CANMET Mining and Mineral Sciences Laboratories

The Dynamics of Mineral Reserves

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

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Module 4 Sustainable Mining and Recycling

Natural Resources Canada | Ressources naturelles Canada

Canada

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

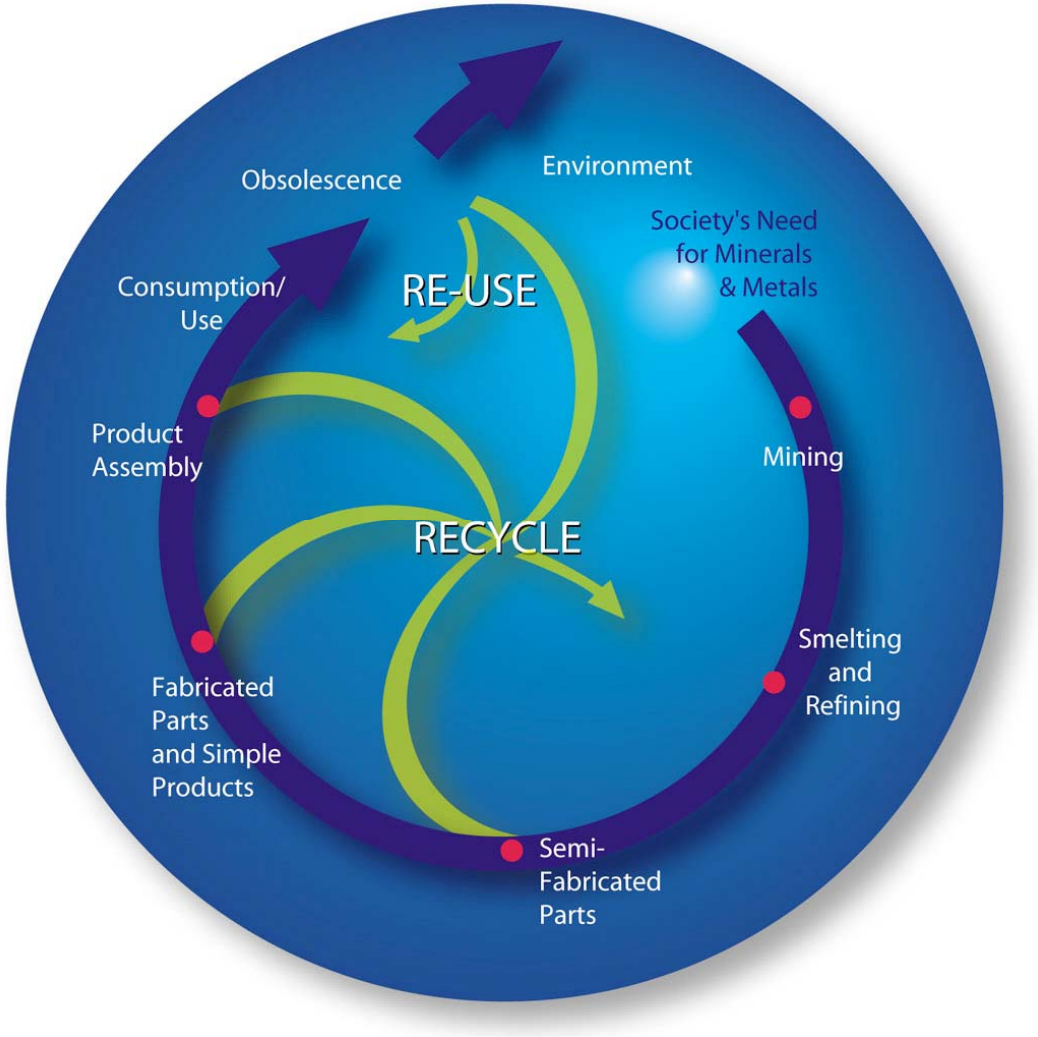
CIM Standing Cttee on Reserve Definitions, 2005

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


Obsolescence
Environment
Society's Need for Minerals & Metals
Consumption/ Use
RE-USE
Product Assembly
Mining
RECYCLE
Smelting and Refining
Fabricated Parts and Simple Products
Semi-Fabricated Parts

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

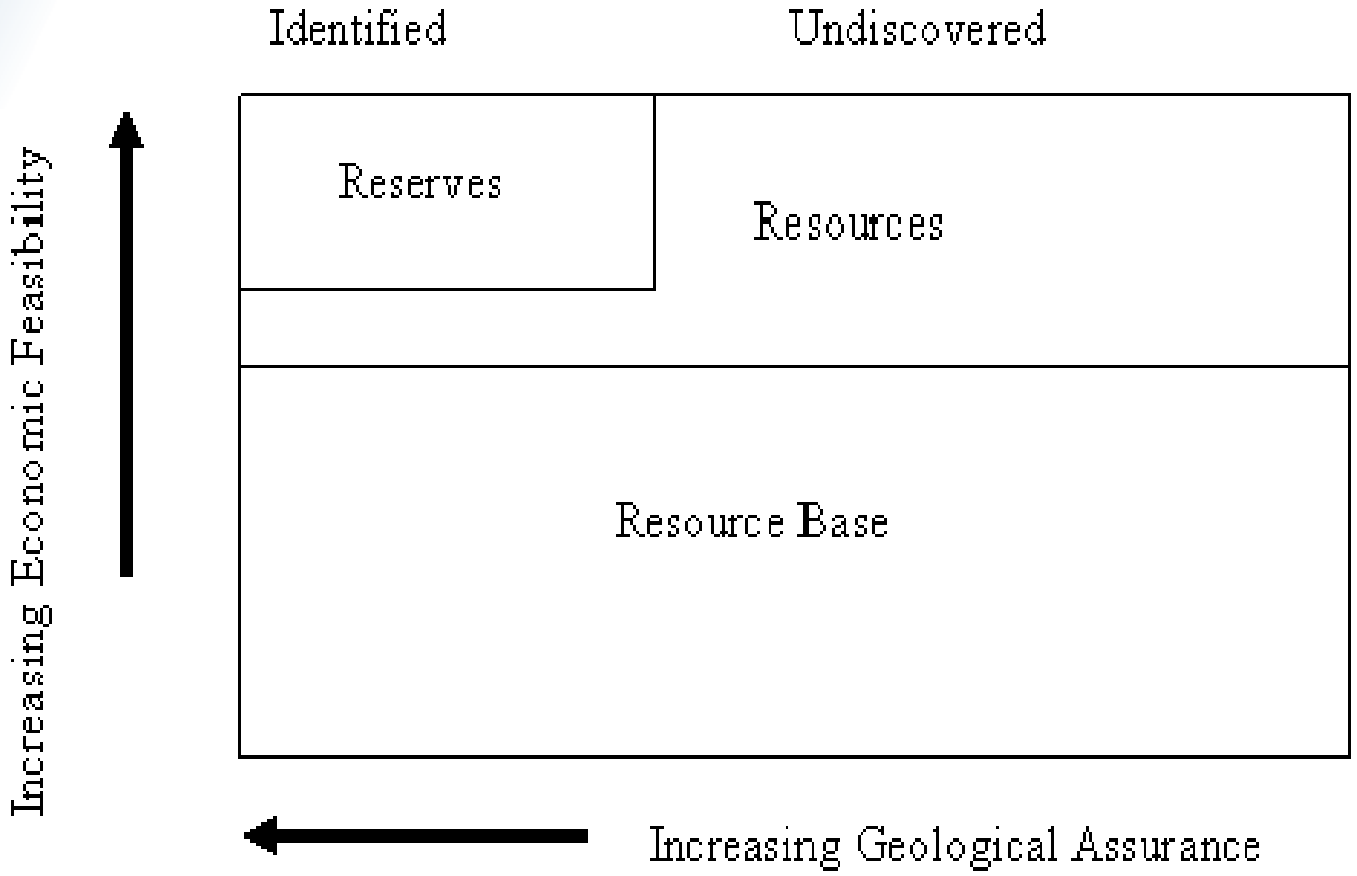
Mineral Scarcity Indicator

= annual demand/reserve

= apparent reserve life (in year)

*Measuring Material Flows and Resource Productivity (ENV/EPOC/SE(2007)5)

Reserves, Resources & the Resource Base



** 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:

Reserve **>** by factor **5**

Production **>** by factor **7**

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

Conclusion

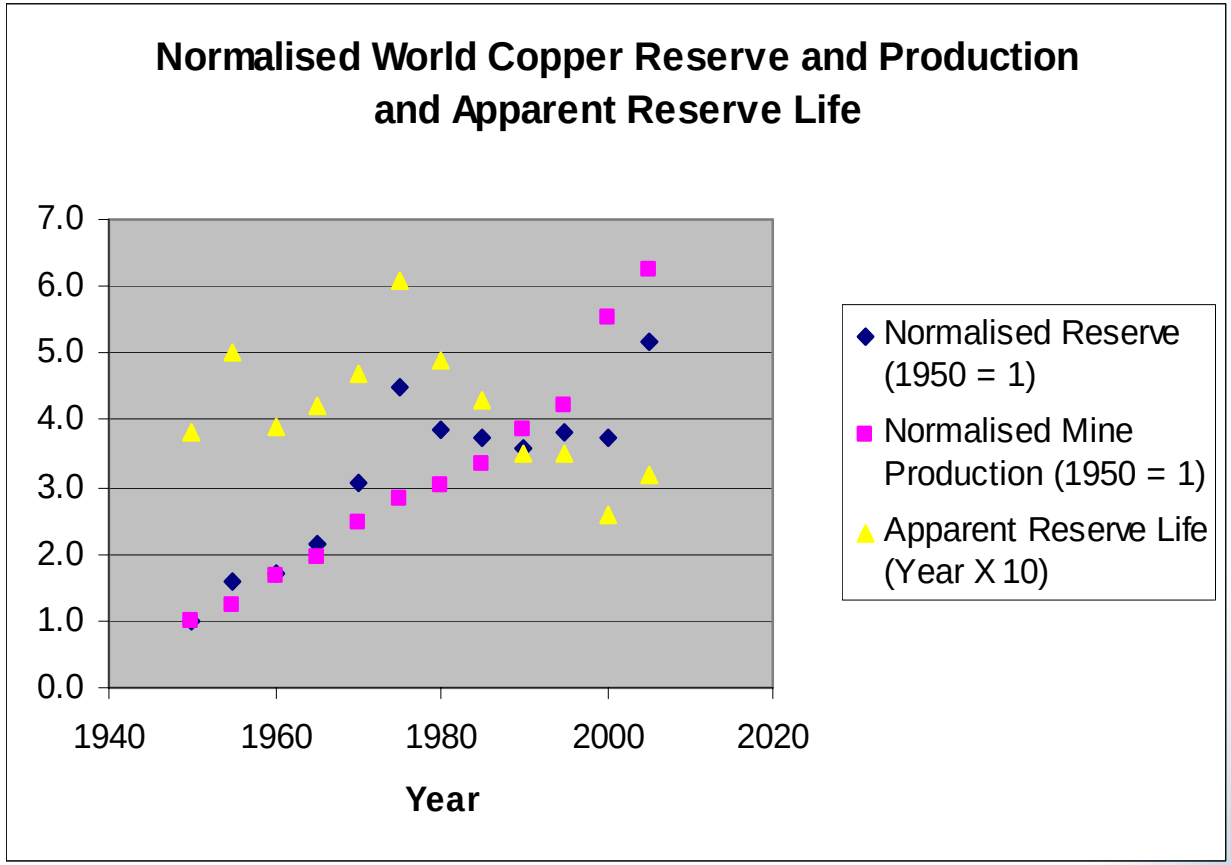
Estimate of apparent reserve life is not indicator of scarcity

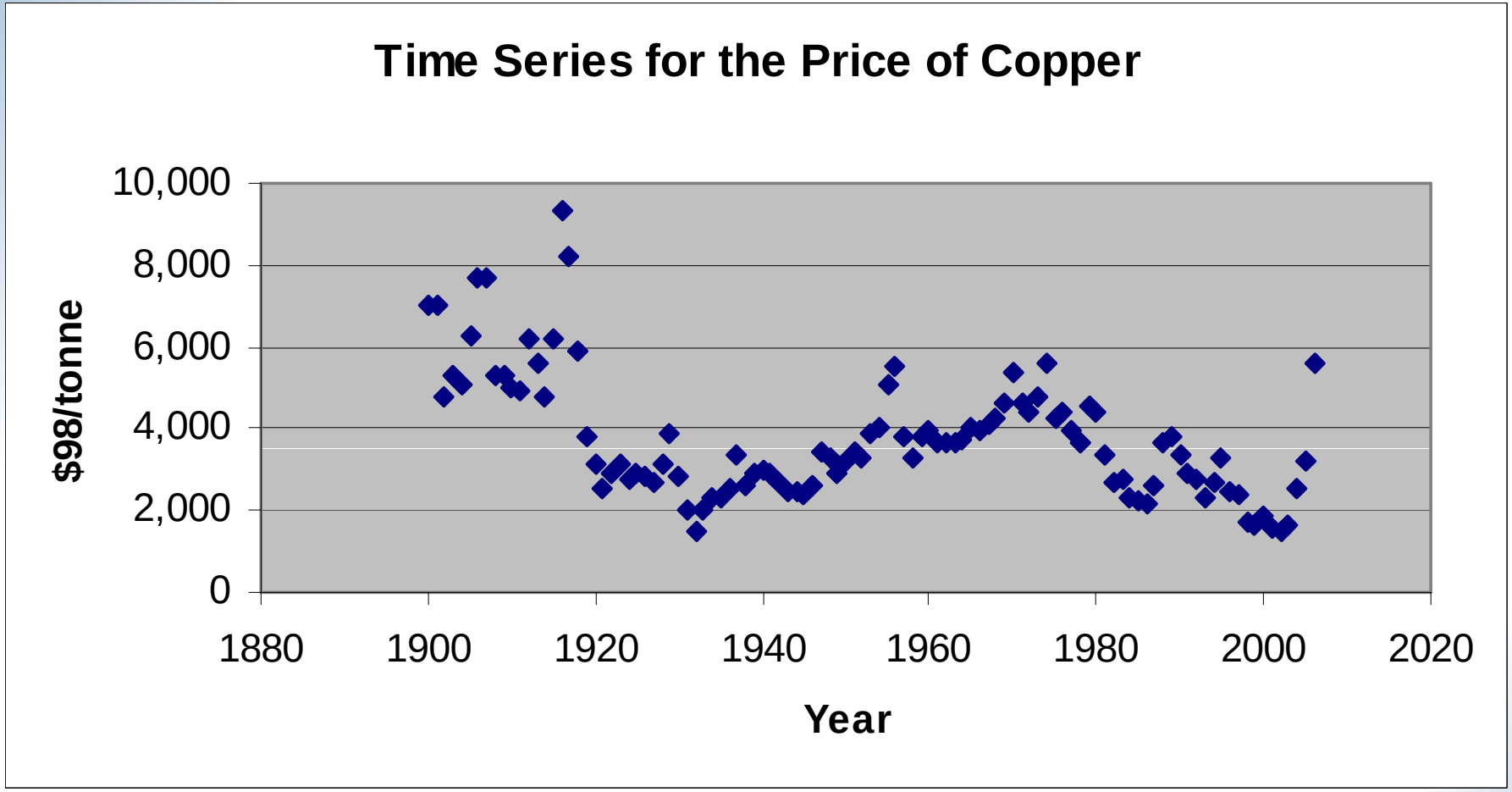
Year	Reserve (million tons)	Mine production (million tons)	Apparent reserve life
1950	91	2.38	38
1955	146	2.90	50
1960	154	3.94	39
1965	195	4.66	42
1970	280	5.90	47
1975	408	6.74	61
1980	350	7.20	49
1985	340	7.99	43
1990	326	9.20	35
1995	348	10.00	35
2000	340	13.20	26
2005	470	14.90	32

J. E. Tilton, G. Lagos, Assessing the Long-run Availability of Copper, Resources - Policy 32 (2007) 19-23

Another way of looking at it ..

Economics drives investment in exploration and technology, which leads to identification of additional reserves.



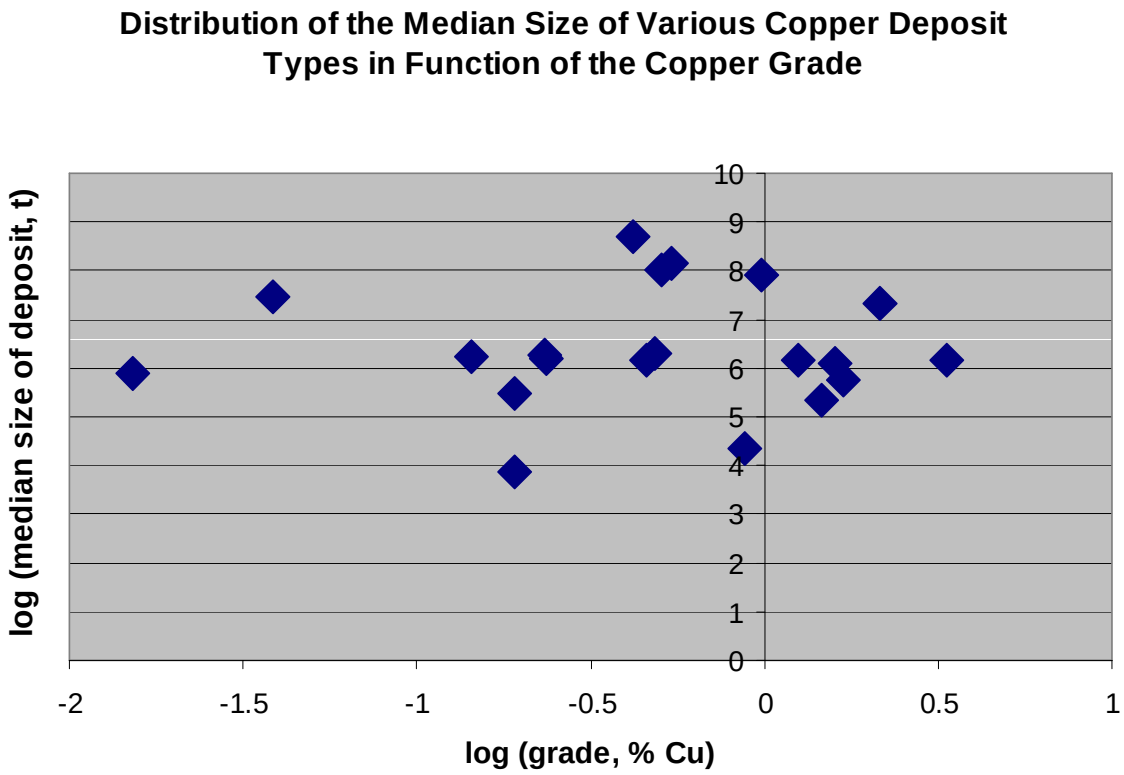


http://minerals.usgs.gov/ds/2005/140/copper.xls

Ore grade & Output

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”