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SLT Europe 2008 & 2009

'Minerals: Who Needs Them, Who Supplies Them and How Much is There?'

Dr. David Roberts

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Biography

- Dr. Roberts discovered his interest in Geology in school where he had an opportunity to study it from school certificates and I then he went on to complete his B.Sc and Ph.D at university.
- In September 1991 Dr. Roberts was appointed Head of Geology at Staffordshire University with the brief to develop Applied Geology courses. During his period at Staffordshire he led the development of BSc.degree courses in Applied Geology, Environmental Geology, Geology, Earth Sciences, Geology with Mountain Leadership, Geology with Industrial Practice (this included an additional year spent in industry or consultancy).
- Dr. Roberts personal achievements include the following:
  - President of the Northwest branch of the Institue of Mining and Metallurgy (subsequently merged to form the Institue of Materials Minerals and Mining).
  - Chairman of the North Staffordshire Group of the Geologists Association
  - Treasurer and member of the Executive Committee of the Committee of Heads of University Geoscience Departments (CHUGD).
  - Member of the working group on Accreditation of UK geology degree course by the Geological Society.
  - Interviewer of applicants for Chartered Geologist (Geological Society) and for Chartered Engineer and Corporate Membership (IMMM).
  - Invited speaker to conferences of the Earth Science Teachers Association.
  - Member of the Organising committee for the bi-annual Extractive Industries Geology conference
  - Invited to meetings of the Department of Trade and Industry Foresight Group on Minerals in the UK
  - Invited member of the Staffordshire County Council Minerals Planning consultative group.
  - Addressed the UK Parliament's All Party Parliamentary Group for Earth Sciences and regularly invited to attend its meetings.
- Since leaving Staffordshire University, August 2006 Dr. Roberts has been invited to serve on the Geological Society's Fellowship and Validation Panel. Dr. Roberts retained interest in the Geological Society and in the IMMM as well as taking up an interest in the Earth Science Education Forum.
- Dr. David Roberts is currently the Lecturer for EAGE's European Student Lecture Tour for 2008 & 2009 and will be covering *'Minerals: Who Needs Them, Who Supplies Them and How Much Is There?'*

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EUROPEAN ASSOCIATION OF GEOSCIENTISTS & ENGINEERS

MINERALS: WHO NEEDS THEM?

or

The Demand for Minerals and Metals

The use we make of minerals is as old as the human race. It is what separates us from the ants and the apes. Modern society would not exist without them.

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A Few Basic Facts

- If it can’t be grown, it has to be mined.
- Mining and Quarrying, along with Agriculture, Forestry and Fishing, are the PRIMARY wealth generators.

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A Few Basic Facts

- The value of minerals is how their use can improve our lives: this is true despite the views of those who think they should be left in the ground for one descendents or to gratify people's intellect.

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A Few Basic Facts

- Minerals can only be extracted from those locations where nature has concentrated them.
- All countries have systems of mineral disposal permitting in order to control mineral extraction and these are governed by the Laws of each country.

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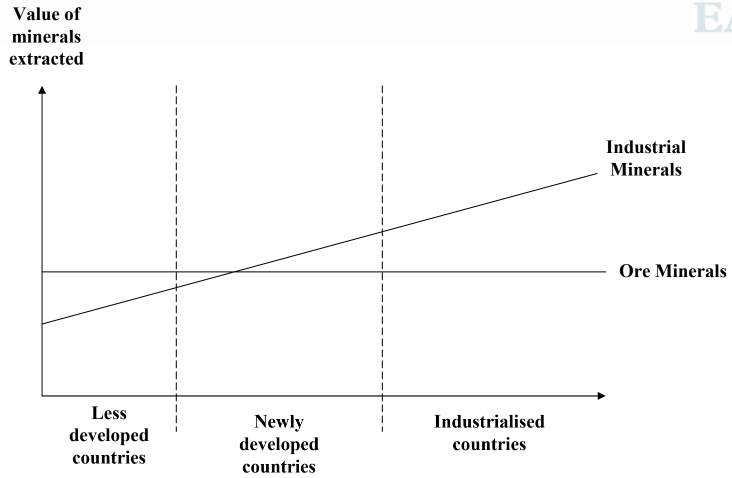

Relative importance of industrial and ore mineral exploitation in evolving economies

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A Few Basic Facts

- Despite the prophets of gloom (such as the Club of Rome 1972) we have not run out of any mineral commodity yet. In fact mineral reserves are higher now than they were when the Club of Rome made its predictions.

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Some Predictions of the Club of Rome (1972)

- Gold would have been depleted about 1980
- Tin would have been exhausted in 1989
- Lead and Zinc would have been exhausted in the 1990s
- We have just used our last bit of Copper
- We are about to use our last drop of Oil
- Most mineral deposits would have been exhausted by now

FACTS

- We have not run out of anything yet
- Reserves of Copper, for example, at the end of the twentieth century are greater than they were at the beginning

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Conceptual Errors by the Club of Rome

- They regarded mineral reserves as static but projected increase in consumption commensurate with an exponentially increasing population.

- They ignored the skills of the geologist to discover and define more mineral reserves and the ability of engineers to extract and process leaner deposits and to make use of different materials.

Some Major Mines Discovered Between 1975 and 1996

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- Olympic Dam, Australia (1975) – Uranium,
- Athabasca Province, Canada (1975) – Uranium
- Fazenda Braziliera, Brazil (1976) – Gold
- Salobo, Brazil (1977) – Gold
- Neves-Corvo, Portugal (1977) – Lead, Zinc, Copper, Tin
- Rampura Agucha, India (1977) – Zinc, Lead, Silver
- Navan, Ireland (Production 1977) – Lead and Zinc
- Gold Quarry, Nevada,USA (1979) – Gold
- Porega, PNG (1979) – Gold
- Red Dog, Alaska (1980)– Zinc
- La Escondida, Chile (198I) – Copper
- Hemlo, Canada (1981) – Gold
- Goldstrike, Nevada, USA (1982) – Gold
- Lihir (Ladolam), PNG (1983) – Gold
- Hilton North, Australia (1985) – Zinc, Lead, silver
- Candelaria, Chile (1987) – Copper
- Grasberg, Indonesia (1988) – Copper, Gold
- Century, N. Queensland, Australia (1990) – Zinc
- Radomiro-Tomic, Chile (1990) – Copper
- Collahuasi, Chile (1991) – Copper
- Mansa, Chile (1991)– Copper
- Batua Hijau, Indonesia (1991) – Copper, Gold
- Voisey's Bay, Labrador, Canada (1993) – Nickel
- Spense, Chile (1996) – Copper
- Galmoy/ Lisheen, Ireland (Production 1997) – Lead and Zinc

Criteria for Inclusion

- Must be a "world class deposit"
- Minimum 3mt contained metal for copper.
- Minimum 6mt contained metal for zinc (except Navan and Lisheen)
- Minimum 10 m contained ounces (311 tonnes) for gold

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A Few Basic Facts

- Many of the materials we use today were not used to any significant degree at the start of the 20th Century and some of these are common elements such as Aluminium and Titanium not to mention plastics derived from petroleum.
- As an example 40 different elements are used in a standard telephone hand set.

Elements in the Telephone Handset

Aluminium	Alloy in dial mechanism etc.
Antimony	Alloy in dial mechanism
Arsenic	Alloy in dial mechanism
Berylium	Alloy in dial mechanism
Bismuth	Alloy in dial mechanism
Boron	Touch-tone dial mechanism
Cadmium	Colour in yellow plastic
Calcium	In lubricant for moving parts
Chlorine	Wire insulation
Chromium	Plating; stainless steel; colour
Cobalt	Magnetic material in receiver
Copper	Wire; plating; brass parts
Fluorine	Plastic piece parts
Germanium	Transistors in touch-tone dial mechanism
Gold	Electrical contacts
Hydrogen	Plastic housing; wire insulation
Indium	Touch-tone dial mechanism
Iron	Steel; magnetic materials
Krypton	Ringer in Touch-tone set
Lead	Solder in connections
Lithium	In lubricant for moving parts
Magnesium	Die castings in transmitter; ringer
Manganese	Steel in piece parts
Molybdenum	Magnet in receiver
Nickel	Magnet in receiver; Stainless steel
Nitrogen	Hardened heat-treated piece parts
Oxygen	Plastic housing; Wire insulation
Palladium	Electrical contacts
Phosphorus	Steel in piece parts
Platinum	Electrical contacts
Silicon	Touch-tone dial mechanism
Silver	Plating
Sodium	In lubricant for moving parts
Sulphur	Steel in body parts
Tantalum	Integrated circuits in trim-line set
Tin	Solder; plating
Titanium	Colour in white plastic
Tungsten	Lights and key sets
Vanadium	Receiver
Zinc	Brass; die casting in transmitter; ringer

Courtesy of Dr Bob Little

How Much Do We Use?

- UK consumption of minerals is about 626mt.
- About 10 tonnes per resident of the UK made up of;
- Energy Minerals 245 million t
- Industrial Minerals & Metals 110 million t
- Aggregates 271 million t
  - Primary Aggregates 204mt made up of:
    - 34% Land won Sand and Gravel
    - 6% Marine dredged Sand and Gravel
    - 60 % Crushed Rock
  - Supplemented by 64mt of secondary and recycled aggregates and 3mt imported.)

(Source: British Geological Survey)

http://www.bgs.ac.uk/mineralsuk/statistics/

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Value of Minerals to the UK

- Minerals as dug contribute about £25 billion (about 3%) of the UK GDP. (GVA)
- Downstream activities contribute a further £100 billion (11%) of the UK GDP (GVA).
- The GVA per employee in the non-energy mineral extractive industry in 2001 was £54,483: manufacturing as a whole was £36,587.

(Source:BGS)

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What About Future Need?

A new-born infant will need a life-time supply of:

- 365Kg of Lead
- 345 Kg of Zinc
- 680 Kg of Copper
- 1633 Kg of Aluminium
- 15 tonnes of Iron
- 12 tonnes of Clay
- 13 tonnes of Salt
- 560 tonnes of Stone, Sand, Gravel and Cement

Plus a lot of the high tech elements as he/she grows up

Plus a source of energy: Could it be Nuclear Power?

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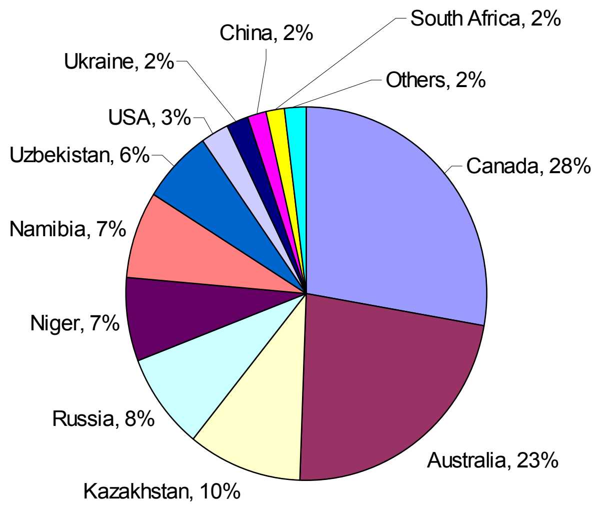
Global Uranium Production 2005



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What is driving the industry?

The Global Minerals Industry is driven by the demand created by society: the more we want, the more it has to produce or we will complain.

What is the European contribution to mineral supply?

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Significant European Mineral Production

Country	Mineral	% Global Production
Austria	Magnesite	4%
Czech Republic	Diatomite	2%
	Feldspar	3%
	Kaolinite	3%
Finland	Mica (Flake)	20%
	Talc	7%

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Significant European Mineral Production

Country	Mineral	% Global Production
France	Arsenic	1.5%
	Cobalt (New Caledonia)	3%
	Diatomite	4%
	Feldspar	4%
	Gypsum	4%
	Mica (Flake)	3%
	Nickel (New Caledonia)	10%
	Pumice	2.5%
	Salt	3%
	Silicon	3.5%

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Significant European Mineral Production

Country	Mineral	% Global Production
Germany	Barite	1%
	Diatomite	2.5%
	Feldspar	1%
	Gypsum	1.5%
	Kaolinite	10%
	Potash	5%
	Salt	7%

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Significant European Mineral Production

Country	Mineral	% Global Production
Greece	Nickel	1%
	Magnesite	3%
Ireland	Lead	1%
Italy	Diatomite	1%
	Feldspar	25%
	Gypsum	1%
	Pumice	25%
	Sulphur	1%
	Also the leading producer of polished stone	
Netherlands	Salt	2%

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Significant European Mineral Production

Country	Mineral	% Global Production
Norway	Ilmenite	7%
	Flake Mica	7%
	Silicon	3%
Poland	Copper	3%
	Feldspar	2%
	Gypsum	1%
	Lead	1%
	Salt	2%
	Silver	6.5%
	Sulphur	2%

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Significant European Mineral Production

Country	Mineral	% Global Production
Portugal	Tungsten	1%
Romania	Salt	1%
Slovakia	Magnesite	2%
Sweden	Iron	1.3%
	Lead	2%
UK	Kaolinite	6%
	Gypsum	2%
	Salt	3%

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Significant European Mineral Production

Country	Mineral	% Global Production
Spain	Diatomite	1.5%
	Feldspar	3.5%
	Fluorspar	3%
	Gypsum	10%
	Magnesite	3%
	Potash	1.5%
	Pumice	3%
	Salt	1%
	Silicon	1%
	Strontium	33%

Significant European Mineral Production

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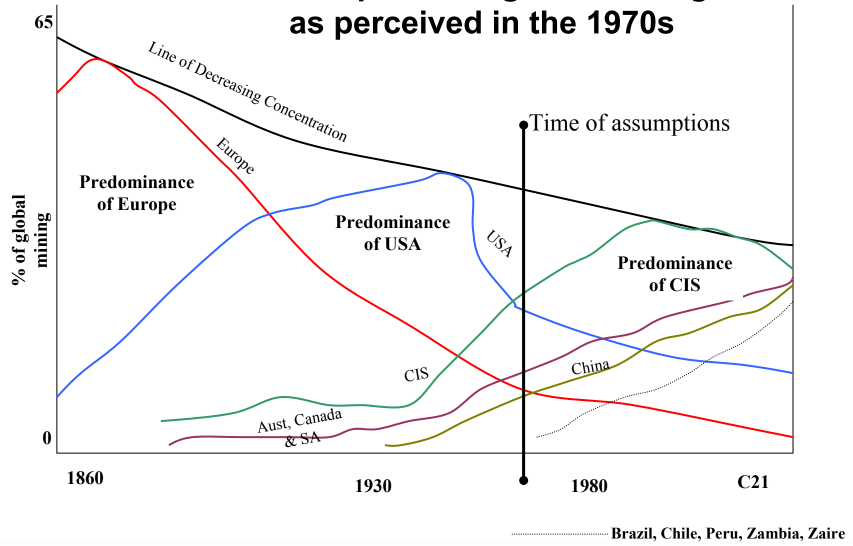
Country	Mineral	% Global Production	Mineral	% Global Production
Russia	Antimony	3%	Flake Mica	30%
	Arsenic	2.5%	Sheet Mica	30%
	Asbestos	4.5%	Molybdenum	1%
	Bauxite	3.5%	Nickel	20%
	Cadmium	6%	Platinum	12%
	Cobalt	7.5%	Palladium	41%
	Copper	5%	Phosphate Rock	7%
	Industrial Diamonds	20%	Potash	12%
	Gem Diamonds	34.5%	Salt	1%
	Diatomite	4%	Silicon	10%
	Fluorspar	4%	Sulphur	10%
	Gypsum	1.5%	Tin	1.6%
	Iron	6%	Tungsten	4%
	Lithium	9%	Vanadium	27%
	Magnesite	7%	Vermiculite	5%

Historic and projected development of global mining as perceived in the 1970s



CHINA

- "The demand for metals and minerals from emerging industrial giants, China and India, continues to drive the world economy." *(Pat Leahy, Director, U.S.G.S. 24th Jan.2006)*
- "Strong demand from China continued to drive up the prices for metals and some industrial minerals and has led to increased production of some commodities." *(U.S.G.S. Annual Report, Mineral Commodity Summaries 2006)*

  http://minerals.usgs.gov/minerals/pubs/mcs/

CHINA

- China is the world's leading producer of some 25 different metals and minerals and closely follows the leading producer for another 6 mineral commodities.
- Most Chinese mineral production is consumed internally and exports are in the form of manufactured goods.

CHINA – Aluminium

	Production 2007 (t)	% of Global Production	Capacity 2007 (t)	% of Global Capacity
Primary Aluminium	12,000,000	32%	14,000,000	26%

Main Bauxite producers were Australia (34%), Brazil (13%), Jamaica (7%) and Guinea (7%) but in 2007 China produced 32 million tonnes of Bauxite (17% of global total) though its reserve base is not high as yet.

CHINA – Iron

	Production 2007 (t)	% of Global Production
Iron Ore	600,000,000	30%
Pig Iron	419,000,000	38%
Raw Steel	482,000,000	37%

Major iron ore producers

- Brazil – 360,000,000 (19%)
- Australia – 320,000,000 (17%)
- India – 160,000,000 (9%)
- Russia-110mt (6%)

CHINA – Metals

	Production 2007 (tonnes)	% of Global Production	Chinese Reserves (tonnes)	% of Global Reserves
Antimony	**110,000**	**82%**	**2,400,000**	**56%**
Arsenic	**30,000**	**50%**	**Not available**	
Bismuth	**3,000**	**53%**	**470,000**	**69%**
Cadmium	**3,400,000**	**17%**	**280,000,000**	**25%**
Vanadium	**RSA 23,500**	**39%**	**12,000,000**	**32%**
	China 18,500	**32%**	**14,000,000**	**36%**
Tungsten	**77,000**	**87%**	**4,200,000**	**70%**
Tin	**130,000**	**43%**	**3,500,000**	**30%**
Magnesium Metal	**550,000**	**82%**	**Virtually unlimited**	
Mercury	**1100**	**73%**	**Not known**	
Lead	**1,320,000**	**37%**	**36,000,000**	**21%**
Zinc	**2,800,000**	**28%**	**92,000,000**	**19%**
Molybdenum	**46,000**	**25%**	**8,300,000**	**44%**

CHINA – Industrial Minerals

	Production 2007 (tonnes)	% of Global Production	Chinese Reserves (tonnes)	% of Global Reserves
Abrasives				
Fused Al Oxide	**700,000**	**59%**		
Silicon Carbide	**455,000**	**45%**		
Barite	**4,400,000**	**55%**	**360,000,000**	**41%**
Fluorspar	**2,750,000**	**52%**	**110,000,000**	**23%**
Graphite	**720,000**	**70%**	**140,000,000**	**67%**
Lime (CaO)	**170,000,000**	**61%**	**V large globally**	
Magnesite	**1,350,000**	**31%**	**860,000,000**	**24%**
Strontium	**190,000**	**32%**		
Talc	**2,500,000**	**31%**	**V Large**	
Phosphates	**35,000,000**	**24%**	**13,000,000,000**	**26%**

CHINA – High Tech Elements

	Production 2007 (tonnes)	% of Global Production	Chinese Reserves (tonnes)	% of Global Reserves
Gallium	**Leading producer of world production at 80 tonnes**			
Germanium	**China 27%, second to Canada 29% of 87 tonnes, 2004**			
Indium	**250t**	**50%**	**10,000t**	**60%**
Rare Earth Elements	**120,000t**	**97%**	**89,000,000**	**59%**
Silicon	**2,900,000**	**58%**	**No figures available**	
Yttrium	**8,800t**	**98%**	**240,000**	**40%**

China – Precious Metals

		Production 2007	% Production	Global Production
GOLD	**RSA**	**270t**	**11%**	**2500t**
	Australia	**280t**	**11%**	
	China	**250t**	**10%**	
	USA	**240t**	**9%**	
SILVER	**Peru**	**3400t**	**17%**	**20,500t**
	Mexico	**3000t**	**15%**	
	China	**2700t**	**14%**	

CHINA – Cement

- 1.3 Billion tonnes of cement produced in 2007, which is 50% of global cement production.
- This is almost 1 tonne per person in China
- Globally, only India, with a production of 160 million tonnes, is within a factor of 10 of Chinese production

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Production of Cement

- 1 tonne of Cement requires the input of 1.5 tonnes of calcium carbonate ($CaCO_3$) plus a pozzalanic material such as clay or shale.

  During processing:

  $$CaCO_3 \rightarrow CaO + CO_2$$

  For every tonne of $CaCO_3$, 0.44 tonnes of CO_2 is generated.

- The production of 1.3 billion tonnes of cement in China therefore creates from the breakdown of $CaCO_3$ alone:

  1.3 x 1.5 x 0.44 = 858mt of CO_2

How does this compare with total CO_2 emissions in Europe?

World Rank	Nation	Total k tonnes of CO_2	Emissions as % of Chinese $CaCO_3$ breakdown
3	Russia	1,524,993	178
6	Germany	808,767	94
8	United Kingdom	587,261	68
10	Italy	449,948	52
15	France	373,693	44
17	Spain	330,497	39
21	Poland	307,238	36
30	Netherlands	142,061	17
34	Czech Republic	116,991	14
36	Belgium	100,716	12
39	Greece	96,695	11
40	Romania	90,425	11
41	Norway	87,602	10
46	Austria	69,846	8
48	Finland	65,799	8
52	Portugal	58,906	7
53	Hungary	57,183	7
56	Sweden	53,033	6
57	Denmark	52,956	6
60	Bulgaria	42,558	5
61	Ireland	42,353	5
64	Switzerland	40,457	5
67	Slovakia	36,289	4
71	Azerbaijan	31,365	4

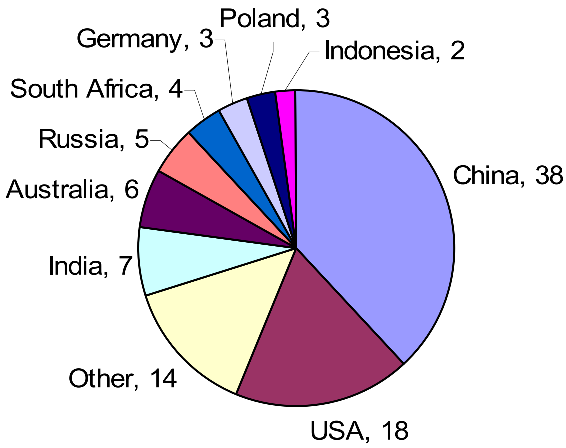
CHINA – Coal

China	2000	2004	2006
Anthracite	175,727,200	220,000,000	267,000,000
Bituminous Coal	780,669,000	1,690,000,000	2,052,000,000
Lignite	42,773,600	50,000,000	61,000,000
Total	999,169,800	1,960,000,000	2,380,000,000

USA	2000	2004	2006
Anthracite	4,148,000	1,540,000	1,374,000
Bituminous Coal	520,974,000	495,870,000	512,189,000
Sub-Bituminous	371,223,000	435,090,000	463,669,000
Lignite	77,620,000	75,750,000	76,430,000
Total	973,965,000	1,008,250,000	1,053,662,000

Source (BGS)

Global Coal Production 2005



Source (BGS)

CHINA – Mineral/Metal Import Dependence

- Bauxite to produce primary Al
- Chromium
- Copper
- Nickel
- Platinum Group Metals

What About Sustainable Mineral Development?

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- "Meeting the needs of the present without compromising the needs of future generations."
- "Converting natural capital into useable capital to the long term benefit of the communities where the minerals occur."
- There has to be a balance between:
  - The needs of society and economic development
  - Community benefits
  - Environment protection
  - Government Responsibilities

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A FEW PERTINANT QUESTIONS

- WHERE ARE WE GOING TO GET OUR FUTURE MINERAL SUPPLY?
- WHAT WILL BE THE DOMINANT FUEL?
- HOW WELL WILL THE INDUSTRY BE REGULATED IN OTHER COUNTRIES?
- WHERE IS THE BOUNDARY BETWEEN “DERELICTION” AND “HERITAGE”?
- WILL THE EU HAVE ADEQUATE HUMAN RESOURCES FOR THE MINERALS INDUSTRY?

MINERALS: WHO SUPPLIES THEM?

or

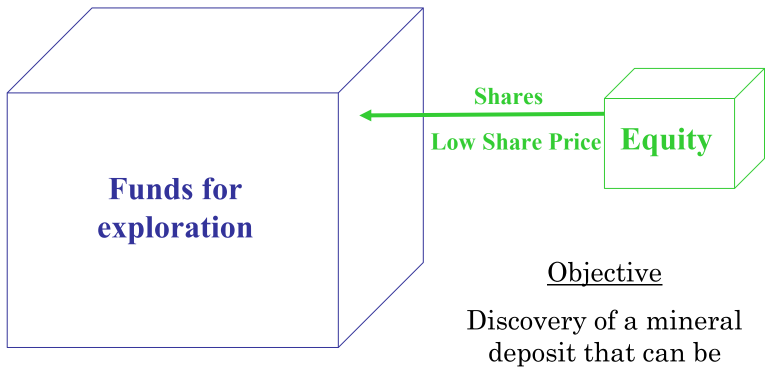
- Investment in Mineral Properties:
- The Risks and Rewards

Answers required from a coal-mining geologist in regards to a proposed coal mine.

Big Pit – South Wales

- Is it black?
- Will it burn?
- How much is there?
- Can we dig it? (Are there any significant geological problems that will affect extraction?)
- Can we sell it?
- Can we get planning consent?
- Will it make a profit?

Funding a mineral exploration company



Objective

Discovery of a mineral deposit that can be developed into a profitable mine

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Equity is the total value of the treasury. All investors are shareholders who will receive a good return if successful but could lose everything if it fails.

Junior exploration companies are frequently listed on Stock Exchanges that have many high-risk companies listed. Vancouver SEX is well known exchange for mining juniors. The AIM on the LSE is another place for such listings.

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What is the collateral?

Normally not much more than options on exploration targets which may or may not have undergone some exploratory drilling. The legal status of those properties is critical as is an indication of the value of a mineable discovery.

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What is the risk?

Very High

Rarely does 1 target in 1000 (some claim 1 in 5000) result in a producing mine. Even after it has been drilled and several million dollars spent on the work the chances of success are rarely better than 1 in 10.

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Who will invest?

- Not many! Those that do are risk taking individuals that like a gamble and should be able to afford a total loss of investment. It is not for widows and orphans!
- Will the Banks invest or advance a loan?
- NO!! This is far too risky for an investment bank.

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What should happen to the sums invested?

They should be used exclusively to test the property for a viable deposit, to define the resource that could be developed into a profitable mine. At the end, all the money has gone and nothing of value has been discovered or, as sometimes happens, a good deposit has been defined.

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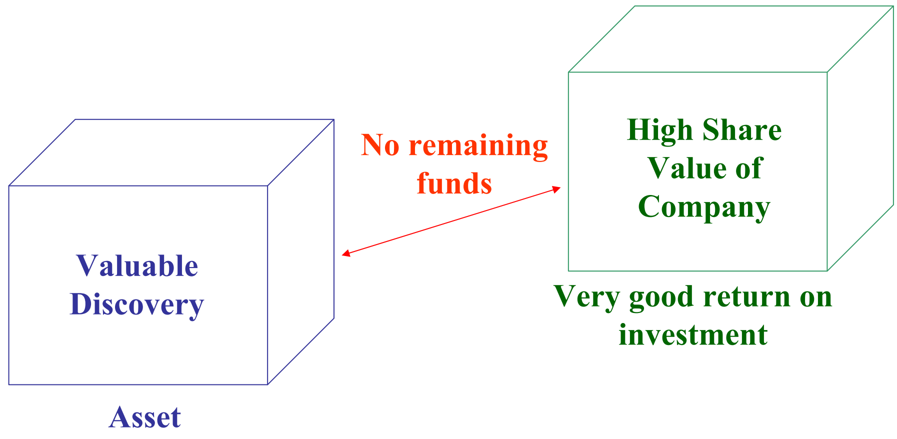
Ideal outcome for a mineral exploration company



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- At this point the junior, which does not have the expertise or capital to develop the property, seeks a partner in a mid range or major company to mine the resource or sells the property at a value much higher than when it was just an exploration target.

- A value has to be placed on the deposit for acquisition purposes and this is often carried out by independent professionals who should undertake the valuation according to an accepted code of practice. E.g.Valmin. At this point the investors will see a very good return on their investment but in this business there will always be more losers than winners. More investment is required to develop the mine and this could be raised partly by equity and partly by loans. If a good and verifiable Feasibility Study has been undertaken which indicates a good property the banks may consider a loan.

Does this always happen? NO!!!

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The property is sometimes used as a Stock Market vehicle where the directors of the company publish unverifiable favourable results to attract the greedy and unwary investor who is looking for a quick return. This results in a rise in the share price and those that invested low will sell and make a profit. Mass selling results in a drop in share price and the original investor can repurchase the same volume of shares back and have cash to spare. Short trading is where an individual sells his shares and then makes public unfavourable remarks about the property to depress the share price at which point he re-purchases his original share volume at a lower price and makes money. This is all legal.

Investors beware!

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Poseidon Nickel

Western Australia 1969 at the height of the Nickel Exploration boom.

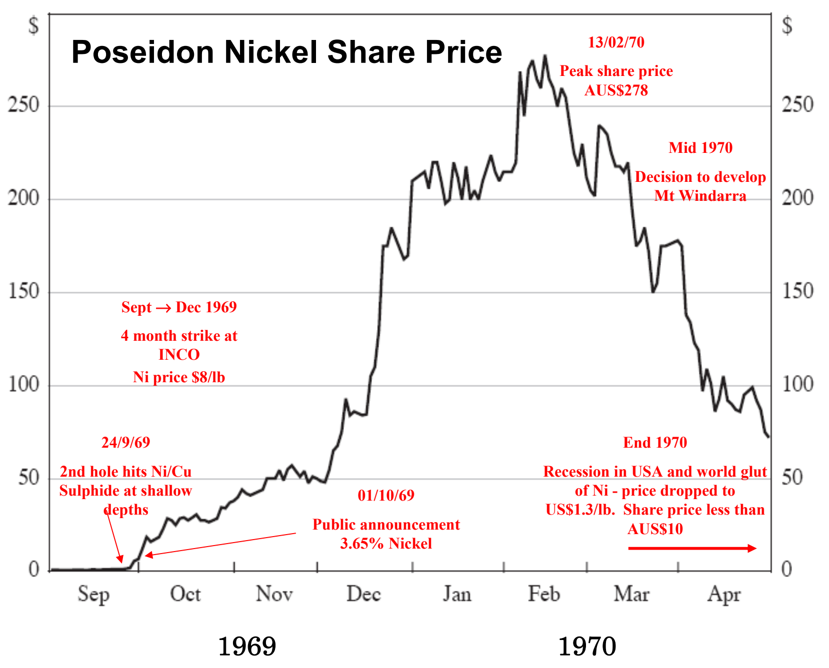
The price of Nickel was at an all time high

There was a four months miners' strike in the major nickel mining area of Sudbury, Ontario

Komatiite hosted Nickel deposits had just been identified in the gold mining area of Kalgoorlie

A prospector, Ken Shirley, who had been looking for gold in the remote Mt. Windarra area 400 Km north of Kalgoorlie discovered a nickel rich gossan and he sold options for the claim to Poseidon for A $500 and became an employee of the company.

Then it all happened...



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Poseidon Bust – Aftermath

Trevor Sykes in *The Money Miners* says:

"One disturbing feature of the boom-time geological statements is their misleading air of precision. Poseidon's statement of 3.56 percent nickel looked like a fine calculation to one-hundredth of one percent. ***In fact, Poseidon had no basis on which to make such a calculation at the time and the actual assay of the core turned out to be substantially lower, although still of ore grade."***

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Poseidon Bust – Aftermath

In the early 1970s, the Melbourne Stock Exchange and the Federal Government (Rae Commission) requested AMIC (now the Minerals Council of Australia) to develop a code. AMIC responded and AusIMM joined promptly, resulting in The Joint Ore Reserves Commission (JORC).

- The Code applies to Public Reports or Public Reporting, that is "a report or reporting on Exploration Results, Mineral Resources or Ore Reserves, prepared for the purpose of informing investors or potential investors and their advisers."

- So the JORC Code is a Code for Reporting for the benefit of investors.

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JORC

- Sets minimum standards for public reporting (in Australia & New Zealand) of Exploration Results, Mineral Resources and Ore Reserves

- Provides a mandatory system for classification of tonnage/grade estimates according to geological confidence and technical/economic considerations

- Requires Public Reports to be based on work undertaken by a Competent Person; describes the qualifications and type of experience required to be a Competent Person

- Provides extensive guidelines on the criteria to be considered when preparing reports on Exploration Results, Mineral Resources and Ore Reserves

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Poseidon Bust – Aftermath

Since that date over 30 years work has been undertaken to establish internationally recognised codes for the reporting of Mineral Reserves and Resources.

These are not uniform due to differences in financial regulations in different countries but each one is very clear in terms of its definitions and requirements.

JORC is used in Australia,

the CIM system in Canada,

the SEM and the SEC have produced procedures for the USA

and in Europe the Pan- European Reserves and Resources Reporting Committee (PERC) was formed in 2006 to take over from the IMM which had developed its original code in 1991. The release of the final version is expected to be in December 2008.

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Bre-X Minerals

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Bre-X Share Price 1995 - 1997

The Chronology.

1993. Bre-X begins exploring at Busang

1995 (Oct) Bre-x claimed that Busang could contain more than 30m oz. of gold.

1996 (Feb) Indonesian Ministry says that Bre-X has found about 40m oz. of gold.

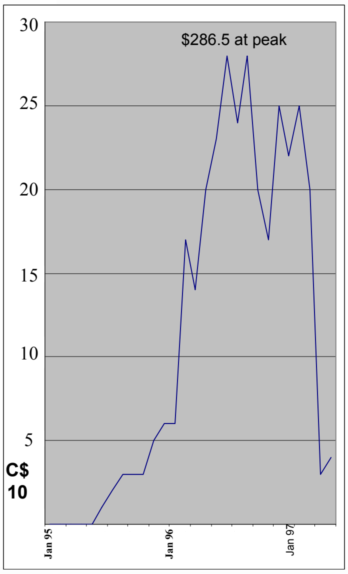
(April) Shares listed in Toronto

(July) Bre-X lifts estimate to 47m oz. gold

(Aug) Shares begin trading on Nasdaq

(Sept) Bre-x announces search for a major mining partner.

(Oct-Dec) Negotiations between Bre-X, international mining companies, local partners and Indonesian Government.



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Bre-X Share Price 1995 - 1997

The Chronology Continued 1997 .

(16th Feb) Deal signed giving Bre-X 45%, Freeport McMoRan Copper and Gold 15% and various Indonesian interests 40%.

(17th Feb) Bre-X raises estimate to 71m oz.

(19th Feb) Head of Exploration, John Felderhof says Busang could contain 200m oz. of gold.

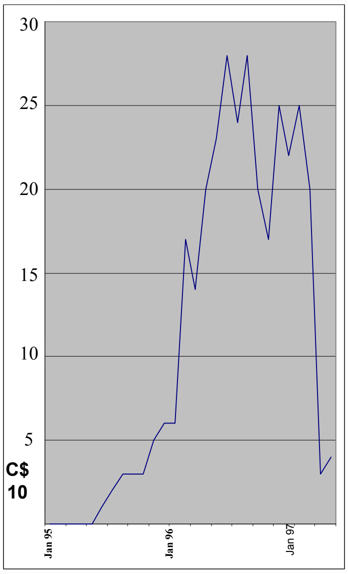
(19th March) Senior Geologist Michael de Guzman falls to his death from helicopter on his way to a meeting at Busang with Freeport.

(21st March) Shares plummet after newspaper report that Freeport's tests did not match Bre-X's findings.

(26th March) Strathcona Services hired for an independent review of Busang.

(April 23rd) Shares jump after Bre-X says it has further evidence of gold.

(4th May) Strathcona finds "tampering" with and "falsification" of samples is "without precedent in the history of mining".



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Strathcona Comments

- Only trace amounts of gold have been found in the samples analysed and there were no samples that gave gold values of economic interest.
- As a consequence, we believe there to be virtually no possibility of an economic gold deposit in the south-east zone south of the Busang property.

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Ingredients of Mining Frauds

- The property has to be plausible geologically: i.e. associated with other properties.
- It has to be remote so that inspection of the ground is difficult to achieve.
- There has to be a fire that destroyed all drilling and other records.

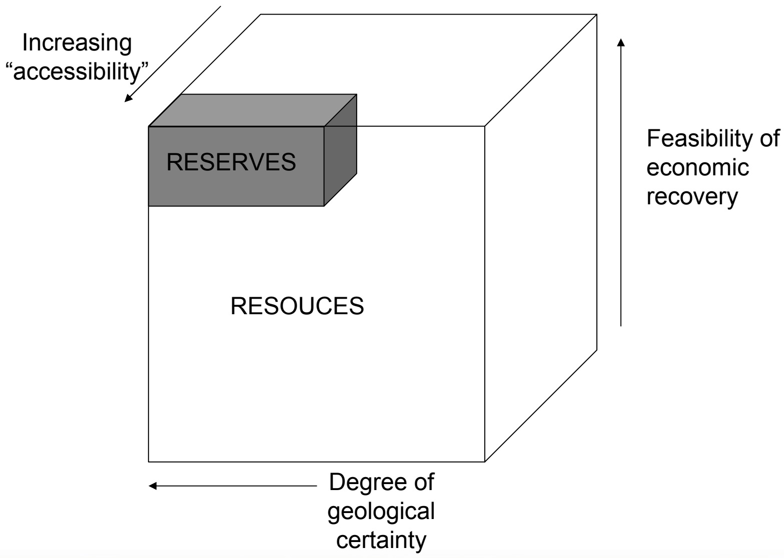
All three aspects were present at Busang

Aftermath of Bre-X

- Bre-X chairman, David Walsh (worth $1.5 billion on paper at the height of the scam) described as a fast-talking, beer-swilling Calgary wheeler dealer died in 1998 of a brain aneurism.
- John Felderhof went to hide in The Cayman Islands with his millions (claimed by some to be as much as $250m) acquired through insider trading: he sold a lot of his shares when the price was high shortly before the crash. He applied for citizenship. He was eventually extradited to Canada and prosecuted by the Ontario Superior Court in 1999 but was acquitted in July 2007 because the prosecution failed to prove that he had done so knowingly and with the intent to deceive investors. He now lives in Indonesia.
- Freeport McMoRan is still a big mining company after a rather nasty shock with Bre-X and currently runs the Grassberg Mine in PNG
- The real hero is the quiet Canadian Engineer with Strathcona who spotted the fraud.
- Investors in Bre-X lost $6 Billion which was the maximum capitalisation of the company.

The International Stock Exchanges and other investment bodies insisted that the mining industry states its reserves and resources in a properly defined manner, compliant with regulations and that reports must be draw up by competent and qualified people.

Mineral Resources and Reserves



General relationship between Exploration Results, Mineral Resources & Ore Reserves

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Exploration Results

MINERAL RESOURCES

ORE RESERVES

Inferred

Increasing level of geological knowledge and confidence

Indicated ⟷ Probable

Measured ⟷ Proved

Consideration of mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors (the “Modifying Factors").

UN Classification of Resources and Reserves

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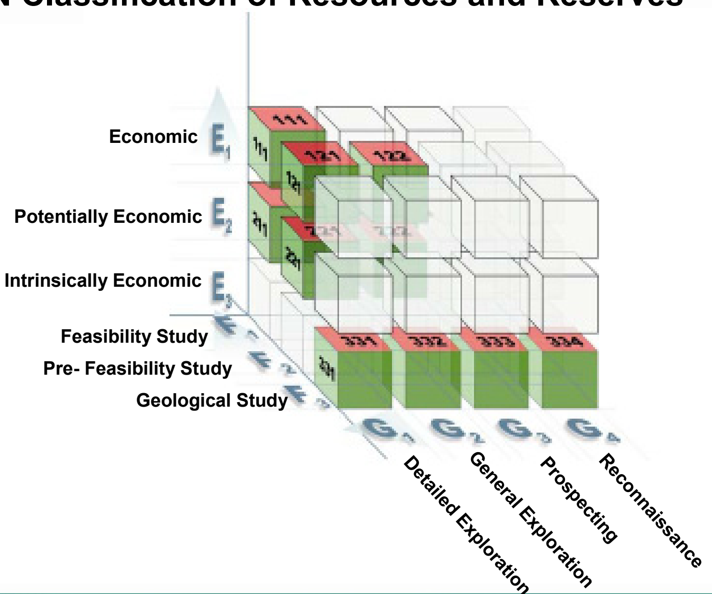

Movement of Funds In a Major Mining Company

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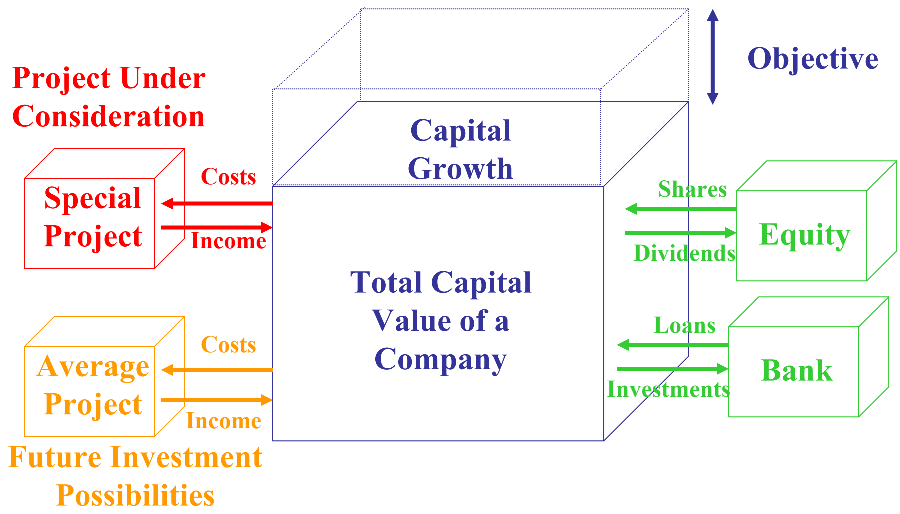

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Consider a Mining Major.

- What is the level of Risk? All mining investments are high risk but the majors are the lowest risk of all mining ventures.
- What will happen to the investment? It will rise and fall with the share value of the company: there may be short-term losses but in the long run there should be growth.
- What is the collateral? The total portfolio of the company.

What is of interest to investors?

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- Long term increase in share value. NPV of the mineral deposit is important
- Short term dividends. ROR on extracting the mineral is important. Investors should understand the Dividend Policy of the Company

Who will invest?

- Fund Managers
- Individuals
- Corporations
- Investment Houses

Are there risks?

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Yes!

Sometimes even the biggest and best run companies can make mistakes and a few years ago Anglo wrote off a $300 million investment in a copper mine in Zambia when they discovered that the operating costs would be too high…………But, the copper price was much lower then.

How can this risk be reduced?

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1. A full feasibility study must be undertaken
2. This should be followed by a full sensitivity analysis
3. There should also be an independent Due Diligence Study
4. There should also be in place factors of financial risk management and possibly risk sharing

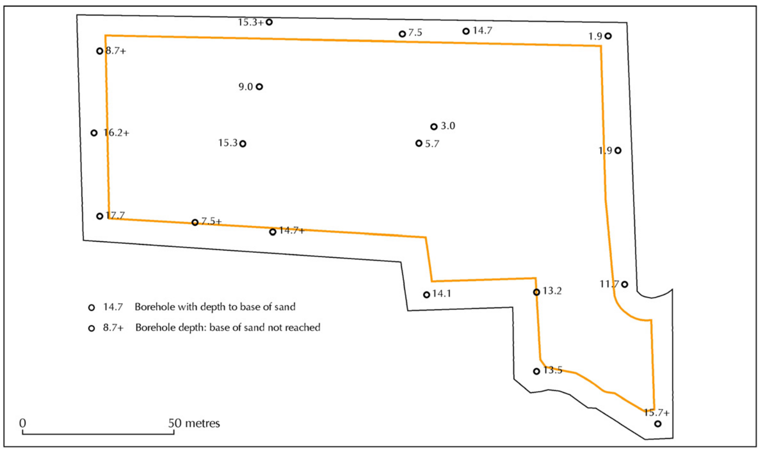
However, if the basic Geological Investigation has not been undertaken in a completely thorough and professional manner, all of these studies are, at the best, meaningless, and at the worst misleading, because they add an air of security to an insecure situation. Errors in the Geology are multiplied and their effect magnified through the other investigations and their effects can be disastrous. In the end it all comes down to an as accurate as possible estimate of the mineral and rock in the ground. In this business investors are buying chunks of Geology and if they do not understand that Geology thoroughly the investment is foolhardy.

MINERALS – HOW MUCH IS THERE?

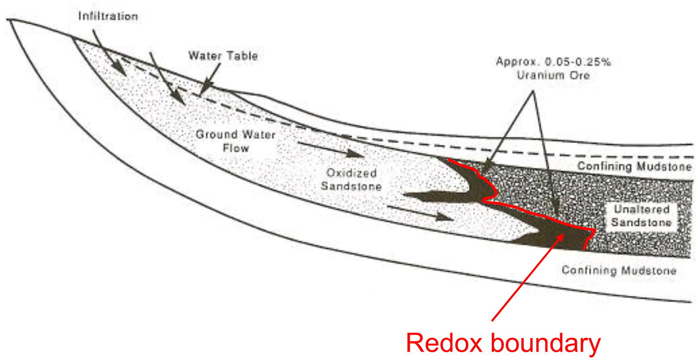
or

An Outline of Mineral Reserve Estimation

Map of evaluation drilling on a potential brick clay site



Cross Section of a Uranium Roll Front Deposit



Production Results

Tons of Ore – 9063

U_3O_8 - 0.26 %

Geologist	Ratio of geologists estimates to production results		
	Tons of Ore	U_3O_8 (%)	U_3O_8 (lb)
1	**154**	**335**	**514**
2	**66**	**673**	**442**
3	**58**	**442**	**255**
4	**88**	**638**	**560**
5	**133**	**608**	**808**
6	**27**	**642**	**176**
7	**106**	**562**	**598**
8	**38**	**569**	**215**

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Geology of the Palabora Igneous Complex -1

An alkaline intrusive cycle which emplaced in the Archaean Shield of the Northern Transvaal in successive stages:

- Pyroxenite 6.5km (N-S), 2.5km (E-W), approximately 1655ha.
- Small Syenite Plugs forcibly injected into Archaean Gneiss.
- Extended period of non-violent and partly metasomatic activity to form irregular, vertical, ultrabasic pegmatoids at 3 centres in the Pyroxenites.
- The Palabora mine developed in the central body (age 2060ma) around the Loolekop Hill (80m).

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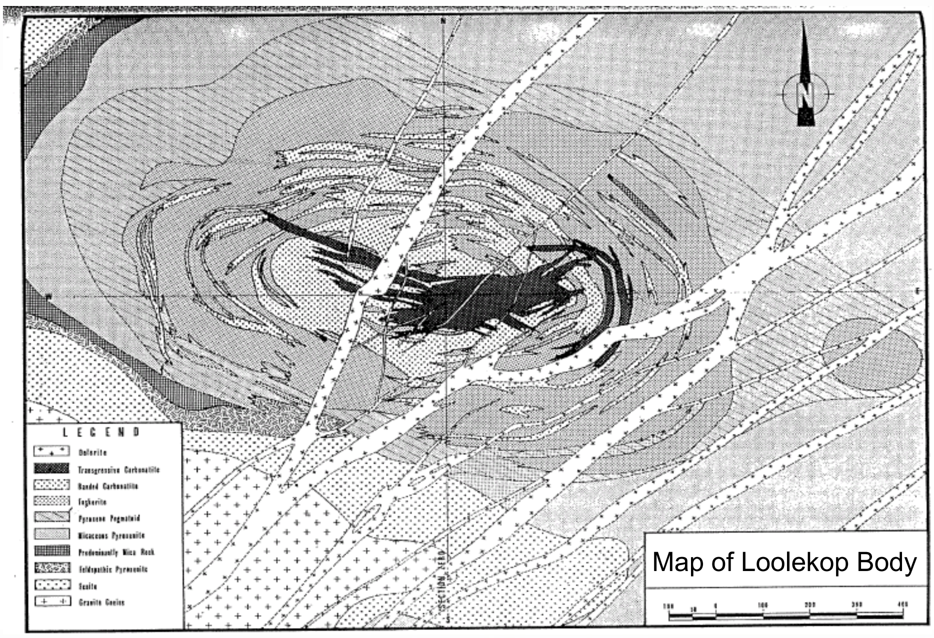
Geology of the Palabora Igneous Complex -2

Loolekop Body (1.4km x 0.8km)

The ultrabasic core consists of:

- Phoscorite (Foskorite) – an olivine apatite rock with magnetite and Phlogopite – $(K,H)_3Mg_3Al(SiO_4)_3$. In the weathered zone Pholgopite has altered to Hydrophlogopite and Vermiculite.
- Banded Carbonatite: Magnesium Calcite, Magnetite, and Apatite
- Transgresive Carbonatite forced into the shattered core of the banded Carbonatite.
- These are the host rocks to the copper sulphides Apatite, Titaniferous Magnetite plus Uranothorianite $[(Th,U)O_2]$, and Baddeleyite (ZnO_2).



Map of Loolekop Body

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Geology of the Palabora Igneous Complex -3

Loolekop Body (1.4km x 0.8km)

Occurrence of Metals:

• Copper bearing mineralising fluids migrated along fractures within the Carbonatites and deposited copper sulphides in several cycles.

• First cycle pre-dates the younger Carbonatite and is mainly Bornite.

• Second phase was Chalcopyrite in veinlets up to 1cm wide and less than one meter in length: these occur in zones up to 10m wide.

• Valleriite [$CuFeS_2$] 1.57-1.70 [$Mg,Al,Fe(OH)_2$] occurs in a broad shear zone crossing the body. It is a highly variable late stage mineral that occurs as replacement intergrowths and coatings along grain boundaries, cracks, and cleavage planes in the other copper sulphides and in the gangue minerals.

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Geology of the Palabora Igneous Complex -4

Loolekop Body (1.4km x 0.8km)

The Valleriite Problem:

• It is a platy mineral of hardness 1 and smears easily, thus causing problems in processing.

• Recovery of Valleriite is only 20% whereas that of other copper minerals is 90%.

• Hence, a mineralogical study is vital to determine the proportion of Valleriite and its distribution: an assay alone will not give this alone and the Valleriite content will affect the amount of recovered copper and hence the economics of the mine.

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Geology of the Palabora Igneous Complex -5

Loolekop Body (1.4km x 0.8km)

- There is a marked lateral zoning within the Loolekop pipe with copper minerals, Uranothorianite and carbonates increasing towards the centre and Apatite, Zirconium, Magnetite and Titanium in Magnetite increasing outwards.

- There is no change in this pattern to depths as much as a 1000m.

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Information Required for the Resource Assessment

The basic estimate was to be made primarily on the copper content since this was the metal of main interest and the economics of the mine were essentially dependent on copper.

- Total tonnage of ore and waste with corresponding Cu grade
- How much ore would contain +5% P_2O_5.
- How much ore would contain +2% TiO_2 in Magnetite.
- How much ore would contain 1.0-1.99% TiO_2 in Magnetite.
- How much ore would contain 0-0.99% TiO_2 in Magnetite.

Metallurgists needed to know the expected production of high and low phosphate ore and waste and annual high and low Titanium Magnetite from the copper ore in order to design the processing plants.

Information Required for the Resource Assessment

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A full assessment would also have information on the following:

- The distribution, grade variation and average grade of Uranothorianite
- The distribution, grade variation and average grade of Baddeleyite
- The distribution and quality of the Vermiculite and Phlogopite
- The amount of Phoscorite that would be recovered as part of the mining operation because a neighbouring Phoscorite processing plant would except the material. This ceased to be waste rock but part of the mineral inventory of the mine.

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Assessment Investigations -1

- An enormous exploration developed in the 1950s following the discovery Uranothorianite. This initially involved the geological mapping, trenching, and some surface drilling to gain an overall appraisal of the geology of the deposit.
- Between June 1957 and Feb 1962 111 holes were drilled, totalling over 41,000m and sampled at 1.5m lengths giving over 27,000 samples for analysis. Surface holes were drilled at 75m intervals and inclined at 45°.
- A exploratory shaft was sunk, tunnels driven into the body and mapped and in addition 7,000m of horizontal drilling took place of which some 1,500m of material was sampled.
- Bulk sampling from the 400 level was also undertaken.

Assessment Investigations -2

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• Geologists produced manually 13 sections and projected the data onto bench plans for the proposed mine.

• The volume of data became far too great to handle in this manner and pioneering computer programmes were written to produce the estimates and plans for the proposed mine.

• On the basis of all this data an open pit mine was proposed with surface dimensions of 1500m x 900m and to an initial depth of 360m though eventually the pit extended to a depth of 822m.

• An initial estimate gave 315Mt of ore averaging 0.69% Cu with a cut-off at 0.3% Cu.

• These design parameters were based on the geology, geotechnics, mining methods, mineral processing and economics.

• It took a team of Geologists and Engineers over 5 years to carry out this work

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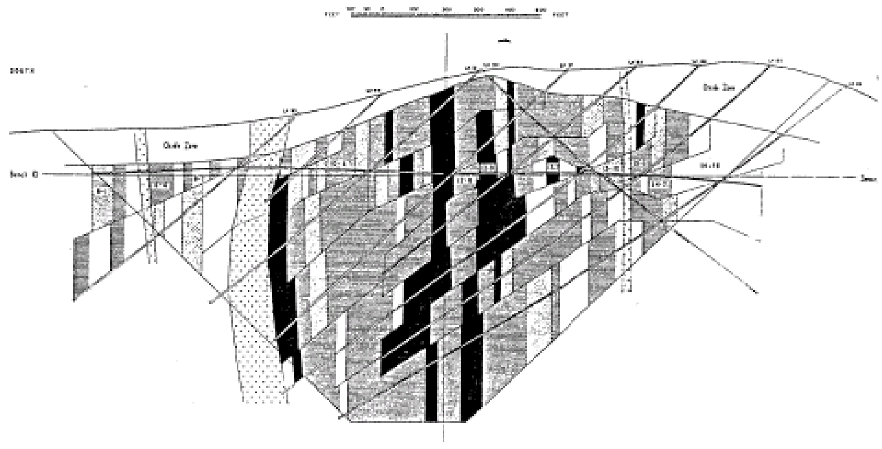
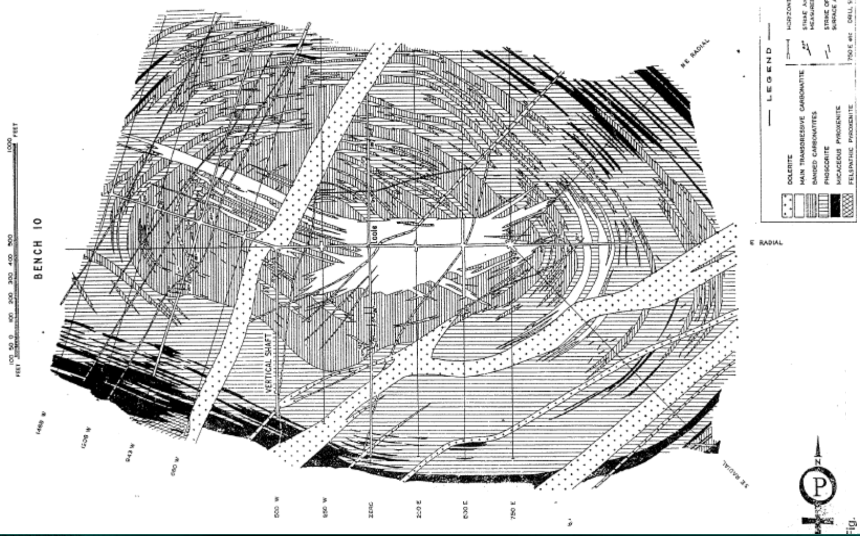
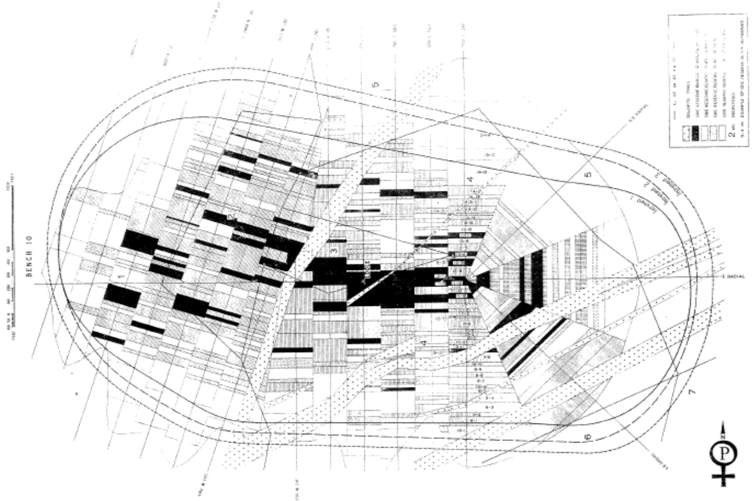


Ore Reserve Blocks on Section 750 East

Geology of the 400 ft. Level



Ore Reserve Blocks on 400ft Level



Non technical factors to be evaluated before a mineral resource can be considered as a mineral reserve.

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Environmental: the degree of significance is dependent on locality

1. Competition for land use: e.g.Farming
2. Conservation
3. Pollution
4. Environmental Impact of the operation.

Economic: In addition to all costs associated with exploitation

1. Government Regulations:- Taxes and/or subsidies
2. Location and availability of transport infrastructure
3. Land costs
4. Availability of water, power,skilled labour etc.
5. Economic forecasts for the mineral/metal
6. Price (Stability) and Market (no market = no ore body)

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Aerial View – Palabora Mine

Aerial View – Palabora Mine November 2004

The Current Approach to a Similar Estimate

- The basic geological investigations would still be required but the data achieved would be handled completely in a highly sophisticated computer model, such as Data Mine, Surpac, Gemcom or Techbase.
- These programmes require all data to be given x,y,z co-ordinates at the outset in order for continuous 3D modelling to take place.
- Throughout sophisticated statistical analysis of the grade distributions would be undertaken in order to help determine basic statistical parameters for each element and these would be superimposed on the geological model.
- The ore blocks would be assigned a mean grade achieved by a geostatistical evaluation of the data and this in itself requires highly sophisticated software.

Later Developments at Palabora

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- The open pit ended in 2002 with exhaustion of reserves.
- Leading up to this inevitable scenario a strategy to extend the life of the mine through the development of an underground mine had been implemented. The sunk costs of this mine were $465M and a projected life of 20 years.
- A reserve estimation (2004) indicated:
  - Proven reserves – 225Mt at 0.7% Cu
  - Probable reserves – 16Mt at 0.49% Cu
- A reserve estimation (2005) indicated:
  - Proven and probable reserves – 112Mt at 0.56% Cu
- Rio Tinto recorded a $161M asset write down in its 2005 accounts to reflect this.

3D Diagram of Block Caving

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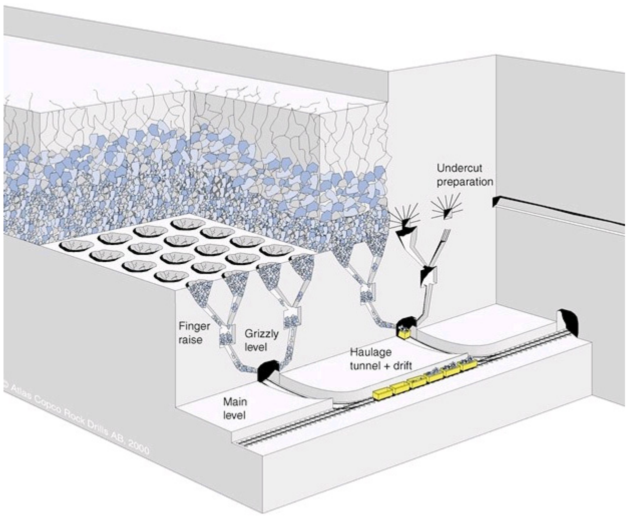

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Some Concluding Points

• All calculations and subsequent evaluation is based on the understanding of the geology. If the geological model is wrong all that follows will be flawed. The basis of the geological model is good mapping, thorough and accurate core logging, accurate and careful sampling and an intelligent interpretation of the data.

• The mining engineer and the mineral processors require accurate information from the geologists in order to undertake their work accurately. In turn, all feasibility studies and economic assessment of the project will rely on the combined information produced by this multi-disciplinary professional team. It is on the basis of their results that hundreds of millions of dollars are invested.

• All codes for the reporting of reserves and resources require the people undertaking those estimates to be fully qualified and competent persons.

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Some Concluding Points

• All investment in mining is in fact investing in chunks of geology. If the investor is not certain that the rock has been properly assessed by competent people, then the investment is a foolhardy one. It is for this reason that banks and other major investors require many checks through due diligence studies before considering any investment in a mineral deposit.

• Beware! There are many optimists and clever talkers with exploration prospects and it is prudent to treat all promotional literature on mineral projects with caution until a full feasibility study and risk assessment have been undertaken.

• "*A gold mine is a hole in the ground with a liar on the top*"
(Mark Twain)