Climate neutrality, the circular economy, and earth materials

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Earth Materials for a Sustainable and Thriving Society

UNESCO Lecture Series

Organised in collaboration with IUGS and iCRAG
Key points

*Reimagining metal supply to meet demand and societal expectations*

- Climate neutrality – energy transition, metal use, and supply
- Circular economy – metal reuse and recycling – necessary but challenging
- Responsible primary extraction – technical and social change
- Joining up the value chain – optimizing collaboration from source to customer to reprocessor
Climate, energy, and metals

Increasing and increasing......
Metal production and reserves – supply

- Increasing production
- Increasing reserves
- Reserve/production ratio – relatively constant
- Metal availability – reserves and resources – is not an issue in the short to mid-term
- Providing metal with minimum impact is the challenge

Adapted from Jowitt et al., 2020; USGS data
UN Sustainable Development Goals – SDGs

- Mining and metal production – linked to all SDGs

- Metal use is critical to several SDGs:
  - Major component in renewable energy and electrification of transportation – SDGs: 1, 6, 7, 9, 11, 12 and 13

- Negative impact of metal extraction and use must be reduced:
  - SDGs: 3, 8, 11, 13, 14, 15, 16
Circular economy – importance and challenges
Circular economy?

Recycling Input Rates (EU Raw Materials Scoreboard)

- Lead: 75%
- Silver: 55%
- Copper: 17%
- Neodymium: 1%
- Lithium: 0%
Circular economy?

RE-USING MINE TAILINGS

- 350 Gt produced worldwide each year
- 20 times all municipal solid waste
- 70 billion elephants (Earth to Mars)
- By far our largest wasteform

Panasqueira Mine, Portugal  (F. Wall)

'Circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems.'

*(Ellen MacArthur Foundation)*
‘Designing out waste and pollution’
Don’t’ forget earth materials determine many characteristics of a mine

Geology
• Grade of ore
• Composition and mineralogy of the ore
• Size of ore deposit
• Depth of ore deposit
• Location of ore deposit

Mining and Processing
- Resource efficiency
- Energy use
- Carbon footprint
- Water use
- Environmental contamination
- Financial profitability
- Biodiversity and landscape degradation

Corporate Social Responsibility
- Health and safety and well-being of workforce
- Community interaction and well-being
- Contribution to national economy
- Compliance with regulatory frameworks
- Land use during and after mining

Geometallurgy
‘designing out waste and pollution’

Geological Exploration

Environment and Social responsibility

Desk study
First results, e.g. preliminary economic assessment
Prefeasibility study
Feasibility study

Mine

Life Cycle Assessment

See Wall et al (2017) Elements, 13, 313-318 for discussion of use of LCA in responsible sourcing of rare earths
Start early with life cycle assessment

- Desk study
- First results, e.g. preliminary economic assessment
- Prefeasibility study
- Feasibility study

Environment and Social responsibility

Mine

Life Cycle Assessment

Start early with life cycle assessment

- Desk Study
- Exploration and Field Study
- Pre-Feasibility Study
- Bankable Feasibility Study
- Construction
- Operation
- Closure

Data quality and availability
Ability to influence the project

Life Cycle Assessment
‘keeping products and materials in use’

Do you need a new smartphone?

Rio Tinto customers in North America will have a new scrap take-back solution for production of high quality alloys made with recycled content.

‘and regenerating natural systems’
‘Sustainable mining’ – two views – both good!

1. Supply chain to mines

   ‘Public’
   (direct neighbours and societal acceptance)

2. ‘Banks and shareholders’

   Governments (legislation)

   Mines

   Manufacturing supply chain

   Consumers
Sustainable mining – view 2
Sustaining the life of the metals – thinking ahead to where the metals will go
Efficient and responsible primary production

• Discovery – data
• Extraction challenges and solutions
• Critical minor metals and recycling
Discovery challenge

• Need for new discoveries – “quality” resources
• Select the best area to explore – understanding metallogeny and fertility

“Quality” resource:
• Metal content – grade
• Size and geometry
• Suitability for mining
• Good recovery of metals
• Environmentally benign
• No use-conflicts

Copper deposits – types with distinct characteristics concentrated in different regions – countries
Remote data

- Geophysics
  - Satellite and airborne
  - Ground surveys
- Remote sensing
  - Satellite and airborne multispectral data
- Geochemistry
  - Large-scale sampling – streams, lakes, soils
  - Microbial data

Stein et al., 2015
Discovering quality resources

• Integrated knowledge and technology
  • Field work – geology, geochemistry, geophysics
  • Real time data – field sensors, drones
  • Data – integration, AI/ML

• Drilling: rapid testing, minimum impact
Mineral alteration data

Spectral data – raw SWIR assemblages

Kişladağ project – Eldorado Gold
Interpreted alteration mineralogy

Mineral distribution: aiSIRIS* Spectral Contribution (‘SC’) data

- Machine learning spectral recognition software – library of >1M spectra

>35% white mica

>50% kaolinite

>25% tourmaline

>10% alunite

* Artifical Intelligence Spectral InfraRed Interpretation System

Kişladağ project – Eldorado Gold; AusSpec
Creating quality

Data collection → Interpretation → Integration → Understanding
Mining challenge – scale

- Breaking, moving and grinding rocks – energy requirements
- Vast amounts of waste – long-term management, unacceptable disasters
Innovation and solutions

• Electrification

• Automation
  • Improved safety and efficiency

• Improving selectivity
  Separate metal-rich rocks from waste during mining
  ➡️ Less rock processed, less waste
  ➡️ Lower energy consumption per unit

• Digital transformation – smart mines

• Mine to metal
In situ recovery – no mining, no waste

• Dissolve the metals in place – underground
• Already used for potash and uranium
• Advantages
  • Limited footprint, low cost
• Challenge
  • Water management
Capturing by-product metals

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Cu concentrate – **products, byproducts, byproducts/deleterious elements**

Mo concentrate – **products, byproduct**
Mineral resources – a critical input

• Increasing metal demand – driven in part by SDG goals
• Efficiency and recycling – critical
• New resources will be required
• Responsible discovery, delivery and recycling
• Input to the circular economy – must be aligned with SDG goals
Joining up the value chain

Vision

• Mining – a valuable and responsible input
• Efficient use of metals and design of materials
• Sustainable use, capture and recycling of metals – minimum loss
• Completion of the circular economy
• Mining companies become metal/material suppliers/owners within an integrated circular economy
Collaboration

• Challenges – complicated and complex
  • Maximize benefits and minimize impacts
  • Meet societal needs – metal use and ESG and SDG

Collaboration and partnerships – necessary

• Indigenous people and communities, companies, technology providers and consumers
• Different sectors and disciplines

HiTech AlkCarb, Italy, EU H2020 Grant Agreement no. 689909

HiTech AlkCarb, Malawi, EU H2020 Grant Agreement no. 689909