The Dynamics of Mineral Reserves
The impact of demand and technology on the supply of minerals & metals

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Outline

• Importance of minerals & metals
• Key Definitions
• Mineral scarcity
• Cost of production
• Ore grade and tonnage
• Recycling
• Other means of achieving functionality
• Conclusions
Context for Sustainable Mining

"Mining, minerals and metals are important to the economic and social development of many countries (and) essential for modern living. . ."

Para 46, Plan of Implementation
2002 World Summit on Sustainable Development (WSSD)

Includes commitment to sustainable development and an enhanced contribution of mining, minerals and metals by addressing environmental, health & social impacts and benefits over their life cycle, promoting participation of stakeholders in mining operations, including post-closure and fostering of sustainable mining in developing countries through financial/technical assistance and capacity building.
Mineral Reserve

A concentration or occurrence of diamonds, natural solid inorganic or fossilized inorganic material including base and precious metals, coal and industrial minerals in or on the Earth’s crust in a form, quantity, grade or quality to create “reasonable prospects for economic extraction”

- Based on specific geological evidence/knowledge

CIM Standing Cttee on Reserve Definitions, 2005
Mineral Reserves

Defined by consideration and application of technical, economic, legal, environmental, socio-economic and governmental factors

Forces affecting size of reserve:

- Mining production (depletes specific reserves)
- Entrepreneurial activities (mineral exploration, technology development) create new reserves
Fixed or Static Approach?

Minerals & metals are used to provide specific product functions and performance criteria.

As the earth is finite, it is intuitively appealing to consider mineral resources as static.

Historical data suggests that a dynamic system requiring consideration of trade-offs or opportunity costs is more useful.
Mineral scarcity

OECD Synthesis Report* – provides context, identifies concern re: depletion of mineral resources, finite stock

Mineral Scarcity Indicator
= annual demand/reserve
= apparent reserve life (in year)

Reserves, Resources & the Resource Base

Identified

Reserves

Undiscovered

Resources

Resource Base

Increasing Economic Feasibility

Increasing Geological Assurance

* McKelvey box

Note: Because metals are transformed not lost and their almost infinite recyclability, metals in use can be considered another form of “reserve”
## World Cu Reserves & Annual Production 1950-2005

### Over the last 50 years:

<table>
<thead>
<tr>
<th>Year</th>
<th>Reserve (million tons)</th>
<th>Mine production (million tons)</th>
<th>Apparent reserve life</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>91</td>
<td>2.38</td>
<td>38</td>
</tr>
<tr>
<td>1955</td>
<td>146</td>
<td>2.90</td>
<td>50</td>
</tr>
<tr>
<td>1960</td>
<td>154</td>
<td>3.94</td>
<td>39</td>
</tr>
<tr>
<td>1965</td>
<td>195</td>
<td>4.66</td>
<td>42</td>
</tr>
<tr>
<td>1970</td>
<td>280</td>
<td>5.90</td>
<td>47</td>
</tr>
<tr>
<td>1975</td>
<td>408</td>
<td>6.74</td>
<td>61</td>
</tr>
<tr>
<td>1980</td>
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<tr>
<td>1985</td>
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<td>43</td>
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<tr>
<td>1990</td>
<td>326</td>
<td>9.20</td>
<td>35</td>
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<td>1995</td>
<td>348</td>
<td>10.00</td>
<td>35</td>
</tr>
<tr>
<td>2000</td>
<td>340</td>
<td>13.20</td>
<td>26</td>
</tr>
<tr>
<td>2005</td>
<td>470</td>
<td>14.90</td>
<td>32</td>
</tr>
</tbody>
</table>

Reserve > by factor 5

Production > by factor 7

Estimated reserves have fluctuated from 26 – 61 years despite 7 fold increase in mine production

### Conclusion

Estimate of apparent reserve life is not indicator of scarcity

Another way of looking at it ..

Economics drives investment in exploration and technology, which leads to identification of additional reserves.
Time Series for the Price of Copper

The grade and size are two important and independent factors in the economic viability.

No obvious relationship between the size of a deposit and the grade of ore.

Source: USGS, D. A. Singer et al
Factors affecting mining investment

- Geological data
- Infrastructure
- Price of the commodity
- Cost of production
Recycling

- Longevity of metals in use in products, plants and infrastructure contributes to a lag in availability for recycling
- Need to place greater emphasis on end of life recycling VS recycled content approach
Other means of meeting demand

Use of alternate way to deliver a function:

- Fibre optic for copper wire
- Rare earth metal as substitute for cobalt in magnet
- Production of synthetic nitrate fertiliser
Conclusions

• Minerals and metals are produced to deliver function in products

• Estimates of apparent reserve life not useful means to assess scarcity

• Technological productivity i.e. improved exploration, mining, production and use, recycling, substitutability have, in the past, and will, in the future, lead to the creation of “reserve”