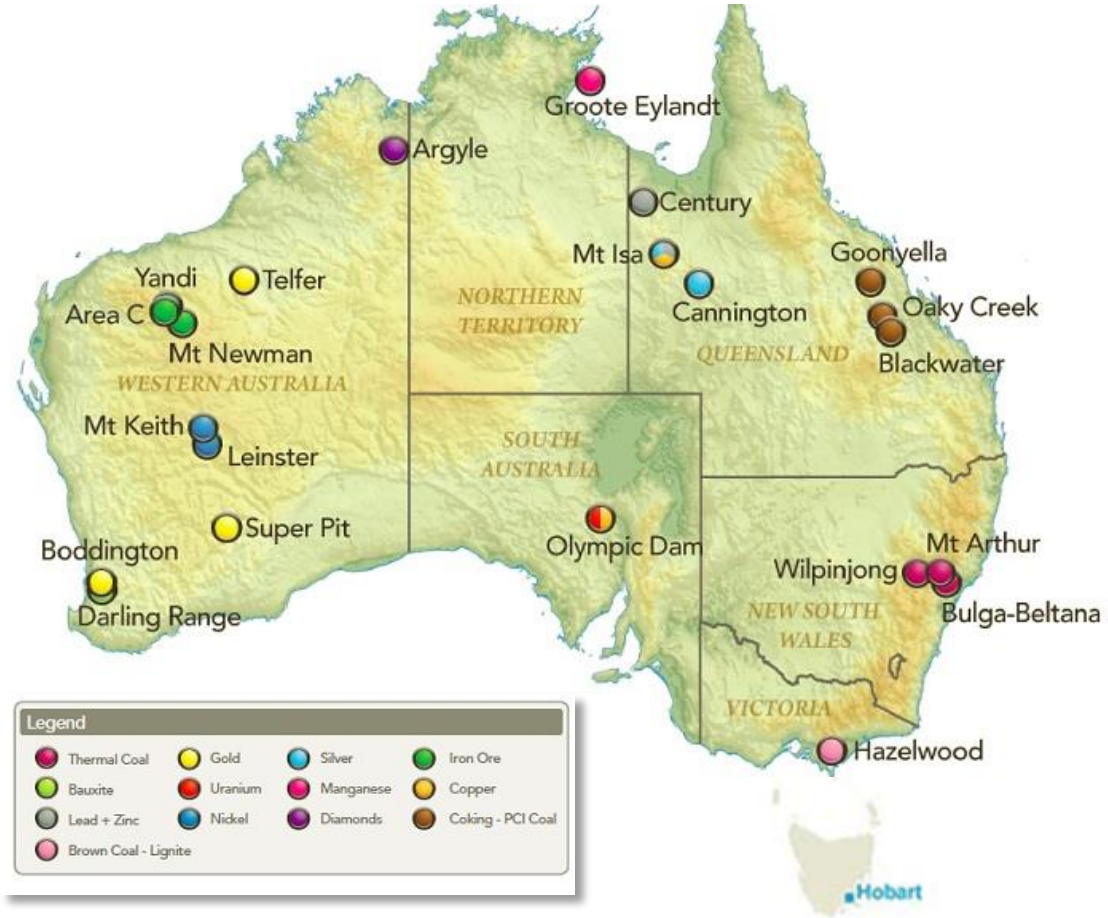
Expanding the Extractive Metallurgy Discipline

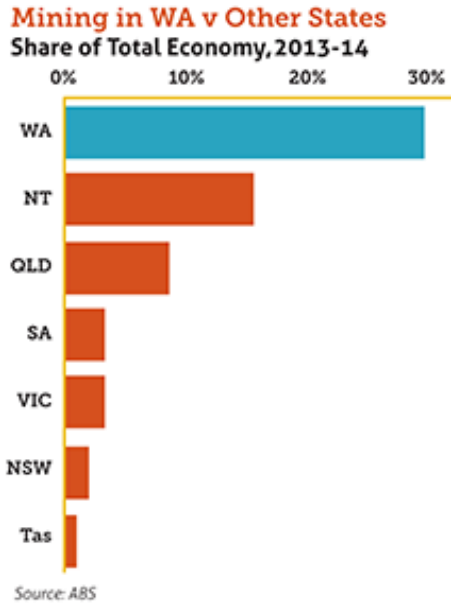
Louisa O'Connor & Sam Spearing

20.10.2017

A review of the importance of the mining sector
The mining industry by State in Australia

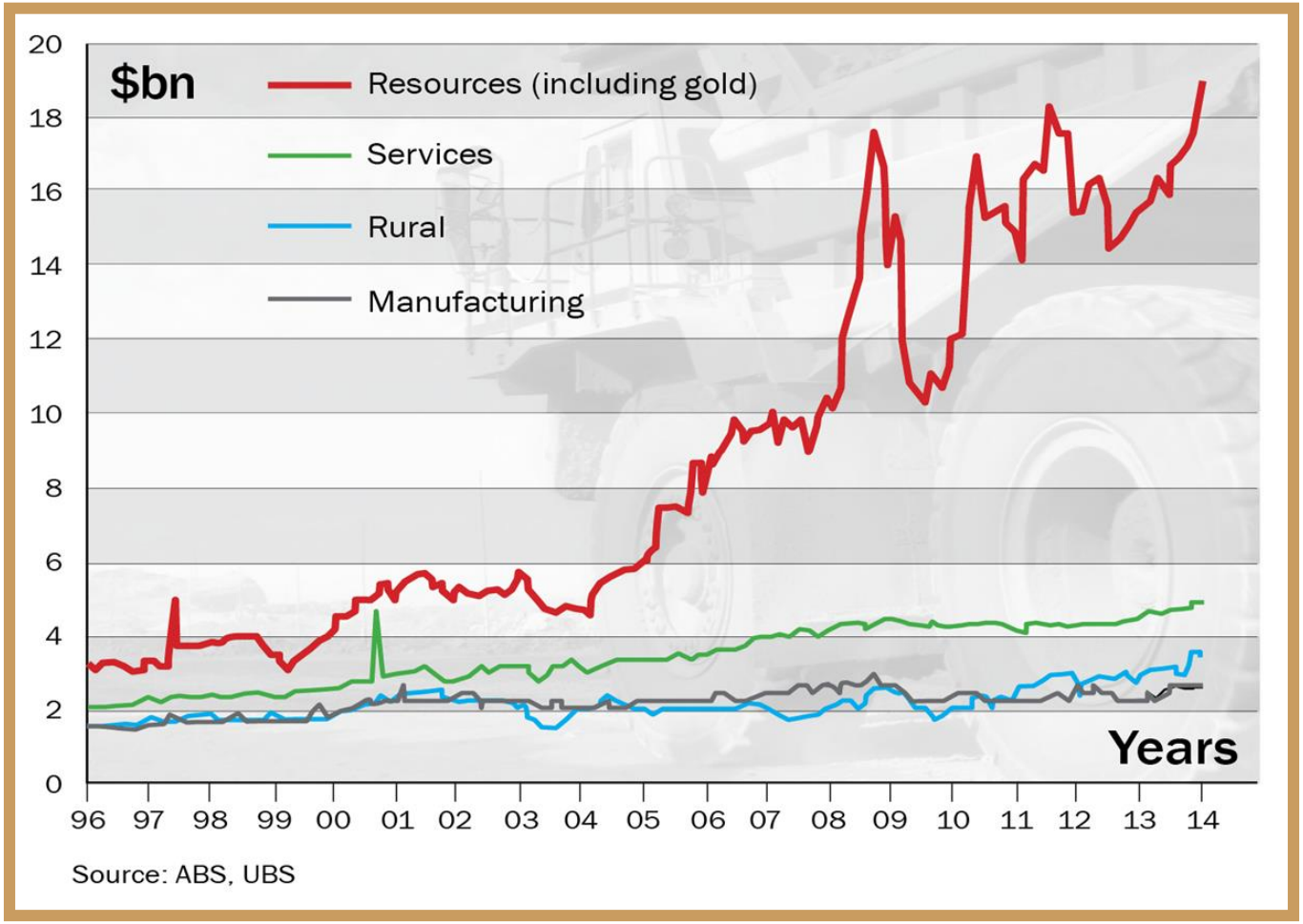
Mining is a key driver in the Australian economy and will remain so.





Curtin University

Australian Resource Sector Supply Growth

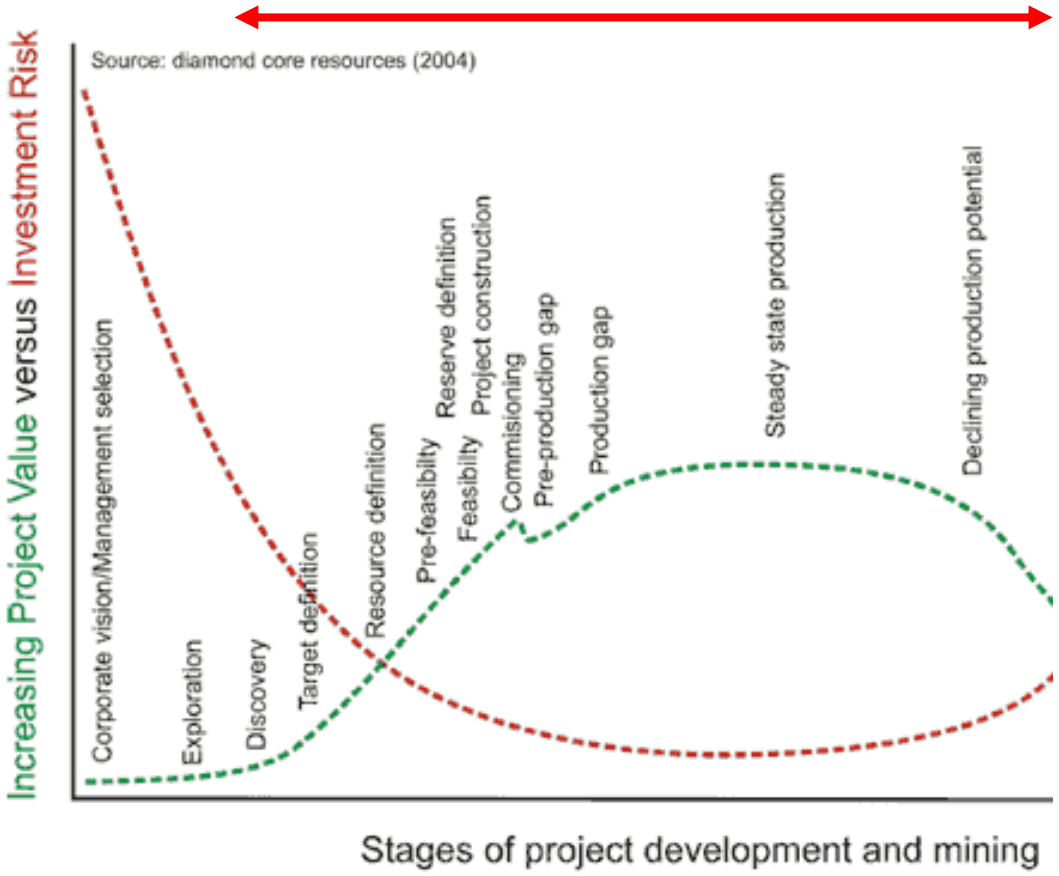


Curtin University

Ideal metallurgical involvement during the life of a mine

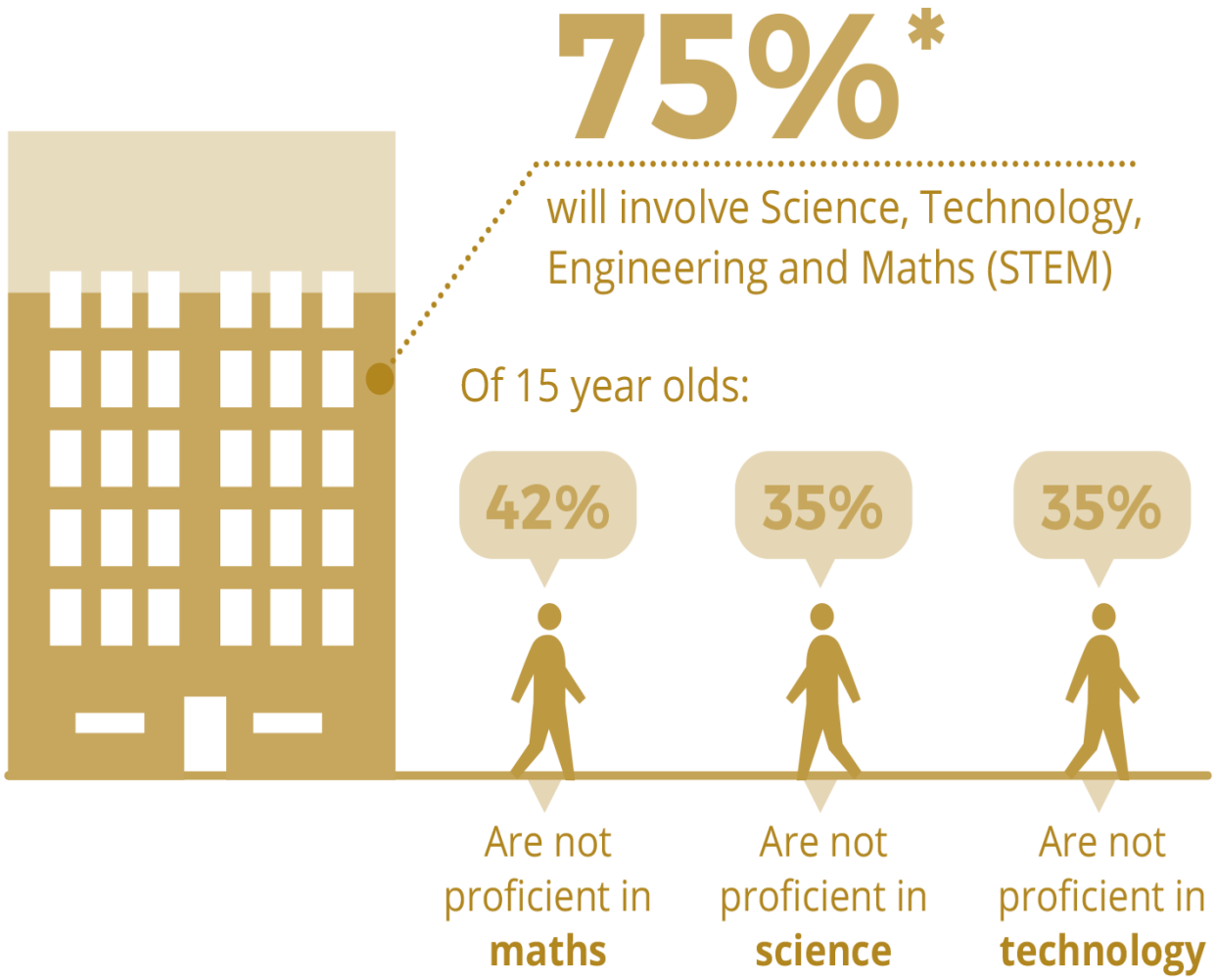
Mine stages

- The graph shows a typical graph of mining risk and value during a mine's life.
- Note that in the 1970s, reclamation was not considered part of a mine life cycle.



Curtin University

Future employment



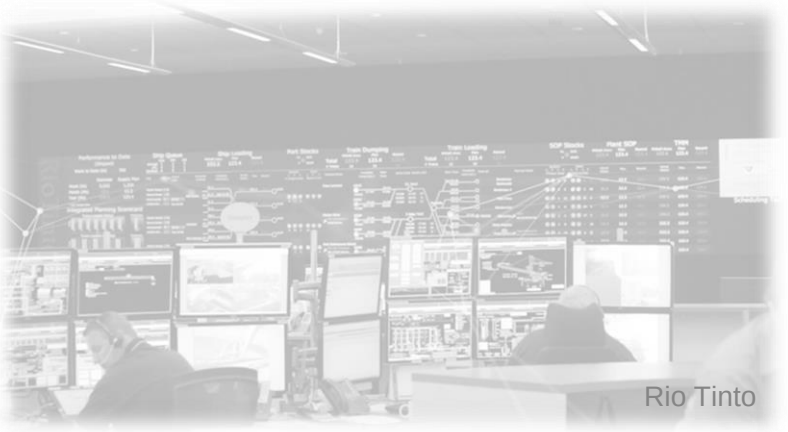
Source: Foundations for Young Australians, 2015

Curtin University

Australia's innovation contributions to mining

Examples of Australian led mining related innovations:

- METS contribute over 75% of Australian mining patents (Source: ipaustralia.gov.au)
- 60% of the mining software solutions (eg; Whittle Mine Planning) in use around the world is Australian made (Source: srotechnology.com).
- Warman slurry pump.
- Kelsey centrifugal jig.
- Froth flotation (Prof. Graeme Jameson).
- SmartCap for stopping driver fatigue.
- Mine of the Future - Rio Tinto


Rio Tinto

Curtin University

METS Ignited

The Challenge

Currently the needs of METS, mining companies and researchers are not always aligned and solutions are not always in sync; innovations are not pursued collaboratively, resulting in implementation risk, low rates of commercialisation and sub-optimal benefit.

METS IGNITED
Engage in our future

Six key Trends in the Evolution of Mining

1. **Plugged In and Switched On**
   Digital technologies, data analytics and automation along with greater mobility and increasing connectivity is creating exciting opportunities for the mining industry.

2. **The Era of Accountability**
   Mining companies are expected to be good corporate citizens, meeting public expectations regarding accountability, sustainability and environmental responsibilities.

3. **New supply, New Demand**
   Increasing urbanisation and rapid development of emerging economies will continue to raise demand for mineral resources.

4. **The Knowledge Economy**
   An opportunity for developed countries to export advanced knowledge, skills, expertise and technology.

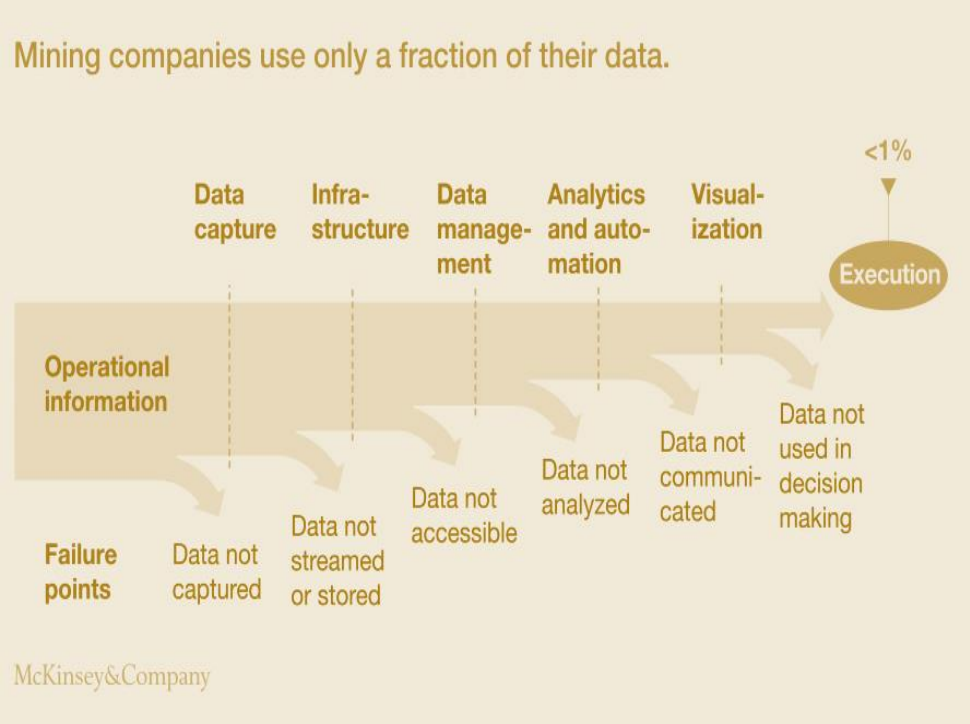
5. **The Innovation Imperative**
   Companies require new solutions and technologies to become more productive.

6. **Rethinking our Reserves**
   The need for continued exploration and solutions that extend the life of a mine.

Curtin University

Big data in mining

Live monitoring and processing of huge amounts of data in real time is becoming a useful reality on mines especially for:



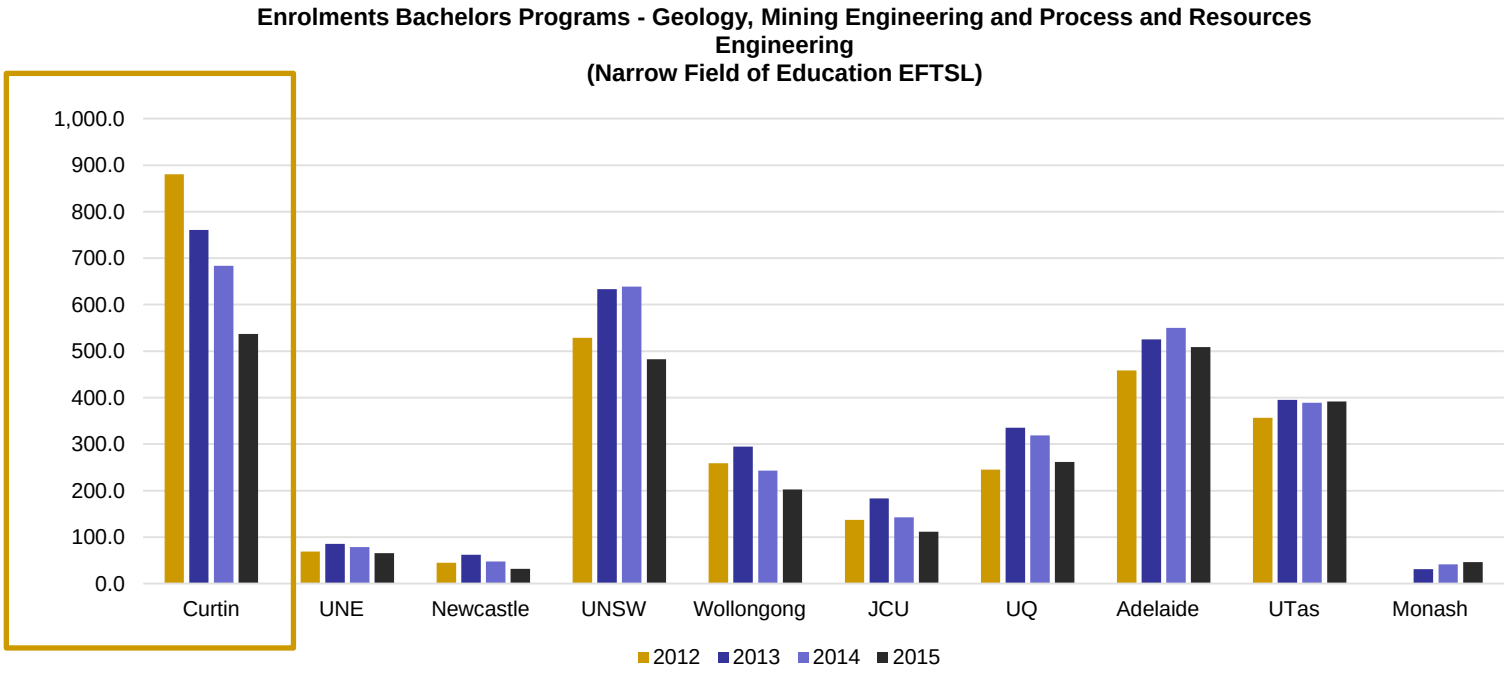
- Remote or autonomous equipment control.
- Instrumentation (key system and conditioning monitoring).
- Geology, grade planning (geomet), mine planning and processing.
- Spatial information.

Curtin University

Mineral resources training and education

The industry suffers from a *poor public image* based now of misperception and misinformation.

The mining industry now and in the future should be appealing to *school leavers* if marketed correctly as it uses:

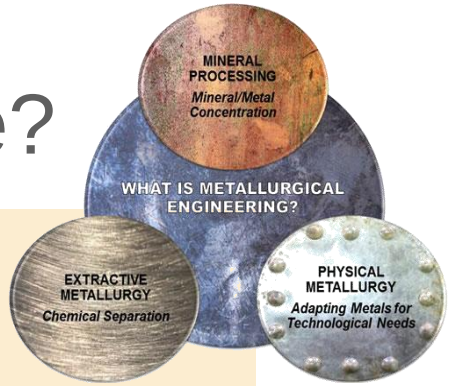


Curtin University

The processing challenges facing the mining industry of the future

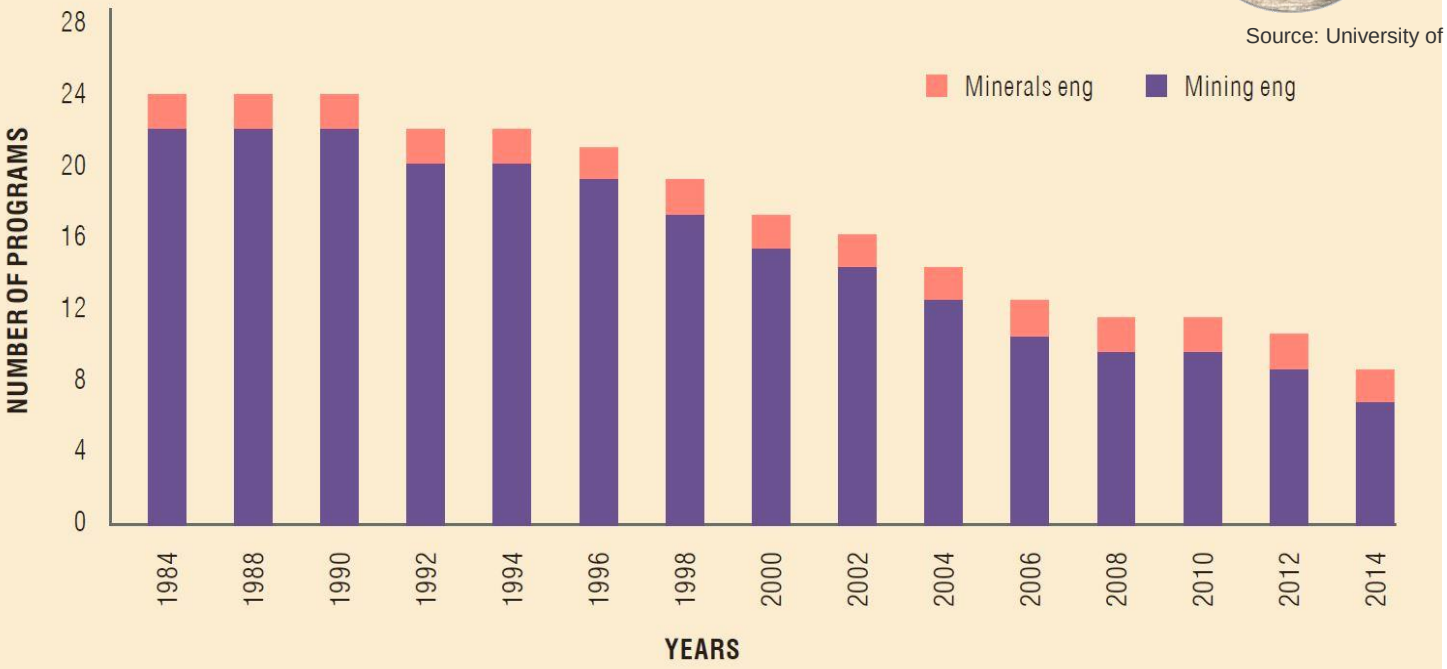
- Complex ore with generally low grades and high mining costs (deeper underground), leading to processing issues.
- Extreme ore variability.
- Increase in costs for processing: water, chemicals, energy and safe waste disposal.
- Fluctuating commodity prices influencing sustainability of long term operations.
- More strict licence to operate, environmental and social/sustainability requirements.

Where is the metallurgical discipline?



Source: University of Utah

Figure 1. Mining and minerals engineering departments in the last 30 years in the USA (Deniz, 2015).



Clearly not in a good and healthy space!

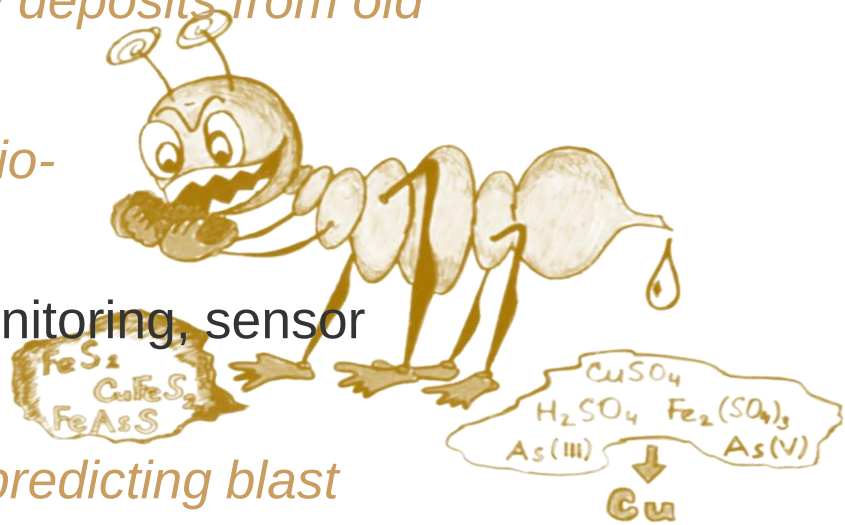
Curtin University

Why is it in *decline*?

- The metallurgical discipline needs to be ‘remarketed’. It is lost in the general understanding of *mining*. It’s not seen as standalone, professional role by many.
- There needs to be better *communication* about studying metallurgy at university, or re-train as a metallurgist post graduation of the first degree.
- Geologists can be turned along with chemical engineers. Geologists provide a different perspective to the role as will chemical engineers.

New or under-developed opportunities

- Geometallurgy – *both engineering and a science…*
- Urban mining and general recycling
- Mine waste management - tailings dams, waste dumps and backfill. *Are tailings dams our new deposits from old operations?*
- New biological processes – *revisiting bio-hydrometallurgy*
- Advanced processing and real time monitoring, sensor technology.
- DTH data (imagery and geophysics) - *predicting blast fragmentation and processing performance by rock characterisation*.



http://orion.chemi.muni.cz/biosulfur/

Geometallurgy

Geometallurgy is an important addition to any evaluation project or mining operation. It should be viewed as a discipline in its own right. It is a comprehensive characterisation of ore mass, which integrates along the Mine Value Chain.

Key points of **geometallurgy**:

1. Seeks to maximise the Net Present Value (NPV) of an orebody
2. Minimises technical and operational risk.
3. Promotes sustainable development, ensuring that all stages of extraction are optimised from a technical, environmental and social perspective.
4. Uses innovative technologies.
5. Geometallurgy thrives upon operational stakeholder collaboration - knowledge sharing and improved data acquisition and interrogation.

BETTER BUSINESS OPTIMISATION. BETTER UTILISATION OF STAFF.

TARGETED, REALISTIC, KPIs.

(source: Dominy & O'Connor 2016)

Curtin University

Urban Mining (example)

Comminution –
Energy input?

Magnetic separation

Flotation –
Metals/alloys from circuit board ‘gangue’…

Leaching –
Floatation residue

Recovery –
Which metals? Sn, Cu, W, REE??

Saleable product –
Concentrates? Or, is urban mining to scope in adding value and creating actual products?

Sorting –
What technologies are utilised?

Source: Leon Aurnhammer

Curtin University

Mine Waste Management

Environmental issues?

Structural integrity?

Potential source of Backfill? (Engineering Properties?)

How old is the dam/pile?

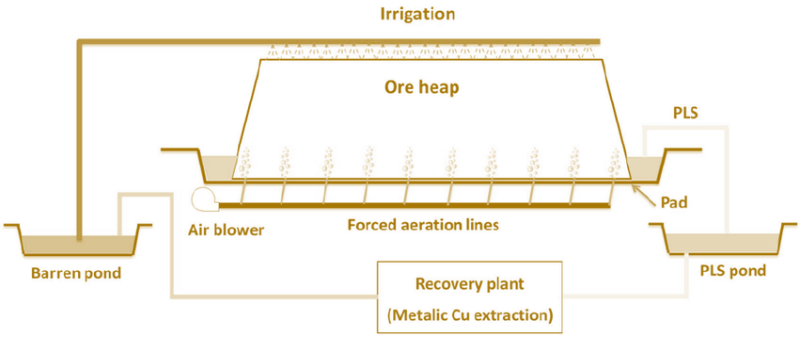
- Is there a potential secondary ‘deposit’

(a geometallurgical study required)

Potential source of ‘industrial mineral’ usage ? Could it replace primary industrial Minerals?

Bio-hydrometallurgy – Bugs!

- It is not new to utilise bacteria for leaching purposes, but new innovations are sought, especially with an upsurge in interest of heap leaching and bug capabilities.



- European initiative – FAME

(Flexible and Mobile Economic Processing Technologies)

Aimed at small and low-grade ore deposits, targeting "critical metals" (Reichel et al, 2017)

Source: J. Petersen & Core Resources

Curtin University

Sensors and real-time data collection

- We have the automation of trucks, now look at the automation of plants – cut the tinkering!
- Brings together technical knowhow and computational abilities.
- CRCSi – innovation through spatial technology – great for geometallurgical aspects and production.
- Real-time data - can significantly decrease risk for day-to-day operational decision making.

Down-the-hole (DTH) – Future scope

- Use of geophysics further into the mine value chain. Innovative? Essential collaboration.

Key predictive outcomes:

- Blasting fragmentation
- Ore mass imagery
- Mineral textures
- Assay? Pulsed Fast and Thermal Neutron Analysis (PFTNA)
- ‘Elastic’ gangue minerals –energy consumption during comminution

Future Education Innovations

- Delivery units and courses on flexible terms.
  - Block content teaching/ Intensive training
  - Online where suitable
  - Block taught laboratory sessions
  - Stackable learning – 'pick-n-mix'
  - Integrated professional development with postgraduate courses – learning more and in-depth, whilst climbing the ladder…

Overarching necessity is to combat negative press and media misinterpretations and strategically market to prospective students and graduates…***New and Life-long-learning***.

Thanks for listening

Source: Anderson Williams

Curtin University