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Sustainability and metal extraction:

The role of Geometallurgy & emerging technologies

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Extractive Metallurgy Research Group

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Photo by Stefan Els

Extractive Metallurgy - Who we are

Researchers

Prof Guven Akdogan

Pyrometallurgy

Metal Recycling

Tailings Reprocessing

Plastics

Prof Steven Bradshaw

Metal Extraction

Metal Recycling

Machine Learning

Prof Christie Dorfling

Urban Mining

Metal Recycling

Process Modelling

Life Cycle Assessments

Dr Margreth Tadie

Geometallurgy

Mine Tailing Valorisation

Environmental Assessment

Mr Petrie van Wyk

Metal Recycling

PGM Recovery

Techno-economic Analyses

Extractive Metallurgy - Context

The sustainable production of valuable minerals and metals is critical for a prosperous and safe world. Ore is typically a complex raw material, requiring a wide variety of treatment processes in intricate flowsheets to unlock valuable minerals and metals.

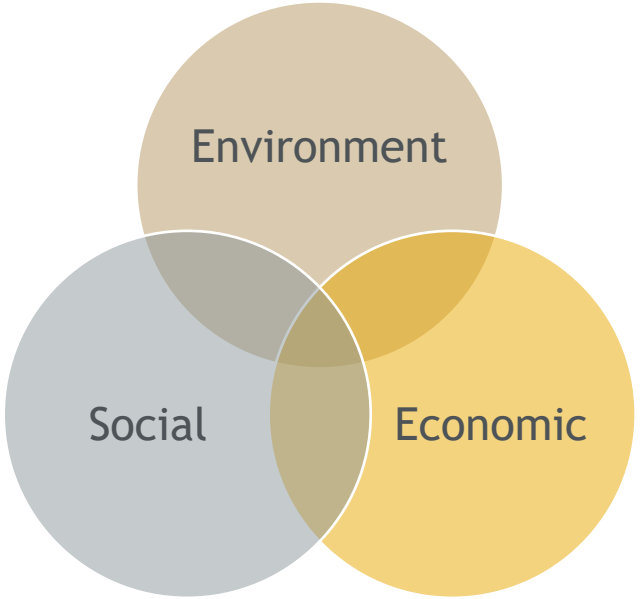
- Key challenges in extractive metallurgy include:
  - changing raw material characteristics (e.g. diminishing mineral/metal content as easy-to-access ore bodies are depleted);
  - energy use minimization (to minimize carbon footprint);
  - water use minimization (to reduce impact on scarce natural resources);
  - as well as effectively dealing with the emergent complex behaviour from intricate flowsheets and heterogenous, multiphase raw materials.

Objectives

- Provide an overview of sustainability in today's mining industry
- Introduce Geometallurgy and its role in optimizing metal extraction processes for sustainability
- Benefits of adopting geometallurgical approaches in terms of efficiency, resource utilization, and reduced environmental impact
- Discuss research work conducted in Department of Chemical Engineering in Extractive Metallurgy

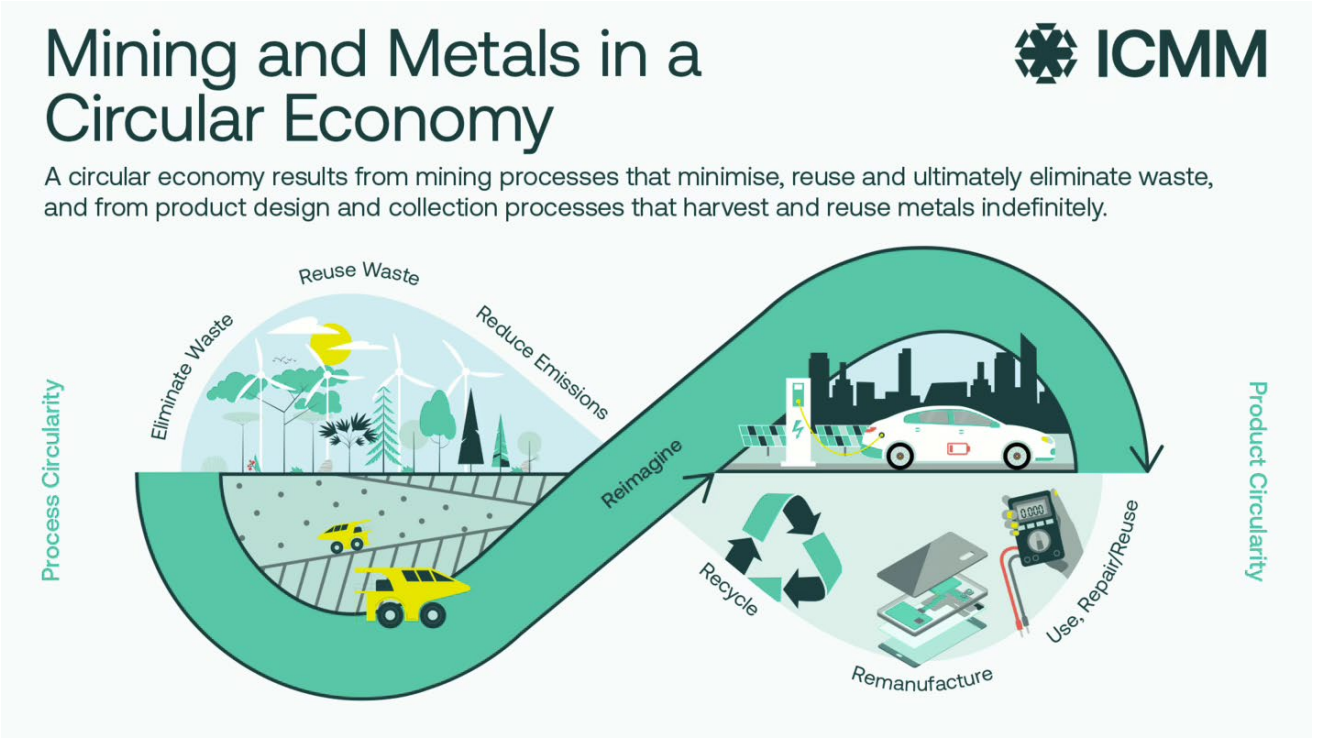
Understanding Sustainability in Metal Extraction

- Meeting the “needs of the present without compromising the ability of future generations to meet their own needs”.

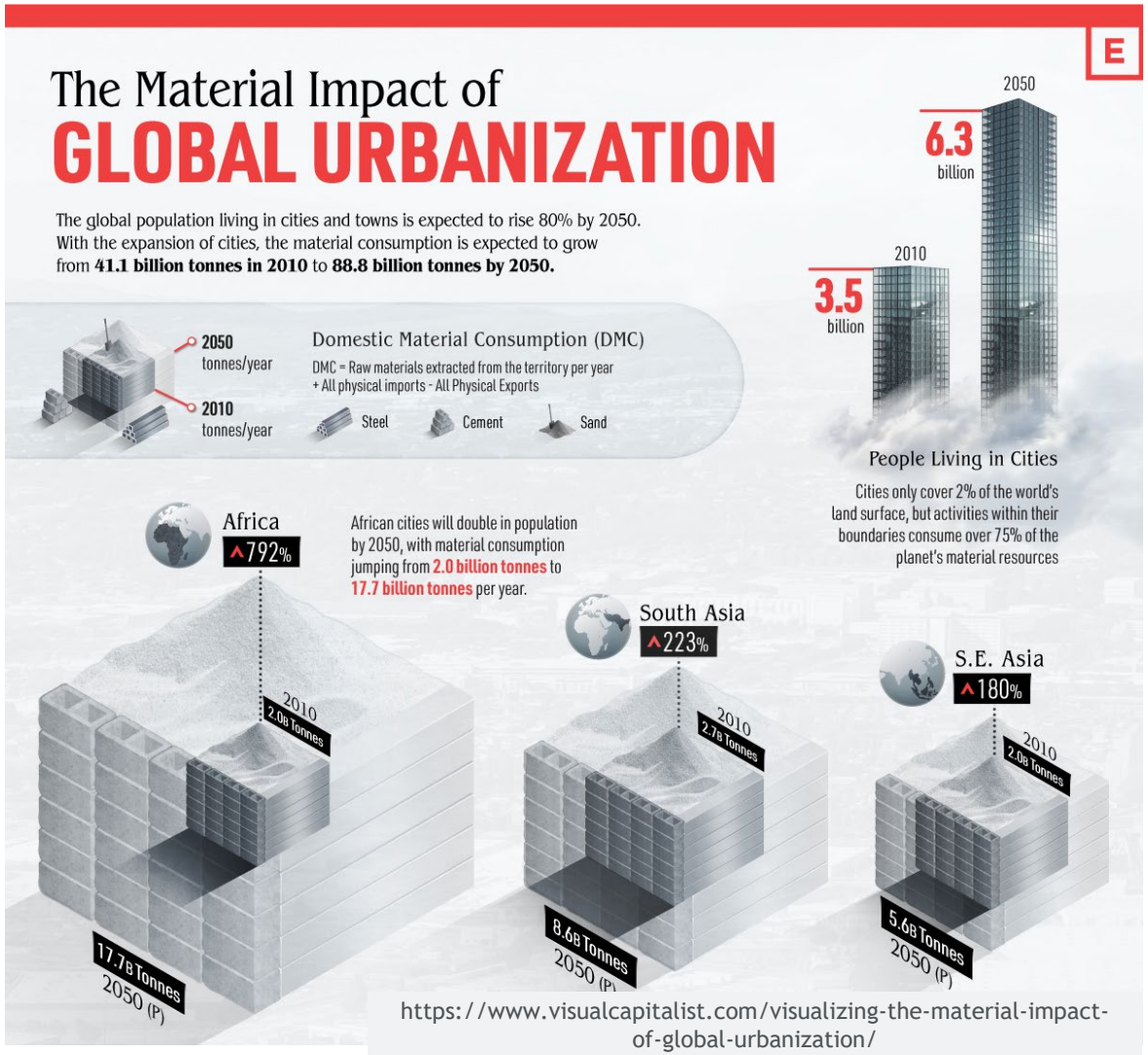


- Mining involves non-renewable resources !

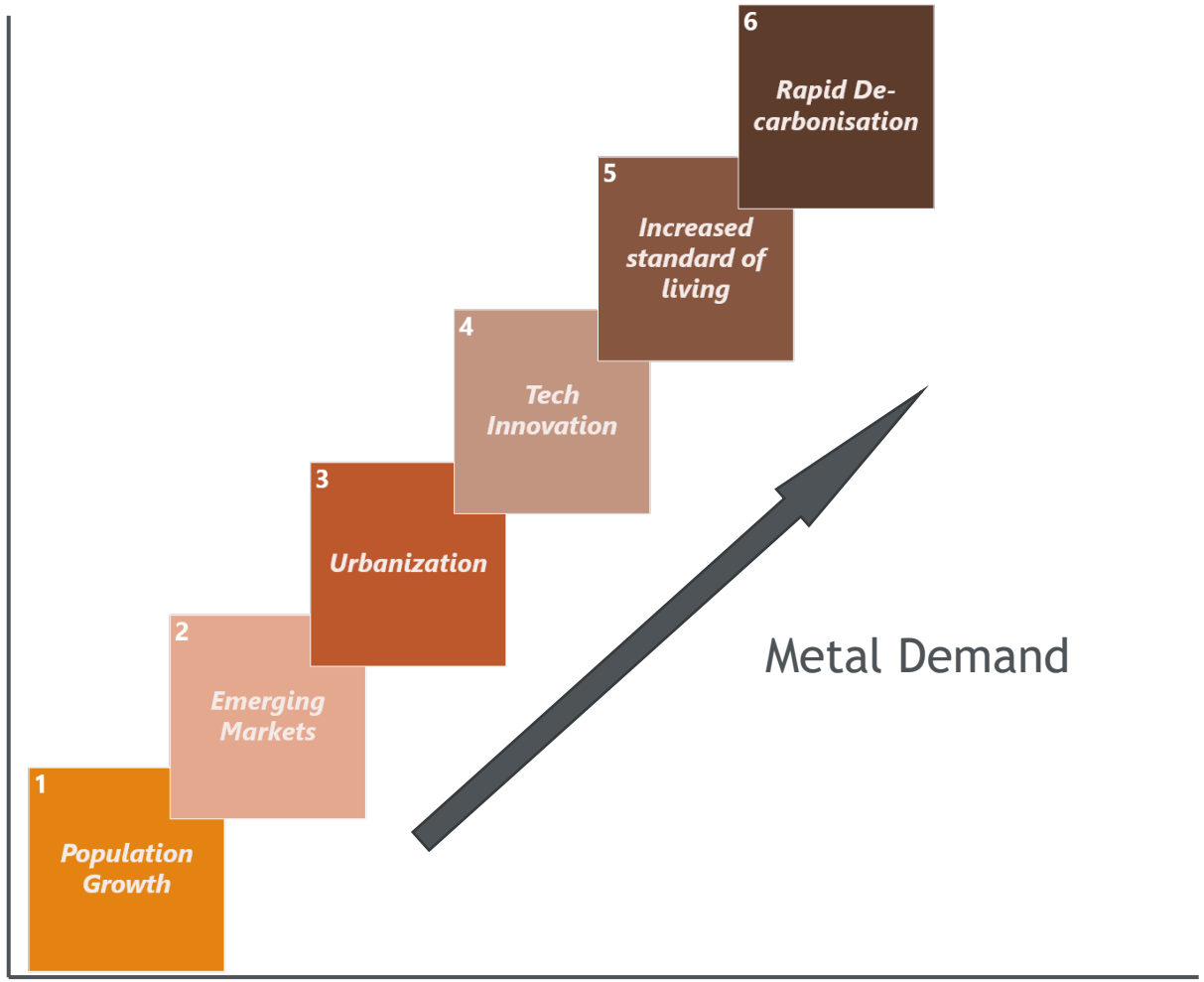
“Sustainable mining operations have a focus on enhanced and optimized metal recovery systems in combination with minimizing environmental and social impacts”



Industry drivers



https://www.visualcapitalist.com/visualizing-the-material-impact-of-global-urbanization/



Social, economic and environmental challenges of extraction

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Negative Effects of Extraction

- Habitat destruction
  - displacement of communities, loss of livelihoods and conflict over land-use
- Social conflicts – Social License to operate
- Rising costs of extraction,
  - labour, equipment, low productivity due to outdated technology or inefficient processes
- Regulatory risks –
  - ESG compliance, limited access to finance and investment

Benefits of Sustainable Extraction

- Efficiency in extraction
  - Reduced costs associated with waste management and environmental remediation
- Brand reputation
  - Meeting evolving regulatory requirements and consumer expectations for responsible sourcing of minerals and metals
- Reduced regulatory risk
  - Improved access to financing or investment due to greater transparency and accountability

Geometallurgy

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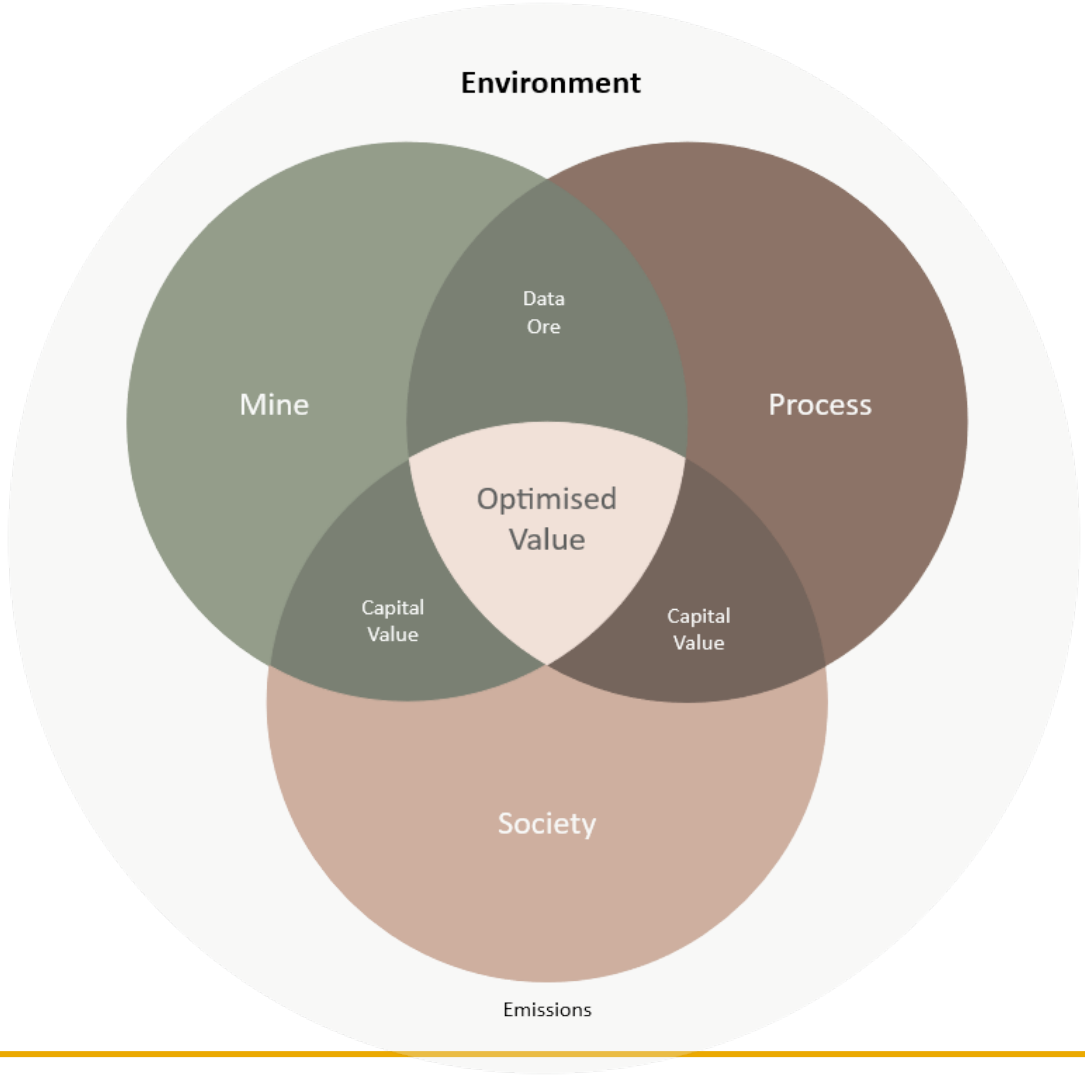
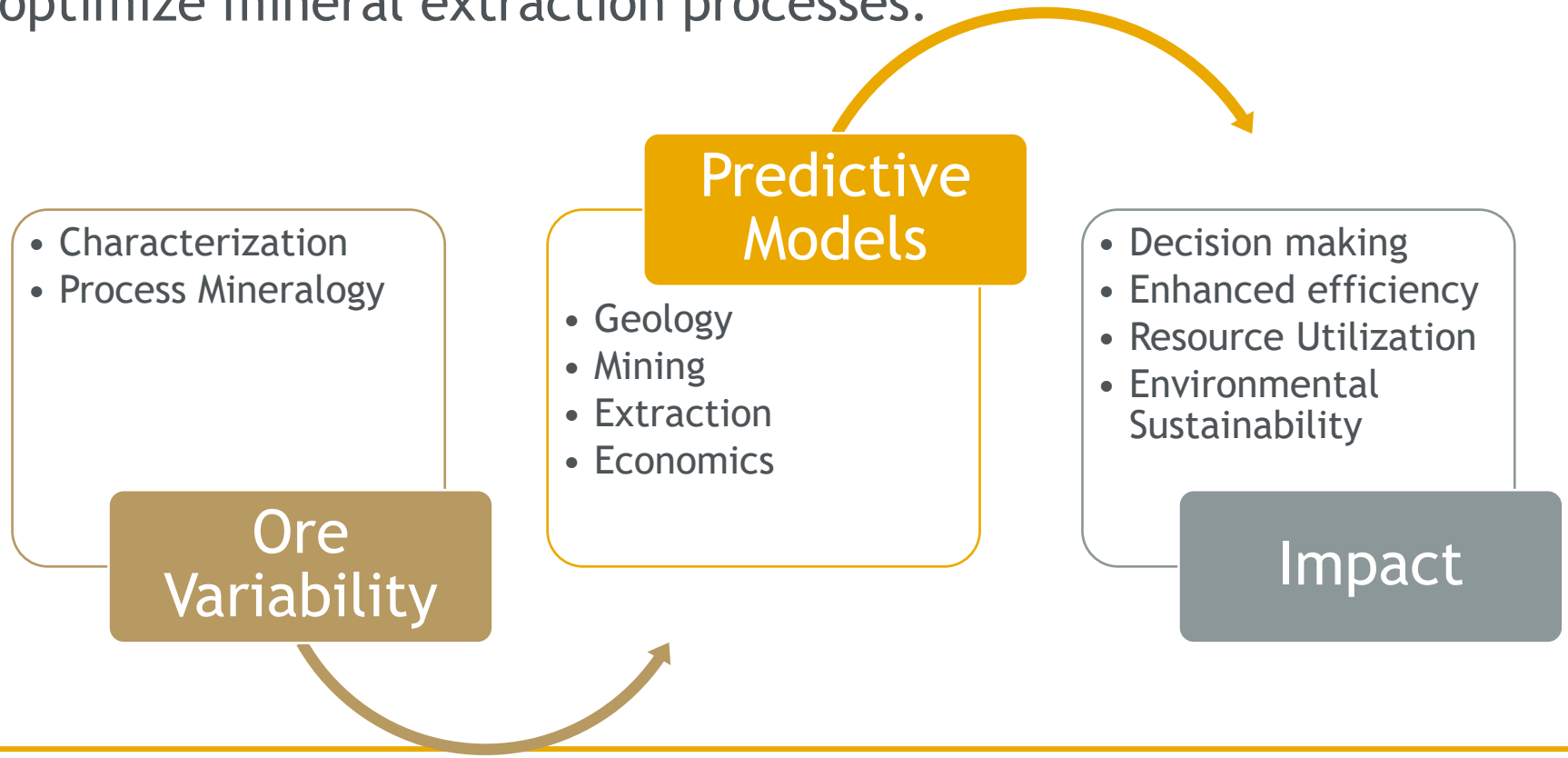
"Holistic approach to maximizing value before operation (pre-emptive) and after (retrospective) mining."

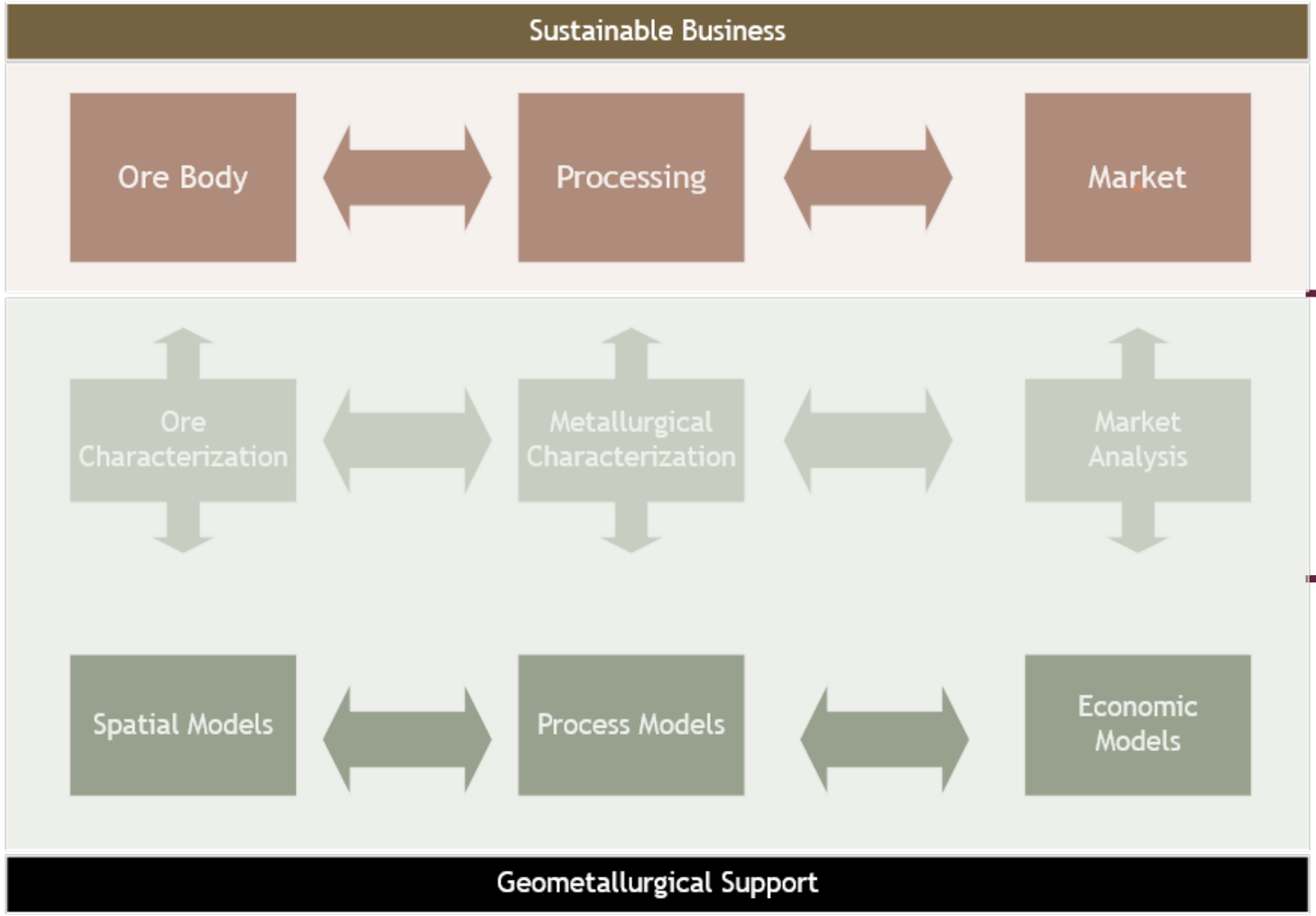


Geometallurgy

- "Geometallurgy: Maximizing Efficiency and Sustainability in Mineral Extraction.“
  - Interdisciplinary approach that integrates geological, mining and metallurgical data to optimize mineral extraction processes.

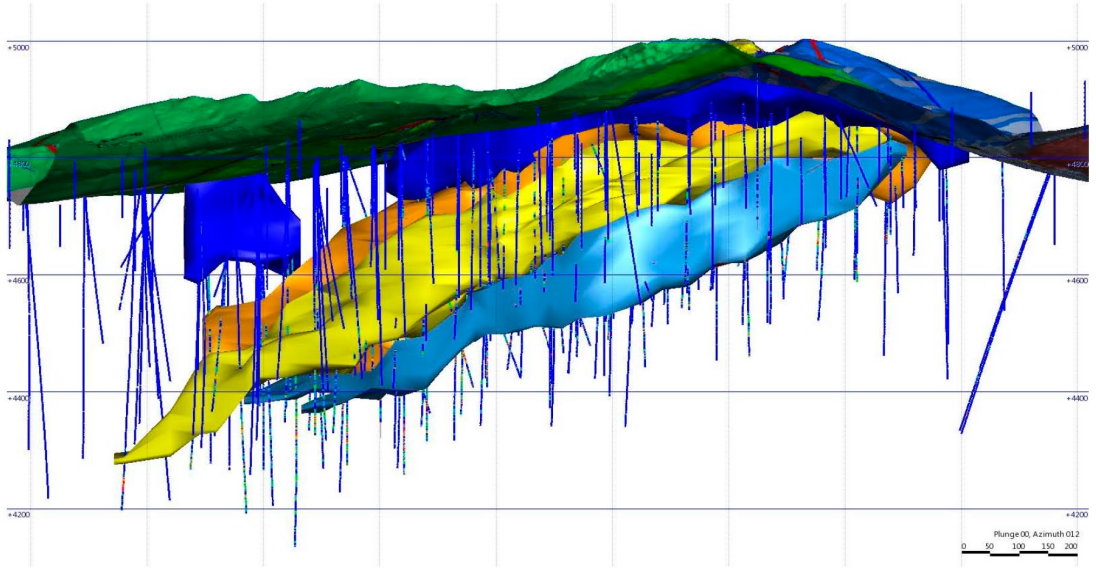


Geometallurgical Approach



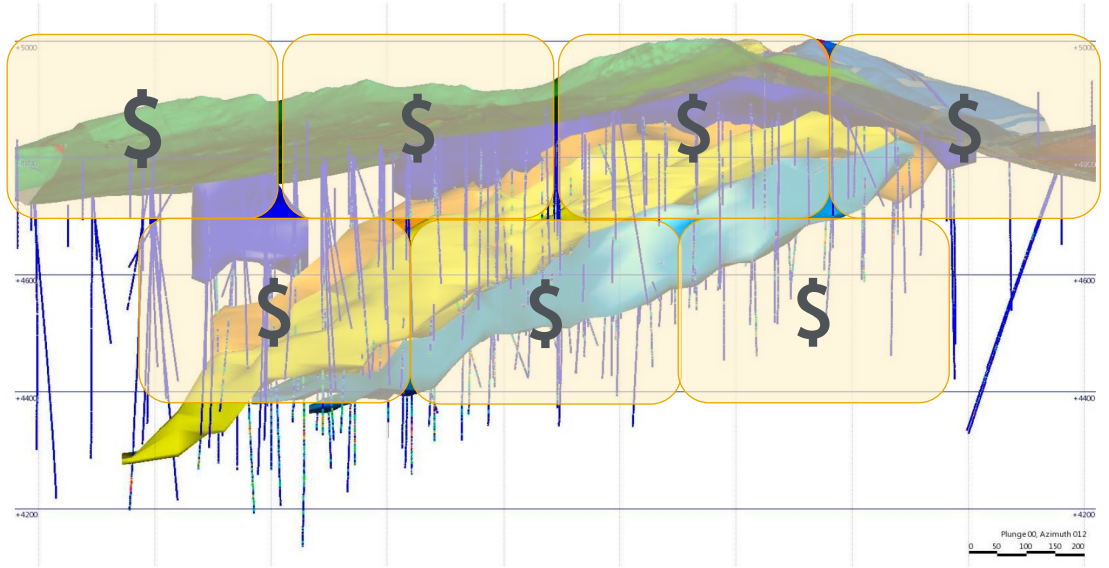
Geometallurgical Data
Chemical Assays
Grade
Mineralogy – Particles, Texture, Liberation
Mining schedules
Metal Prices
CAPEX,OPEX
ESG targets

Geometallurgical Block Model



3D Block Model, showing drill holes sampling points for characterisation

Minerals 2018, 8, 560; doi:10.3390/min8120560

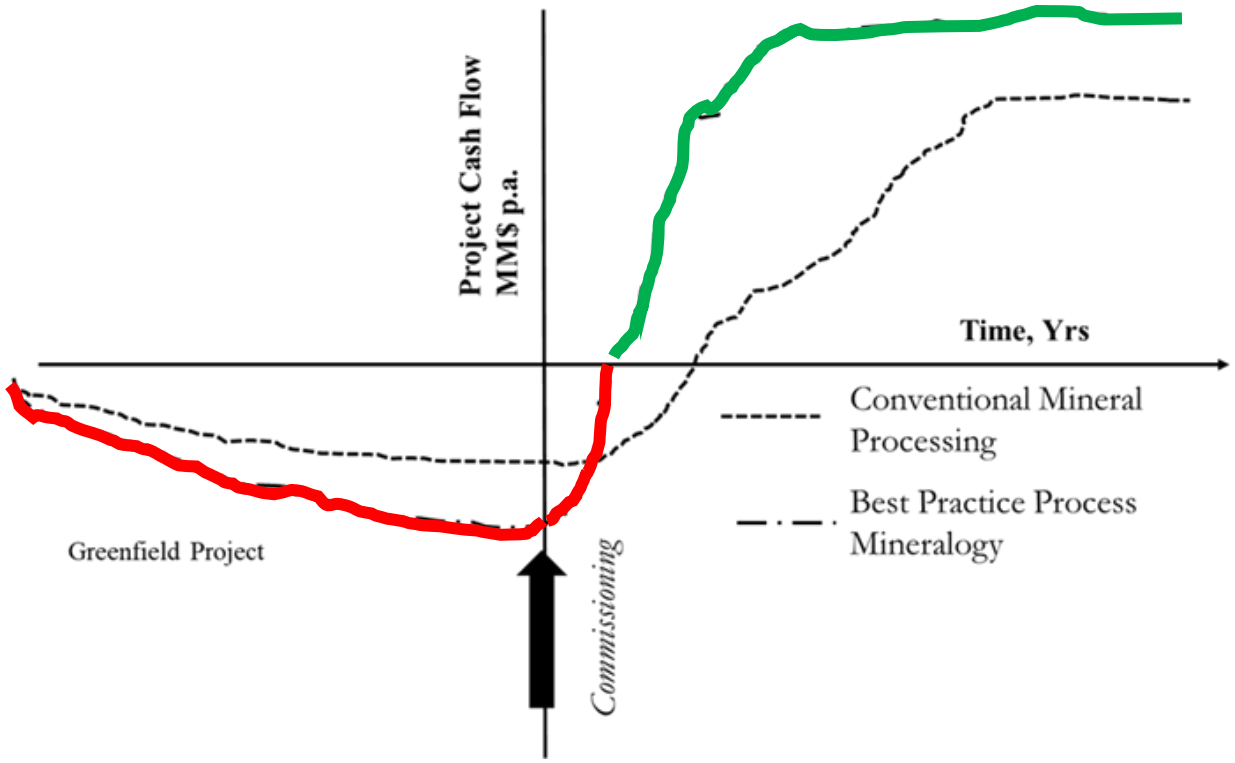


Simplistic illustration of geometallurgical domains, associated with dollars and cents

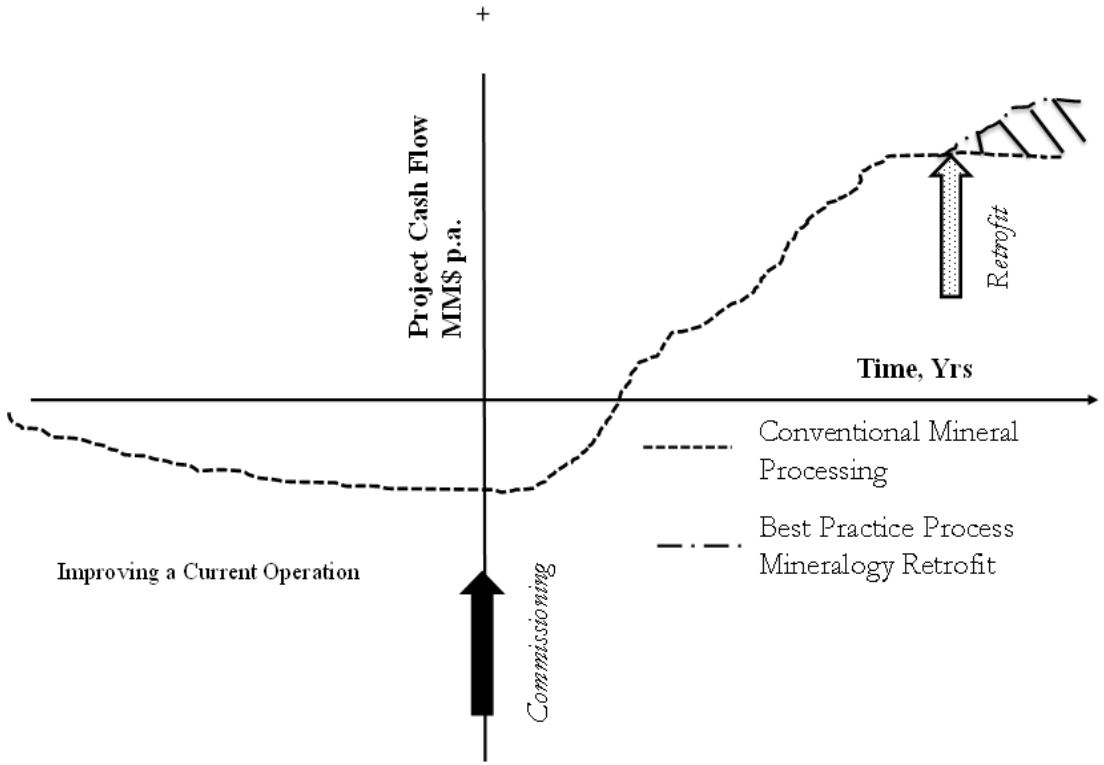
Minerals 2018, 8, 560; doi:10.3390/min8120560

Economic Impacts of Geometallurgical Approaches

"Geometallurgy unlocks the potential of mineral deposits by bridging the gap between geology and metallurgy, enabling smarter decisions and sustainable practices in mining."



Impact of Process Mineralogy on Greenfield operations. Lotter et al., (2018)



Impact of Process Mineralogy on retrofits to existing operations. Lotter et al., (2018)

Emerging Technologies in Metal Extraction

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Purpose

- Unlocking value out of complex ores
- Reducing impact of waste
- Reducing energy inputs
- Maximising resource utilisation
- Examples →

Bio-Technology

1. Bio-energy
2. Bio - chemicals
3. Bio - treatment of complex ores (BIOX - Gold)
4. Bio - water treatment etc.

Hydrometallurgy

1. Less energy intensive than pyrometallurgy (potentially lower costs)
2. Control on emissions
3. Process control
4. Alternative Green Chemistry lixiviants under development

Recycling/ Reprocessing

1. Circular Economy
2. Tailings - Secondary Resource
3. Metal Recycling - Secondary Resource. E.g. Autocats, Batteries, etc
4. Repurpose - Waste valorisation

Synergetic Framework e.g Manganese

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Geo - Block Model

HG – High Grade (Market)
LG – Low Grade (Waste?)

Metallurgical Model
Flowsheet Development

PYROMET

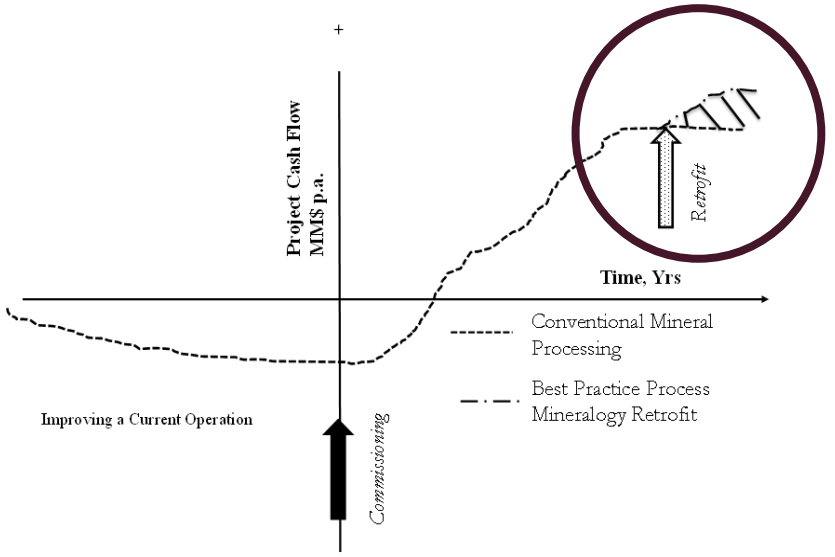
HYDROMET

Economic Model

Main Market

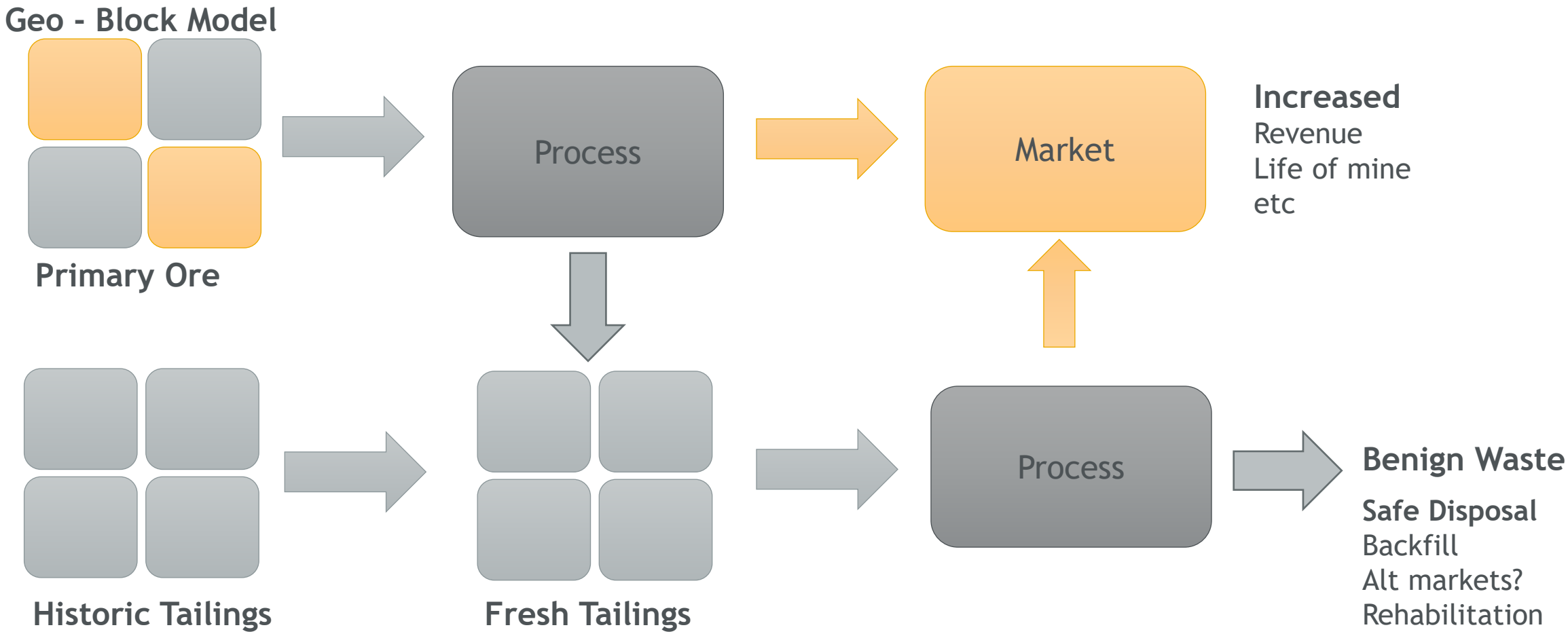
Alt Market

Increased
Revenue
Life of mine
etc

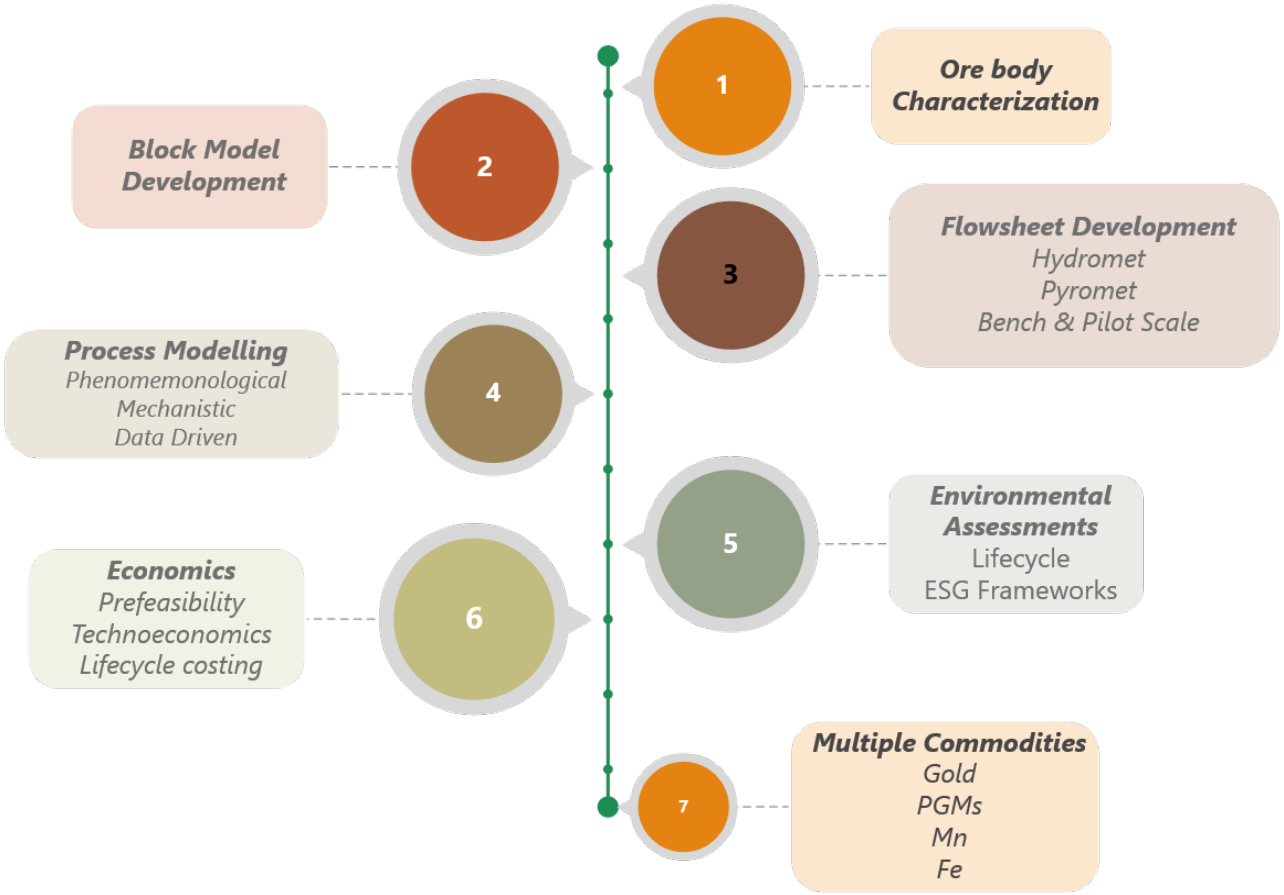


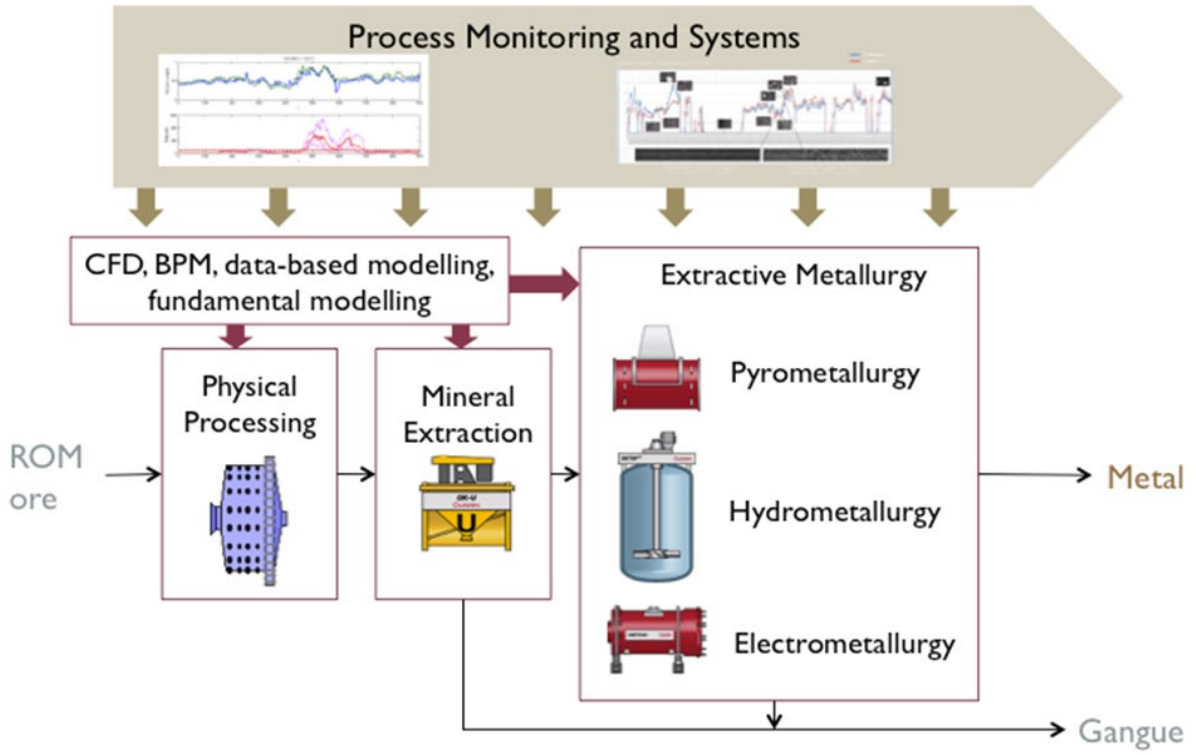
Impact of Process Mineralogy on retrofits to existing operations. Lotter et al., (2018)

Synergy Model, e.g. Gold, PGMs



Extractive Metallurgy





Extractive Metallurgy

- Industry Partners and Collaborators
- We offer industrially funded projects with real-world application and impact

Thank you
Enkosi
Dankie