Overview of presentation

1. Global Mining Industry
2. Exploration
3. Development
4. Mining methods
5. Mineral processing
6. Market
Global Mining Industry
Nature of the Industry

» 90% of mined products (value) come from 2,000 mines
» 3,000 listed exploration & mining companies
» Top ten companies = 1/3 of mined production
## Commodity Production & Value

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Mined ('000t)</th>
<th>Price (US$/t)</th>
<th>Value PA ( $bn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal &amp; Lignite</td>
<td>4,100,000</td>
<td>75</td>
<td>308</td>
</tr>
<tr>
<td>Iron Ore</td>
<td>1,630,000</td>
<td>90</td>
<td>147</td>
</tr>
<tr>
<td>Gold</td>
<td>2.47</td>
<td>27,300,000</td>
<td>67</td>
</tr>
<tr>
<td>Copper</td>
<td>15,800</td>
<td>3,200</td>
<td>50</td>
</tr>
<tr>
<td>Nickel</td>
<td>1,600</td>
<td>11,100</td>
<td>18</td>
</tr>
<tr>
<td>Diamonds</td>
<td>0.035</td>
<td>370,000,000</td>
<td>13</td>
</tr>
<tr>
<td>Zinc</td>
<td>12,000</td>
<td>1,100</td>
<td>13</td>
</tr>
<tr>
<td>PGMs</td>
<td>0.38</td>
<td>29,900,000</td>
<td>11</td>
</tr>
<tr>
<td>Bauxite</td>
<td>180,000</td>
<td>55</td>
<td>10</td>
</tr>
<tr>
<td>Lead</td>
<td>3,900</td>
<td>1,100</td>
<td>4</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td></td>
<td><strong>641</strong></td>
</tr>
</tbody>
</table>
Exploration
Factors influencing exploration investments

<table>
<thead>
<tr>
<th>RESPONSES RANKED</th>
<th>DECISION CRITERIA BASED ON</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>geological potential for target mineral</td>
</tr>
<tr>
<td>2</td>
<td>security of tenure</td>
</tr>
<tr>
<td>3</td>
<td>ability to repatriate profits</td>
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<td>consistency and constancy of mineral policies</td>
</tr>
<tr>
<td>5</td>
<td>company has management control</td>
</tr>
<tr>
<td>6</td>
<td>mineral ownership</td>
</tr>
<tr>
<td>7</td>
<td>realistic foreign exchange regulations</td>
</tr>
<tr>
<td>8</td>
<td>stability of exploration/mining terms</td>
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<td>ability to predetermine tax liability</td>
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</tbody>
</table>
## Finding mineral deposits

<table>
<thead>
<tr>
<th>Phase of activity</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground selection</td>
<td>Conceptual geological models</td>
</tr>
<tr>
<td></td>
<td>Licence application</td>
</tr>
<tr>
<td></td>
<td>Logistics and cost issues</td>
</tr>
<tr>
<td>Regional exploration</td>
<td>Satellite imagery</td>
</tr>
<tr>
<td></td>
<td>Airborne geophysical surveys</td>
</tr>
<tr>
<td></td>
<td>Digital database compilation</td>
</tr>
<tr>
<td></td>
<td>Regional geochemistry</td>
</tr>
<tr>
<td>Follow-up exploration</td>
<td>Geological mapping</td>
</tr>
<tr>
<td></td>
<td>Ground geophysics</td>
</tr>
<tr>
<td></td>
<td>Soil geochemistry</td>
</tr>
<tr>
<td>Anomaly testing</td>
<td>Trenching and pitting</td>
</tr>
<tr>
<td></td>
<td>Drilling</td>
</tr>
<tr>
<td>Discovery and evaluation</td>
<td>Further detailed surveys</td>
</tr>
<tr>
<td></td>
<td>More drilling</td>
</tr>
<tr>
<td></td>
<td>Surface and underground sampling</td>
</tr>
</tbody>
</table>
Exploration – putting it in perspective

- 100,000 exploration licences per year
- 8,000 drilling projects
- 1,500 reserve definition studies
- 800 feasibility studies
- 400 mines under construction
Reporting results of exploration

Mineral Resources

Ore Reserves

Inferred

Indicated

Probable

Measured

Proven

Increase geological knowledge

Consideration of mining, metallurgical, economic, marketing, legal environmental, social, governmental factors
Feasibility & Impact Assessments

- **Economic**
  - Size and grade of ore, mineralogy
  - Investment and operating costs
  - Price and revenue
- **Legal and regulatory impacts**
- **Environmental impact assessments**
- **Social impact assessment**
Factors influencing mining investments

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Development
Raising Capital

» Major purpose of feasibility study

» Juniors – selling project to major

» Mix of debt and equity
  » Capital markets – corporate bonds
  » Financial institutions – debt
  » Off take agreements

» Risks
  » Political
  » Market
Mine Design

» Focused on planning how to extract the mineral
  » Mining method
  » Mine layout
  » Waste management
  » Water management
  » Haulage and transport
  » Social & Environmental
Infrastructure Requirements

» Power
  » Availability - grid or local
  » Cost

» Water
  » Too much
  » Too little

» Transport
  » Distance to markets
  » Bulk vs. refined

» Public private partnerships
» Shared and dual uses
Construction

» All requisite permissions
» Significant capital requirements
» Availability and timing equipment
» Labour requirements
» Remote locations
» Duration and delays
Mining Methods
Types of mining

» Surface <400m
  » Dry mining
    » Open Cast (soft commodities e.g. Coal)
    » Open Pit (hard commodities e.g. Copper)
  » Wet mining
    » Sluicing (hydraulic mining)
    » Dredging

» Underground
  » Insitu mining
Open Cast Mining

» Grade does not change significantly, and operation is generally configured to maximise equipment efficiency

» Softer rock can be recovered directly using powerful excavators
Open Pit Mining

» Hard rock deposits, smaller and more varied than for softer rocks

» Operations usually more constrained

» Extraction involved drilling and blasting, rather than digging

» Broken ore lifted by excavators and front end loaders.

» Haulage and conveyors
Mineral Processing
Mineral processing

1. Crushing/grinding
2. Concentration
3. Metal recovery
4. Waste storage

» First two stages = mills
» Third stage = smelters and refineries
Crushing/grinding

1. Primary crushing – jaw breakers
2. Secondary crushing – cone or double roll crusher
3. Screening
4. Grinding
   1. autogenous mills
   2. semi-autogenous mills
5. Classification
Concentration

» Series of processes that concentrates the ore by removing the waste material

» Flotation
  » involves treating ground ore with bubble mixture of water and chemical reagent – mineral adheres to gas bubble and float to surface

» Heavy Media Separation

» Thickeners

» Filters

» Specialised
  » Diamond – grease tables and x-ray
  » Iron Ore - magnetic
Metal recovery

» Hydrometallurgy – use of liquids to recover metal
  » Cyanidation – gold dissolves with cyanide
  » Heap leach – similar but low grade surface stacking
  » Pressure cells – nickel & ammonia
  » Solvent extraction & electo-winning – dissolved then electrolysis

» Pyrometallurgy – use of heat to recover metal
  » Smelters
  » Refineries
Waste handling – tailing dams

» Waste material from processing plant usually transported to a tailing dam.

» Various types of dam but most are built with waste product
  » containment or toe wall
  » drainage system
  » delivery system
  » decant and water return system
Closure

» Closure plan – commitment to Gov and affected persons
» Financial surety
» Need an agreed end state
» Reclamation, re-vegetation
» Post closure monitoring
  » (defined liability)
Markets
Share of total revenue by customer location

% of revenue by customer location

30%
25%
20%
15%
10%
5%
0%

North America  |  China  |  Europe

2009  |  Orange
2010  |  Light Orange

Source: PwC analysis.