Means and Policy for Securing Supply Security

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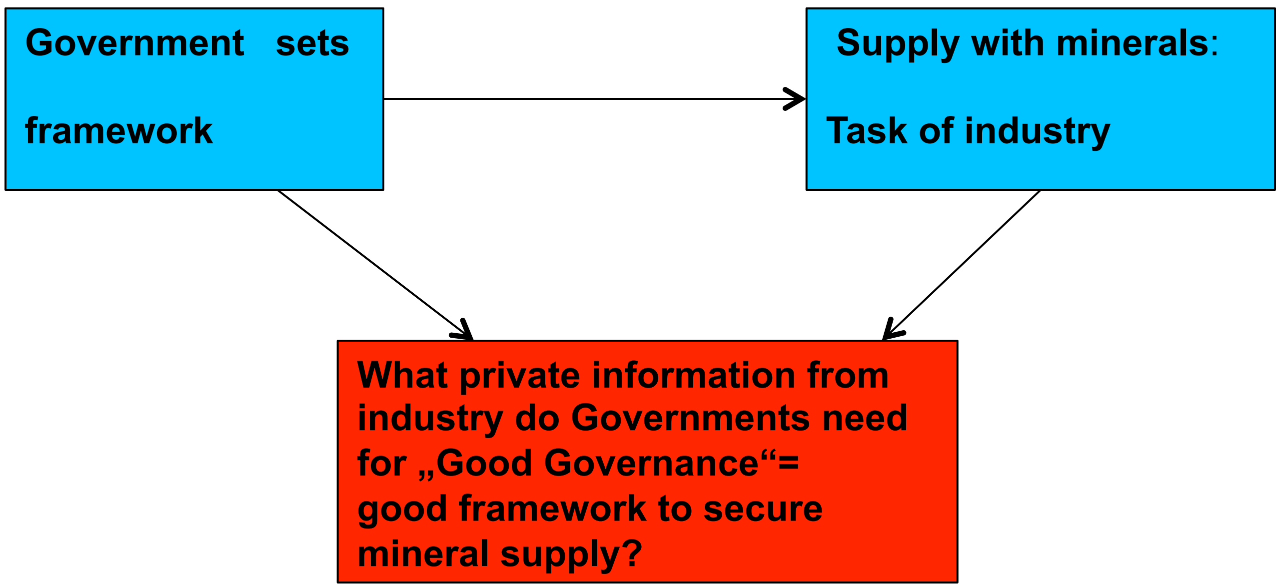
Means and Policy for Securing Supply Security



Security of Supply

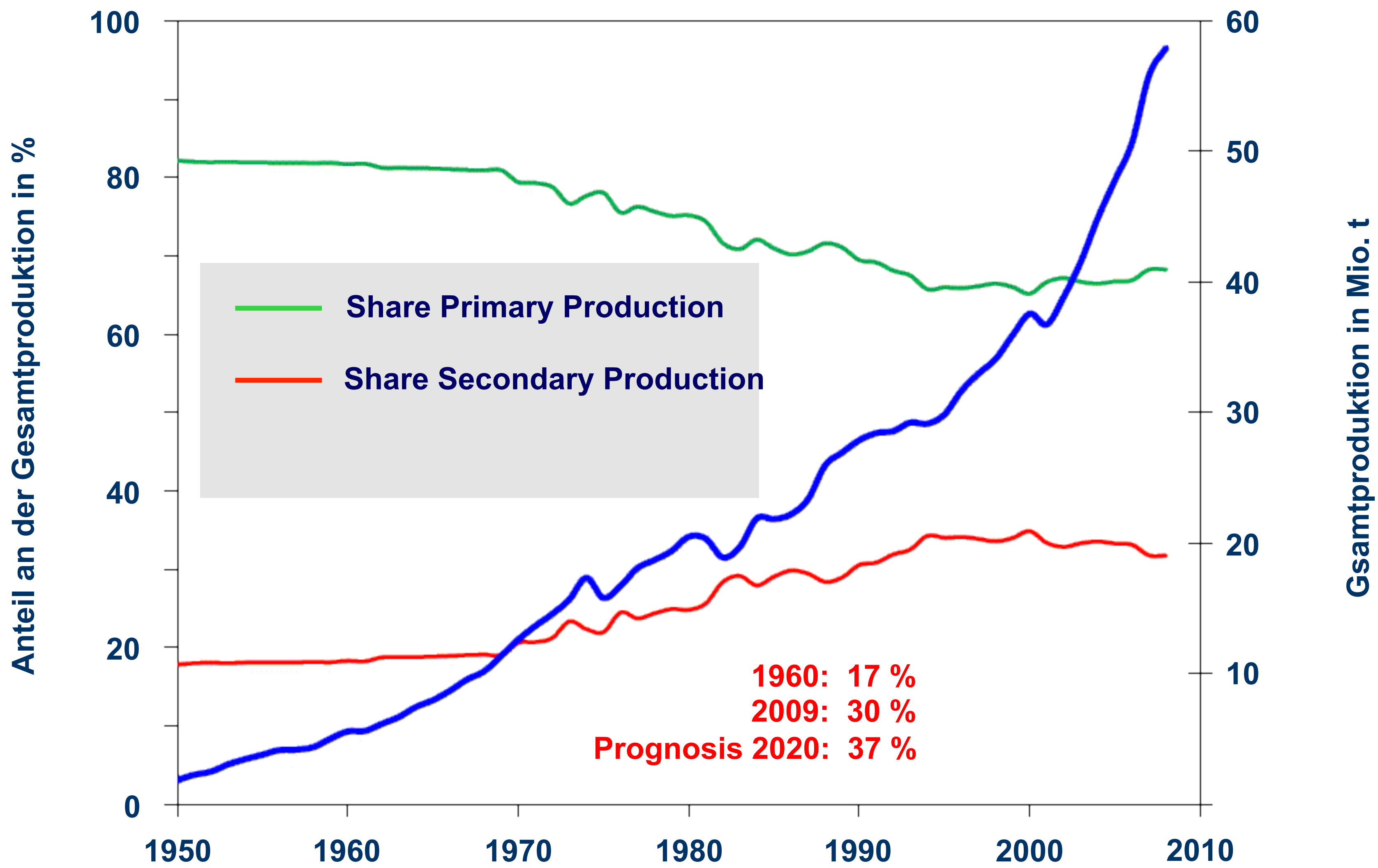
Supply from primary resources

question of
- --- reserves
- --- resources
- --- geopotential

Supply from secondary resources

- --- existing capacities
- --- planned capacities
- --- forecast: cost of recycling vs. price of primary phosphate

Development of total Al-Production (Primary + Secondary Aluminium)



Quelle: International Aluminium Institute

(Deutsche Rohstoffagentur DERA /BGR)

Security of Supply

Supply from primary resources

question of --- reserves

--- resources

--- geopotential

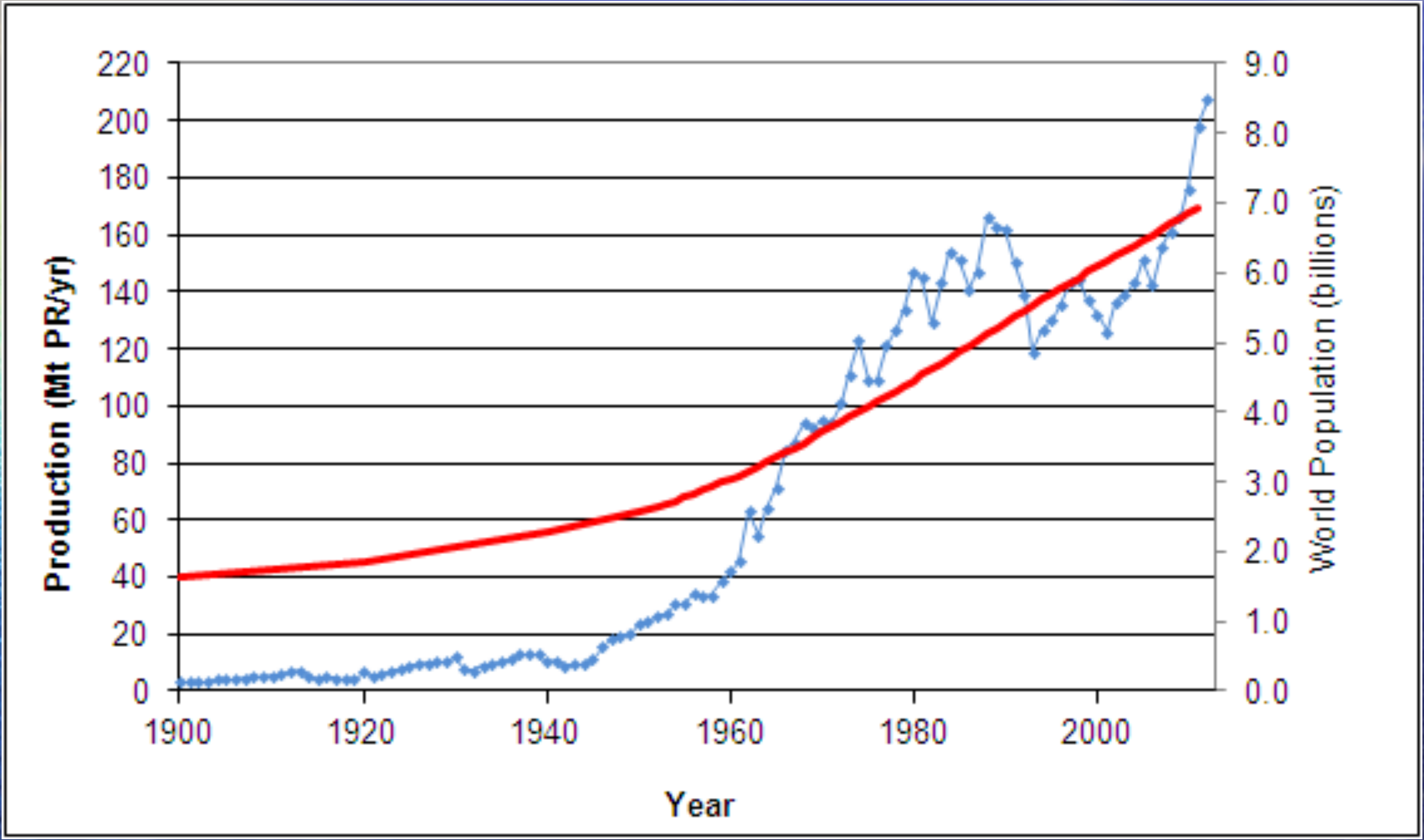
Supply from secondary resources

--- existing capacities

--- planned capacities

--- forecast: cost of recycling vs. price of primary phosphate

Global Trend in Production and Population



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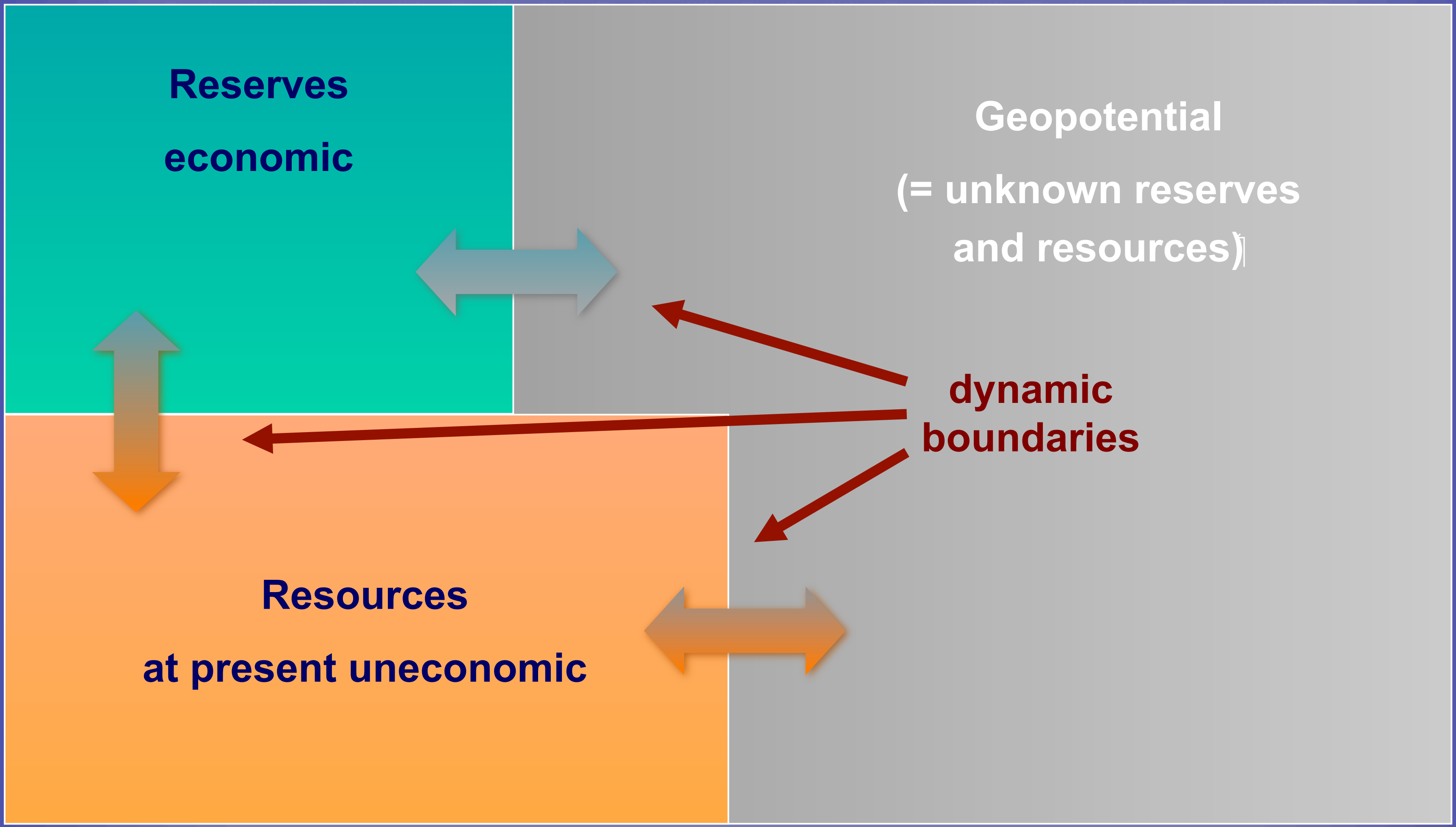

Reserves
economic
Geopotential
(= unknown reserves
and resources)
dynamic
boundaries
Resources
at present uneconomic

Examples for transfer of resources to reserves and vice versa from Germany:

Case 1: potash mine south of Hannover (Siegfried Giesen) closed 1991: reserves → resources

prepared for reopening 2014: resources → reserves

Case 2: Graphite mine Kropfmühl in Bavaria, closed in 2005: reserves → resources

reopended in 2012: resources → reserves

The Growing of Reserves –

Example: Oil

	Production	Reserves	Ratio reserve/production
1950	543 Mio t	11,277 Mio t	20
2010	3,937 Mio t	216,900 Mio t	55

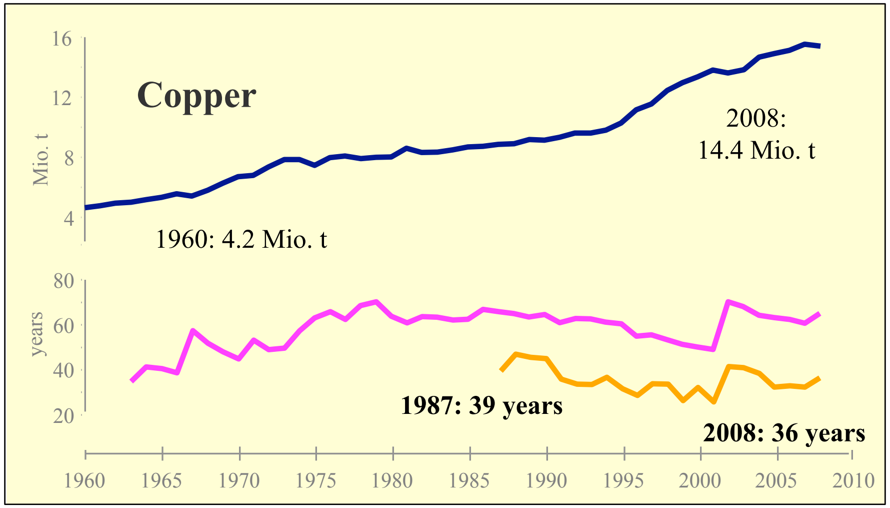
The Growing of Reserves –

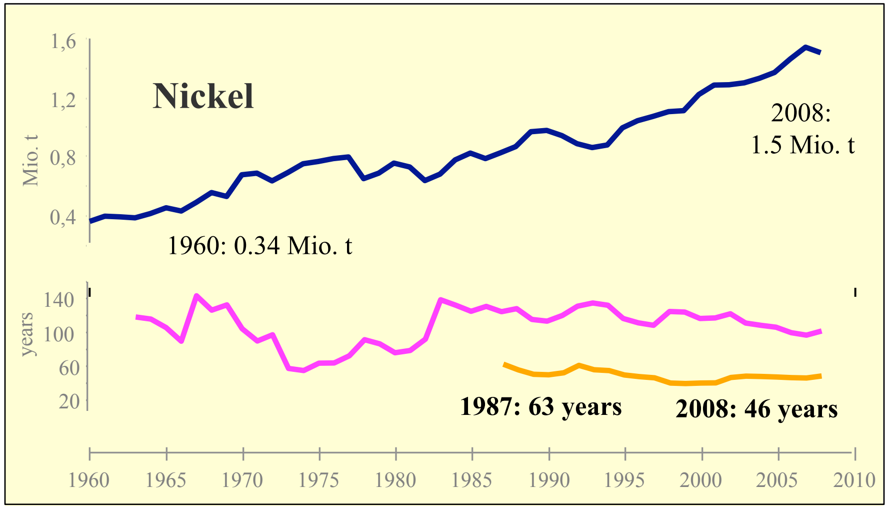
Example: Phosphate

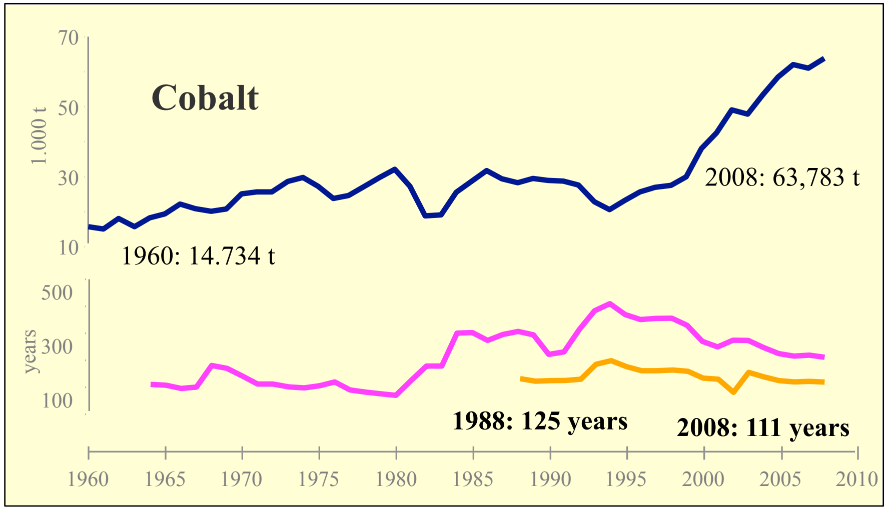
	Production	Reserves	Ratio $\frac{\text{Reserves}}{\text{production}}$
1988	**152.6 Mio t**	**13 855 Mio t**	**91**
2011	**191.0 Mio t**	**71 000 Mio t**	**372**

(Source: USGS, Mineral Commodity Summaries)

Static life time – the reality







- Mine production
- Static life time of reserve base*
- Static life time of reserves

Data sources: USGS, BGR database, 2009
*Before 1988, the USGS only classified reserve base

Meaning of R/C Ratio

- Not a “lifetime”, but rather:
  - “an indication for the time available to find solutions to availability problems” (Scholz and Wellmer)
- Could the same be said for other extrapolation approaches?

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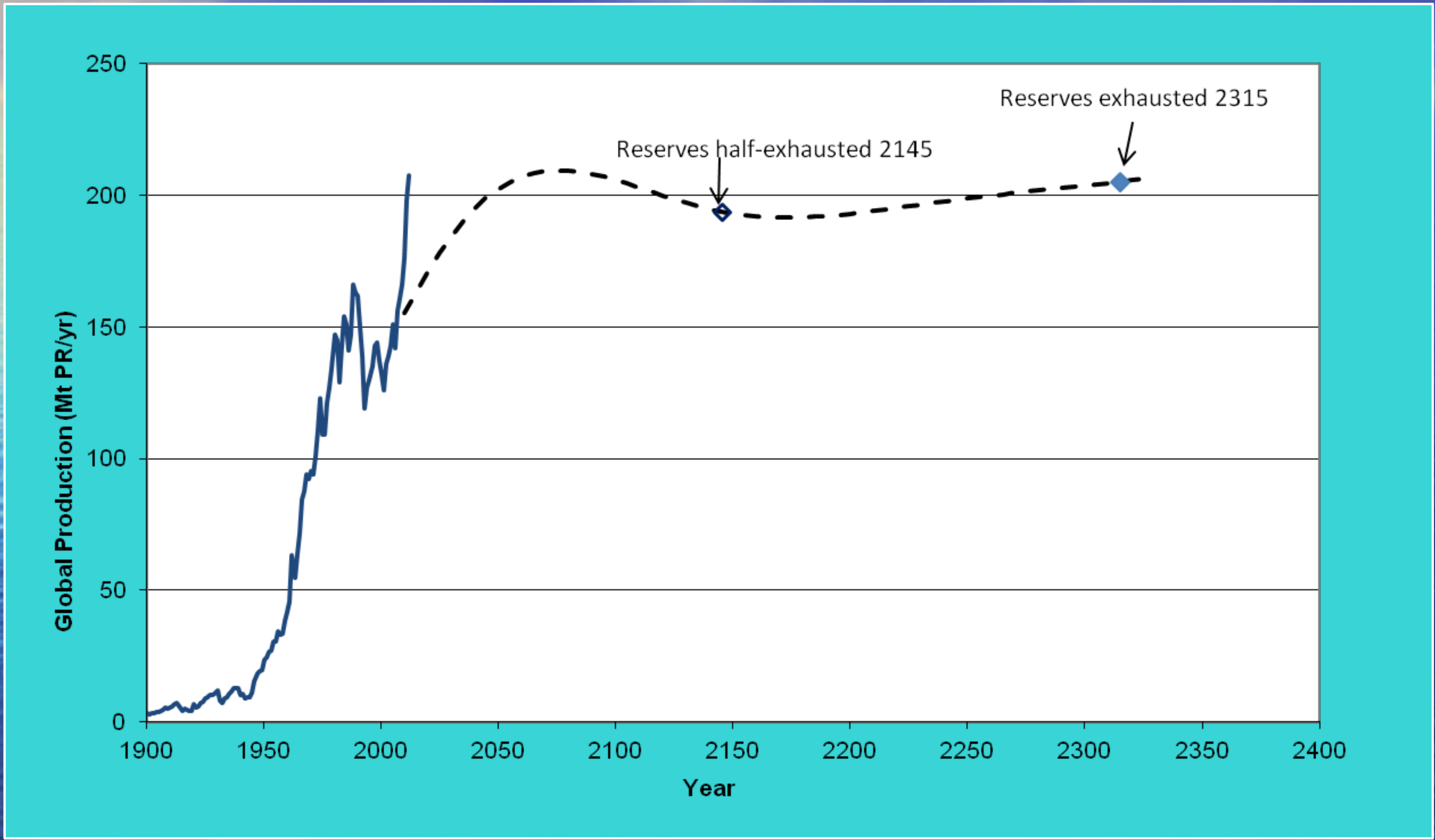
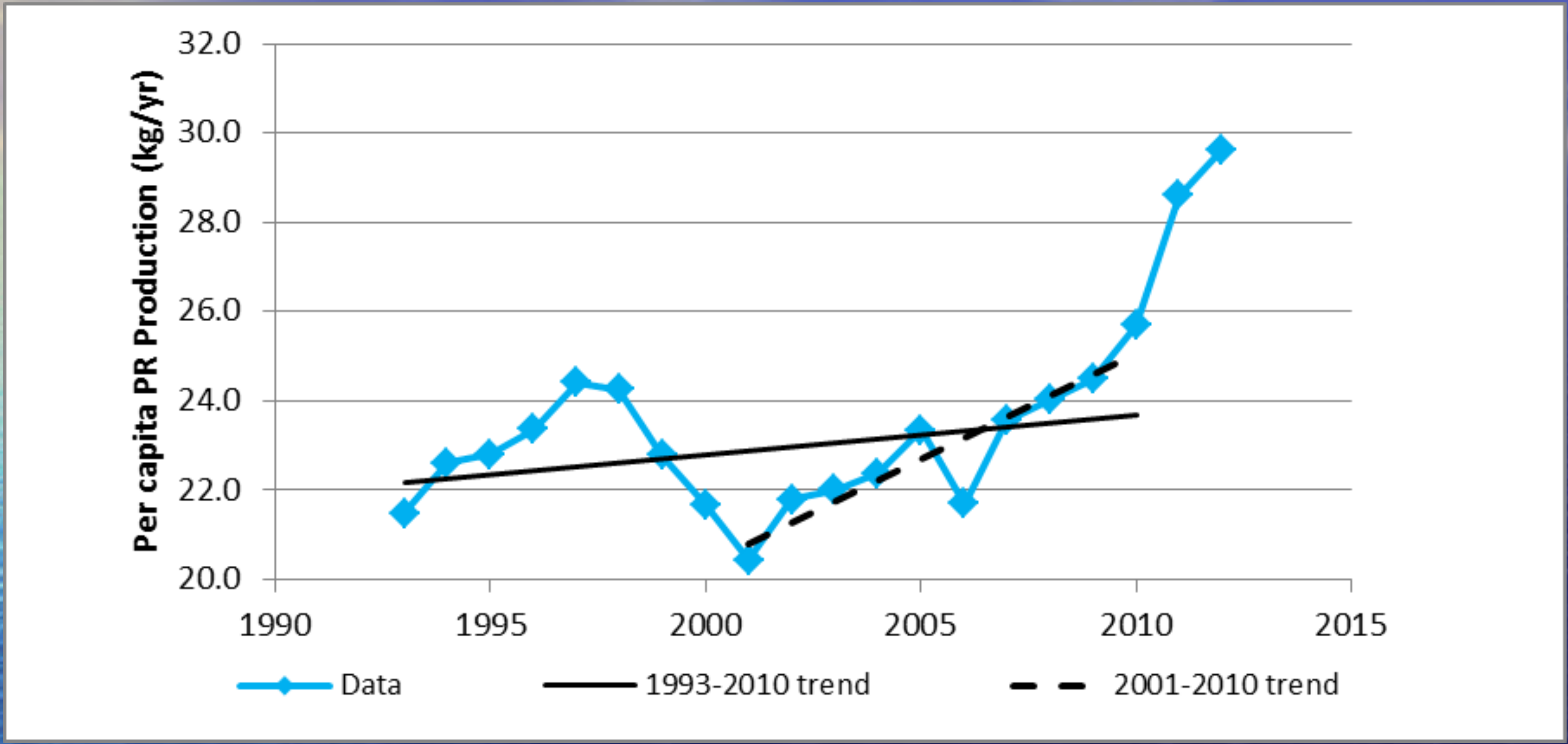
Assume constant per-capita PR



Recent Per Capita Global PR Production



Annual rate of increase			
	kg PR /cap/yr	g P /cap/d	Annual rate
1993-2010 (17 yrs)	0.10	0.036	1.1%
2001-2010 (9 yrs)	0.52	0.19	2.6%
2009-2012 (3 yrs)	1.17	0.61	6.5%

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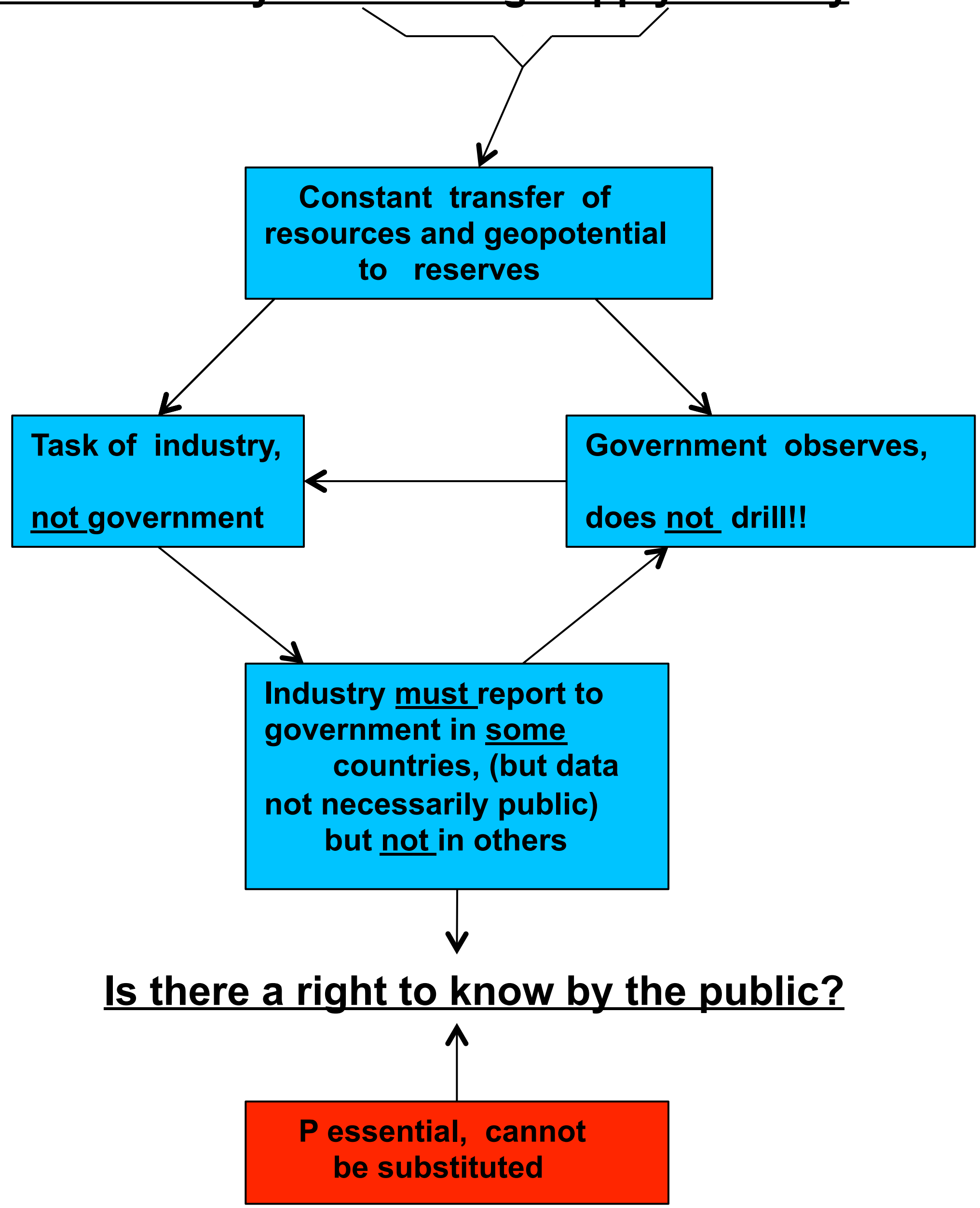
Means and Policy for Securing Supply Security



Who are the biggest players in the phosphate field?

a.) Integrated fertilizer companies

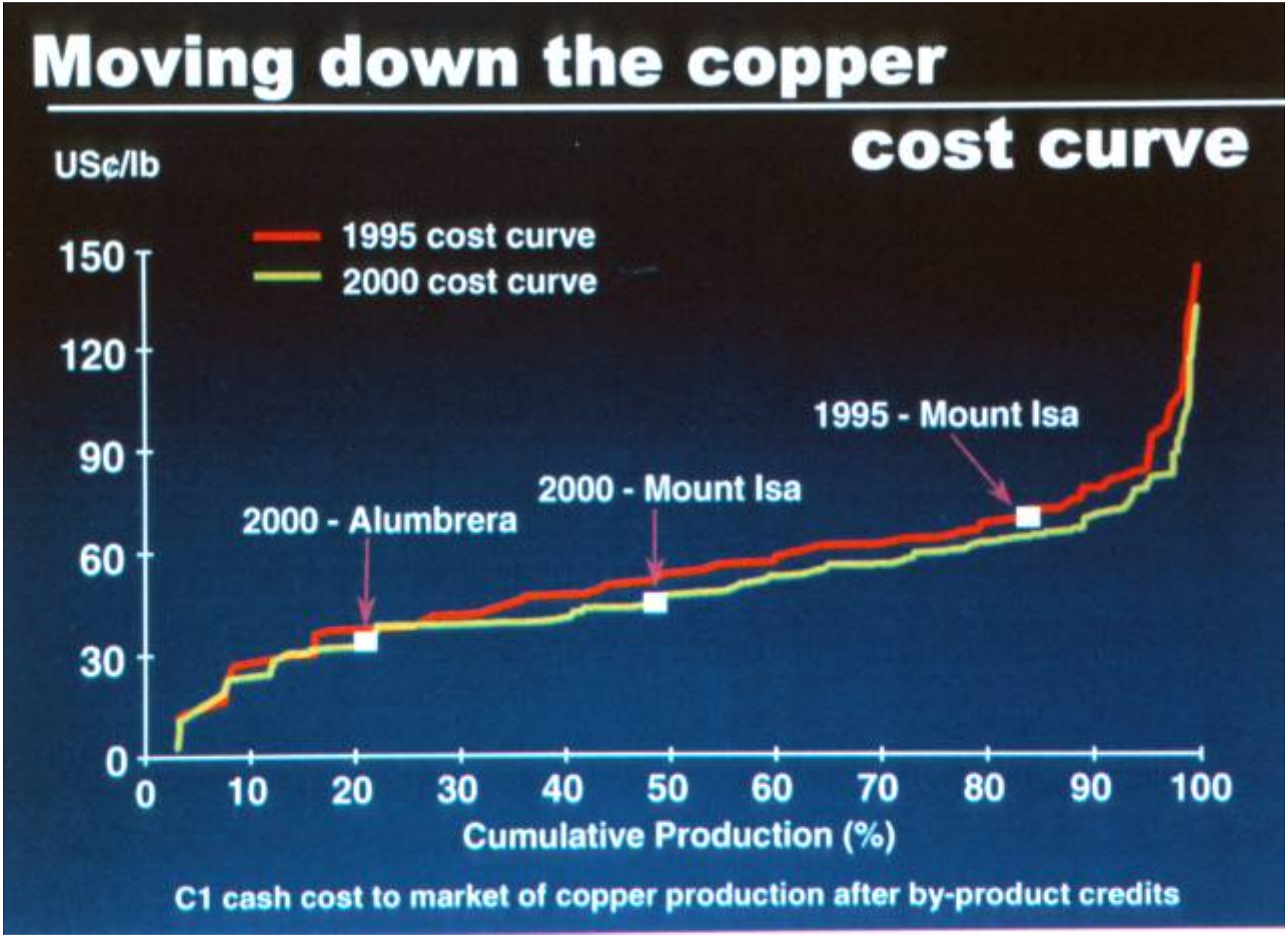
b.) More and more target of multinational big mining companies

Their targets: **Tier one projects** (large, long-lived projects with prospectively low costs)

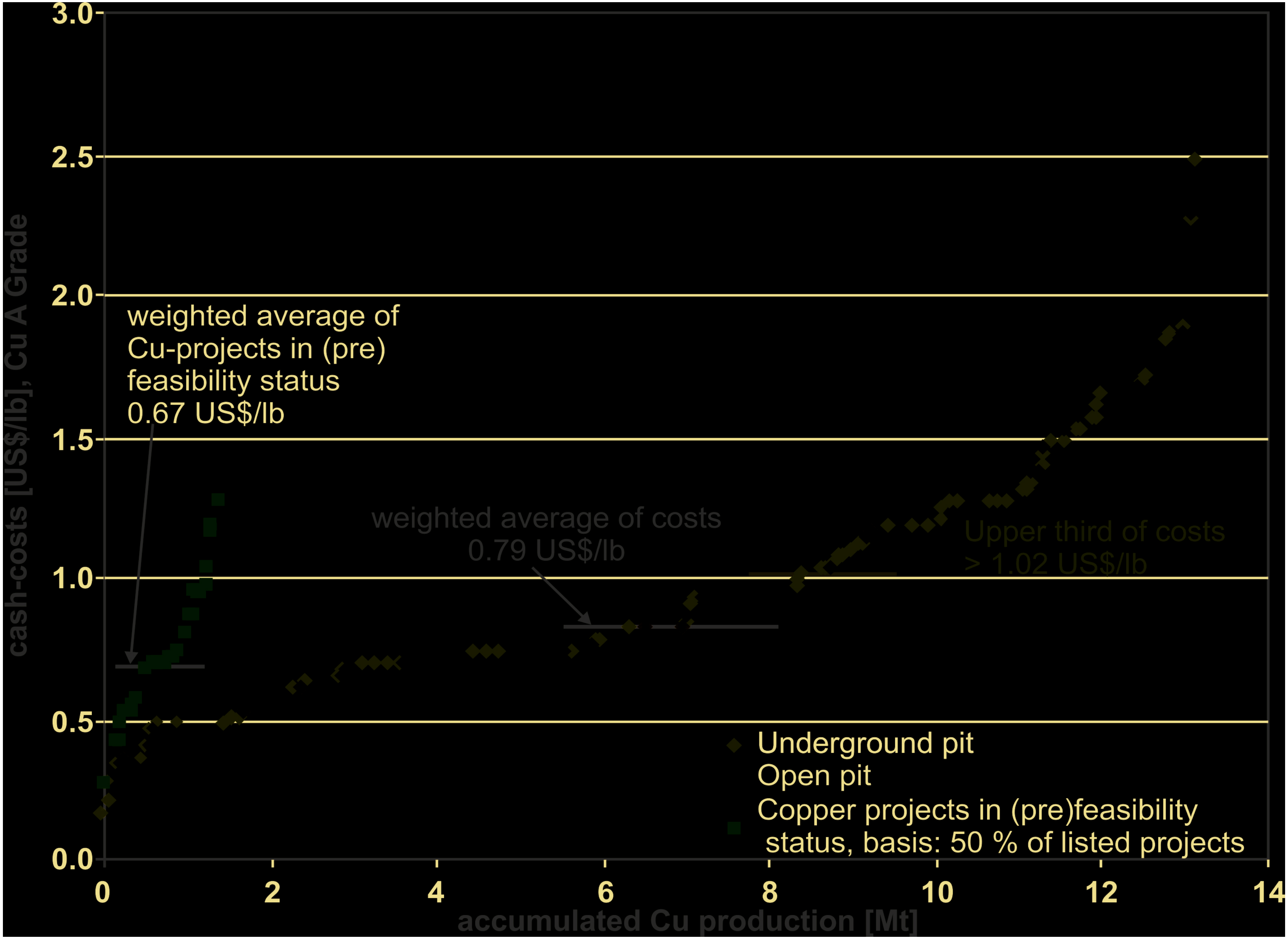
Commodities: copper, iron ore, coal, gold, (diamonds)

New targets: **potash, phosphate** (nickel, zinc)

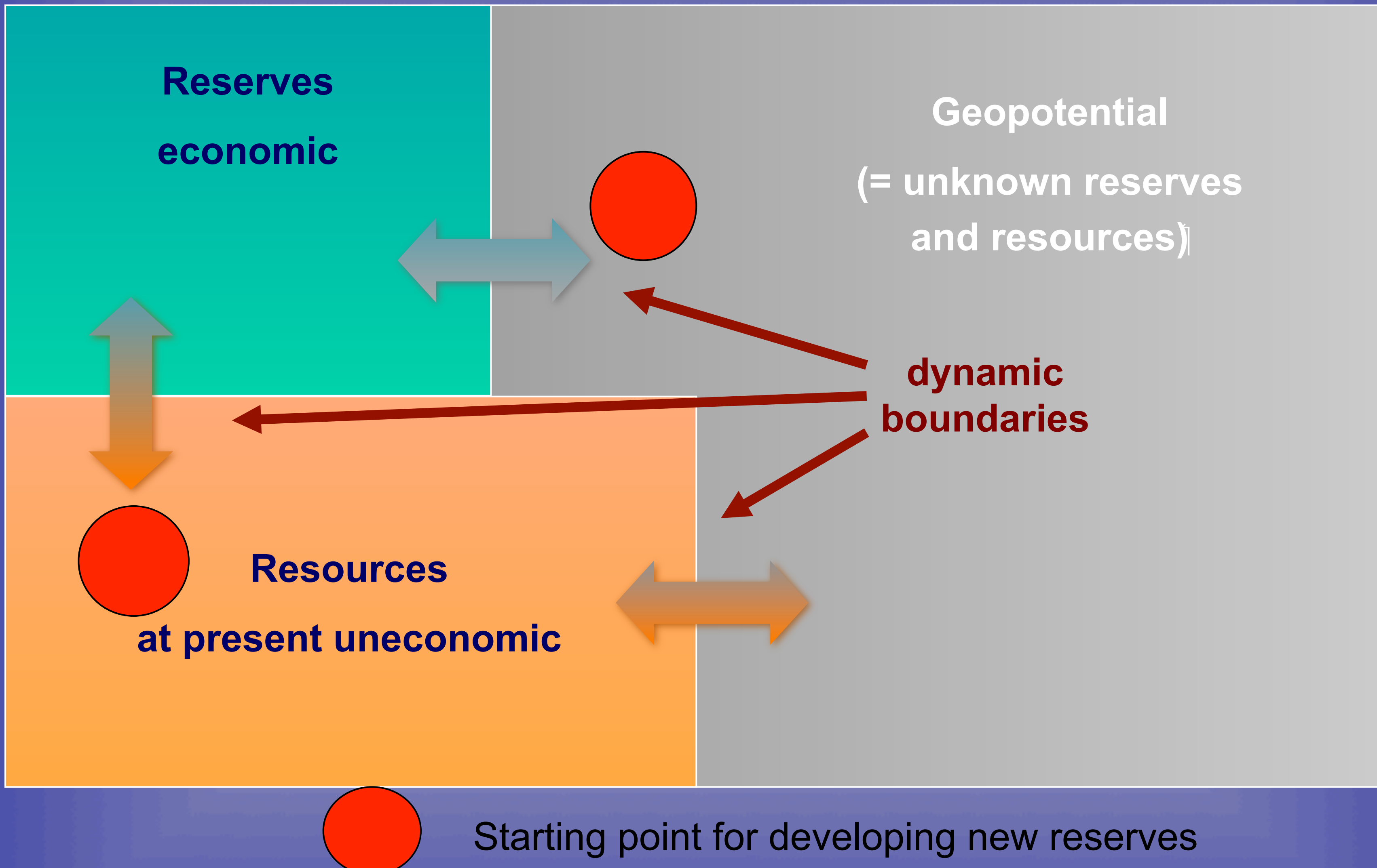
(Crowson, P. (2012): Solving the minerals equation? Demand, prices and supply. Paper LE STUDIUM conference Life and Innovation Cycles in the Field of Raw Materials Supply and Demand—a Transdisciplinary Approach, 19.–20. April 2012, Orléans, France)



Moving down the copper cost curve
USc/lb
1995 cost curve
2000 cost curve
150
120
90
60
30
0
1995 - Mount Isa
2000 - Mount Isa
2000 - Alumbrera
0
10
20
30
40
50
60
70
80
90
100
Cumulative Production (%)
C1 cash cost to market of copper production after by-product credits



(Source: J.Vasters, Commodity Fact Sheet 2011, BGR/DERA)


Reserves
economic
Geopotential
(= unknown reserves
and resources)
dynamic
boundaries
Resources
at present uneconomic
Starting point for developing new reserves

New Projects: Two Alternatives:

a.) Start in Geopotential field, i.e. invest in exploration

b.) Start in Resources field (known, but uneconomic at present),

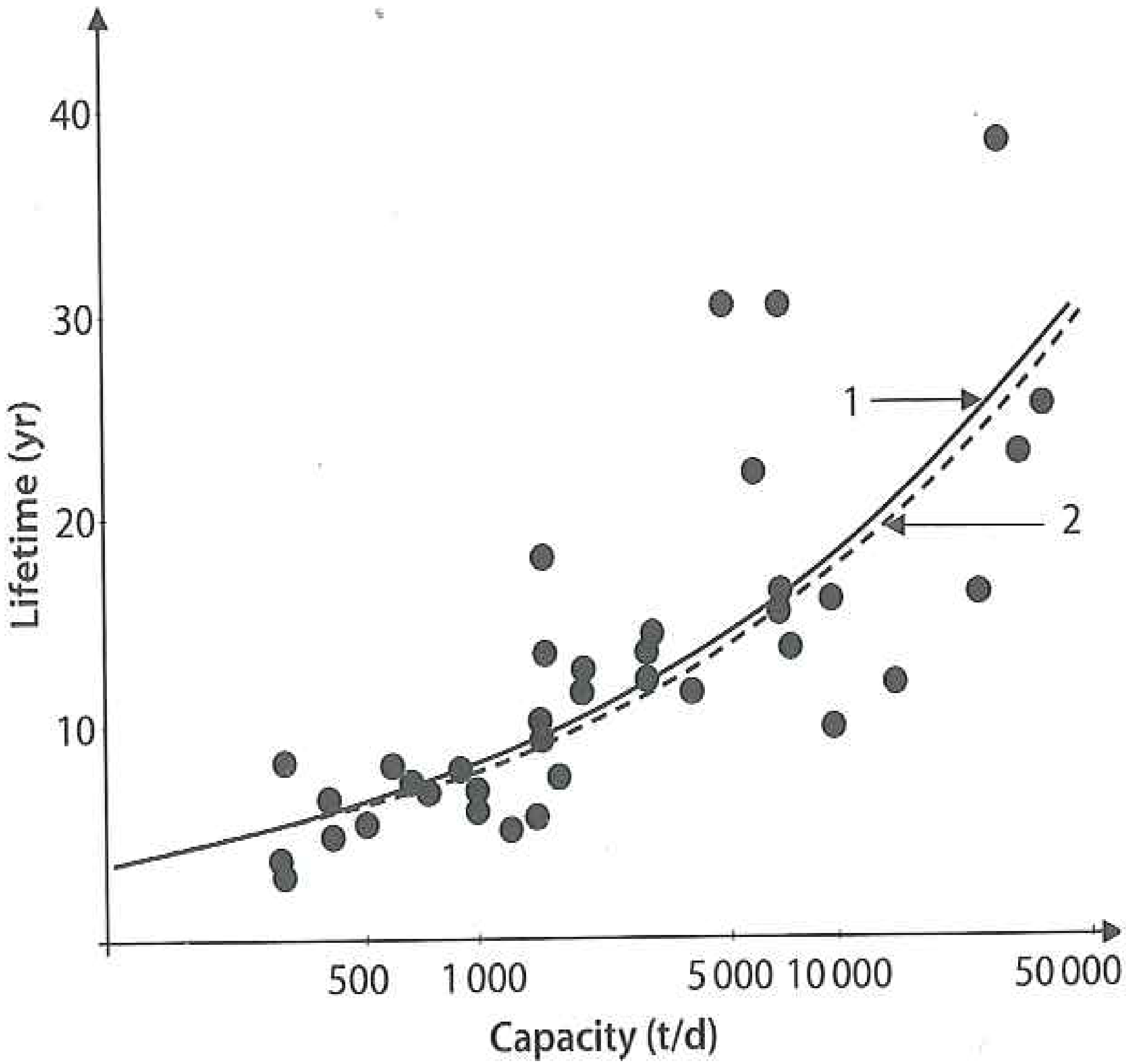
Consequences:

1.) For some commodities grades become higher and higher

2.) For others grades decline due to new technologies

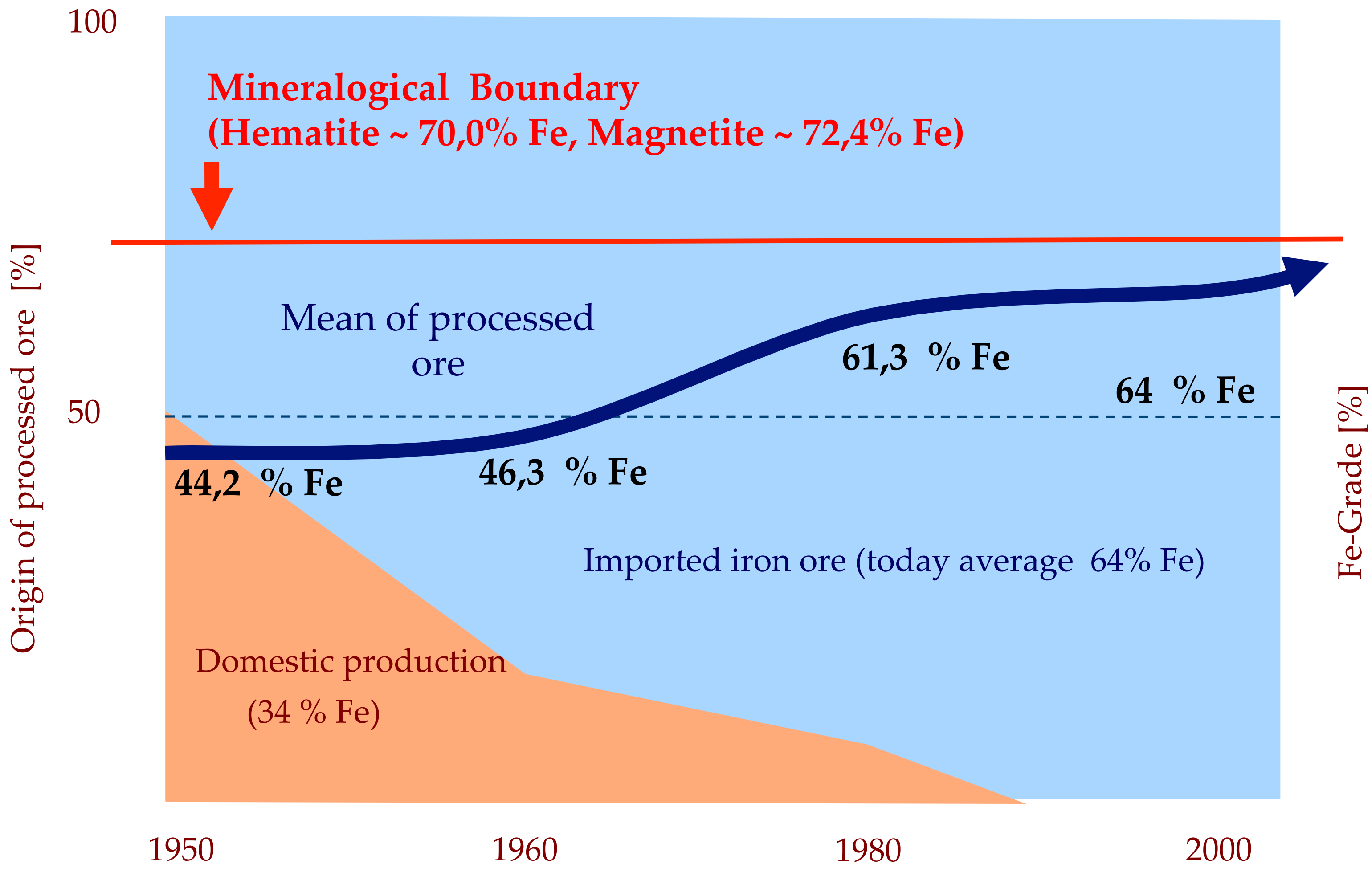
3.) Operations become larger and larger, requiring larger reserves.
(Economics of scale, Taylor Rule)

Fig. 8.1a.
Lifetime of Canadian base-metal mines at the time of production decision (1967–1977) (Wellmer 1979):
1. the relationship postulated by Taylor (1977): $y = 0.83x^{0.34}$;
2. interpolation of the real data points $y = 0.69x^{0.35}$



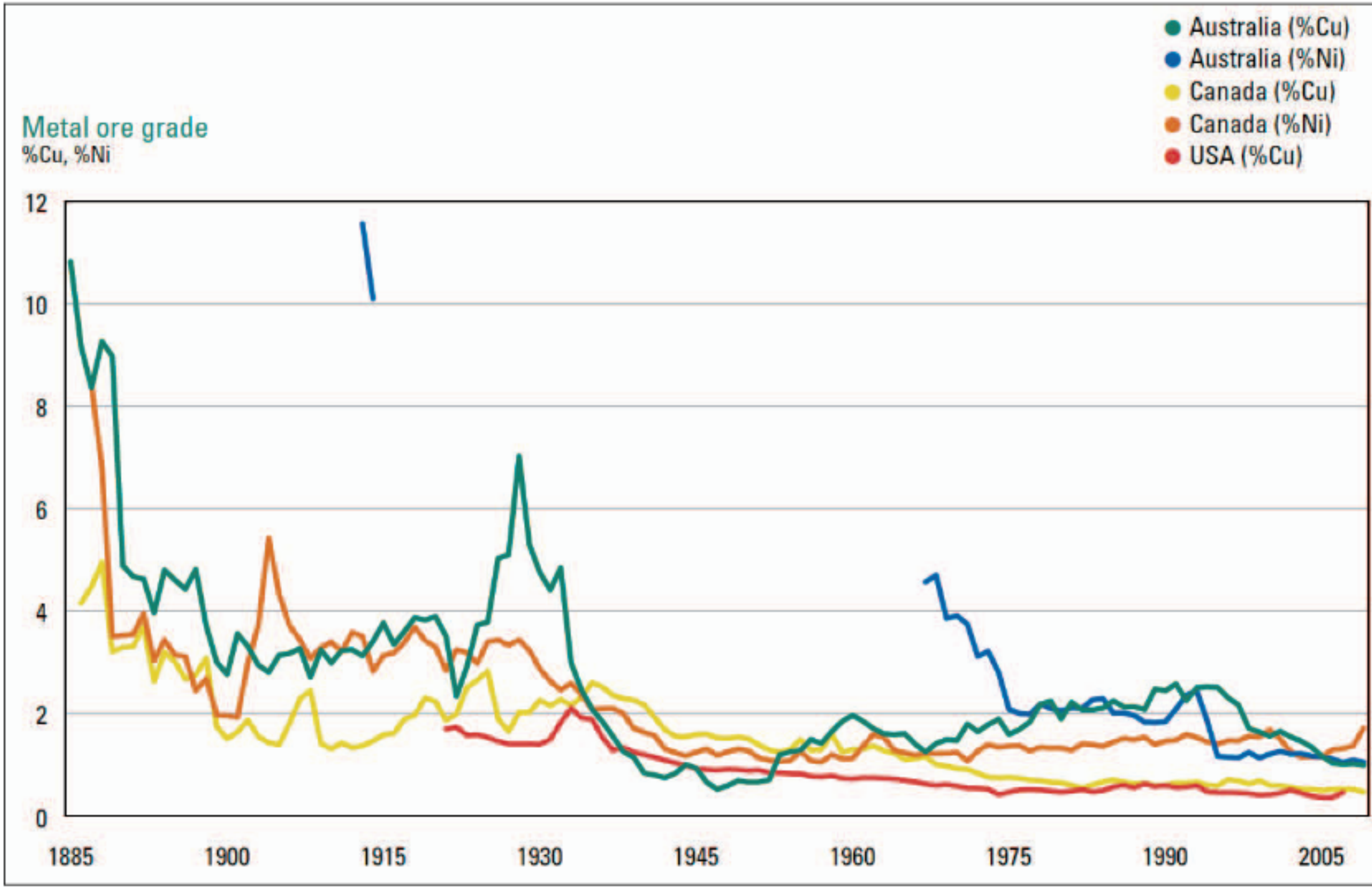
(Source: F.-W. Wellmer, M.Dalheimer, M. Wagner: Economic Evaluations in Exploration, Heidelberg, New York etc. (Springer) 2008)

Iron Ore Supply Germany since 1950



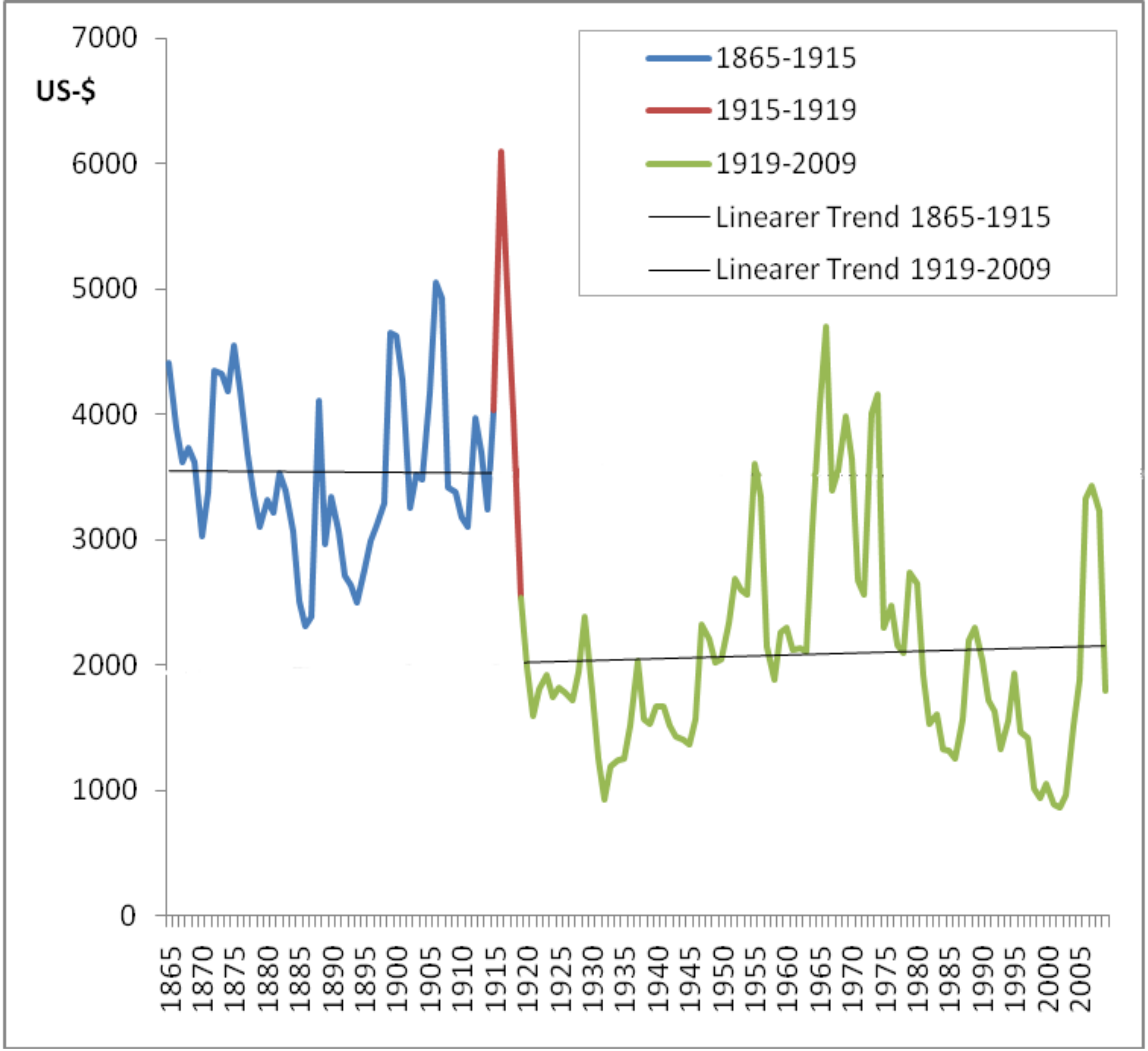
Source: BGR-Data-Bank

Development mean grades of Cu and Ni-mines in Australia, Canada und USA



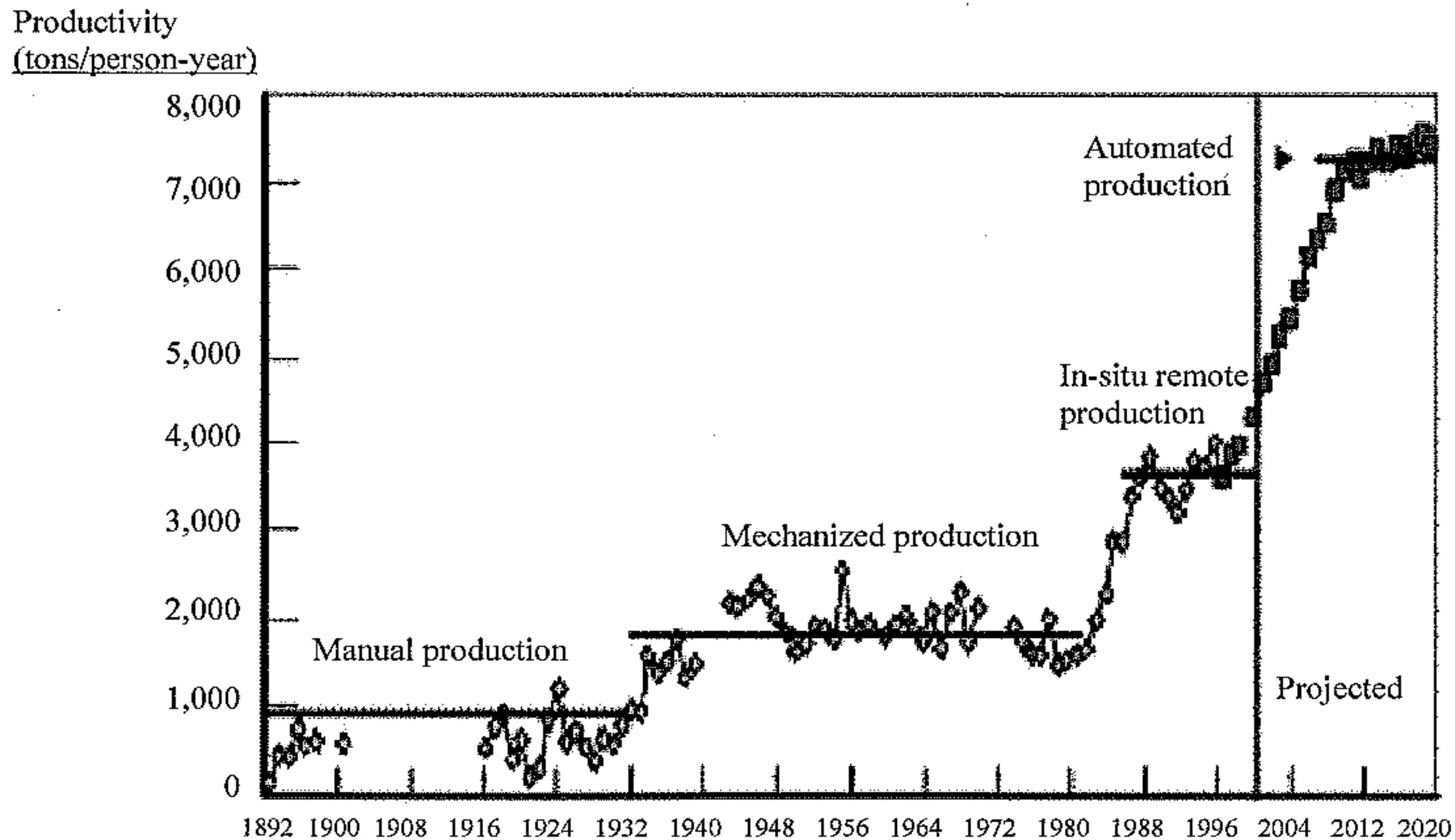
Quelle: FISCHER-KOWALSKI et al. 2011, S. 24

Paper H. Mischo. TU Bergakademie Freiberg, 24.5.13



(Source: M.Stürmer, Univ. of Bonn, Germany)

Figure 1-2. Past Productivity and Anticipated Productivity from Technology Change from One Company



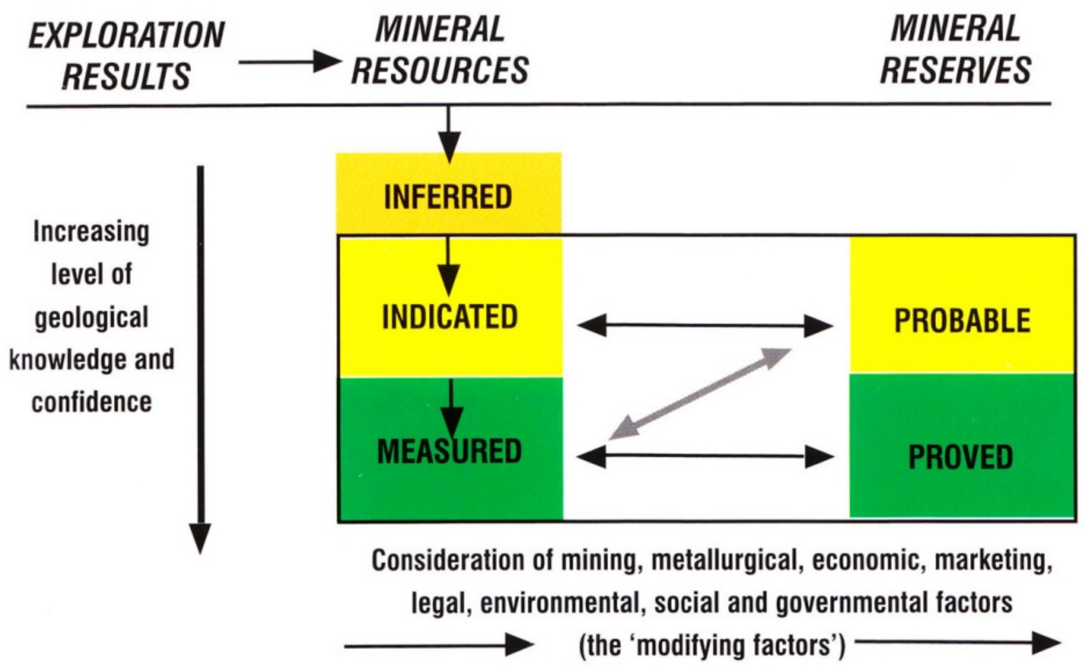
Source: RAND, *New Forces at Work In Mining: Industry Views of Critical Technologies*, 2001

ITP : Energy and environmental profile of the US Mining Industry, www1.eere.energy.gov/manufacturing/industries_technologies/mining/pdfs

Transparency:

Two main aspects:

-- production/consumption	**precise figures**
-- **reserves**	**estimates** , ***not*** **precise figures and** ***dynamic figures***



All these codes include the concept of Competent Persons. A Competent Person is a suitably experienced professional who has a minimum of five years' experience which is relevant to the style of mineralisation and scope of the report. The Competent Person must also be a member of a recognised professional association

Figure 33:

Relation between Mineral Resources and Mineral Reserves showing classification with increasing quality of data. Redrawn after CIM [2011]

(Source: S. Schmidt: From Deposit to Concentrate: The Basics of Tungsten Mining, Part 1: Project Generation and Project Development , Tungsten—Internat.Tungsten Industry Ass., June 2012)

Measured Resource

- A 'Measured Mineral Resource' is that part of a Mineral Resource for which tonnage, densities, shape, physical characteristics, grade and mineral content can be estimated with a high level of confidence.
- It is based on detailed and reliable exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes. The locations are spaced closely enough to confirm geological and grade continuity.

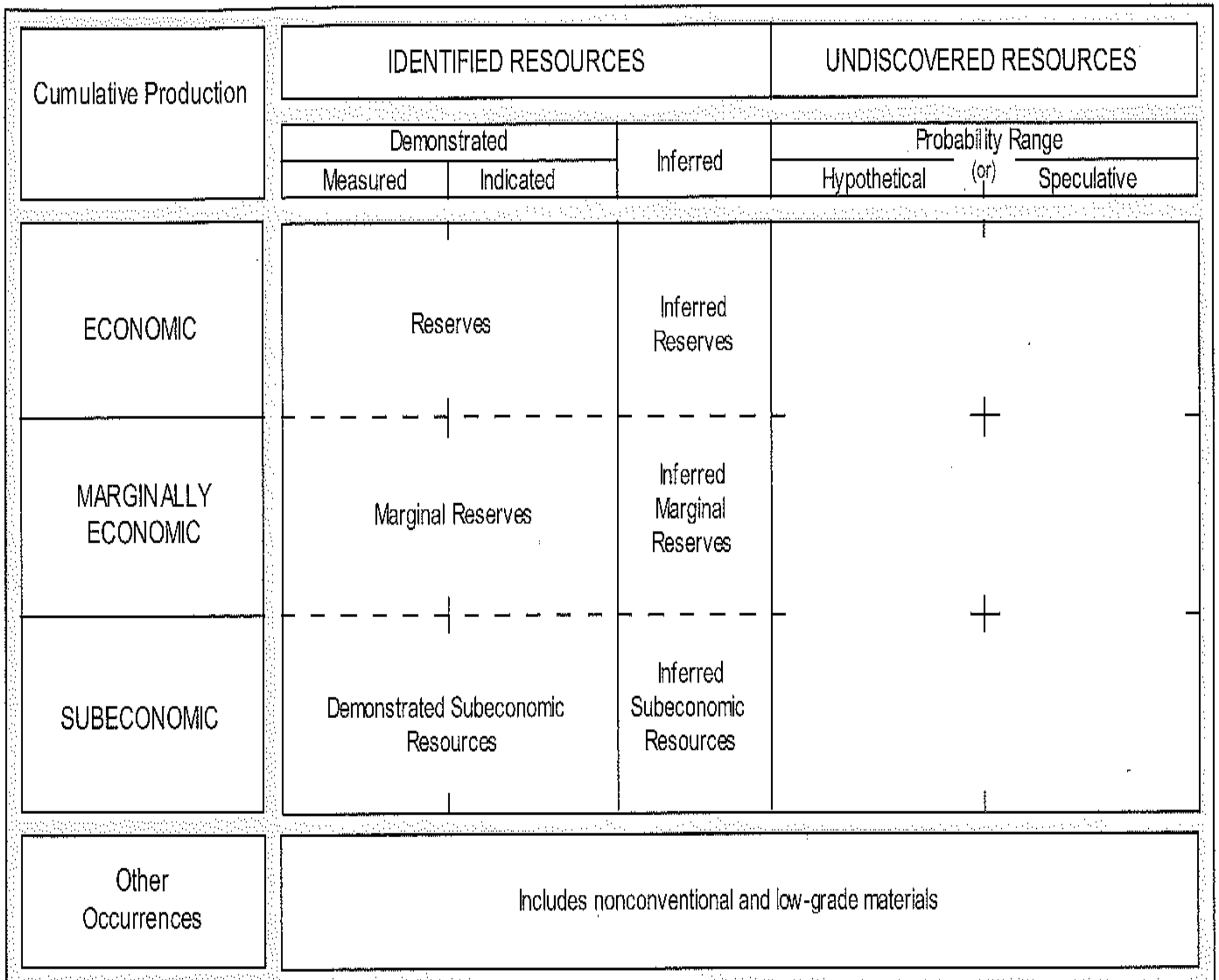
U.S. Department of the Interior
U.S. Geological Survey

MINERAL COMMODITY SUMMARIES 2013

Abrasives
Aluminum
Antimony
Arsenic
Asbestos
Barite
Bauxite
Beryllium
Bismuth
Boron
Bromine
Cadmium
Cement
Cesium
Chromium
Clays
Cobalt
Copper
Diamond
Diatomite
Feldspar
Fluorspar
Gallium
Garnet
Gemstones
Germanium
Gold
Graphite
Gypsum
Hafnium
Helium
Indium
Iodine
Iron and Steel
Iron Ore
Iron Oxide Pigments
Kyanite
Lead
Lime
Lithium
Magnesium
Manganese
Mercury
Mica
Molybdenum
Nickel
Niobium
Nitrogen
Peat
Perlite
Phosphate Rock
Platinum
Potash
Pumice
Quartz Crystal
Rare Earths
Rhenium
Rubidium
Salt
Sand and Gravel
Scandium
Selenium
Silicon
Silver
Soda Ash
Sodium Sulfate
Stone
Strontium
Sulfur
Talc
Tantalum
Tellurium
Thallium
Thorium
Tin
Titanium
Tungsten
Vanadium
Vermiculite
Wollastonite
Yttrium
Zeolites
Zinc
Zirconium

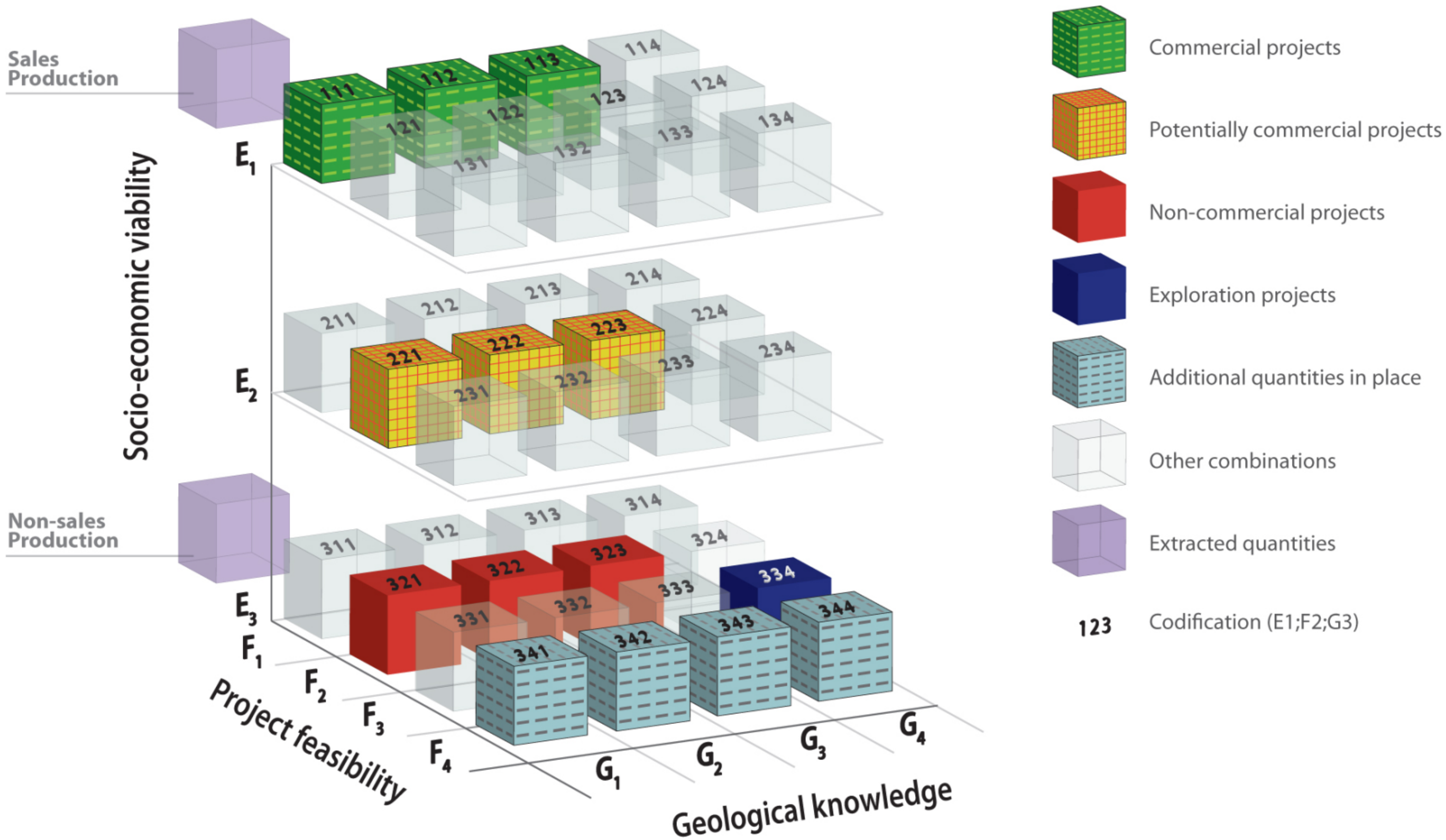
USGS
science for a changing world

FIGURE 1.—Major Elements of Mineral-Resource Classification, Excluding *Reserve Base* and *Inferred Reserve Base*



(Source USGS, MCS = Mineral Comm. Summaries 2011)

Three dimensional UN Framework Classification System (UNFC)



(http://www.unece.org/fileadmin/DAM/energy/se/pdfs/UNFC/unfc_pres/S.Foster_NFC_BlackSea_CaspianEnConf_14.02.2013.pdf)

European Sustainable Phosphorus Conference 2013

Overall conclusions ESPC2013

6-7 March 2013, Brussels

- We should and can take action today by being more efficient in our use, by wasting less, recycling more, reducing environmental losses, and by smart cooperation. The idea of creating a European market for recycled phosphorus with a value chain approach received strong support.

Knowledge, benchmarking, dissemination

- **monitoring P flows, P reserves**
- **risk assessments, LCAs, decision support systems,**
- **contaminants**
- **agronomy, soil P status, plant breeding**

From a perspective of knowledge creation and dissemination, there are several important steps to be taken. First the European Union should set up its own monitoring system that provides insight into phosphorus flows and global phosphorus rock reserves. This will enhance our capacity to identify which measures should be taken by which player and a P-footprint could be developed. Secondly the creation of business cases should be strengthened by the use of risk assessments, LCAs and decision support systems. Thirdly the information on contaminants should be expanded. Finally, information on agronomy, soil P status and plant breeding should be intensified.

Example: NE-Metal-Study Groups

International Lead- and Zinc Study Group (ILZSG, since 1959)

- 30 Members, among them China, EU, USA
- ILZSG: 85% world production and consumption

International Nickel Study Group (INSG, since 1990)

- 15 Members, among them Australia, Brazil, EU, Japan, Russia
- INSG : 37 % ore production, 51 % primary production, 34 % consumption

Internationale Copper Study Group (ICSG, seit 1992)

- 24 Members, among them Australia, China, EU, USA
- ICSG: 76% ore production, 84% refinery production, 80% consumption

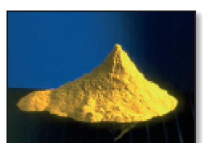
→ Consultations between Producer- and Consumer-Countries (Market Analyses, Data, Informations)

A Joint Report by the OECD Nuclear Energy Agency
and the International Atomic Energy Agency
2012

AIEA IAEA

OECD

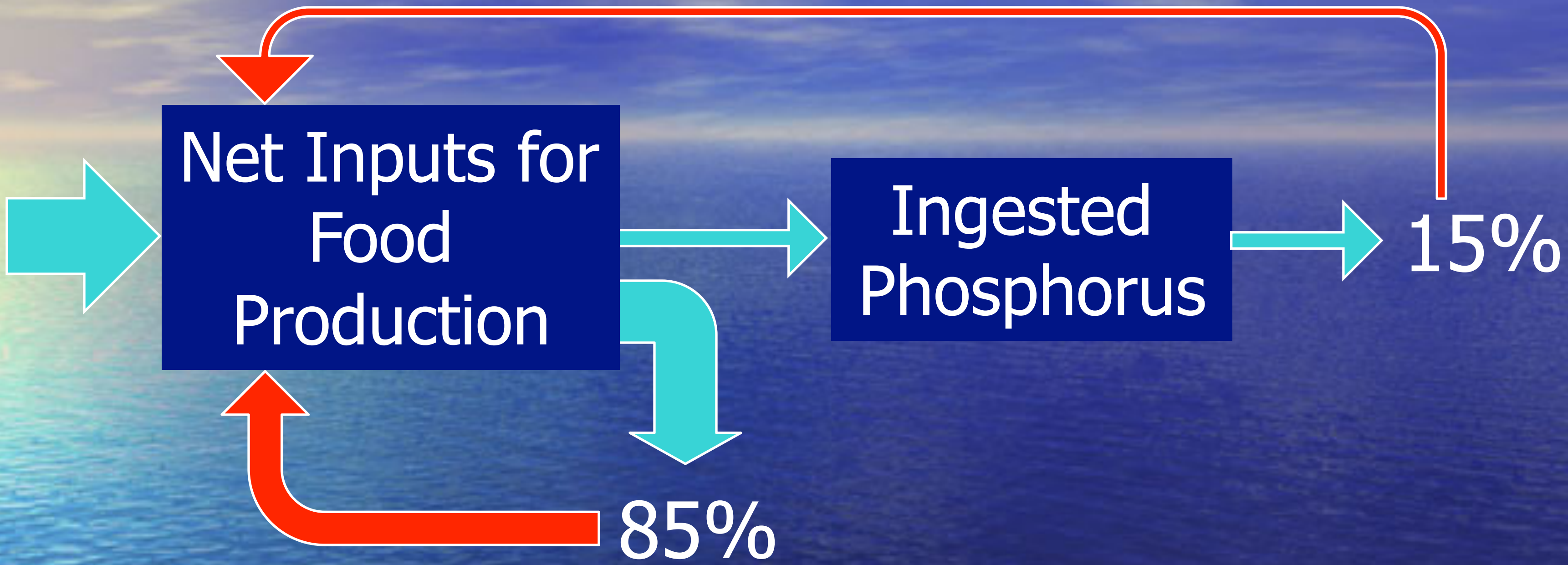
Uranium 2011: Resources, Production and Demand



AEN
NEA

NUCLEAR ENERGY AGENCY

Simplified MFA



50% Recovery of Waste => 7.5% conserved

50% Reduction in consumption => 42.5% conserved

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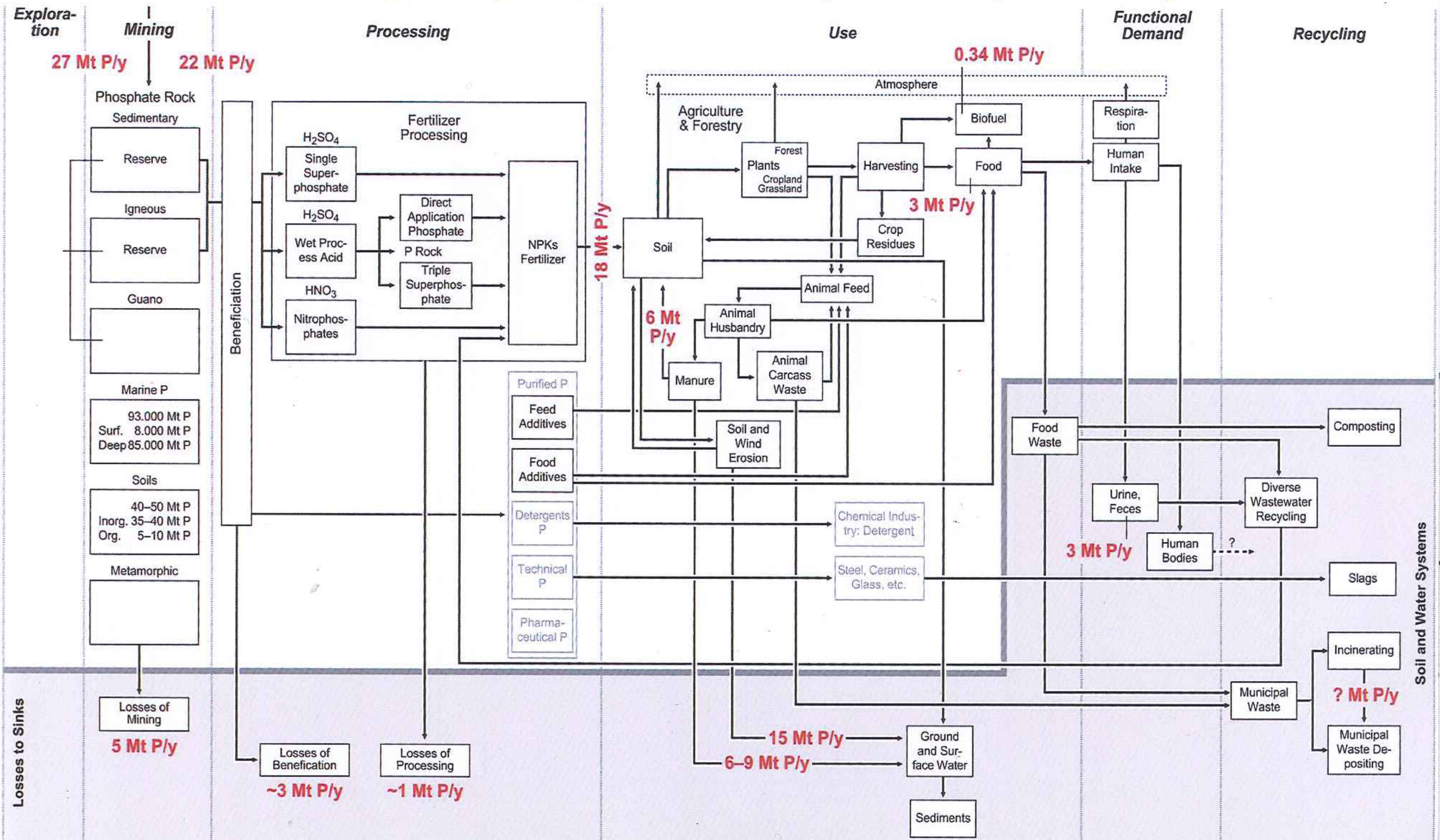
Global Material Flow Analysis (MFA) for identifying sinks (of P) – preliminary data (~2010)



Domain of potential sinks to water (9.5 – 13 Mt P/y) and earth compartments

See IFA (2006); Liu et al. 2005; Mac Donald et al. 2011, Seyhan, 2009; Schröder et al. 2011; Smil (2000a,b), Smit et al. 2010

The International
Nuclear Fuel Cycle Evaluation
INFCE
(from 1977 to 1980, set up on intitiative of the USA)

Working Group 1: Fuel and Heavy Water Availability

Working Group 2: Enrichment Availability

Working Group 3: Assurances of Long-Term Supply of Technology, Fuel and Heavy Water and Services in the Interest of National Needs Consistent with Non-Proliferation

Working Group 4: Reprocessing, Plutonium Handling, Recycling

Working Group 5: Fast Breeders

Working Group 6: Spent Fuel Management

Working Group 7: Waste Management and Disposal

Working Group 8: Advanced Fuel Cycle and Reactor Concepts

UNEP

International
Resource
Panel

Phosphate deposits of the world

VOLUME 3

Neogene to Modern phosphorites

EDITED BY

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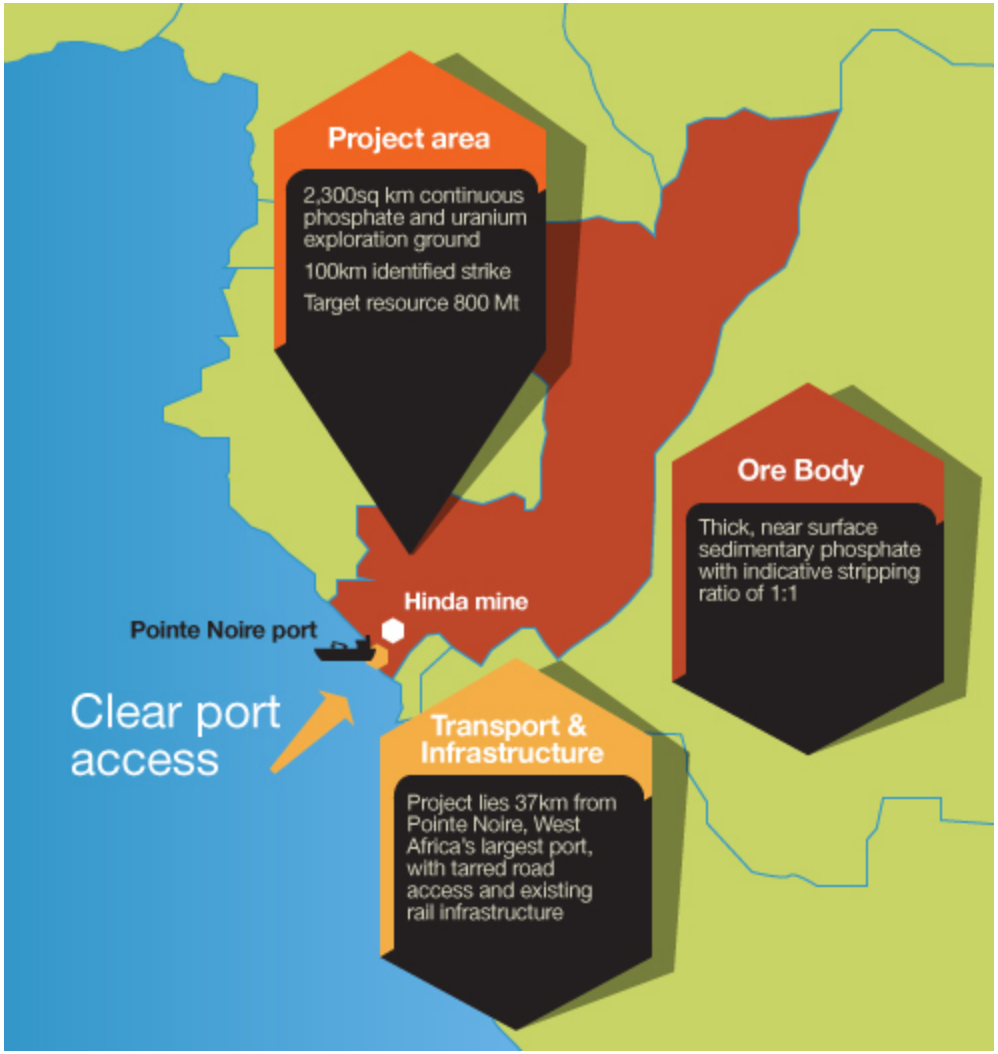
International
Geological Correlation Programme
Project 156:
Phosphorites

Working Group I – 'Proterozoic and Cambrian Phosphorites', (Co-Chairmen: P.J. Cook and J.H. Shergold);
Working Group II – 'International Phosphate Resource Data Base', (Co-Chairmen: A.J.G. Notholt and R.P. Sheldon);
Working Group III – 'Young Phosphogenic Systems', (Co-Chairmen: W.C. Burnett and S.R. Riggs); and
Working Group IV – 'Cretaceous and Tertiary Phosphorites', (Co-Chairmen: K. Al-Bassam, J. Lucas, and S. Sassi).

(start 1977 to 1988)



http://www.comincoresources.com/about-us/company-profile

Future Scenarios

- Hard landing – Roger Pielke Jr.'s "Iron Law"
  - "When policies on emissions reductions collide with policies focused on economic growth,
    economic growth will win out every time.
  - "To succeed, any policies … will necessarily have to offer ***short-term benefits*** that are in some manner proportional to the short-term costs."
- Soft landing (Cordell et al, Scholz & Wellmer)
  - Preferred scenario: Phosphate rock demand decreases as secondary sources increase, due to increasing awareness of high environmental and social costs, and increasing price of mineral fertilizers

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Conclusions

Need for better transparency:

- **--- monitoring of material flows**
- **--- dynamics of reserves and resources**
- **--- understanding the geopotential as source of future reserves**
- **--- understanding learning curves for future P supply**

Organisational framework: Possibilities

- **--- revive IGCP phosphate project for geopotential**
- **--- adopt existing or former structure to P: (UNEP International Resource Panel, NE-Study groups, Uranium Redbook, INFCE)**

Reserve Slides

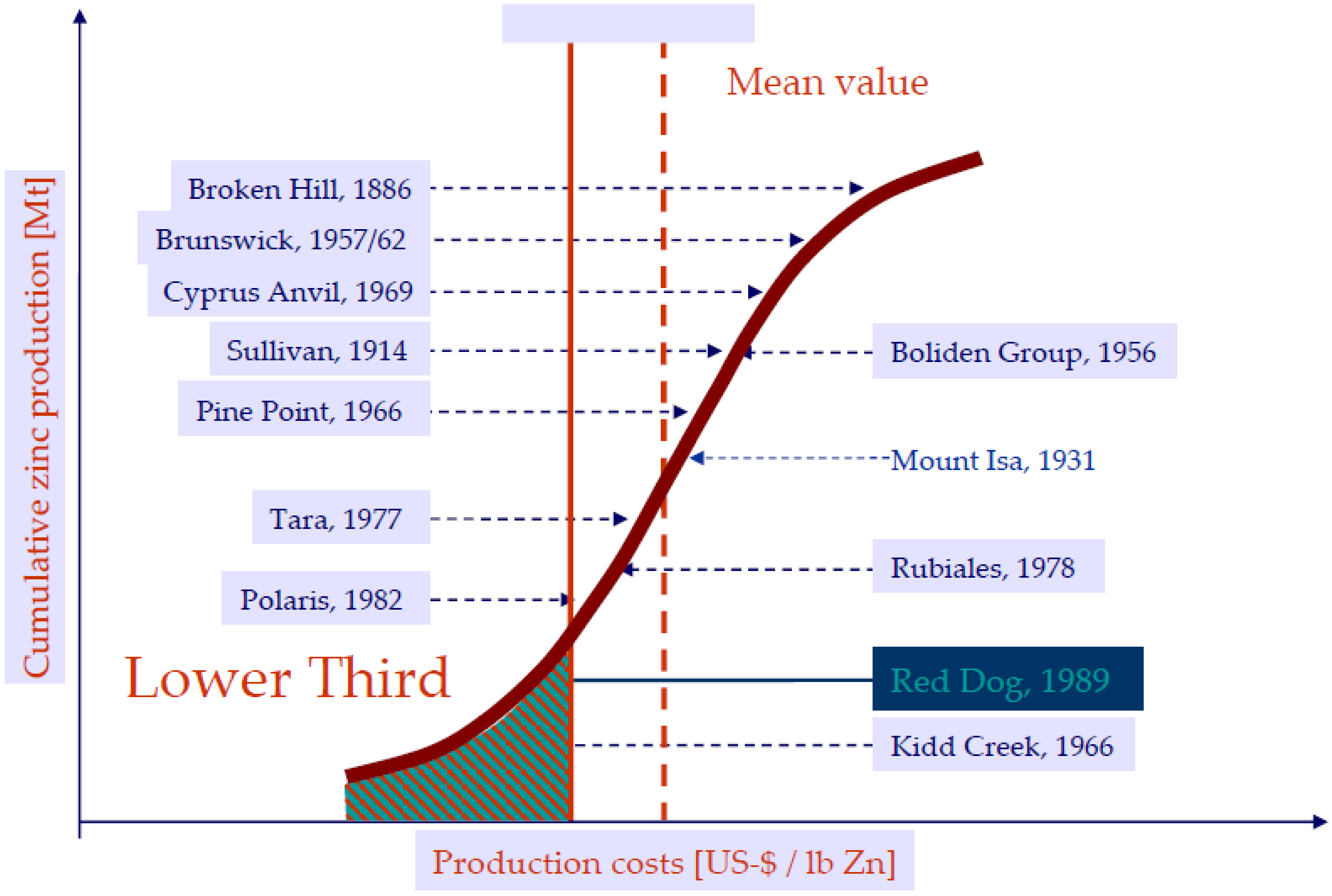
$$\textbf{Ratio} = \frac{\textbf{Reserves}}{\textbf{Production (Consumption)}}$$

is always only a **Snapshot** of a

dynamically developing Reserve-/Resource System.

It is **not** the life time of a commodity.

Lower-Third-Rule: Technical Availability of Metals

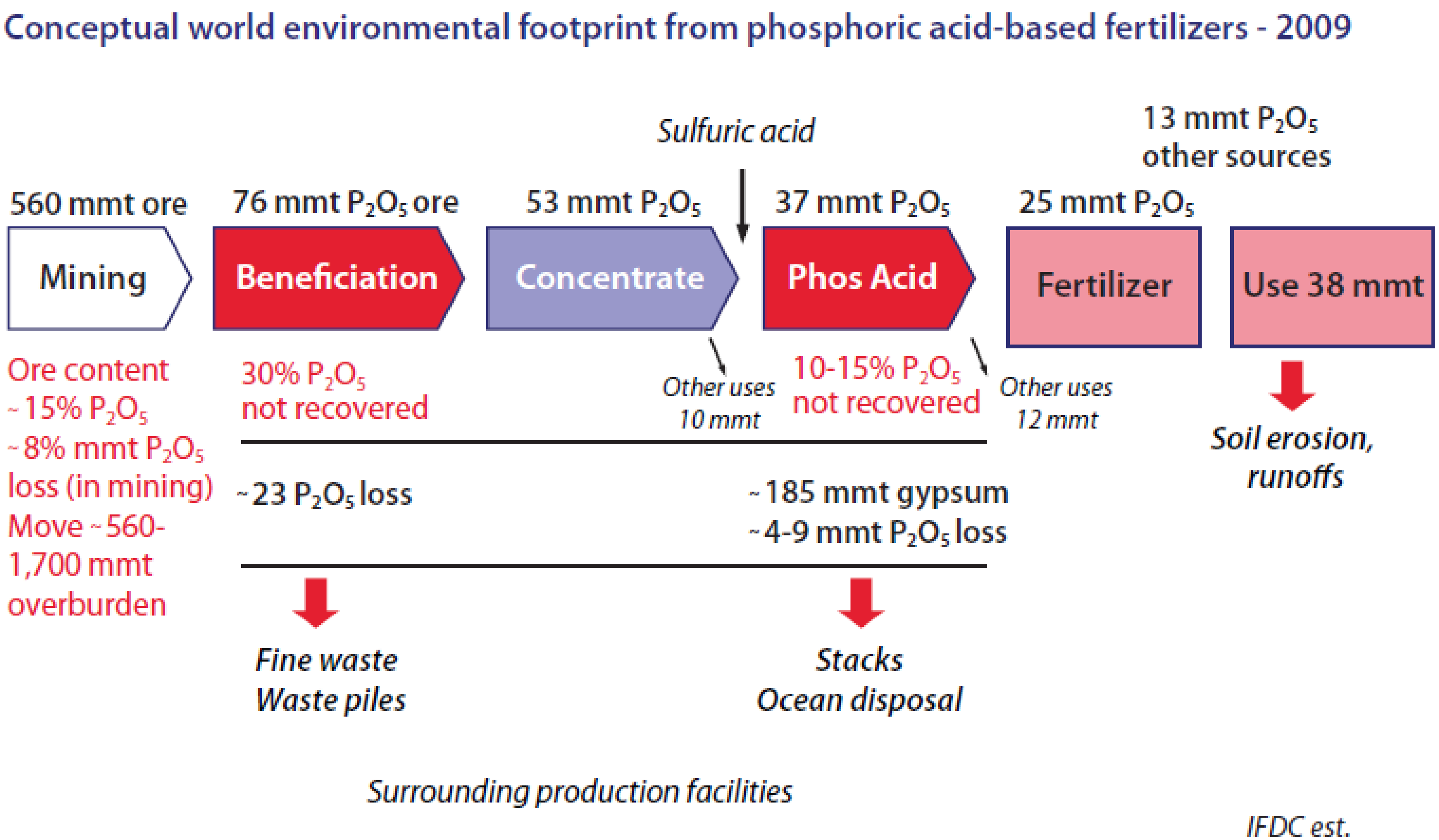


What motivates companies, government bodies, governments or other institutions to move to quantify reserves, i.e. to move rersources out of the „potential field“ into the Reserve Block?

1.) Companies – JORC Code

2.) Regional planning authorities

3.) Governments



(Source: Global research to nourish the world, Virtual Fertilizer Research Center/ IFDC)
*www.**vfrc**.org/.../**vfrc**_blueprint_for_**global**_security-1.pdf)*

Fig. 10

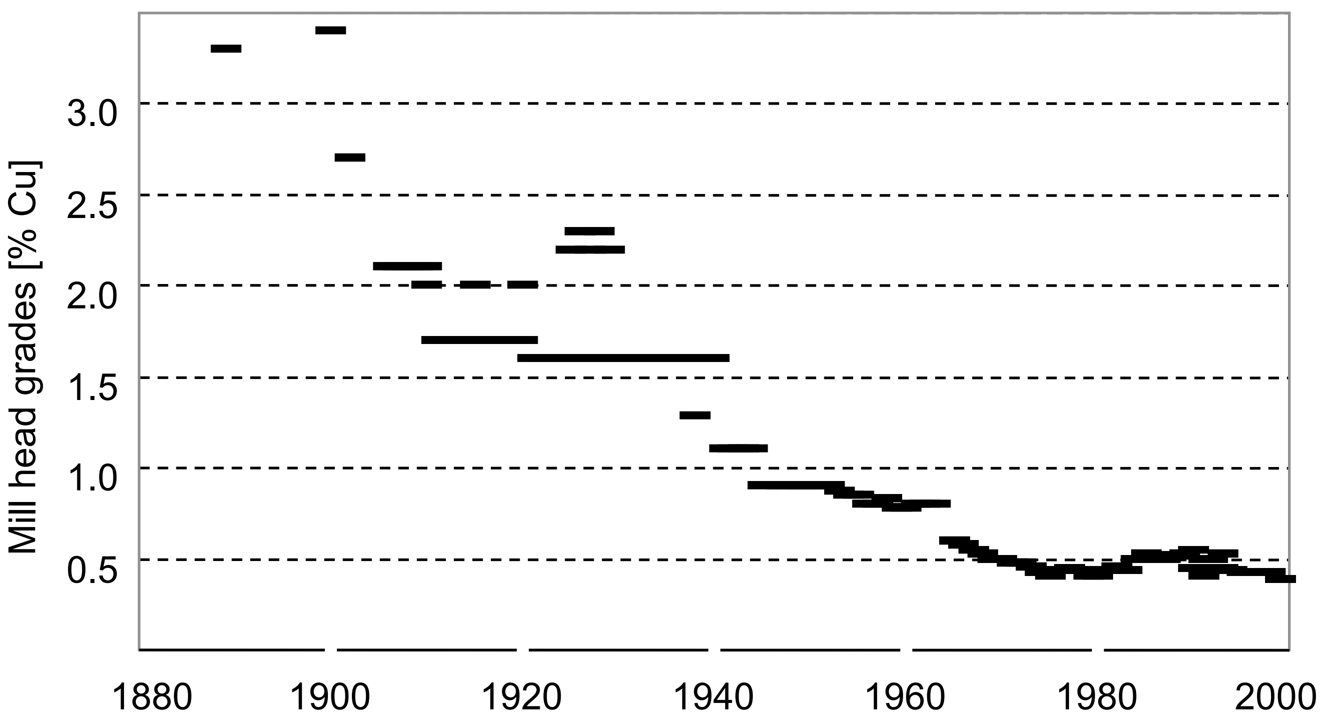
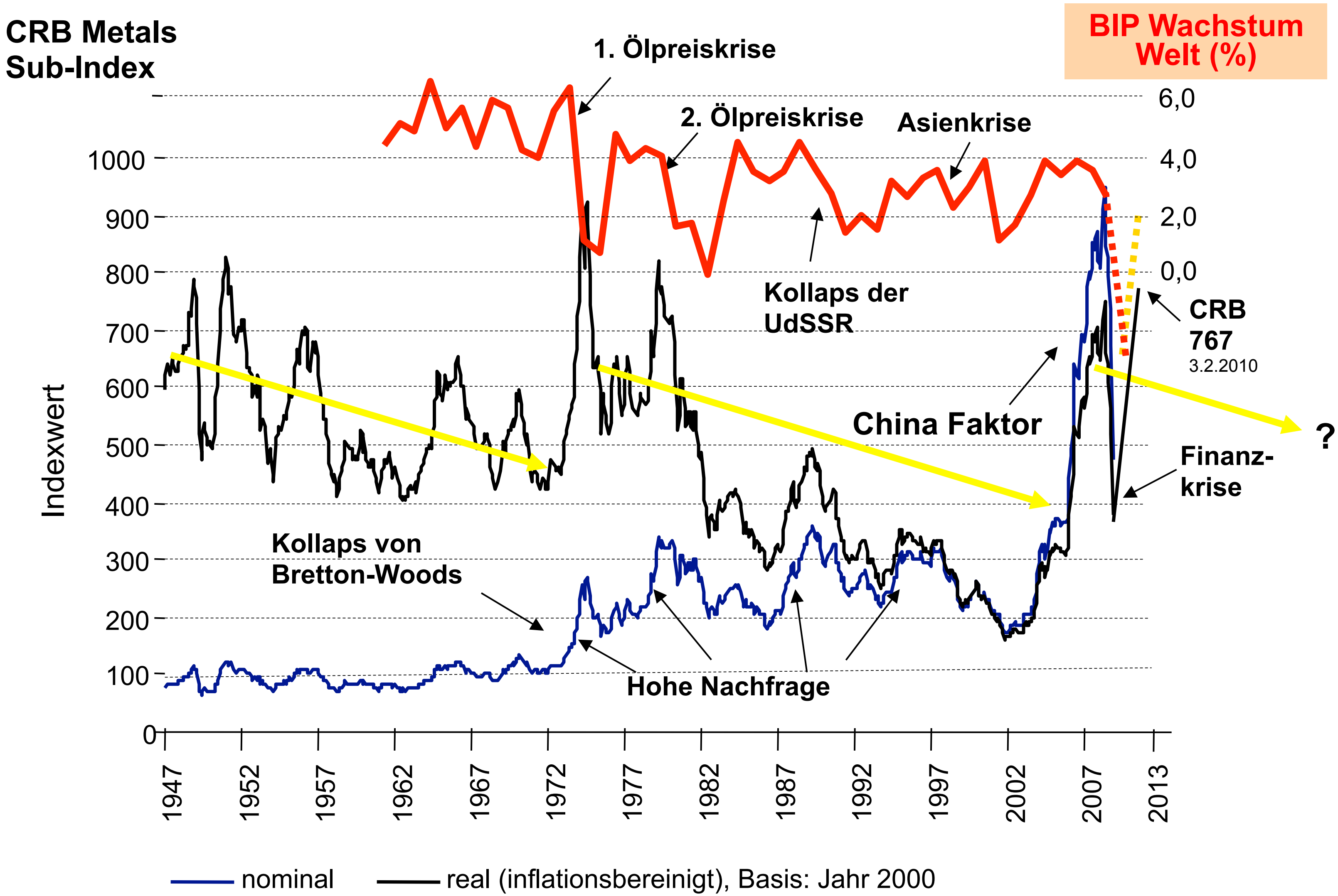


Figure 10: *Development of copper grades of ores mined in the US (after Ayres et al. 2002).*

Rohstoffpreis und BIP: langfristige Preisschwankungen



Reuters CRB-Metals-Subindex Kupfer-, Stahl-, Bleischrott, Zink, Zinn

Quelle: BGR Datenbank, CRB, World Bank

Fig. 9.3.
Specific operating costs of various non-ferrous metal mines (Table 9.3a)

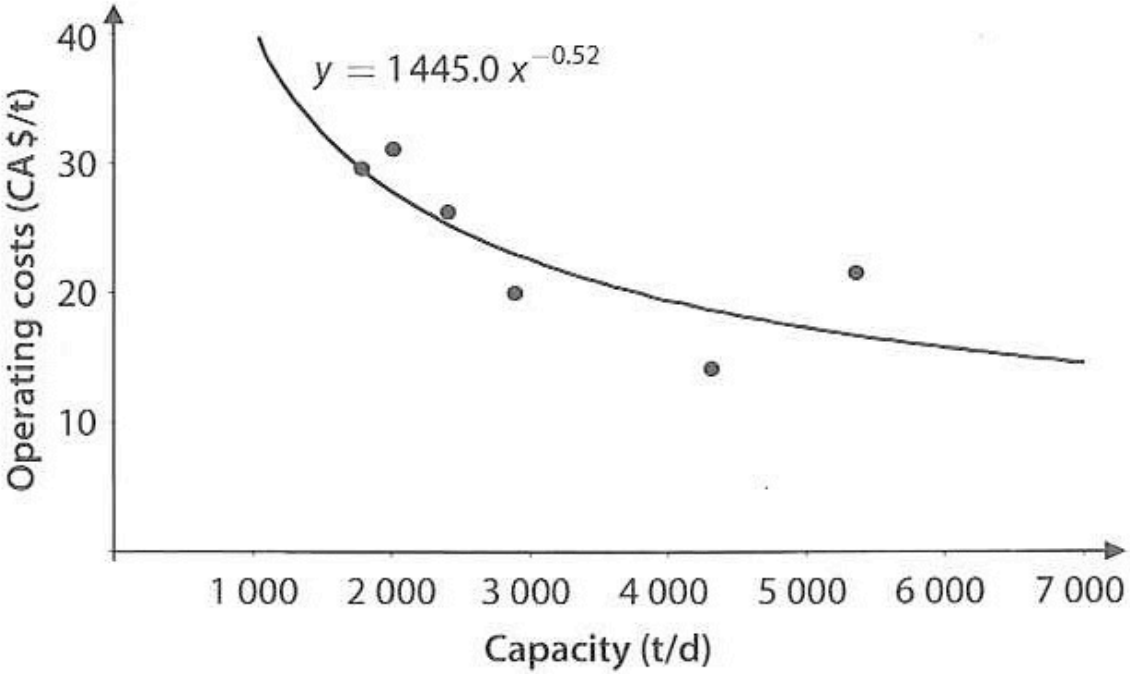
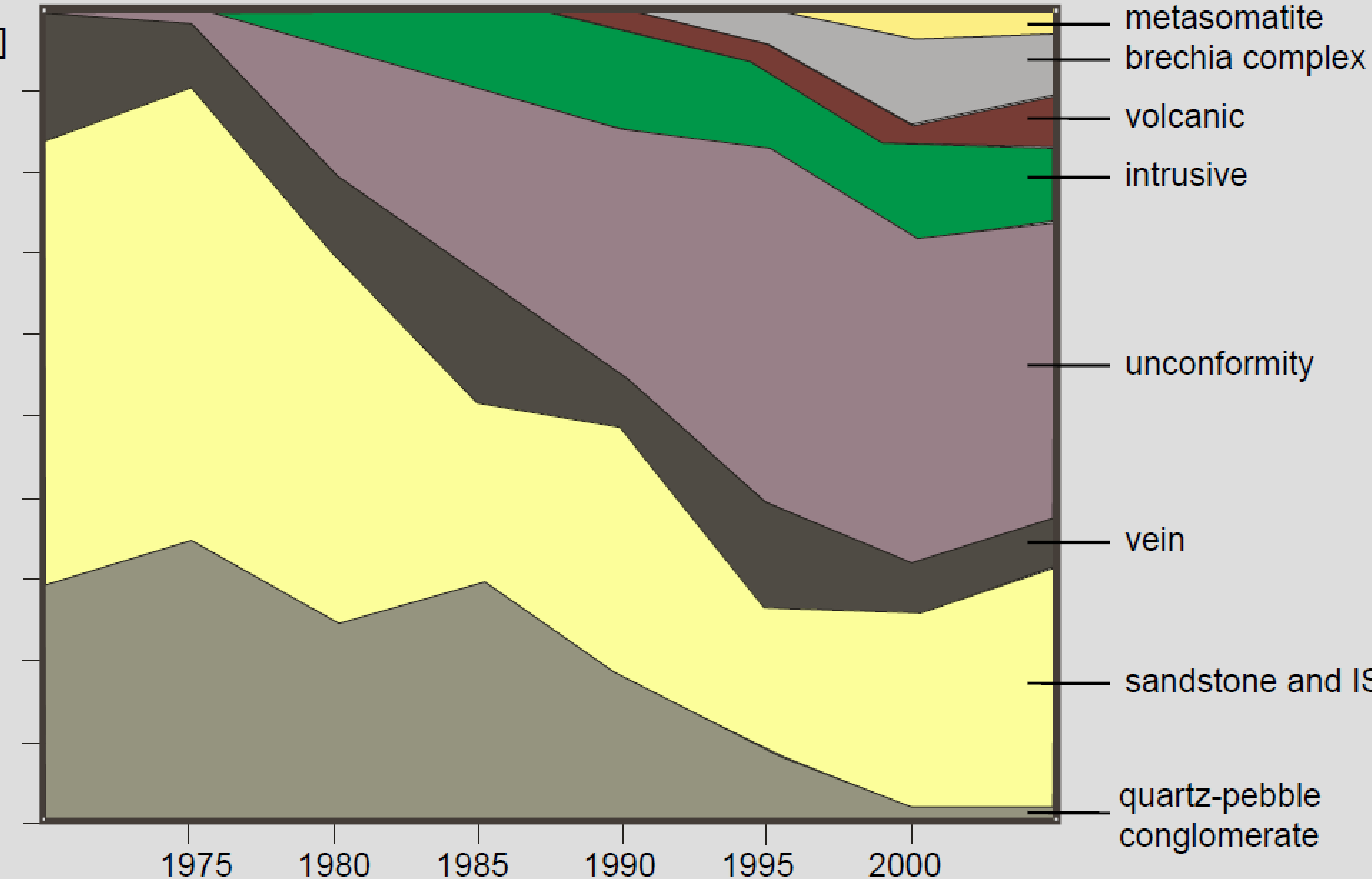


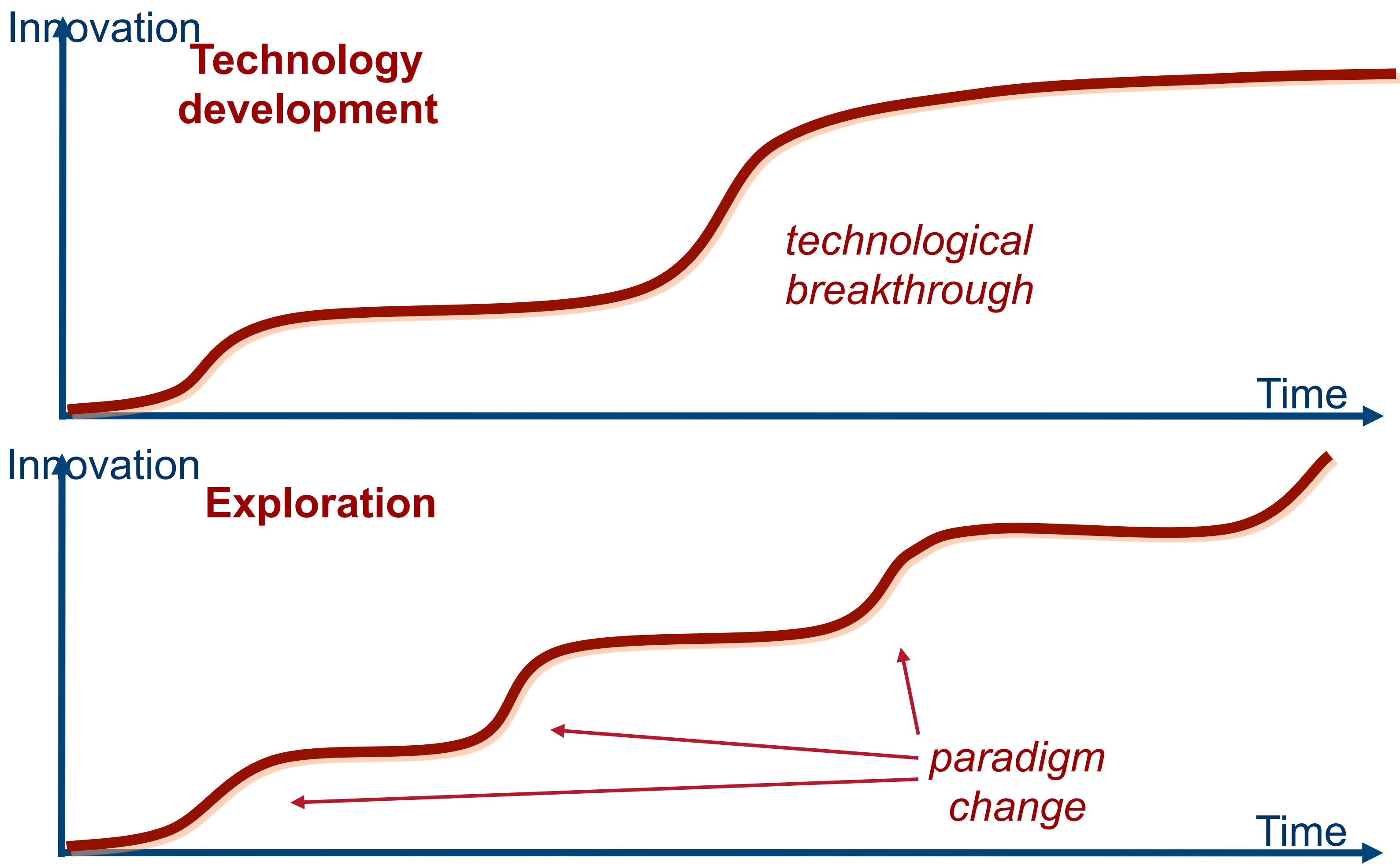
Table 9.3a.
Operating costs of some selected mines

Mine	Capacity x (t/d)	Operating costs y (CA $/t)
Aur, Louvicourt	4 300	14.22
Barrick, Bousquet	2 400	26.33
Barrick, Holt-McDermott	1 775	29.72
Breakwater, Bouchard-Hebert	2 880	20.11
Newmont, Holloway	2 000	31.18
Hudson Bay, Ruttan	5 350	21.62



metasomatite
brechia complex
volcanic
intrusive
unconformity
vein
sandstone and IS
quartz-pebble conglomerate
1975
1980
1985
1990
1995
2000

Consecutive learning curves in technology and exploration

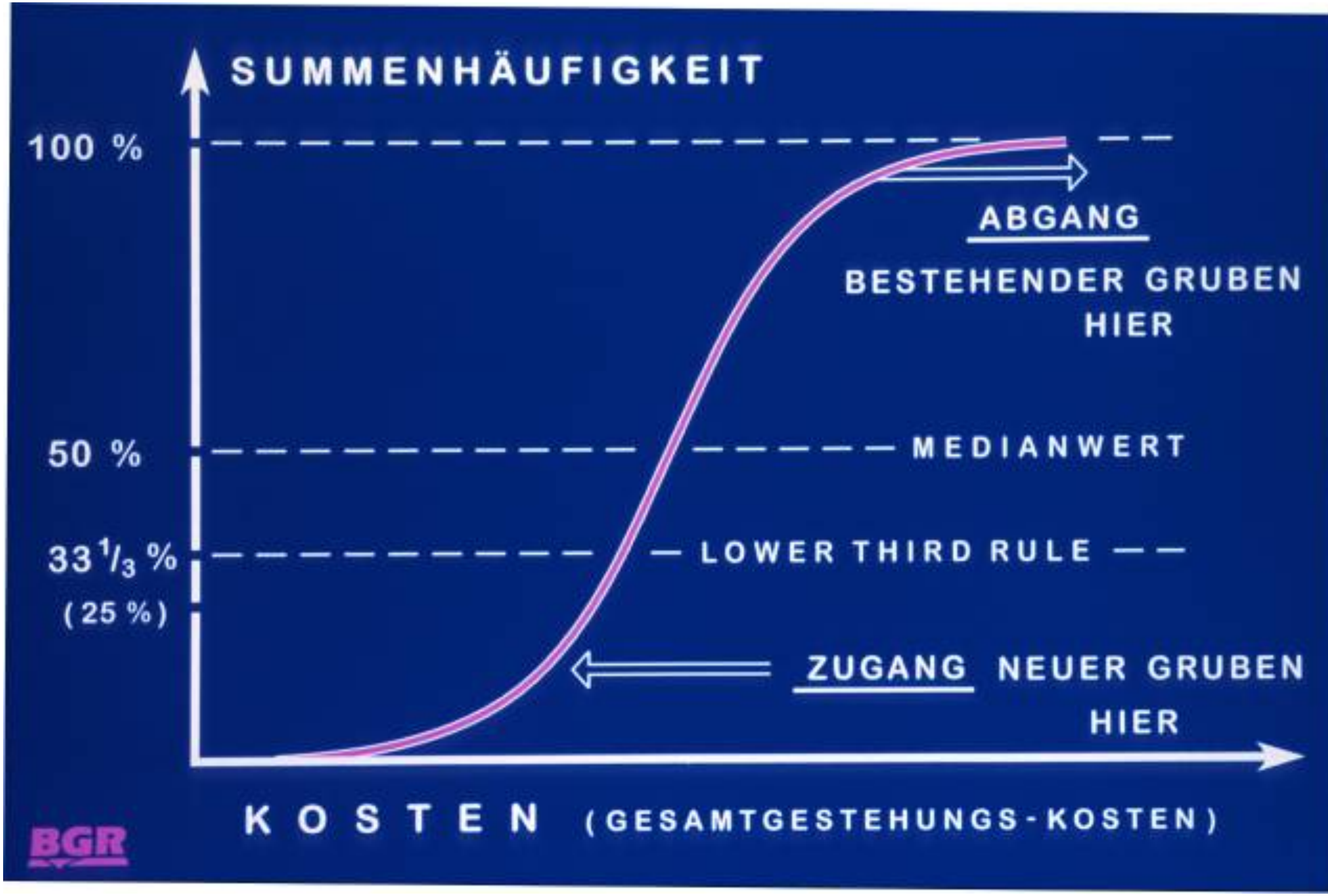


Conclusions

- Phosphorus is an essential daily component of our diet and agriculture system and the world is dependent on finite fossil sources
- Commercial sources are dominated by only a few countries and these are outside the EU
- Rock phosphate extraction is not monitored by weither the UN or the EU
- Geopolitical changes could affect the stability of supply
- Global demand mainly from the developing countries is increasing currently at 5-6% per year and prices are increasing
- Only about 16% of the mined P-rock is traded
- Only 20-25% of the mined P-rock ends up in the food we eat
- Now important to become more efficient with how we use the mined sources and secure and reuse the P we have in manure and solid and liquid waste streams

A

(Source: A.Rosemarin & L.S.Jensen：The Phosphorus Challenge: European Sustainable Phosphorus Conference, Brussels, 6. March 2013.)


SUMMENHÄUFIGKEIT
100 %
ABGANG
BESTEHENDER GRUBEN
HIER
50 %
MEDIANWERT
33 1/3 %
(25 %)
LOWER THIRD RULE
ZUGANG NEUER GRUBEN
HIER
KOSTEN (GESAMTGESTEHUNGS-KOSTEN)
BGR