

Mining 101 – how Materials are extracted from the Earth

By the end of this session, you will know:

- What mining is
- What factors determine how a resource is mined
- The modern equipment facilitating mining
- The challenges linked to distinct mining methods

Click to start



How to study this DTM

Your path through the DTM:

1. Start at the main hub and click an item to see its details.
2. Use the Return buttons to jump back to a hub at any time.
3. Open another hub to explore the topic from a new angle.
4. Click an item to open its detailed profile page.
5. Visit each content hub to explore the full topic.
6. Finish with the Key Takeaways.

Time needed

about 30–45 minutes

Format

self-study

How to explore

Click on icons, underlined words to explore and return

Files

This presentation and the interactive quiz on the NEXPERT Website

Target Group

Upper-secondary, introductory university and vocational learners with no prior mining knowledge.

Continue

What is mining?

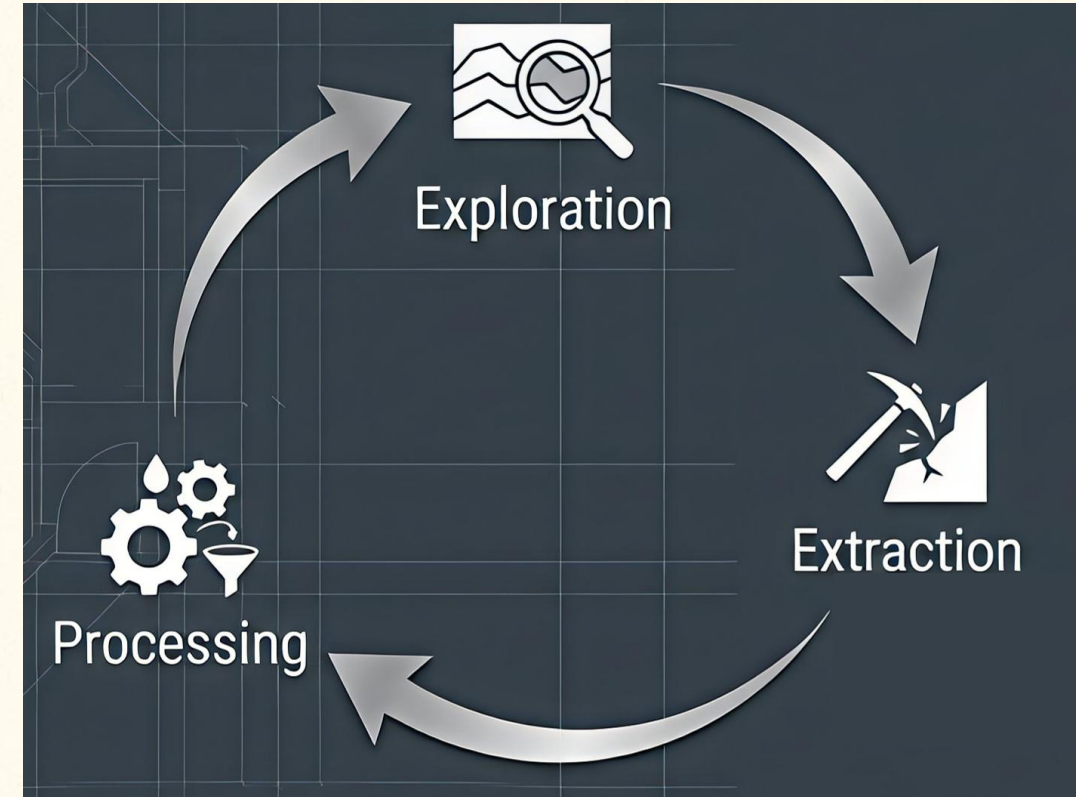
Mining

extracts valuable raw materials from the Earth and is part of a wider chain from **exploration** to **processing**.

Mined raw materials

Are behind almost everything we use, from copper wires to smartphone batteries.

What determines the mining method?



Mining, Ore & Grade? Some basic terms for newbies.

Grade

Concentration of the valuable component. Expressed as % or ppm (parts per million = grams per metric ton)

Ore

Material that can be economically extracted and processed under current conditions.

Waste

Material that is not treated as ore under those conditions.



What determines the mining method?



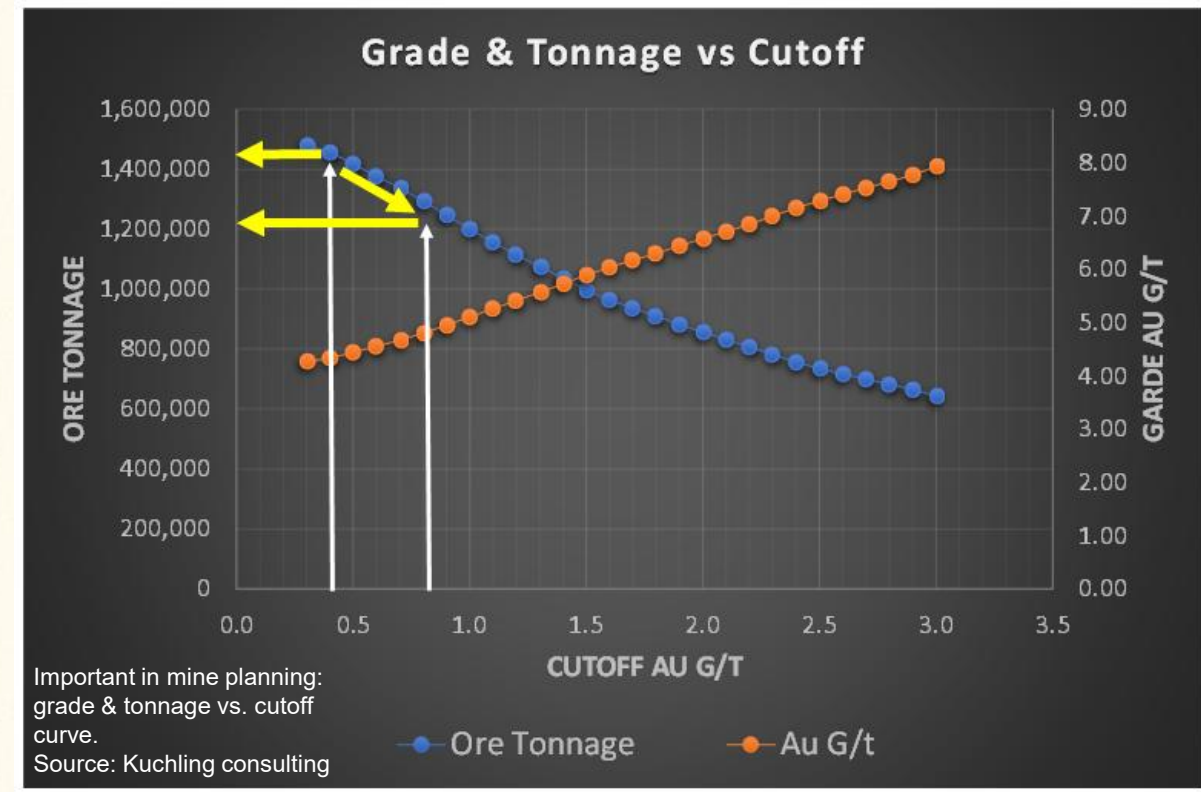
The boundary is not fixed: prices, costs, technology and regulation can change what counts as ore.

Why the mining method matters

Cut-off grade is the minimum grade at which material is worth the treatment as ore (processing)

Higher cut-off means fewer ore tonnes at higher average grade; lower cut-off increases the total ore, but at lower value per tonne.

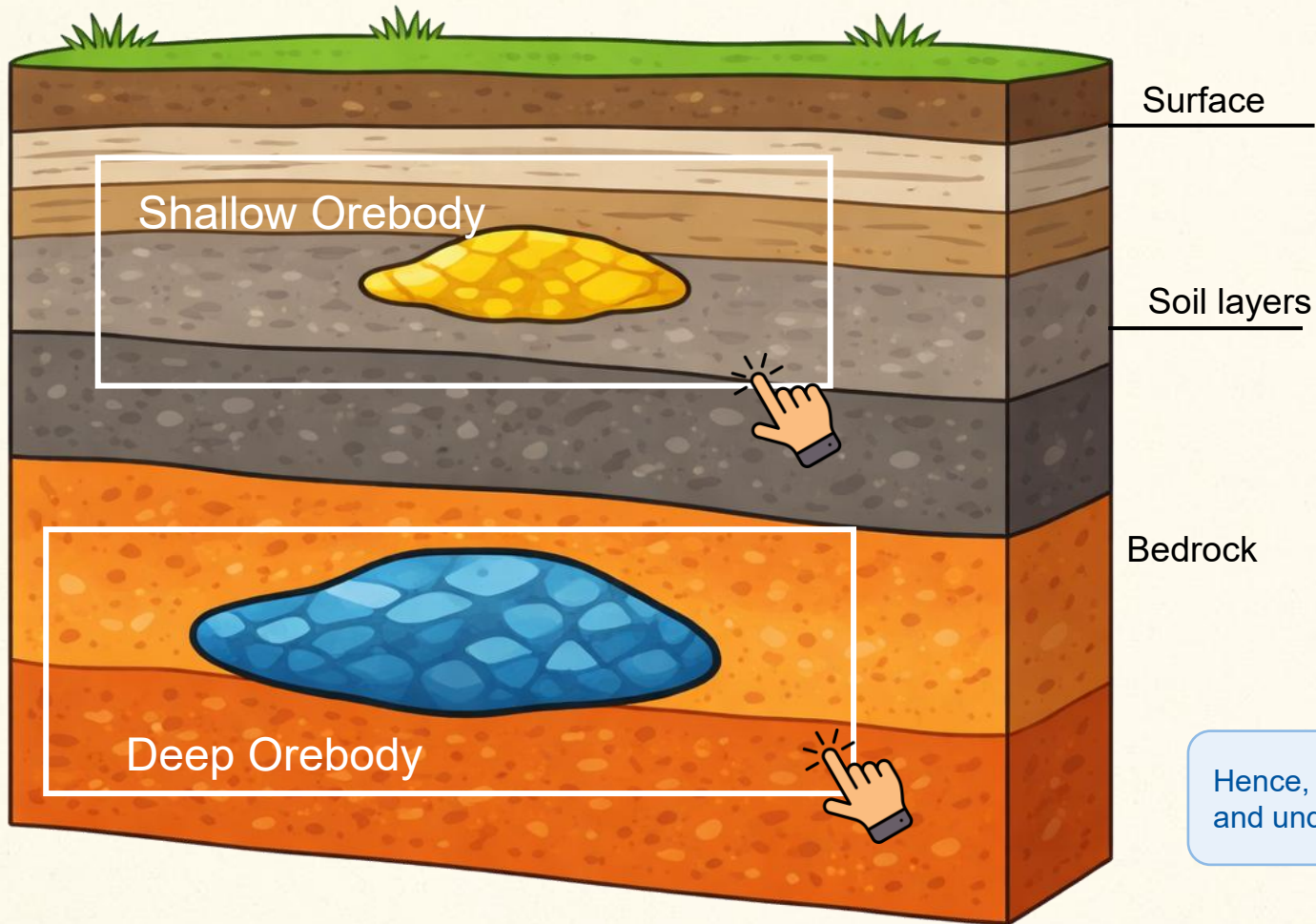
Due to changing economic and technical conditions, the cut-off grade varies over time and differs from mine to mine



Return to
overview



Depth & orebody geology



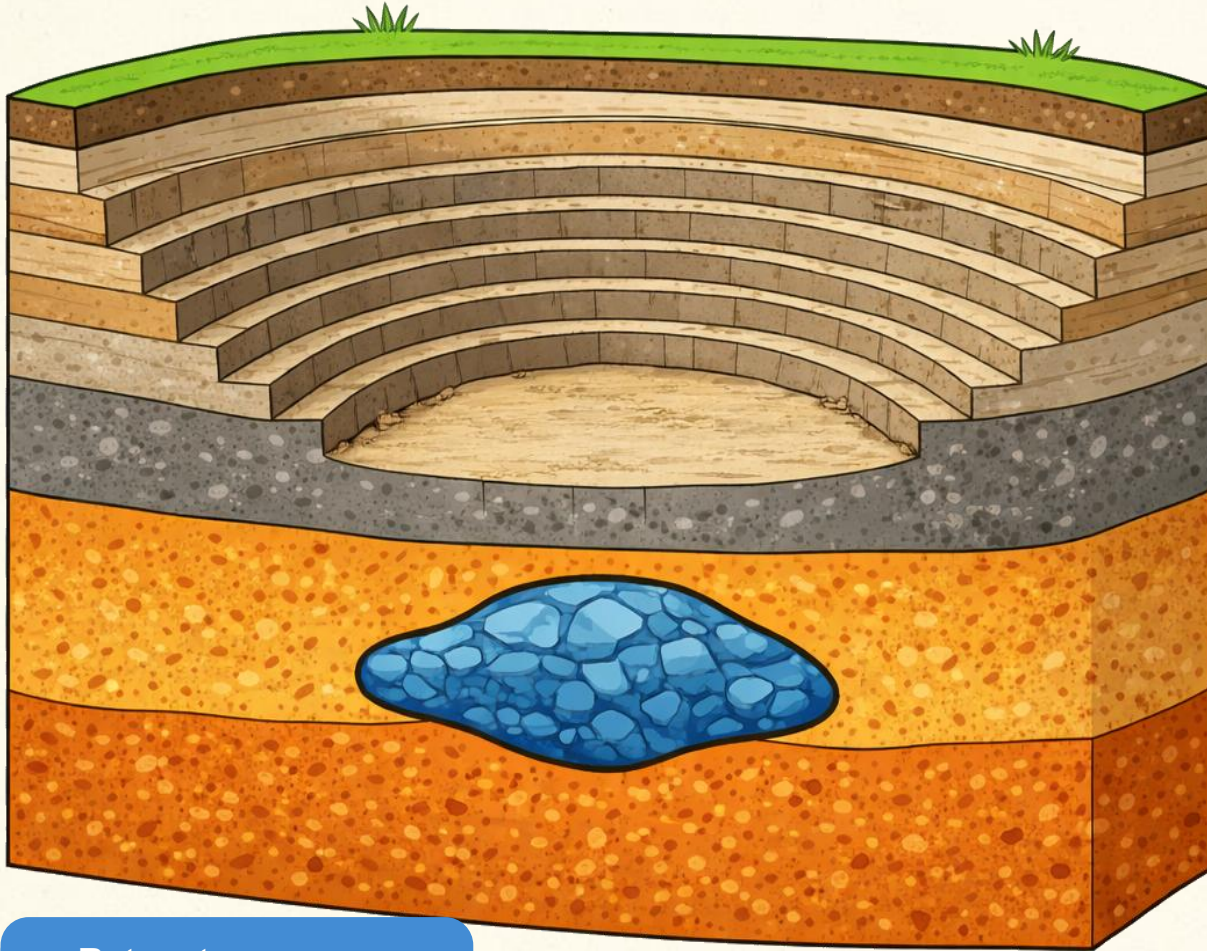
Mining methods are strongly influenced by the deposit depth.

Besides that, the technical, economical, environmental and regulatory feasibility of the method

Strongly influenced by geographical location, authorities & local communities

Hence, they can be distinguished by open pit and underground mining methods.

Shallow orebody - Mined in open pits



Shallow orebodies can be extracted in open pits, where all overburden must be removed to access the deposit.



With increasing depth, progressively more waste material may need to be moved, which can make surface mining uneconomical.

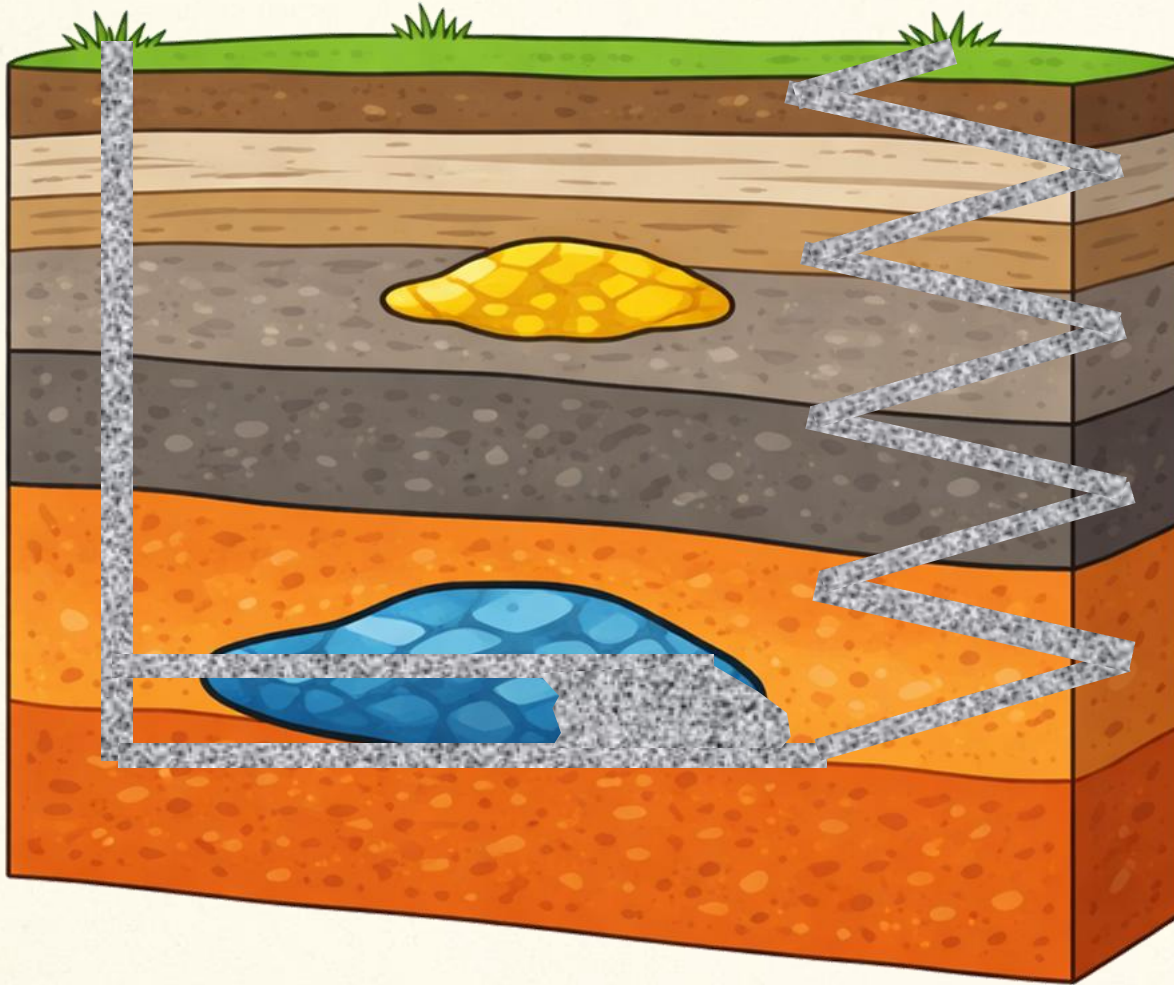
But what can open pits look like, depending on the deposit size and shape?



Return to
orebody
overview



Mining deep orebodies underground



Deep deposits are extracted in underground mines, accessed by vertical shafts, spiral ramps, or inclined drifts.

Going deep brings its own challenges: rock pressure, high temperatures, and long transport distances all rise with depth.



But what can underground mines look like, depending on the deposit size and shape?



Return to
overview

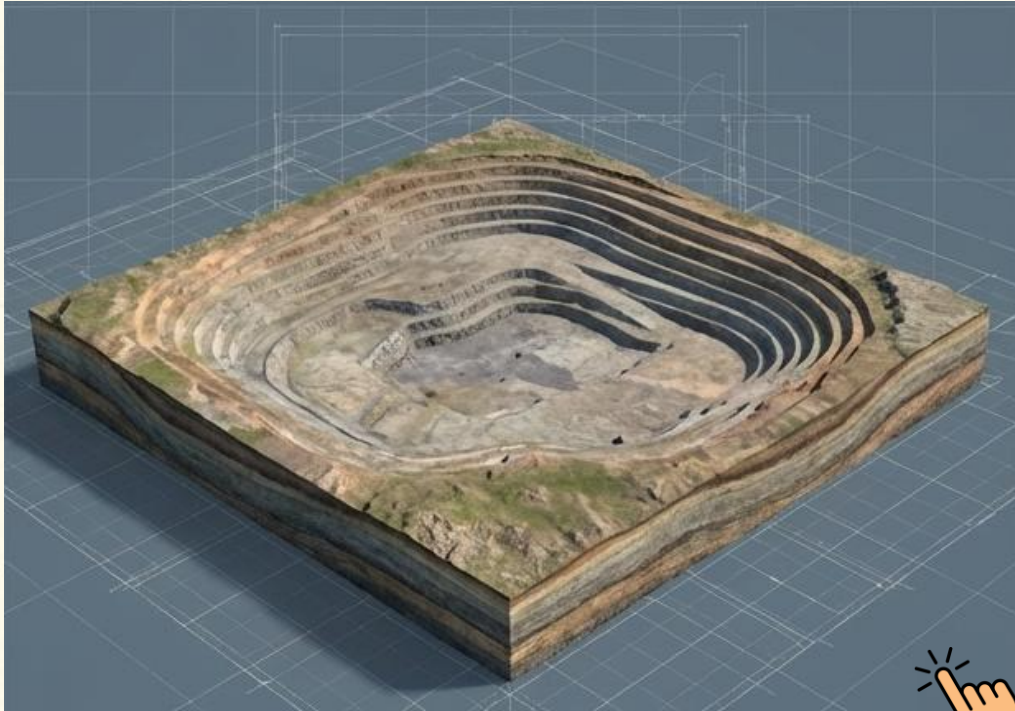


Adapting the pit to the orebody



Material covering the ore within the pit footprint must be removed to access the deposit.

Return to
shallow
orebody



Flat, laterally extensive deposit



Deep and narrow deposit

Different pit types may require different equipment for resource extraction

Areal open pit mines

Common in brown coal / lignite deposits

Orebody: flat, tabular, soft rock

Equipment: BWE, conveyor, spreader

Advantages: low unit cost, high recovery, safe surface work

Disadvantages: landscape impact, groundwater drawdown, dust

After closure: flooded into recreational lakes (Lusatia, Hambach)



Return to
pit design



Bucket Wheel Excavator (BWE)

Some of the largest machines on earth



Preconditions:

Soft rock
Train- or belt conveying

- Continuous extraction of soft rocks
- Loosening and loading in one step
- High throughput, but sensitive to hard inclusions and changing rock conditions



Return to
pit design



Deep open pit mines

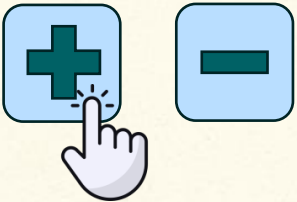
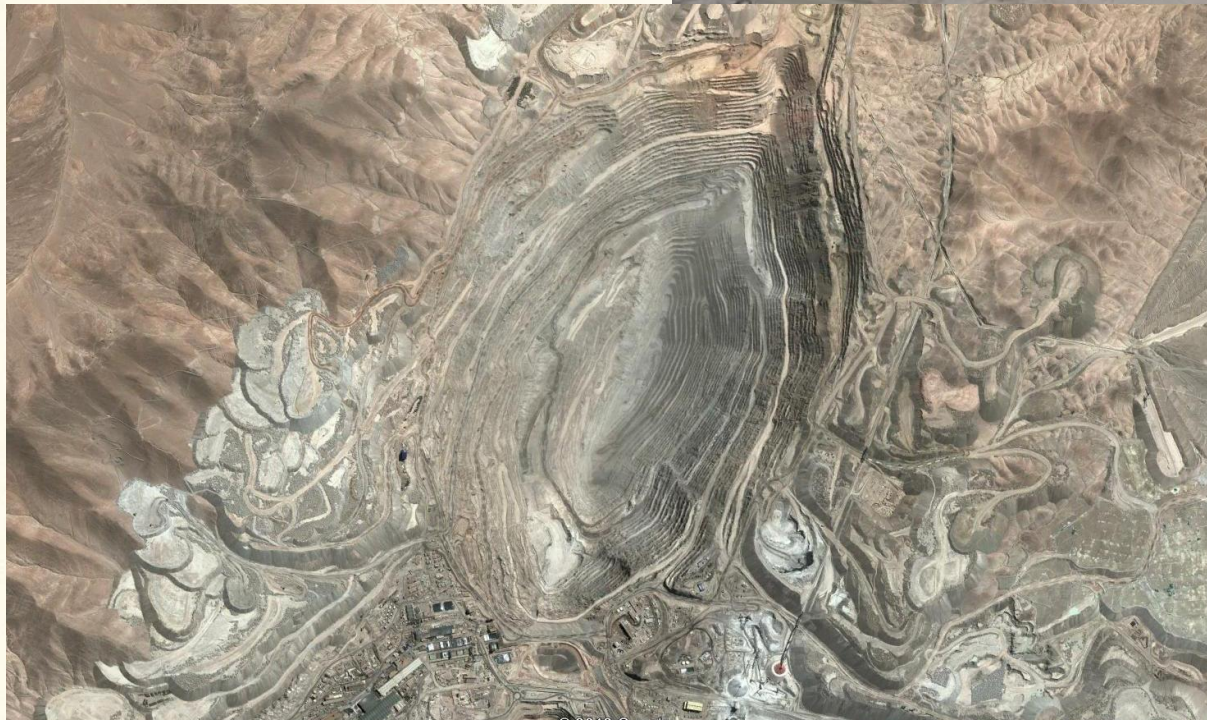
Typical in metal ore Mining e.g. copper porphyry deposits

Orebody dimensions: Massive or steeply dipping orebody, hard rock

Equipment: drilling and blasting, shovel and truck



Pros and Cons:



Deep open pit mines

Typical in metal ore Mining e.g. copper porphyry deposits

Orebody dimensions: Massive or steeply dipping orebody, hard rock

Equipment: drilling and blasting, shovel and truck



Pros and Cons:



Advantages

Economic for large, low-grade deposits; high productivity; better worker safety than underground; high recovery rate (up to 90–98%); long mine lives



Return to
pit design



Deep open pit mines

Typical in metal ore Mining e.g. copper porphyry deposits

Orebody dimensions: Massive or steeply dipping orebody, hard rock

Equipment: drilling and blasting, shovel and truck

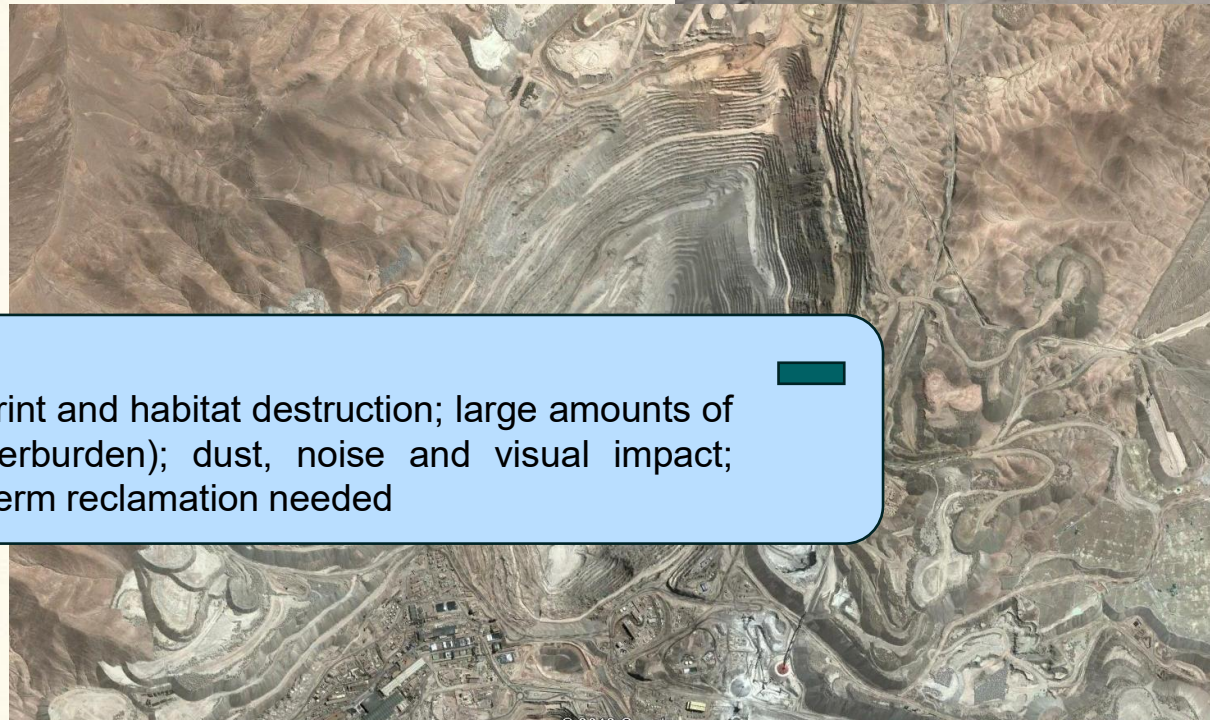


Pros and Cons:



Disadvantages

Huge land footprint and habitat destruction; large amounts of waste rock (overburden); dust, noise and visual impact; extensive long-term reclamation needed



Return to
pit design



Truck and shovel

Discontinuous loading and hauling in open pits

Suitable for all geologies, hard and soft rock.
Equipment must be well matched and coordinated for efficient operation

Mostly diesel-powered due to high payloads and flexibility requirements.

Payload of shown Komatsu 930E truck: 320 t

Bucket capacities can range up to 50 m³



Return to deep pit



Geometry of deep orebodies...

...is just one of many factors influencing underground mine design

[Return to orebody overview](#)



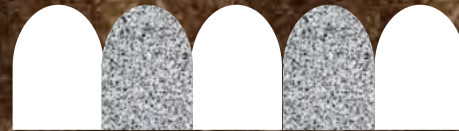
Based on stability, mining methods can be classified by how the roof is carried to keep open the void
Orebody geometry then serves as secondary criterion to further specify a mining method

Besides size and shape of the orebody, a range of other factors dictate which mining method to use
A very important factor is the strength and stability of both the orebody and the surrounding rock

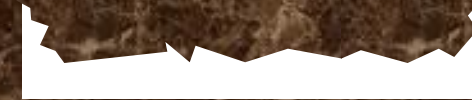
Naturally supported methods



Artificially supported methods



Unsupported (caving) methods

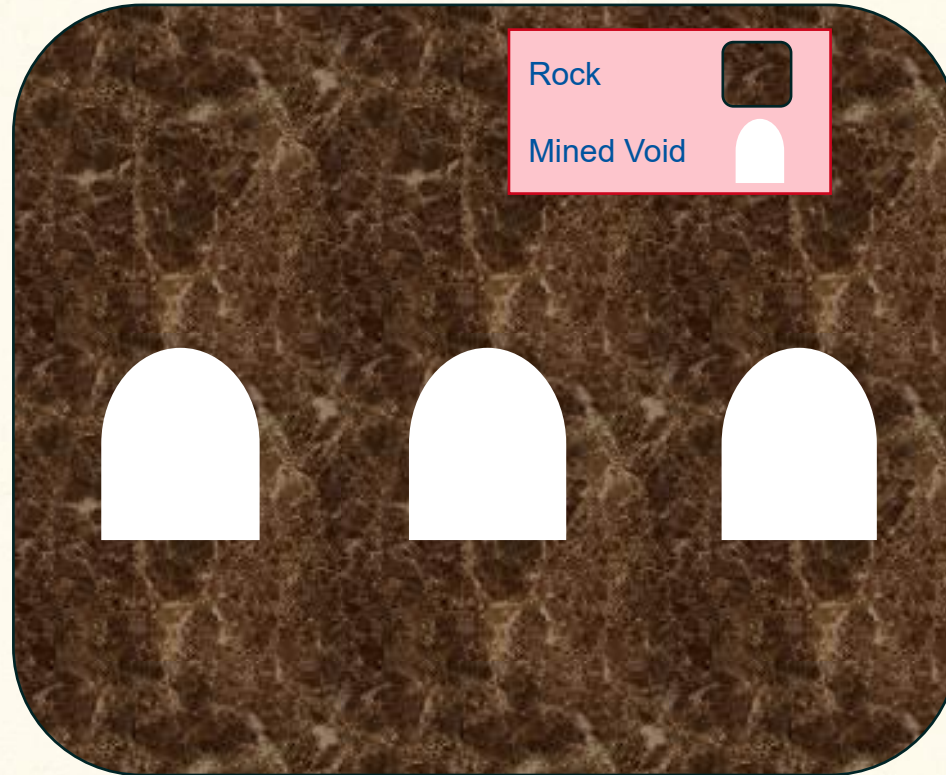


Naturally supported mining methods

The oldest family of systematic underground mining!

Dates back to at least the 13th century!

Typical tradeoff: high safety at low cost and simple logistics, but low extraction ratio
Methods include room and pillar, sublevel stoping



Openings remain stable due to competent rock and, depending on the method, unmined pillars.

Return to
underground
mine design



Artificially supported mining methods

Strong popularity since the 20th century due to new technologies and economic advantages!

Typical tradeoff: high cost and long cycle times, but high extraction ratio and good ore control

Methods include pillar recovery and cut and fill



Mined-out voids are filled with engineered backfill to improve stability and support continued extraction.

Return to
underground
mine design

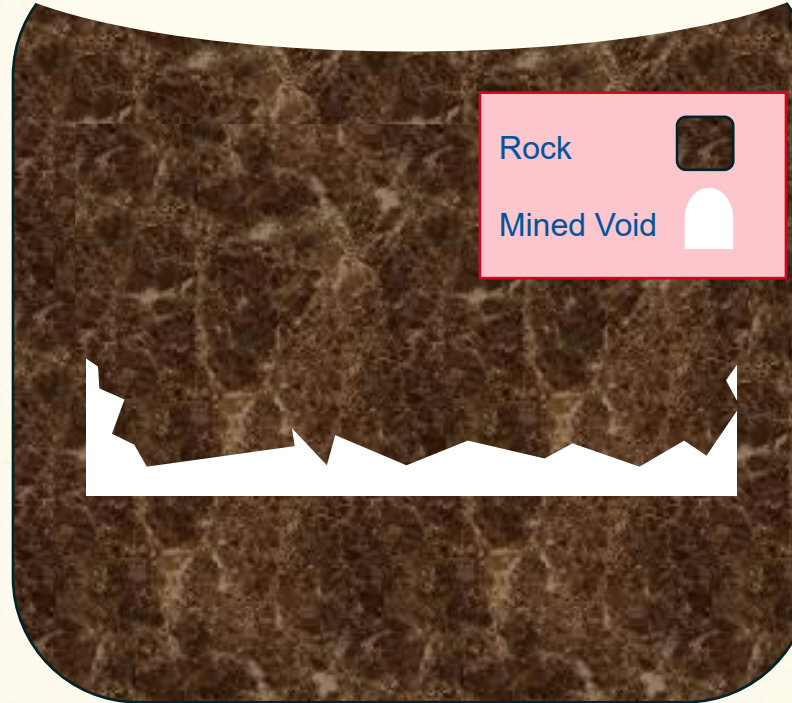


Unsupported mining (caving) methods

Very high potential for large-scale automation.

Typical tradeoff: very high productivity at low unit cost, but less selectivity and high impacts

Methods include longwall mining and block caving



The roof is not carried and deliberately collapses, causing subsidence on the surface

Return to
underground
mine design



Room and pillar mining

Naturally supported mining of flat & tabular, competent orebodies



Principle: grid layout of voids (“rooms”) and pillars. Once in the deposit, advancement = production



Typical resources



Typical equipment



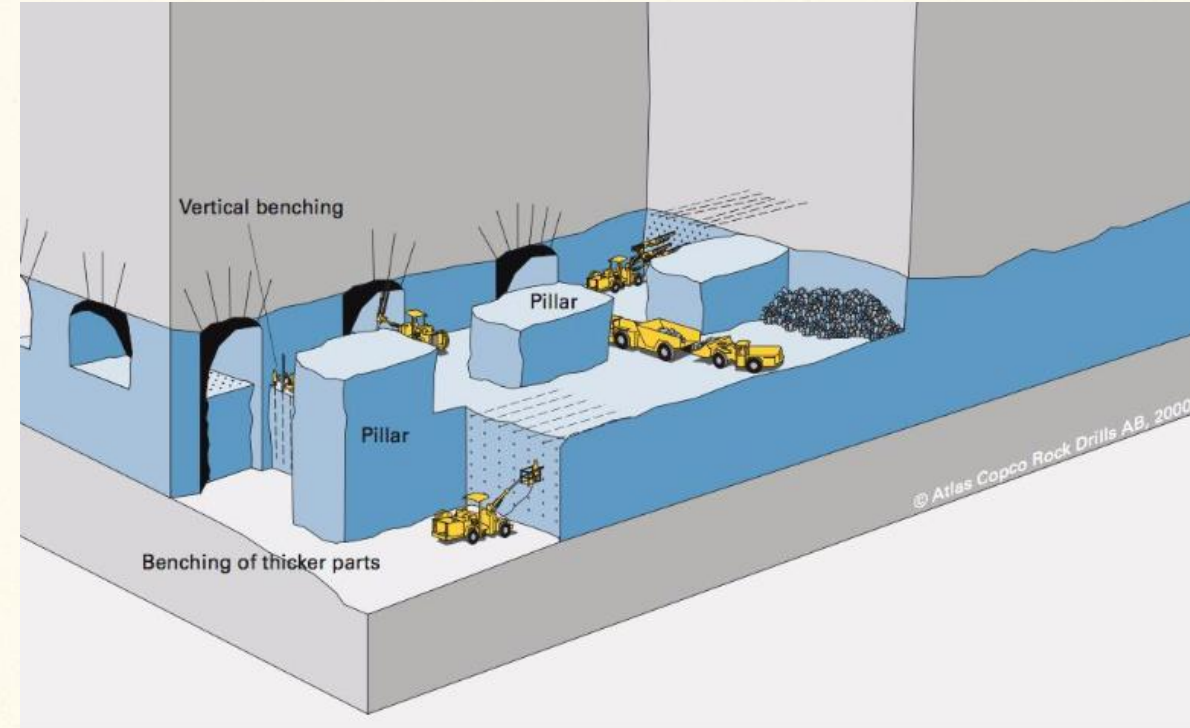
Advantages



Disadvantages



Strongest operational control



Return to naturally supported methods



Room and pillar mining

Naturally supported mining of flat & tabular, competent orebodies



Principle



Typical resources: evaporites like rock salt or potash



Typical equipment



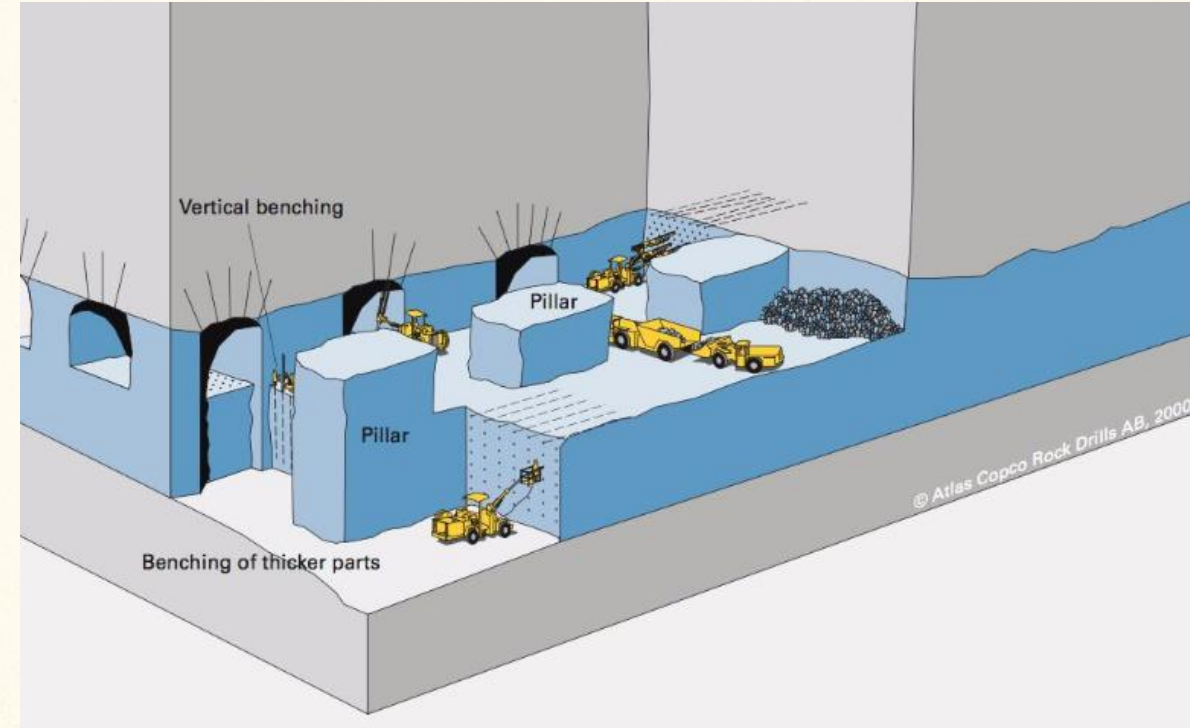
Advantages



Disadvantages



Strongest operational control



Return to naturally supported methods



Room and pillar mining

Naturally supported mining of flat & tabular, competent orebodies



Principle



Typical resources



Typical equipment: drilling & blasting, LHDs, conveyor belts, partially continuous miners



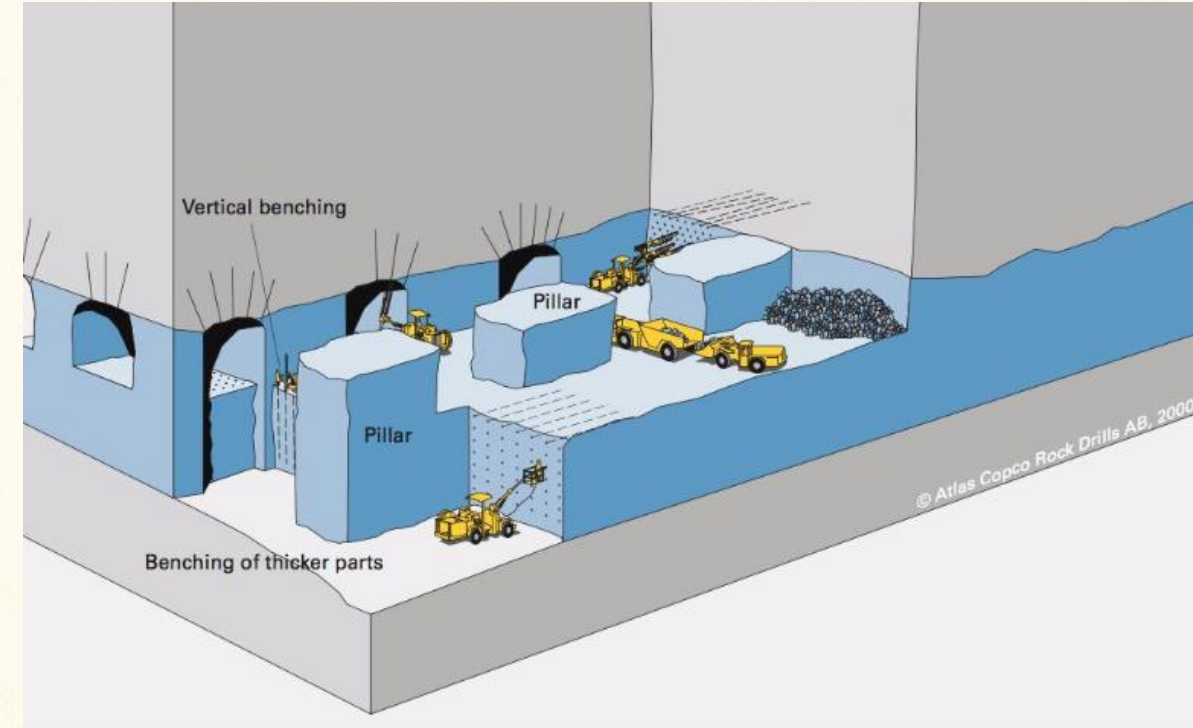
Advantages



Disadvantages



Strongest operational control



Return to naturally supported methods



Room and pillar mining

Naturally supported mining of flat & tabular, competent orebodies



Principle



Typical resources



Typical equipment



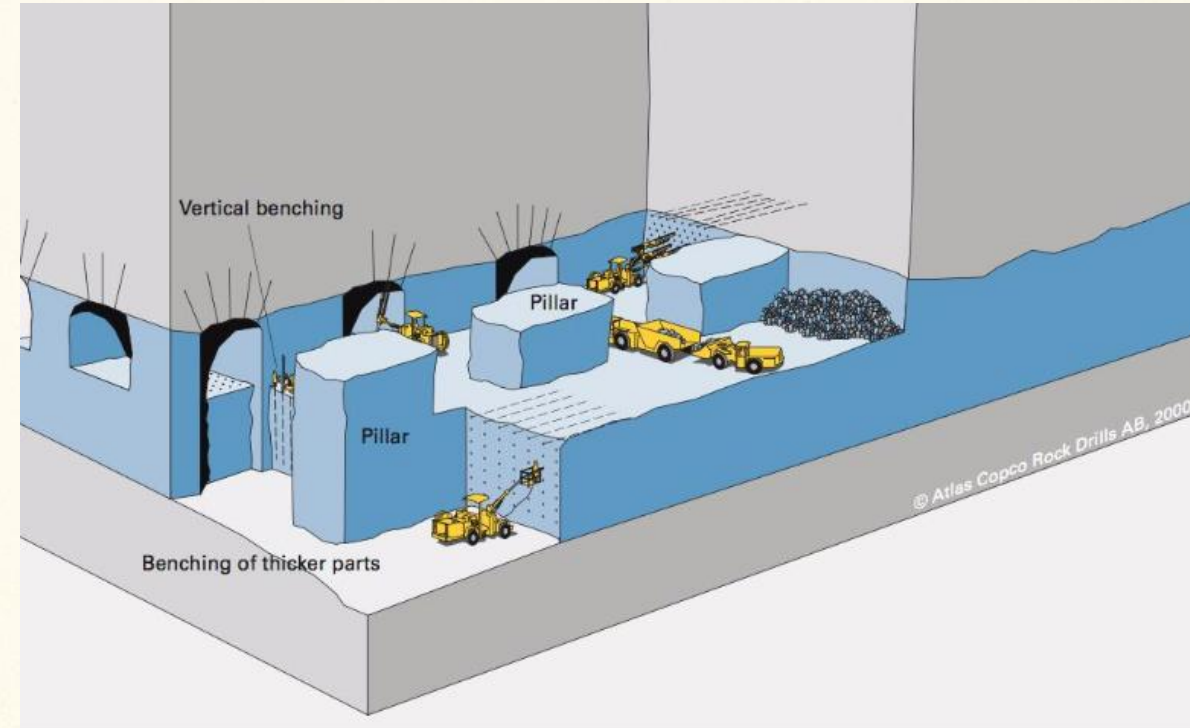
Advantages: simple, good ventilation control, flexible



Disadvantages



Strongest operational control



Return to naturally supported methods



Room and pillar mining

Naturally supported mining of flat & tabular, competent orebodies



Principle



Typical resources



Typical equipment



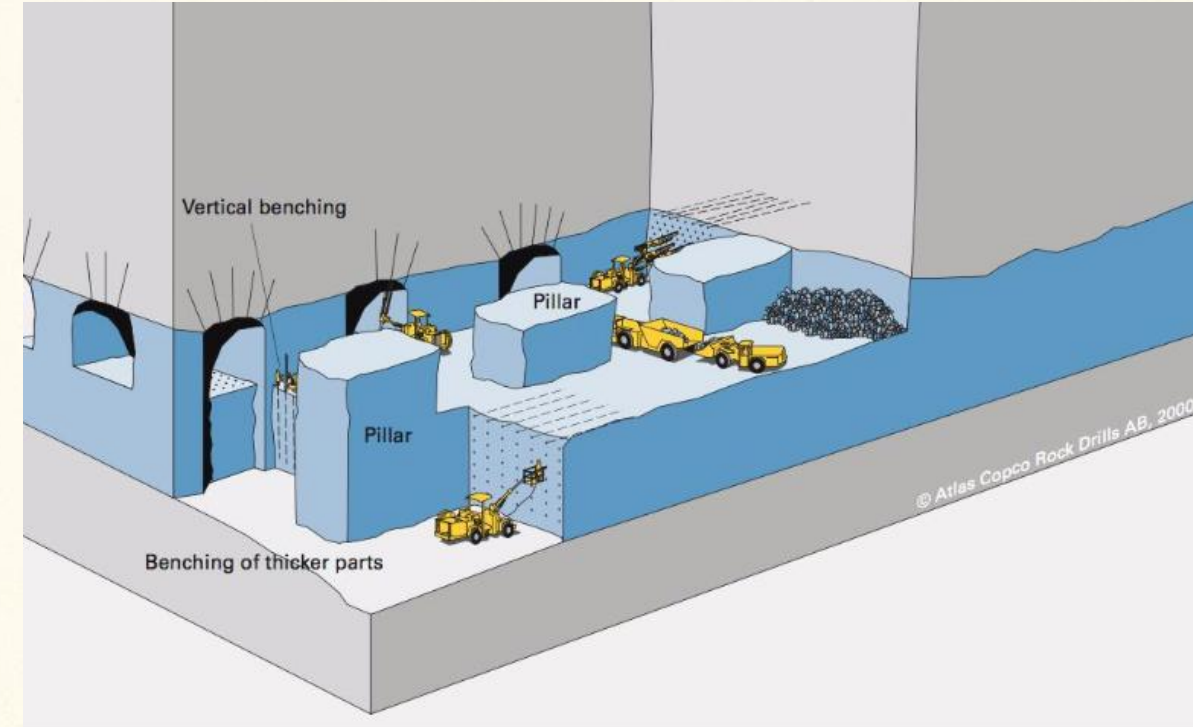
Advantages



Disadvantages: 40–60 % of ore locked in pillars, risk of pillar/roof collapse, ventilation harder over large areas



Strongest operational control



Return to naturally supported methods



Room and pillar mining

Naturally supported mining of flat & tabular, competent orebodies



Principle



Typical resources



Typical equipment



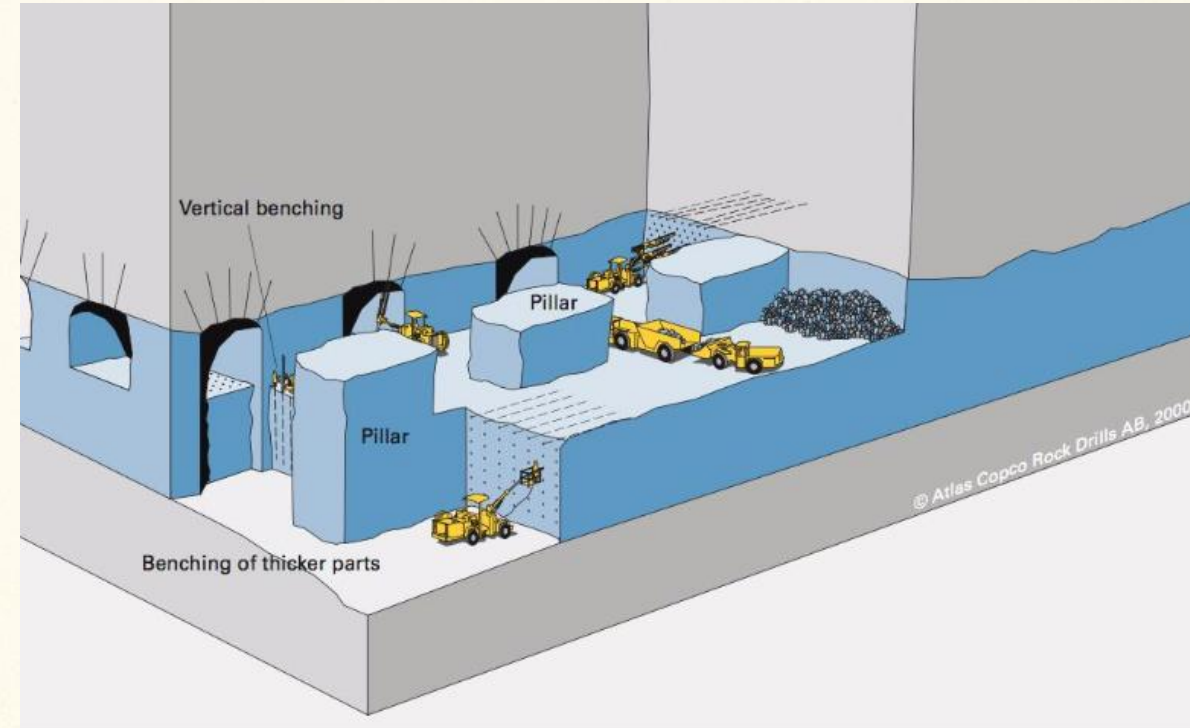
Advantages



Disadvantages



Strongest operational control: pillar dimensions – stability vs. ore losses



Return to naturally supported methods



Sublevel (open) stoping

Naturally supported mining of steeply dipping, competent orebodies



Principle: long-hole drilling and blasting from sublevels into large open stopes; ore drawn from below



Typical resources



Typical equipment



Advantages



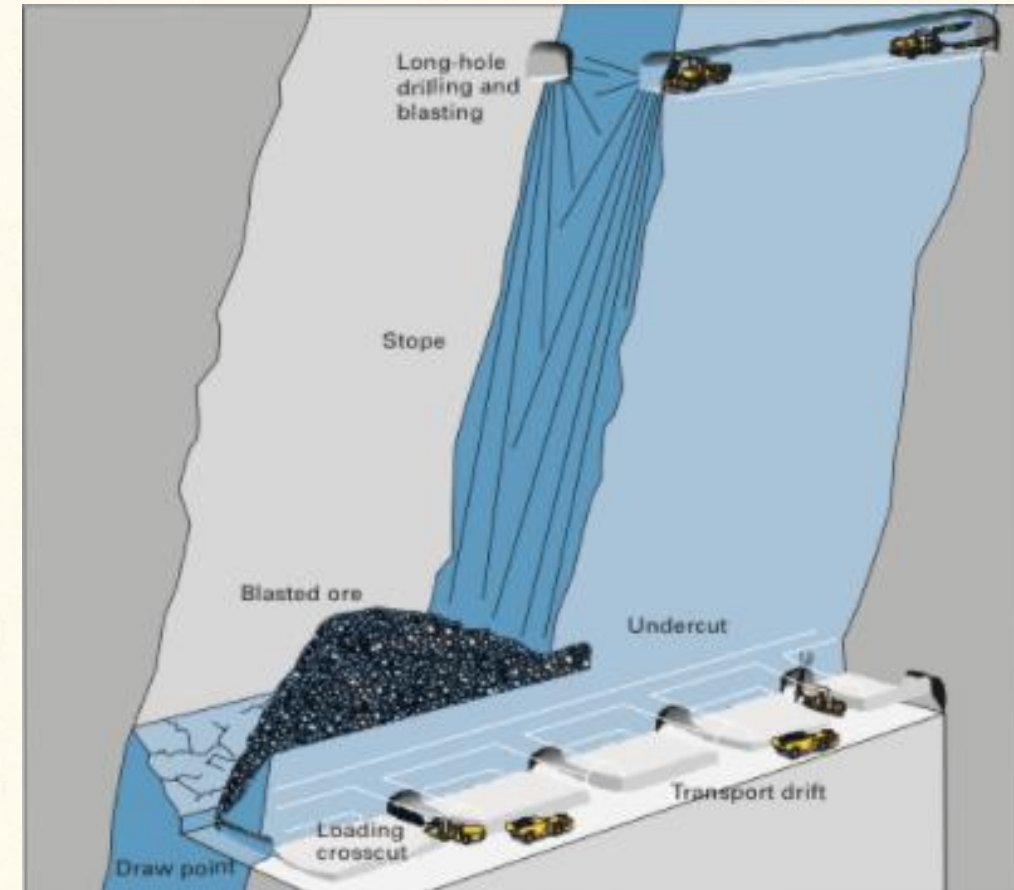
Disadvantages



Strongest operational control



Return to naturally supported methods



Sublevel (open) stoping

Naturally supported mining of steeply dipping, competent orebodies



Principle



Typical resources: steeply dipping, competent orebodies – Zn, Pb, Cu, Au



Typical equipment



Advantages



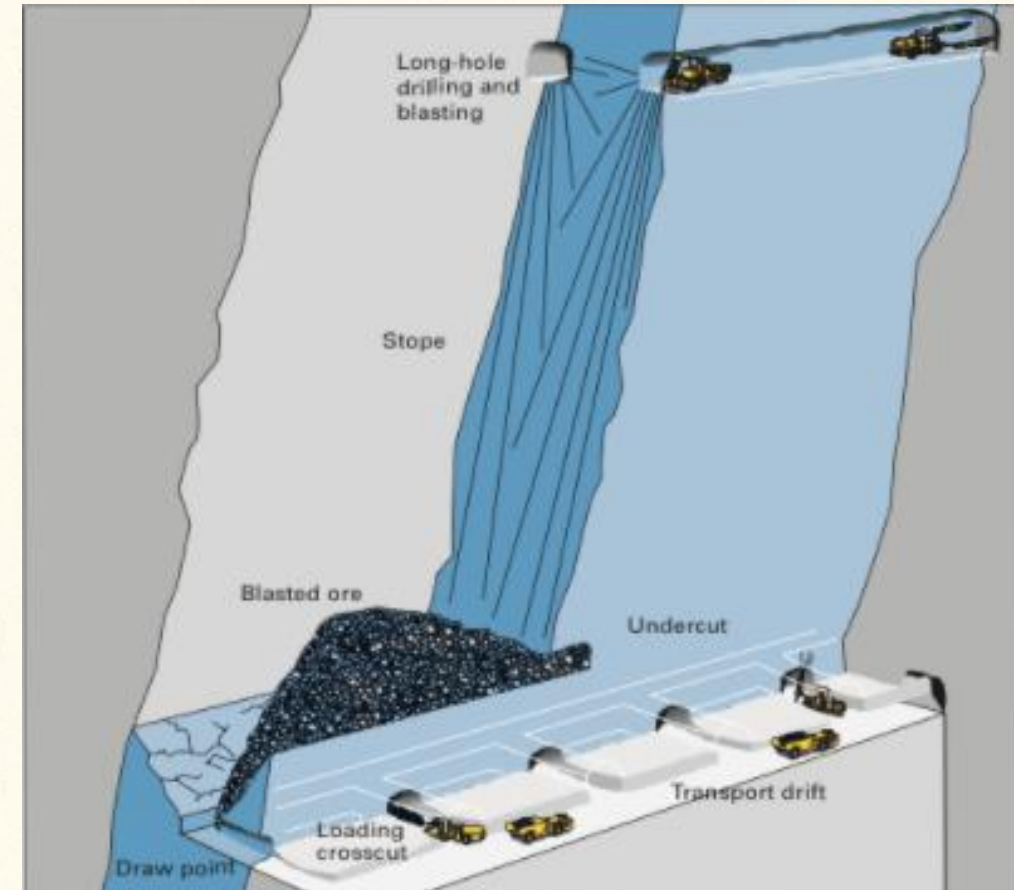
Disadvantages



Strongest operational control



Return to naturally supported methods



Sublevel (open) stoping

Naturally supported mining of steeply dipping, competent orebodies



Principle



Typical resources



Typical equipment: long-hole production drill, jumbo, LHD, trucks, rock bolters



Advantages



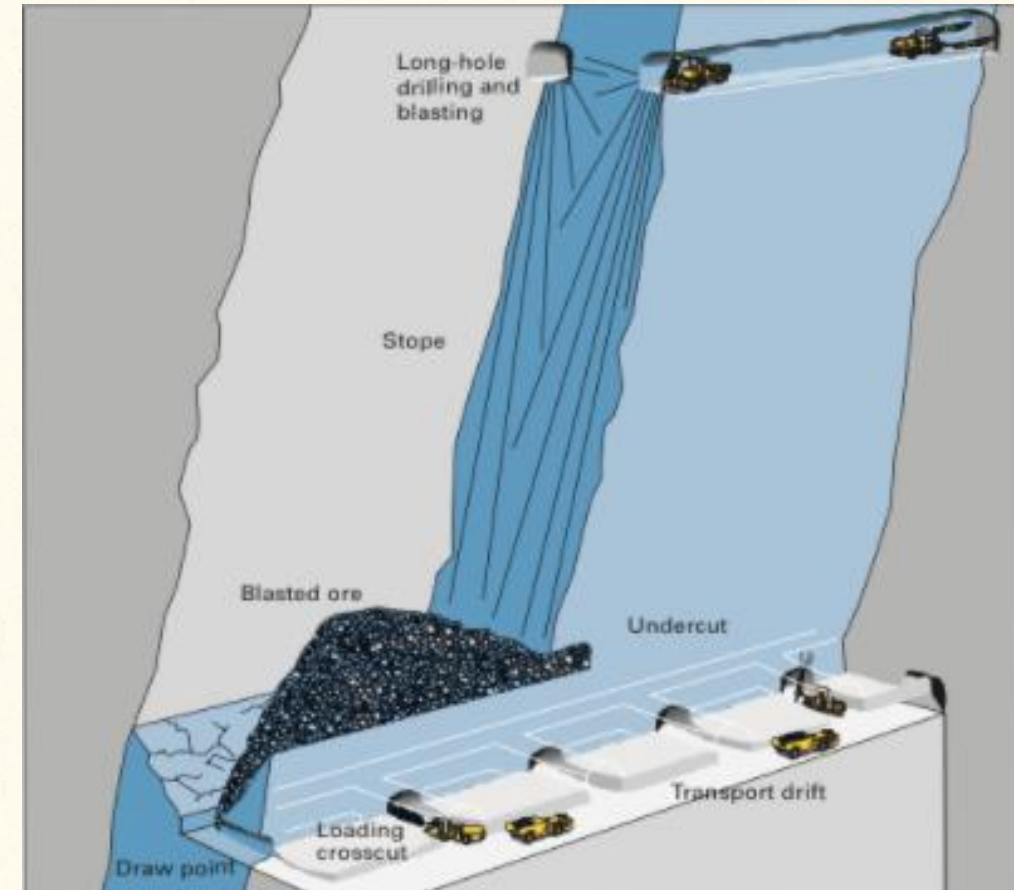
Disadvantages



Strongest operational control



Return to naturally supported methods



Sublevel (open) stoping

Naturally supported mining of steeply dipping, competent orebodies



Principle



Typical resources



Typical equipment



Advantages: high productivity, low unit cost, highly mechanised, safe (no workers in open stope)



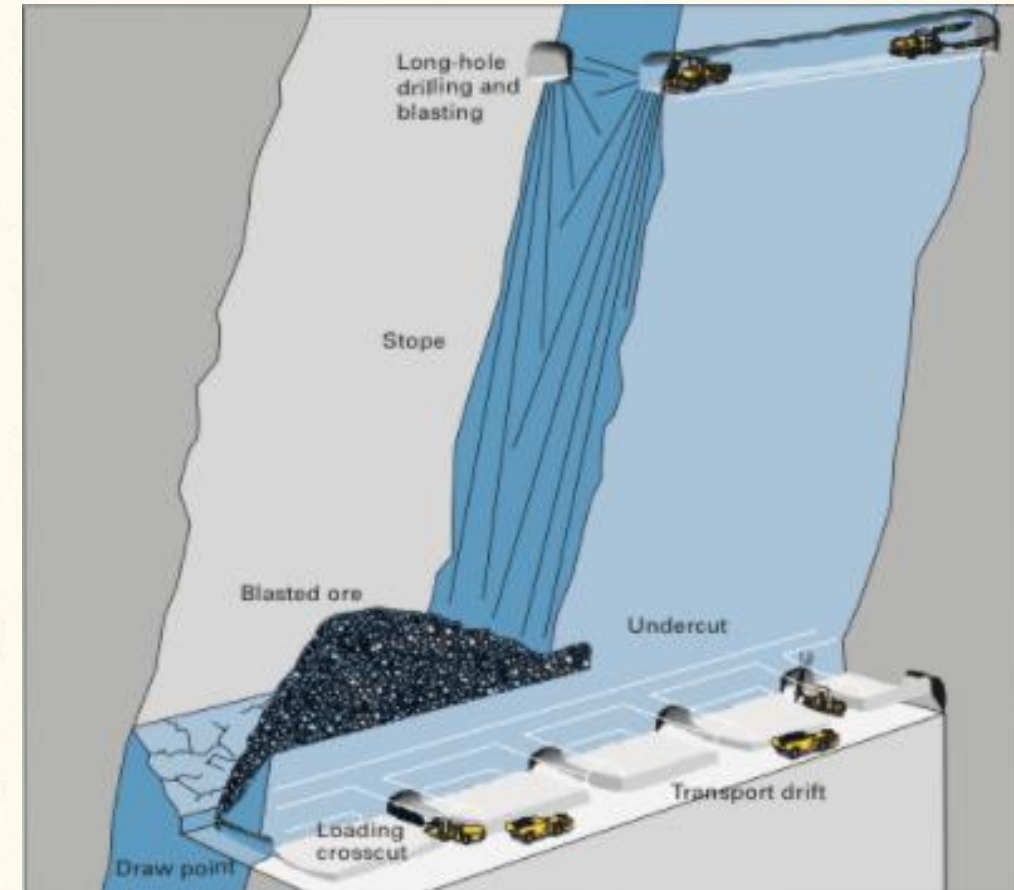
Disadvantages



Strongest operational control



Return to naturally supported methods



Sublevel (open) stoping

Naturally supported mining of steeply dipping, competent orebodies



Principle



Typical resources



Typical equipment



Advantages



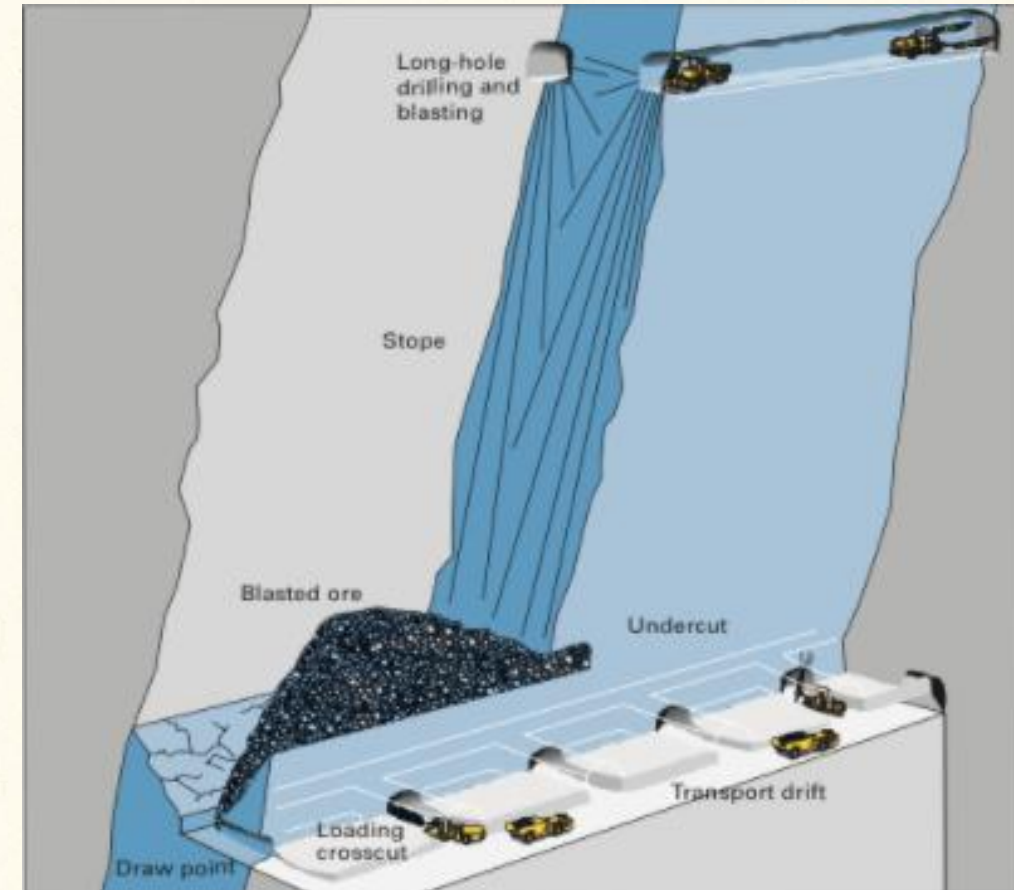
requires competent rock; extensive development; dilution from the stope walls



Strongest operational control



Return to naturally supported methods



Sublevel (open) stoping

Naturally supported mining of steeply dipping, competent orebodies



Principle



Typical resources



Typical equipment



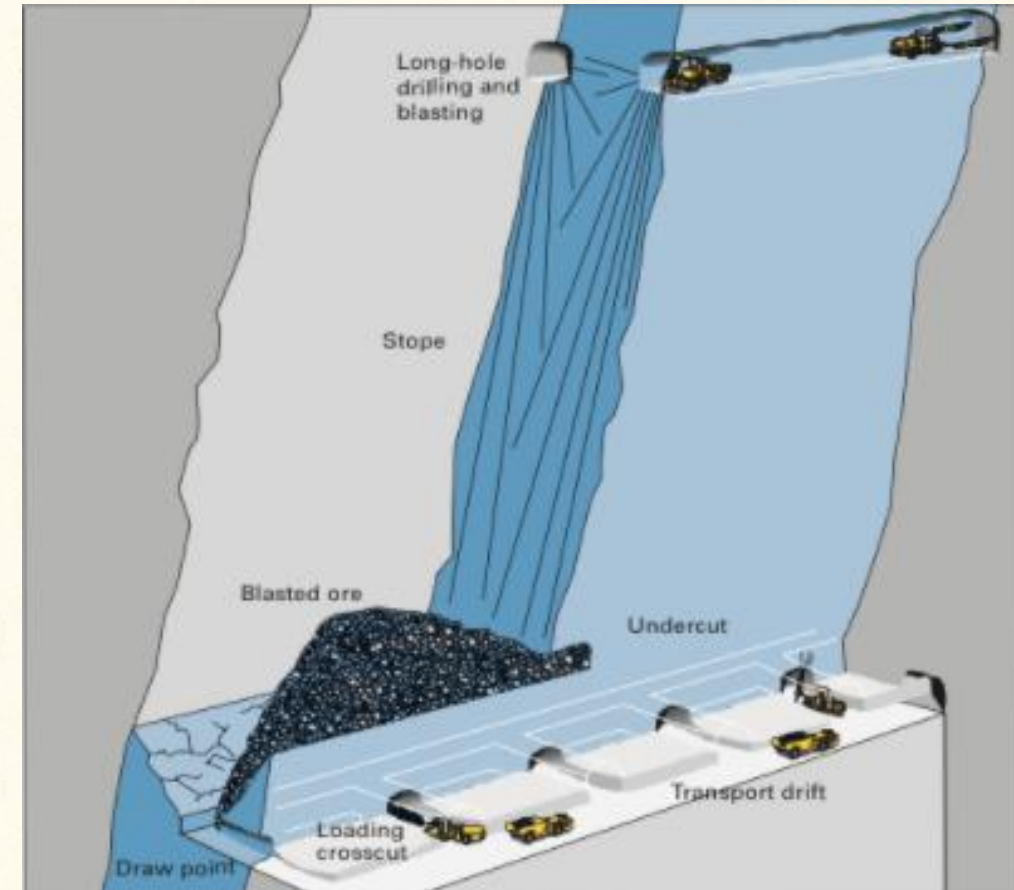
Advantages



Disadvantages



Strongest operational control: drilling accuracy, ore fragmentation, dilution



Cut and fill mining

Artificially supported mining of narrow, steeply dipping orebodies



Principle: mine in horizontal slices, load ore, then place backfill upward to support the next cut



Typical resources



Types of backfill



Advantages



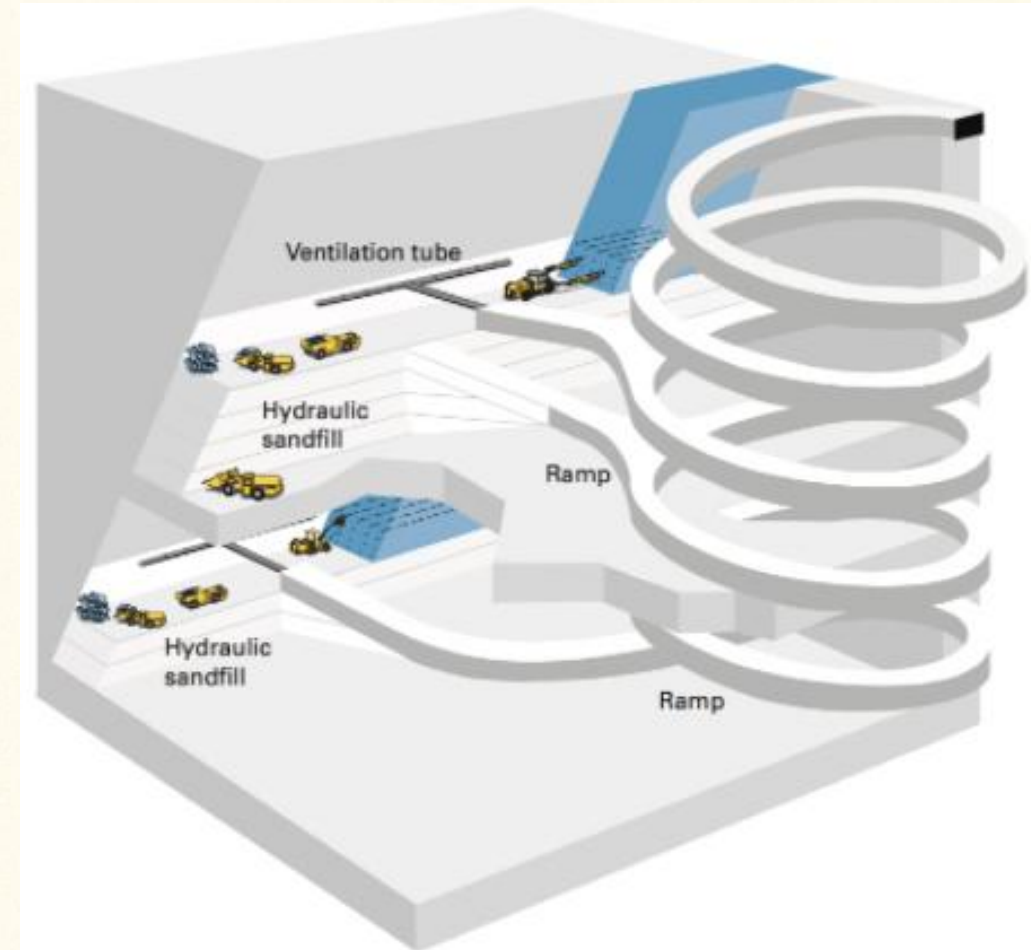
Disadvantages



Strongest operational control



Return to Artificially supported methods



Cut and fill mining

Artificially supported mining of narrow, steeply dipping orebodies



Principle



Typical resources: high-value, steeply dipping veins – gold and base metals



Types of backfill



Advantages



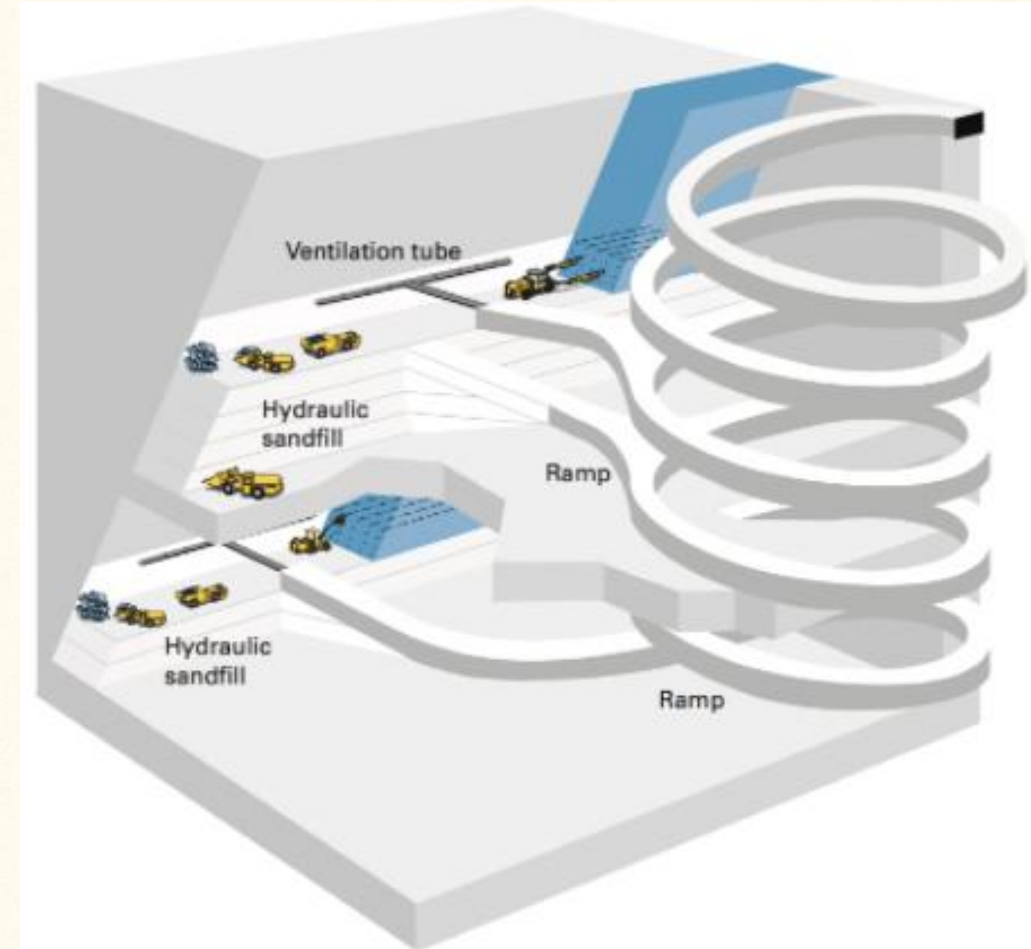
Disadvantages



Strongest operational control



Return to Artificially supported methods



Cut and fill mining

Artificially supported mining of narrow, steeply dipping orebodies



Principle



Typical resources



Types of backfill: usually paste fill (also hydraulic or rock fill)



Advantages



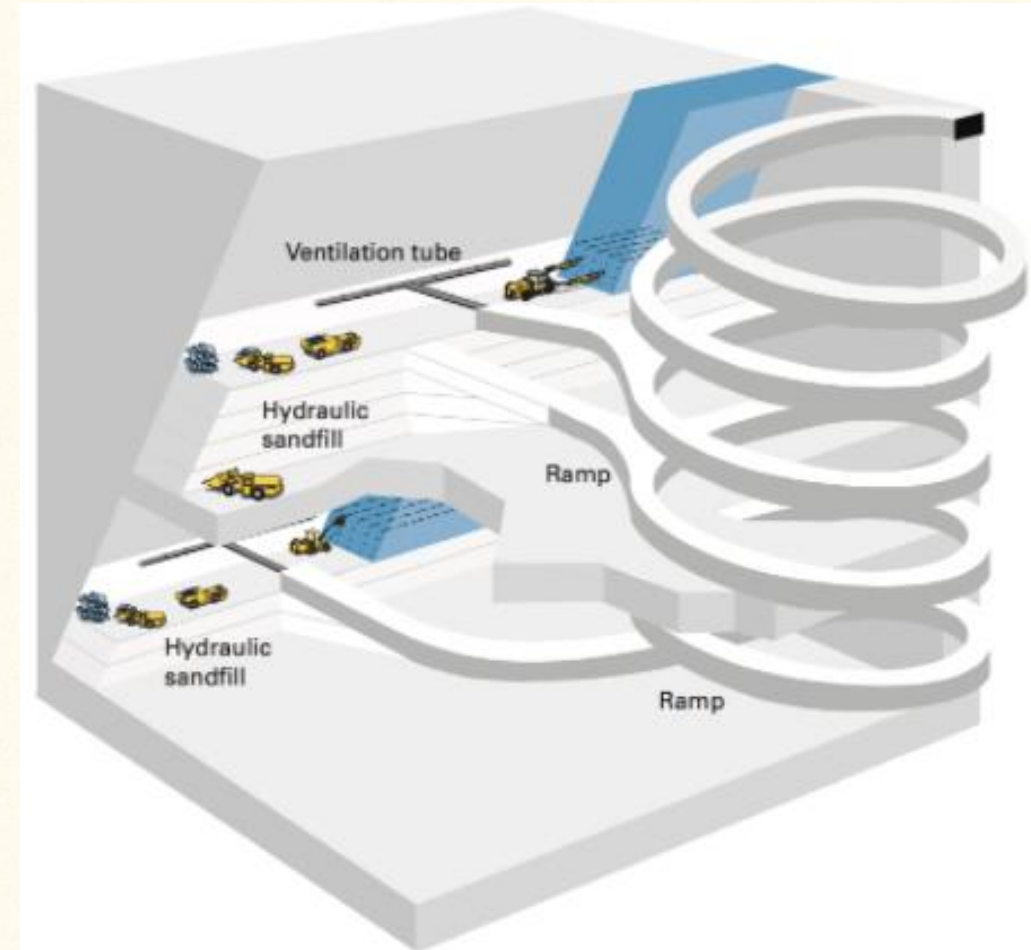
Disadvantages



Strongest operational control



Return to Artificially supported methods



Cut and fill mining

Artificially supported mining of narrow, steeply dipping orebodies



Principle



Typical resources



Types of backfill



Advantages: highly selective, low dilution, suits irregular orebodies

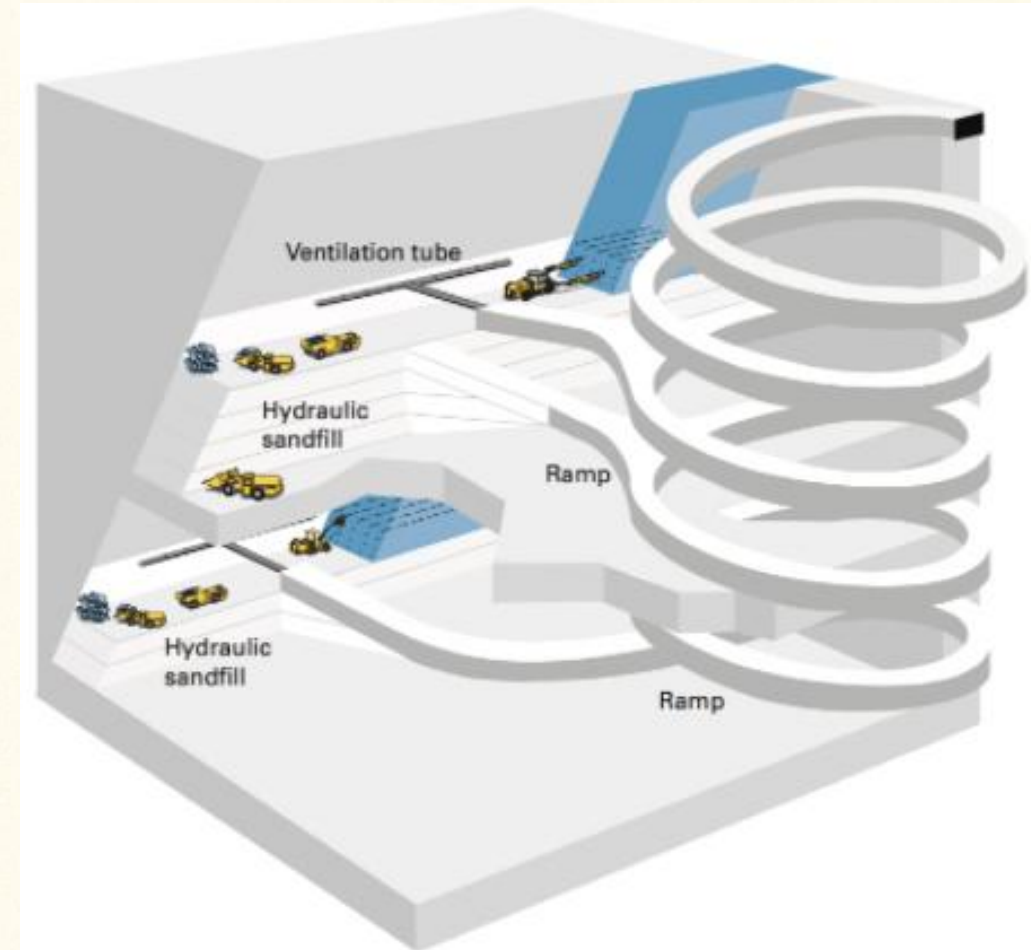


Disadvantages



Strongest operational control

Return to Artificially supported methods



Cut and fill mining

Artificially supported mining of narrow, steeply dipping orebodies



Principle



Typical resources



Types of backfill



Advantages

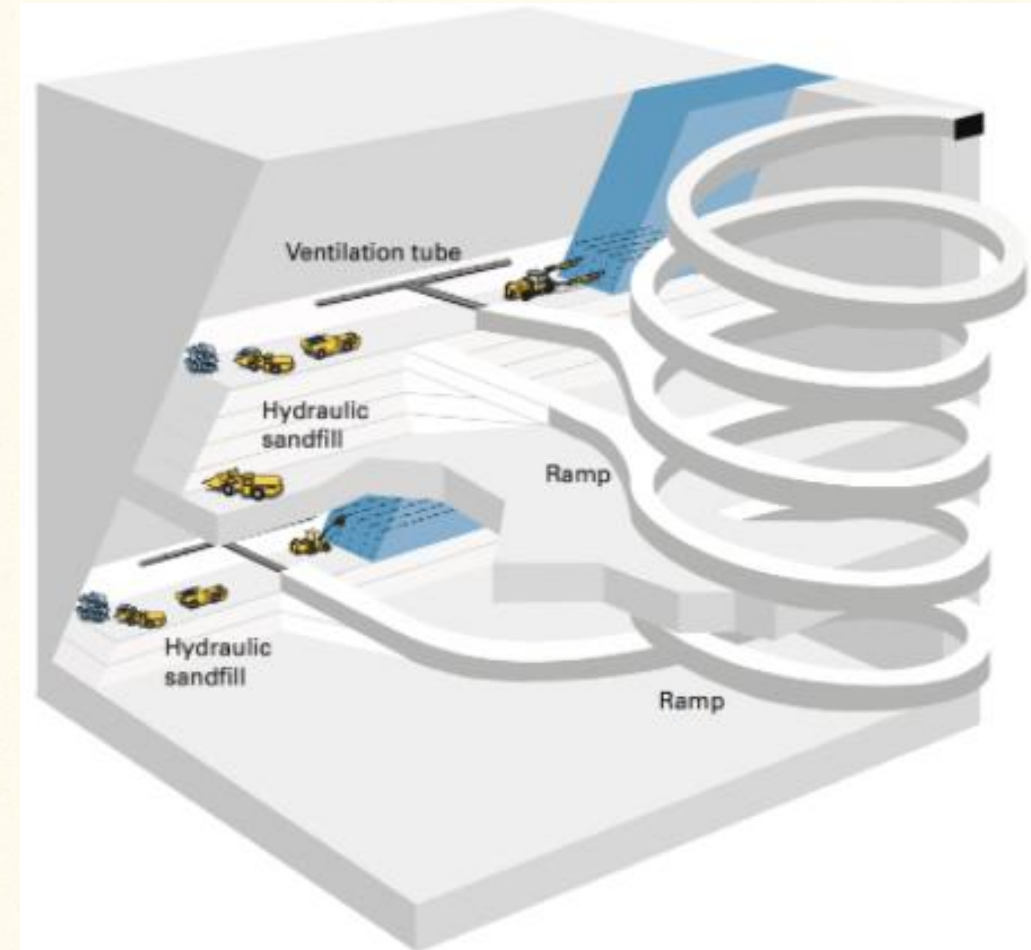


Disadvantages: high unit costs, fill handling is a logistical challenge



Strongest operational control

Return to Artificially supported methods



Cut and fill mining

Artificially supported mining of narrow, steeply dipping orebodies



Principle



Typical resources



Types of backfill



Advantages



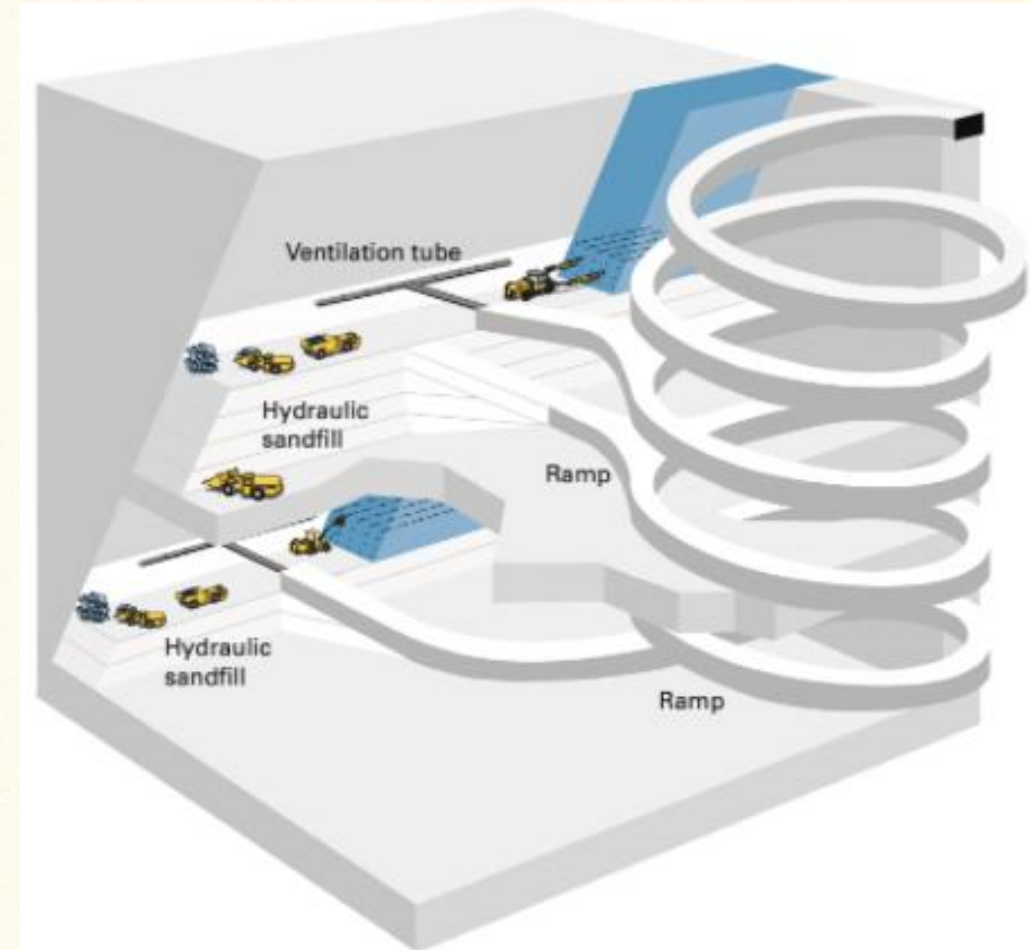
Disadvantages



Strongest operational control: backfill quality
– stability and dilution control



Return to Artificially
supported methods



Longwall mining



Principle: shearer cuts long face under hydraulic supports, roof caves behind



Typical resources



Typical equipment



Advantages



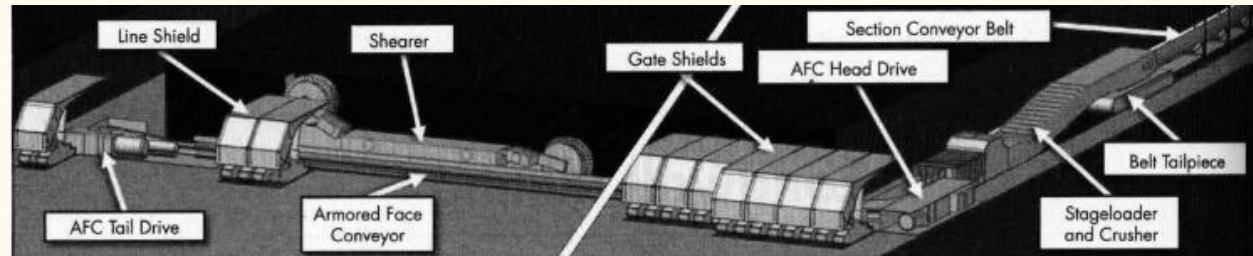
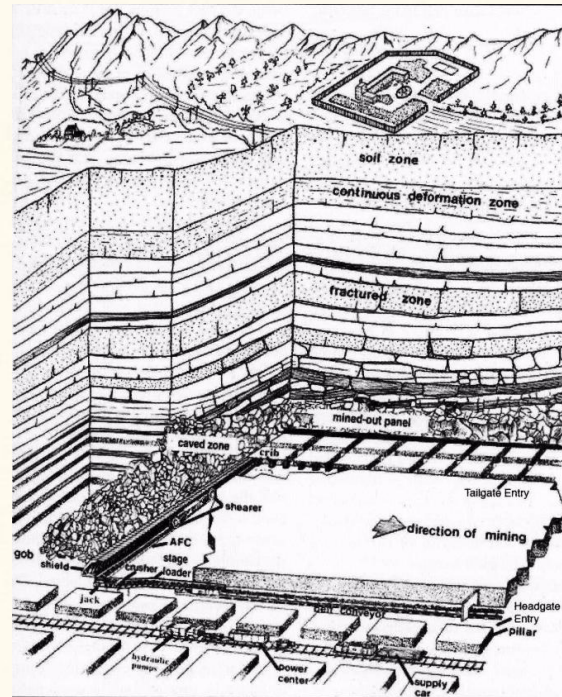
Disadvantages



Strongest operational Control



Return to
unsupported
methods



Longwall mining



Principle



Typical resources: flat coal seams, tabular soft deposits



Typical equipment



Advantages



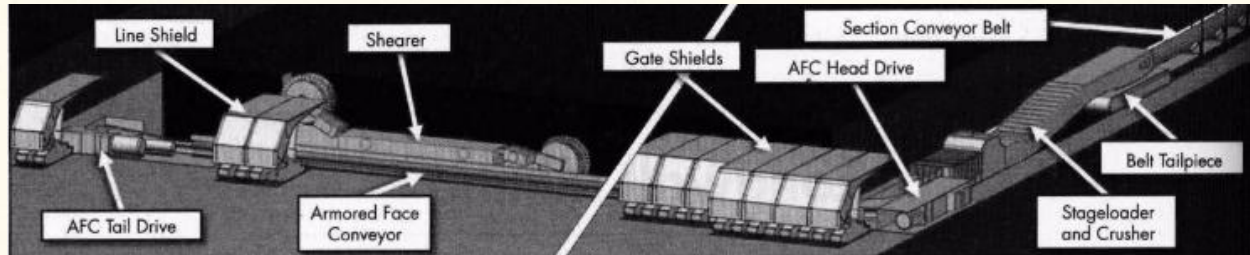
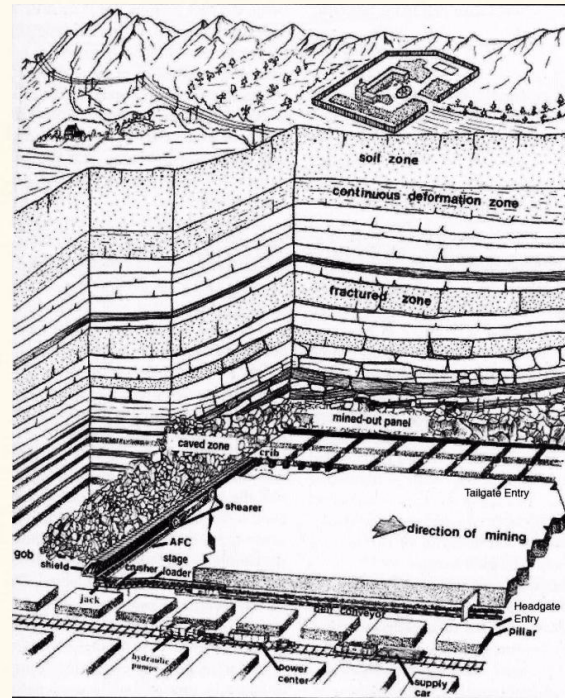
Disadvantages



Strongest operational Control



Return to
unsupported
methods



Longwall mining



Principle



Typical resources



Typical equipment: shearer, AFC conveyor, hydraulic shields, stage loader



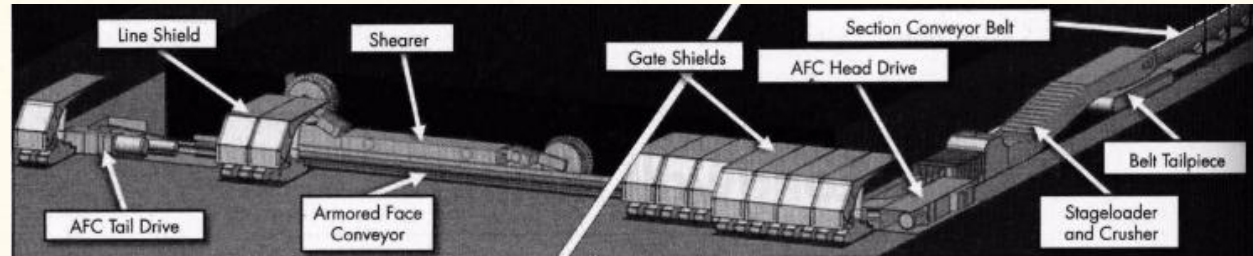
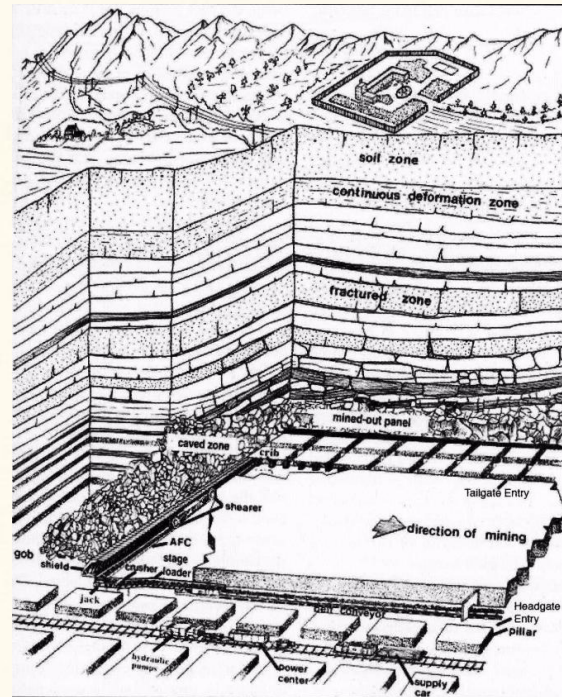
Advantages



Disadvantages



Strongest operational Control



Longwall mining



Principle



Typical resources



Typical equipment



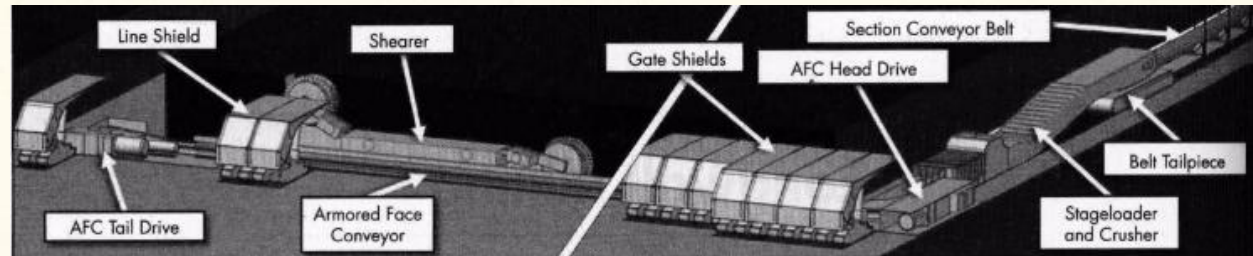
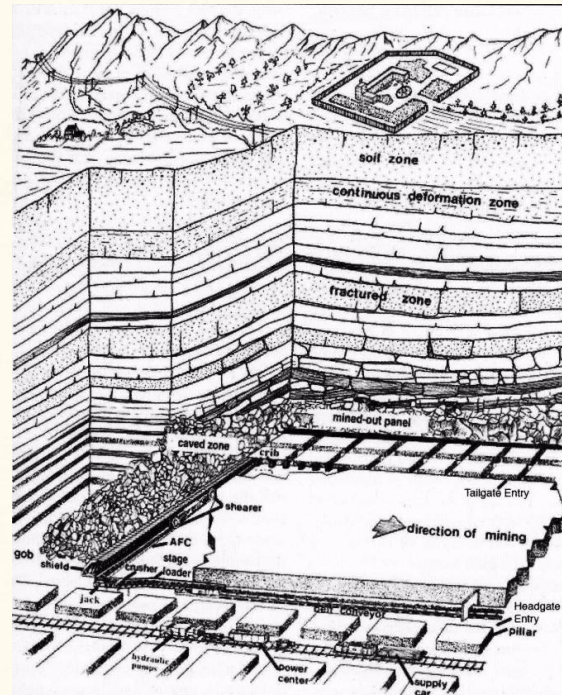
Advantages: highly productive, low unit cost, high automation potential



Disadvantages



Strongest operational Control



Longwall mining



Principle



Typical resources



Typical equipment



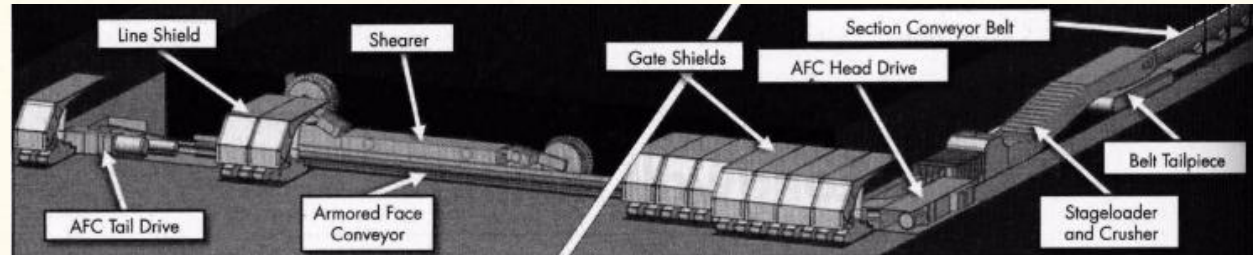
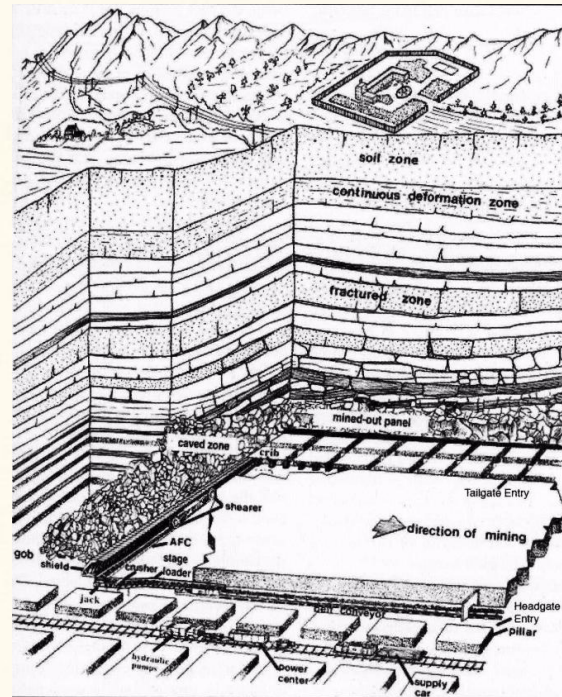
Advantages



Disadvantages: high capital cost, low flexibility, controlled subsidence



Strongest operational Control



Longwall mining



Principle



Typical resources



Typical equipment



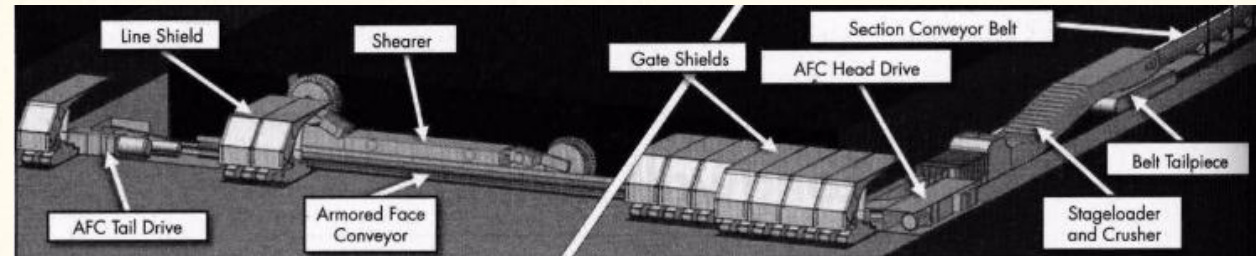
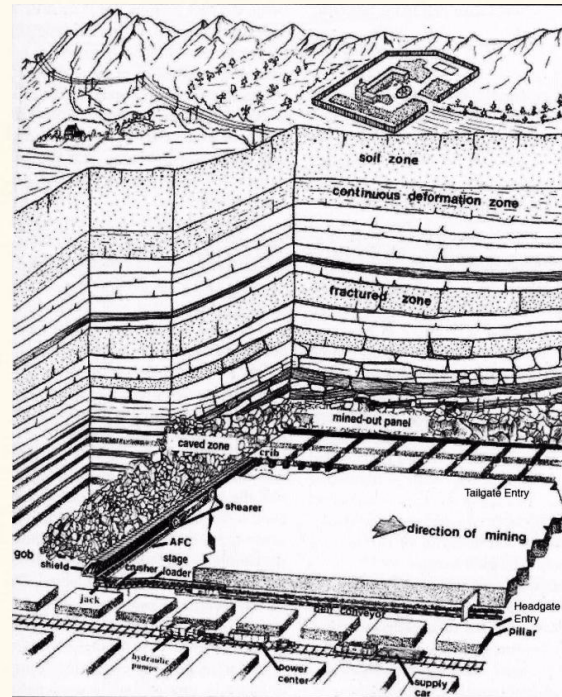
Advantages



Disadvantages



Face advance, roof support and conveyor continuity



Block caving



Principle: undercut the orebody so gravity fractures and caves it; ore flows to drawpoints



Typical resources



Typical equipment



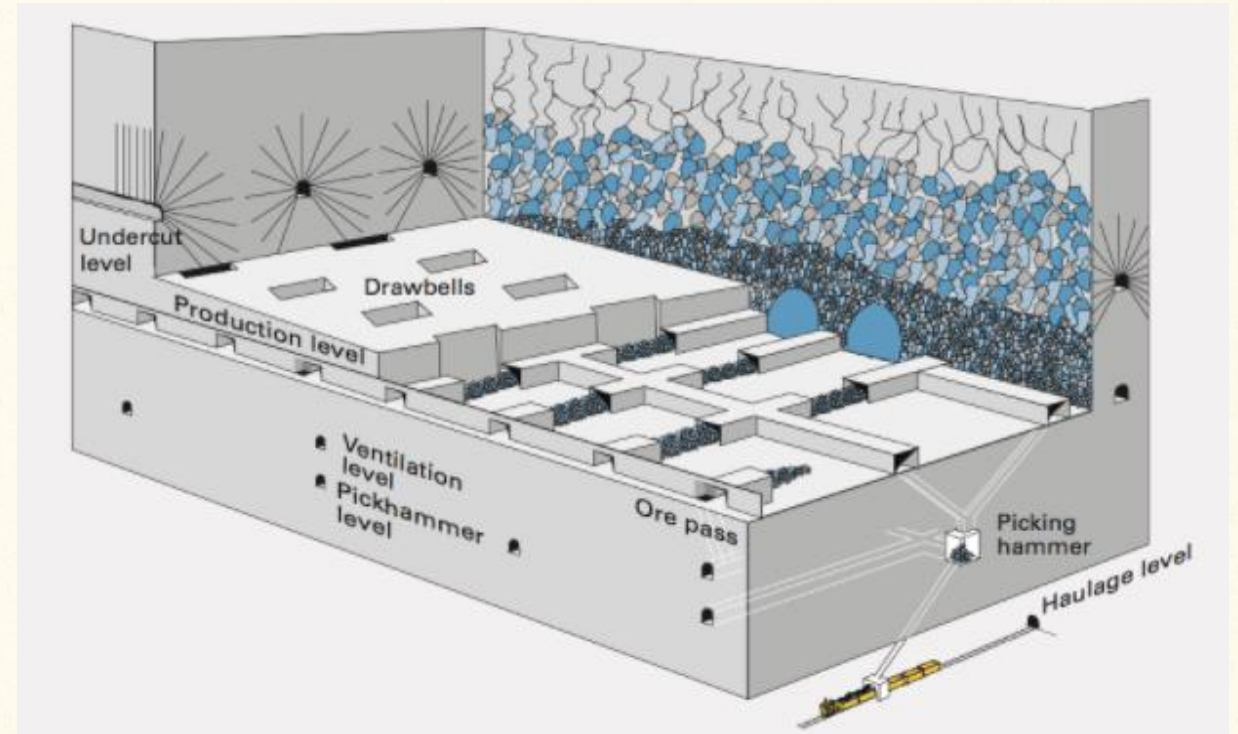
Advantages



Disadvantages



Strongest operational Control



Block caving



Principle



Typical resources: large low-grade orebodies
– Cu, Mo, Fe, diamond (kimberlite)



Typical equipment



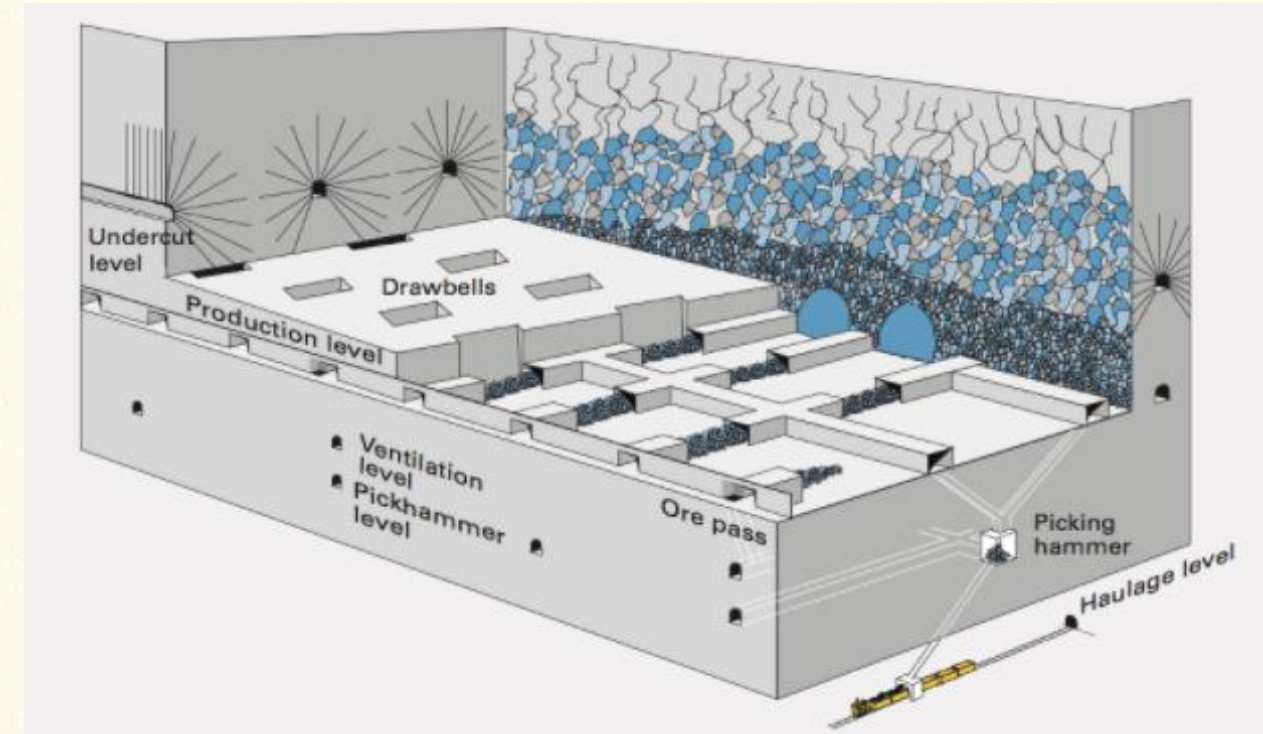
Advantages



Disadvantages



Strongest operational Control



Block caving



Principle



Typical resources



Typical equipment: jumbo drills, LHDs, trucks, gyratory crushers, conveyors, rock bolters



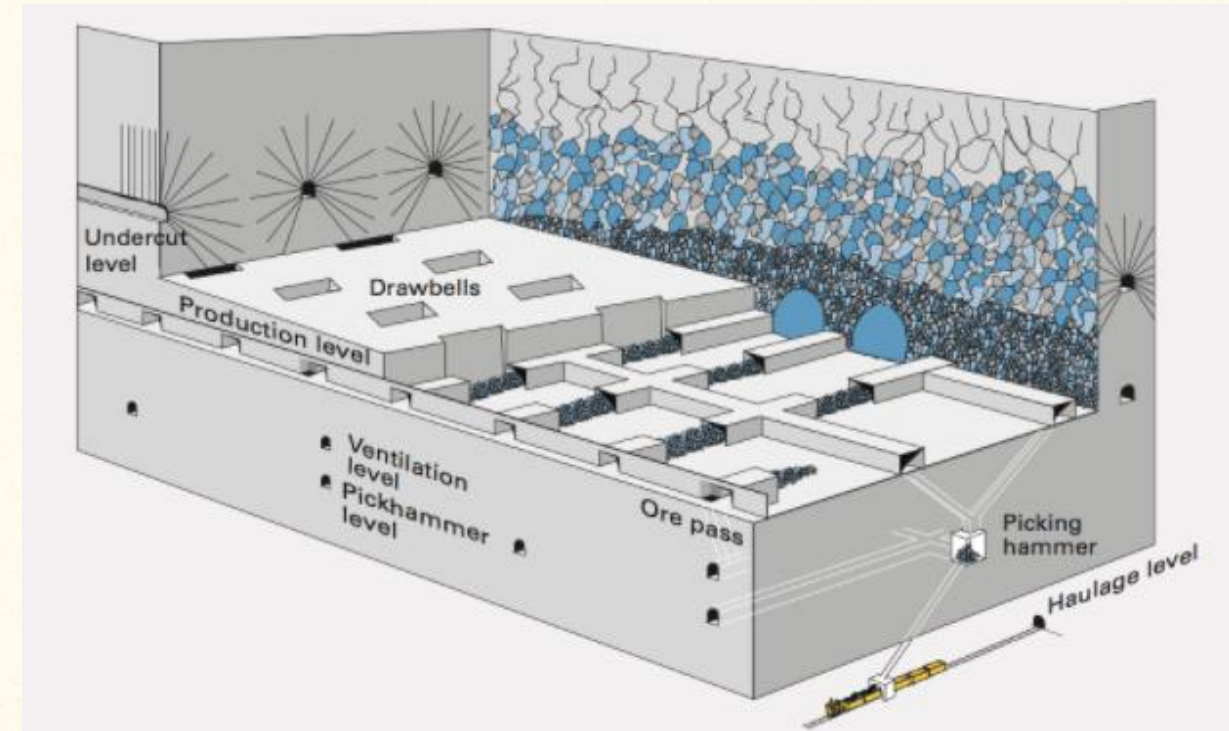
Advantages



Disadvantages



Strongest operational Control



Block caving



Principle



Typical resources



Typical equipment



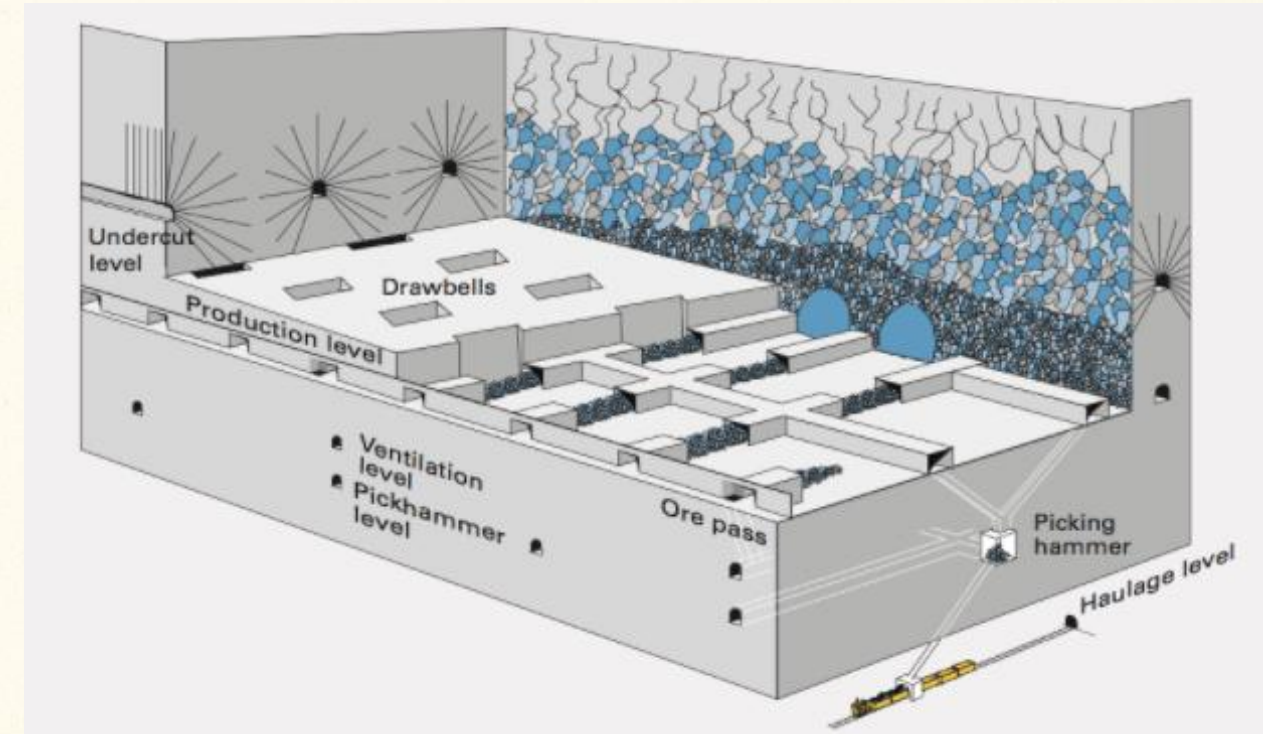
Advantages: low op cost / tonne, 20–40 kt / day, highly mechanised



Disadvantages



Strongest operational Control



Block caving



Principle



Typical resources



Typical equipment



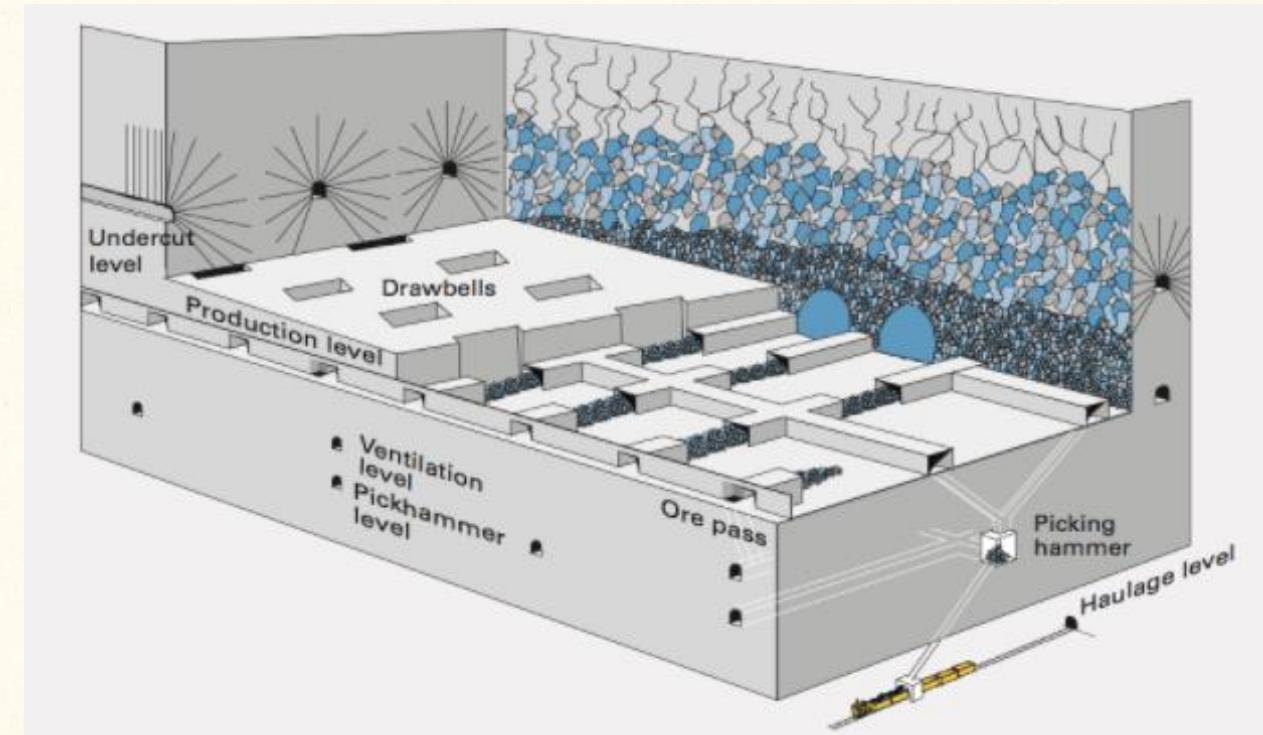
Advantages



Disadvantages: extensive development, slow ramp-up, large surface subsidence



Strongest operational Control



Block caving



Principle



Typical resources



Typical equipment



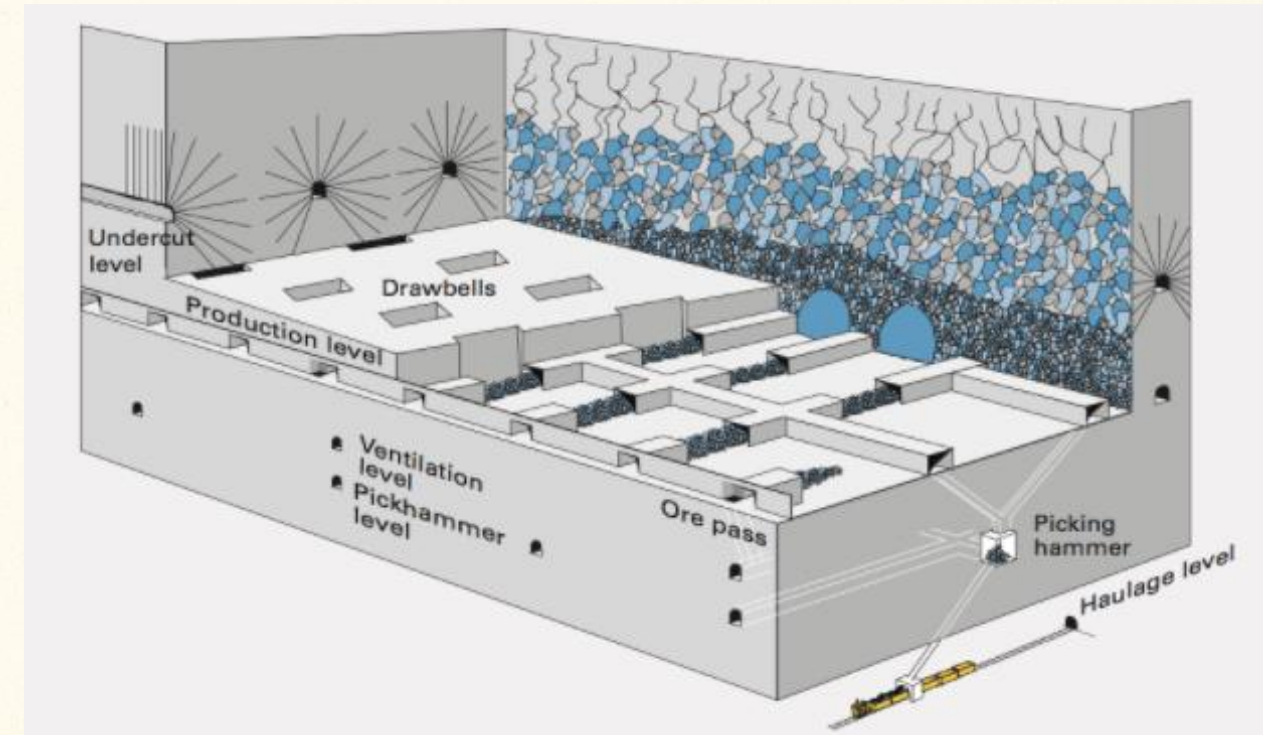
Advantages



Disadvantages



Draw control – balancing ore recovery, dilution and cave propagation



Safety...



...first, last,
and always!

For a long time, the mining industry has been putting a focus on occupational safety:

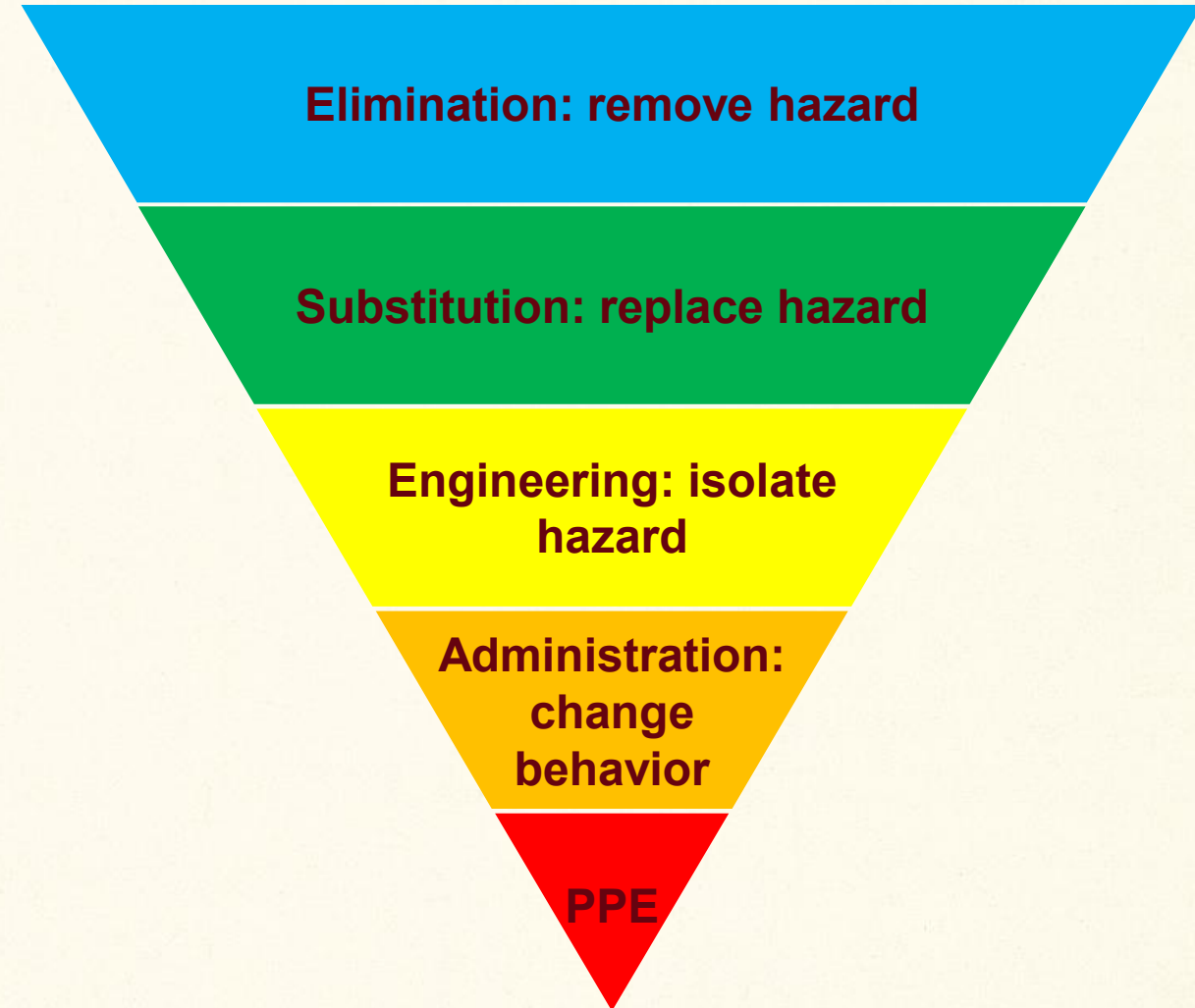
PPE is just the “last layer”

Safety procedures, training, and engineered controls aim to avoid or reduce hazards in the first place

Areas most relevant to safety include ground control, ventilation, energy isolation, and traffic management

In modern operations, automation and remote operation boost safety by moving humans further away from hazardous areas

Return to
underground
mine design



Selectivity as a key consideration: maximize ore tonnage or minimize dilution?

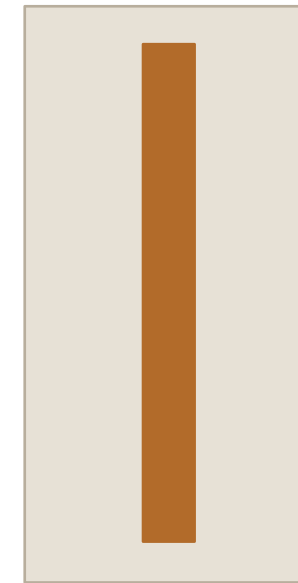
Depends on the ore type:

- Narrow, high-grade ore zones generally require very selective mining
- Wide orebodies with some grade continuity allow for bulk mining, posing higher requirements to processing

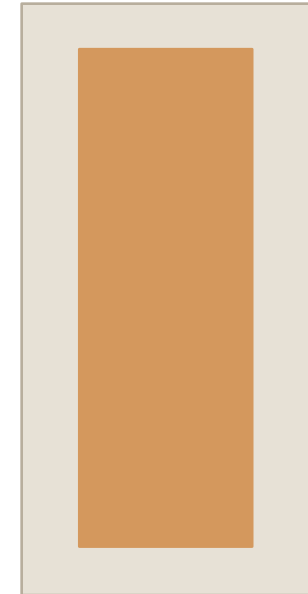
Can be controlled via drillhole spacing, size of blasting rounds, and other parameters

Highly selective mining is very precise, but usually much slower than bulk mining

Selective vs. bulk extraction



Narrow ore zone



Wider mined zone
more tonnes,
more dilution

Longwall mining



Equipment: Powered shield support, shearer and face conveyor

Automation of underground mining began in the 1950s in coal mines with longwall mining.

In consequence, efficiency AND safety were strongly boosted



Addressing the Impacts: Shifting towards sustainable mining

Modern mining acknowledges the huge impacts of mining and shift the mindset from “extract only” to a bigger picture:

Issues like mine wastes, energy consumption, water pollution and community are planned together and for the full life cycle of the mine

Technologies like electric fleets can reduce environmental impacts

Responsible mining depends on a “social license to operate” – the ongoing acceptance and trust of local communities and society at large scale

Return to
underground
mine design



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Acid mine drainage (AMD): a typical problem of metal mining. If not addressed, severe environmental impacts are possible.

Learn more about **AMD** in the “Mine Wastes” DTM

Drilling and Blasting Equipment

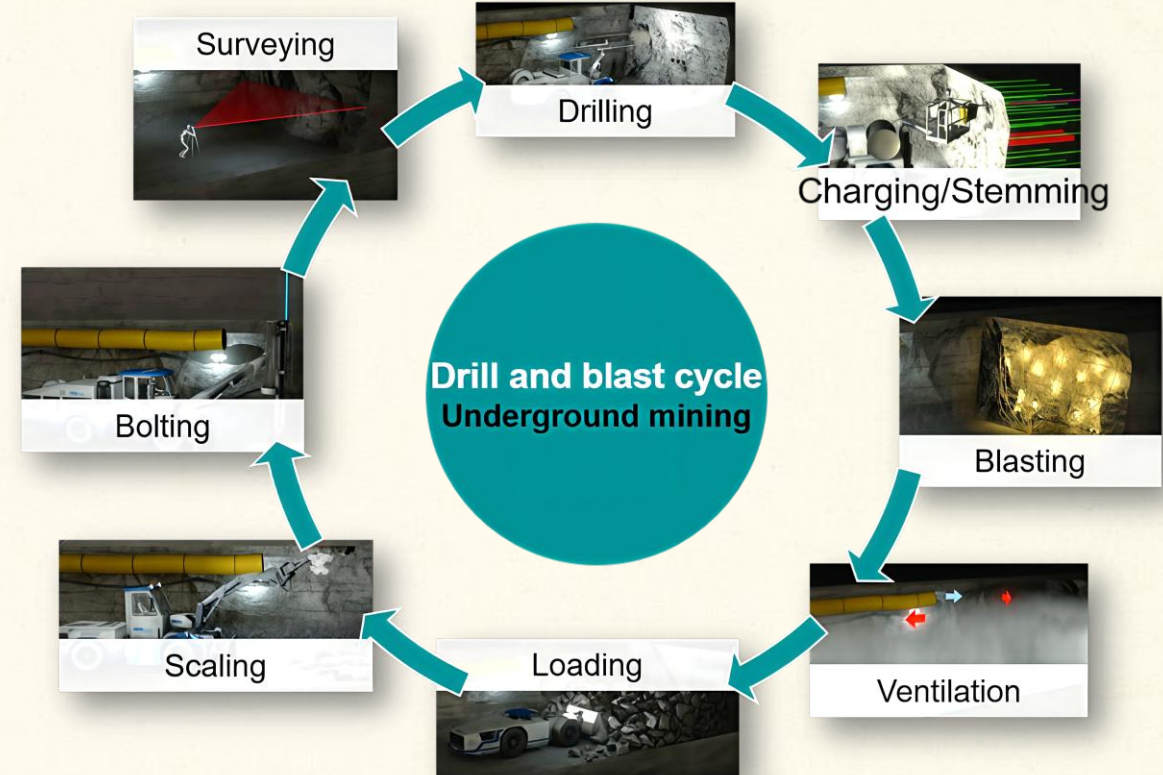
Different drilling equipment depending on the purpose:

- Jumbos for drifting of tunnels
- Longhole drills for production rings in stoping

Controlled by complex combinations of drillhole diameter & spacing, explosive type, detonation timing and more

Drilling and blasting practice shapes the whole mining parameters:

- Void geometry
- Fragmentation
- Dilution
- Ventilation



Deliberate blasting chain as shown below



Return to room and pillar overview



Load-Haul-Dump (LHD)

LHDs load blasted ore at the face or draw point and moves it to an ore pass, truck, or crusher

The typical shape allows to minimize the required void cross-section area

Operators sit sideways in the LHD for equal vision to both sides

For practical and safety reasons, LHDs drive mainly with the bucket facing backwards



Return to room and
pillar overview



Continuous miners

Instead of drilling and blasting, a **continuous miner mechanically cuts material**

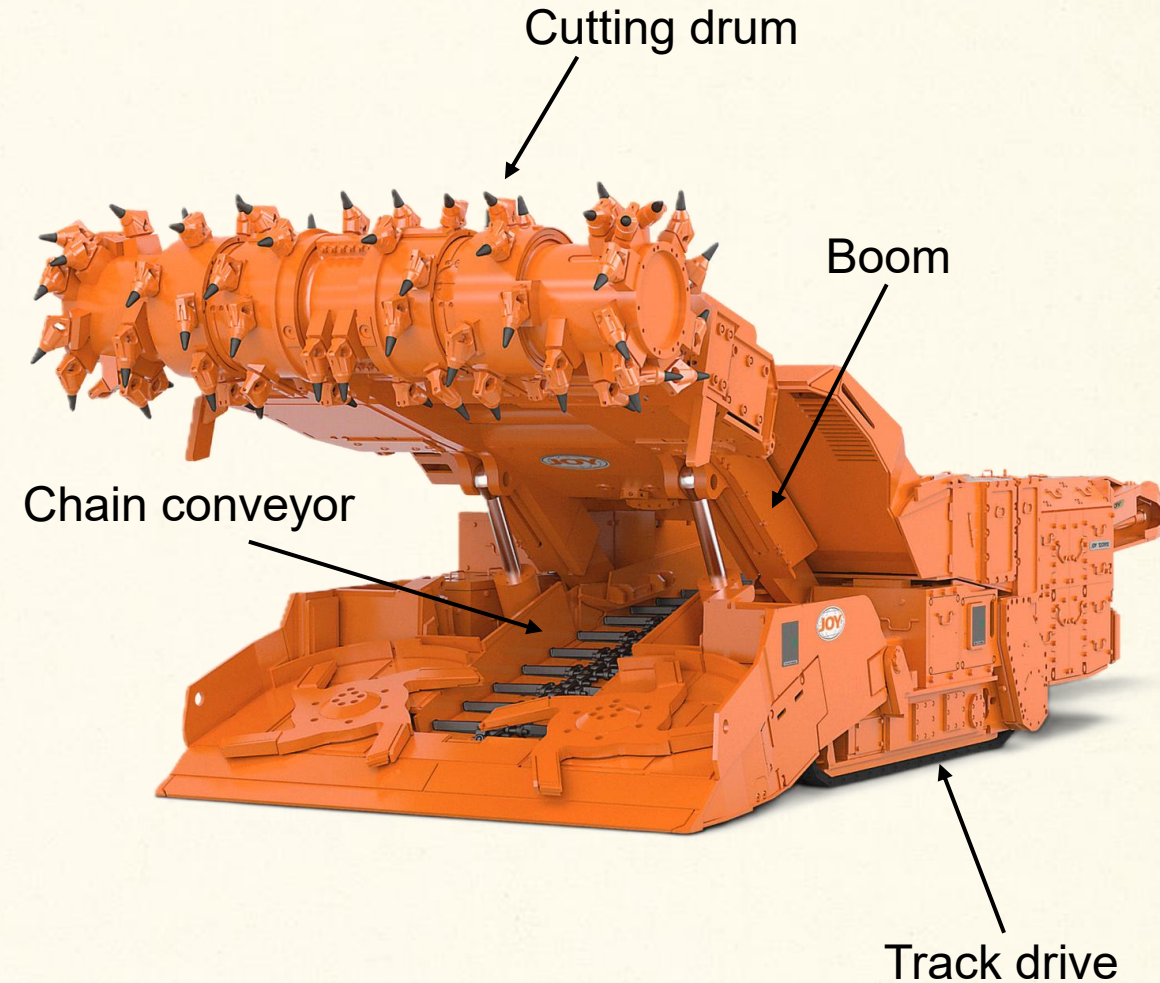
Cutting is usually executed by a **rotating drum** with conical bits

System integrates other steps such as the **transportation of cut material**

Therefore, these machines are **more complicated and sensitive** towards changing conditions



Continuous miners are particularly suited to suitable soft to medium-strength rock and relatively uniform conditions.



Return to room and
pillar overview



Mine ventilation



Every mine has to breathe

Ventilation supplies **fresh air** and removes unwanted components like dust, exhaust gases, blast fumes, or methane

Ventilation is also used to **cool down the mine air**.

While the basic logic is simple (**intake air to workplace, return air out of the mine**), the design of a ventilation network is **very site-specific** for each mine and can be **complicated** in some cases



Main fans. Source: CPC Engineering



Auxiliary fan. Source: Redpath Mining



Pillar dimensions

Safety vs. recovery

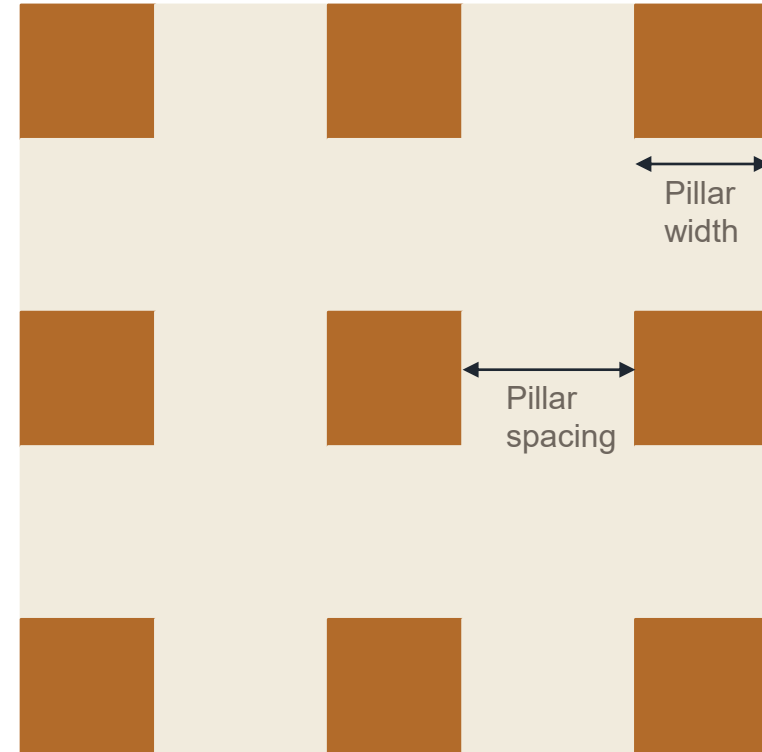
Pillar sizing is a classical tradeoff:

- Large pillars improve stability, but leave more ore unmined
- For small pillars, vice versa

Rule of thumb: as small as possible, as large as needed

The right dimensions of pillar width and spacing is individual and depends on rock properties and depth.

Top view on room and pillar layout



Types of backfill

Reducing the footprint and improving stability

Backfill replaces mined-out void volumes with waste or production tailings.



Three types of backfill differ mainly by water content and transportation method.

Benefits

- Structural support required by mining method
- Decrease subsidence
- Increase recovery
- Deposit mine wastes underground to avoid heaps at the surface

Hydraulic fill

- Slurry-like
- “Bleeds” (drains) water
- Requires barricades



Paste fill

- Dense, pumpable mix
- “Bleeds” less water
- Good fill control



Rockfill

- Coarse to fine rock, loose or big-bags
- High strength
- Simplest type of backfill



Return to cut
and fill



Mine development

The backbone of mine infrastructure!

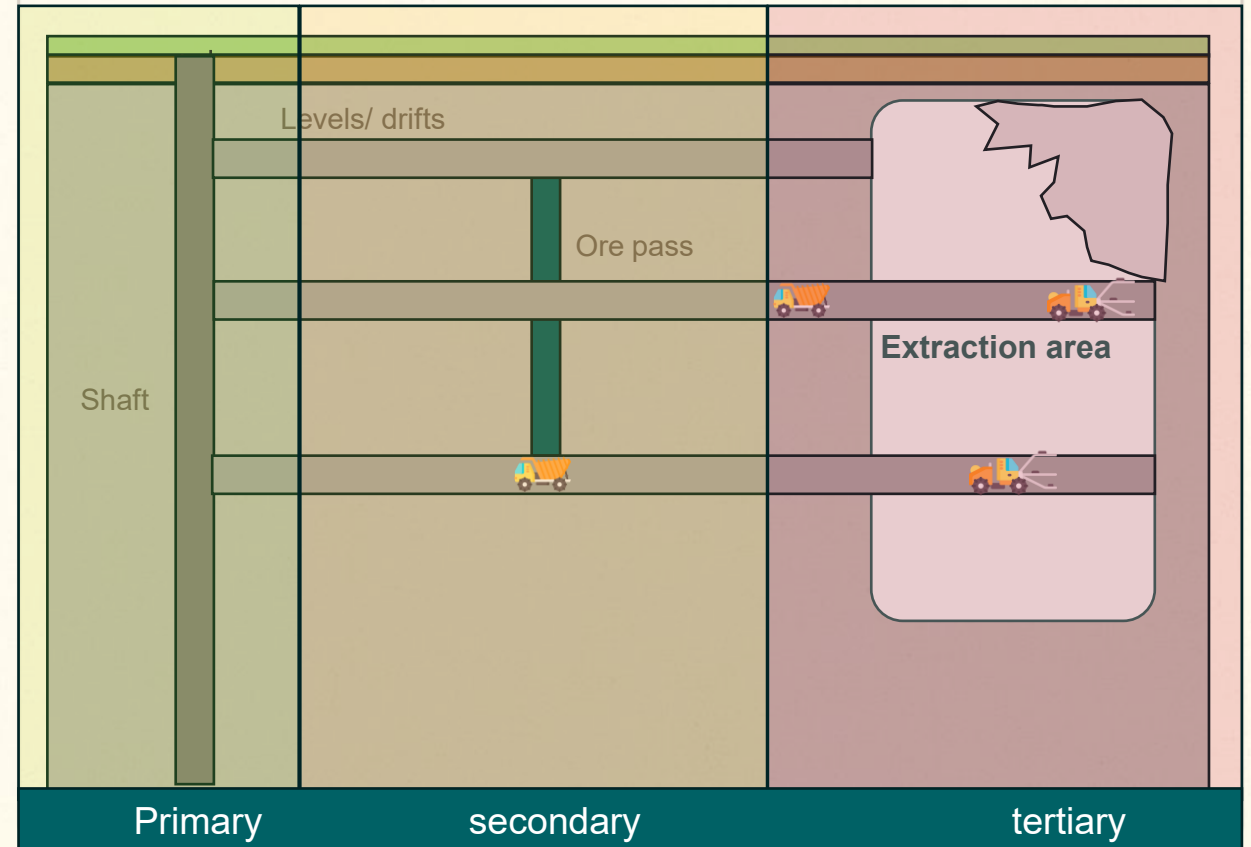
Mine development serves as access to the working place for staff, equipment, air and supplies.

Mine development can be divided into three categories: primary, secondary and tertiary development

Production can only start after the development, this implies:

- High costs before any return on investment before mining has started
- Development governs the ramp-up time of a mine

Side view on sublevel stoping mine sections



Primary development

The door to an underground deposit

Depending on site-specific conditions and requirements, the primary access to a mine can be provided by inclines, (spiral) ramps, or shafts

Shafts are vertical and generally offer the highest capacity for transporting people, material, and air to the mine and the surface

Shaft sinking is a very complex project itself and can consume years of time and billions of €



View up a concrete-lined shaft in construction.
Source: Redpath Deilmann



Key takeaways



Mining method is influenced by natural and external **factors**



Geology (**orebody** characteristics) is the strongest factor



Further considerations include **economical**, **environmental** and **safety** instances



Therefore, **every mine** is **individual**



Mining is a complex, **interdisciplinary** matter

Return to Start

