

Eco-efficient processing – fantasy or reality?

Peter Craven

EuroMine Expo, Skelleftea, June 2010

Eco-efficiency – the established definition

"Creating more goods and services while using fewer resources, and creating less waste and pollution"

- Admirable ambition, but too glib in the mining context

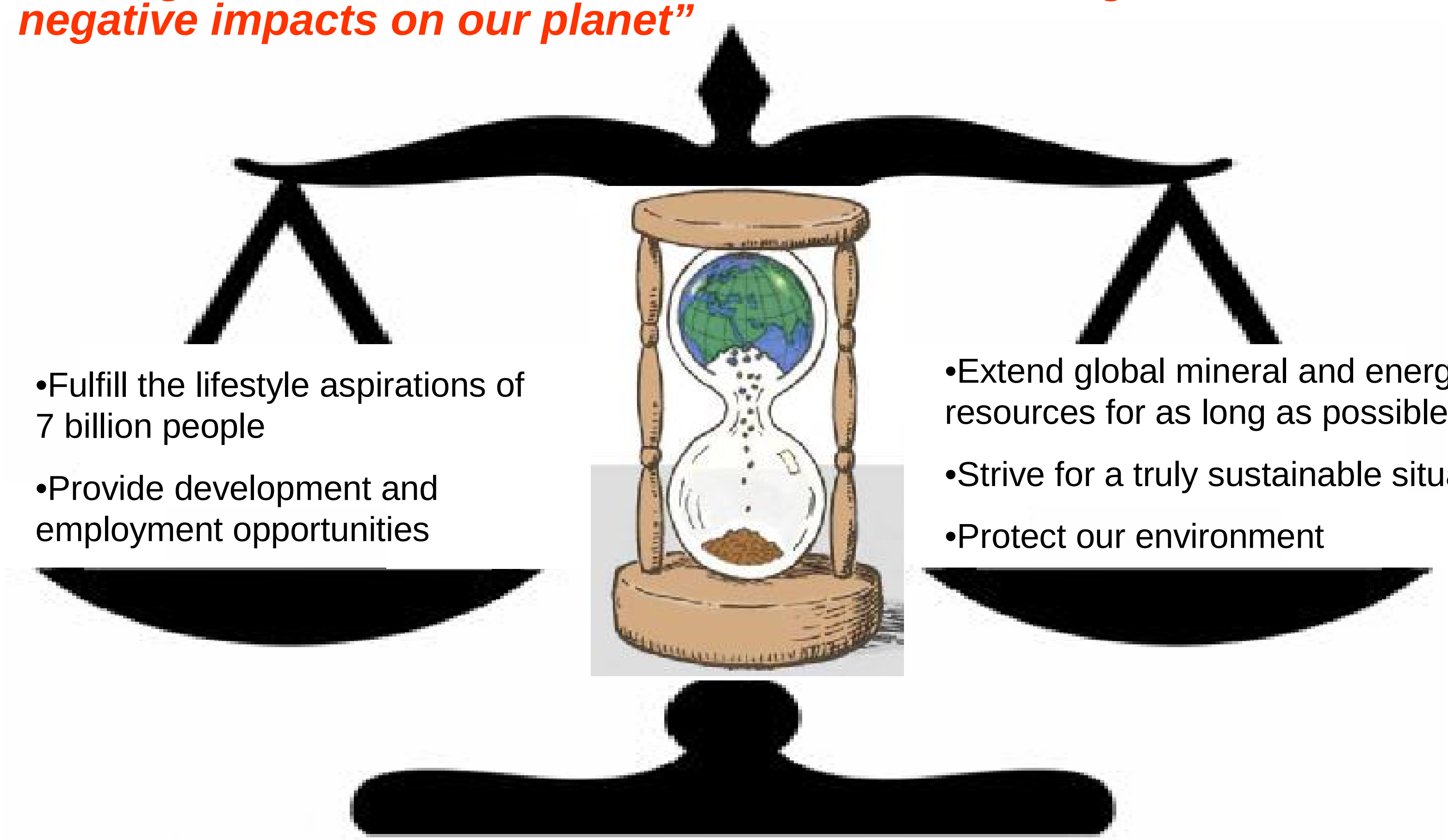
- No sense of the competition between
  - Increasing demand, *versus*
  - Economic realities faced by mining companies, *versus*
  - Environmental and sustainable consequences

- In this competition, the economic realities always win, unless society and governments tilt the balance

Definition sourced from "A European Eco-Efficient Economy". Report for the 2009 Swedish Presidency of the European Union. Nielsson, et al . Stockholm Environmental Institute 2009

Eco-efficiency – what do I think it means?

"Balancing the socio-economic demands of our time against the negative impacts on our planet"



- Fulfill the lifestyle aspirations of 7 billion people
- Provide development and employment opportunities

- Extend global mineral and energy resources for as long as possible
- Strive for a truly sustainable situation
- Protect our environment

It's clear that we have to strive for some compromise

“..there is greater detriment from mining than the value of the metals which mining produces.” *Agricola (1556)*

MINTEK

Producing 1kg of gold….

- requires 140kg cyanide
- requires 700m^3 water
- consumes 25MWh of electricity
- produces 15t of CO_2
- creates 2,000t of tailings

Coal mining in the Appalachian Mountains …

- has damaged >1 million acres of forest
- has buried more than 1,000 miles of streams
- will cost $5-15 billion to remediate

These activities are ongoing

From Mudd G., USGS, Graedel T.

Photo credit: Yale Environment 360

Eco-efficient mineral processing should **idealistically** aim for ….

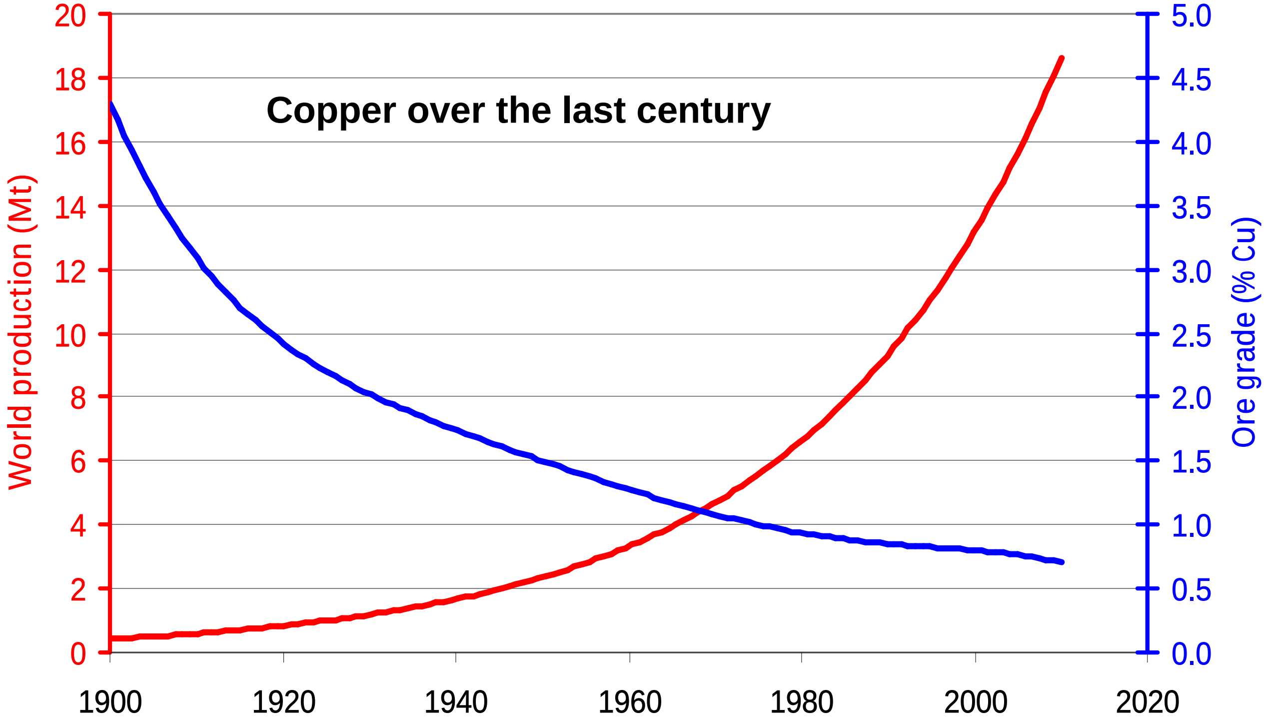
- Complete use of the ore resource
  - *Currently determined by financially optimal Cut-off Grade*
- Minimal energy input
  - *South African minerals and metals industry currently use 18GW out of total 42GW*
- Minimal fresh water input
  - *5 biggest mining companies currently use ~4 billion m^3 annually*
- Minimal carbon footprint
  - *Refining of 1t of aluminium produces 2.6t CO_2 equivalent*
- Zero tailings and effluent discharge
  - *Australia has accumulated 420 million tons of waste rock from copper and gold mining over the past century*
- Zero health and safety hazard
  - *105,000 USA coal mining fatalities between 1900-2009; 1 fatality per ton gold produced in SA; >10 miners die every day in China*

My view on the key factors that will shape the industry over the next century

1. Alarming increase in demand for minerals and metals
2. Deeper, lower grade and more complex ore
3. Competition for water and energy
4. Ore and energy resources in increasingly remote or sensitive locations
5. “Global village” – resources, energy, water and markets in different locations
6. Resource-rich countries drive to “add value” to their resources by local beneficiation
7. Industry investors becoming increasingly risk averse
8. Growing awareness of environmental consequences

Increasing demand for metals and minerals

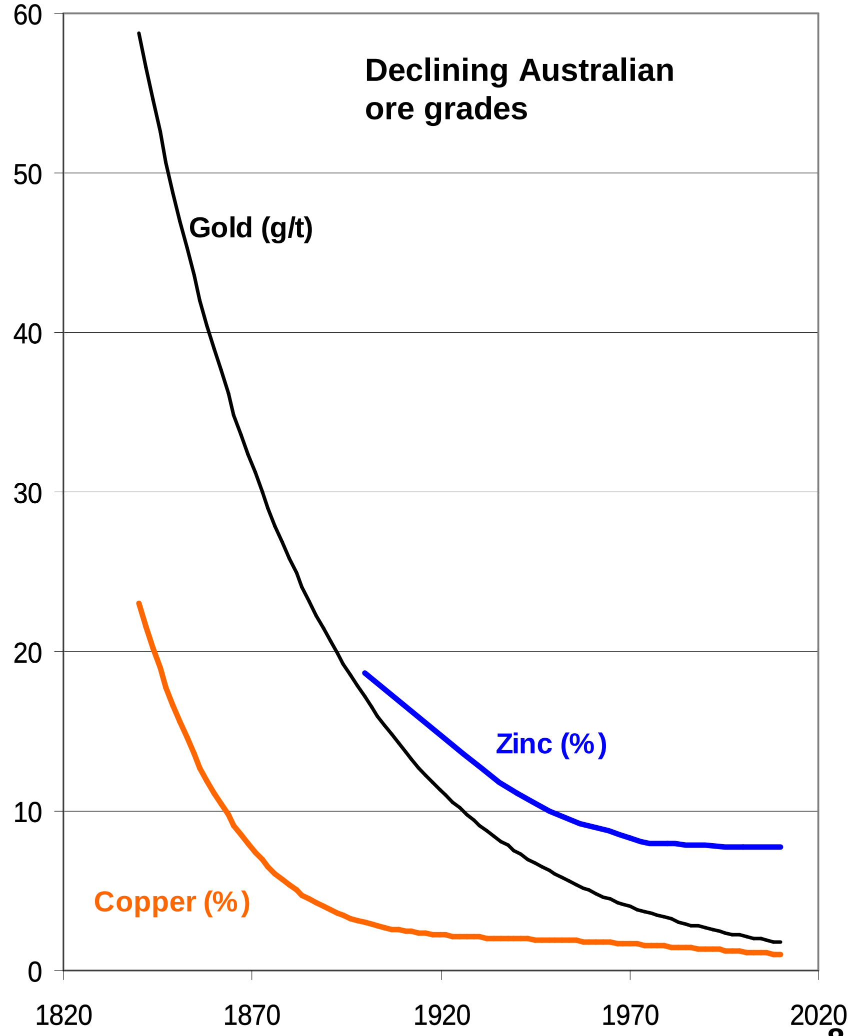
- Great for producers and investors, dreadful for the planet!
- North America, Europe and Japan set the goalposts and aspirations for the developing economies
- The increase in demand will continue for a long time to come!



Computer chips in the 1980s used 11 elements
- they now use about 60 elements!

Deeper, lower grade and more complex ore resources

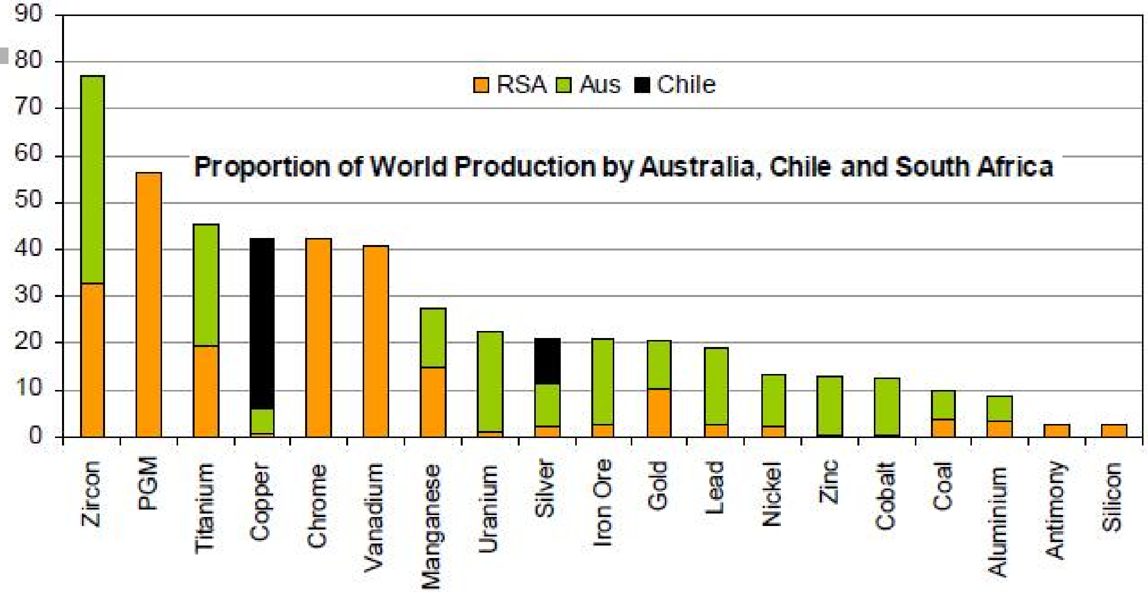
- Deeper resources require more energy
- The lower the grade, the more energy and water is required per ton of product
- More complex mineralogy requires more aggressive processing, generally with higher energy requirement and more reagents – in turn resulting in more effluent



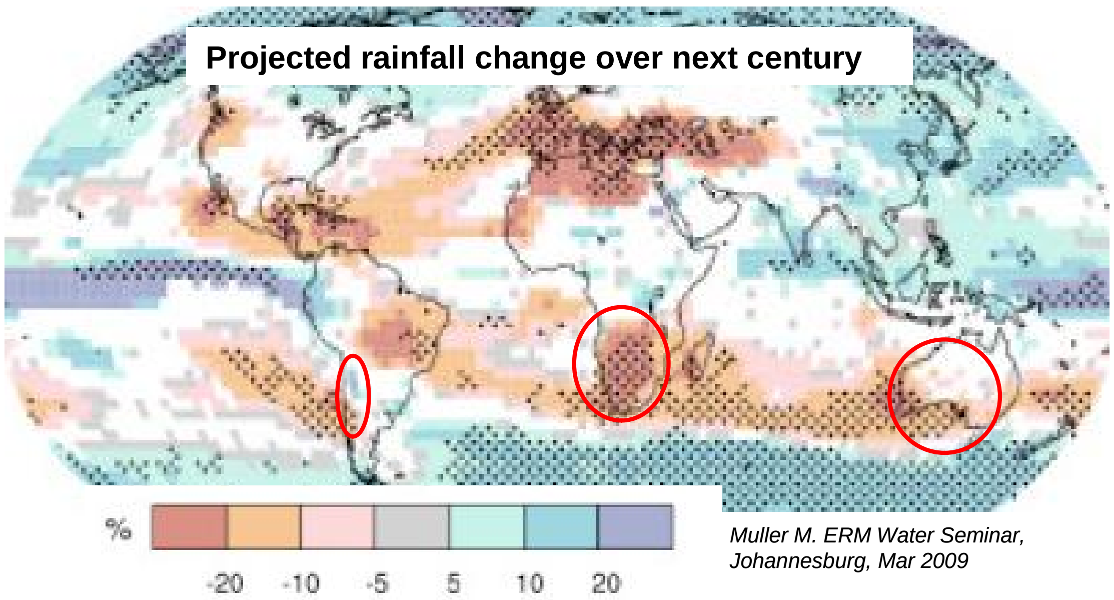
Some of the largest resources of strategic metals are located in the driest regions of the world

Renewable fresh water supply

	(mm/a)
Sweden	406
South Africa	41
Australia	52
Chile	1,219 *(nearly all in south)*



Europe not exempt - first stages of desertification evident in Spain, Portugal, Greece and Italy

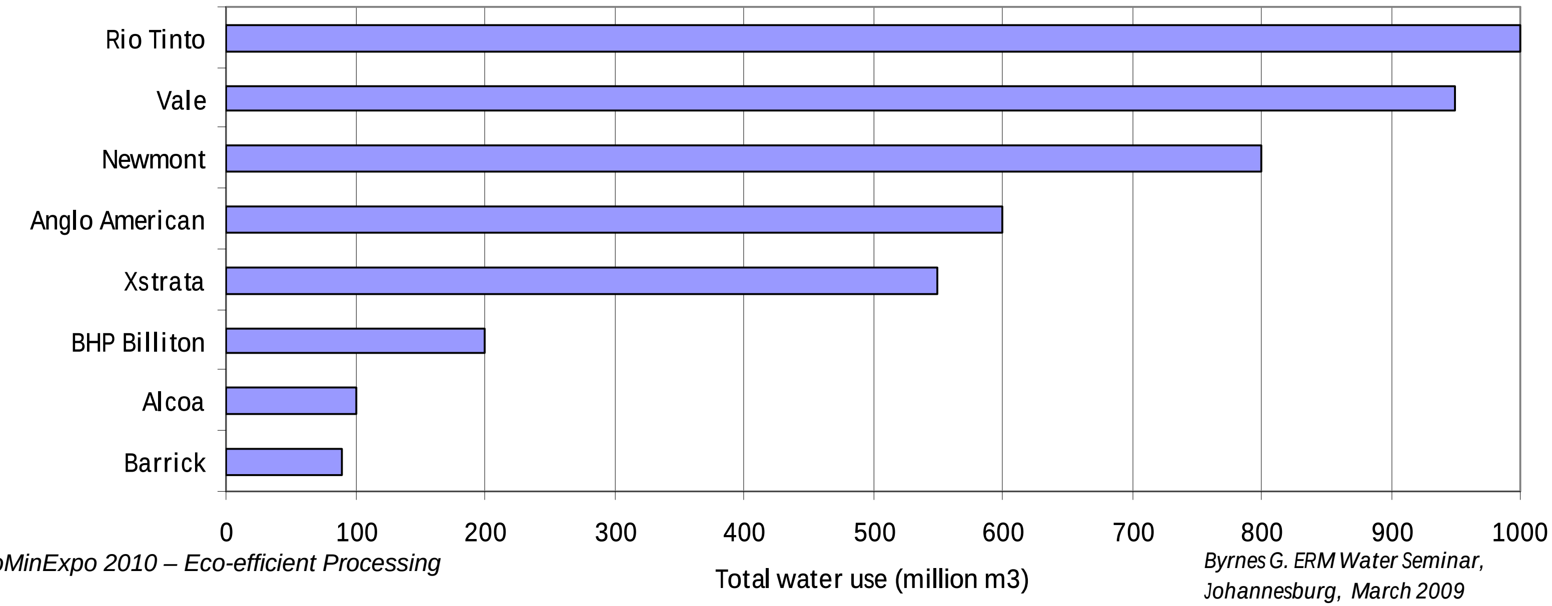


Muller M. ERM Water Seminar, Johannesburg, Mar 2009

Competition for water and energy

In future, water will determine extent of utilization of many ore resources

- Water use in the mining industry is substantially less than the agricultural and domestic sectors, but…
  - is often withdrawn in arid areas
  - Is often an indicator of the quantity of effluent generated
- Tremendous competition for water for domestic, agricultural and industrial use
- Water and energy interlinked
  - coal fired power plants consume ~2t water per MWh
- Arguments revolve around economic value created per m^3 of water used
  - mining claimed to be A$80 versus A$5 for agriculture



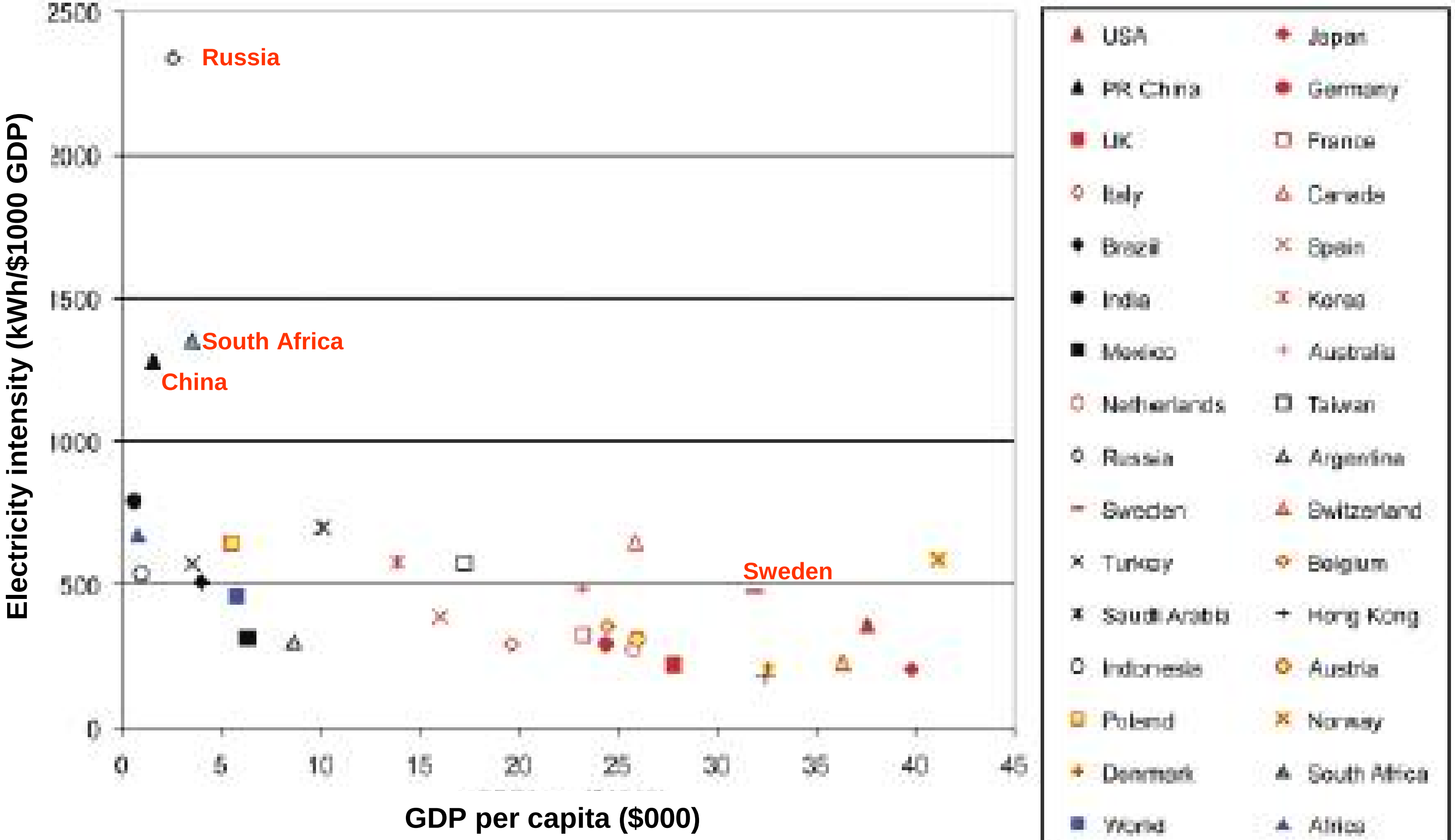
Byrnes G. ERM Water Seminar, Johannesburg, March 2009

Relative locations of ore, energy, water and markets

- Ore resources often remote from markets
- Ore resources often in locations with a water or energy deficiency
  - South Africa, Australia, Northern Chile have water shortage
- South Africa, Australia and Brazil fortunate to have both ore and energy – but is there enough energy?
  - Study in South Africa concluded that 26% of its coal resources would be required to mine and process 50% of its gold, platinum, iron, chrome and manganese resources
  - Good prospects for Congo, Nigeria, Angola, Mocambique, etc
- Do we transport ore to energy, or energy to ore?
  - Aluminium refining in Gulf states, Iceland and Greenland
- Do we beneficiate at mine site, at a location with cheap energy or at the market?

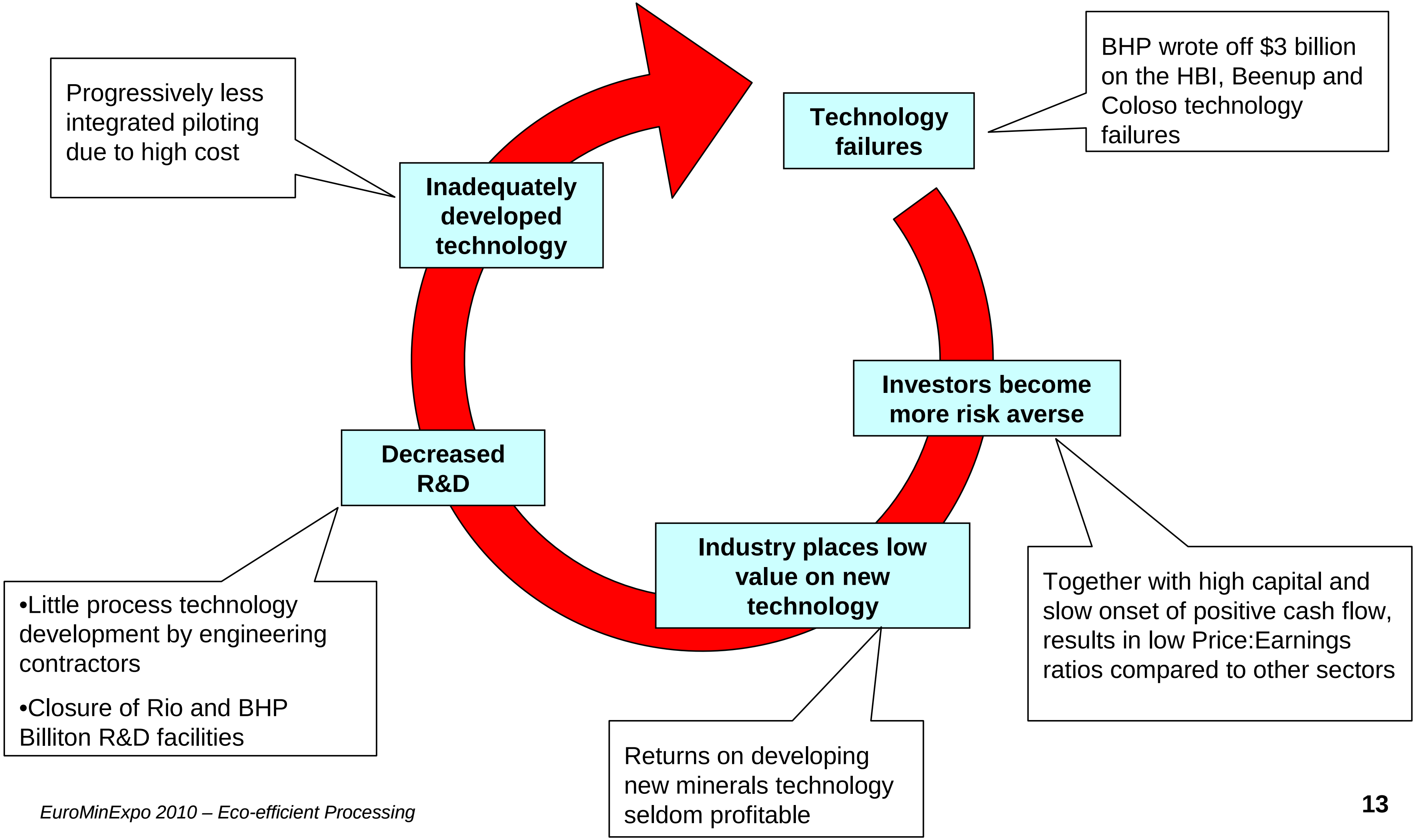
Resource-rich, developing economies (like South Africa) strive for more local beneficiation ….

… but this often comes at the cost of extremely high energy-intensity and greenhouse gas emissions



Roos T. CSIR ScienceScope June 2009

Technology spiral is moving technology development focus from ***revolutionary*** to ***evolutionary***



Revolutionary versus ***evolutionary*** improvements in mineral processing

Evolutionary technology…

- matches industry appetite
- has shorter term benefits
- requires less capital to implement
- Is lower risk (add-ons to existing processes)
- has larger market

Helps cross the
Technology Chasm

A possible strategy for developing Eco-efficient Processing technology?

- Benchmark to identify world best, short-term targets
- Strive for most efficient, complete use of ore resource
- Suite of application-specific (niche) processing variants
- Staged pre-concentration
  - rather than aiming for simplicity
- More emphasis on environmentally-friendly process technologies
  - Rather than economically optimal
- More efficient processing technologies
  - Aim for highest recovery, and minimum energy, water and effluent rather than economic optimum
- Regard water as an expensive, reusable reagent rather than a default carrying medium
- Zero-discharge operations

Concept for 7th Framework Programme Project – *Eco-efficient Industrial Management of Water*

European Technology Platform on Sustainable Mineral Resources

SEVENTH FRAMEWORK PROGRAMME

AngloGold	***IMNR***	***Mintek***	***University of Aachen***
BRGM	***KGHM***	***Outotec***	***University of Leoben***
Commodas	***Lafarge***	***Polysius***	***University of Stuttgart***
GTK	***Lulea University***	***Tecnicas Reunidas***	***University of Wales***
IMN	***Metso***	***TNO***	***Veolia***

1. Water and energy efficient concentration technologies (sensor sorting, HPGR and electric shock comminution, coarse particle and saline flotation, etc)

2. In-circuit and external water and effluent treatment technologies

3. Process flowsheet evaluation and optimisation, operational and regional water management tools

The industry has to evolve in response to these conflicting pressures

- **Higher metal prices**
- **Full pricing for water and energy**
- **End user-based tax on CO_2 emissions**
- **Producer-driven recycling**

- **Increased stimulus for R&D**
- **First World restraint in metal use**
- **Stringent environment compliance**

Thank you, and please visit us

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