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2012 Americas School of Mines

Basics of Mining and Mineral Processing

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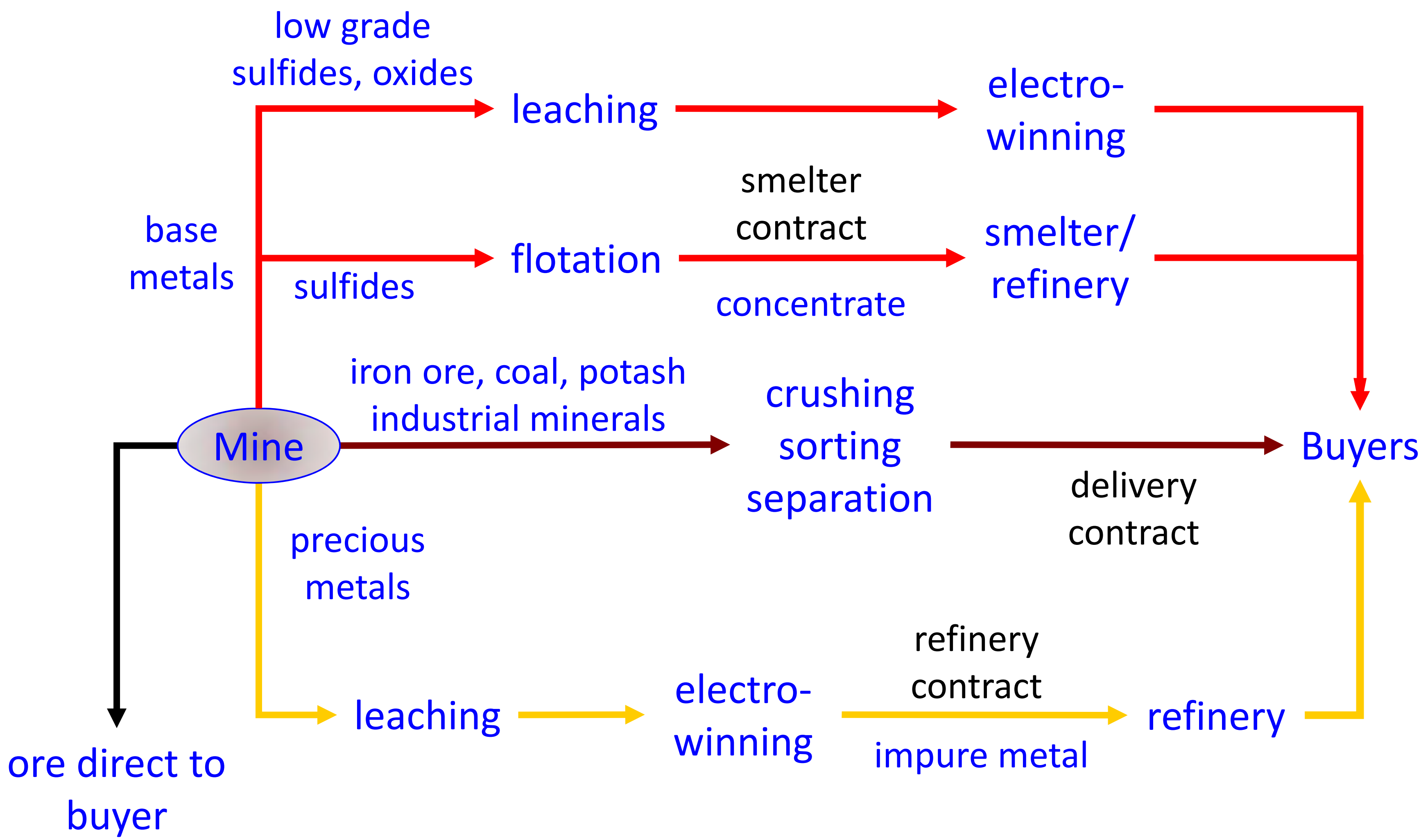
Agenda

- Geological Concepts
- Mining Methods
- Mineral Processing Methods
- Mine Waste Management
- Mining and Money
- A Future of Mining

Mining and Money: The Topics

- Mineral and metal products, sales contracts
- Metal markets and prices
- Resources and reserves
- Reporting standards

Metal and Mineral Production



Notes: Metals and Mineral Production

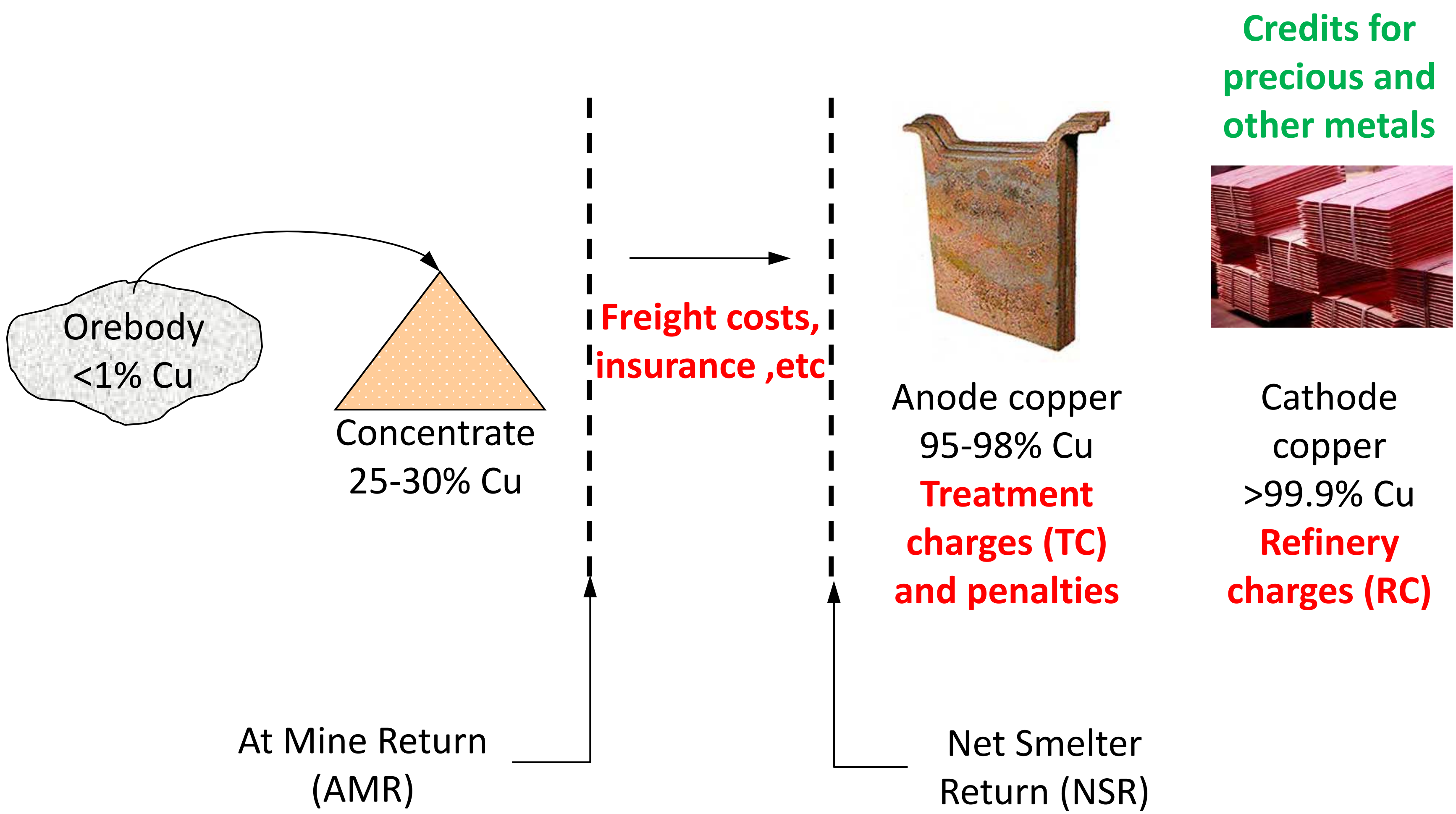
A mill at a base metal mine typically uses flotation to produce a concentrate that has a concentration of 20-40% of a primary metal. Copper concentrates are typically 25-30%. The concentrate is transported to a smelter/refinery complex where pure metal is made. Unless the mining company owns the smelter/refinery, the sale of concentrate is governed by a smelter contract. The concentrate might be processed by pressure leaching and electro-winning to form pure metal.

The mill at a precious metal mine uses leaching and electro-winning to produce an impure metal product which must be refined to produce pure metal (99.99% pure) The impure metal at a gold mine is called doré, a mixture of 60-90% gold and other metals, often silver. Unless the mining company owns the refinery, the sale of the impure metal is governed by a refinery contract.

Iron ore, potash and industrial minerals typically require some form of separation technology to produce a desired product. Flotation is used to obtain fertilizer grade potassium chloride and to separate fine coal. Grinders, cyclones, and magnetic separation methods are used to produce iron ore products. The processed ore is shipped to a buyer under terms of a delivery contract which specifies the delivery times of required quantities and the required grades.

In some rare cases, the ore from a mine is so rich, it is shipped directly to a smelter or refinery. For some time the ore from the Eskay Creek mine in British Columbia was shipped by train to smelter/refineries in Quebec or Japan.

Smelter contracts



Notes: Smelter contracts

A smelter contract contains details concerning:

- how the mine will be paid for the principal metal in its concentrate,
- how the mine will be credited for other desirable metals in the concentrate (e.g., by-products such as gold),
- what penalties will be applied for materials that affect the performance of the smelter (e.g., antimony, bismuth, moisture)
- how the delivery is to be made, and
- the manner in which check assays of the concentrate will be done.

The payment received by the mine is often called the **Net Smelter Return** (NSR). The mine is usually responsible for transportation, insurance, and agents' costs (realization costs). These costs are subtracted from the net smelter return to obtain the **At Mine Return** (AMR). The AMR can be as little as 60% of the value of the metal shipped to the smelter.

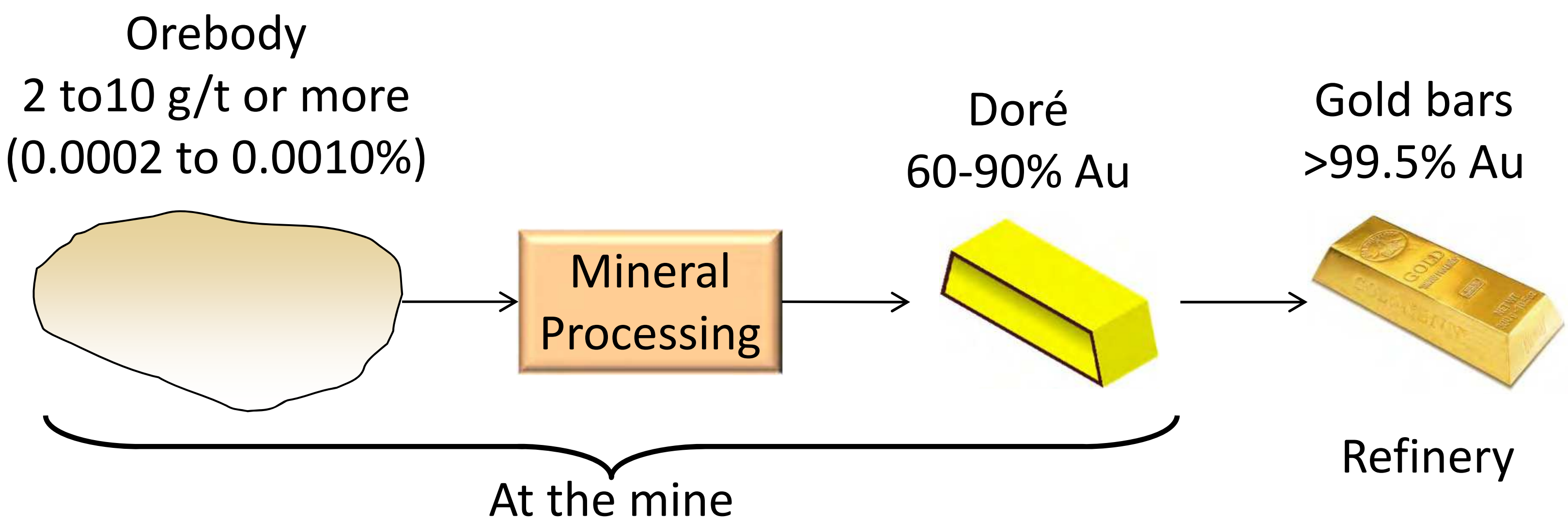
A simple mass balance between ore and concentrate can be used to determine how many tons of ore are needed to produce one ton of concentrate:

$$K \text{ tons} \times \text{grade } g \times \text{recovery } r = 1 \text{ ton} \times \text{grade } G$$

Given the concentrate grade G, the ore grade g, and the metal recovery r, K can be computed. For example: g = 0.5%, r = 92%, G = 28% gives K = 60.9 tons.

Refinery contracts

In the case of gold



Refinery contract dictates what percentage of the gold price the mine will receive, typically 98-99.95%.

Larger mining operations have their own refineries

Notes: Refinery contracts

Typical terms of a gold refinery contract are:

- A treatment charge of $0.80 to $1.20 per oz, depending on current market conditions
- The refinery typically pays the mine for 98% to 99.95% of the gold contained in the doré, depending on market conditions.
- Penalties are applied for deleterious elements such as iron, lead, tellurium and nickel.
- The refinery will pay between 95% and 99% of the silver content of the doré.

The complexity of refinery contracts lies in the procedures established for weighing and assaying. Security measures, delivery dates, disposition of refinery waste, and transportation of the gold are all dealt with in a refinery contract.

By-products and Co-products

- By-product
  - secondary metal produced in the mining and processing of another metal
  - usually not important to the viability of mine
  - e.g. gold/silver in copper concentrate
- Co-products
  - metals that are mined and produced together
  - important to the viability of a mine
  - e.g. lead and zinc usually produced together

From an accounting perspective, this distinction does not exist.

Notes: By-products and Co-products

Prices can determine whether a metal is a by-product or co-product. For example, in a period of high metal prices, each metal could be considered a co-product (or simply a product). During periods of low metal prices, the gold in a copper concentrate may be important to the viability of the mine. Mines with poly-metallic ores (e.g., Myra Falls) sometimes call themselves different types of mine depending on prices.

Current accounting rules (GAAP) specify that revenue from by-products and co-products be stated as a line item for each individual product. Costs for production of a particular by-product or co-product cannot be used to reduce overall operating costs. Thus, by-product gold credit for a copper concentrate cannot be used to reduce the operating cost of a copper mine. Essentially the new accounting rules eliminate the distinction between by-products and co-products.

Before the current accounting rules were established, in some cases the high prices of a by-product caused operating costs to become negative, clearly not representative of the actual conditions.

Negative costs?

This kind of statement is unrepresentative:

“... mining a variety of metals reduces XXX's cost per ounce of silver to less than nothing or a negative cost. The other metals pay for everything and make lots of profit, so the silver is free.”

Metal equivalents

Expressing the quantity of metal in the deposit in terms of the more abundant metal (main metal) in the deposit

Common in polymetallic mines

$$\text{Main metal equivalent grade} = \frac{\text{Value of all metals in ground}}{\text{Unit value of main metal}}$$

Ignores two things:

- grade variations within deposit
- price (value) changes

} both vary with time

See example on notes slide

Notes: Metal equivalents

Metal equivalents are similar to a weighted average. Consider a polymetallic deposit containing silver, gold and some base metals. Ignoring the base metals, the concentrations of silver and gold in grams per tonne are

Silver: 400 g/t

Gold: 0.5 g/t

Suppose the current prices are: gold $30/g, silver $0.40/g. The total value of the metals in the ground is

$$400 \times 0.4 + 0.5 \times 30 = \$175/t$$

Therefore if silver is the main metal, the silver equivalent grade is

$$175/0.4 = 437.5 \text{ g silver/t}$$

It can be seen that, although this accounts for the gold in the deposit, it depends on both prices and grade and thus it is time-dependent depending on how prices behave and how grades vary during the operation.

How metal prices are determined

- Producer Prices
  - producers set price
  - common for industrial minerals
- Negotiated Prices
  - pricing determined by direct negotiation between buyer and seller
  - prices may be linked to commodity exchange prices
  - long-term contracts for metals or concentrates
- Independent Pricing
- Commodity Exchanges
  - London Metals Exchange (LME)
  - CME Group (includes COMEX and NYMEX exchanges)

Notes: How metal prices are determined

Producer Prices

Producer(s) set price taking into account costs, potential markets, and levels of competition
Was common in aluminum, molybdenum, cobalt, and nickel industries
Common for industrial minerals where transportation costs are high

Negotiated Prices

Pricing determined by direct negotiation between buyer and seller
Common in long-term contracts for ore, metal concentrates or metal products

Independent Pricing

Pricing determined by sources that are neither buyer nor seller of metals
Prices are averages of prices of actual transactions between producers, consumers, and metals traders
Metals include: magnesium, titanium, iridium, aluminum, uranium
Examples: Platts, Metal Bulletin, Handy and Harman, London bullion dealers, Uranium: Ux, Trade Tech, Nukem

Iron ore prices used to be based on a long term benchmark price established by a small group of producers and steel makers. Recently there has been a shift to more short term pricing based on transactions between a larger group of companies and to the development of a futures market.
See http://en.wikipedia.org/wiki/Iron_ore#Iron_ore_market and http://www.thesteelindex.com/

Precious Metals Markets

Examples of *independent pricing*

London Bullion Market Association (LBMA)
London Platinum and Palladium Market (LPPM)

Members meet twice daily to review offers from worldwide sources to buy and sell these metals

Results averaged and announced as the official AM and PM "fixings" for each of the metals.

Notes: Precious Metals Markets

The London Bullion Market and the London Platinum and Palladium Market are "over-the-counter" markets where prices are determined by a group of member dealers based on trades in precious metals that occur around the world. The procedures for price fixings are described at the websites shown:

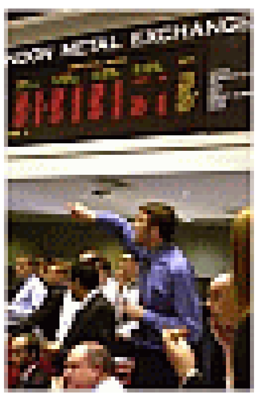
www.lbma.org.uk/london_faq_fixings.htm

www.lppm.org.uk/pgm_fixing_hist.html

Most of the members of these markets are major international banks or bullion dealers and refiners.

Commodity Exchange Pricing

Prices determined by transactions of dealers who are representatives of metal buyers, sellers, and metal traders
Spot (present) or forward (in future) prices are set



CME Group trades in
Silver
Gold
Copper
Platinum
Palladium
Steel products

The "ring" at LME

LME trades in
Aluminum
Cobalt
Copper
Molybdenum
Lead
Nickel
Tin
Zinc
Steel products

Notes: Commodity Exchange Pricing

LME – London Metal Exchange www.lme.co.uk
CME Group – www.cmegroup.com/trading/metals/

Prices at these exchanges are determined by a continuous auction carried between member dealers acting on behalf of their customers, the companies they represent, or themselves. The auction is done by open outcry. See www.lme.co.uk/pricing.asp. Information about metals trading at CME may be found at links on the above CME website.

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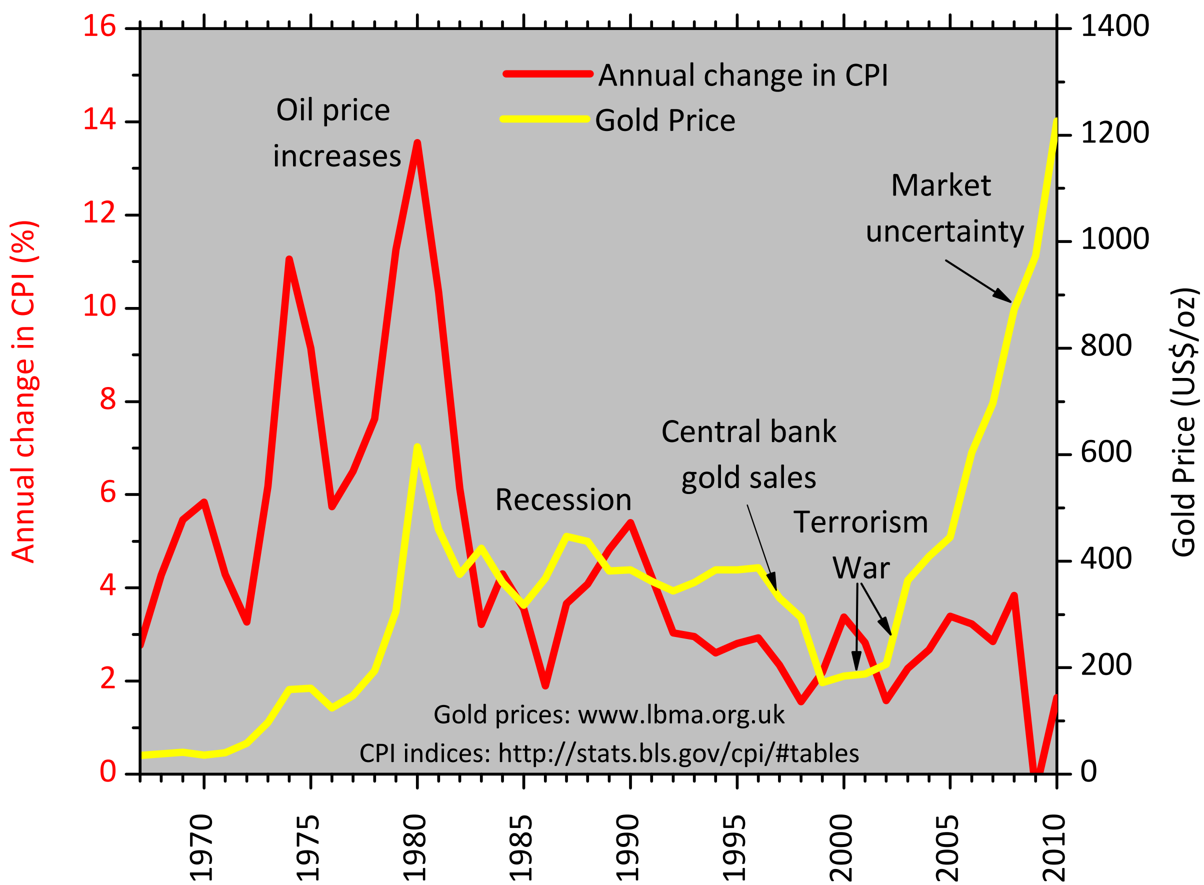
Both CME and LME engage in e-trading of metals.

Gold Prices and Inflation?

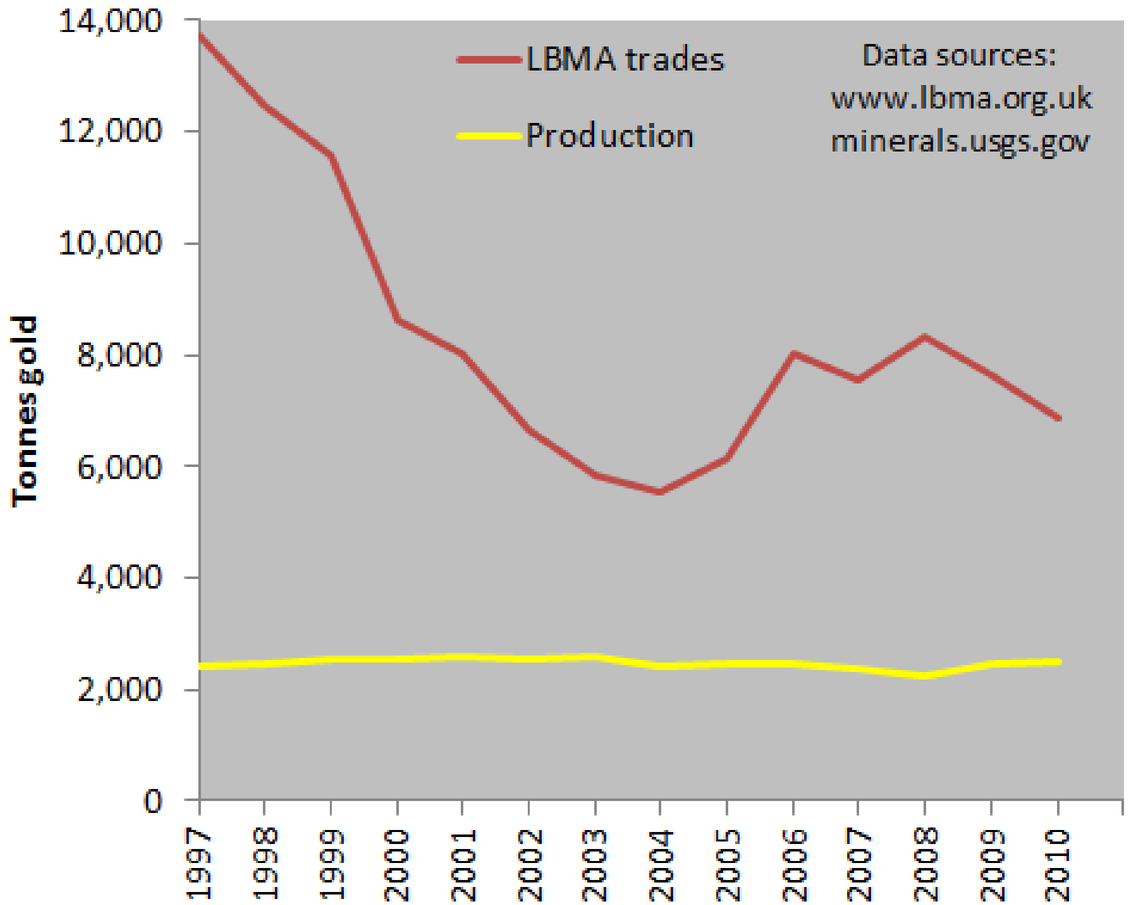


Notes: Gold Prices and Inflation?

Until about 1990, there seems to be a correlation between inflation and gold price. However, after 1990 the correlation is not as good. In the late 1990s, central banks began selling their gold supply so that gold price decreased even though inflation increased. Hedging of gold by gold producers during the same period effectively increased the supply because hedging is effectively selling gold that is not yet mined; however, producers have decreased hedging activity since about 2000. Terrorist activities in 2001-2002 may have caused investors to protect the value of their portfolios with gold causing an increase in price.

The more recent price increase is large and cannot be explained by the increase in inflation or by the need for portfolio protection. Other forces such as sovereign debt and the level of economic uncertainty may be at work.

The gold market is a paper market



Since 2006 the annual mine production of gold has been traded every 70 to 80 days.

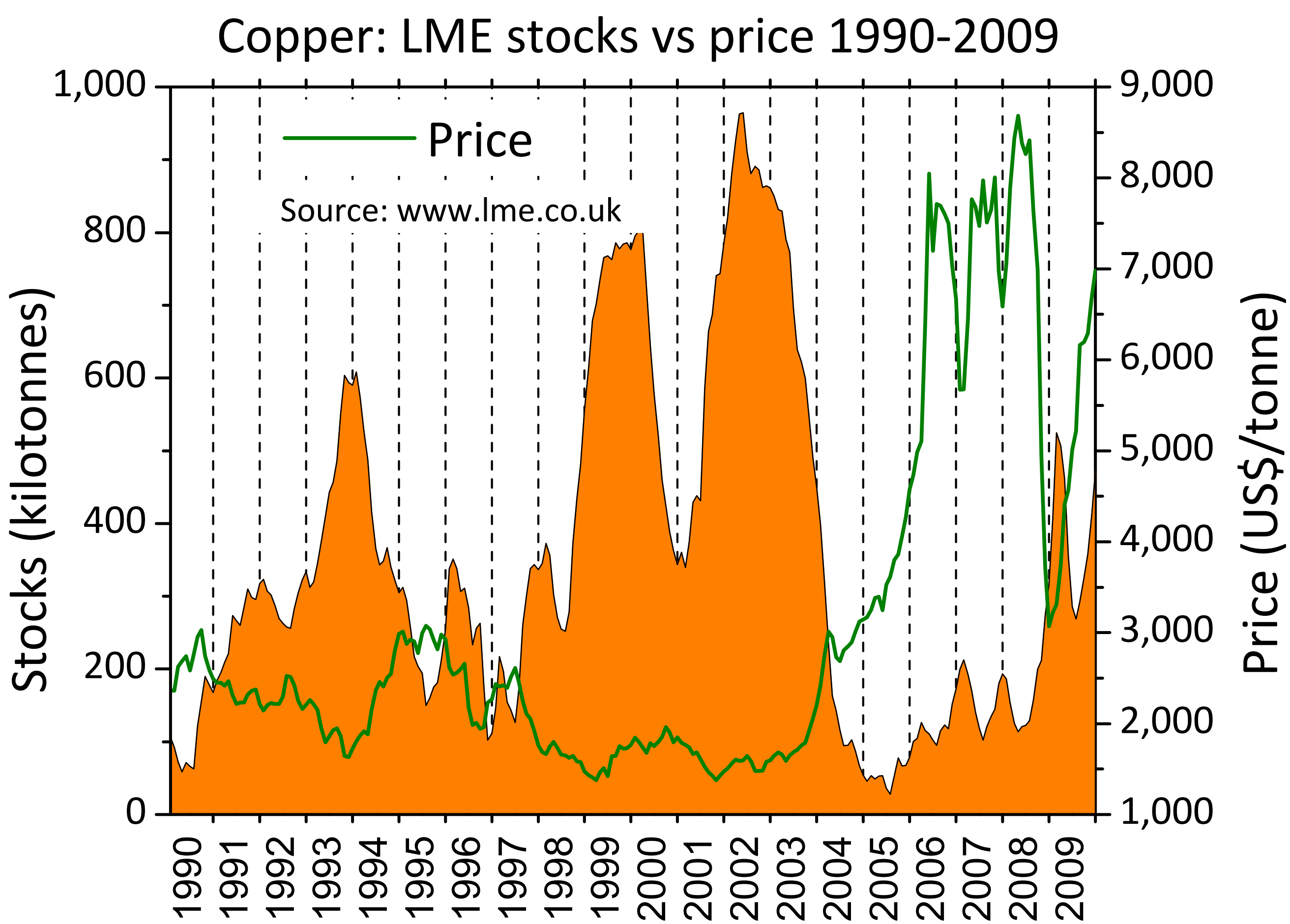
Notes: The gold market Is a paper market

The London Bullion Market trading volume is mainly composed of the purchase of large lots of gold by central banks and financial institutions. One motivation for this type of trading is that central banks lend gold at interest rates which are lower than typical loan interest rates in order to achieve a return on their assets. This encourages borrowing gold from central banks, selling it and investing the proceeds at a higher rate. The physical gold may or may not be returned as the lending contract can be continued indefinitely.

These kinds of trades recur such that since 2006 the annual mine production of gold has been traded every 70 to 80 days. Although there is gold available somewhere in the world to back up these trades, buying the gold in the open market involves credit and/or financial risk and there is production risk associated with obtaining gold from a mine. Hence the term "paper market".

The paper market for gold investment constitutes a fundamental aspect of the gold market. It is believed by some that transactions in the paper market, a representation of the demand for investment in gold, affect the price of gold more than physical transactions.
http://en.wikipedia.org/wiki/London_bullion_market

Copper Supply and Price



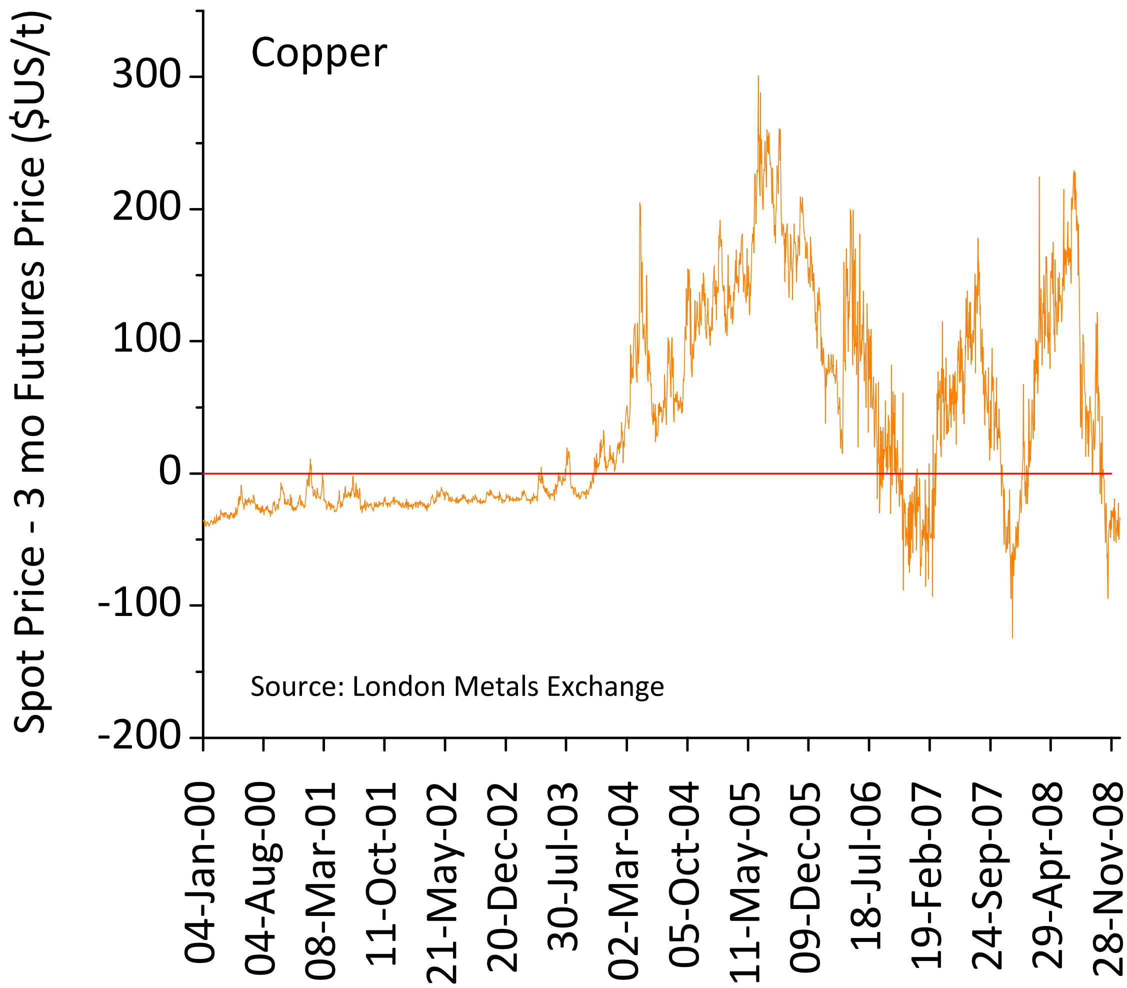
Notes: Copper Supply and Price

Commodity exchanges have warehouses where a physical supply of a metal is stored. In this case the copper supply is the total available for purchase in these warehouses on a particular day. Traders know this supply and also know of any constraints on supply (eg smelter or mine shutdowns) Thus they know as much as possible about the market and bid or ask a price on that basis.

The correlation coefficient between copper stocks and price is -0.76, almost completely anti-correlated. Similar results for other base metals.

From these data, an empirical relationship between supply and price can be determined. Predictions of supply can be made using macro-economic factors. The empirical relationship between supply and price can then be used to predict future price from future predicted supply. Results are generally good.

Speculation in the copper market?



Notes: Speculation in the copper market

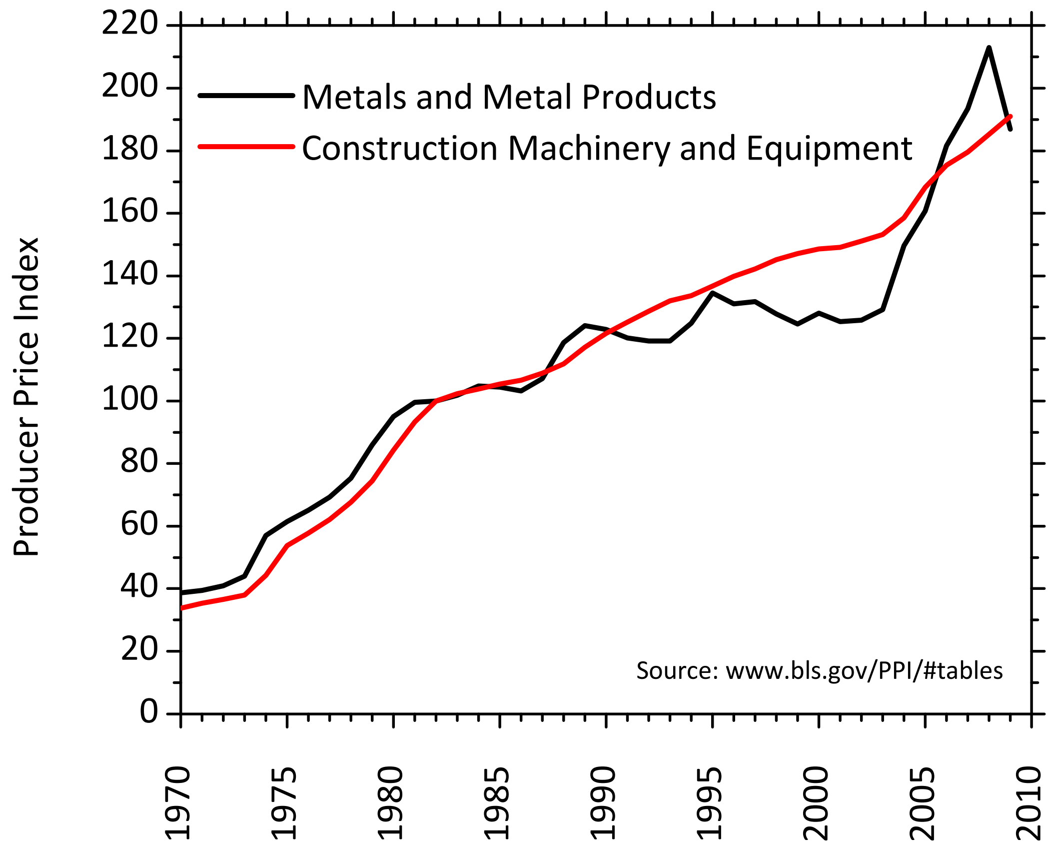
Backwardation is a situation in which the price of a commodity for future delivery is *lower* than the spot price or, more generally, a far future delivery price is lower than a nearer future delivery price. Backwardation is a premium representing what a buyer is willing to pay for the immediate delivery of the commodity. The difference [Spot Price – 3 month Futures price] would be an indication of this premium.

The plot of this difference for copper between 2000 and 2008 shows that until about the end of 2003 there was little to no premium associated with immediate delivery of copper. Then there was a significant premium and some rather wild changes.

The simple explanations for the increase in premium are the increase in demand for copper in China and India and supply interruptions caused by strikes at copper mines in Chile, Peru and Mexico which put pressure on copper supplies so that manufacturers pay more to assure delivery now rather than later. However, the wild changes in the premium suggest to some that the market is being influenced by speculators who have the ability to enter and exit the copper market depending on their investment goals. Their trades typically involve large volumes of copper which have an influence on spot price. Essentially the copper market is becoming a financial market, much like a stock exchange, which introduces an unknown element to the market.

But all prices go up

As measured by Producer Price Indices



Cost of equipment continues to rise regardless of changes in metal prices

Cutoff Grade

Reserves must be extracted economically:

$$\text{Price} \times \text{Grade} \times \text{Recovery} > \text{Total Costs}$$

For equality

$$\text{Cutoff grade (CoG)} = \frac{\text{Total costs}}{\text{Price} \times \text{Recovery}}$$

If grade < CoG $\Rightarrow$ it's waste (but it might be stockpiled)
A Net Smelter Return or Net Refinery Return may also be defined for a block of ore
If Return < Costs $\Rightarrow$ it's waste

Total costs usually include all the costs of mining, processing, and overheads. What overheads and how to attribute them is an interesting question. Should annualized capital costs be included?

How much is in the ground

Two basic classifications of known mineral deposits

Resources	Reserves
commercial extraction is potentially feasible	Can be extracted economically and legally

Reserves and resources are stated in annual financial reports.

Reserves are an asset but do not appear on the balance sheet. The value of reserves is important if the company is an acquisition target.

Notes: How much is in the ground?

In 1989 the Australasian Joint Ore Reserves Committee (JORC) issued the *Code for Reporting of Mineral Resources and Ore Reserves* following some notable "misstatements" in mineral property valuation reports in Australia. The code can be downloaded from www.jorc.org. Various other codes based on JORC have since been developed and are used by regulatory and legal authorities as standards for methods of reserve and resource estimation:

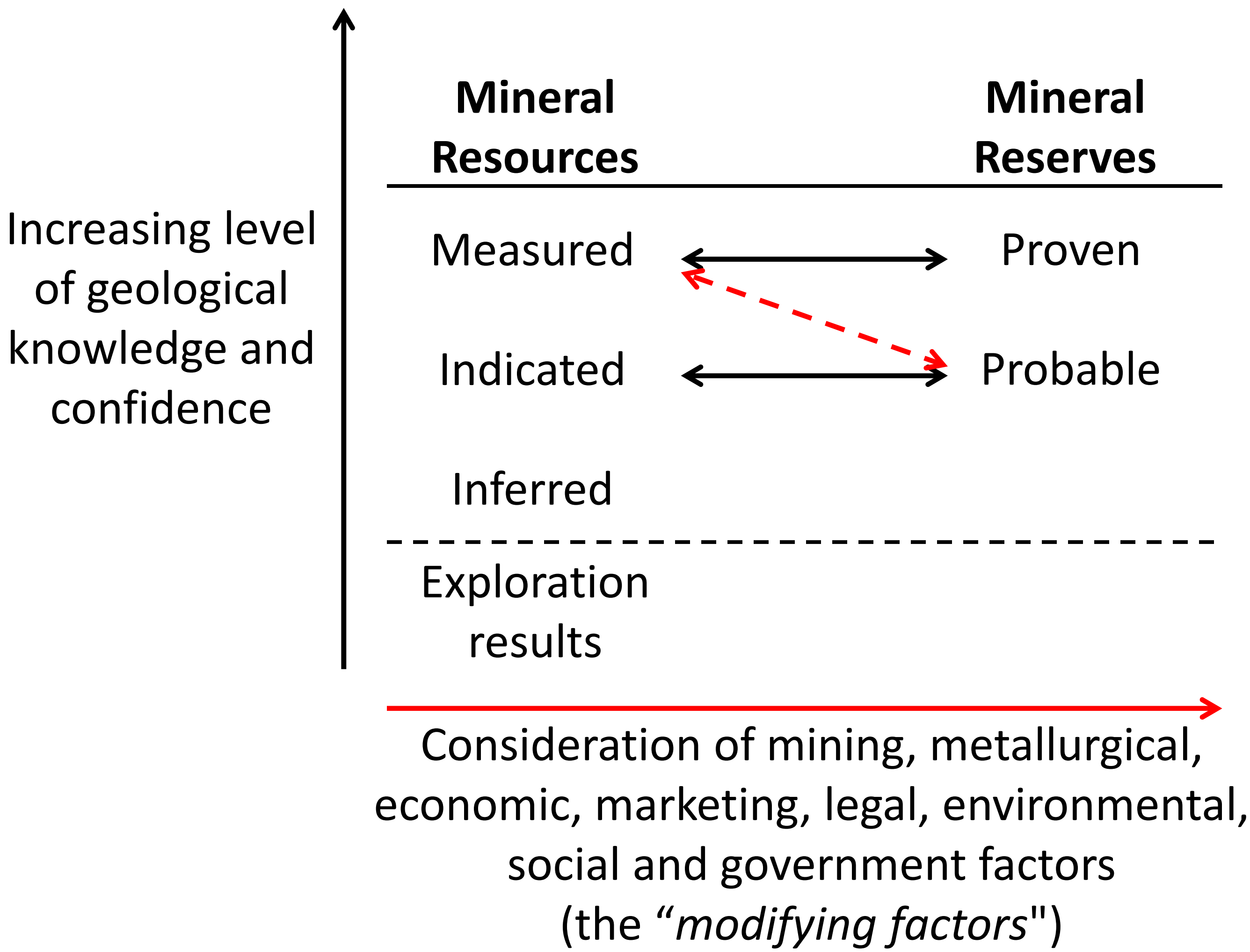
VALMIN: (1995, revised 2005), Australian Institute of Mining and Metallurgy (AusIMM). The VALMIN Code is obligatory for reports relating to mineral and petroleum assets and is supported by other entities, including the Australian Stock Exchange, the Australian Securities and Investment Commission, the Institute of Chartered Accountants in Australia, and the Australian Institute of Company Directors. Download from http://www.mica.org.au/ Click on codes link.

National Instrument 43-101: (Dec 30, 2005) NI 43-101 was formulated by the Canadian Securities Administrators (CSA), an umbrella association of Provincial Securities Commissions across Canada. Download from http://www.ccpg.ca/guidelines/index.html

CIMVAL: (February 2003) Standards and Guidelines for Valuation of Mineral Properties was formulated by a special committee of the Canadian Institute of Mining and Metallurgy. This supplements NI 43-101. Download from www.cim.org/committees/CIMVal_Final_standards.pdf

US Securities & Exchange Commission, 2007. Industry Guides, "Industry Guide 7", available at http://www.sec.gov/about/forms/industryguides.pdf, pp 34-37.

Resources to Reserves



Notes: Resources to Reserves

One way to describe the difference between resources and reserves is

Resources are reported as in situ estimates of mineralization (e.g., “The grade in this drill core is x%.”)

Reserves are reported as masses with a particular grade distribution that can be mined (e.g., “There are X tons of reserves with an average grade of y%”)

Note the need for **geological knowledge** to go from indicated to measured resources or from probable to proven reserves. Several **modifying factors** cause resources to become reserves. Reserves cannot be estimated from inferred resources.

Measured resources often become probable reserves even though geological knowledge does not decrease. For example, the drill hole spacing may not be sufficient to classify the reserves as proven, but a few modifying factors may be established or assumed. For this reason, some think that probable reserves should be moved down to become aligned with measured resources.

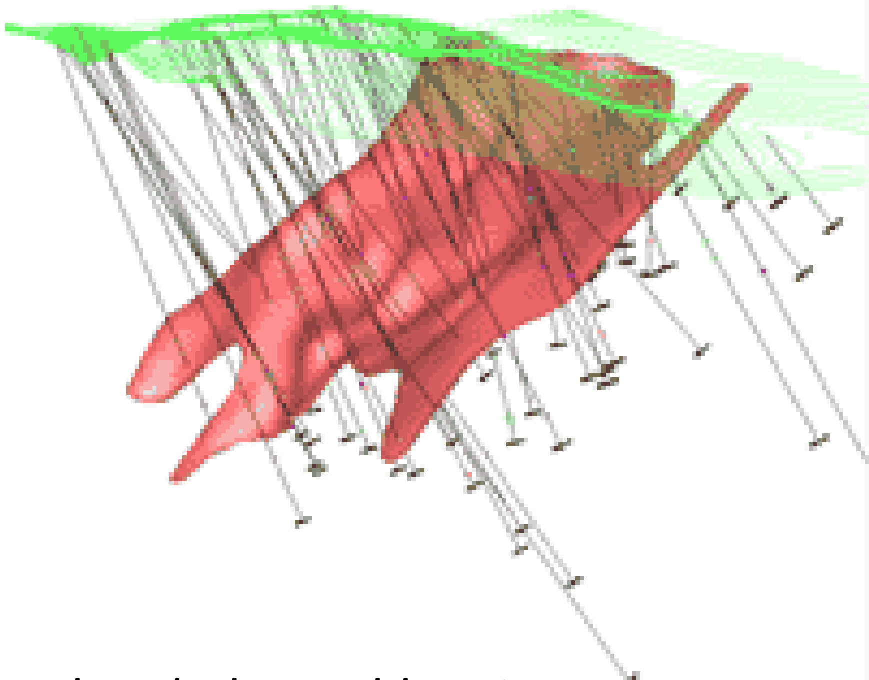
Estimation of reserves involves considerable technical difficulties and uncertainty. Among the considerations are:

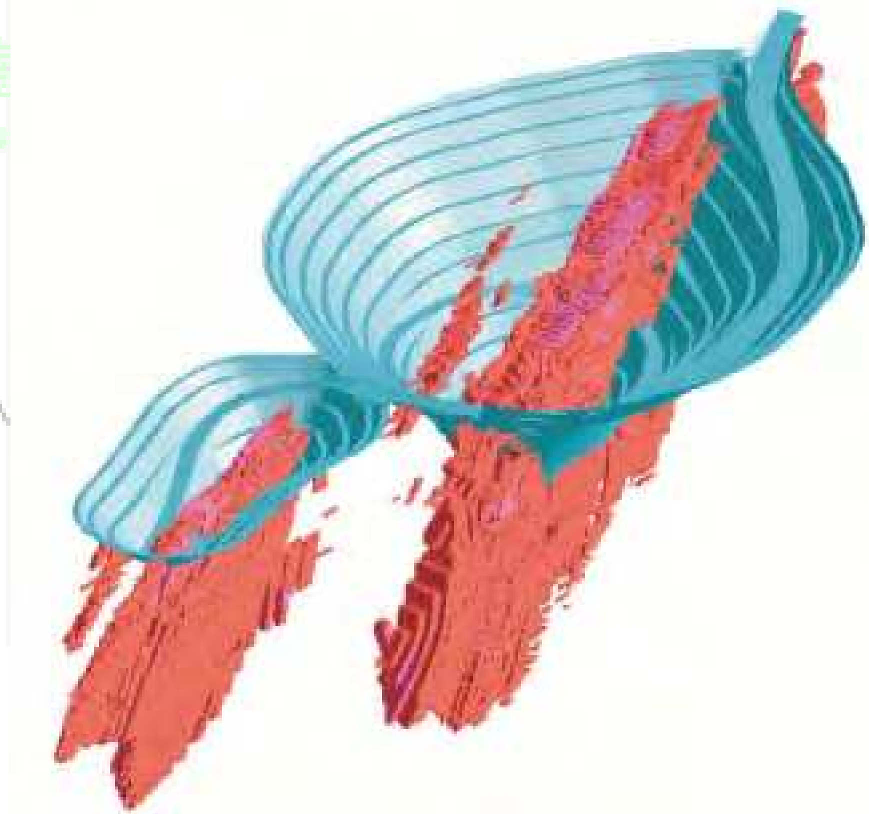
- the distribution of grade in the resource
- the portion of the mineral resource that can be extracted when allowance is made for dilution and recovery
- metal prices
- production costs
- changes in technology

Information concerning the first two items tends to increase as the mine is developed. The last three items can change during the life of the mine and it is not uncommon to see reserve estimates change as a result.

Same mineralized mass

Which is a resource and which is closer to being a reserve?





Thunderbox gold project
Lionore Mining International
2000 Annual Report
www.lionore.com

Notes: Same mineralized mass

On the left is a measured resource because the outline of the orebody has been determined by estimation from measurements (assays) in boreholes. On the right is an open pit mine design. If the design is feasible, then at least a few of the modifying factors have been taken into account and the orebody is a reserve. Most likely it is a probable reserve since there may not be enough drillhole data to prove that the orebody is as shown. A “bankable” feasibility study would have to prove the reserves by means of further drilling on a finer grid (“infill drilling”)

From paper to pit – Thunderbox pit in 2006

Questions

#1

Drilling at the proposed Prosperity mine south of Williams Lake, British Columbia defined a resource of 1.0 billion tonnes. A feasibility study indicated a mine life of 20 to 33 years at a capital cost of ~$800M. Environmental approvals were needed but not obtained.

Could the resource ever have been considered a reserve?

#2

Construction of the Galore Creek project in northwestern British Columbia was halted in 2007 due to high construction costs.

At that time were the minerals in the ground at the mine resources or reserves?

Some things accountants do (in their offices)

Depreciation schedules for assets

Rehabilitation and reclamation costs

Assessment of asset impairment

Each involves uncertainty
Each depends on an estimate of mine life and/or the available ore (reserves or resources)

Notes: Reclamation and closure costs

On the balance sheet in the year of recognition:

Liability: PV(R&C costs)

Annually on the income statement:

Depreciation expense: PV(R&C costs) / Mine Life

The reclamation and closure costs might include:

- Removal of plant and other facilities
- Restoration, rehabilitation and other environmental liabilities

There are several uncertainties in estimation of R&C costs:

- Length of time required to treat acid drainage or mine waste water
- Whether reclamation/rehabilitation methods will be effective
- Changes to closure costs as a result of changes to an operation

PV(R&C costs) is a function of mine life. Mine life depends on ore available which is also uncertain and may vary over time.

The relevant accounting standards are:

- IAS 37: Provisions, Contingent Liabilities, and Contingent Assets (similar to UK standard FRS 12)
- SFAS 143: Accounting for Asset Retirement Obligations
- CICA Handbook Section 3110: Asset Retirement Obligations

Notes: Asset impairment

Future cash inflows may be affected by such things as changes in future costs, difficult or unstable ground conditions, damage such as flooding, tailings dam failure, etc., and difficulties or delays with development or expansion. These are "physical" impairment of assets. Economic impairment might be caused by decreases in grade or the amount of ore and decreases in metal prices i.e., what was ore becomes rock.

Depreciation expense is computed on a unit-of-production basis:

$$\text{Depreciation rate} = (\text{Acquisition cost} - \text{Residual value})/\text{Estimated production}$$

$$\text{Depreciation expense} = \text{Depreciation rate} \times \text{Units produced}$$

$$\text{Undepreciated value} = \text{Acquisition cost} - \Sigma\text{Depreciation expense}$$

Only proven and probable reserves are used in calculating the estimated production of a mine. This affects estimates of the depreciation rate.

Each of the factors involved in determining impairment interact. For example, if the estimated production decreases because reserves decrease, the depreciation rate increases. However, if the units produced decrease for other reasons, the depreciation expense might remain the same.

The relevant standards are:

IAS 36: Impairment of Assets

FASB 144: Accounting for the Impairment or Disposal of Long-Lived Assets

CICA Handbook, Section 3063: Impairment of Long-lived Assets

How to estimate mineral resources

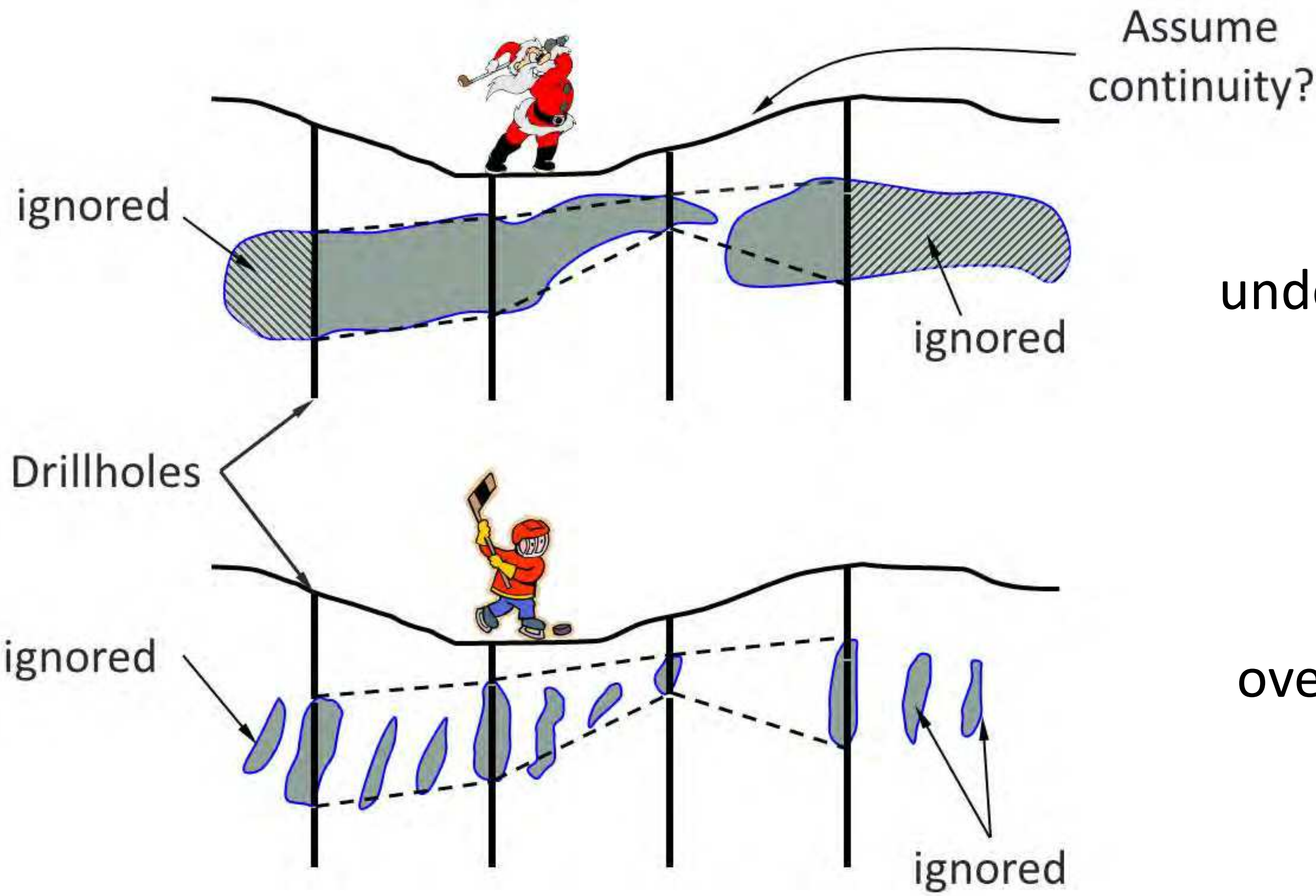
Map and sample deposit (e.g., drillholes)

Use appropriate estimation technique (determined by geologist)

Geological interpretation done by geologist who
- carries out the estimation
- decides whether resource is inferred, indicated, or measured

Reporting standards (discussed later) do not specify the estimation method to be used nor the procedures for use of any method

Resource estimation – two examples



Possible underestimation

Possible overestimation

Notes: Resource Estimation – two examples

Two possible orebody configurations are shown. The data from the drillholes would be the same for both configurations. Assuming continuity between each drillhole may lead to over or under-estimation of the resource depending on the configuration. Possibly the only way to resolve the interpretation of the data is to drill more holes (so-called “infill” drilling) An experienced geologist is required to interpret the available data.

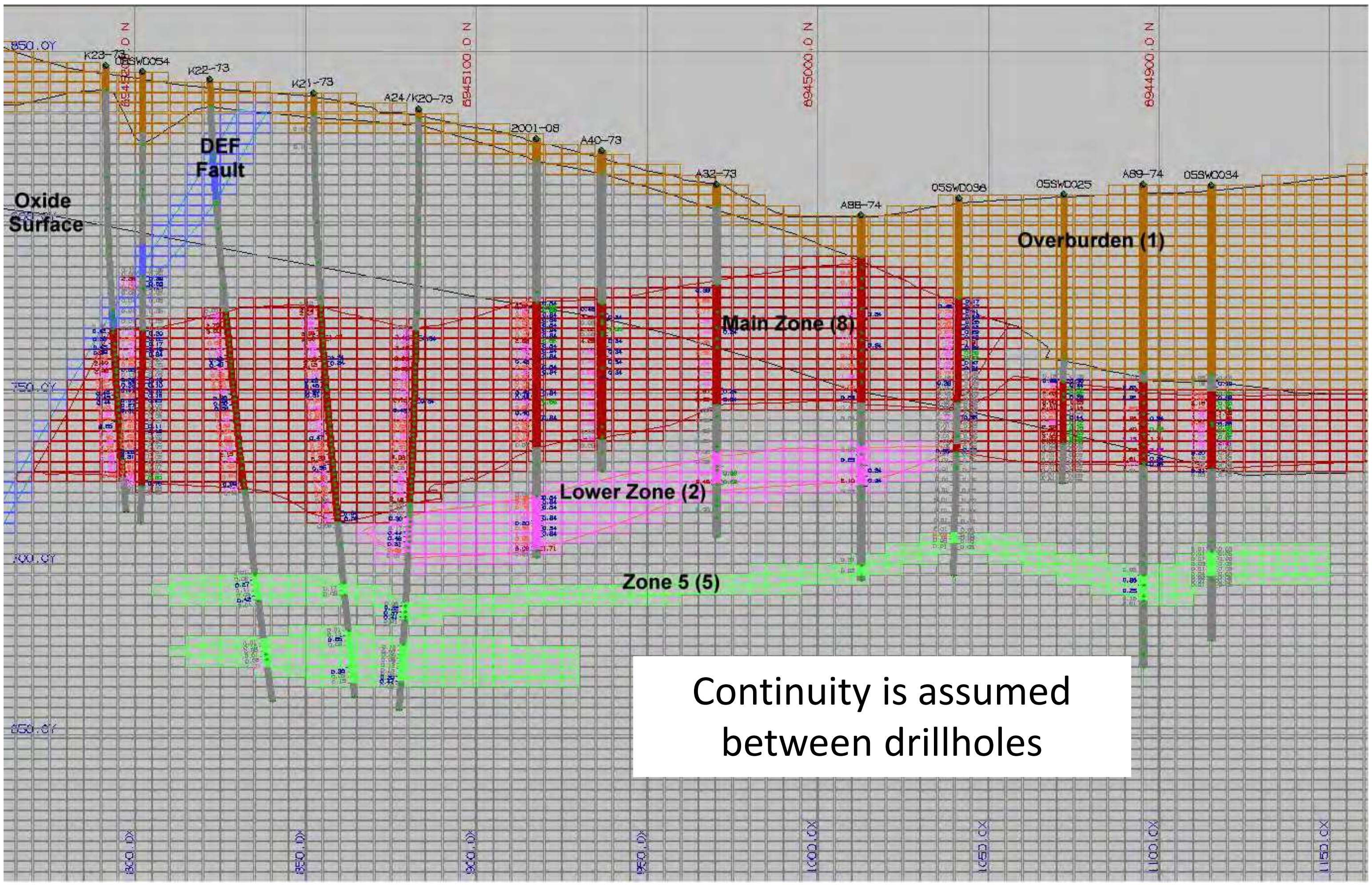
Minto Project, Yukon Territories

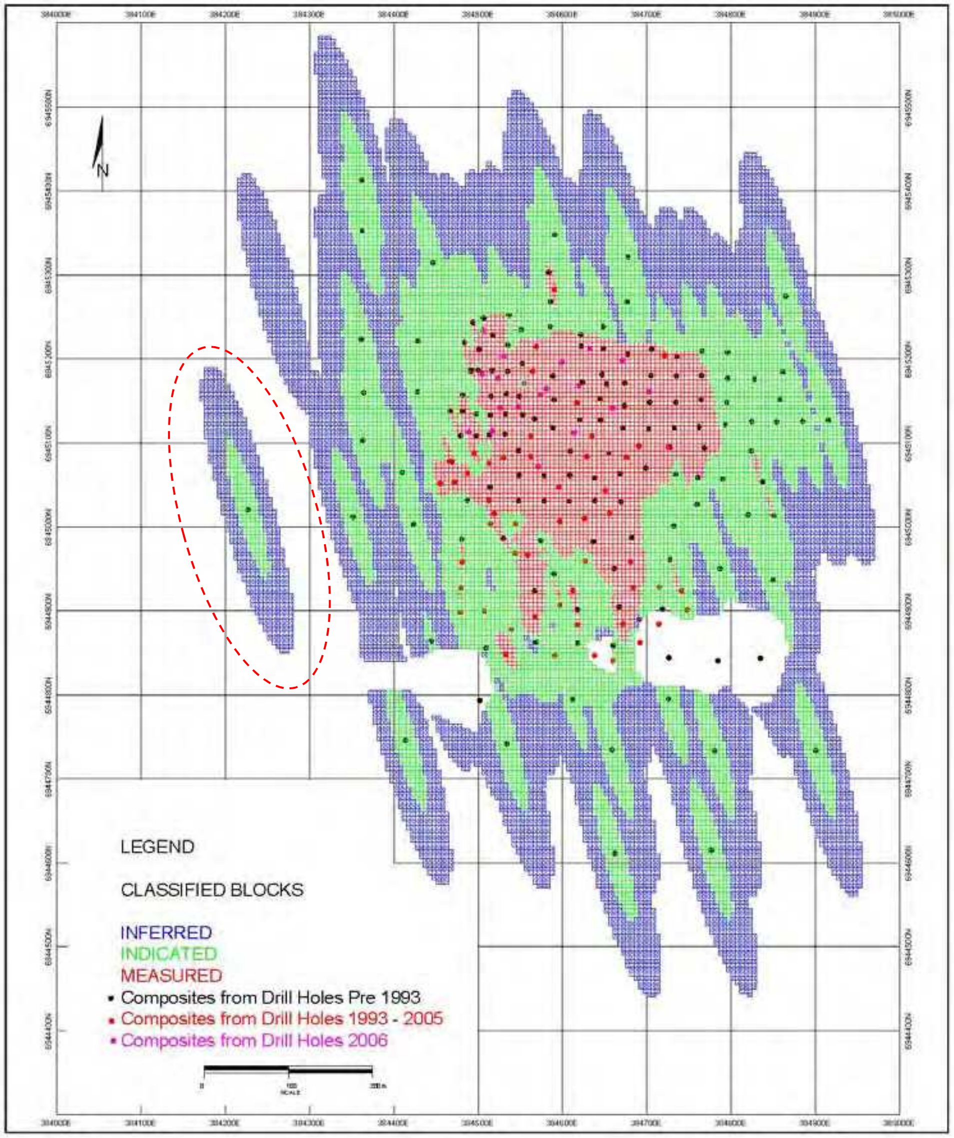
Capstone Mining Corporation
Chalcopyrite and bornite mineralization
9 Mt ore with average grades:
- 1.78% copper
- 0.62 g/t gold
- 7.3 g/t silver

7 year mine life

Source: Technical Report (NI 43-101) for the Minto Project, Hatch Associates, August 2006

Minto Project: N-S Geological Cross-section





Minto Project Resource Estimate

From inferred to indicated to measured
Shape of resource dictated by geological cross-section

Notes: Minto Project Resource Estimate

The resource estimate is classified into inferred, indicated and measured. The measured resource is the area where the most drill hole data are available while the inferred and indicated resources are in areas with fewer drill holes.

The extent and orientation of the inferred and indicated resources are suggested by the geological cross-section which shows a northerly-southerly orientation of the mineralization. Thus, for example, the inferred and indicated resources circled with the dashed red line is oriented as shown even though there is only one drill hole at the center of the indicated resource. Note that no continuity is assumed between these resources and the other resources to the east.

Source: Technical Report (NI 43-101) for the Minto Project, Hatch Associates, August 2006

A quote defining a distinction

From Teck Cominco 2006 Annual Report, p. 110 in reference to Highland Valley Copper:

> Reserves have been drill defined at 60 to 115 meter [197-377 ft] centres and resources at 125 meter [410 ft] centres.

Notes: A quote defining a distinction

The transition from probable to proven reserves depends on geological information obtained from drillholes. Consider the quote from Teck Cominco 2006 Annual Report, p. 110 in reference to Highland Valley Copper:

> Reserves have been drill defined at 60 to 115 meter [197-377 ft] centres and resources at 125 meter [410 ft] centres.

Note that at Highland Valley, all reserves are proven and all resources are indicated.

At the Bagdad mine different drillhole spacings are used to establish estimates of probable and proven reserves of concentrator ore. For probable reserves, it is 440 ft whereas for proven reserves it is 190 ft. (Phelps Dodge 2005 Annual Report, p. 16) Different spacings are used for leach ore and the spacings change depending on the characteristics of the orebody.

For proven reserves the drill spacing to define reserves at Highland Valley is greater than that at Bagdad. There is no specific drill spacing that defines reserves – it depends partly on the geological environment and partly on the physical conditions at a mine.

National Instrument 43-101 (NI 43-101)

Rules developed by Canadian Securities Administrators (CSA) to govern how issuers of shares in a mining company disclose scientific and technical information about mineral projects to the public

Applies to:

- oral statements
- written documents (eg feasibility studies)
- websites

Requires that all disclosure be supervised by or advised by a "qualified person" (QP)

Notes: National Instrument 43-101 (NI 43-101)

Copies of NI 43-101 can be found at
http://www.ccpg.ca/profprac/index.php?lang=en&subpg=natguidelines

A "qualified person" is responsible for the content of any technical report or disclosure of scientific information concerning mineral projects. The QP must be independent of the owner of the mineral project and must have demonstrable experience and competence in the preparation or evaluation of information and data related to mineral projects.

A qualified person is an individual who

a) is an engineer or geoscientist with at least five years of experience in mineral exploration, mine development or operation or mineral project assessment, or any combination of these;
b) has experience relevant to the subject matter of the mineral project and the technical report; and
c) is in good standing with a professional association and, in the case of a foreign association listed in Appendix A, has the corresponding designation in Appendix A

See Appendix A in NI 43-101 for foreign designations recognized.

Feasibility Studies

Comprehensive documents usually carried out by consulting engineering companies

Cost: \$100k to >\$1M-\$4M depending on level of detail, time

NI 43-101 defines two types:

Pre-feasibility study – makes reasonable assumptions about relevant factors

Feasibility study – all factors considered in sufficient detail to allow a decision on financing project

Notes: Feasibility Studies

Pre-feasibility study (aka "Preliminary Feasibility Study")
a comprehensive study of the viability of a mineral project that has advanced to a stage where the mining method, in the case of underground mining, or the pit configuration, in the case of an open pit, has been established and an effective method of mineral processing has been determined, and includes a financial analysis based on reasonable assumptions of technical, engineering, legal, operating, economic, social, and environmental factors and the evaluation of other relevant factors which are sufficient for a qualified person, acting reasonably, to determine if all or part of the mineral resource may be classified as a mineral reserve

Feasibility study
a comprehensive study of a mineral deposit in which all geological, engineering, legal, operating, economic, social, environmental and other relevant factors are considered in sufficient detail that it could reasonably serve as the basis for a final decision by a financial institution to finance the development of the deposit for mineral production

Note: financial institution *or* a mining company. Sometimes the adjective "bankable" is used but this can only be decided by a bank or lending institution.

See www.sedar.com to download copies of feasibility studies or technical reports from public companies.

The need for reporting standards

Actual cases of information withheld in direct conflict with NI 43-101 or similar:

- Significant parts of orebody are difficult to process – poor recovery
- Large water-bearing fault intersects orebody
- Local groups do not want mine
- Legislation may change economic viability
- 7% royalty paid to numbered company owned by CEO and three directors on board of six

Palabora, South Africa – open pit to underground

After start-up of underground operation

2005 photo, courtesy Rio Tinto Technical Services

Notes: After start-up of underground operation

Underground caving began in April 2002. Cave breakthrough to the pit floor is estimated to have occurred in December 2003. Cracks were then observed in northwest wall and the failure grew to involve 100Mt over a period of 18 months. Movement and cracking occurred within 300 m from the pit rim and affected or damaged the following facilities:

haul road and access road
tailings and water supply lines
water supply reservoir
railway line
44 KV power line

The failure is composed of waste material and some of it entered the underground mine and diluted the ore. The underground operation was seriously jeopardized as a result.

Source:

Moss A, Diachenko S, and Townsend P, 2006 Interaction between the block cave and the pit slopes at Palabora mine, *The Journal of The South African Institute of Mining and Metallurgy,* **106**:479-484

But more importantly …

The slide caused a loss of ore reserves in the underground operation. The slide might have been predicted had there been sufficient geotechnical information.

Grade and tonnage of reserves and resources can be defined with sufficient drillhole data. But reserves imply mining and other technical factors have been considered. This raises a question:

Can reserves be defined without geotechnical information?

Likely not, but no standard is available yet.

The Large Open Pit Project (http://www.lop.csiro.au/) has developed guidelines for dealing with uncertainty in geotechnical data. It will be some time before these are incorporated into a standard having the same authority as NI 43-101.

END OF PART 5