FROM DEPOSIT TO MINE
FROM MINE TO MINING VALUE CHAINS

Diversifying a Mineral Based Economy

Neale Baartjes
Mineral Resource Consultant
1. Commodity Supply and Demand
2. Life Cycle of a Deposit and Mine
3. Logistics of Mining and Minerals
4. Value Chain Analysis of Minerals
5. Mining Inputs – Water; Electricity and Skills
6. Mining Law – an Overview
7. Mining Tax and Remittance to State
8. Beneficiation as Policy and Strategy
9. Private Sector vs Public Sector expectations
10. Upstream – Downstream - Sidestream
SOUTH AFRICA’S MINERAL INDUSTRY STRENGTHS

South Africa’s mineral wealth is typically found in the following well-known geological formations and settings:

• The **Witwatersrand Basin** yields some 94 percent of South Africa’s gold output and contains considerable resources of uranium, silver, pyrite and osmiridium;
• The **Bushveld Complex** is known for its platinum-group-metals (with associated copper, nickel and cobalt mineralisation), chromium and vanadium bearing titanium iron ore formations as well as large deposits of the industrial minerals, including fluorspar and andalusite;
• The **Transvaal Supergroup** contains enormous resources of manganese and iron ore;
• The **Karoo Basin** extends through Mpumalanga, KwaZulu-Natal, Free State as well as Limpopo Province hosting considerable bituminous coal and anthracite resources;
• The **Phalaborwa Igneous Complex** hosts extensive deposits of copper, phosphate, titanium, vermiculite, feldspar and zirconium ores;
• **Kimberlite** pipes host diamonds that also occur in alluvial, fluvial and marine settings;
• **Heavy mineral sands** contain ilmenite, rutile and zircon;
• Significant deposits of **lead-zinc** ores associated with copper and silver are found in the Northern Cape near Aggeneys.
<table>
<thead>
<tr>
<th>Mineral</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chrome</td>
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<tr>
<td>Gold</td>
<td>1</td>
</tr>
<tr>
<td>Manganese Ore</td>
<td>1</td>
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<tr>
<td>PGM</td>
<td>1</td>
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<tr>
<td>Vanadium</td>
<td>1</td>
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<tr>
<td>Fluorspar</td>
<td>2</td>
</tr>
<tr>
<td>Titanium Minerals</td>
<td>2</td>
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<tr>
<td>Vermiculite</td>
<td>2</td>
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<tr>
<td>Zirconium</td>
<td>2</td>
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<tr>
<td>Antimony</td>
<td>4</td>
</tr>
<tr>
<td>Phosphate Rock</td>
<td>4</td>
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<tr>
<td>Nickel</td>
<td>5</td>
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<tr>
<td>Uranium</td>
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<tr>
<td>Lead</td>
<td>6</td>
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<tr>
<td>Coal</td>
<td>8</td>
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<tr>
<td>Zinc</td>
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<tr>
<td>Iron Ore</td>
<td>9</td>
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<tr>
<td>Copper</td>
<td>14</td>
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MINING’s ROLE IN THE NATIONAL ECONOMY

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP Contribution</th>
<th>Employment</th>
<th>JSE Market Capitalisation</th>
</tr>
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<tbody>
<tr>
<td>1999</td>
<td>400 000</td>
<td>420 000</td>
<td>440 000</td>
</tr>
<tr>
<td>2000</td>
<td>460 000</td>
<td>480 000</td>
<td>500 000</td>
</tr>
<tr>
<td>2001</td>
<td>520 000</td>
<td>520 000</td>
<td>520 000</td>
</tr>
</tbody>
</table>

GDP Contribution: 7%
Employment: 450,000
JSE Market Capitalisation: R3,500 bn
MINING’s ROLE IN THE NATIONAL ECONOMY

Bar chart showing the percentage of mining in the national economy from 1999 to 2008, with a peak in 2008.
A deposit is a concentration (or occurrence) of material of possible economic interest, in or on the earth’s crust, that may include mineralised material that cannot be estimated with sufficient confidence to be classified in the Inferred category. Portions of a deposit that do not have reasonable and realistic prospects for eventual economic extraction are not included in a Mineral Resource.
There are currently no accepted standards regulating such reporting, great confusion exists in the terminology and numbers used. This reporting is required amongst other reasons for national and international inventory documentation, policy and land utilisation decisions.
FROM DEPOSIT TO MINE

- Exploration Results
- Mineral Resource
  - Inferred
  - Indicated
  - Measured
- Mineral Reserve
  - Probable
  - Proved

Reported as in situ mineralisation estimates
Reported as mineable production estimates

Increasing Level Of Geoscientific Knowledge And Confidence

Consideration of mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors (the ‘modifying’ factors)
ATTRACTING INVESTMENT

Mineral Deposit → Mine Development → Public Infrastructure

Investment Growth → Economic Development → Clustering

Public Sector

Private Sector
EIGHT STAGES OF THE LIFE OF A DEPOSIT

- No Activity
- Target Generation
- Pre-Feasibility
- Feasibility
- Commissioning
- Mining
- Expansion
- Mine Closure

Output
Revenue

PITTING → OPENCAST → UNDERGROUND → OPENCAST
FROM MINE TO MINING VALUE CHAIN

Value Chain: Porter’s 1985 “discovery”

A value chain is the chain of activities for a firm operating in a specific industry.

A Strategy Tool

Primary Activities and Support Activities

Business Unit Level and Sector Level
SOUTH AFRICAN JARGON

Stage 1: Mining
Stage 2: Processing
Stage 3: Refining
Stage 4: Fabrication
### SOUTH AFRICAN JARGON

<table>
<thead>
<tr>
<th>Stage</th>
<th>Mineral Beneficiation Process Category</th>
<th>Process Flow-Chart</th>
<th>Labour Intensity</th>
<th>Capital Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The action of mining and producing an ore or concentrate (primary product)</td>
<td>Run-of Mine Ores (\rightarrow) Washed and Sized Concentrates</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>The action of converting a concentrate into a bulk tonnage intermediate product (example a metal alloy)</td>
<td>Mattes/Slags/ Bulk Chemicals (\rightarrow) Ferro Alloys/ Pure Metals</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>The action of converting the intermediate goods into a refined product suitable for purchase by both small and sophisticated industries.</td>
<td>Steel/Alloys (\rightarrow) Worked Shapes and Forms</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>4</td>
<td>The action of manufacturing a final product for sale</td>
<td>Worked Shapes and Forms (\rightarrow) Worked Shapes and Forms</td>
<td>Medium to High</td>
<td>Medium to High</td>
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<tr>
<td>Geographical Location</td>
<td>Mining</td>
<td>Transport</td>
<td>Processing</td>
<td>Transport</td>
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<tr>
<td>-----------------------</td>
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<tr>
<td>Market Concentration</td>
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<tr>
<td>Legal Status</td>
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<tr>
<td>No. of Employees</td>
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<tr>
<td>SWOT</td>
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<tr>
<td>Top 3 Risks</td>
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<tr>
<td>Inputs</td>
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<tr>
<td>Outputs</td>
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<tr>
<td>Tonnage</td>
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</tr>
<tr>
<td>Grade</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost/Unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Profit/Unit</td>
<td></td>
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## ANALYSING THE VALUE CHAIN

<table>
<thead>
<tr>
<th></th>
<th>Mining</th>
<th>Transport</th>
<th>Processing</th>
<th>Transport</th>
<th>Refining</th>
<th>Transport</th>
<th>Fabrication</th>
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<tbody>
<tr>
<td>Revenue/Capita</td>
<td></td>
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<td>Profit/Capita</td>
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<tr>
<td>Tonnage per Capita</td>
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<tr>
<td>Revenue /Unit</td>
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<td>Overhead/Unit</td>
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<td>Grade Improvement</td>
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<tr>
<td>Cost /10% Grade Improvement</td>
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<tr>
<td>Inputs/Capita</td>
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<td>Revenue/Inputs</td>
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<tr>
<td>Outputs/Capita</td>
<td></td>
<td></td>
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</tbody>
</table>

Revenue% Region A

Revenue% Region B
TYPES OF VALUE CHAINS

Simple

Complex
VALUE IS NOT COST

Value Chain driven by Buyer not Supplier
Supply Chain is what a company can do to access the Value Chain

In which direction can pressure be applied?
VALUE IS NOT COST

New Technology required
Subsidy required
Merger required
EXAMPLE OF VALUE CHAIN

Value Chain By Handler

Value Chain Retained By Handler

Money Retained per Region (%)

Value Retained per capita
EXAMPLE OF VALUE CHAIN

**Irregular Payments**

- Mine Ore: 12%
- Carry to Load Area and Stockpile: 1%
- Transport to Vendor: 1%
- Stockpile Sorting: 2%
- Mine Owner Profit: 1%
- Second Stockpile Sorting: 3%
- Load onto Large Trucks: 5%
- Transport to Client: 1%
- Levy on Large Trucks: 1%
- Offload Truck: 0%
- Assay Sample: 0%
- Government Royalty: 31%
THE MINERAL VALUE CHAIN

Exploration
- geophysical
- drilling
- survey
- etc.

Mining
- capital goods
  - crushing/mills
- materials handling
- furnaces, etc.

Mineral Processing
- capital goods
  - crushers/mills
- hydromet plant
- materials handling
- furnaces, etc.

Reffining Cap. Goods
- smelters
- furnaces
- electro winning cells
- casters

Fabrication Cap. Goods
- rolling
- moulding
- machining
- assembling

Exploration services
- GIS
- analytical
- data processing
- financing
- etc

Mining services
- mine planning
- consumables/spares
- sub-contracting
- financing
- analytical, etc

Processing services
- comminution
- grinding media
- chem/reagents
- process control
- analytical, etc

Refining services
- reductants
- chemicals
- assaying

Value adding services
- design
- marketing
- distribution
- services
• Value is perceived by the customers rather than objectively determined by the seller;

• Value is a subjective experience that is dependent on context and varies in the eyes of the beholder;

• Value occurs when needs are met through the provision of products, resources, or services;

• Value typically involves a trade-off between what the customers receive and what they give up to acquire and use a product or service.
ALLOCATE COST CORRECTLY FIRST

Why are cost poorly allocated

Finance systems are not able to deal with all eventualities so sub-routines and off-system parallel systems are developed and averaging becomes commonplace

- Waste Disposal
- Electricity
- Water
- Security
- Maintenance
- Some training
- Spill contingency
- ICT

Floor Plan Allocation
Wage Bill Allocation
Degrees Allocation
EMLOYMENT ‘U’ CURVE

Employment Numbers are highest at start and end of the value chain

Employment Opportunities

1. Mining
2. Processing
3. Refining
4. Fabrication
DIAMONDS
MINERAL ECONOMIC STRATEGY

Regulation
Authorisations
Nationalisation
Transformation
Relocation
Innovation
Foreign Investment
Planning Models
Tax and Incentives
Market Structure
Labour Regulation
Future Scenarios

Labour Strategy (K/L)
Risk Mitigation
Input / Output Modelling
Skills Development
Localisation
International Relations
Globalisation
M&A
Economic Shock
Economic Diversification
LED
Anti-competitive behaviour
BENEFICIATION STRATEGY FOR SOUTH AFRICA

BY COMMODITY

1. Coal and Uranium
2. Iron
3. Chrome
4. Vanadium
5. Nickel
6. Manganese
7. Titanium
8. PGM
9. Diamond
10. Gold
BENEFICIATION STRATEGY FOR SOUTH AFRICA

BY VALUE CHAIN

1. Energy Commodities
2. Iron and Steel
3. Pigment and Titanium Metal Production
4. Autocatalytic Converters and Diesel Particulate
5. Diamond Cutting and Polishing and Jewellery Fabrication
ENERGY COMMODITIES

- Reduce concentration in the market place by increasing number of JRC and competing producers
- Emphasis remains Mpumalanga
- KwaZulu-Natal important source of anthracite coal
- Waterberg Coalfield – opportunity for large or small players?
- Other stranded coal deposits
• Kumba, Assmang, Arcelor Mittal and new players

• Significant producer of seaborne ore but beneficiation looks towards additional manufacturing

• Chrome ore exports ~10% only

• Vanadium and nickel for the export market
PIGMENT AND TITANIUM METAL

• Difficult markets to penetrate;

• High levels of technology required to develop metal usage

• Markets in Northern Hemisphere and needs to be closely integrated between producers and consumers.
10%+ of SA PGM beneficiated already (cf. <2% Au)

What is a car without an auto catalyst? A hulk of unsalable steel and composite…

Manufacturing of vehicle components

Identify linkages to other programmes of government, for example MIDP, AMI, etc.

High levels of technology required
• Combines platinum, gold and diamonds
• The use of IDZs as a platform to launch these
• Johannesburg; Kimberley; Mafikeng
• Strongly linked to skills development
THE “DST BENEFICIATION STRATEGY”?

<table>
<thead>
<tr>
<th>Commodity</th>
<th>SA % World Reserve</th>
<th>Stage I</th>
<th>Stage II</th>
<th>Stage III</th>
<th>Stage IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ilmenite</td>
<td>16.9%</td>
<td>Ore</td>
<td>Titania slag/Pig Iron</td>
<td>TiO₂ Pigment</td>
<td>Paint, plastic, paper</td>
</tr>
<tr>
<td>Fluorspar</td>
<td>16.7%</td>
<td>Ore</td>
<td>Hydrofluoric Acid</td>
<td>Fluorine</td>
<td>Fluoro-chemicals</td>
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</table>

**Partnership for Growth and Development**

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Stage I</th>
<th>Stage II</th>
<th>Stage III</th>
<th>Stage IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ilmenite</td>
<td>Titania slag for processing; pig iron for steel industry; direct castings for motor industry; titanium metal for aerospace</td>
<td>JV for pigment plant; Pigment for paint, paper, plastic</td>
<td>Expand local Pigment industry</td>
<td></td>
</tr>
<tr>
<td>Fluorspar</td>
<td>Hydrofluoric acid feedstock; new technologies for fluorosilicic acid</td>
<td>Fluorine for uranium enrichment – PBMR; Flux for aluminium smelting - Coega</td>
<td></td>
<td>Leverage off Chinese shortage</td>
</tr>
</tbody>
</table>

**Environment**

- Environmental pressure on producers of titanium because of location and type of deposits in sensitive areas
- Potential for REACH considerations with fluoro-chemicals; also nuclear power generation concerns

**Infrastructure**

- Feasibility into new large pigment facilities
- NECSA potential for producing fluoro-chemicals locally as well as processing or uranium for PBMR
That beneficiation is a bad policy paradigm and should be dropped from South Africa’s development strategy…The ‘Harvard Group’

The skills and other inputs required to process raw materials and market finished products could be very different from those required to mine or grow them.

Moreover, there are strong reasons to believe that whatever was true in the past, as transportation costs have declined, and global markets have become more integrated, the advantage of proximity to raw materials production has diminished.

Countries do not move downstream in their export development. This is as true for rich countries as for poor countries, and even more true for downstream movements from raw materials than for other manufactured goods. The generalization that countries should beneficiate as a development strategy is rejected by the data and it suggests that rather than presuming that beneficiation provides an appropriate development path, those advocating such an approach in any given situation, need to provide a case by case justification of their reasoning. Without such justification beneficiation could prove extremely costly.
The Panel uses beneficiation itself in a very narrow technical sense of immediate processing of raw materials. Policy debates within South Africa are more concerned with the extent to which there has been limited diversification out of core primary sectors as the potential basis for industrialisation. This is not simply a matter of differences in meaning but also over the role of the state...For the beneficiation argument is based upon an extraordinarily crude technological determinism. However legitimately, it argues that beneficiation has not been characteristic of successful industrialisation and, so, South Africa should not seek to break with such an iron law...More substantively, by reducing industrialisation to narrowly defined physical integration of inputs and outputs, the Panel’s rejection of beneficiation fails to take account of the different factors that promote industrialisation out of existing capacity and activity and also fails to descend to an appropriate level of detail across different activities and sectors.

In a sense, the Panel is correct to reject beneficiation, narrowly interpreted, as a general, universal policy – we must process all our minerals. But this is open to misinterpretation as a stance against targeted policies for diversification on the basis of existing industrial activity, of which beneficiation as such is just one possibility.

B. Fine, 2008
MINERAL ECONOMIC STRATEGY – SCENARIO PLANNING

- Regulation
- Authorisations
- Nationalisation
- Transformation
- Relocation
- Innovation
- Foreign Investment
- Planning Models
- Tax and Incentives
- Market Structure
- Labour Regulation
- Future Scenarios

- Labour Strategy (K/L)
- Risk Mitigation
- Input / Output Modelling
- Skills Development
- Localisation
- International Relations
- Globalisation
- M&A
- Economic Shock
- Economic Diversification
- LED
- Anti-competitive behaviour