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MINING FOR NON-MINERS

A technical introduction to geology, mining and metallurgy.

Department for International Development Extractive Industries Training Event

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2. Nature of the mining industry and its life cycle
3. Geosciences and Geology
   - Technical risk and reality
4. Mining
   - Technical risk and reality
5. Metallurgy
   - Technical risk and reality
6. Conclusion

Interaction! **Questions please!**

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The Development Context

2002 Johannesburg World Summit on Sustainable Development

“Mining, minerals and metals are important to the economic and social development of many countries. Minerals are essential to modern living.”

2012 Rio + 20 UN Conference on Sustainable Development

“We acknowledge that minerals and metals make a major contribution to the world economy and modern societies. … mining industries are important to all countries with mineral resources, in particular developing countries . … mining offers the opportunity to catalyse broad-based economic development, reduce poverty and assist countries in meeting … development goals … when managed effectively and properly. … We recognise the importance of strong and effective legal and regulatory frameworks, policies and practices for the that mining sector …”

The nature of the industry

category	approximate asset base, $USD	approximate numbers of companies	comment
Global giants	Exceeds $10 billion	50	global giants and seniors control the majority of available capital, their focus in on the industry; they have multiple operations
Seniors	$3 - $10 billion	100	
Intermediates	$1 - $3 billion	350	often on their way up; their focus is on growing their reserves
Juniors: small (often one mine) producers	$500 million - $1 billion	1,000	some growing, some shrinking; their focus is on their mine
Juniors: exploration	$5 - $500 million	2,000	volatile and market dependent; they are finders, not producers and their focus is on their exploration project
Junior juniors	Below $5 million	2,500	Their focus is on accessing venture capital and optimizing their stock price

Spectrum of corporate behaviour

Hostile Avoiders
Opposers

Rearguard
Resistors

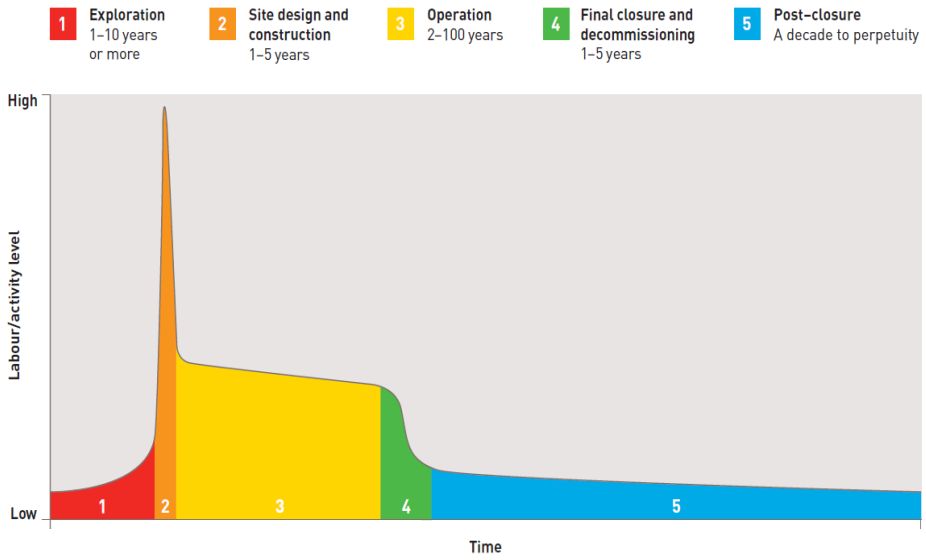
Corporate Couch Potatoes
Slow adapters

Vanguard of the Rearguard
Cautious innovators

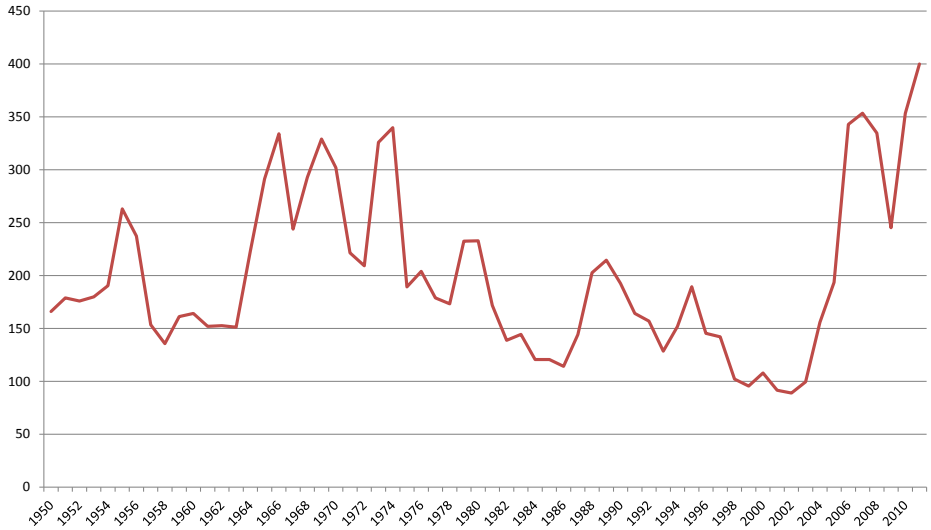
Leading Edge
Doers

The time horizon disconnect

Mine project life cycle



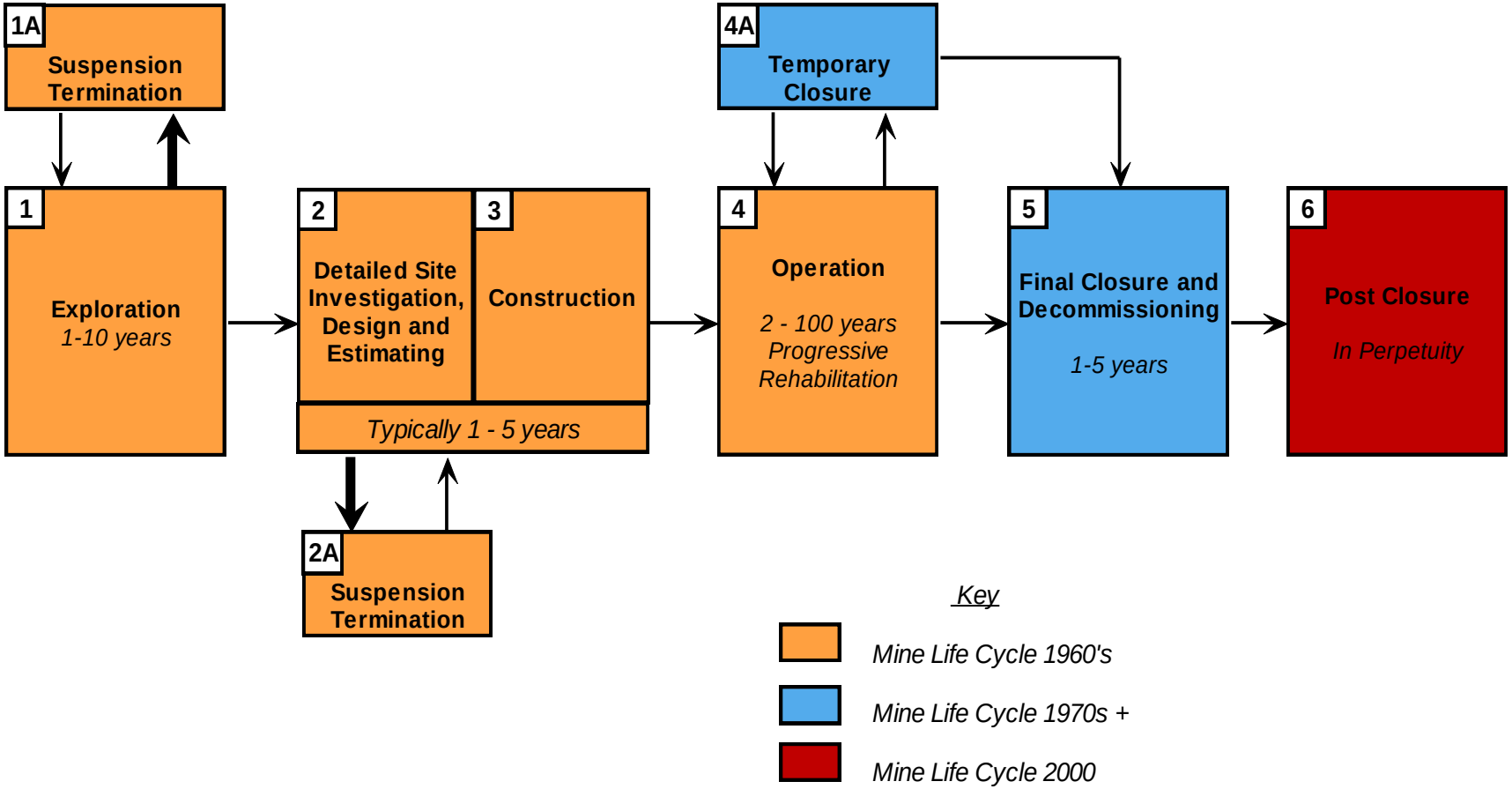
Copper price, 1950 – 2012, US cents (2012)/lb



Time horizon disconnect

- Mining investments, 30-100 year horizon
- Indigenous peoples, multi-generation
- Government, 3-5 year horizon
- Investors, quarterly results
- Communities, often immediate
- Price, constant change

Project Life Cycle



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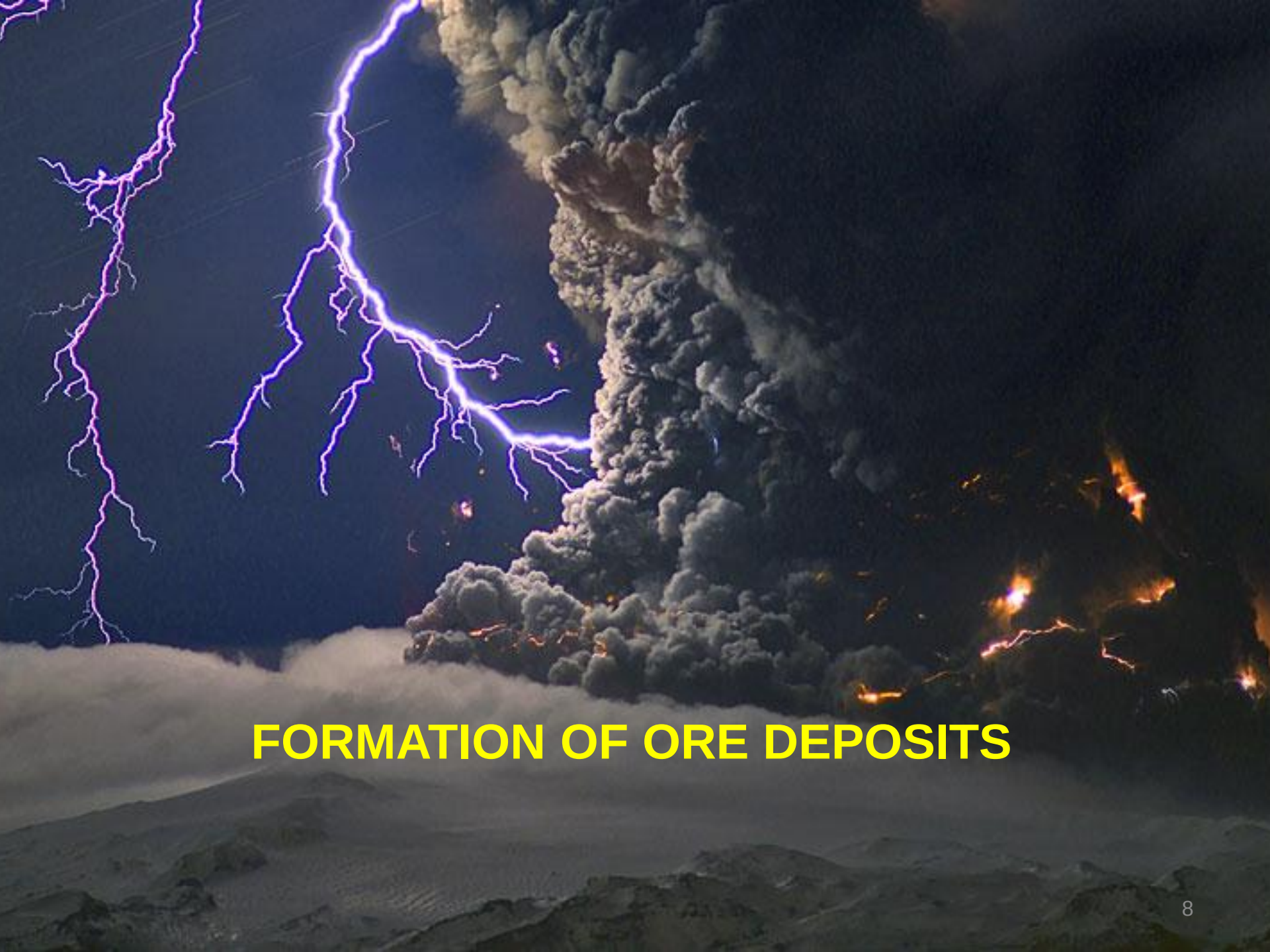
GEOSCIENCES/GEOLOGY

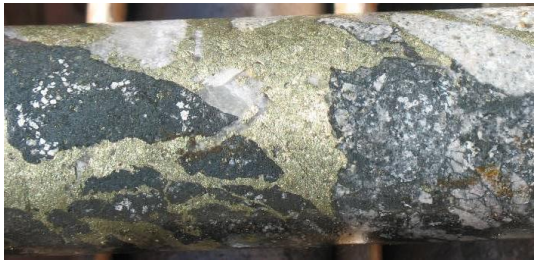
Ore Deposits: Formation, Discovery, Evaluation and Reporting



FORMATION OF ORE DEPOSITS

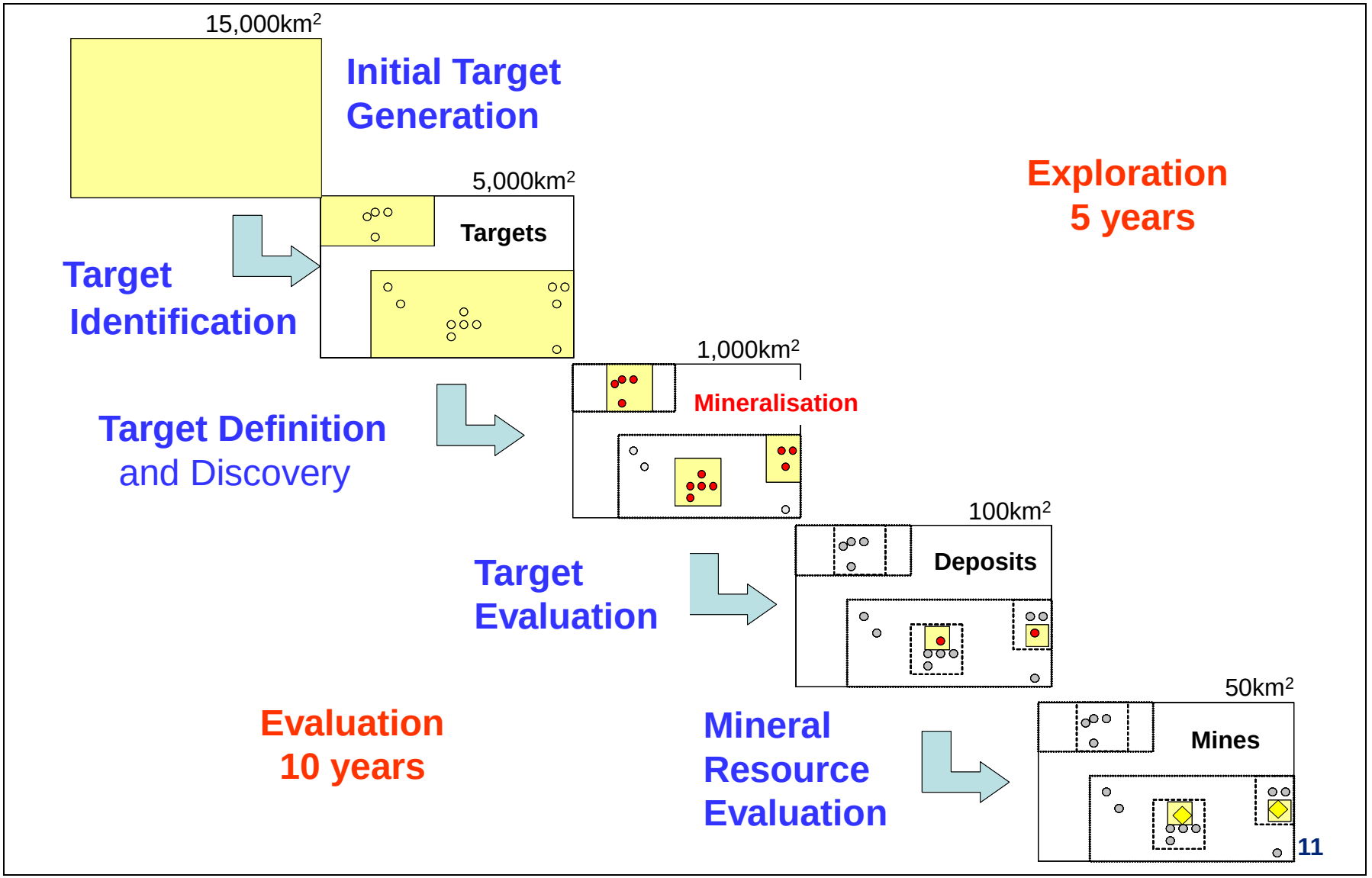
Ore Deposit Types:

- Porphyry Copper – common around Pacific “Ring of Fire”. Form below active volcanic centres
- Iron Ore – old continental crusts (2.5bn years)
- Coal – sedimentary rock; lithified plant remains (250-350m years)
- Nickel – sulphide or oxide. >2bn years – associated with rifts
- Diamonds – formed 140-190kms down and brought to the surface by volcanic eruptions




EXPLORATION FOR ORE DEPOSITS

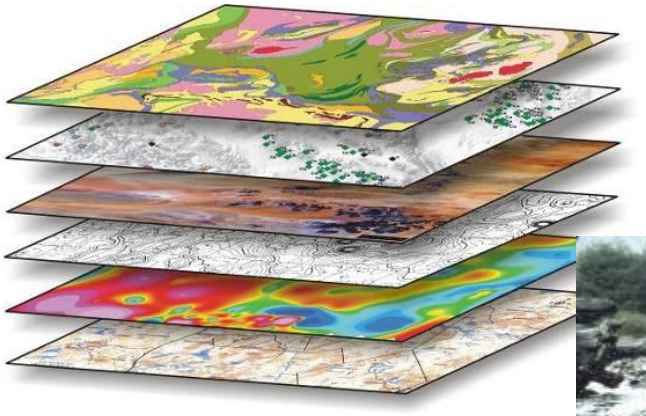
Exploration

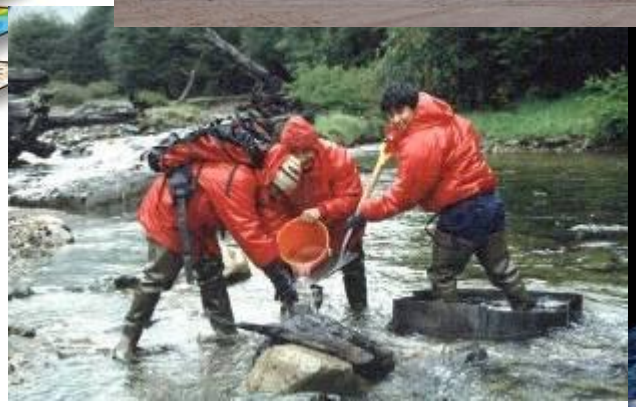


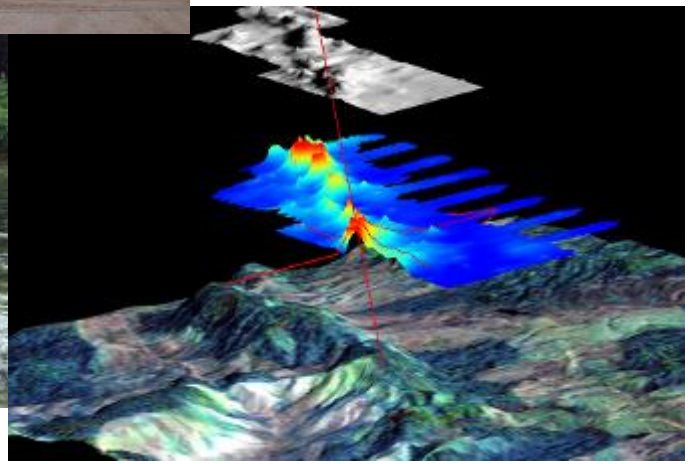
Exploration Targets

EXPOSED **HIDDEN** **BURIED**

Exploration Data

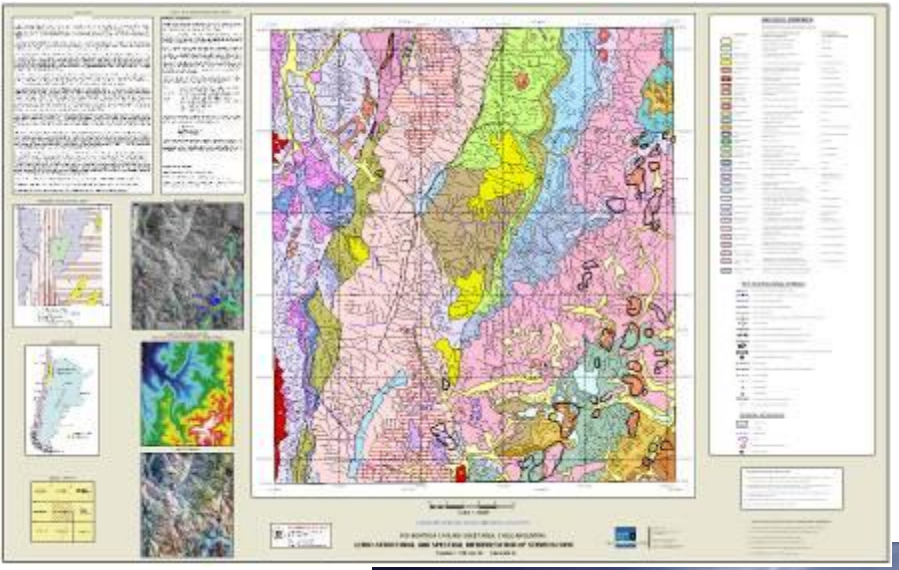






Using existing: Geological, Satellite and Aircraft Remote Sensed Data, Geochemical, Geophysical, Topographic, Mineral occurrence and Licence information.

If data doesn't exist you have to go and get it !

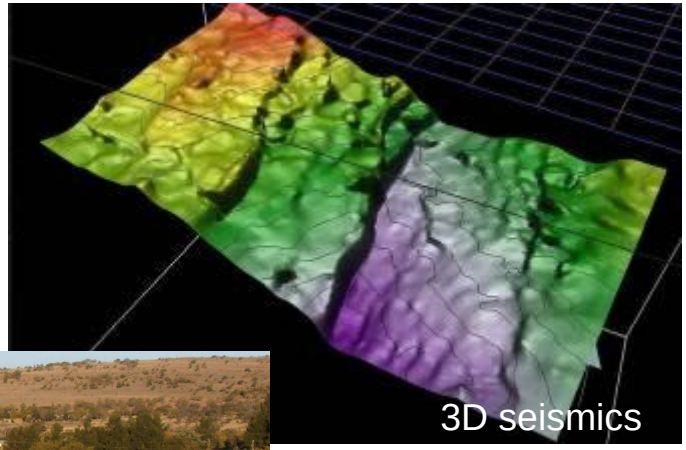


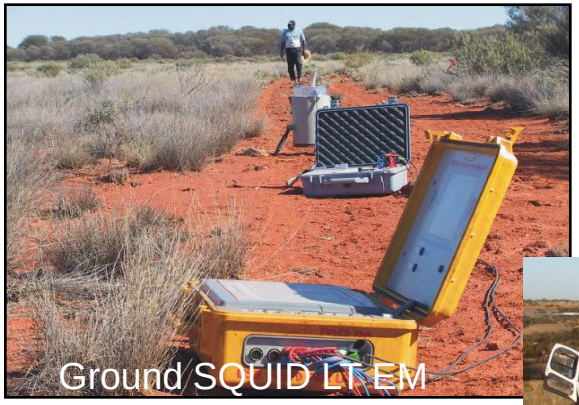
Geology

- Direct ground follow up of known targets or remotely-sensed anomalies
- Identification of mineralization and/or alteration at outcrop, in overburden and glacial till
- Reconnaissance identification, mapping and sampling

Geophysics – AA plc techniques

- Ground and Airborne geophysical system (Magnetic / EM)
  - SQUID-based magnetic & electromagnetic sensors
- Using and evaluating 2D and 3D seismic surveys in the Bushveld;
- Down hole and in mine radar
- Application of multispectral sensors for remote sensing, core logging and ore sorting applications

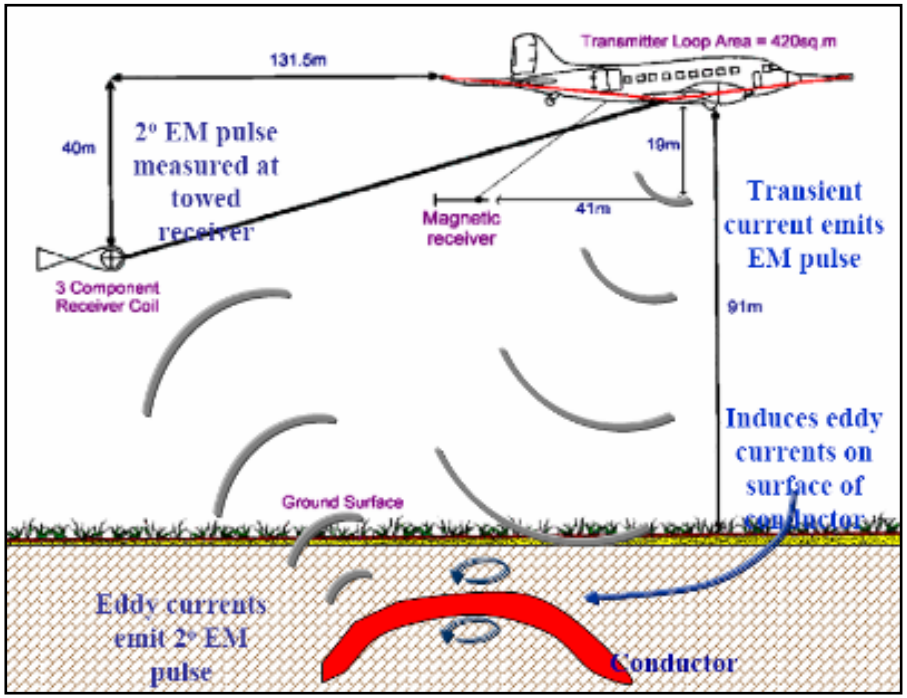

3D seismics


Ground SQUID LT EM


Airborne Mag SQUID

Geophysics – Spectrem

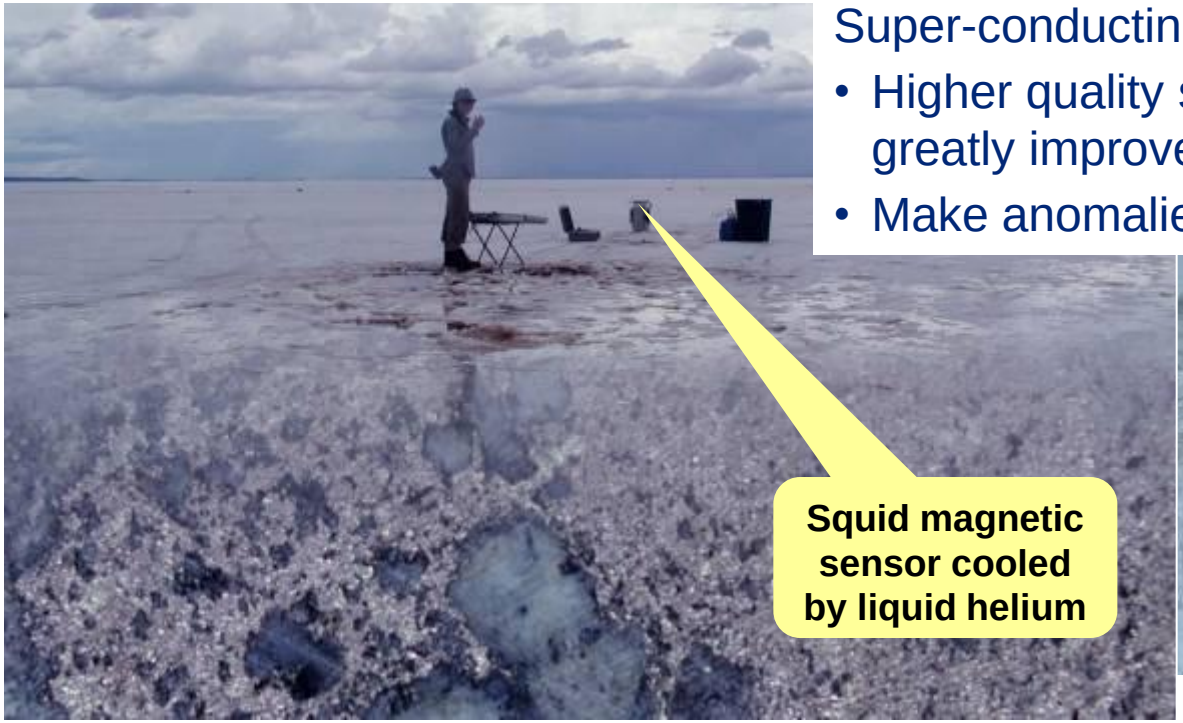
- Successfully used to detect buried targets with no surface expression
- Under >400m of cover

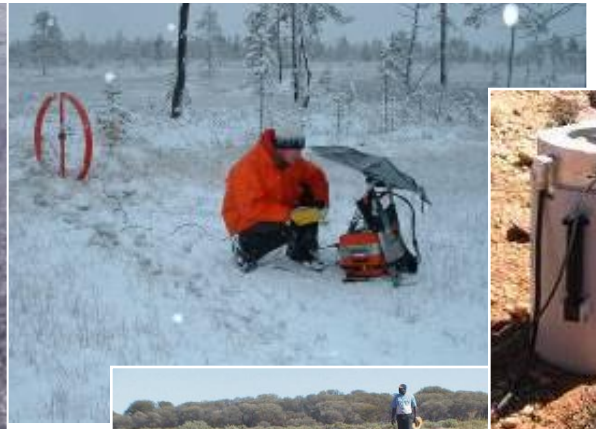


Geophysics – LT SQUIDs

Super-conducting Quantum Interference Devices

- Higher quality signals, greater sensitivity, greatly improve signal to noise
- Make anomalies clearer





Targets:

Sulphide mineral conductors under conductive cover.

e.g. Massive Nickel sulphides under sand cover with saline water.

Geochemical Sampling

The aim of a sampling programme is to identify patterns and anomalies related to potential ore mineralisation

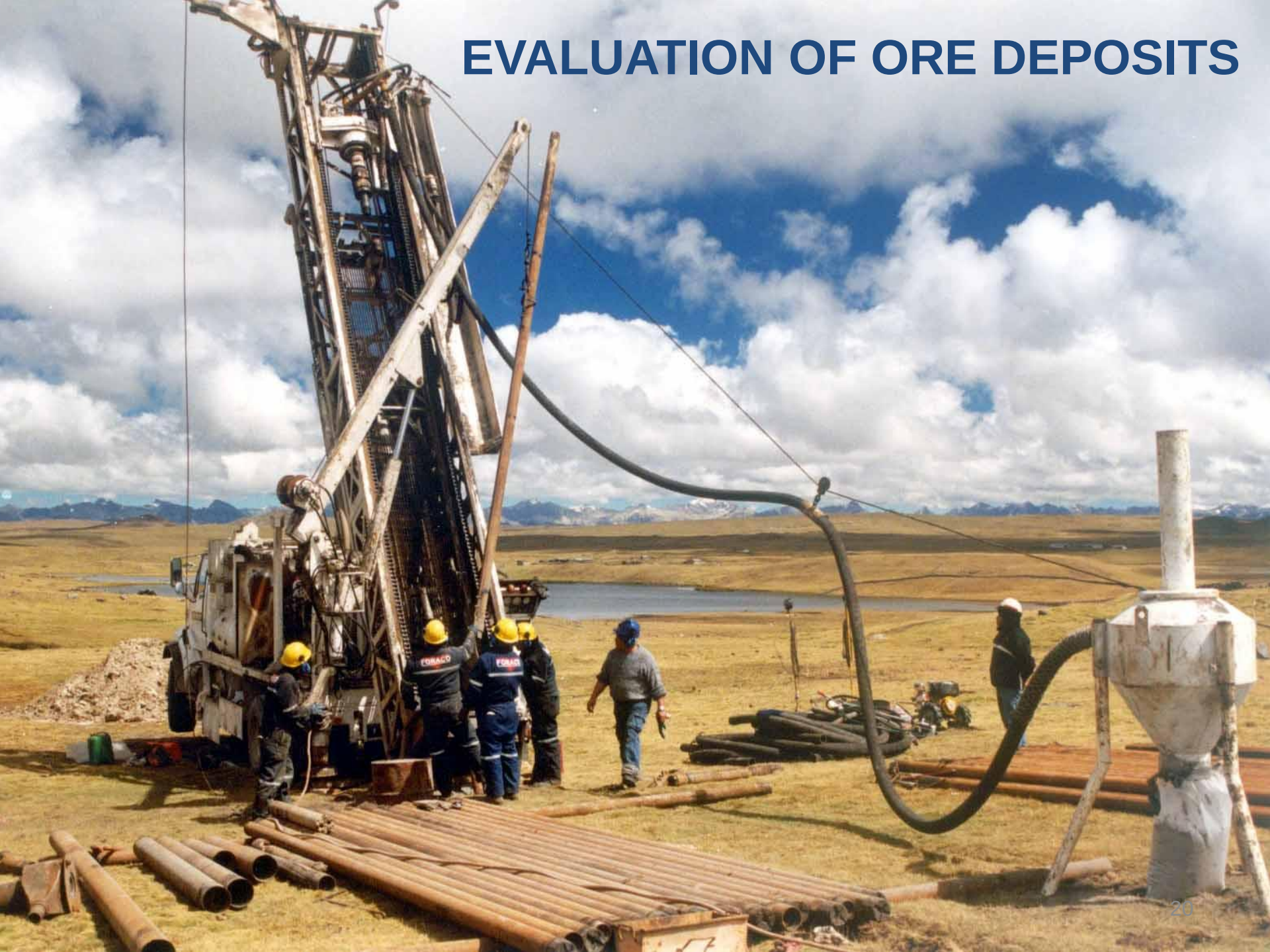
- Material is collected over a defined grid or pattern
- More detailed sampling over first pass targets

Target Definition - Drilling

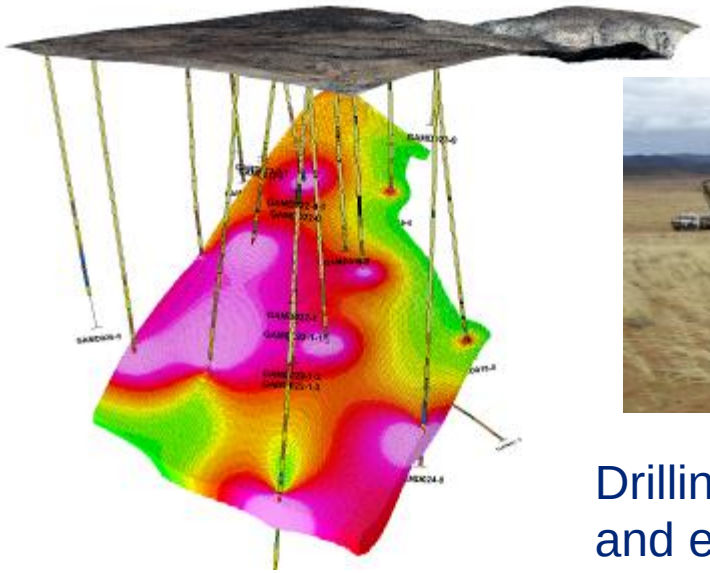
The only way to test a concealed mineral deposit or deep anomaly.

- Diamond Core Drills
- Rotary Drills (including RC drills)
- Percussion (Hammer) Drills

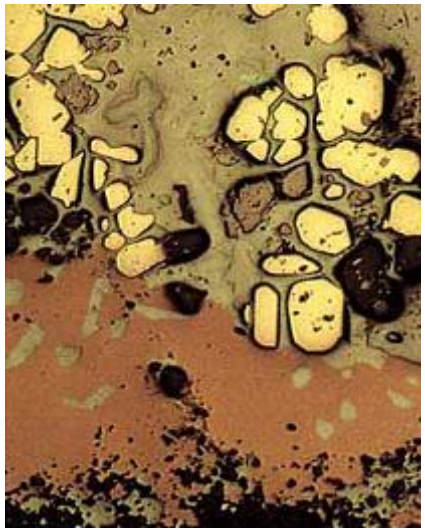
EVALUATION OF ORE DEPOSITS



Turning Mineralisation into Ore



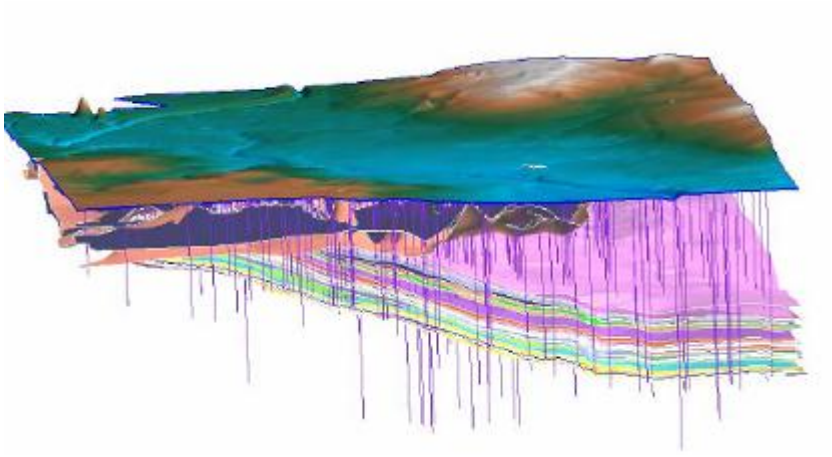
Drilling, assays, 3D geology, mineral resource estimation and evaluation

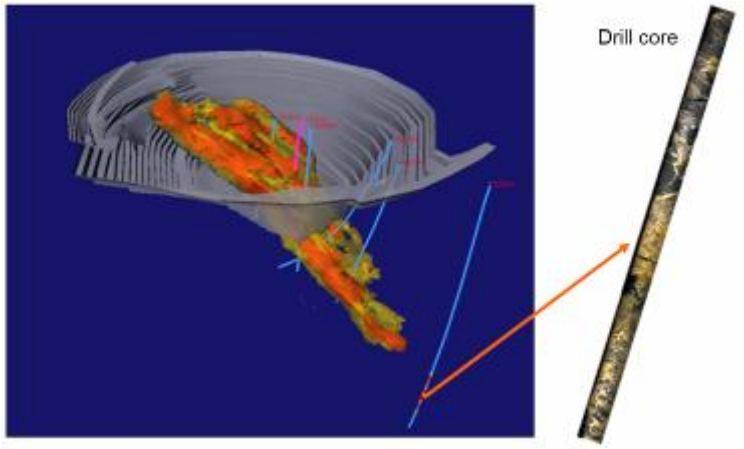


Concept and Pre-feasibility

The initial project evaluation of a mineral deposit addresses the question "Is this an orebody?"

The 3D shape, volume, tonnage, grade, grade variation etc are based on very thin cores through a much larger mineral deposit - the data is extrapolated to represent the whole.





Feasibility and Development

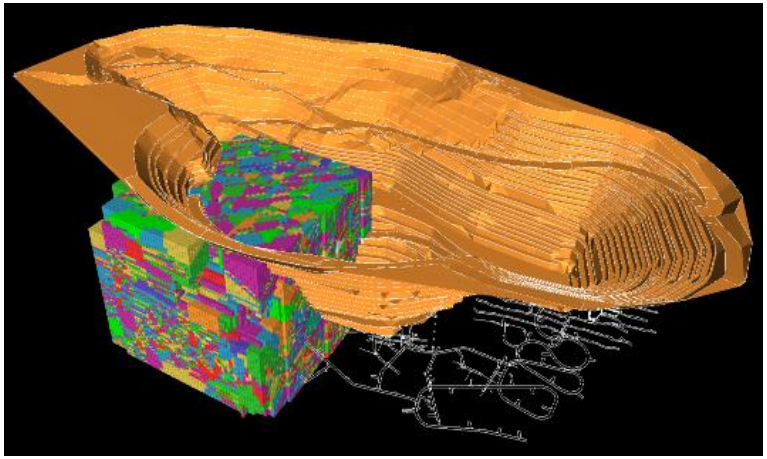
Geoscientists have the role of constantly up-dating the orebody model as data is acquired.

This is a process of mitigating risk - increasing the degree of certainty

Optimising Capital Efficiency - Detecting “show-stoppers”
Detecting and mitigating major hazards
Optimising mine design

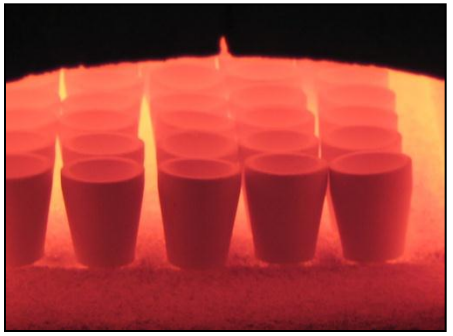
Optimising Operational Efficiency - Acquiring maximum geological data at minimum cost

- Ensuring that the mine design caters for optimal operational efficiency during the mine life
- Ensuring early mine development does not sterilise later potential ore or orebody extensions



From Data to Information

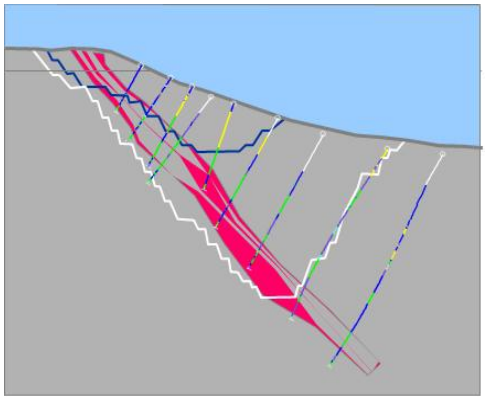
Data turned into information is the crux of Mineral Resource Evaluation



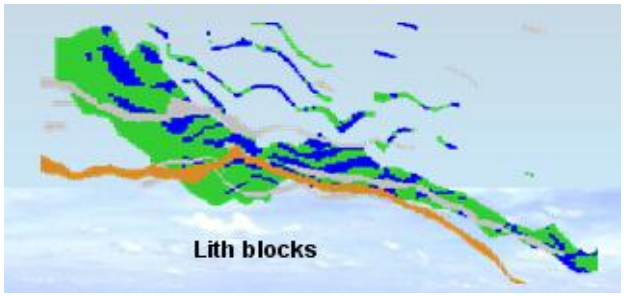
Evaluation Process

The effect of the level of information available at the time of Estimation is generally poorly understood

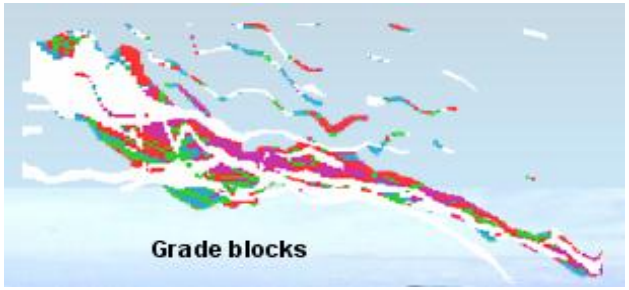
Information



Interpretation



Estimation



Reality

Mineral Resources

A Mineral Resource is a concentration or occurrence of material of economic interest in or on the earth's crust in such form, quality and quantity that there are reasonable prospects for eventual economic extraction (RPEEE).

The location, quantity, grade, continuity and other geological characteristics of a Mineral Resource are known, or estimated from specific geological evidence, sampling and knowledge interpreted from an appropriately constrained and portrayed geological model.

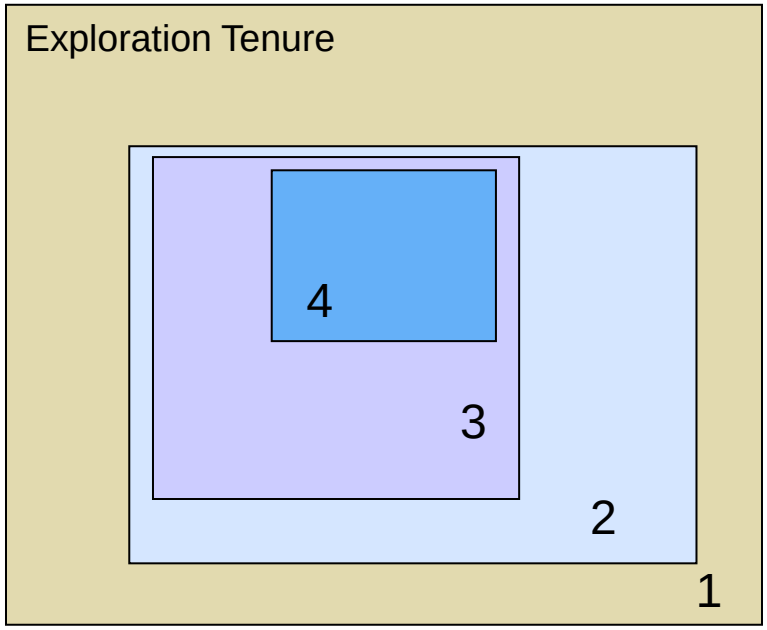
Mineral Resources are subdivided, and must be so reported, in order of increasing confidence in respect of geoscientific evidence, into Inferred, Indicated or Measured categories.

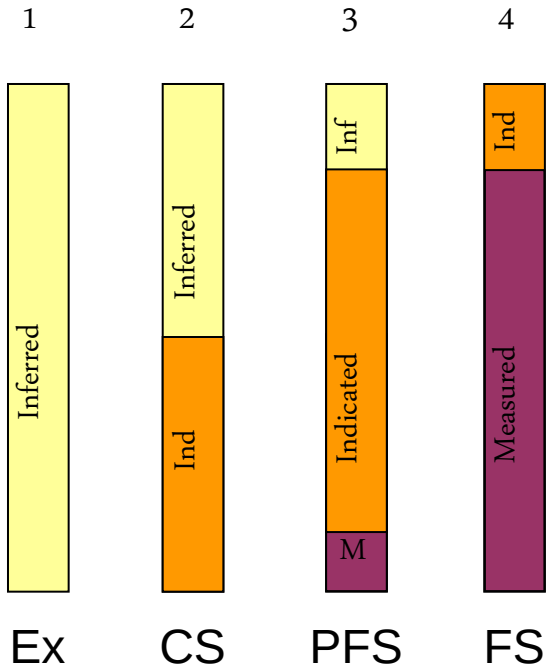
Increasing Confidence

Use ACCRETION (not SATURATION) drilling to increase Resource classification area from Inferred to Indicated or Indicated to Measured by working in smaller selected domains.

1. Ex: sufficient drilling to define an Anglo-sized deposit
2. CS: may need to drill entire area to Inferred for data
3. PFS: may be some latitude in tonnage depending options
4. FS: very little latitude in tonnage (business case)

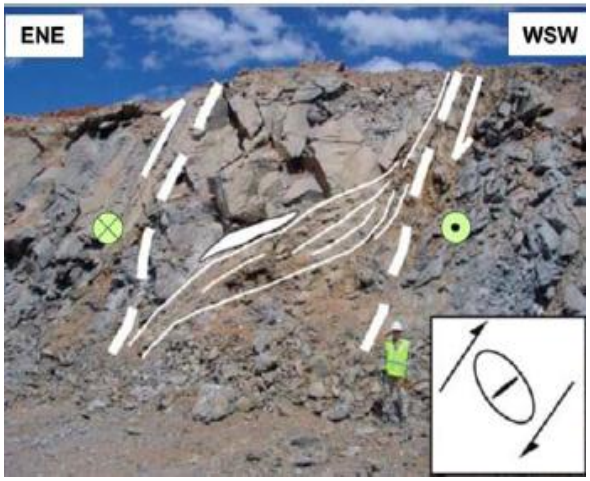
DO NOT DRILL MORE THAN NECESSARY





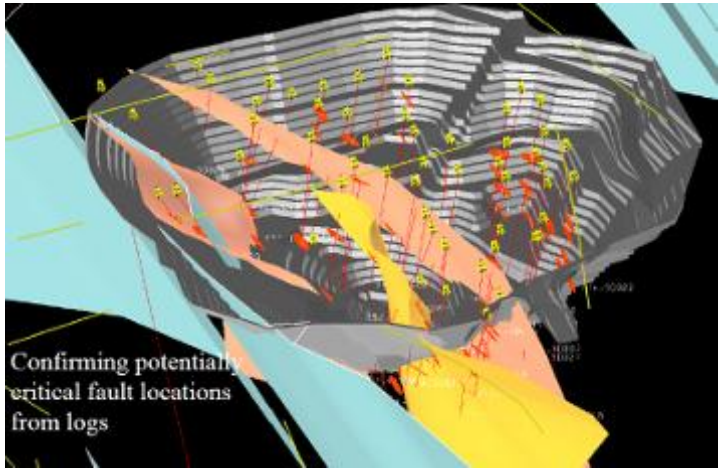
Modifying Factors: Geotechnical

- Structural interpretation
- Mine planning and design
- Geotechnical monitoring
  - to detect poor ground conditions
  - to promote safety/security of operations
  - Ground penetrating (Borehole) radar for safety



Structural mapping

Radar slope monitoring



Geological mapping for planning and design

Modifying Factors: Geometallurgy

Determines the mineral, chemical, physical and rock type characteristics of an orebody and their three dimensional variability to aid mine design, mine plans and ore processing.

Recommendations can be made to the mining and processing engineers to define ore types, crush and liberation parameters, grade and mineral variations, mineralogy and processing factors.

This is a significant part of the mine to mill optimisation process.





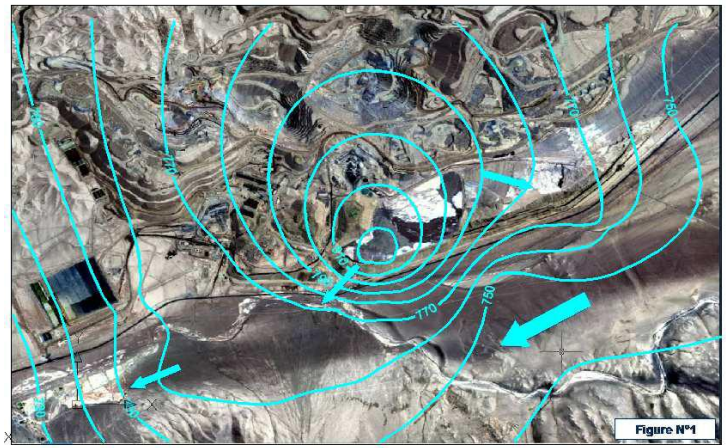
Modifying Factors: Hydrogeology

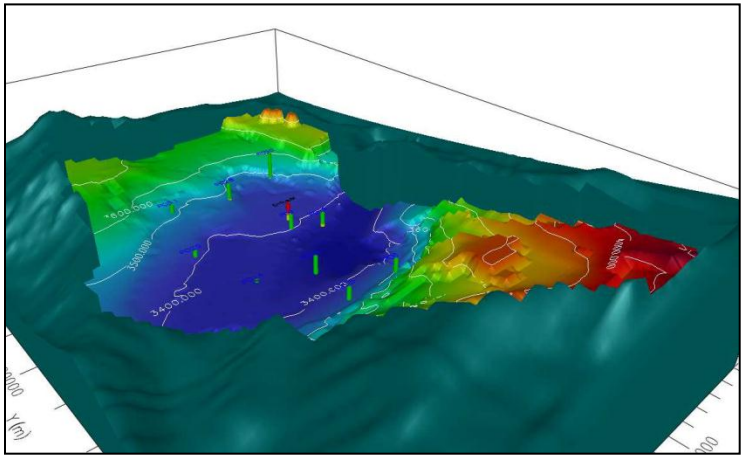
Hydrogeology includes the characterisation and evaluation of ground water and the prediction of it's impact.

Key is the development of a reliable and predictive model to support investment and operational decisions. This includes:

- Defining water resources and minimising environmental impacts
- Optimising mine drainage, dewatering and depressurisation
- Improving ground and slope stability

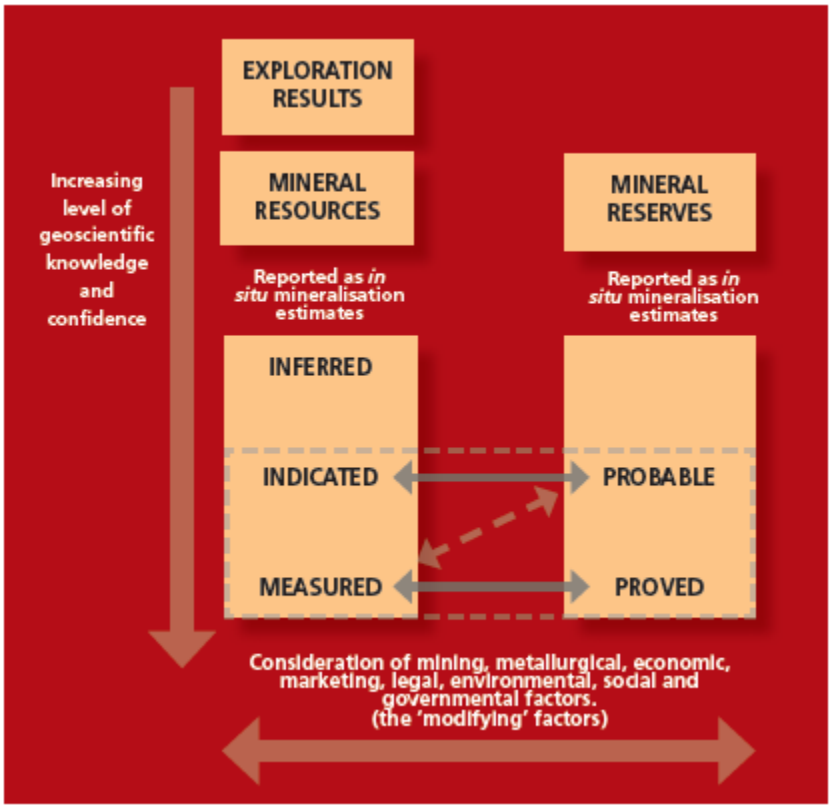
Appropriate knowledge of the hydrogeological regime is essential from the start of a project, though operation to mine closure.





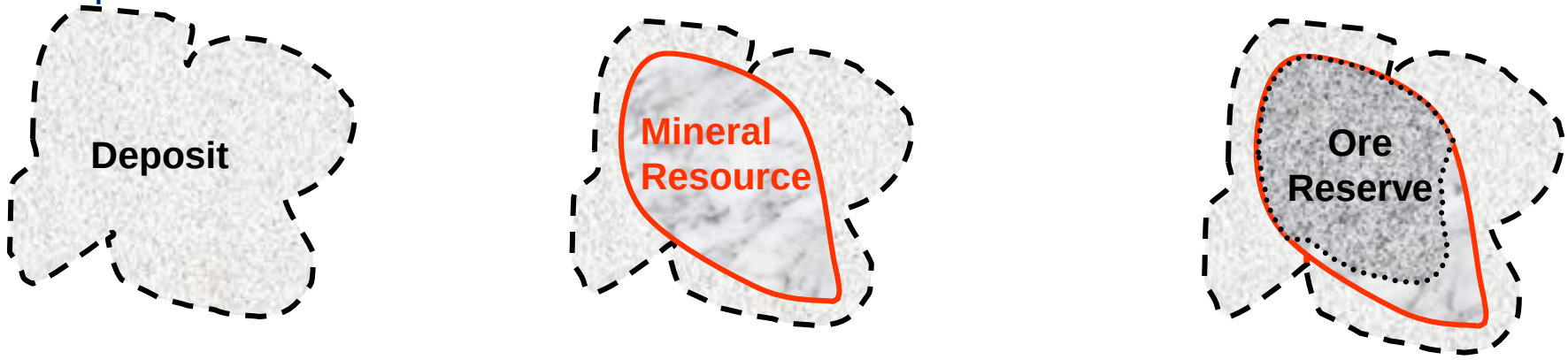
Results, Resources and Reserves

Relationship between Exploration Results, Mineral Resources and Mineral Reserves

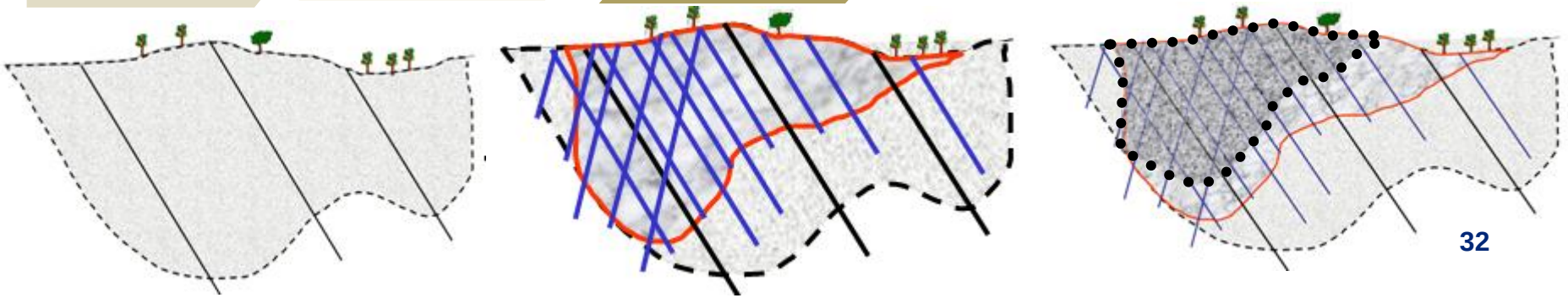


From Deposit to Resource to Reserve

Deposit to Mineral Resource to ORE Reserve

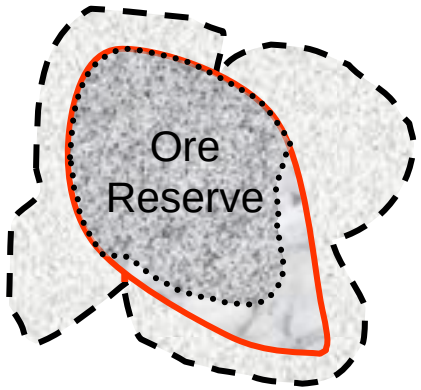


Possible Economic Extraction → Delineate Evaluate Classify → RPEEE → Modifying Factors → Planned Economic Extraction

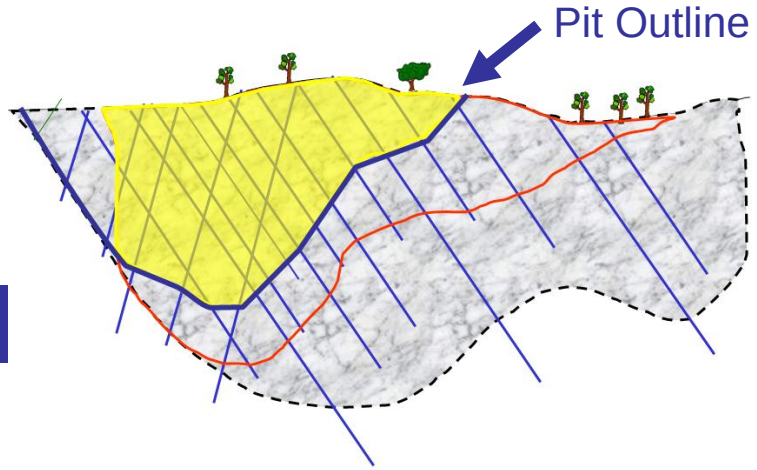


Reserve to Market

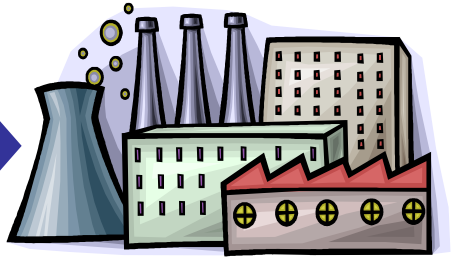
Ore Reserve to Market



Implementation



Mining



Processing

Product

Market

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Geological Risks and Opportunities

- Huge unknowns and long timeframe
- Low probability of converting mineralised resource into a mine
- Technical challenges
- Environmental issues
- Community engagement and expectations
- Regulatory environment and consistency
- etc….

Development opportunities

- Skills
- Geophysical and geological data (National Geological Surveys)
- Mine clearance!

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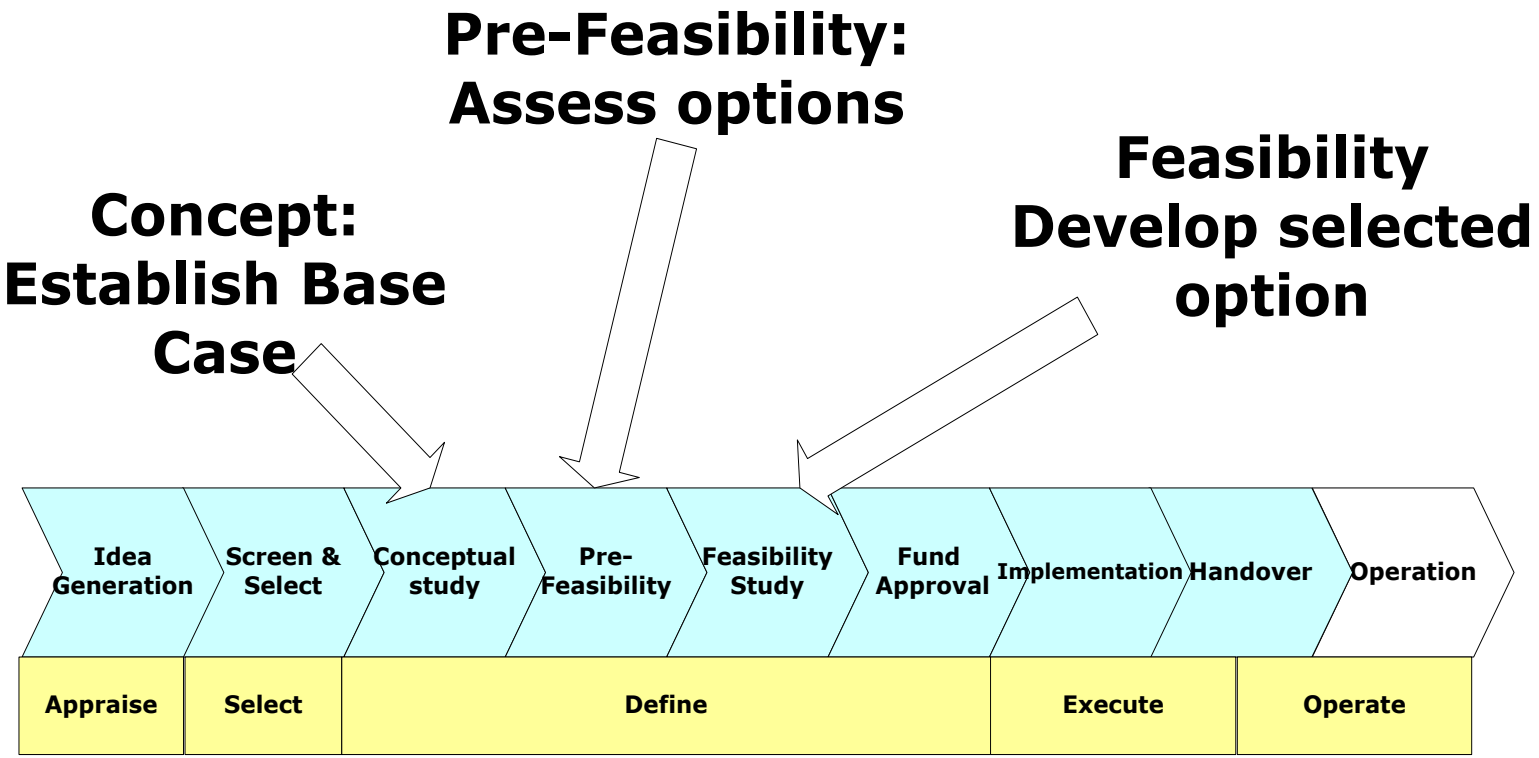
MINING

Steps in Developing a Mine

1. Exploration
2. Study Phase
3. Implementation
4. Production
5. Rehabilitation

2. Study Phase



2. Study Phase: Resource/Reserves

- Reserve Estimation: Tonnes and Grade of Deposit
- Determine In-Place and Recoverable Reserves

Significant uncertainty

Deposit

- Geology
- Geometry
- Geography

Economics

- Markets & Transportation
- Utilities & Water
- Land & Mineral Rights
- Governmental Issues

Still more uncertainty!

2. Study Phase - Required Information: Fund Approval

Mining Methods

- Physical Controls
- Selectivity
- Production Requirements
- Benchmarking v existing and other projects and operations

Processing Methods

- Mineralogy
- Alternative Processes
- Production Quality
- Recoveries

Cost Estimates

- Capital Costs = Mine + Mill + Roads/Rail + Power
- Operating Costs

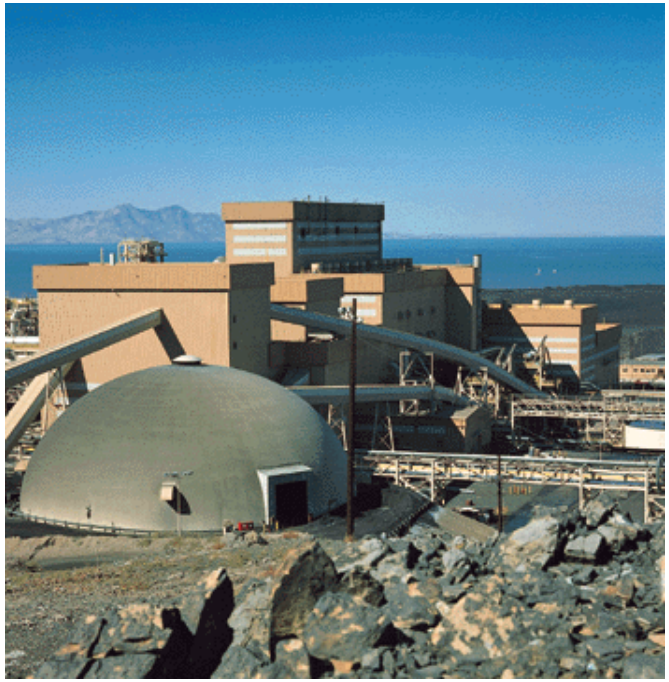
Independent review process: can non-technical decision makers have confidence in the technical aspects of the project?

3. Implementation

- **Permits**

- **Building Surface Facilities**
  - Shop / Offices / Housing
  - Mineral Processing
  - Transportation / Load-out

- **Building Infrastructure**
  - Roads / Rail / Port
  - Power



4. Production

Most of the mine's life.

Extracting Ore and Moving Waste.

Types of Mining:

Surface (Wet and Dry)

a. Hard-rock (metals)
b. Coal
c. Aggregates
d. Industrial Minerals

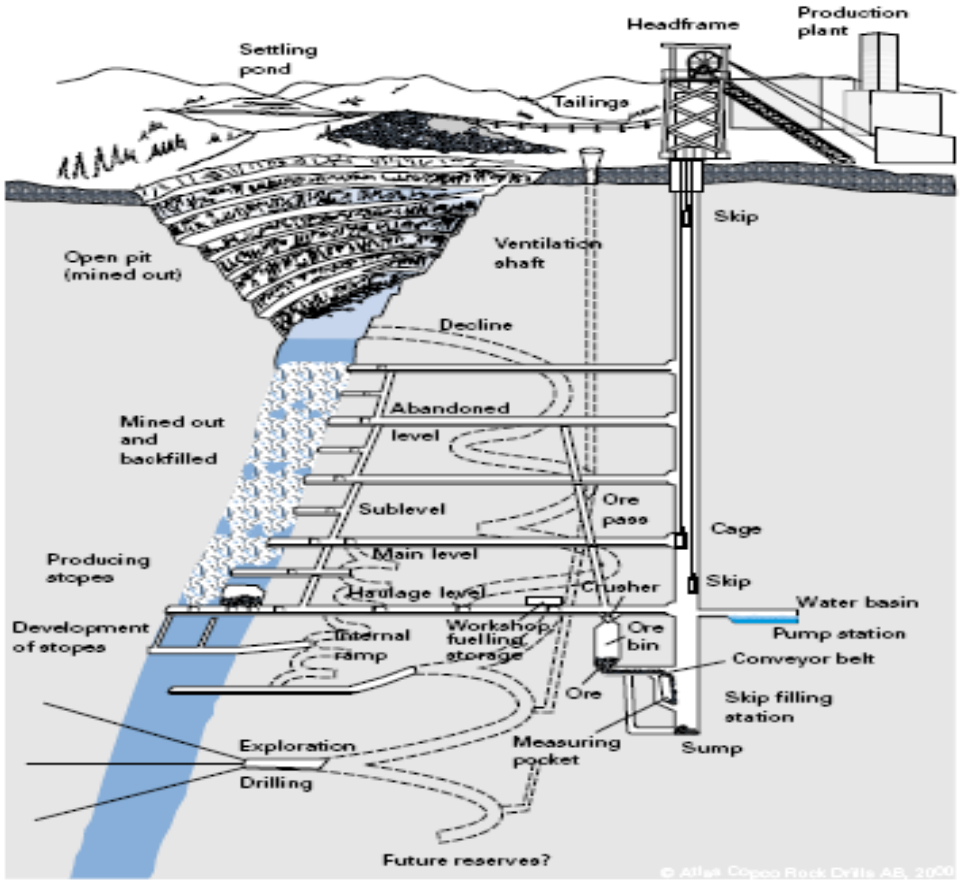
4. Production

Types of Mining:

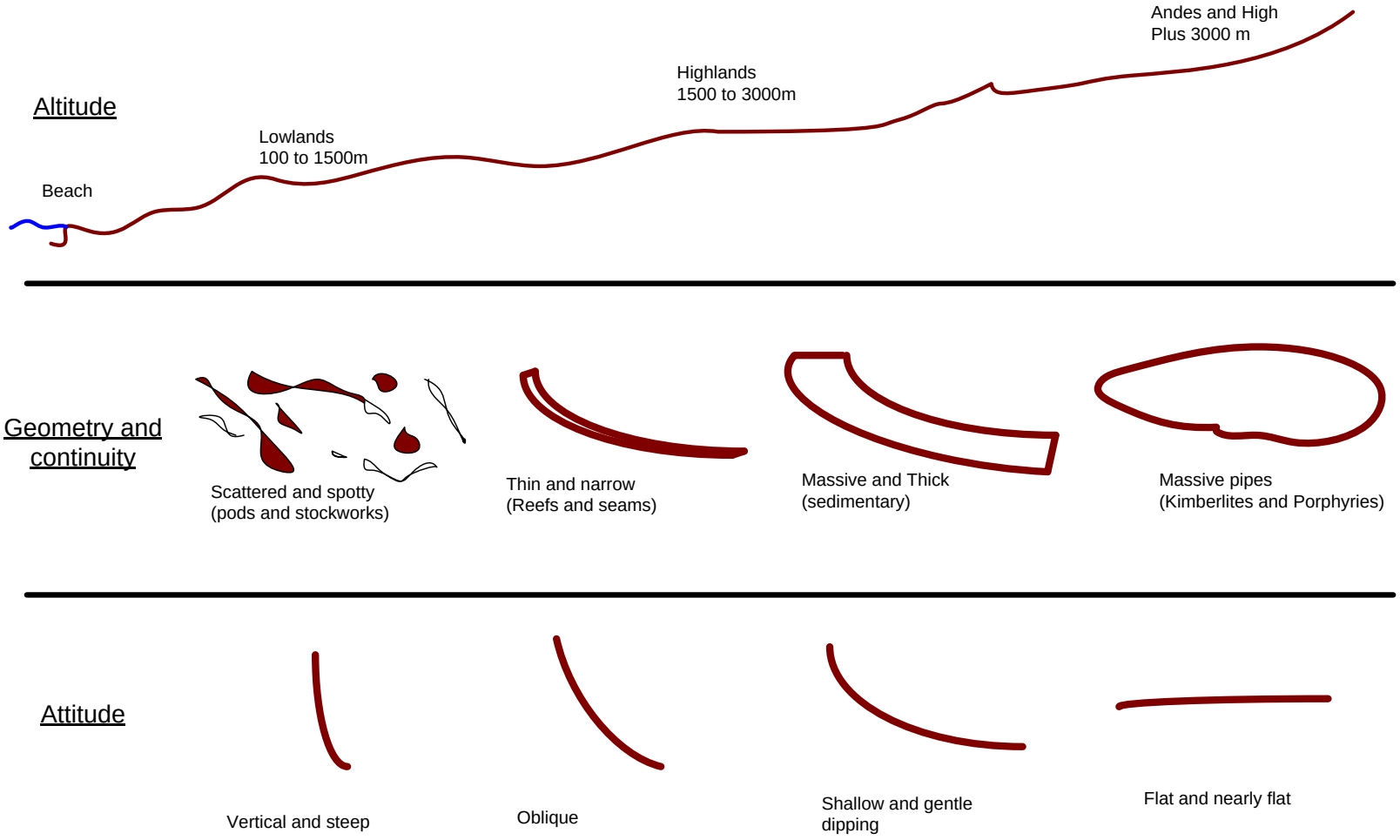
Underground

a. Hard-rock (metals)

b. Coal

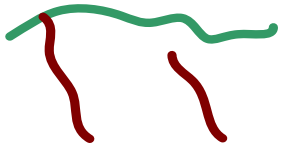


Mine Planning Considerations



Mine Planning Considerations...

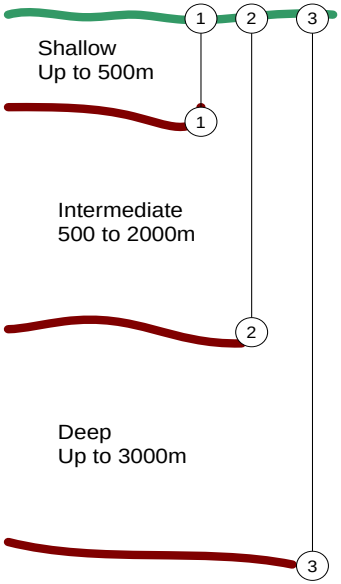
Surface manifestation



Outcrop & sub-outcrop

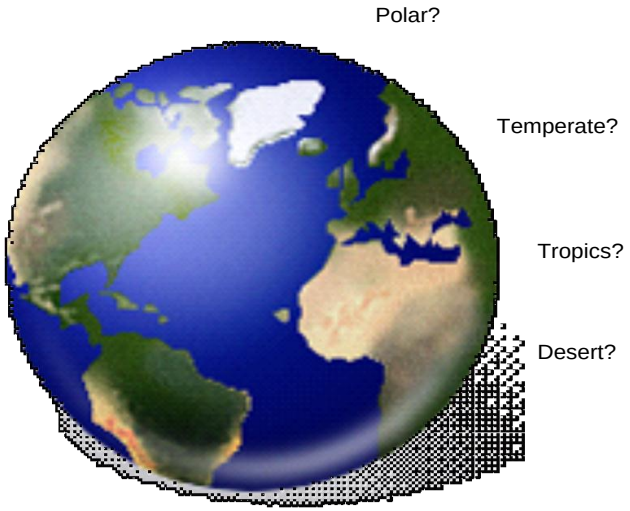
Tropical weathered zone/
Beach terrace

Depth



Ultra – Deep
Plus 3000m

Geographical location



Mining Terminology

Ore (Deposit/Orebody)

A natural mineral found in sufficient quantity, quality and value to be extracted for a profit.
An accumulation of ore or other valuable material

Mineral and Grade

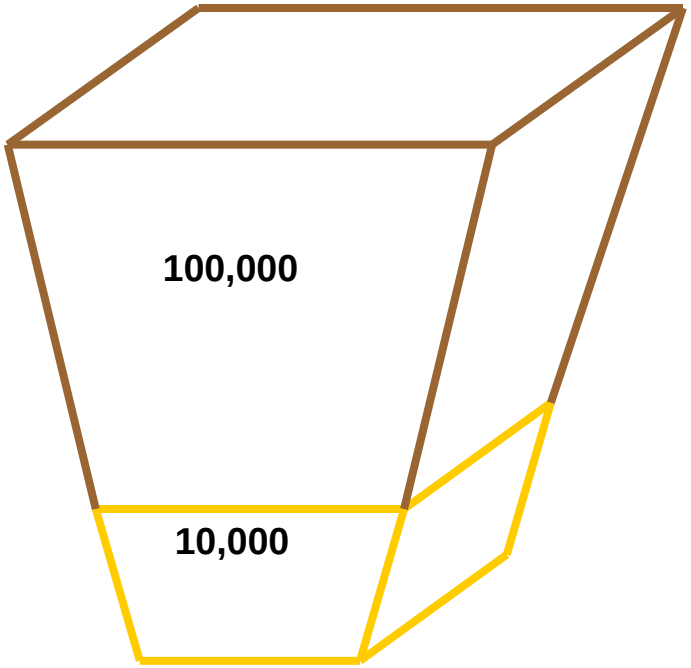
A crystalline chemical compound that has been formed by geological processes.
The relative quantity of the mineral (metal) contained in the ore (%, g/t)

Waste (Overburden) and dilution

Waste is material lying on top or beside ore. Must be removed to access the ore.
Dilution is the contamination of ore with waste material, reducing its grade

Surface Mining Terminology

- Stripping Ratio (to a **Miner**)
  - Ratio of **volume or mass** of waste to **volume or mass** of mineral mined.



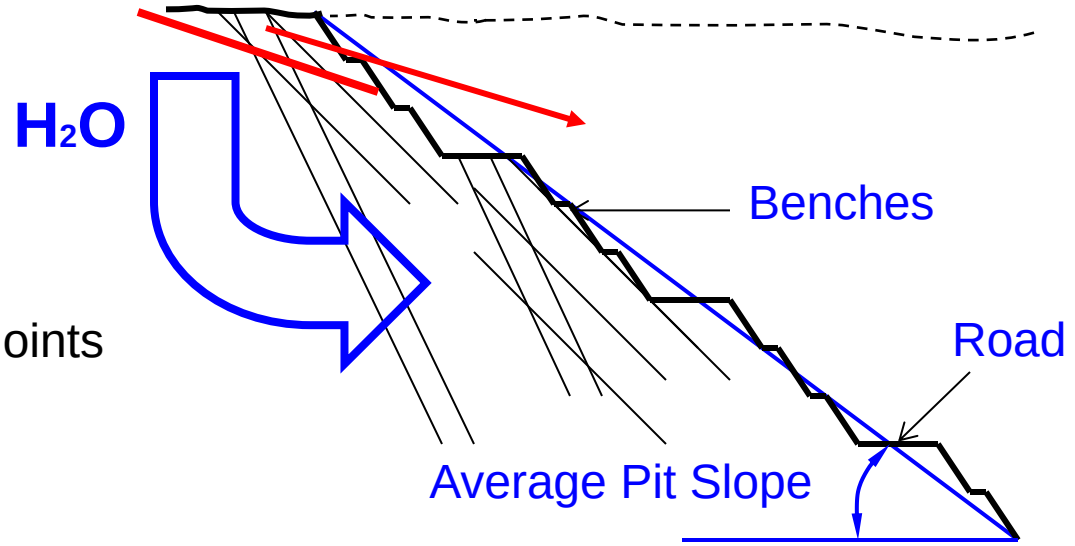
Ratio 100,000 : 10,000
Ratio 10 : 1

Surface Mining Terminology

Pit Slope Angle

Depends on Rock

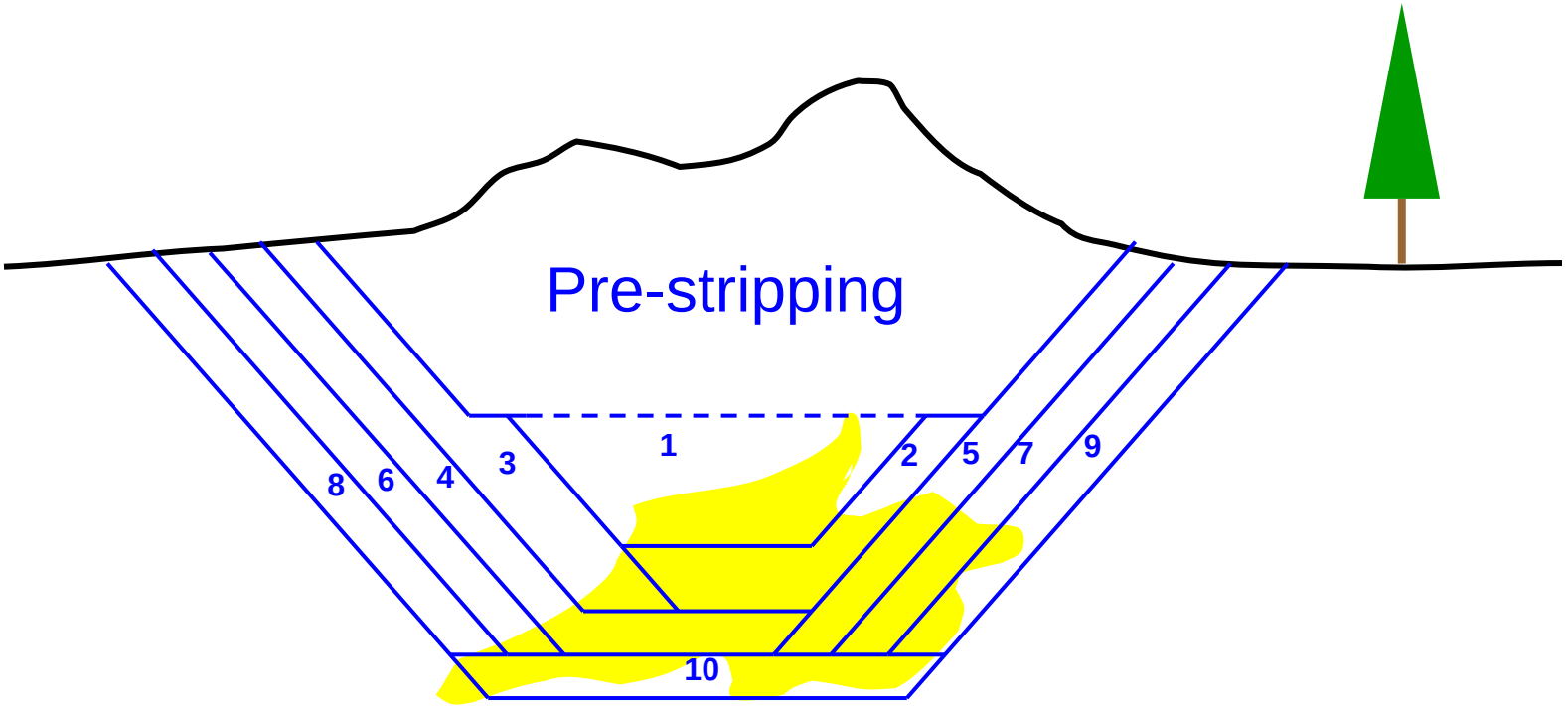
- Faults
- Jointing
- In-filling of Faults and Joints
- Strength
- Water



Surface Mine Planning

Production Planning

Cross sectional view of how production may progress over a 10 year period



Surface Mining Cycle

Drill

Load explosives

Blast

Load & Haul

Prepare bench for next drill sequence

Surface Mine Drill & Blast

- Purpose: prepare waste and/or ore for load & haul, dozing or other handling.
- A good blast creates good fragmentation.
- Good fragmentation creates few boulders and little dust.
- Good fragmentation = better fill factors and faster load cycle times from pit to truck to mill

Surface Mine Loading and Matching Equipment

Broken ore is lifted onto either trucks or conveyors for transportation to the processing plant.

This lifting is usually done by:

- Excavator: Electrically or hydraulically powered, and Shovel or backhoe configuration
- Wheeled Front-end Loader.

Ideally: 3-6 passes to ensure optimal equipment utilisation.

(Here: Komatsu 960E truck and P&H 2800 electric rope shovel)

Surface Mine – Mining systems can go wrong

Cat 777D trucks waiting to be loaded by a Terex O&K RH90 hydraulic excavator at Koisie mine in Guinea.

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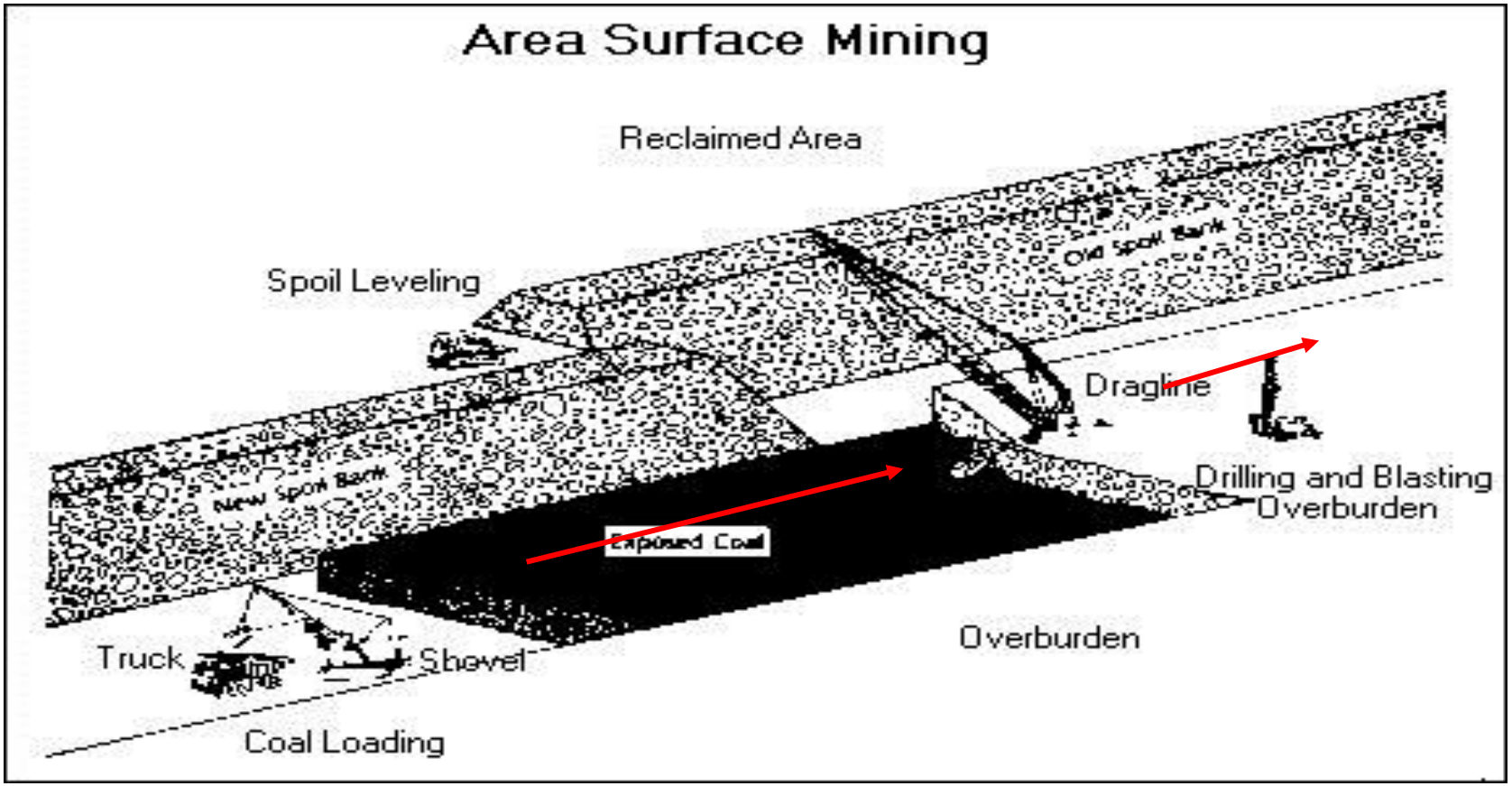
Coal Mining - Surface



Coal Mining – Surface Overburden Removal

Bucyrus (Marion) dragline in Colombia

Coal Mining - Surface

- Example of a Dragline Pit: Spring Creek Mine, Montana
- Pit Advance Is Perpendicular to Direction of Dragline Travel

Surface Mining

- **Favourable**
  - Ventilation
  - No Roof Control
  - Lower Development Costs
  - High Production Level
  - Production may start sooner
- **Unfavourable**
  - Overburden Removal
  - Dust & Noise Control
  - Reclamation
  - Visible impact
  - Waste has to be removed in addition to ore

Underground Mining

- **Favourable**
  - Move More Ore and Less Waste
  - Less Reclamation
  - Less Surface Environmental Impact
- **Unfavourable**
  - Roof Control
  - Ventilation
  - Equipment Transport
  - Higher Development Costs
  - Normally longer wait time to produce ore.

Underground Mining

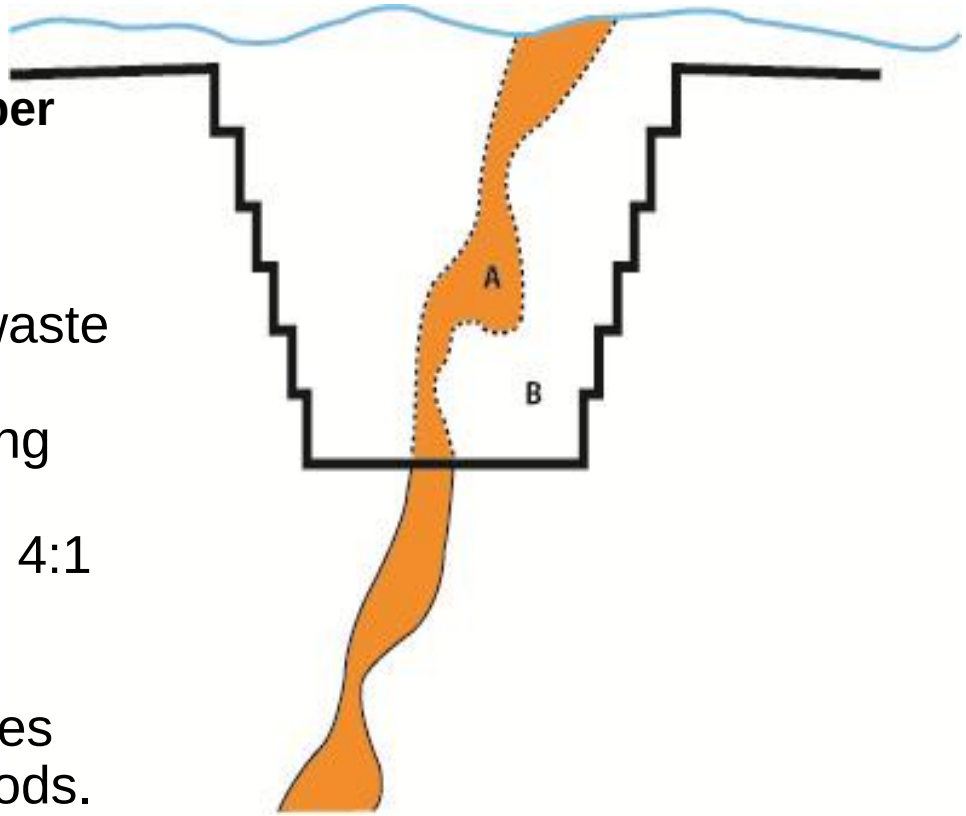
When do you go underground?

Switch to U/G mining when it is cheaper than surface mining
Example:

$1.00 per ton each for ore and waste using Surface Mining
$5.00 per ton Underground Mining

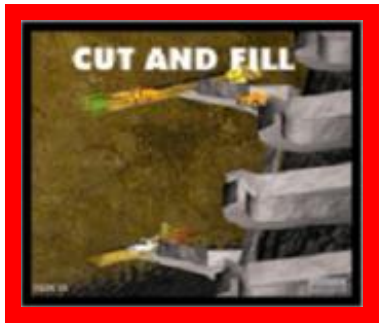
As long as strip ratio is less than 4:1 then Surface Mining is cheaper.

Cut-off depends on the economies of surface vs underground methods.

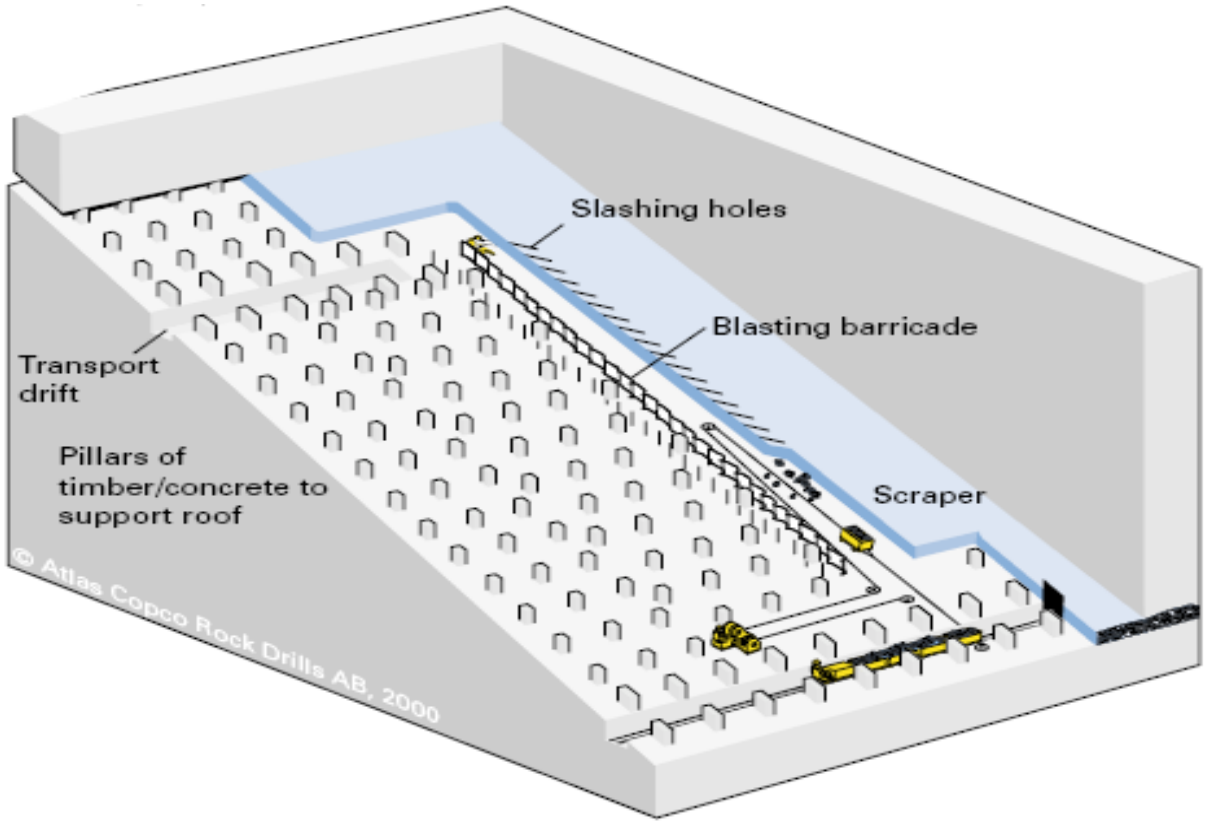


Underground Hardrock Mining Methods

- **Understanding the mining methods from selective to bulk mining**
  - Flat Ore Bodies: Nearly Horizontal Extraction
    - Narrow Vein Reef mining
    - Room and Pillar
  - Steep Ore Bodies: Based on Gravity
    - Block Caving
    - Sub Level Stoping
    - Sub Level Caving
    - Cut & Fill

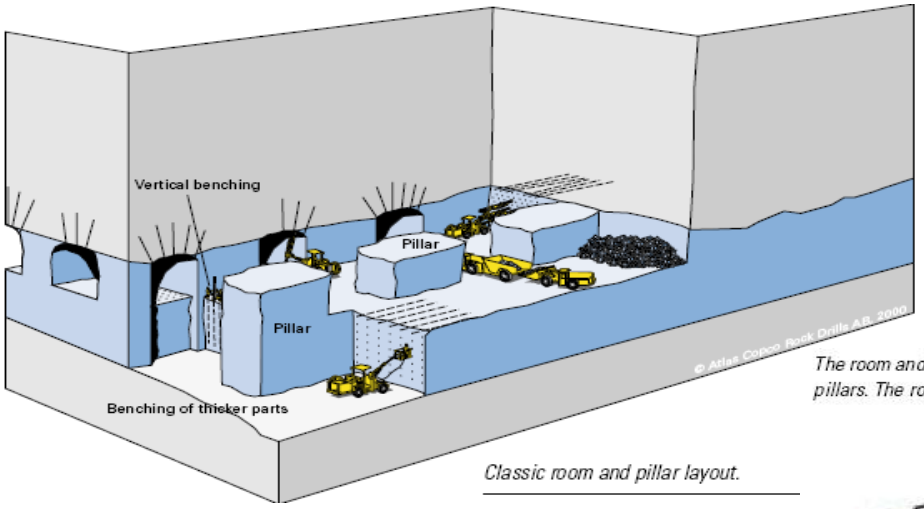


Hardrock Mining: Narrow Reef



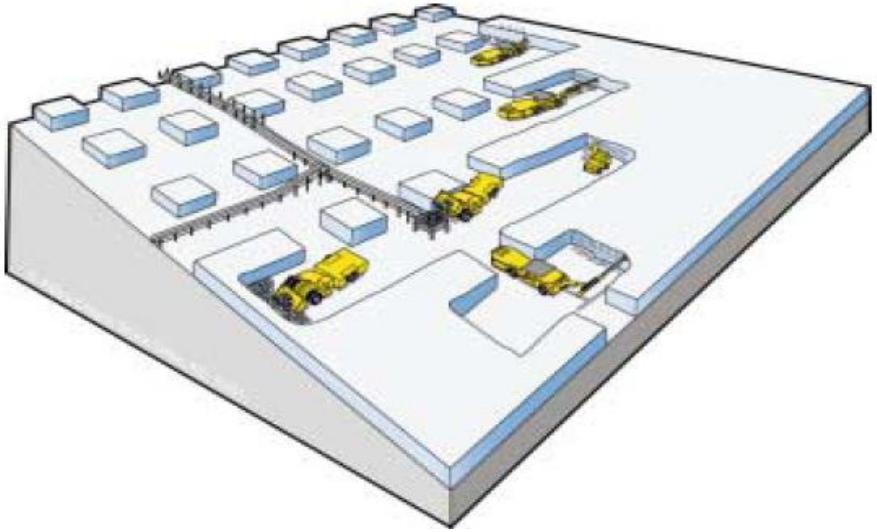
Typical steep longwall layout.

Hardrock Mining: Room & Pillar

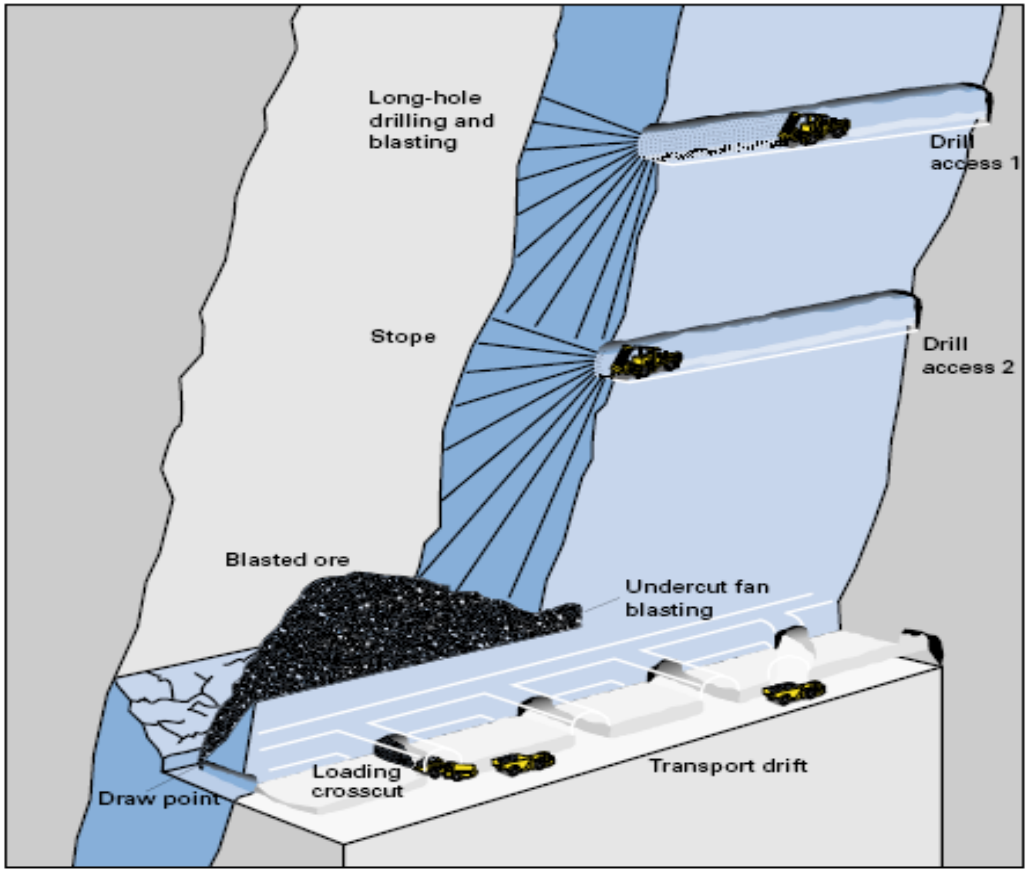


Classic room and pillar layout.

The room and pillar layout at the Waterval Mine comprises 12 sections with 12 m-wide panels and 6 x 6 m pillars. The roof height varies between 1.8 and 2.0 m.

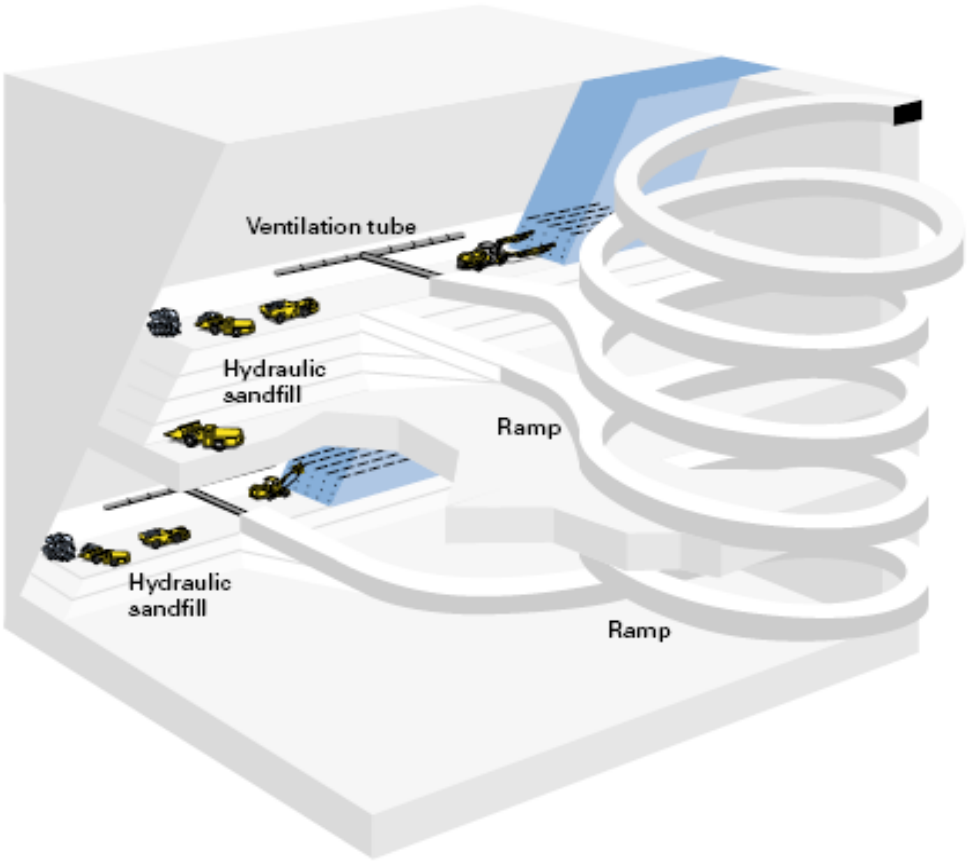


Hardrock Mining: Sublevel open stoping



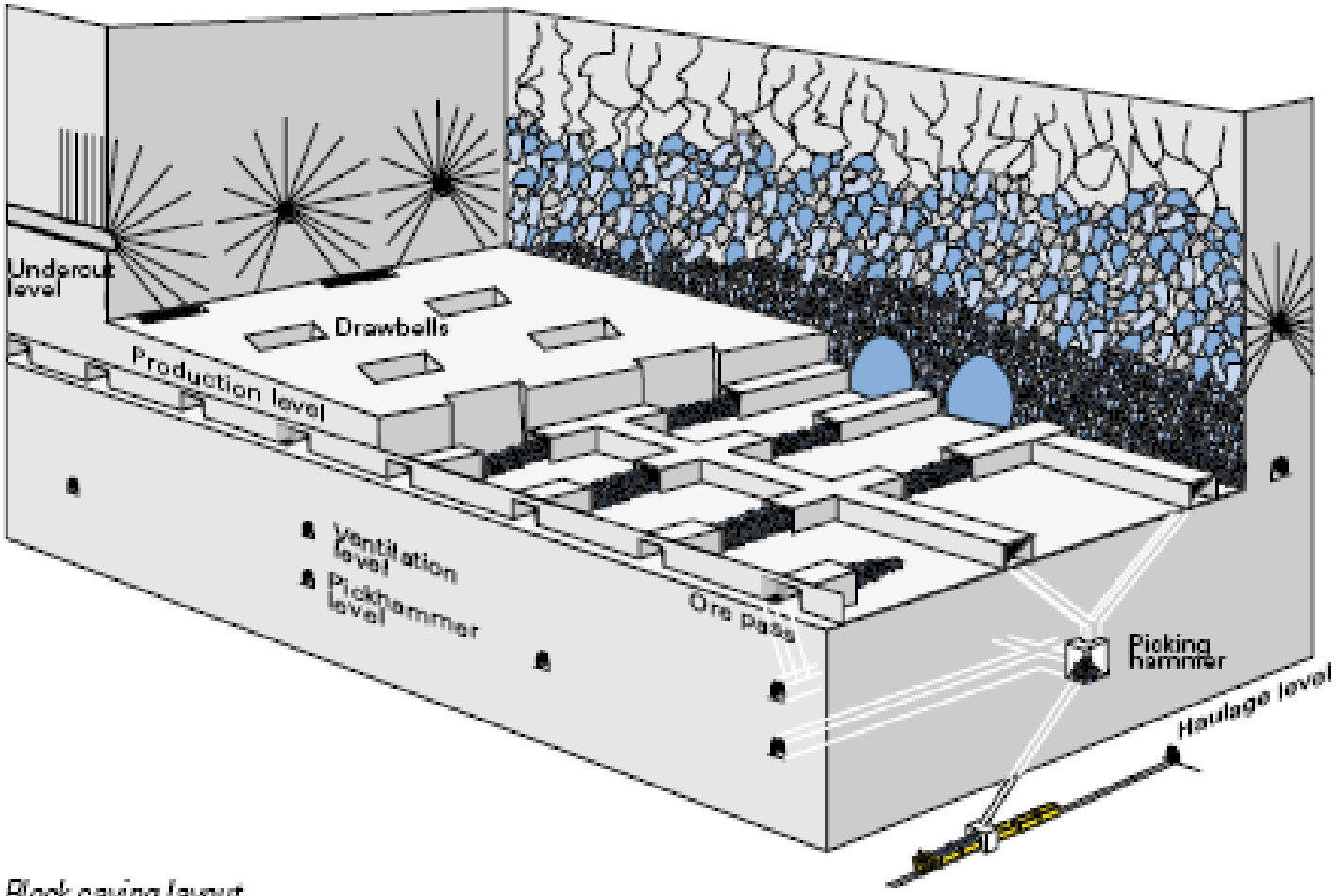
Sublevel open stoping layout.

Hardrock Mining: Cut-and-Fill

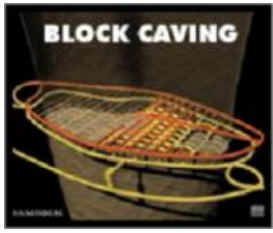


Cut-and-fill stope layout.

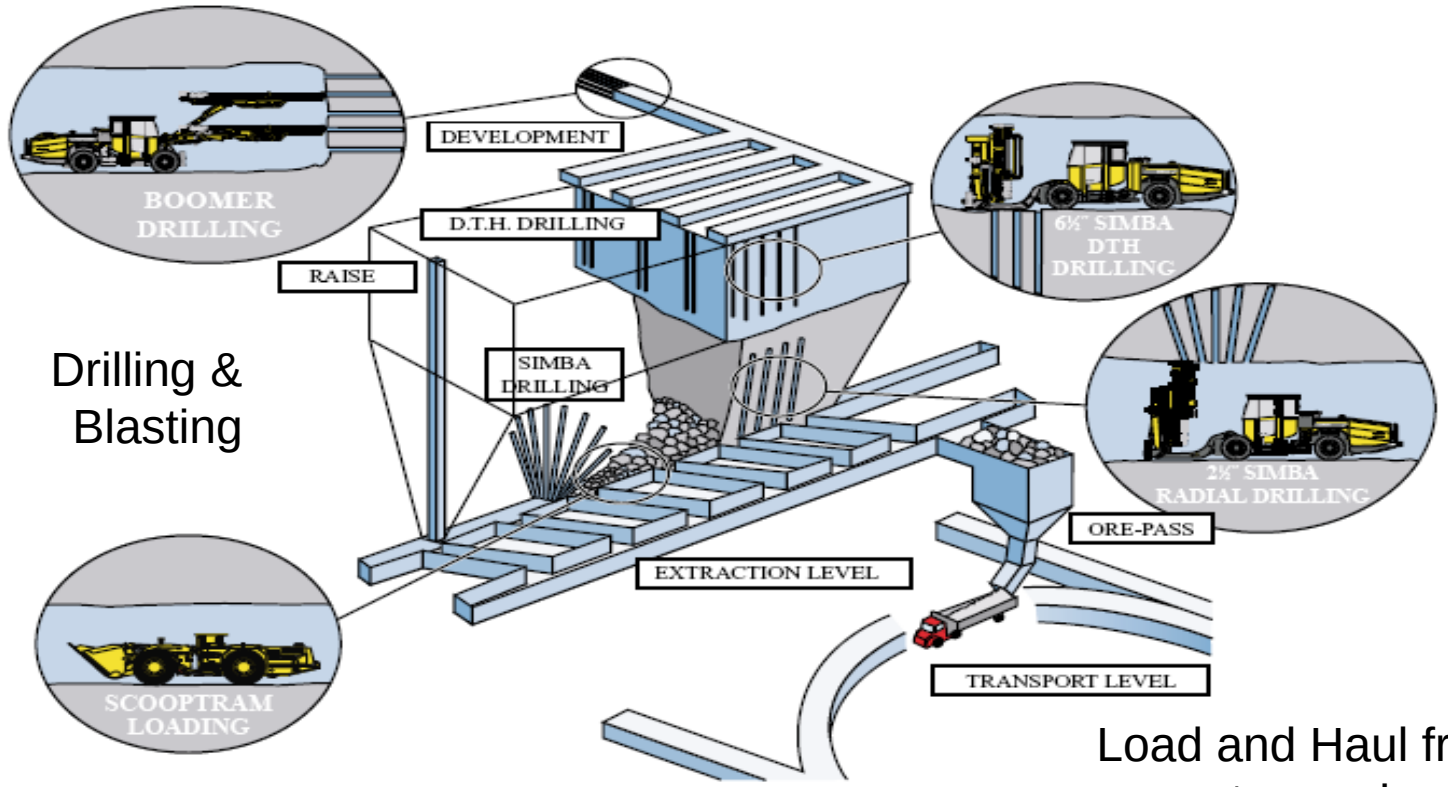
Hardrock Mining: Block Caving



Block caving layout.



Mining Cycle UG

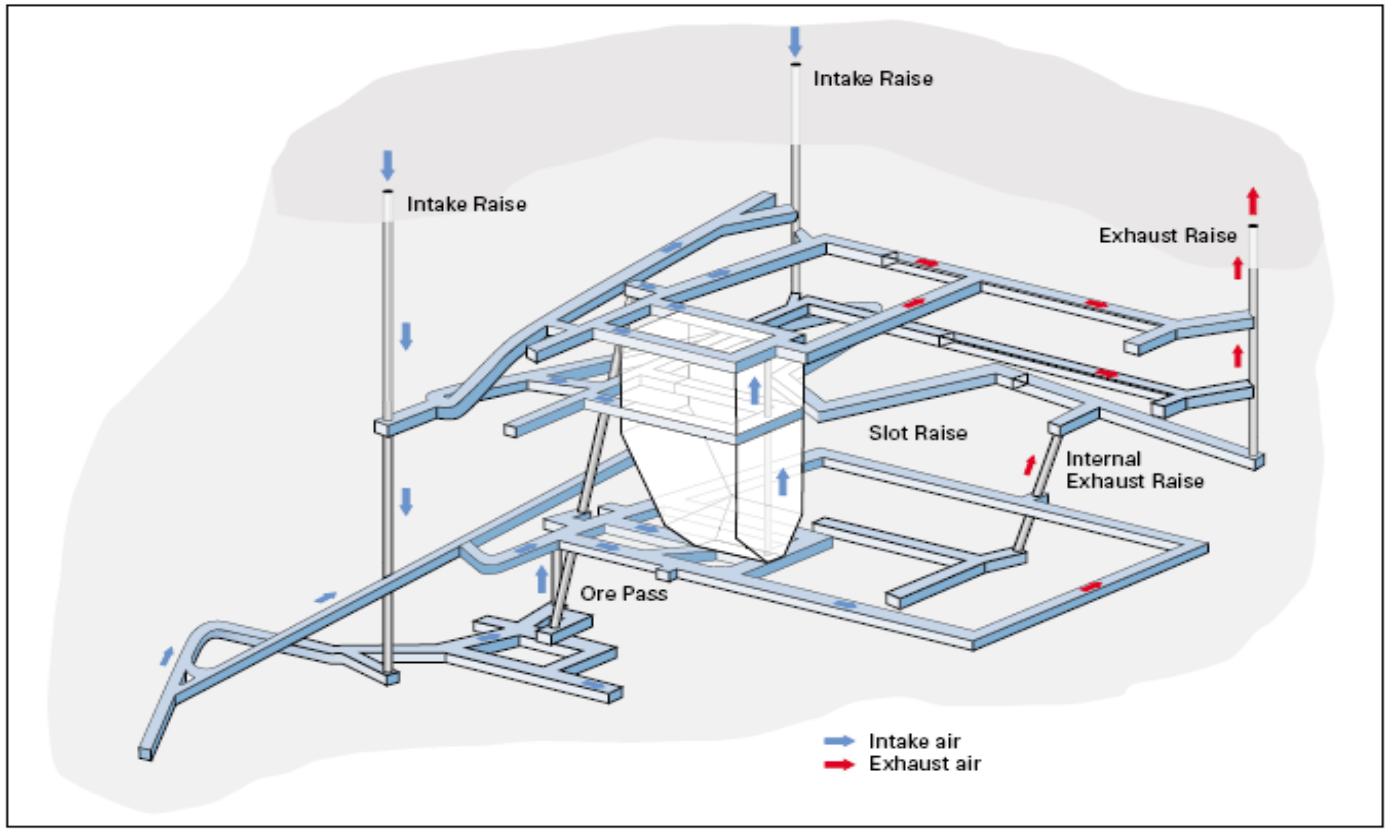


Drilling & Blasting

Load and Haul from Face to required location

El Soldado underground mining schematic overview.

Mining UG Ventilation



Typical stope ventilation layout.

Coal Mining – Underground

Roadheaders - Ranging arm with a cone-shaped cutting head.

Continuous Miners - wide cylindrical drum(s), which has only an up-down motion (as photo).

Coal Mining - Underground

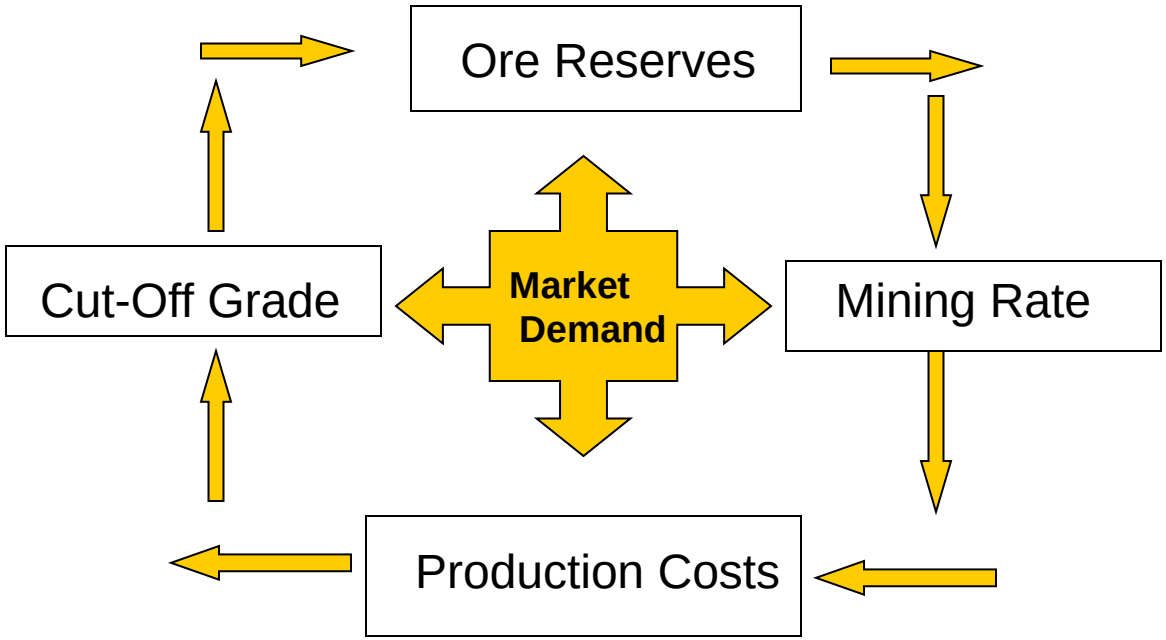
- **Longwall mining:**
  - Mechanised shearers cut and remove the coal at the face, which can vary in length from 100-250 m.
  - Self-advancing, hydraulic-powered supports temporarily hold up the roof whilst the coal is extracted.
  - The roof over the area behind the face, from which the coal has been removed, is then allowed to collapse.
  - Over 75 per cent of the coal in the deposit can be extracted using this method.

Coal Mining – Underground Longwall

Joy Mining's 61t monster at Moranbah mine

Project Evaluation

Process of evaluating mine investment.
Constantly changes as prices change.



Rehabilitation

Often includes:

- Recreating Original Contour of the Land
- Erosion / Sediment Control
- Re-vegetation
- Water Treatment / Acid Mine Drainage
- Wildlife

Integrated Planning for Mine Waste

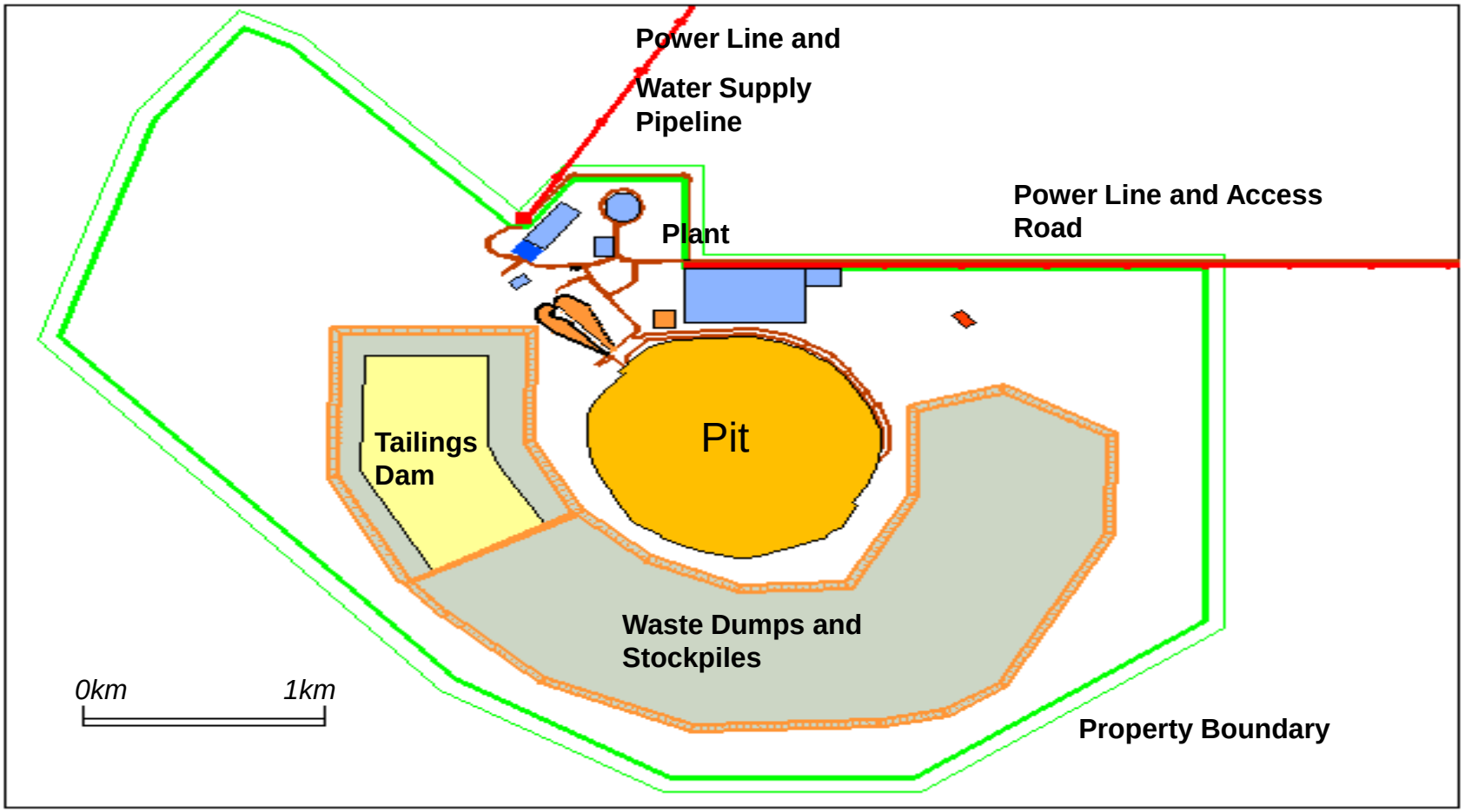
The three largest footprints remaining after open-pit mining are:

- Open pit
- Waste rock or overburden dumps
- Tailings (process waste) disposal facilities

The opportunity exists to reduce footprint by forming waste rock impoundments into which tailings are placed.

Advantages include;

- Reduced mine footprint and hence impacted land-use
- Reduced overall costs (increase in mining budget, reduced plant budget)
- Easier to rehabilitate and close – reduced environmental liability
- Stable walls and simple disposal system
- Potential to reduce water consumption through improved recovery rates



OPTIMISED MINE LAYOUT

TAILINGS IMPOUNDED IN OVERBURDEN - SMALLER AREA


Plant and office complex
Open pit
Rehabilitation in progress
Tailings impoundments
Waste-rock dump
Integrated Mine Planning

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Real Mining. Real People. Real Difference.

Mining Risks and Opportunities

- How good is the geology?
- Technology risk
- Infrastructure
- Local skills availability
- Environmental and Social Impact
- Closure implications of mining decisions
- Capital and operating cost estimation and currency risk
- Political

Development opportunities

- Infrastructure – is there a national development plan?
- Skills
- Job creation
- Local content provision

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Real Mining. Real People. Real Difference.

METALLURGY

Extraction of metals and minerals from their ores by a combination of :

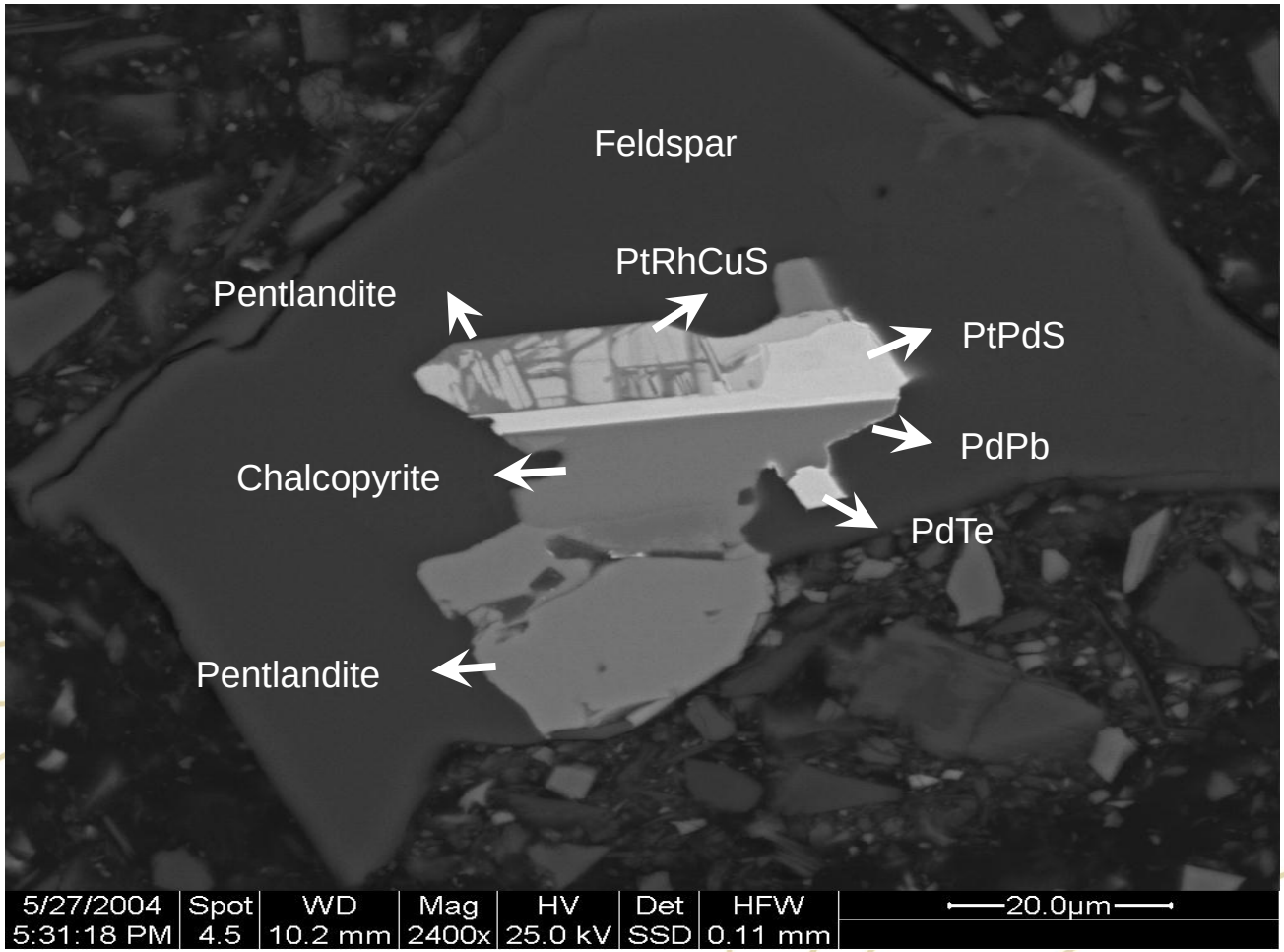
- LIBERATION
- SEPARATION
- TRANSFORMATION

CONTENTS

- Mineralogy
- Unit Processes
- Process Routes
- New Technologies

PLATINUM MINERALS:

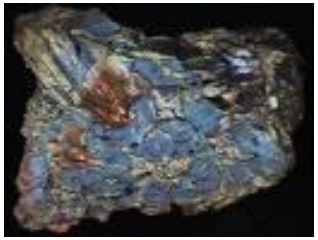
- PGE-sulphides
- PGE-bisulphides
- PGE- selenides
- PGE-arsenides
- PGE-sulparsenides
- PGE-tellurides
- PGE-alloys
- PGE-metals

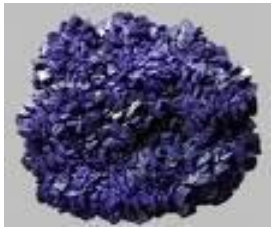


COPPER

- Copper occurs in sulphide form as chalcopyrite, chalcocite, bornite, covellite and in oxide form as cuprite, azurite, malachite. Separate from silicate minerals. Molybdenite associated occurrence.



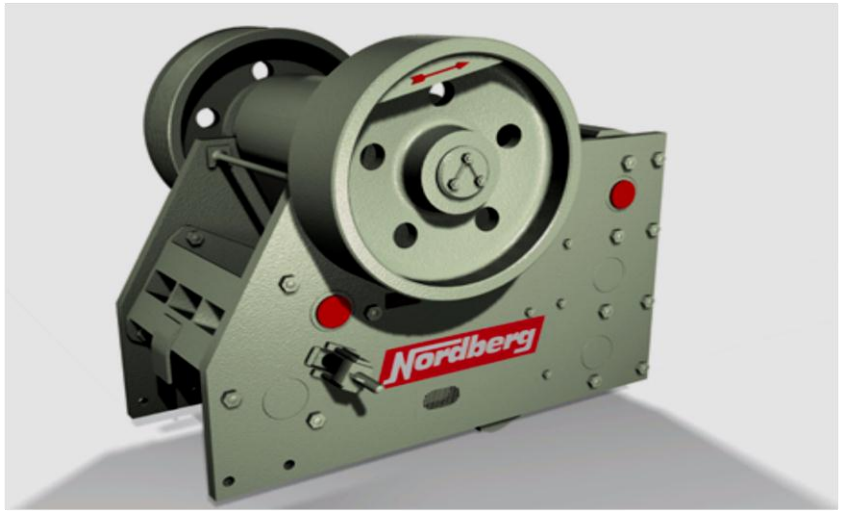
Definitions

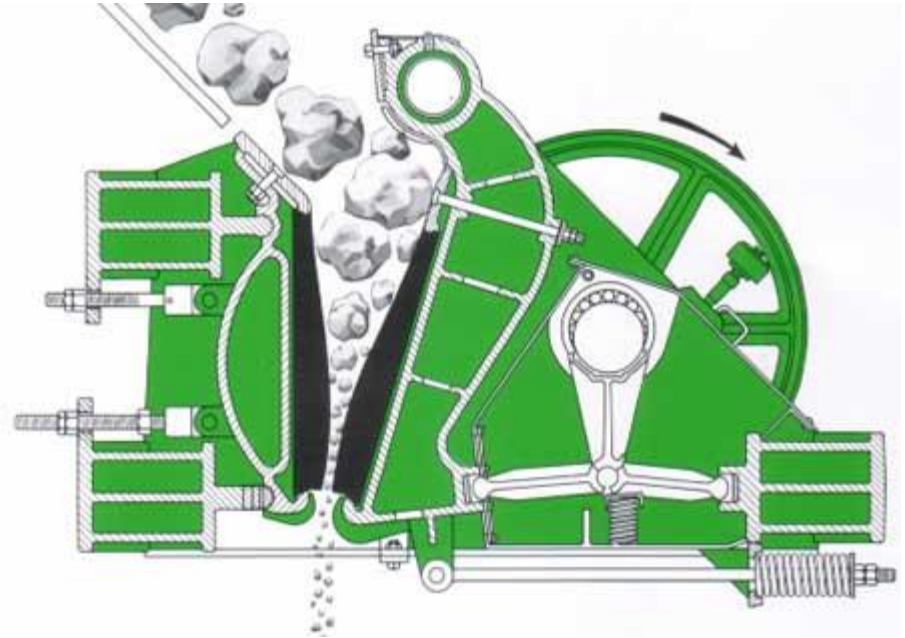
A common way of sub-dividing Metallurgy :

- ***Mineral Processing*** – this covers the physical aspects of liberation and separation
- ***Pyrometallurgy*** – this covers transformation processes by thermal means
- ***Hydrometallurgy*** – this covers transformation processes by chemical means

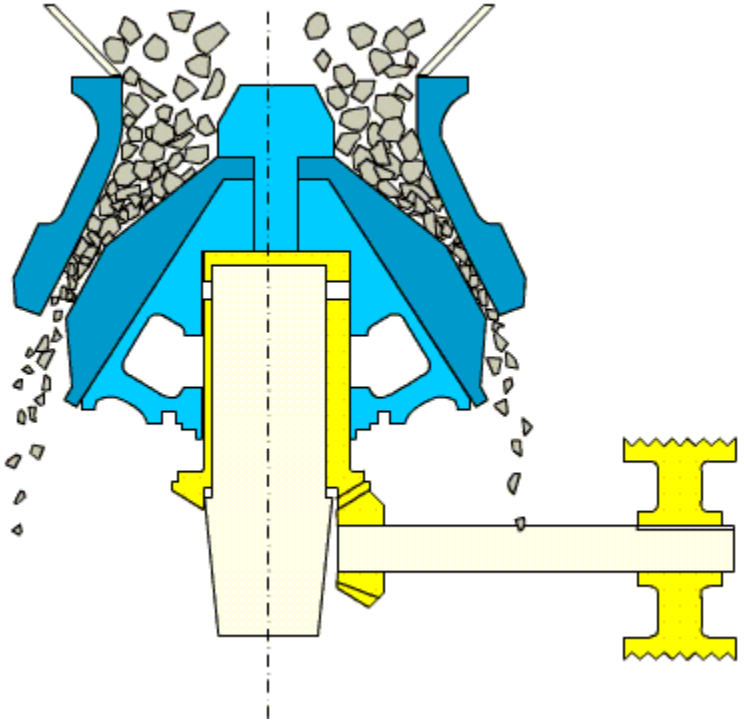
Each step requires one or more unit processes

Crushing – Jaw Crusher



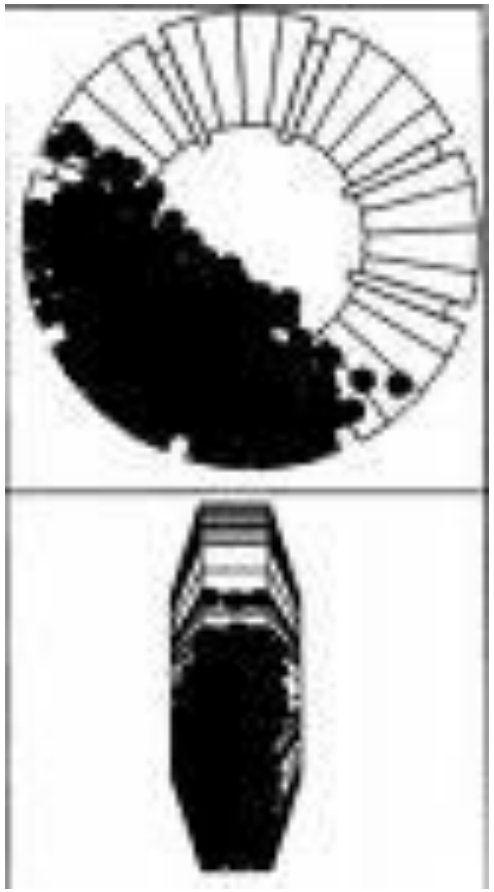


Crushing - Cone crushers

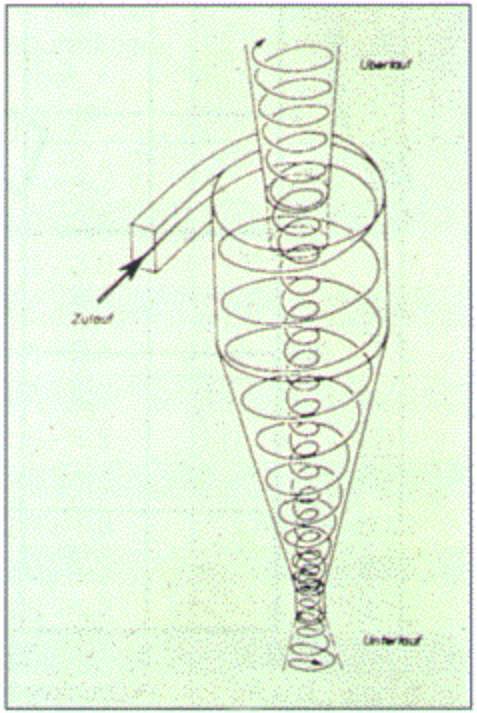


Screening – vibrating screen

Grinding – Fully Autogenous grinding (FAG) & Semi Autogenous grinding (SAG) mills



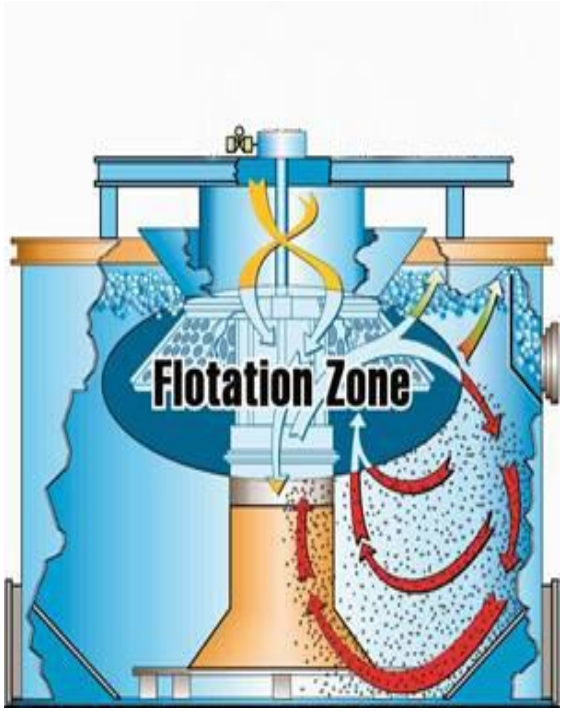
Classification - Hydrocyclones



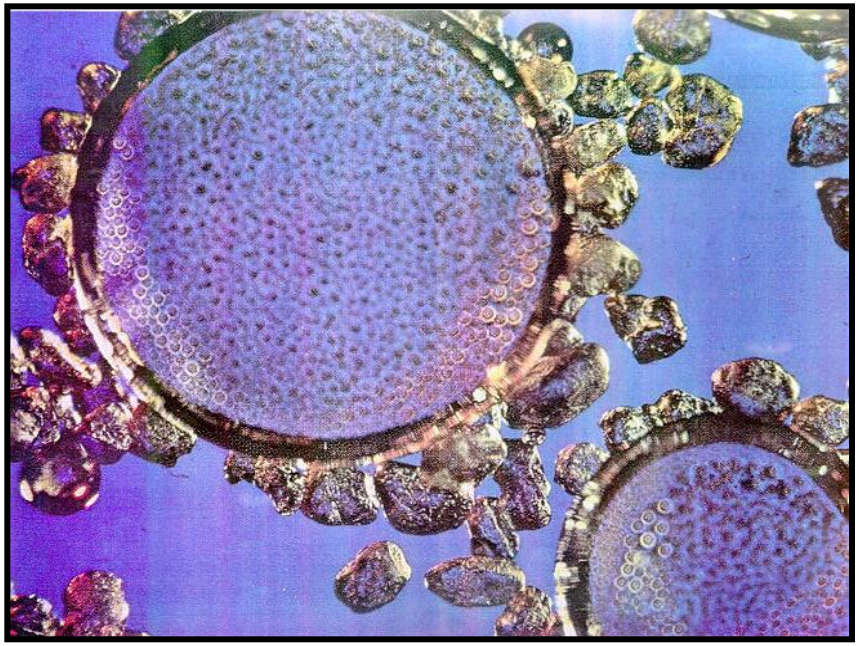
Funktionsschema des Hydrozyklons

Function scheme of a hydrocyclone

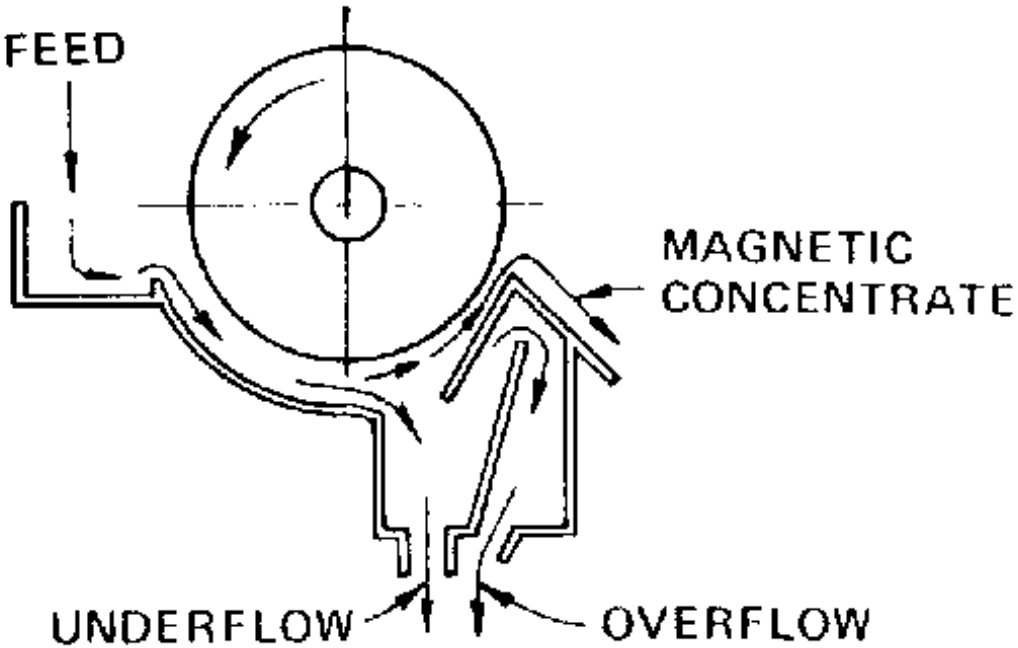
Flotation – Mechanical flotation cells



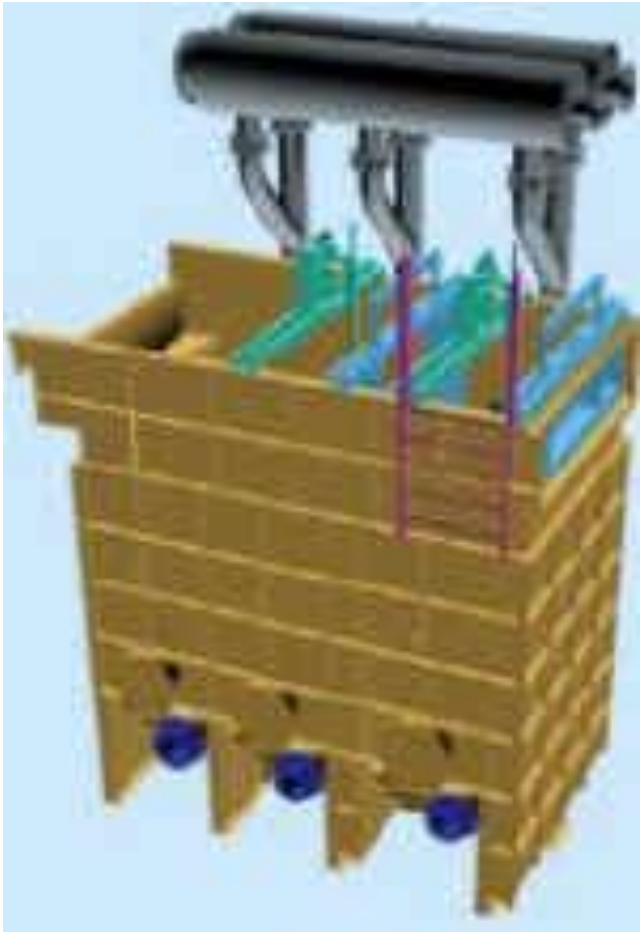
FLOTATION



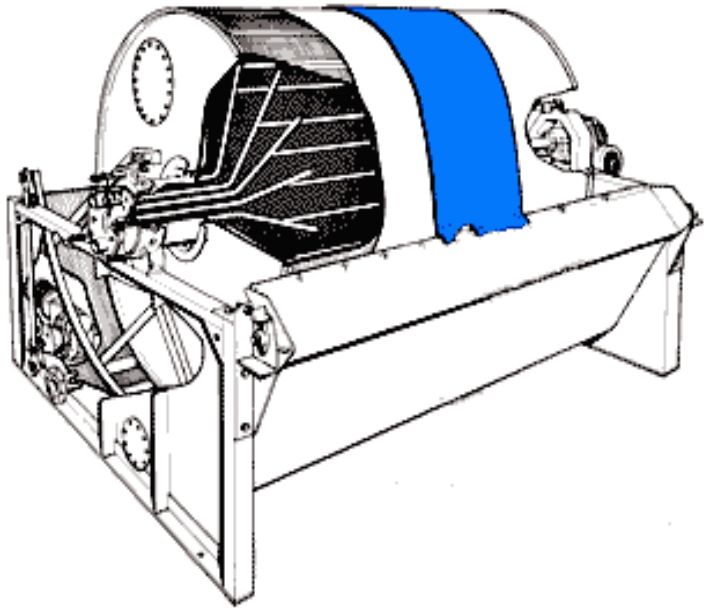
Magnetic separation – wet drum low and high intensity separators



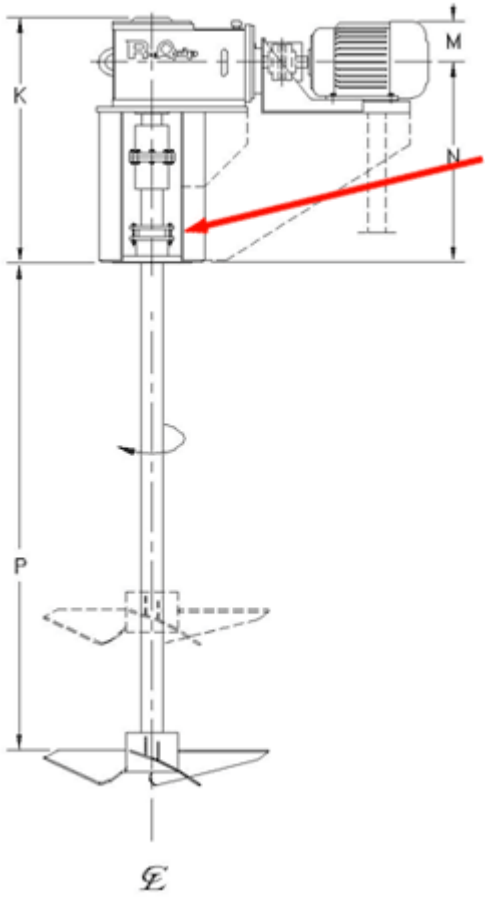
Gravity Concentration – Jig & Spirals



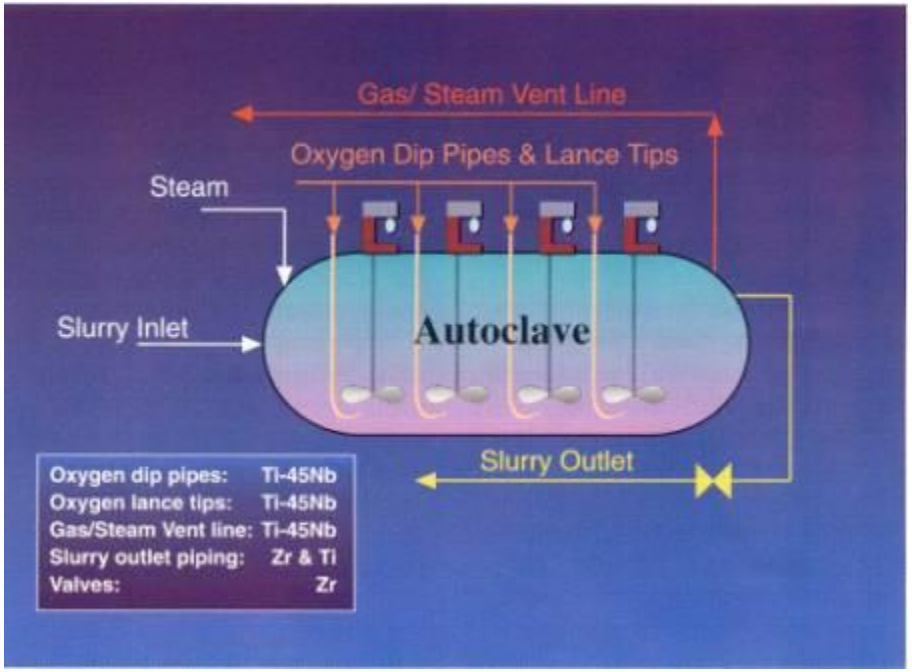
Solid / Liquid separation – vacuum drum and belt filters



Leaching – Atmospheric agitated leach



Leaching – Pressure leach autoclave



Leaching – Heap leach pads

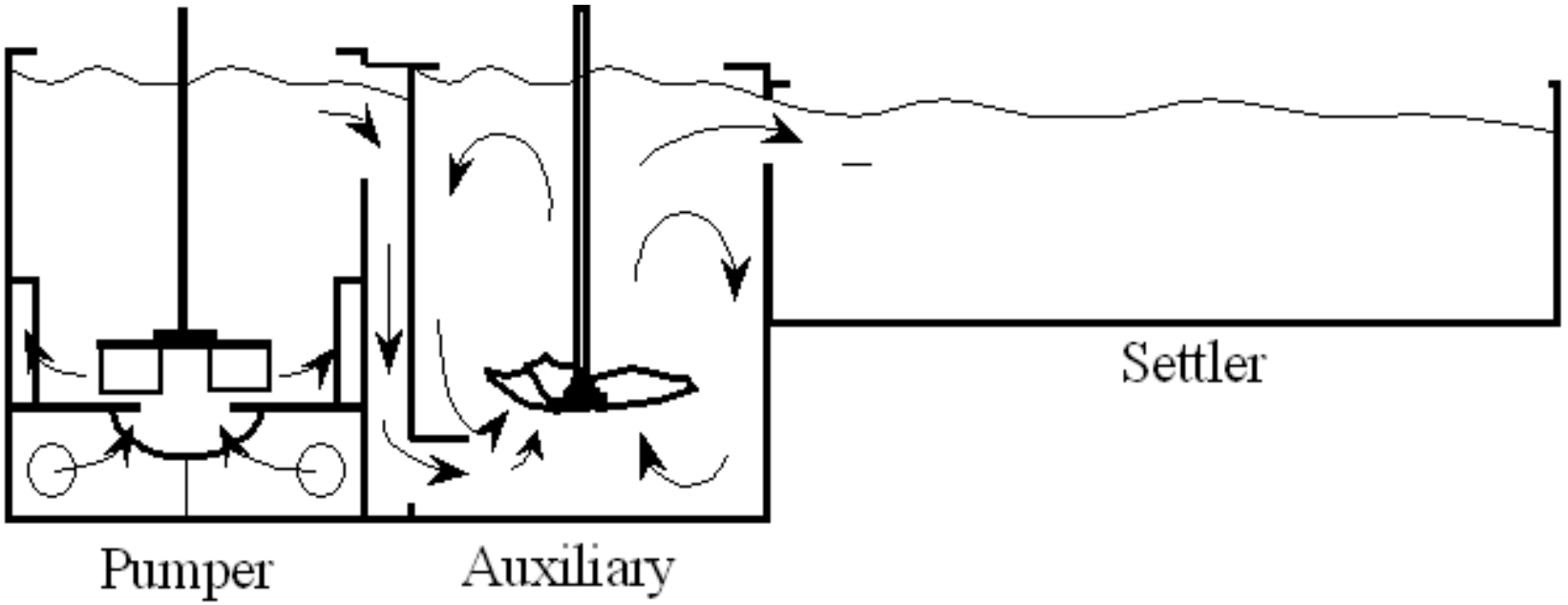
PURIFICATION

- Purification is employed in hydrometallurgical plants where contaminants have to be removed from an aqueous solution before final metal recovery
- Purification is a combination of one or more of the following steps: Precipitation, cementation, crystallisation, solvent extraction, ion exchange

SOLVENT EXTRACTION

- Solvent extraction utilises organic liquids which selectively remove metal ions from aqueous solutions and then concentrates them
- Solvent extraction process consists of 2 basic steps: extraction and stripping. Washing and regeneration steps are often required as well

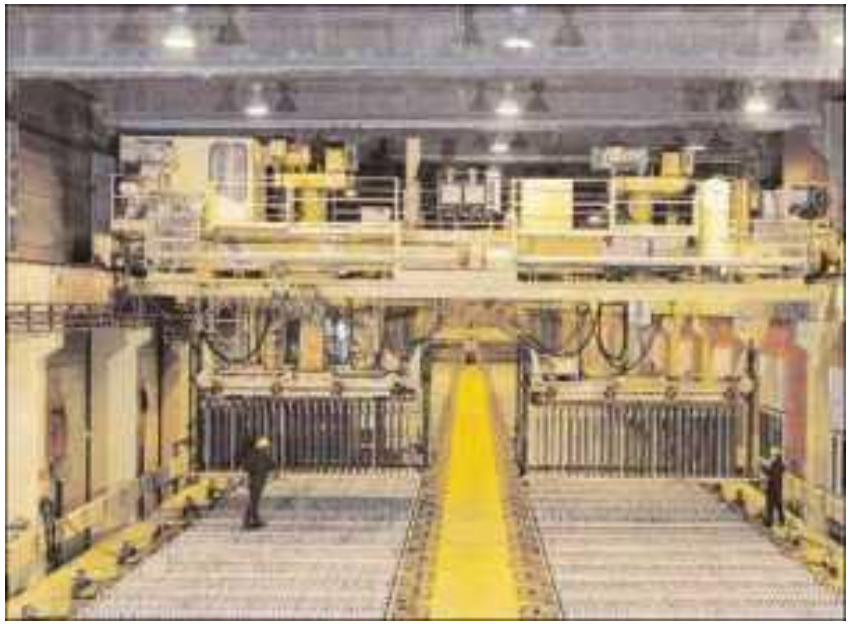
Solvent Extraction

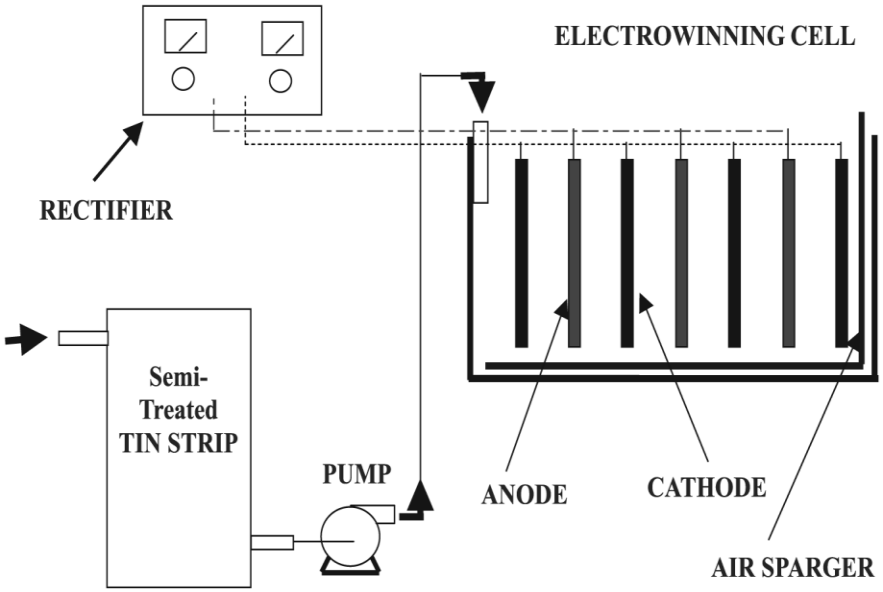


ELECTROWINNING

- Electrowinning is the recovery of metal from an aqueous solution by means of an electric current
- The anode (positive electrode) is made from an inert lead alloy
- The cathode (negative electrode) is made from a metal or alloy

Electrowinning tankhouse





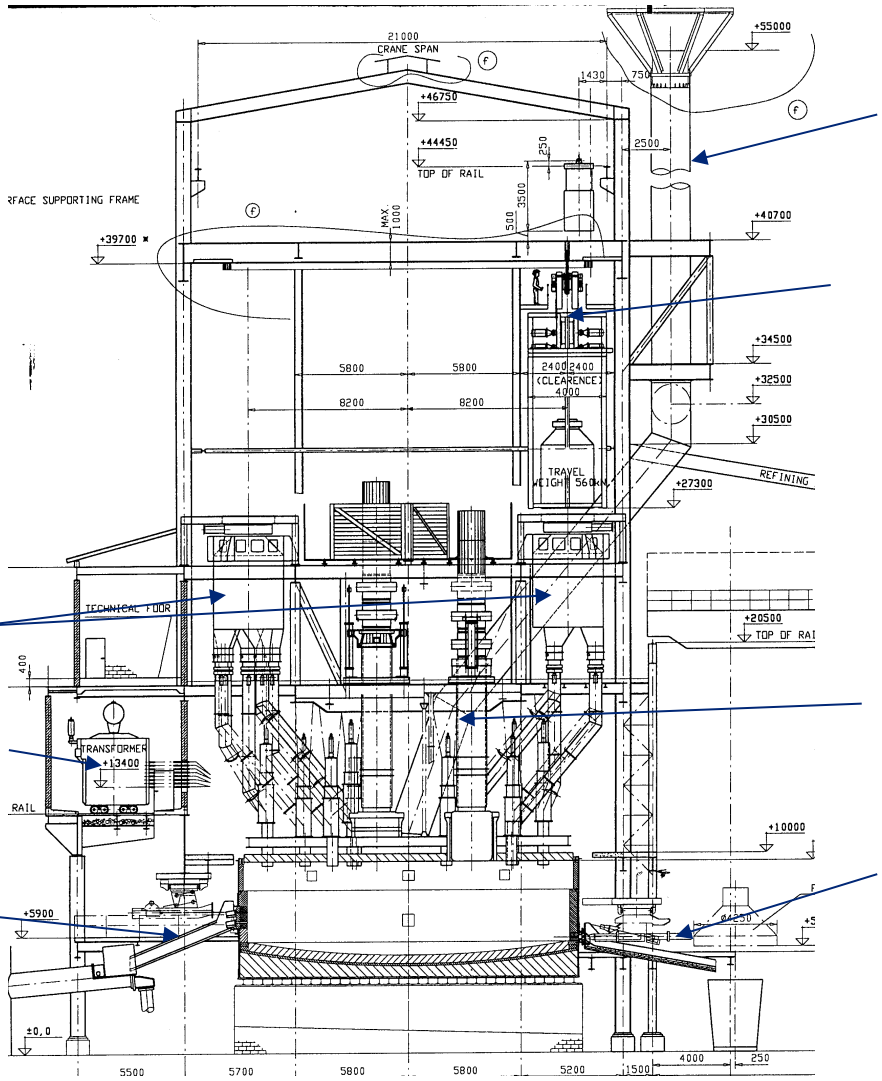
Drying – rotary drum dryer

SMELTING

- Smelting is a thermal process whereby the feed material is transformed into two products – a slag which contains the majority of the contaminants and a matte (mixture of metal sulphides) or alloy
- Smelting is generally conducted in electric furnaces (Platinum, Ferronickel, Ferrochromium) or flash furnaces (Copper, Nickel)

Smelting – Electric Furnaces

Smelting
Electric Furnaces



Stacks

Charging System (Monorails)

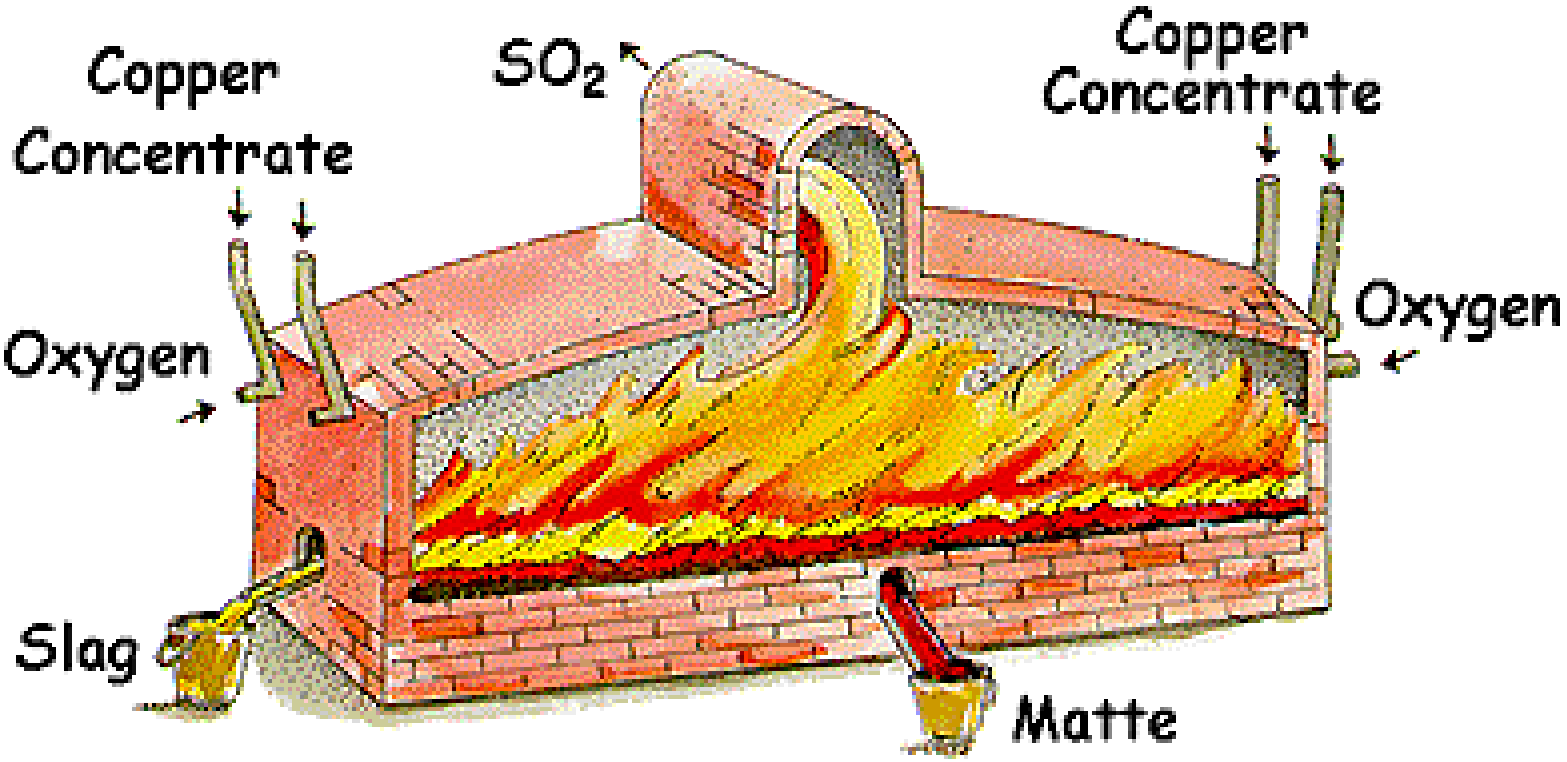
Charging Bins

Electrodes

Slag Tapping

Metal Tapping

Smelting – flash furnace



CONVERTING

- Converting is a thermal process whereby molten matte is oxidised in two steps. The first step removes iron as a slag. The second step removes the sulphur partially (Platinum) or completely (Copper)
- Converting is generally conducted in Ausmelt converters (Platinum) or Pierce Smith converters (Copper)

Converting – Ausmelt converter

Converting – Pierce Smith converter

FIRE REFINING

- The product from copper converting, known as blister copper, is partially refined in a separate furnace to remove excess sulphur and oxygen. The product from this step is cast into anodes
- Fire refining is generally conducted in anode furnaces and casting in anode casting wheels

Fire refining – anode furnace

PROCESS ROUTES

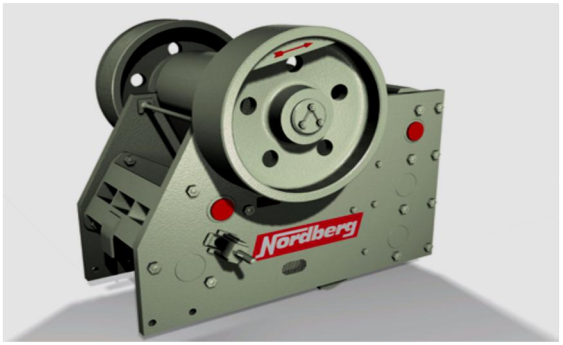
Two examples by way of recap.

PLATINUM

- When describing the process routes for “platinum”, this covers platinum, palladium, rhodium, ruthenium, iridium, osmium, gold, nickel, copper, cobalt

PLATINUM

- Liberation & Separation – Crushing, Screening, Grinding, Flotation



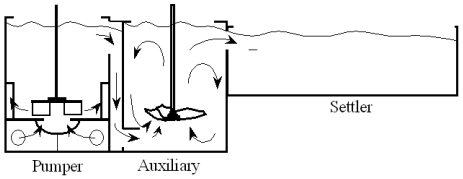
Four 24 ft. x 30.5 ft. - 14,000 HP Ball Mills @ Freeport Indonesia

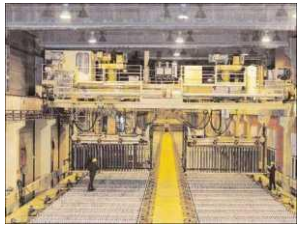
PLATINUM

- **Transformation (smelters)**
  - Smelting
  - Converting
  - Slow cooling

PLATINUM

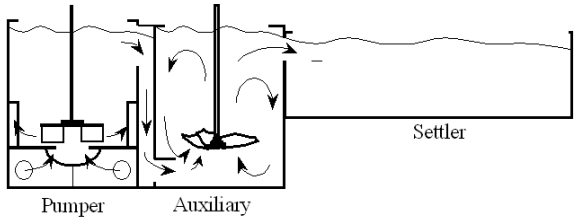
- **Transformation (Base Metals refinery)**

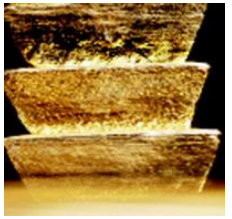




PLATINUM

- **Transformation (Precious Metals refinery)**

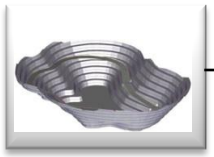
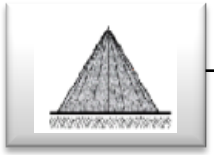
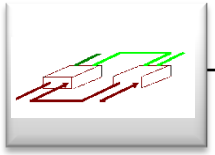
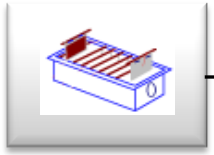




COPPER

COPPER – Los Bronces

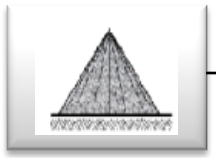
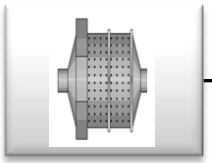
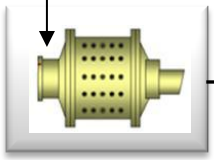
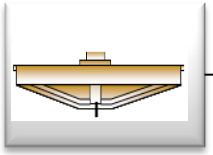
Mineralogy	Processes	Routes	Technologies


Leaching SX EW Cathodes

	Fine Copper, Ton
Oxide Minerals	50 000
Sulphurs Minerals	220 000
Total Production	270 000

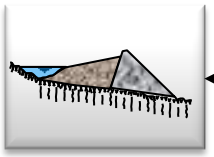
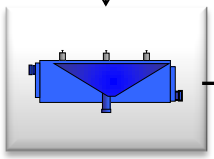
Pebble Crusher

Primary Crusher Ore Stockpile SAG Mill Ball Mill Thickener

Flotation Filters Final Cu Concentrate

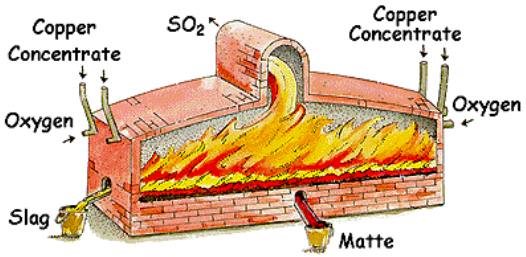
Tailings dam

COPPER

Transformation (copper sulphides)

- Smelting to matte
- Converting matte to blister copper
- Fire refining blister copper to anode copper
- Electrorefining anode copper to cathode copper



COPPER

Transformation (copper sulphides)

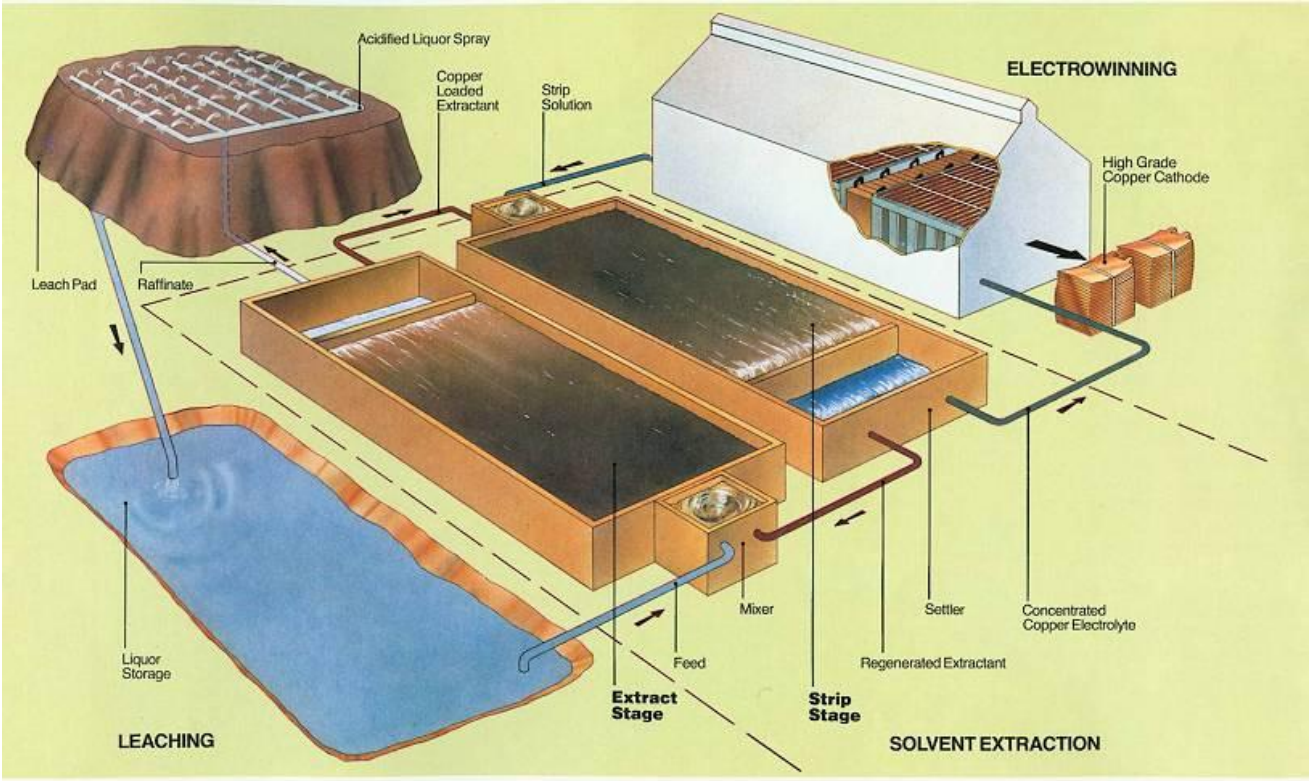
COPPER

Transformation (copper oxides heap leach)

- Leaching with sulphuric acid
- Solvent extraction
- Electrowinning

COPPER

Transformation (copper oxides heap leach)



COPPER

Molybdenum is associated with copper and is separated from the copper by flotation. The molybdenum sulphide product is then converted to the oxide which in turn is converted to ferromolybdenum

AngloAmerican

Real Mining. Real People. Real Difference.

Metallurgical Risks and Opportunities

- Process selection and operability
- Will the ore grade and composition be as predicted?
- Capital and operating costs
- Environmental issues
- Community engagement and expectations
- Regulatory environment and consistency

Development opportunities

- Training and skills development
- Some local procurement

Nearly the End

“If we remove metals from the service of man, all methods of protecting and sustaining health and more carefully preserving the course of life are done away with.”

“Now a miner, before he begins to mine the veins, must consider seven things, namely: - the situation, the conditions, the water, the roads, the climate, the right of ownership, and the neighbours.”

Georgius Agricola 1556

The End

THANK YOU

ANY QUESTIONS ?