NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Faculty of Engineering and the Built Environment
Department of Civil, Mining and Process Engineering

A Contribution to Mineral Beneficiation and Further Value Addition in the 21st Century

By
Prof. Godfrey Dzinomwa

Presentation Outline

- Introduction & Background
- Mineral Beneficiation and Further Value Addition – the Gap
- Strategies and Implementation – national
- Research focused on attaining effective beneficiation – Plant and Laboratory Studies
  - Comminution and Liberation Challenges
  - Flotation optimisation
- Ongoing research
  - Dense Medium Separation & X-ray Concentration (Diamonds, Lithium, Tantalite, Tin)
  - Flotation and Smelting
  - Green Hydrogen applications in mineral beneficiation

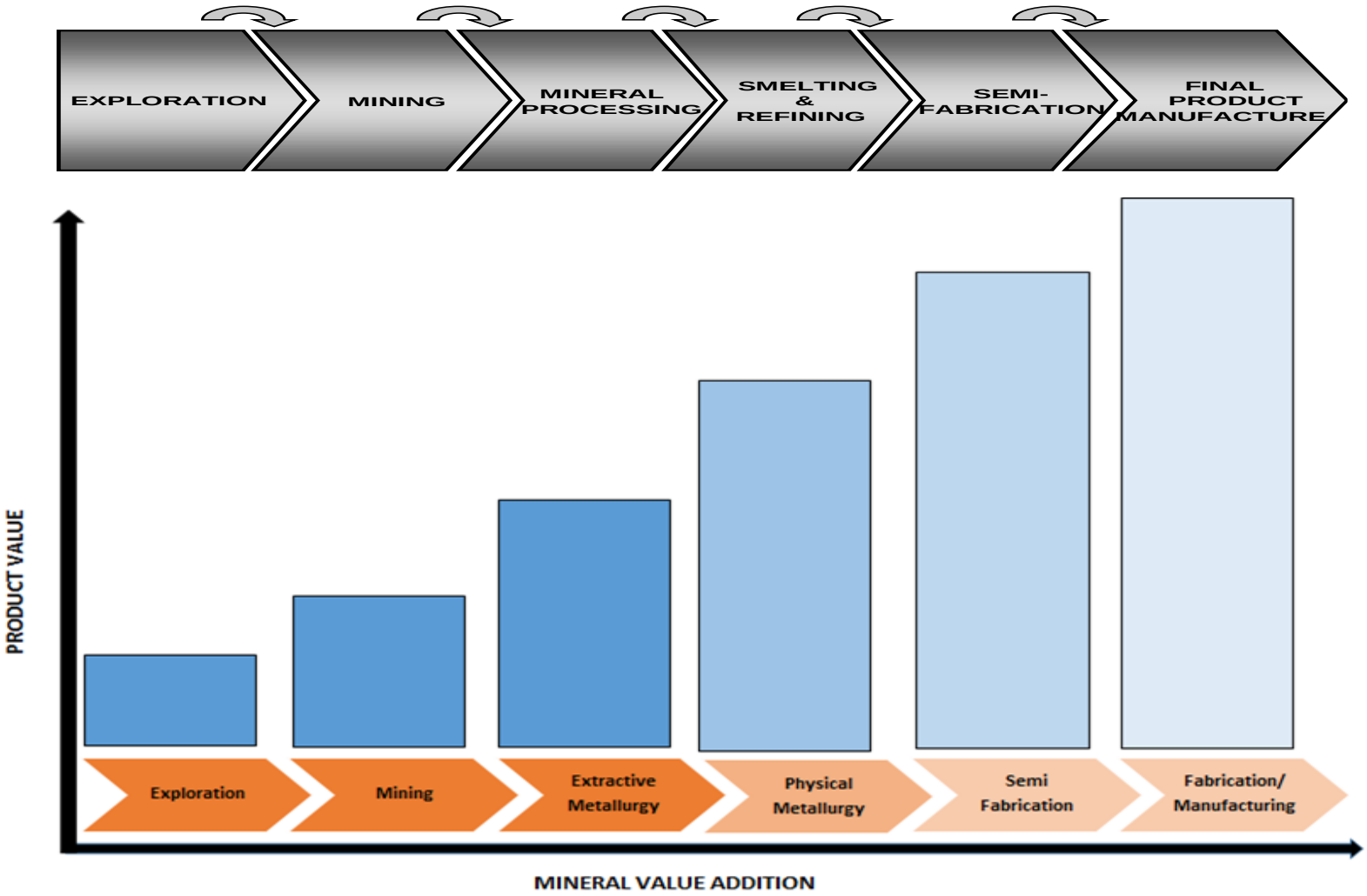
Introduction & Background

Generally, minerals in Africa are exported as unprocessed or semi-processed products whose value is much lower than that of finished goods. This results in low levels of industrialization and socio-economic development. The goal is to increase value addition;

- Agenda 2063 The Africa we want
- SADC Industrialization Strategy and Roadmap, (2015-2063) (Policy Brief on the *Mining Sector and Prospects for Beneficiation)*
- National Development Plans

The mining industry contributes about 10% of Gross Domestic Product and 50% of export earnings (Namibia and Zimbabwe)

THE MINERAL VALUE CHAIN – THE GAP



HIGH GROWTH MINERALS IN SADC

Country	Minerals/Metals				
Botswana	Diamonds	Copper Nickel	Gold	Diamonds	Coal
DRC	Copper	Cobalt	Tantalum	Diamonds	Lithium
Namibia	Uranium	Diamonds	Copper/Tin /Zinc	Gold	Lithium
Mozambique	Tantalum	Graphite	Aluminium	Titanium	Coal
Tanzania	Uranium	Gold	Silver	Diamonds	Coal
Zambia	Copper	Cobalt	Gold	Silver	Coal
South Africa	PGMs	Manganese	Copper Nickel	Chrome	Coal
Zimbabwe	PGMs	Lithium	Nickel Copper	Chrome	Coal

MINERAL BENEFICIATION STUDY - ZIMBABWE

Was Lead Researcher in the study whose main objective was; to evaluate beneficiation possibilities across the major minerals in Zimbabwe, focusing on the beneficiation stages, enabling conditions, key stakeholders and feasibility for each targeted mineral to inform a mineral specific beneficiation strategy for Zimbabwe.

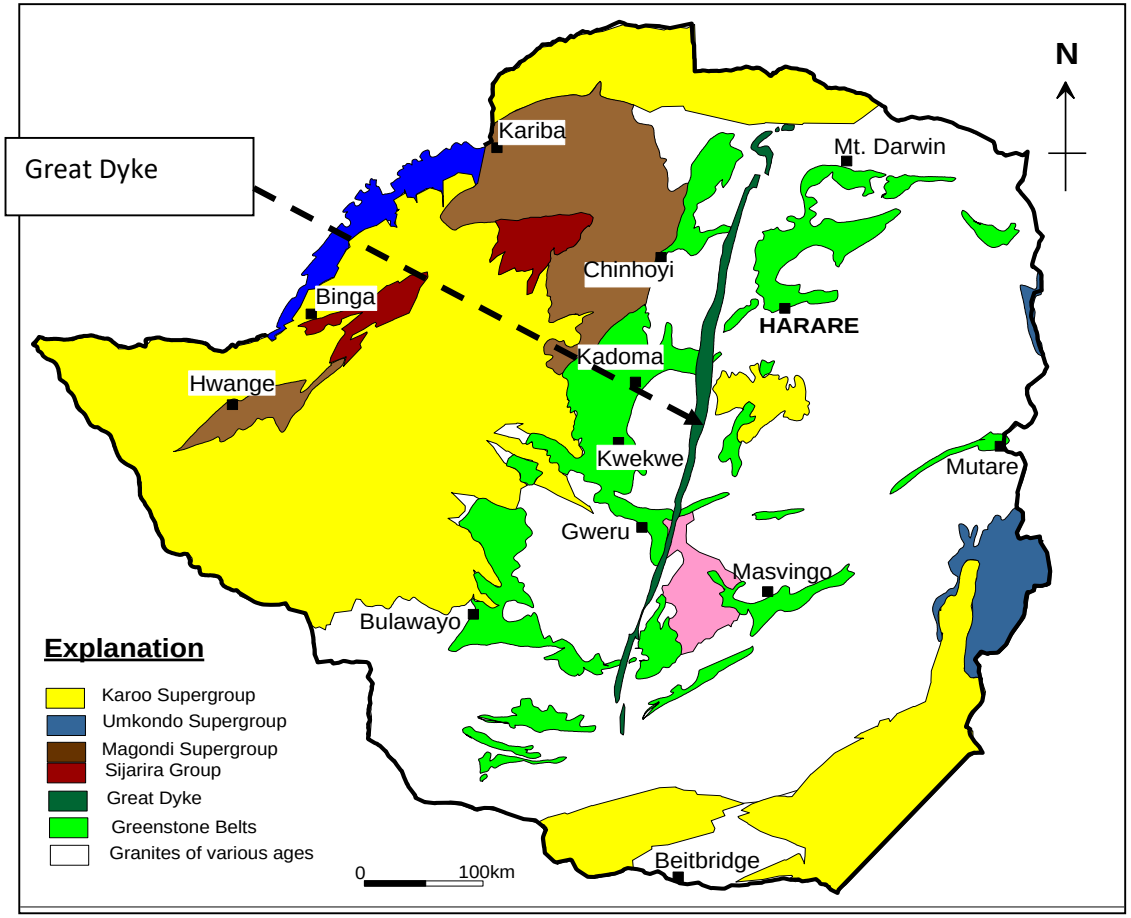
METHODOLOGY OF THE STUDY

- Qualitative research techniques based on literature reviews, case studies; assessment of industry progress with regards to value addition and beneficiation policy, technology and practice.
- Quantitative analysis of available secondary data, especially published official data from the ZIMSTAT, Government departments and Chamber of Mines of Zimbabwe, and collection from primary sources.
- Benchmarking with other countries
- Workshops and Interviews with Stakeholders

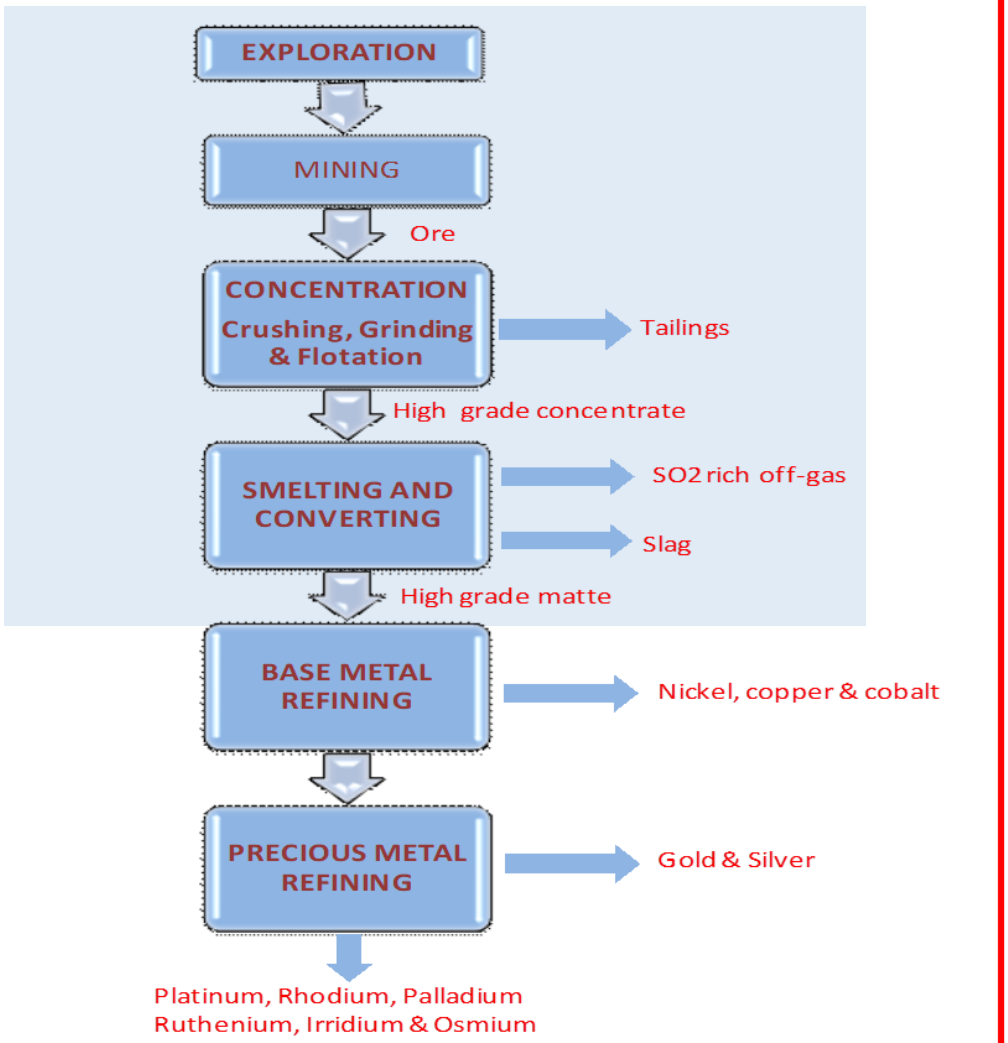
MINERAL WEALTH OF ZIMBABWE

Zimbabwe is endowed with;

Gold, platinum group minerals, chromite, nickel, copper, lithium, tantalite, coal, diamonds, gemstones, tin, limestone, graphite



PLATINUM GROUP MINERALS BENEFICIATION



Shaded area shows status in Zimbabwe

RECOMMENDATIONS FROM THE STUDY

- Promote investment in local beneficiation and further value addition esp. PGMs and base metals
- Enforce stipulated quotas of diamonds and granite stone for local value addition
- Invest in support infrastructure i.e. water, roads and power generation.
- Government policy and legislation to
  - create a stable and predictable investment climate, access to international markets
  - provide investment incentives and reduce cost of doing business
  - promote detailed exploration
  - promote skills development
  - promote research and technology development

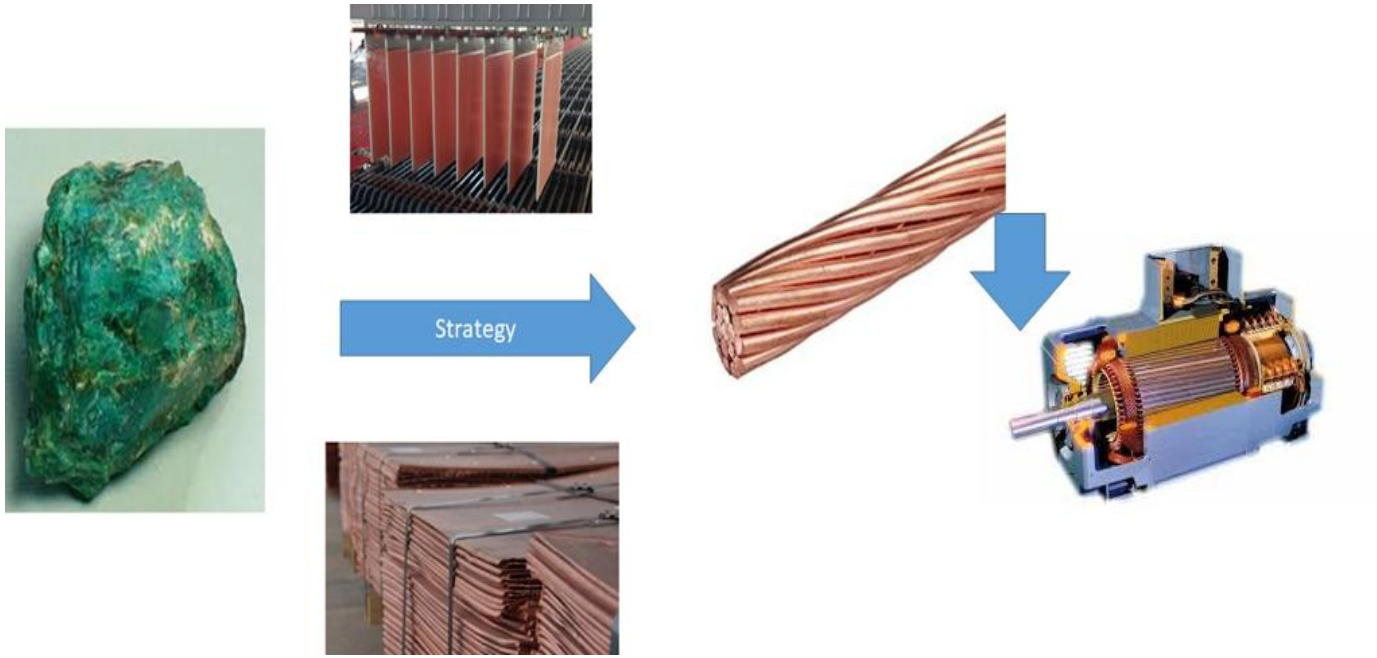
MINERAL BENEFICIATION STRATEGY - ZIMBABWE

Following recommendations from the Study, the Government of Zimbabwe, through the Ministry of Mines and Mining Development developed the Strategy which aimed to grow the mining industry from US$3 billion to US$12 billion by 2023.

Some progress had been made by the end of 2021 to US$5.7 billion...the target might be a stretch given disruptions due to Covid-19 and other factors.

One PGM producer has commissioned a Smelter

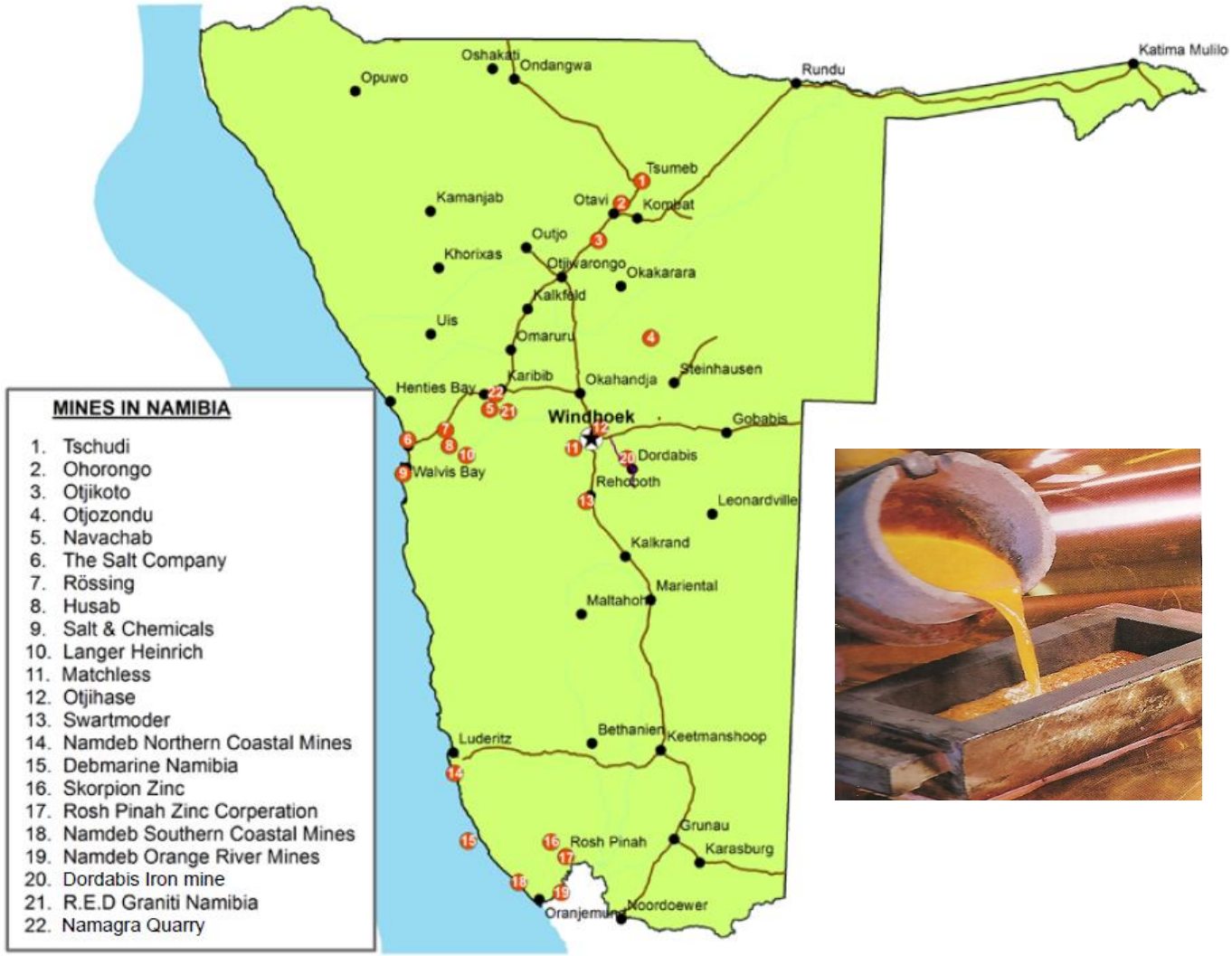
DEVELOPED THE MINERAL BENEFICIATION STRATEGY FOR NAMIBIA AND IMPLEMENTATION PLAN



The Department of Mining and Process Engineering developed a Mineral Beneficiation Strategy for Namibia and the Implementation Plan (2019-2021). Was the Lead researcher, with HOD as Project Manager and participation of a multi-disciplinary team from DMPE and Economics. Project commissioned by Govt of Namibia

MINERAL WEALTH OF NAMIBIA

Namibia is well endowed with diamonds, uranium, gold, copper, zinc, lithium, tin, salt, dimension stone, limestone, silica sand, etc



The Overarching Strategy

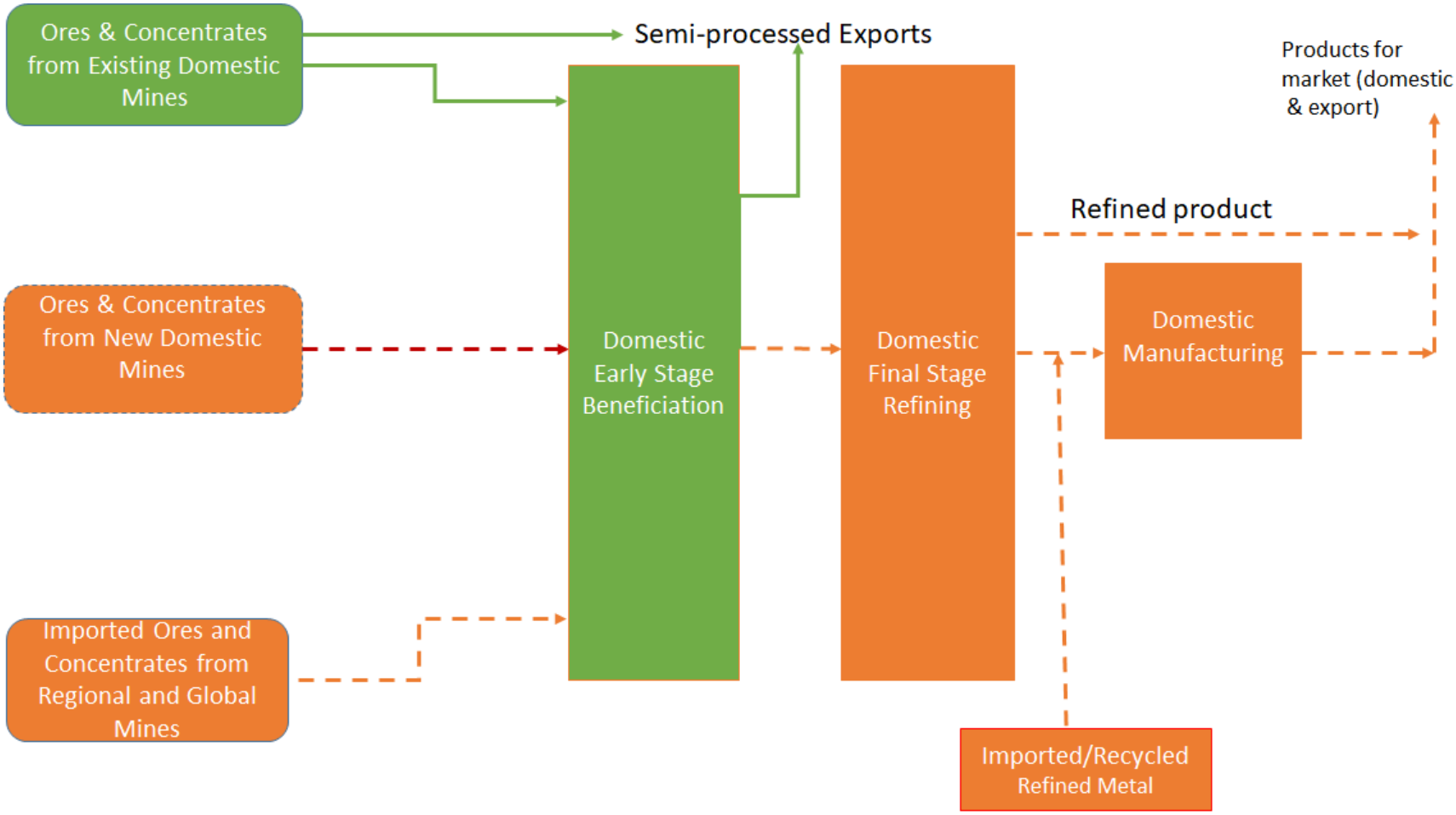
1. **Overarching Strategy**
2. Grouped Minerals Strategies
3. Individual Mineral Strategies

MINERAL BENEFICIATION STRATEGY GOALS

Six main intervention areas were identified, namely;

- Enhanced mineral sector governance.
- Securing raw material and intermediate resources.
- Skills development, research and innovation.
- Investment attraction and retention.
- Beneficiation technology, enabling infrastructure and environment; and
- Marketing and trading of beneficiated products

The Overarching Strategy



IMPLEMENTATION PLAN – ZINC STRATEGY

Milestones for Pilot MBS Mining & Beneficiation Projects – Zinc Ore Mining, Concentrating & Roasting

Initiation
- Strategic Plan & Project Schedule
- Organisational Structure
- Market Study
- Deposit identification

Pre-feasibility study
- Licences and Permits
- Environmental Impact Study
- Environmental Management Plan
- Drilling and geological Interpretation
- Resource Statement
- Selection of suitable Mining Method
- Metallurgical Testwork and Selection of suitable Processing Method
- Logistical Study
- Engineering estimates

Feasibility Study
- Trial Mining
- Process Pilot Plant Trial Run
- Mine & Concentrating & Roasting Plant Designs
- Mine Closure Plan
- Financial Requirements Estimates
- Bankable Feasibility Study document
- Project Financing

Engineering Procurement
- Detailed Designs of Mine & Plant (Concentrating & Roasting)
- Selection of Construction Experts & Suppliers
- Mine & Plant construction and Project Delivery

Commissioning
- Operation
- Closure
- Environmental Rehabilitation

Would enable utilization of existing facilities

IMPLEMENTATION PLAN - FOUNDRY

Milestones for Pilot MBS Metal Recycling & Manufacturing Projects – Foundry

Initiation
- Strategic Plan & Project Schedule
- Organisational Structure for all phases
- Market/Demand Study

Pre-feasibility study
- Study of scrap metal sources
- Location, Licences and Permits
- Environmental Impact Study
- Environmental Management Plan
- Selection of suitable Processing Method & Equipment
- Logistical Study
- Engineering estimates

Feasibility Study
- Pocess Pilot Plant Trial Run
- Foundry Plant Designs
- Plant Closure Plan
- Financial Requirements Estimates
- Bankable Feasibility Study document
- Project Financing

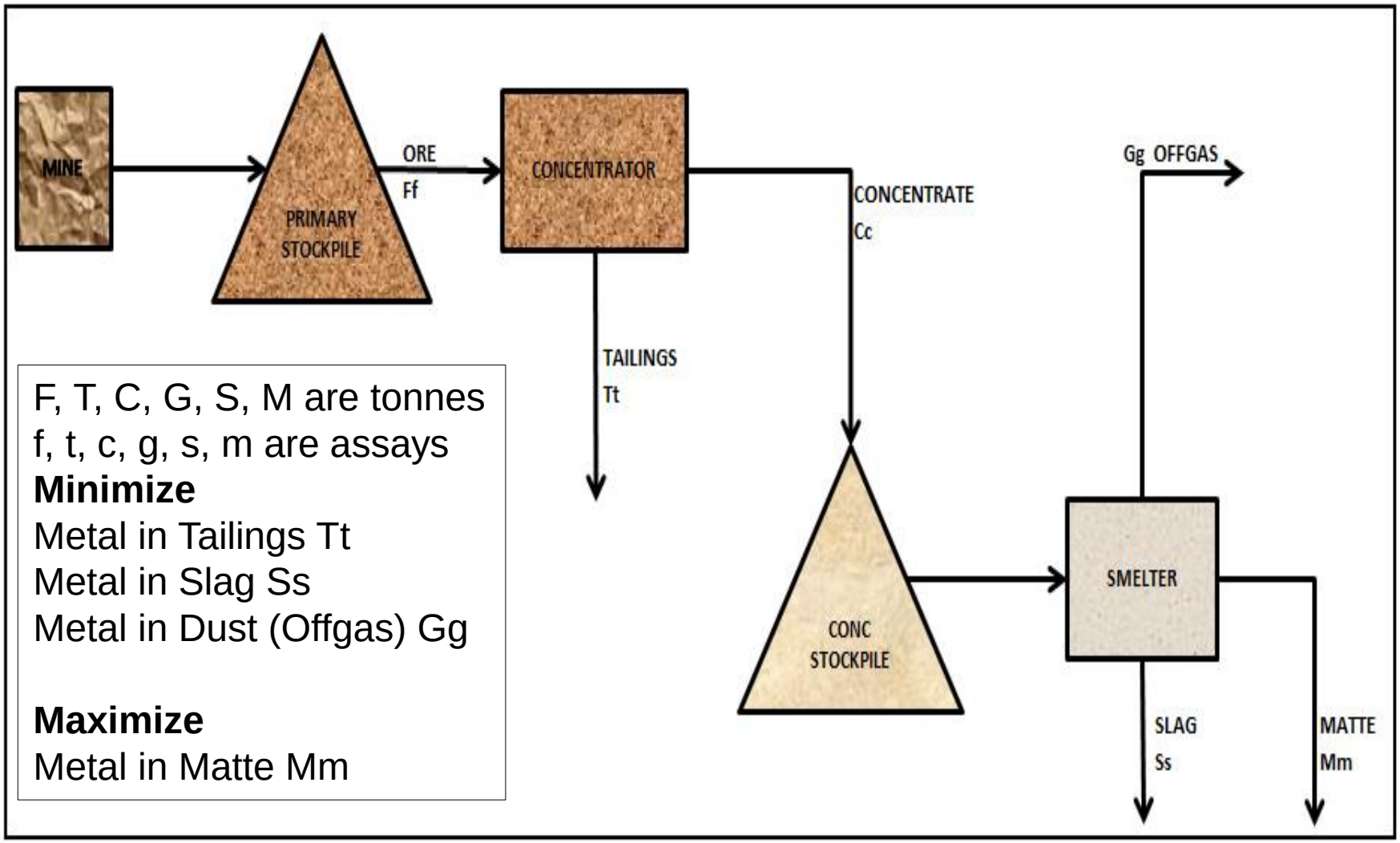
Engineering Procurement
- Detailed Designs of Foundry & Machining Plant
- Selection of Construction Experts & Suppliers
- Foundry & Machining Plant construction and Project Delivery

Commissioning
- Operation
- Closure
- Environmental Rehabilitation

For manufacturing mining and industry inputs, eg. mill balls

PLANT AND LABORATORY STUDIES

METAL BALANCING AND ACCOUNTING



F, T, C, G, S, M are tonnes
f, t, c, g, s, m are assays

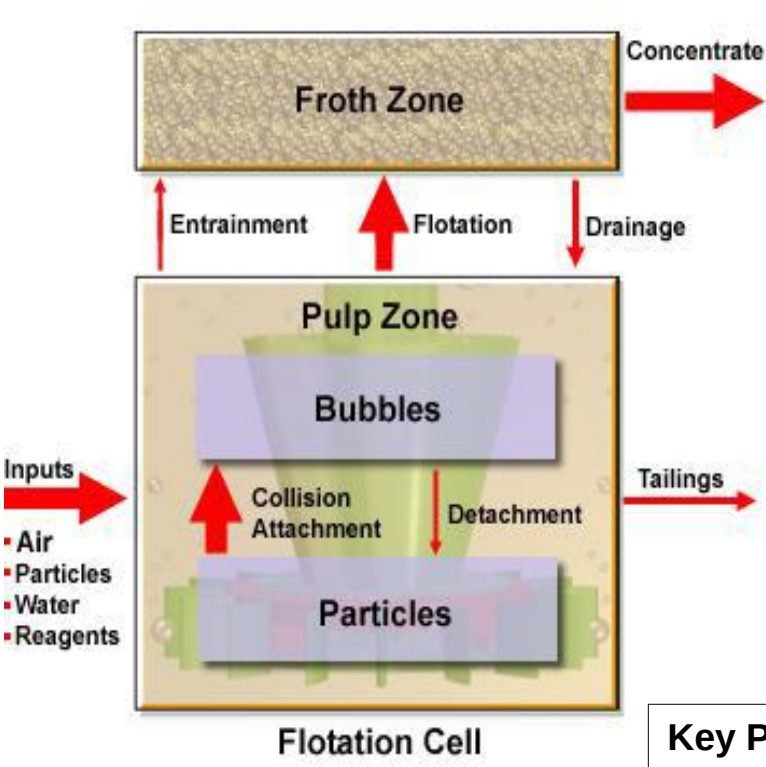
Minimize

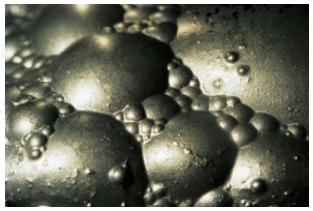
Metal in Tailings Tt
Metal in Slag Ss
Metal in Dust (Offgas) Gg

Maximize

Metal in Matte Mm

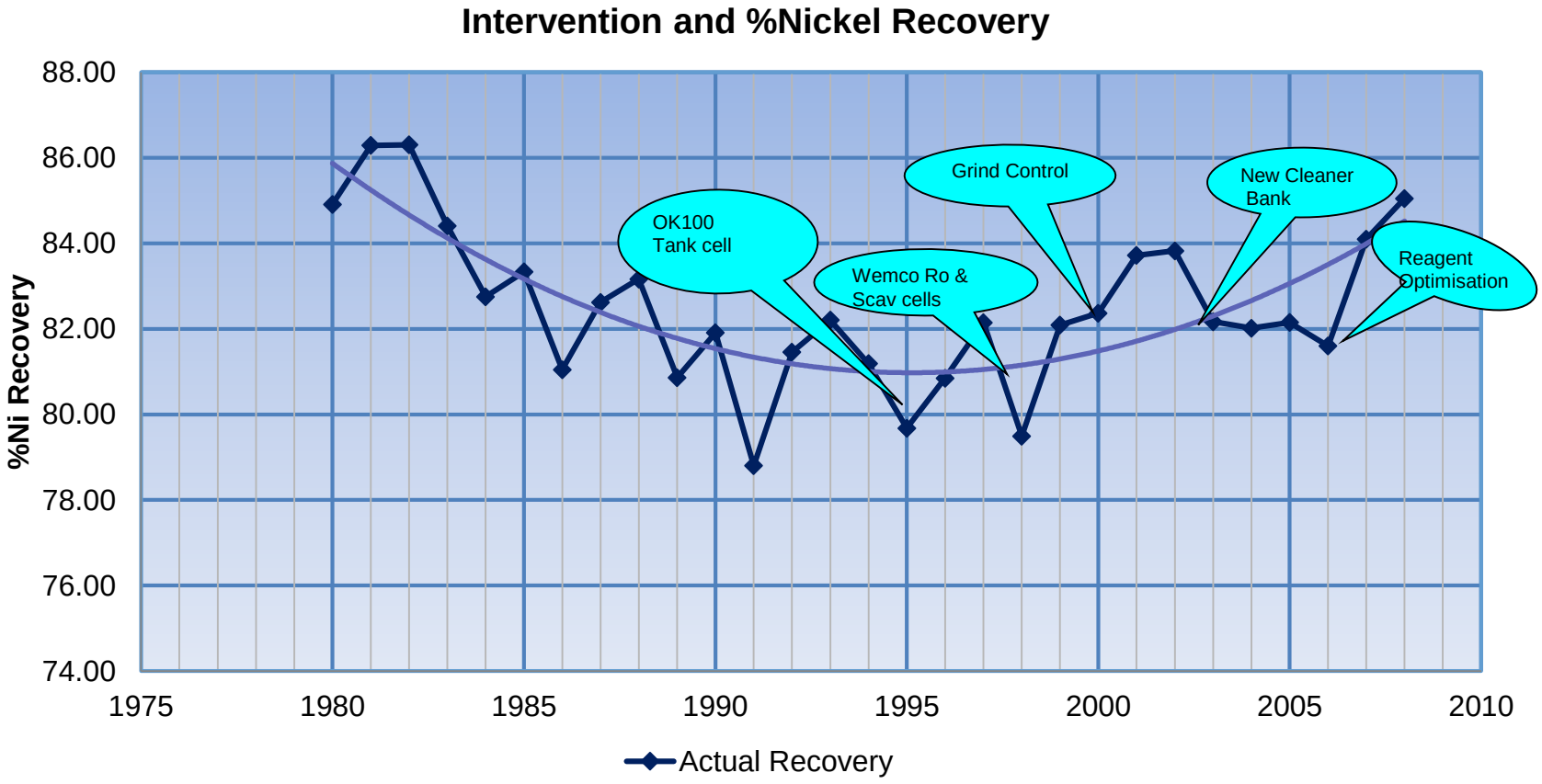
ENHANCING RECOVERY - FLOTATION PROCESS





Key Parameters
-Reagents optimisation
-Particle Liberation
-Residence Time
-Bubble size
-Aeration

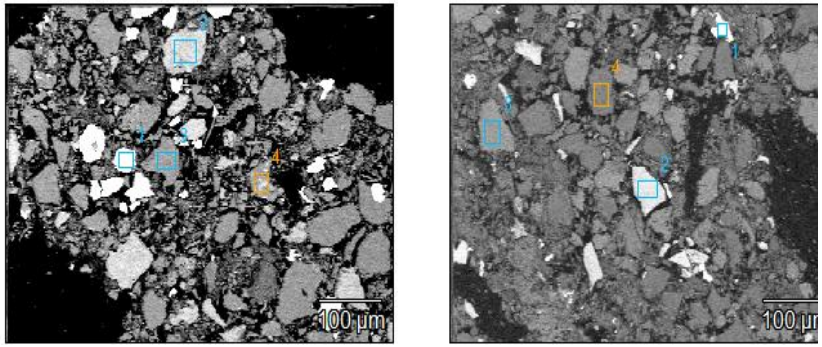
TECHNOLOGICAL AND PROCESS CHANGES - FLOTATION



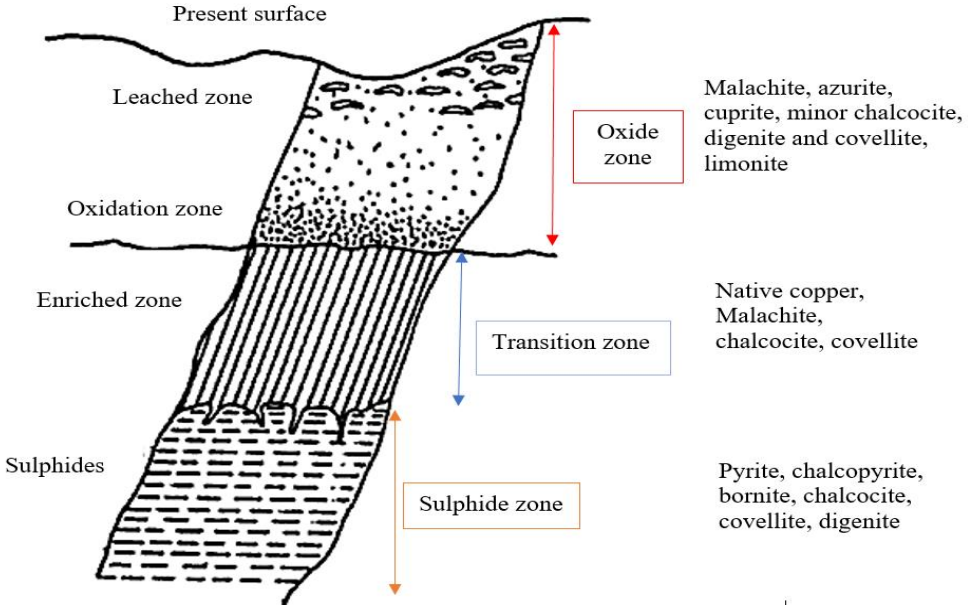
Led process improvement (2006/7)

RECOVERING METAL FROM FULL COPPER OREBODY

Challenges are often experienced with the transition zone, hence focus of research



Scanning Electron Microscopy (SEM) images



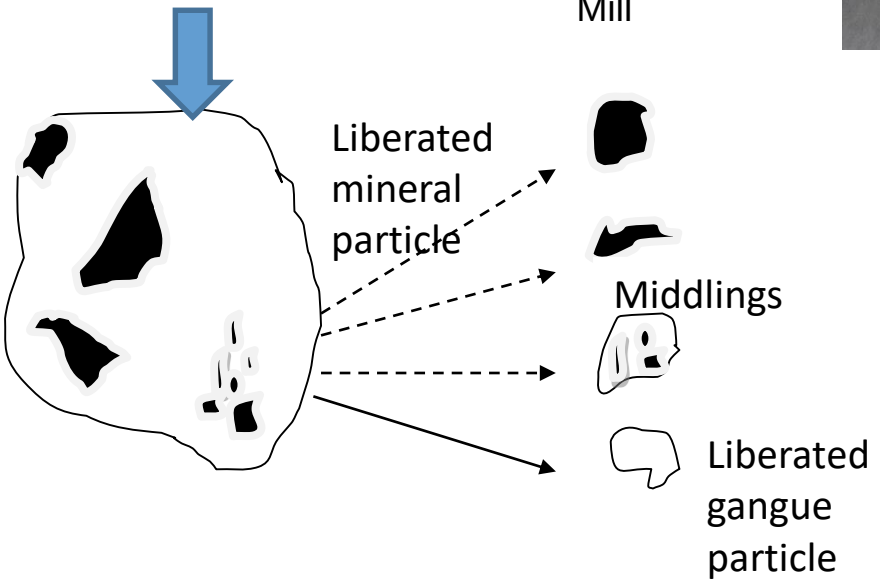
XRF analysis for the composite head samples

Ore type	Elemental compositions (%)					
	Cu	Fe	S	Si	Ca	Others
Oxide	1.27	0.89	-	32.33	0.33	65.18
Transition	1.59	2.68	0.16	30.34	1.72	63.51
Sulphide	1.13	1.44	1.15	32.19	0.24	63.85

COMMINUTION AND LIBERATION

CRUSHING FORCES

Mill

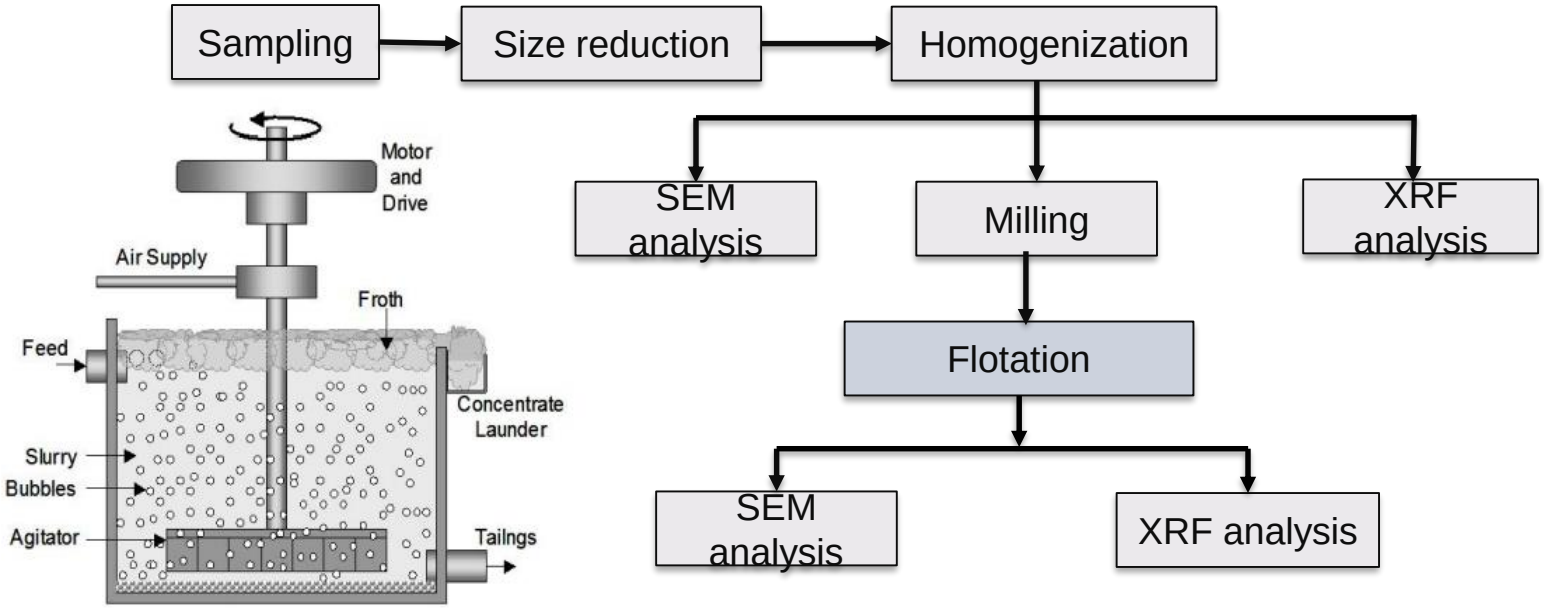


Scanning Electron Microscope (SEM)

Recovery of metal from **slag**, **refractory bricks** and also **tailings** has been carried out for the Namibian industry. Recovery is enhanced by effective comminution and liberation

CURRENT RESEARCH

- Methodology applied to study the flotation characteristics of the sulphide and transition ores.



- Effect of
- sulphidizer dosage
- pH of operation
- collector type (Potassium Amyl Xanthate (PAX), Diothiophospahate (DTP))

Modelling the Milling Kinetics - Relationship Breakage Parameters and Mineralogical Data

For a batch milling process – treated as a first-order kinetic process, the breakage process is described by (Austin, 1971)

$$\frac{dw_i(t)}{dt} = -S_i w_i(t) + \sum b_{ij} S_j w_j(t)$$

Where w_i is the mass fraction of material in size class i, S_i is the selection function or rate of breakage of size class i, b_{ij} is the breakage function of fragments into size class i from size class j, S_j is the selection function of size class j, w_j is the mass fraction of material in size class j, and t is the grinding time.

minerals

MDPI

Article

Evaluation of the Relationship between the Milling Breakage Parameters and Mineralogical Data: A Case Study of Three Copper Ores from a Multi-Mineralised Deposit

Titus Nghipulile [1,*], Thomas Ehongo Moongo [2], Godfrey Dzinomwa [2], Sandile Nkwanyana [1], Benjamin Mapani [2] and Jaquiline Tatenda Kurasha [2]

ONGOING RESEARCH

- **Dense medium separation performance improvement using radio frequency identifiable (RFID) and luminescent density tracers (to improve diamond, tin, tantalite, lithium recovery)**

- **Green Hydrogen Applications**

1. **Direct Reduction of Oxide Minerals, esp. production of green steel**
   - » $Fe_3O_4 + 4H_2 = 3Fe + 4H_2O$
   - (Direct reduced iron for smelting and steelmaking,
   - eg. Lodestone (Dordabis),
   - Shiyela (Walvis Bay) iron ore projects

2. **Production of Ammonia for NH_4NO_3, used in**;
   - Fertilizers
   - Mining Explosives

SUSTAINABILITY IN RESEARCH

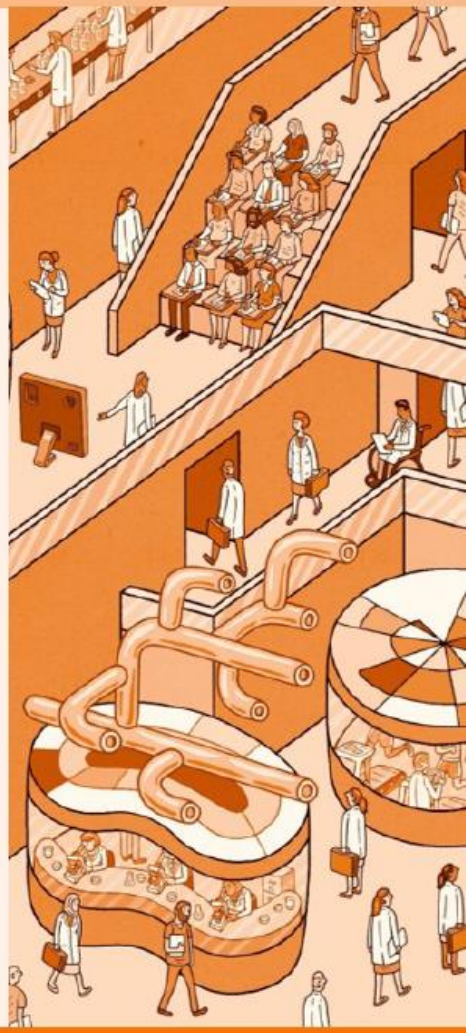
ELSEVIER

Congratulations

Godfrey Dzinomwa

For publishing an open access article with Elsevier between 2019–2021!

Your article was linked to the United Nations Sustainable Development Goals, helping to tackle some of the world's greatest challenges.



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I would like to thank
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- **Friends**
- **Family, especially my children and my wife Chipo Victoria**

And You..if you have not been included above!