Mining Methods

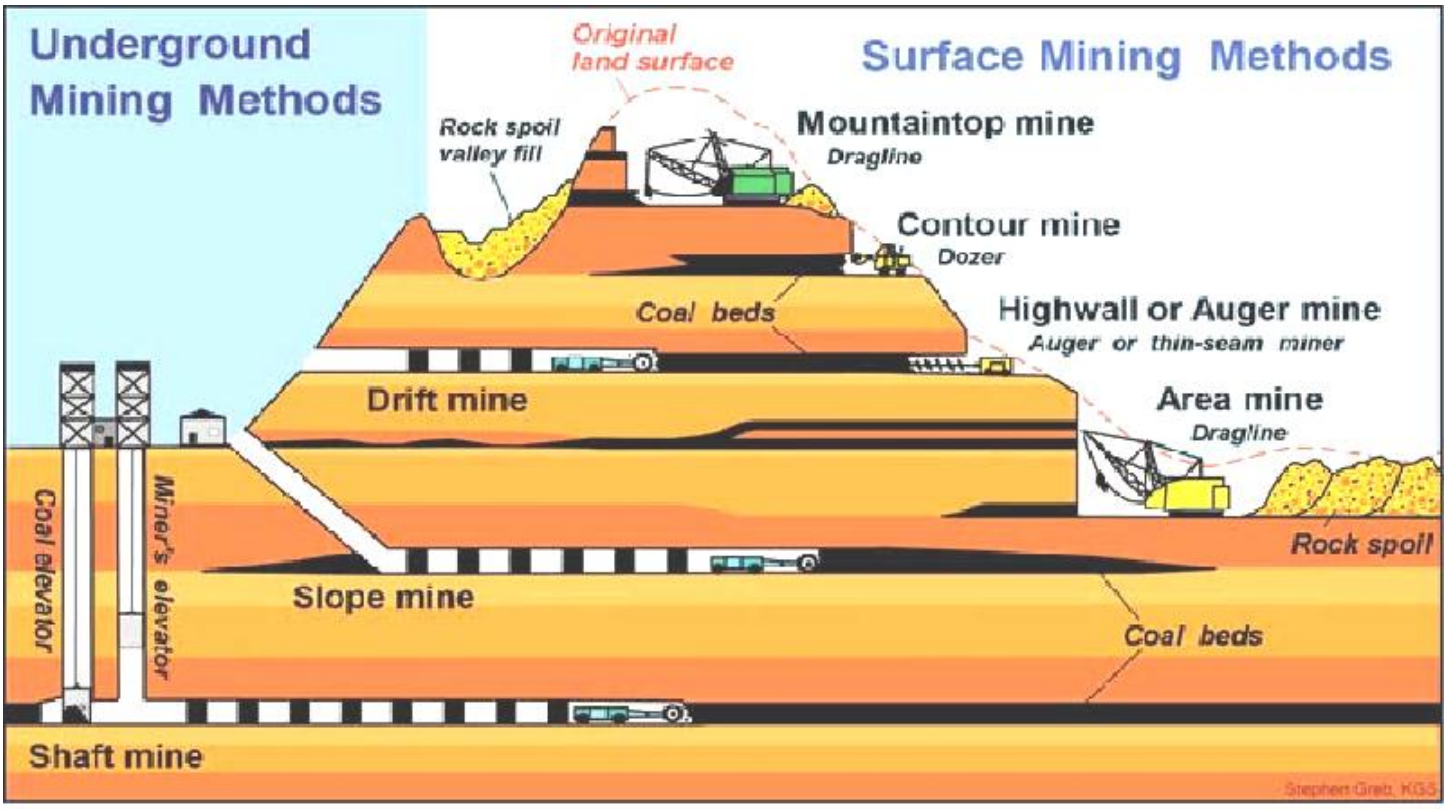
Traditional mining methods fall into two broad categories based on locale: surface or underground.

1) Surface mining: includes

i) **Mechanical excavation methods**; such as *Open-pit and Strip mining*.

ii) **Aqueous methods;** such as *placer and solution mining*.

2) Underground mining: is usually classified in three categories of methods: unsupported, supported, and caving.



Choice of mining method:

The choice of mining method depends on many factors, including:

- Shape of the ore body: tabular, cylindrical, spherical.
- Orientation of the ore body: sub-horizontal, sub-vertical.
- Continuity of the ore body.
- Ore-grade: high-grade, low-grade.
- Distribution of ore-bearing minerals within the orebody: massive or disseminated (with a cut-off grade).
- Depth to the ore body.
- Strength of the ore body and overburden/host-rocks rocks.
- Area of land available for waste disposal – open-pit mines cover a larger surface area and generate a greater volume of wastes.
- Impacts on surface: environmental, surface drainage and sub-surface aquifers, land-use changes, social.
- Projected production rates.
- Capital costs, rate of (financial recovery), cash-flow.
- Safety concerns – surface mining methods have a better safety record.

Difference between surface and subsurface mining. Pros and Cons

Surface	Subsurface
disturbs large area -produces large amounts of spoil -relatively safe -cheaper -more efficient	-disturbs much smaller surface area -spoil often left in mine -dangerous -expensive -less efficient

Surface mining:

- ***Is a type of mining in which soil and rock overlying the mineral deposit (the overburden) are removed.***
- ***Surface mining is the predominant exploitation method worldwide***.
- ***Surface mining requires large capital investment*** (primarily expensive transportation equipment), but generally results in:
    - High productivity (i.e., high output rate of ore)
    - Low operating costs
    - Safer working conditions and a better safety record than underground mining.
- ***Surface mining is used when deposits of commercially useful minerals or rock are found near the surface; that is, where the overburden is relatively thin or the material of interest is structurally unsuitable for tunneling (as would usually be the case for <u>sand</u> ،and <u>gravel</u>.)***
- ***In most forms of surface mining, heavy equipment, such as earthmovers, first remove the overburden (the soil and rock above the deposit). Next, huge machines such as dragline excavators extract the mineral.***
- ***Once the material has been removed, the land is recovered for safe use on the surface through <u>a process called reclamation.</u>***

Advantages

Surface mining has several advantages over shaft mining:

1. An increase in worker productivity in tons per man-day by at least three fold.
2. A resource recovery of approximately 90% versus 60% or less for underground mining (room and pillar).
3. A reduction in initial site preparation costs.
4. Less than one-half the injuries per work-hour and avoidance of high death rate from respiratory diseases.
5. Less vulnerability to labor strikes, due to lower manpower requirements

Operational Details – Surface Mines

In surface mines the following logical steps should be followed to mine-out a deposit:

- Planning
- Site preparation
- Opening up the deposit
- Pit development
- Ore production
- Environment and land reclamation
- Liquidation phase and post mining operations.

Surface mining Methods or Techniques

When mining of a mineral deposit including stones of various kinds is undertaken by exposing them to the atmosphere (i.e. open air and sun), it is known as surface mining. Based on the location of the deposit, the surface datum, the mines can be classified as open pit, opencast, quarrying or underground.

An ***open pit mine*** is the mine to exploit the deposits which are outcropping to the surface, or those which are confined to a shallow depth, and the waste rock lying above (over burden) and at their sides are removed and transported away from the place of their deposition.

Strip Mining (Open cast) is also a surface mine to mine out the flat deposits but the overburden is backfilled in the worked out area.

The term ***quarrying*** of course is very loosely applied to any of the surface mining

operations but it should be confined to a surface mining method to mine out the dimensional stones such as slate, marble, granite etc.

The deposits are sometimes located near the surface datum but covered by an aqueous body such as lake, tank, river, or even by seawater. Mining of such deposits is also a part of surface mining practices. These are known as ***aqueous extraction methods.***

OPEN PIT MINING

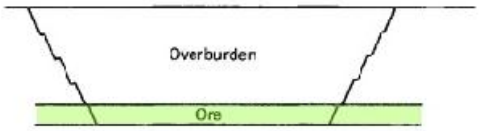
Open Pit Mining

Open pit mines involve digging large open holes in the ground as opposed to a small shaft in hard rock mining. This method of mining is most often used with minerals like copper and molybdenum

Open pit coal mining has been popular in Europe, but is used on a more limited basis in the United States for lignite. The method is a type of area stripping which allows almost complete removal of coal from very thick seams, using a mining approach reminiscent of rock quarrying. Multiple benches are employed to reach greater depths than normally achieved in area stripping. Open pit mining does not allow for refilling of the coal voidage and because of the thick seams, a permanent depression is left. Open pit mining has been practiced extensively in Germany for the mining of lignite.

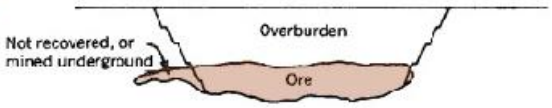
Various open-pit and ore body configurations:

(i)



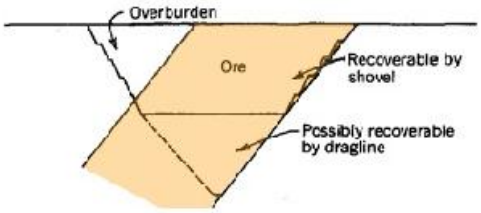
Flat lying seam or bed, flat terrain. Example platinum reefs, coal.

(ii)



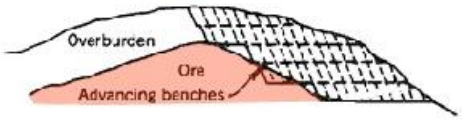
Massive deposit, flat terrain. Example iron-ore or sulphide deposits.

(iii)



Dipping seam or bed, flat terrain. Example anthracite.

(iv)



Massive deposit, high relief. Example copper sulphide.

(v)

Thick bedded deposits, little overburden, flat terrain. Example iron ore, coal.

Main features of Open Pit mining

- Mine working open to the surface.

•Operation designed to extract minerals that lie close to the surface

•It is used when the orebody is near the surface and little overburden (waste rock) needs to be removed.

•It is usually employed to exploit a near-surface deposit or one that has a low stripping ratio.

•Waste is first removed, then the ore is broken and loaded.

•Generally low grade, shallow ore bodies.

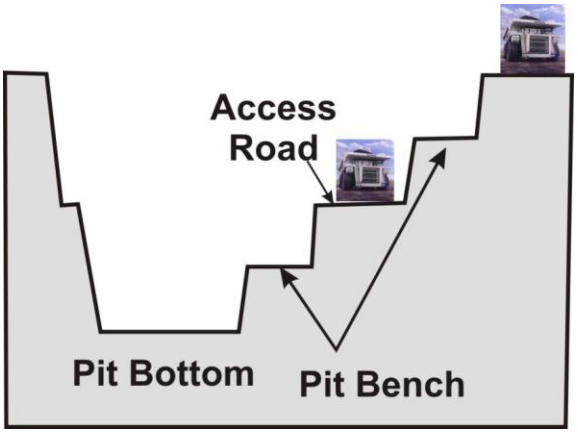
•Non-selective ? all high and low grade zones mined

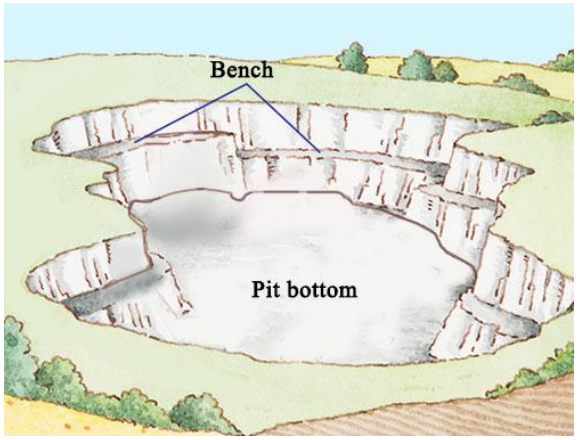
•Mining rate > 20,000 tons mined per day (tpd).

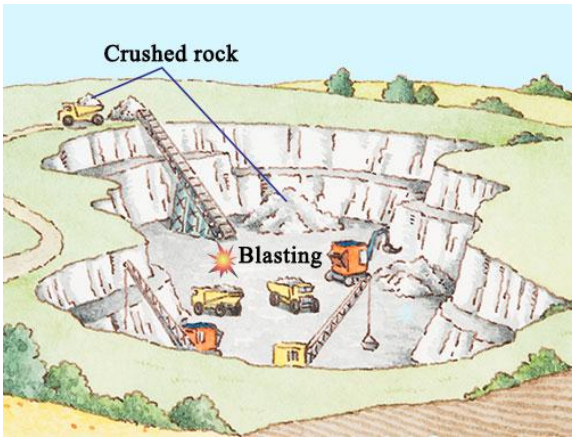
•It often necessitates a large capital investment but generally results in high productivity, low operating cost, and good safety conditions.

•Design issues:

- Stripping overburden
- Location of haul roads
- Equipment ? size of trucks and fleet
- Pit slope angle and stability







Stripping Ratio

Stripping ratio refers to the amount of waste rock removed to recover ore. For example, a stripping ratio of 3:1 means to recover one ton of ore you must remove three tons of waste rock.

A large Stripping Ratio is less economical efficient than a small one, because that means more rock will need to be moved without generating revenue.

If The ratio is going to be too large, then underground mining will usually be more efficient

Strip Ratio (SR) When speaking of an open pit mine, the term strip ratio is used. This is simply. Strip Ratio (SR) is the mass of waste to be mined to obtain one unit mass of ore

Open Cast Mining/Strip Mining

Introduction

As the name speaks, it is a surface mining system in which deposit is opened to the atmosphere and after removing the orebody, the over burden which was blanketing it, is cast back in the worked out area. This is also known as **Strip Mining**.

Thus, this system gives an added advantage of:

● Using the same land which was occupied by the deposit for dumping the waste rock and thereby a minimum land degradation.

● The lead for waste dump from the working face is very little; thereby transportation cost is very much reduced. Waste rock recasting goes

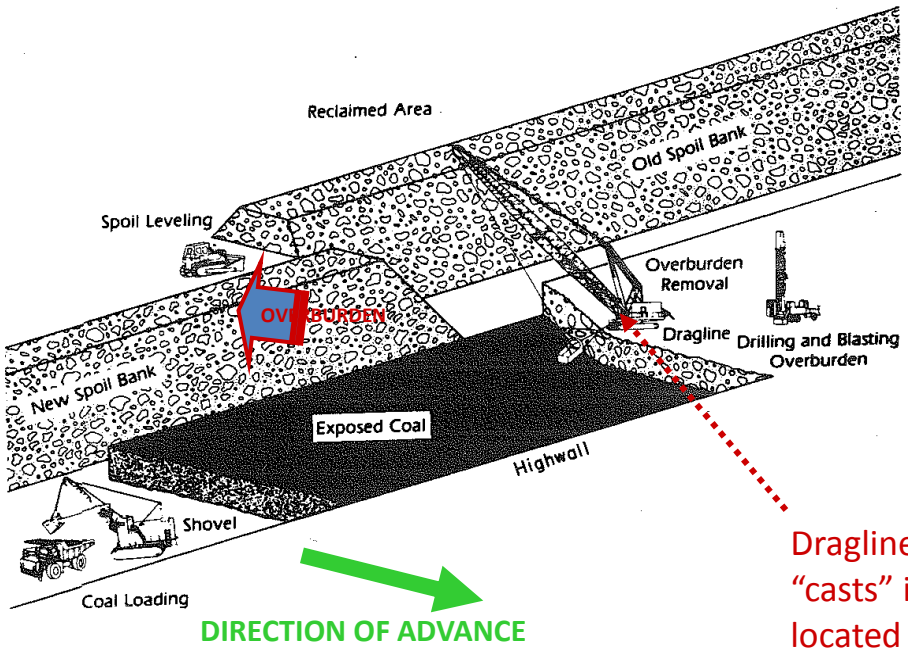
simultaneous with ore mining that allows high production rate and almost continuous muck flow under suitable conditions.

● Application of high capacity and bulky equipment is practical for high outputs. This allows high productivity and low mining costs enabling mining of even low grade and deep-seated deposits with higher stripping ratios.

● Due to these inherent features today development of highest man-made equipment has become possible in the mining operations. In this system use of highly productive equipment such as bucket wheel draglines and high capacity belt conveyors is therefore feasible.

- **Strip mining** is the practice of mining a seam of mineral ore by first removing all of the soil and rock that lies on top of it (the overburden). It is similar to open-pit mining in many regards.
- Used for near-surface, laterally continuous, bedded deposits such as coal, stratified ores such as iron ore, and surficial deposits (nickel laterite or bauxite).
- The pits are shallower that open-pit mines, and the overburden is "***hind-cast***" directly into adjacent mined out panels.
- It is a very low-cost, high-productivity method of mining.
- Strip mining is ideally applied where the surface of the ground and the ore body itself are relatively horizontal and not too deep under the surface, and a wide area is available to be mined in a series of strips. Typical examples of this type of mining are the larger tonnage coal mining operations in Mpumulanga. Favourable conditions are:
- Relatively thin overburden (0-50m maximum otherwise stripping ration and cost of stripping becomes too high)

- Regular and constant surface topography and coal layers (not more than 20º variation from horizontal on the coal seam –topography can vary more since pre-stripping can be used to level it – but this is expensive to apply)
- Extensive area of reserves (to give adequate life of mine (LOM) and to cover all capital loan repayments – typically more than 20 years life at 4-14mt per annum production)



Dragline gathers overburden and "casts" it back onto spoil banks located behind the current working face

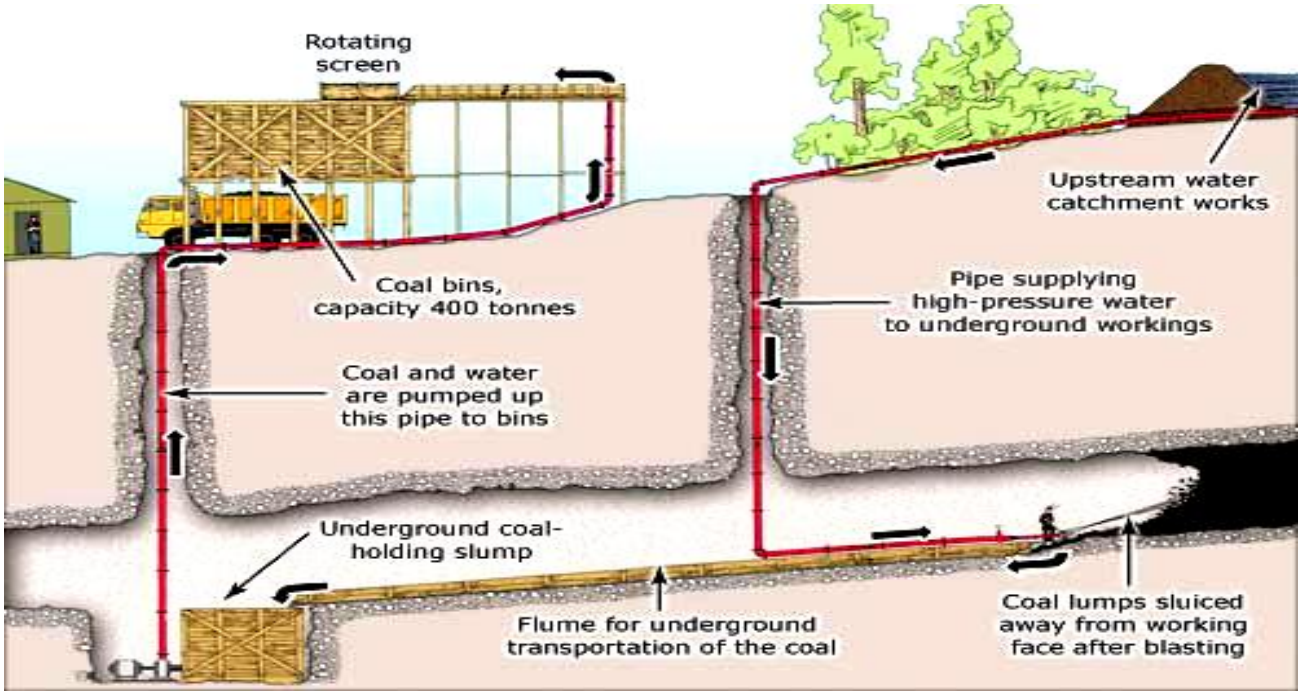
The ***aqueous extraction methods*** depend on water or another liquid (e.g., dilute sulfuric acid, weak cyanide solution, or ammonium carbonate) to extract the mineral.

Placer mining is used to exploit loosely consolidated deposits like common sand and gravel or gravels containing gold, tin, diamonds, platinum, titanium, or coal.

There are two types of placer mining:-

Hydraulic mining: Generally used for weakly cemented near-surface ore deposits. Hydraulic mining of a placer gold deposit. Hydraulic king utilizes a high-pressure stream of water that is directed against the mineral deposit (normally but not always a placer), under-cutting it, and causing its removal by the erosive actions of the water.

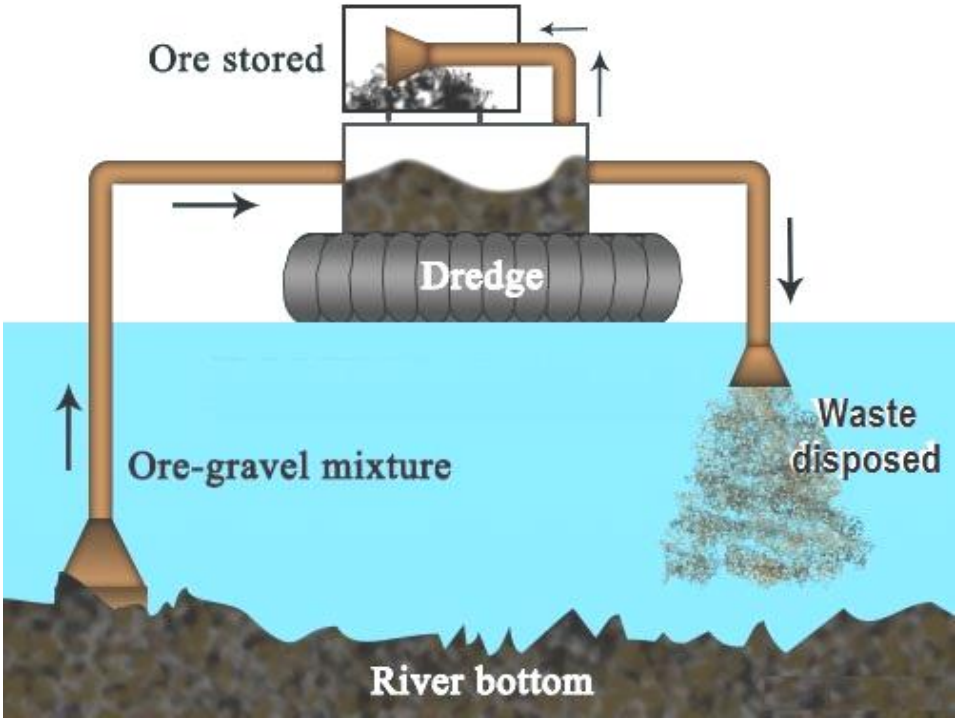
The water is sprayed at an area of rock and/or gravel and the water breaks the rock up, dislodging ore and placer deposits. The water/ore mixture is then milled. This is a very destructive way to mine and has been outlawed in most areas.



Dredging

Dredging is a method often used to bring up underwater mineral deposits. Although dredging is usually employed to clear or enlarge waterways for boats, it can also recover significant amounts of underwater minerals relatively efficiently and cheaply.

Dredging mining generally used most often for mineral-sands and some near-shore alluvial diamond mining operations. Dredging performed from floating vessels, accomplishes the extraction of the minerals mechanically or hydraulically



- ***Solution mining*** includes both ***borehole mining***, such as the methods used to extract sodium chloride or sulfur, and **leaching,** either through drill holes or in dumps or heaps on the surface

In the **solution mining method** of extraction, water is forced under pressure into a cavity which forms in the underground salt bed, as the salt dissolves. This turns the water into brine containing about 30% salt.

The saturated raw brine is pumped to the purification plant where calcium, magnesium and other impurities are removed, prior to the evaporation process.