Documentary on COAL: Mining, History and Future Outlook

https://www.youtube.com/watch?v=23sZ3Ju1fUU

Documentary on oil – Science, History, and Future Outlook

https://www.youtube.com/watch?v=dWZoNccKcr0

NATURAL GAS Documentary: Science, History and Future Outlook

https://www.youtube.com/watch?v=_qU7JHA87w4

Coal is a fossil fuel formed over millions of years from dead plant matter buried in swampy, oxygen-poor environments.

Over time, layers of sediment accumulate, burying the vegetation and subjecting it to intense heat and pressure.

This process, known as coalification, converts the organic material into peat and then through various stages into coal.

The material transforms through 4 main ranks, indicating increasing age, carbon content, and energy value:
Lignite (25%–35%**):** Youngest and lowest rank.
Subbituminous (35%–45%**):** Intermediate stage.
Bituminous (45%–86%)**:** Harder, common coal.
Anthracite (86%–97%)**:** Oldest, hardest, and highest carbon content.

Coal survey and testing involve a two-part process: finding/mapping the coal (exploration) and analyzing its quality (laboratory testing).

1. **Coal Exploration Surveys (To Find/Map Coal)**

Geologists use various techniques to locate coal seams, determine their thickness, and map the sedimentary structures.

Geological Mapping: Initial mapping of the area to identify potential sedimentary basins.

Geophysical Surveys:

3D Seismic Surveys: Used to map underground geological features like faults, folds, and coal seams.

Gravity Methods: Detects variations in the earth's gravitational field, as coal is less dense than surrounding rock.

Magnetic Methods: Maps magnetic anomalies to differentiate sedimentary rock from basement rock.

Electrical Resistivity: Measures the resistance of rock strata, as coal is often more resistive than shale or sandstone.

Exploration Drilling & Core Logging: Drilling to take samples to measure coal thickness and depth, followed by geophysical logging of the hole using:

Gamma-Ray Logging: Coal seams are identified by their very low natural gamma radiation.

Density Logs: Uses radiation to measure the density of the rock, allowing for precise identification of coal.

Neutron Logging: Measures hydrogen content to distinguish between different rock types.

2. Coal Quality Testing (Lab Analysis)
Once samples are collected, they undergo laboratory tests to determine their rank and suitability.
Proximate Analysis: Determines the basic quality components:

Moisture Content (IM/TM): Amount of water in the coal.
Ash Content: Non-combustible residue left after burning.
Volatile Matter (VM): Substances (gases/vapors) released at high temperatures.
Fixed Carbon (FC): Combustible residue remaining after volatiles are driven off.
Ultimate Analysis: Determines the elemental composition: Carbon (C), Hydrogen (H), Nitrogen (N), Sulfur (S), and **Oxygen (O).**

Calorific Value (CV) Test: Measures the energy/heat content of the coal using a bomb calorimeter.
Hardgrove Grindability Index (HGI): Measures how easy it is to crush/pulverize the coal.
Ash Fusion Temperature (AFT): Determines the temperature at which ash melts (clinkering behavior).

Float-Sink Test: Evaluates washability by separating coal from impurities based on density.
Crucible Swelling Index (FSI): Evaluates coking suitability.

METHODS OF EXTRACTION

- The most economical method of coal extraction from coal seams depends on the depth and quality of the seams, and the geology and environmental factors. Many coal deposits are extracted from both surface and underground mines. Surface mining and deep underground mining are the two basic methods adopted for mining coal.
- The choice of mining method depends primarily on depth of burial, density of the overburden and thickness of the coal seam.
- Seams relatively close to the surface, at depths less than approximately 180 ft (50 m), are usually surface mined.
- Coal that occurs at depths of 50 to 100 m are usually deep mined, but in some cases surface mining techniques can be used.
- Coals occurring below 100 m are usually deep mined.

Coal extraction

Coal extraction is the process of removing coal from the Earth. It is mainly done by two methods:

1. Surface Mining

Used when coal seams are close to the surface.

•**Open-cast (open-pit) mining**: Overburden (soil and rock) is removed to access coal.

Coal is extracted in long strips after removing surface layers.

Advantages: Low cost, high recovery, safer.

Disadvantages: Environmental damage, land degradation.

2. Underground Mining

Used when coal is deep underground.

•**Board and pillar method**: Coal pillars support the roof.

•**Longwall mining**: A mechanical shearer removes coal along a long face.

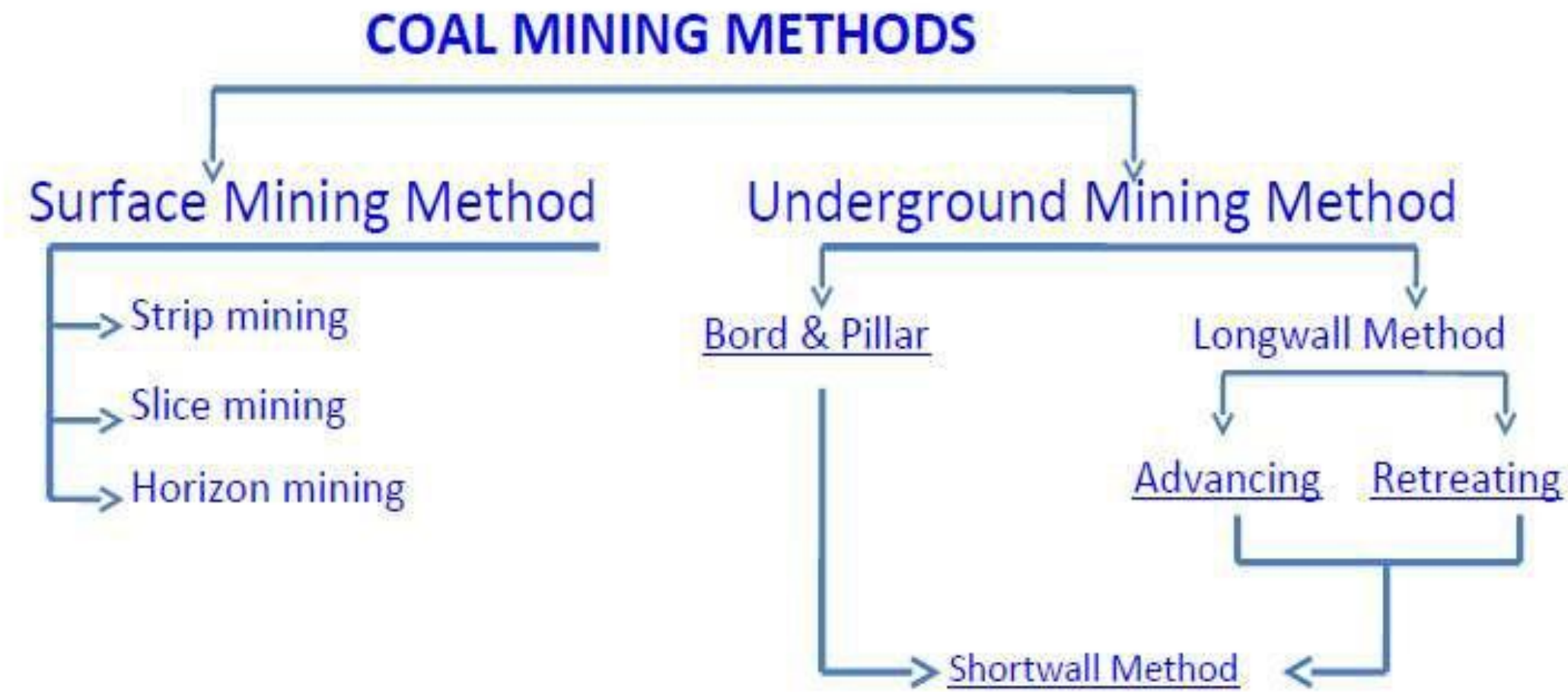
Advantages: Less surface disturbance.

Disadvantages: Higher cost, safety risks.

After extraction, coal is **processed, transported, and used** mainly for power generation and industry.

If you want, I can explain this in **exam-oriented short notes** or with a **diagram description**.

CLASSIFICATION OF COAL MINING METHODS



SURFACE MINING

Surface coal mining generally involves the following sequence of unit operations:

- **clearing the land of trees and vegetation,**
- **removing and storing the top layers of the unconsolidated soil (topsoil),**
- **drilling the hard strata over the coal seam,**
- **fragmenting or blasting the hard strata with explosives, removing the blasted material, exposing the coal seam, and cleaning the top of the coal seam,**
- **fragmenting the coal seam, as required, by drilling and blasting,**
- **loading the loose coal onto haulage conveyances,**
- **transporting the coal from the mine to the plant, and**
- **reclaiming lands affected by the mining activity.**

SURFACE MINING METHODS

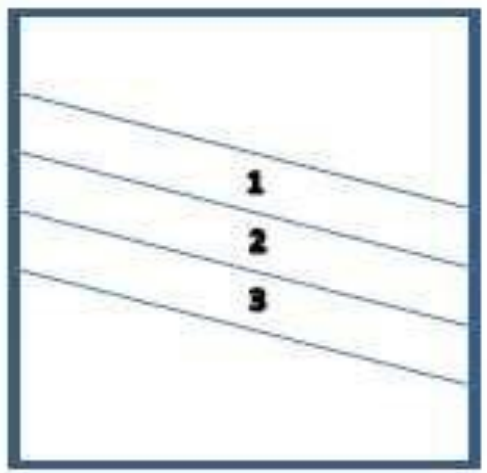
Surface Mining is used for about 40% of coal production in the world. Ore bodies close to the surface at depths less than approximately 180 ft (50 m), are usually surface mined. Coal that occurs at depth of 180 to 300 ft (50 to 100m) is usually deep mined but, surface mining techniques can be used.

a). Strip Mining:

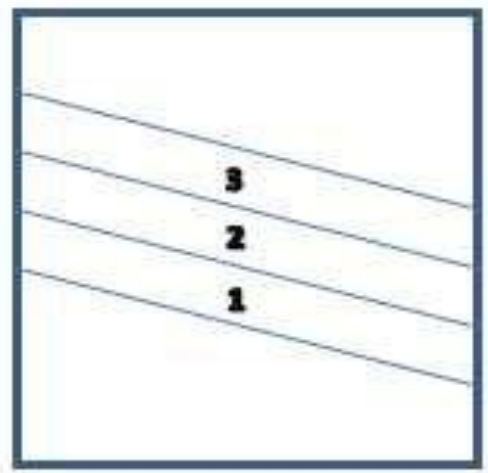
- It is one of the open cast mining methods with a high degree of mechanization employing either power shovel or a combination of dragline and power shovels for striping the overburden.
- The overburden to coal ratio may be as low as 1:12 upto a depth of 30 or 50 ft or 1:15 where the overburden is about 90 ft.
- If the overburden is very thin, being only a few feet and conditions are favorable then stripping can be managed with bulldozers. In this method single stripping shovels and single draglines are use to remove coal. It is commonly practiced in the U.S.A.

b). Slice Mining:

- In slice mining method, a coal seam is divided into slices of suitable thickness and individual slices are worked. The common types in slice mining are inclined slicing, horizontal slicing and diagonal slicing. Slice may be taken in both ascending order and descending order or in mixed order.



Descending



Ascending

Ascending-Descending

c). Horizon Mining:

- This method is adopted in case of very highly disturbed areas where the coal measures have been folded and faulted.

- It is the system of mining which consist of more than one level and the coal seam are opened up by the level roads driven in the rock.

- This method can be employed with advantage in highly disturbed areas where a no. of coal seam is known to occur.

- It is commonly practiced in Germany, France and Belgium.

UNDERGROUND MINING

- **Deep Underground Mining** is needed when coal seams are found too deep underground. 60% of the world coal production is mined by underground mining method. Bord and Pillar method, Longwall method and short wall method are the most commonly used mining method.

1). Bord and Pillar method:

- The Bord and Pillar method of mining coal seam involve the driving of a series of narrow heading in the seams parallel to each other. These headings are connected by cross headings so as to form pillars for subsequent extraction either partially or completely.

- Ideally the pillar should be square but they are sometimes rectangular or of rhombus shape and the galleries surrounding the pillars are invariably of square cross section. The method is best suited to work flat coal seams of 1.8 to 3 m thickness at shallow depth.

2. Longwall Method:

There are two types of long wall methods of mining.

a). Longwall Advancing:

- It involves the extraction of panel of coal to be worked by advancing the face forward on a wide front leaving behind the roadways serving it.

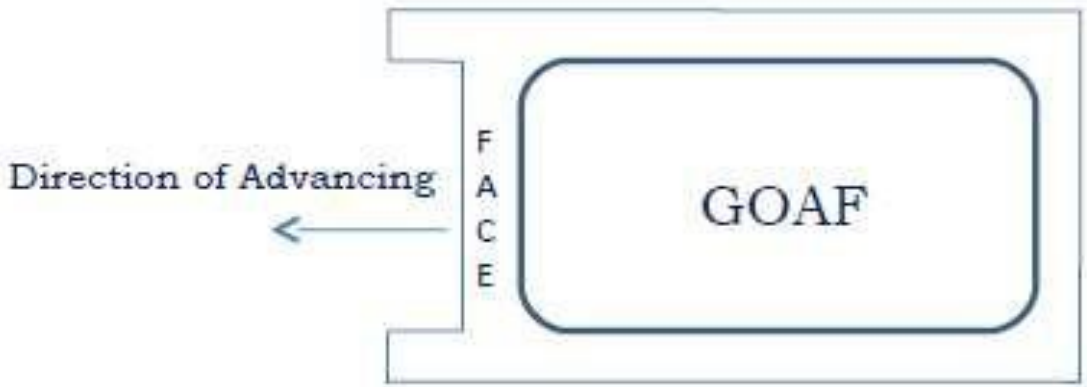


Fig. Longwall Method

b). Longwall retreating:

- In case of longwall retreating, the face is retreated on the roadways driven before opening out the face and as the face is retreated backwards, the ***Goaf*** is allowed to cave in or it is filled and gate roadway is lost in the ***Goaf.***
- This method can be employed almost in all geological conditions, though it is eminently suited for working thinner seams.
- In India, the first longwall face was operated at Narsumuda colliery around 1880 in Raniganj coal field.

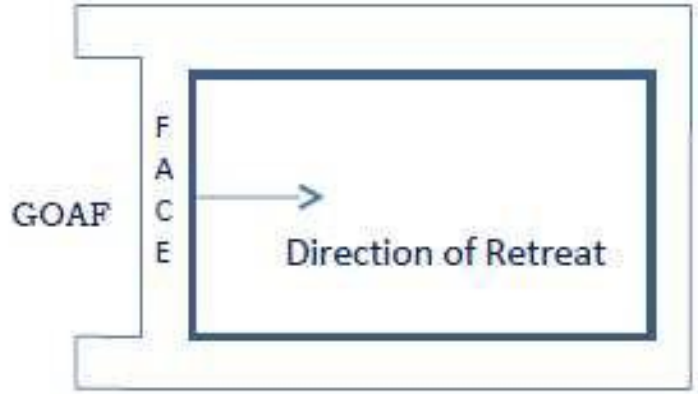


Fig. Longwall Retreating

3). Short wall method:

- This is variant of longwall and bord and pillar method in which the length of face is much smaller than normal with longwall mining and the short wall was developed to employed the usual room and pillar equipment but with geometric simplicity and advantages of self advancing hydraulic roof support.
- This method incorporates the advantage and disadvantage of both board and pillar method and longwall method.

LATEST TECHNIQUES

- Extended application of open cast mining method, long wall mining methods, particularly advanced technology mining (ATM) faces and automations.
- Increased level of mechanization and adaptation of various technique of thick seam mining developed abroad.
- Hydraulic Mining Methods
- Underground Gasification of Coal
- Evolution of suitable techniques for the control of strata and subsidence and for the protection of environment
- Increasing application of computer in mine planning and mining operations.

Factors influencing the choice of coal mining methods

- Thickness and Gradient of the seam
- Depth of the seam
- Structure and geological abnormalities
- Mechanical properties of the coal
- Characteristics of roof and floor
- Gas content of the coal seam
- Hydrogeological conditions of the coal measures.

Availability of machines for mechanizations and development in technology.

Opencast Mining		Underground Mining	
Advantages	Disadvantages	Advantages	Disadvantages
Cheap – low tech and high coal recovery	Can't reach deep seams	Reach deeper seams than open	Expensive – high tech
Easy ventilation and transportation	Overburden storage instability	Mine under sea or areas where open pits would be eyesores	Lower productivity compared to opencast mining
Mine steeply dip seam	Groundwater supply disruption	Less polluting	Only mine horizontal seams
Economically mine thinner seams	Eyesore	Waste backfilled into mine	Water issues – expensive to pump out
Gas dispersed to air	High environmental impact (dust, noise, deforestation)	Less surface land disturbance	Risk of accidents (roof collapse, gas explosion)
Roof collapse less problematic	Affects nearby ecosystems and settlements	Requires less overburden removal	Less safe
Safer			Spoil tips unstable
Water easily dealt with			Ventilation and safety management are complex

MINE VENTILATION

- Underground mine ventilation provides a flow of air to the underground workings of a mine of sufficient volume to dilute and remove dust and noxious gases and to regulate the temperature.

- The source of gases are equipment that runs on diesel engines, blasting with explosives and sometimes, the ore body itself.

  Mine ventilation is done to provide oxygen to the miners and to dilute, render harmless, and carry away dangerous accumulations of gases and dust.

- In some of the gassiest mines, more than six tons of air are circulated through the mine for every ton of coal mined.
- Air circulation is achieved by creating a pressure difference between the mine workings and the surface through the use of fans.

- Fresh air is conducted through a set of mine entries (called intakes) to all places where miners may be working.
- After passing through the workings, this air (now termed return air) is conducted back to the surface through another set of entries (called returns).

MONITORING AND CONTROL

- Advancements in sensor technology and in computer hardware and software capabilities are finding increasing application in underground coal mines, especially in the monitoring and control of ventilation, haulage, and machine condition.

- Longwall shearers and shields can be remotely operated, and continuous miners have also been equipped with automatic controls.

- The atmospheric environment is remotely monitored for air velocity, concentrations of various gases, and airborne dust; fans and pumps are also monitored

Oil Extraction Methods

1. Primary Recovery

Uses natural reservoir pressure to bring oil to the surface.

- **Natural flow**: Oil flows due to pressure difference.
- **Artificial lift**: Pumps (e.g., beam pump, electric submersible pump).

Recovery: ~10–20% of oil.

2. Secondary Recovery

Applied when natural pressure declines.

- **Water flooding**: Water injected to push oil toward production wells.
- **Gas injection**: Natural gas or CO_2 injected to maintain pressure.

Recovery: Additional ~20–30%.

3. Tertiary (Enhanced Oil Recovery – EOR)

Used to extract remaining oil.

- **Thermal methods**: Steam injection, in-situ combustion.
- **Chemical methods**: Polymer flooding, surfactant injection.
- **Miscible gas injection**: CO_2, nitrogen.

Recovery: Up to 60% total.

4. Unconventional Oil Extraction

- **Oil sands**: Surface mining, in-situ steam-assisted gravity drainage (SAGD).
- **Shale oil**: Hydraulic fracturing (fracking) and horizontal drilling.

1. Onshore Extraction Methods (Land-based)

Onshore drilling is the most common and economical method, typically using simpler infrastructure like pump jacks and standard rigs.

Conventional Drilling: Utilises large, stationary rigs for deep or long-term wells, or mobile truck-mounted rigs for quicker deployment in remote fields.

Sucker Rod Pumping (Artificial Lift): Often seen as "nodding donkeys," these mechanical pumps provide lift when natural reservoir pressure drops.

Horizontal Drilling & Hydraulic Fracturing (Fracking): Used primarily in shale formations. High-pressure fluids create micro-fractures in rock to release trapped oil

Recovery Stages:

Primary: Uses natural reservoir pressure.

Secondary: Injects water or gas to maintain pressure.

Tertiary (Enhanced Oil Recovery - EOR): Employs steam injection (Thermal EOR), chemicals, or CO2 to reduce oil viscosity.

2. **Offshore Extraction Methods (Sea-based)**

Offshore operations target massive reservoirs beneath the seabed, requiring complex engineering to handle deep-water pressures and harsh marine environments.

Fixed Platforms: Rigid steel or concrete structures anchored to the seabed, suitable for shallower waters up to 500 metres.

Jack-up Rigs: Mobile platforms with extendable legs that rest on the seafloor; ideal for shallow waters.

Floating Production Systems: For deep-water extraction (up to 3,000+ metres), different floating units are used:

FPSO (Floating Production Storage and Offloading): Ship-shaped vessels that process and store oil until it is transferred to tankers.

Semi-submersible Rigs: Large floating platforms anchored to the seabed; they remain stable in rough seas.

Spar Platforms: Tall, cylindrical hulls that provide excellent stability in ultra-deep waters.

Subsea Production Systems: Wellheads and manifolds installed directly on the seafloor, connected to distant platforms or shore via subsea pipelines.

Natural Gas Extraction Methods

Natural gas extraction methods involve recovering gas trapped beneath the Earth's surface. The methods depend on whether the gas is **conventional or unconventional**.

1. Conventional Natural Gas Extraction

Used when gas is trapped in porous rock with natural permeability.

Steps:

- **Exploration** using seismic surveys
- **Drilling** vertical or directional wells
- **Production** as gas flows naturally or with compressors

Recovery method: Natural reservoir pressure

2. Unconventional Natural Gas Extraction

a) Shale Gas Extraction

- **Horizontal drilling**
- **Hydraulic fracturing (fracking)**: High-pressure water, sand, and chemicals create fractures to release gas.

b) Tight Gas Extraction

- Gas trapped in low-permeability sandstone.
- Requires **hydraulic fracturing**.

c) Coal Bed Methane (CBM)

- Gas adsorbed on coal seams.
- **Dewatering** (pumping out water) reduces pressure and releases gas.

3. Offshore Natural Gas Extraction

- **Fixed platforms, semi-submersibles, drillships**
- **Subsea wells** connected to pipelines or FPSOs
- Similar techniques to offshore oil extraction

4. Enhanced Gas Recovery (EGR)

- **CO_2 or nitrogen injection** to maintain pressure and increase output.