Mining: The Inversion of Industry 4.0

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Summary

• Previous CDO Work
  • Advanced Materials, Rise of Microstructural Manufacturing, Merging of Design & Manufacturing

• CDO Extractive Industries
  • Further Upstream: Digitization of Ore Bodies, Mine Operations

• Digital Value Chain from Mining to Metallurgy to Design/Manufacturing
  • Mining 4.0 vs Industry 4.0
Counter Intuitive: Mining as a Play on the Digital Economy
Mining & Digital Economy

• Productivity Paradox
  • We just had a 10 year Metals Supercycle
  • Mining Productivity Declined by 28%
  • Mining at a Tipping Technology Point: Digitization

• Mining and the Digital Economy
  • Digital Economy Needs Mining: Lots of it.
  • EV’s batteries and Cobalt
  • Digitalization = Electrification = Copper

• Most of the Materials are Underground
  • Next 10 copper mines are underground mine designs
Digital Transformation: Mine Design

- Surface Mining (Open Pit)
- Underground Mining
Underground Mining Yesterday & Today
Mine of the Future
Mining Industry Technology Innovation

• Mine Operations: Lagging, Inflection Point
  • Operating Companies: Little Innovation internally
  • Equipment Manufacturers: Step improvements of bulk mining equipment
  • Supply Chain: Specialized SMEs at the margin

• Exploration and Development
  • Digitization: drones, digital imaging, quantum computing
  • Many innovative SMEs: software, sensors, digital infrastructure
Digitization of Ore Body

Significant potential comes from better understanding the resource base.

Source: Durrant-Whyte 2015
Mining by Robots Already
Underground Drones: Lidar Technology
Positioning Underground
Digitized Mine Plans
Optimization by Montreal Gaming Software
Connecting to the Metallurgy
Mining 4 and Industry 4.0 Model
Mining 4.0: Taking the Lid Off the Mine

“Taking the lid off...”

What this was all about

- Connectivity for real-time monitoring of processes
- Improved operational control
- Optimizing plan execution & elimination of waste
Mining 4.0 vs Industry 4.0

Ore Body Heterogeneity

Metallurgy to Materials Science to Design

Standardized Outputs/Inputs

Consumer Product Heterogeneity
Conclusions

• Three Technology Trajectories:
  • Mining Companies: next to nil
  • Equipment OEMs: Step Functions
  • Exploration & Development: Leading Edge of Digital Technologies
    • SMEs on the Outside: Mining Supercluster

• Technology Lead in Canada by Precious Metals Companies
  • Scale: 1500 TPD vs 10-50K TPD
  • No links to Metallurgy: Financial Economy not the Manufacturing economy
    • Mining-Metallurgy-Materials Science-Design & Manufacturing

• Policy Issue: Can’t get There from Here