul style="list-style-type: none"> Selective Sort Flexible Processing Mineral sensing Low mass high concentration extraction 	Build new intellectual ecosystem <ul style="list-style-type: none"> Drive open innovation and collaboration Hackathon
3-5 Years	Predictive <ul style="list-style-type: none"> Digitally enhanced In-situ Assay by Mineral Bore-hole 	Bulk rock rejection Advanced Model & Simulation Mineral Sensing <ul style="list-style-type: none"> Large batch, Particle, Remote Multi-plant Operations, grade specific sort 	30% energy reduction for Liberation <ul style="list-style-type: none"> CAHM Smart Crush/grind Extend vertical / Disc mills to larger sizes 	Integrated dry Processing <ul style="list-style-type: none"> Low cost Modular process plants In-situ leaching Nano particle collectors/tagging Micro-robotic technology 	Collaborative Ecosystem <ul style="list-style-type: none"> United messaging Government as a stakeholder EDC support
5-10 Years	Targeted <ul style="list-style-type: none"> Separable particle scale Material tracking and reconciliation in real-time 	NSR in-transit Ore Selection <ul style="list-style-type: none"> Advanced Model & Simulation Mineral Recognition 	Targeted Liberation <ul style="list-style-type: none"> Breakage on Mineral/Gangue Boundaries Low Grade Energy Recovery 	Metal (dry) extraction processes <ul style="list-style-type: none"> Next generation Lixivants Fines recovery Dry Metal Mineral Rec'y 1 step to product In-situ leaching 	Open Sharing Ecosystem <ul style="list-style-type: none"> Operators, vendors, EPCM's, gov't Audacious step-change developed collaboratively
End Results	Mineral mapping & tracking "end to end"	Mass Waste rock rejection (Value Concentration)	Decreased energy and more water efficiency	Selective mineral recovery	Open technical sharing ecosystem hub

CMIC 10yr Goals → 50% reduction of Energy, Water and Footprint

Mineral Processing Innovation Themes

Geo-Mine-Met Integration



Orebody knowledge is the priority. The model includes Geological, Mining and Metallurgical criteria to ensure predictability and maximum value.



End Result
Mineral mapping & tracking "end to end"

Intelligent Selectivity

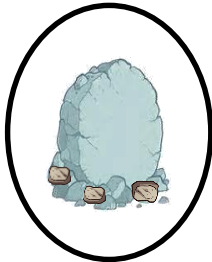


Real-time digital information is used to selectively mine, reduce waste creation and reject waste ahead of processing.



End Result
In-flight Value Concentration "Mass Waste Rock Rejection"

Eco-Liberation Concentration

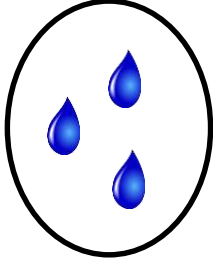


Energy efficient comminution results in a targeted particle separation using limited water.



End Result
Increased energy efficiency and less water

Sustainable Metal Extraction



Water scarce/less metal extraction without deleterious elements impacts ensures a sustainable environment.



End Result
Selective mineral recovery

Bright Minds Ecosystem



People are at the center of everything we do. The new era enables open collaboration and utilizes the full ecosystem.



End Result
Open sharing technical ecosystem hub

CMIC 10yr Goals → 50% reduction of Energy, Water and Footprint

Mineral Processing Innovation Themes

Innovation Theme	Champion	Supporting Company
Geo-Mine-Met Integration	Mick Bunyard	Hatch
Intelligent Selectivity	Paul Cousin	Agnico Eagle
Eco-Liberation Concentration	Paul Staples	Ausenco
Sustainable Metal Extraction	Nathan Stubina & Robin Wolf	McEwen Mining
Bright Minds Ecosystem	Karina Rogers	Amec FosterWheeler (Wood Group)

Next Steps

- **Champions** nominated to lead each of the **Themes**
- Champions will set-up a separate **mini-workshop** to define the detailed plans.
 - Workshops will be facilitated
- **Detailed Plans** will then be marketed to all researchers to determine collaboration partners
- **Establish new members** ~ it's free!
- **Funding requirements** will be identified for feedback to board
- All Mini-workshops to be completed by November

Special Acknowledgement

We would like to thank Hatch Canada, especially Adrian McFadden and Michael MacFarlane for creative input and facilitating the Roadmap.

Along with the efforts of all the active members of CMIC, with a special thanks to Carl Weatherell and Sam Marcuson for their input and guidance

Thank You