1-5 Development

- In the third stage, the work of opening a mineral deposit for exploitation is performed. ***With it begins the actual mining of the deposit, now called the ore***.

  Access to the deposit must be gained either;

  - **by stripping** the overburden, which is the soil and/or rock covering the deposit, to expose the near-surface ore for mining or
  - **by excavating** openings from the surface to access more deeply buried deposits to prepare for underground mining.

- In either case, certain preliminary development work will generally be required before any development takes place, such as:
  - acquiring water and mineral rights,
  - buying surface lands,
  - arranging for financing,
  - preparing permit applications and an environmental impact statement (EIS),.
- When these steps have been achieved, the provision of a number of requirements, must precede actual mining in most cases such as:

  access roads, power sources, mineral transportation systems, mineral processing facilities, waste disposal areas, offices, and other support facilities.
- Stripping of the overburden will then proceed if the minerals are to be mined at the surface.
- Economic considerations determine the *stripping ratio* (ratio of waste removed to ore recovered).
- Some nonmetallic mines have *no overburden* to remove; the mineral is simply excavated at the surface.

- Development for underground mining is generally more complex and expensive. It ***requires*** careful planning and layout of access openings for efficient mining, safety, and permanence.
- The principal openings may be ***shafts***, ***slopes***, or ***adits***; each must be planned to allow passage of workers, machines, ore, waste, air, water, and utilities.

1-6 Exploitation

❖ *Exploitation*, the fourth stage of mining, is associated with the actual recovery of minerals from the earth in quantity.

❖ The mining method selected for exploitation is determined mainly by:

- The characteristics of the mineral deposit
- The limits imposed by safety, technology, environmental concerns, and economics.
- Geologic conditions, such as the dip, shape, and strength of the ore and the surrounding rock.

❖ ***Traditional exploitation methods*** fall into two broad categories based on locale: ***surface*** or ***underground***.

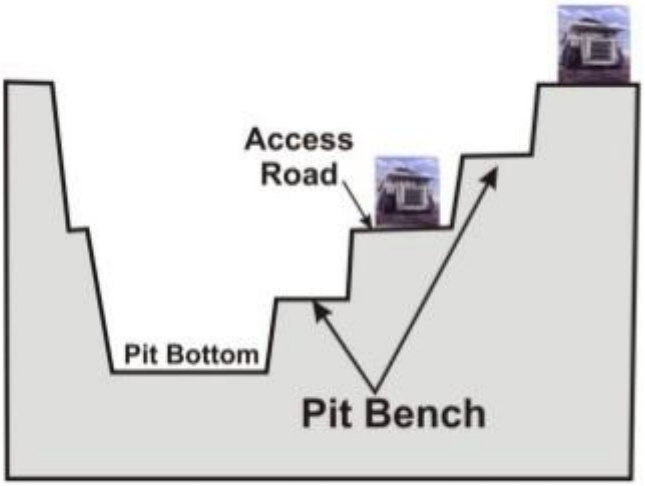
☒ ***Surface mining*** includes;

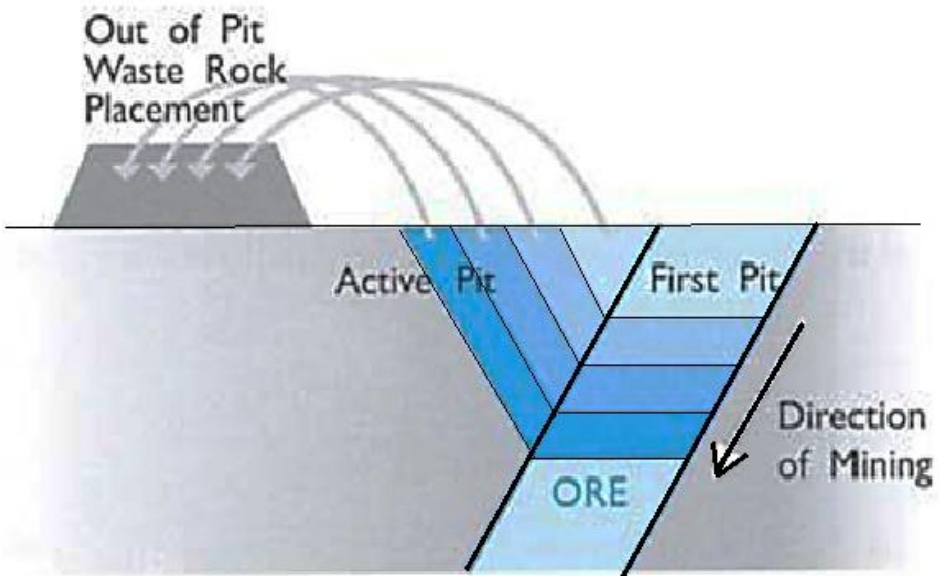
- mechanical excavation methods such as open pit and open cast (strip mining),
- aqueous methods such as placer and solution mining.

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

1-6-1 Surface Mining. Surface mining is the predominant exploitation procedure worldwide, producing in the United States about 85% of all minerals, and most of these are mined by open pit or open cast methods.

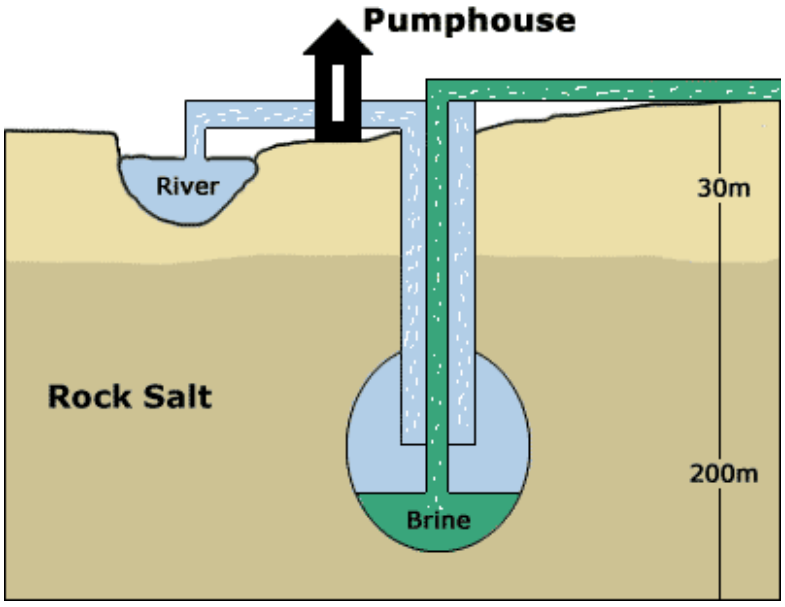
- In ***open pit mining***, a ***mechanical extraction method***, a thick deposit is generally mined in benches or steps, although thin deposits may require only a single bench or face.
- Open pit or open cast mining is usually employed to exploit a near-surface deposit or one that has a low stripping ratio.
- It often necessitates a large capital investment but generally results in high productivity, low operating cost, and good safety conditions.

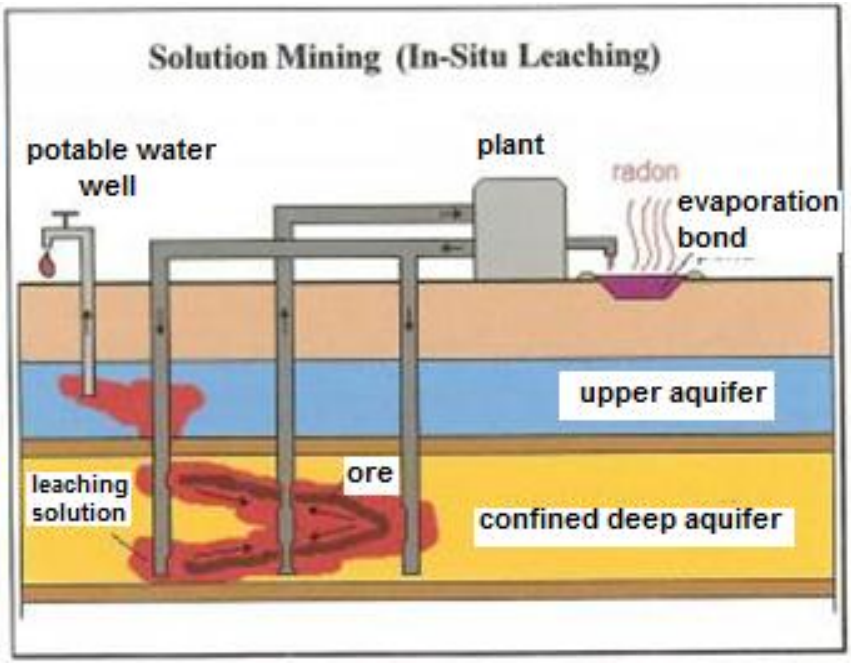




❖ The ***aqueous extraction methods*** depend on water or another liquid to extract the mineral.

- ***Placer mining***
- ***Hydraulic or Hydraulicking***
- ***Dredging***
- ***Solution mining*** includes both ***borehole mining*** and **leaching**





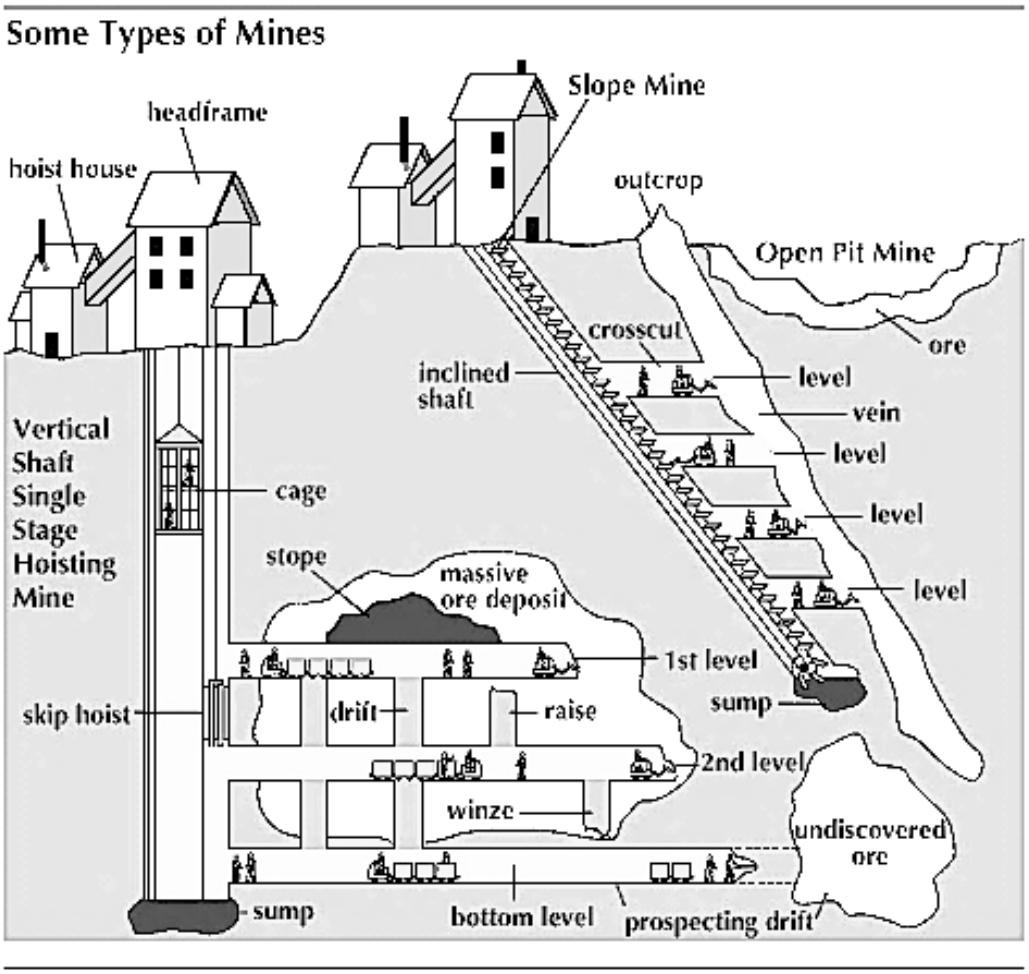
1-6-2 Underground Mining.

Underground methods—unsupported, supported, and caving—are differentiated by;

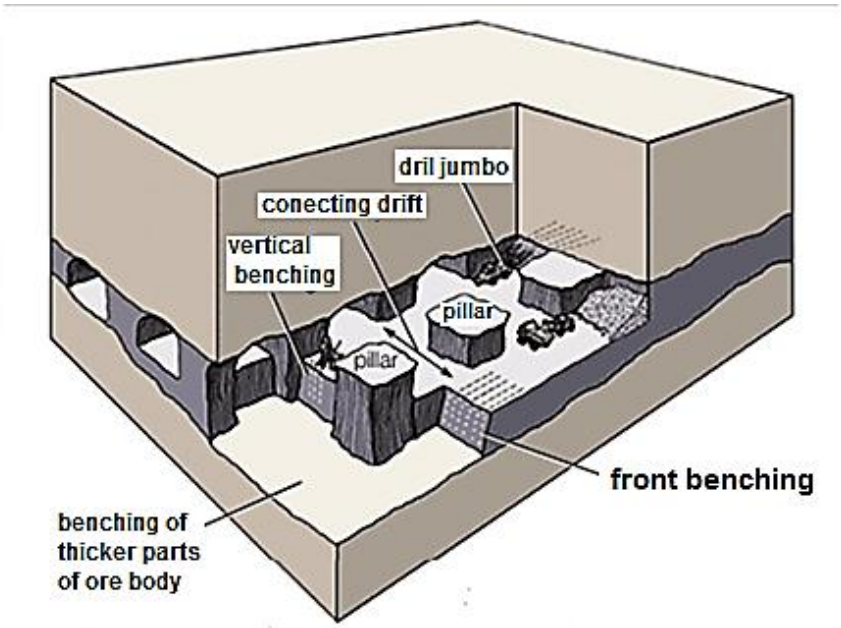
- the type of wall and roof supports used,
- the configuration and size of production openings,
- the direction in which mining operations progress.

❖ The ***unsupported methods*** of mining are used to extract mineral deposits that are roughly tabular (plus flat or steeply dipping) and are generally associated with strong ore and surrounding rock.

❖ These methods are termed ***unsupported*** because they do not use any artificial pillars to assist in the support of the openings. However, generous amounts of roof bolting and localized support measures are often used.



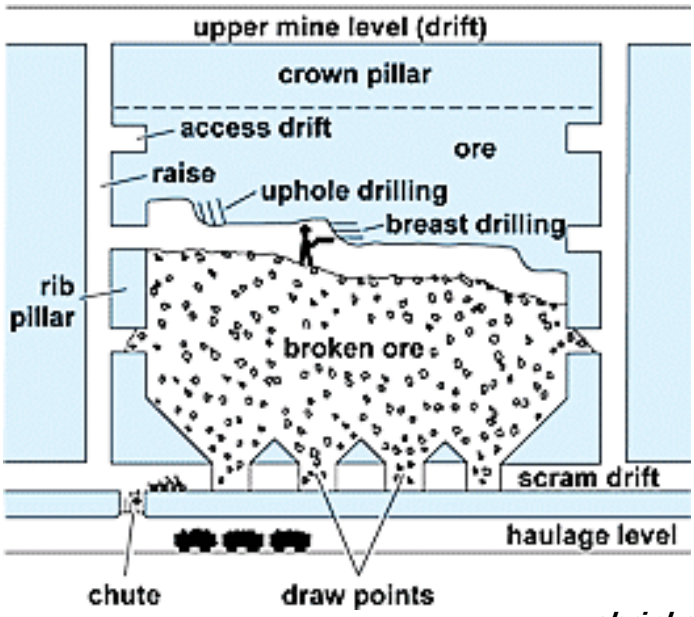
- ***Room-and-pillar mining*** is the most common unsupported method, used primarily for flat-lying seams or bedded deposits like coal, trona, limestone, and salt. Support of the roof is provided by natural pillars of the mineral that are left standing in a systematic pattern.

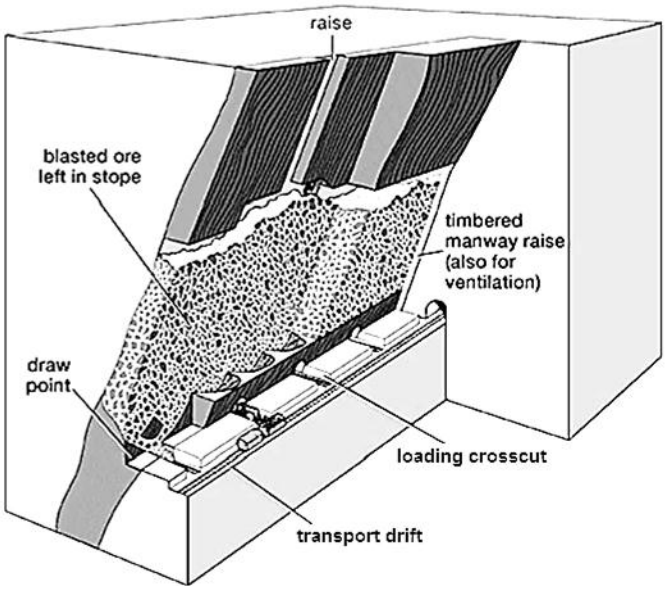


- ***Stope-and-pillar mining*** (a stope is a production opening in a metal mine) is a similar method used in non coal mines where thicker, more irregular ore bodies occur; the pillars are spaced randomly and located in low-grade ore so that the high-grade ore can be extracted.

Two other methods applied to steeply dipping deposits are also included in the unsupported category.

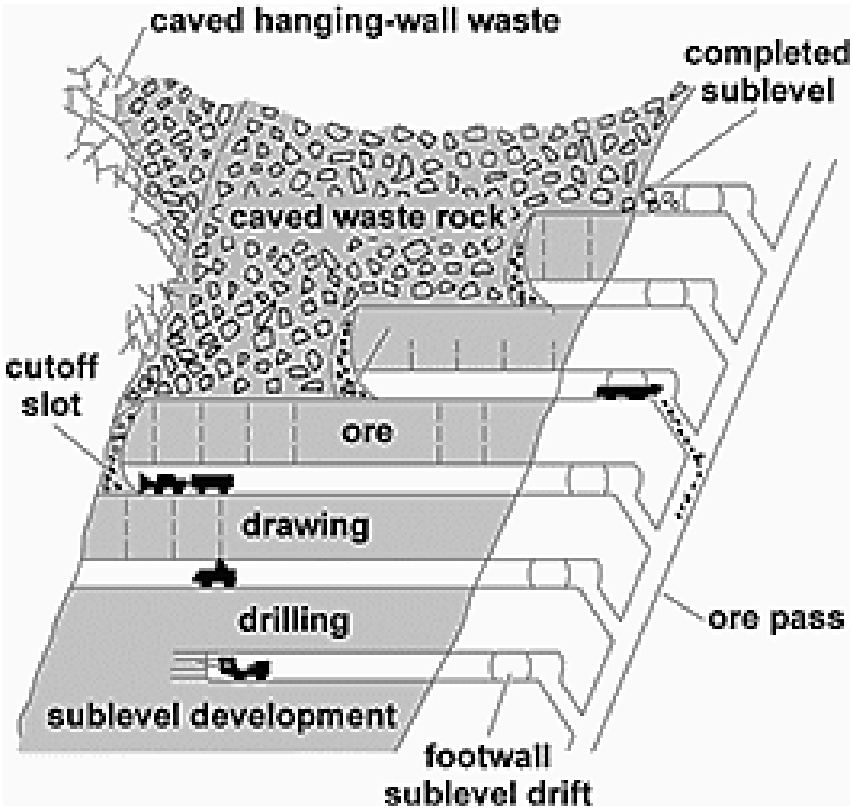
- In ***shrinkage stoping***, mining progresses upward, with horizontal slices of ore being blasted along the length of the stope. A portion of the broken ore is allowed to accumulate in the stope to provide a working platform for the miners and is thereafter withdrawn from the stope through chutes.





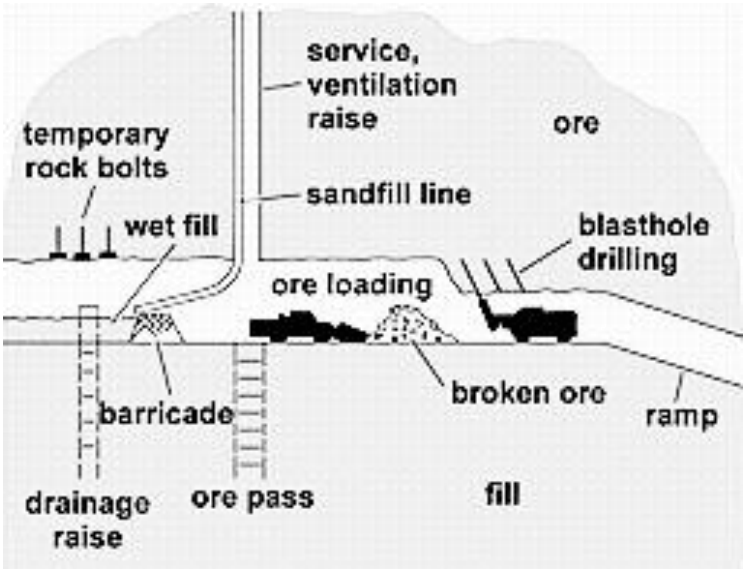
❖ ***shrinkage stoping***

❖ ***Sublevel stoping*** differs from shrinkage stoping by providing sublevels from which vertical slices are blasted. In this manner, the stope is mined horizontally from one end to the other. Shrinkage stoping is more suitable than sublevel stoping for stronger ore and weaker wall rock.

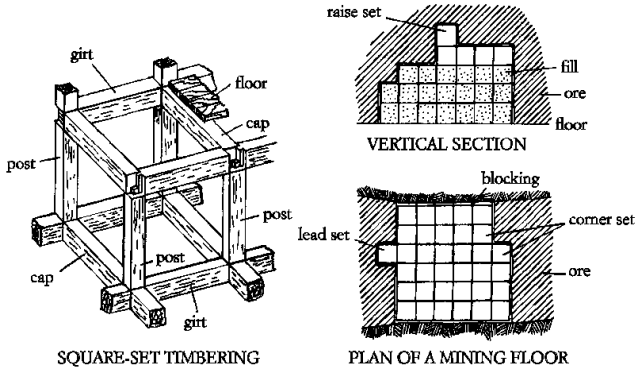


Supported mining methods are often used in mines with weak rock structure.

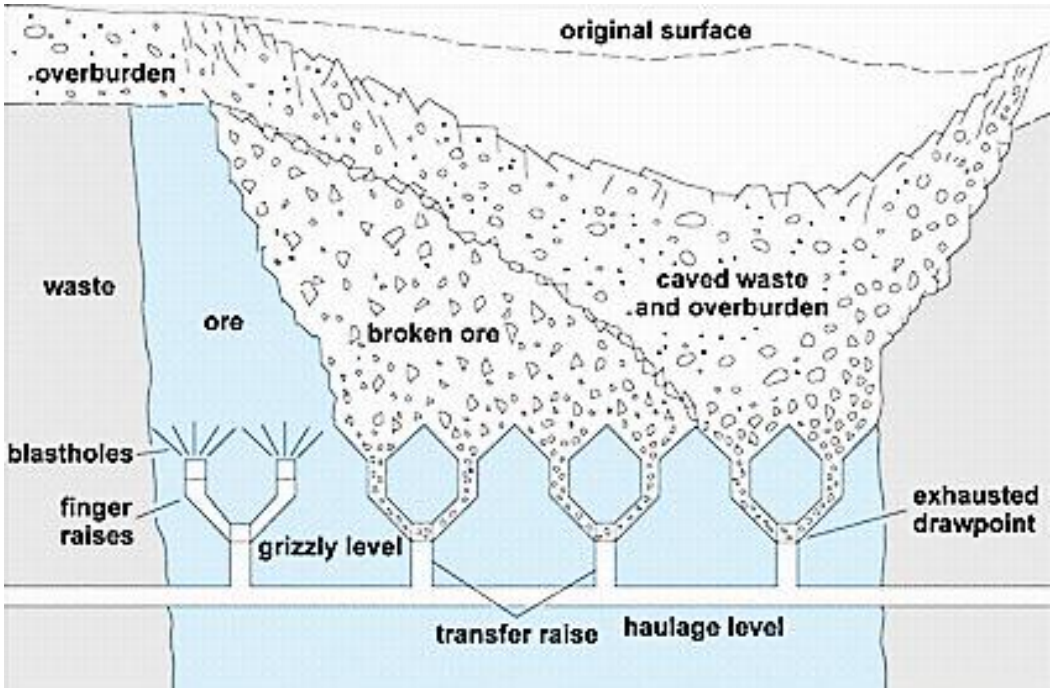
- ***Cut-and-fill stoping*** is the most common of these methods and is used primarily in steeply dipping metal deposits. The cut-and-fill method is practiced both in the overhand (upward) and in the underhand (downward) directions. As each horizontal slice is taken, the voids are filled with a variety of fill types to support the walls. The fill can be rock waste, tailings, cemented tailings, or other suitable materials. Cut-and-fill mining is one of the more popular methods used for vein deposits and has recently grown in use.



- ***Square-set stoping*** also involves backfilling mine voids; however, it relies mainly on timber sets to support the walls during mining. This mining method is rapidly disappearing in North America because of the high cost of labor. However, it still finds occasional use in mining high-grade ores or in countries where labor costs are low.

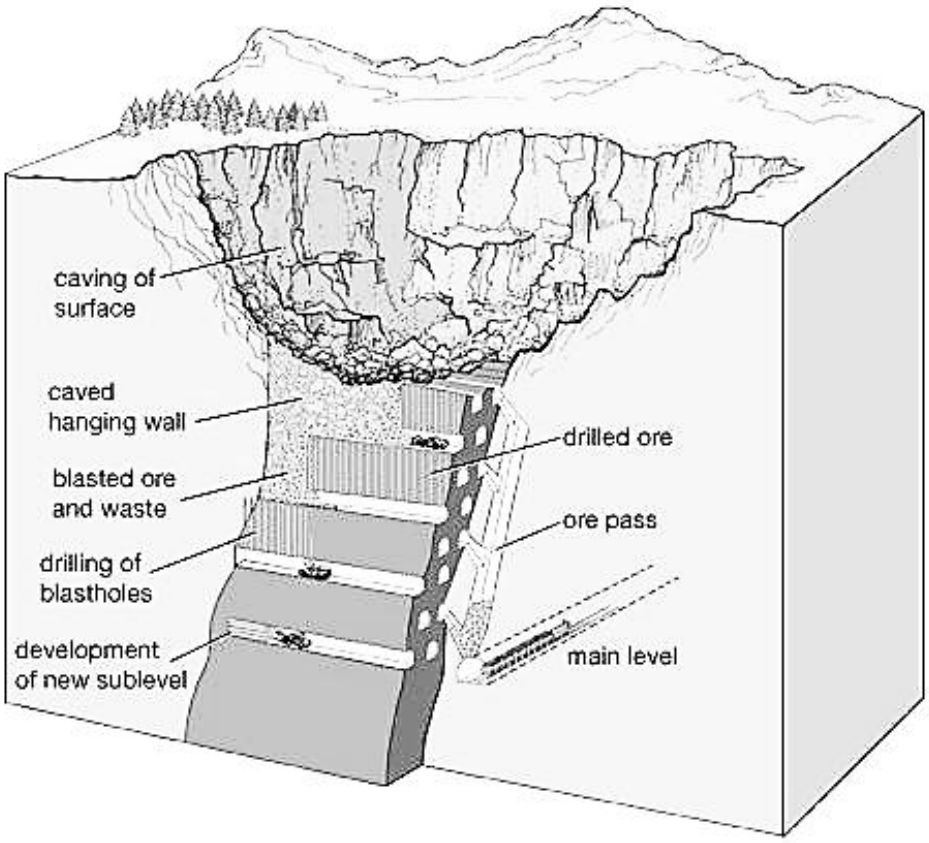


- ***Stull stoping*** is a supported mining method using timber or rock bolts in tabular, pitching ore bodies. It is one of the methods that can be applied to ore bodies that have dips between 10° and 45°. It often utilizes artificial pillars of waste to support the roof.
- ***Caving methods*** are varied and versatile and involve caving the ore and/or the overlying rock. Subsidence of the surface normally occurs afterward.



- ***Longwall mining*** is a caving method particularly well adapted to horizontal seams, usually coal, at some depth. In this method, a face of considerable length (a long face or wall) is maintained, and as the mining progresses, the overlying strata are caved, thus promoting the breakage of the coal itself.

- A different method, ***sublevel caving***, is employed for a dipping tabular or massive deposit. As mining progresses downward, each new level is caved into the mine openings, with the ore materials being recovered while the rock remains behind.



- ***Block caving*** is a large-scale or bulk mining method that is highly productive, low in cost, and used primarily on massive deposits that must be mined underground. It is most applicable to weak or moderately strong ore bodies that readily break up when caved. Both block caving and longwall mining are widely used because of their high productivity.

1-7 Reclamation

- The final stage in the operation of most mines is *reclamation*, the process of closing a mine and recontouring, revegetating, and restoring the water and land values.
- The best time to begin the reclamation process of a mine is before the first excavations are initiated. In other words, mine planning engineers should plan the mine so that the reclamation process is considered and the overall cost of mining plus reclamation is minimized, not just the cost of mining itself.
- The new philosophy in the mining industry is ***sustainability***, that is, the meeting of economic and environmental needs of the present while enhancing the ability of future generations to meet their own needs.
- The successful completion of the reclamation of a mine will enhance public opinion of the mining industry and keep the mining company in the good graces of the regulatory agencies.

In planning for the reclamation of any given mine, there are many concerns that must be addressed.

1. The **first** of these is the **safety of the mine site**, particularly if the area is open to the general public.
    - The removal of office buildings, processing facilities, transportation equipment, utilities, and other surface structures must generally be accomplished.
    - The mining company is then required to seal all mine shafts, adits, and other openings that may present physical hazards.
    - Any existing high walls or other geologic structures may require mitigation to prevent injuries or death due to geologic failures.

2. The **second** is **<u>restoration</u>** of the land surface, the water quality, and the waste disposal areas so that long-term water pollution, soil erosion, dust generation, or vegetation problems do not occur.
    - The restoration of native plants is often a very important part of this process, as the plants help build a stable soil structure and naturalize the area.
    - It may be necessary to carefully place any rock or tailings with acid-producing properties in locations where rainfall has little effect on the material and acid production is minimized. The same may be true of certain of the heavy metals that pollute streams.
    - Planning of the waste dumps, tailings ponds, and other disturbed areas will help prevent pollution problems ,but remediation work may also be necessary to complete the reclamation stage of mining and satisfy the regulatory agencies.
3. The **third** concern is **<u>subsequent use of the land after mining is completed</u>**.
    - Old mine sites have been converted to wildlife refuges, shopping malls, golf courses, airports, lakes, underground storage facilities, real estate developments, solid waste disposal areas, and other uses that can benefit society.
    - By planning the mine for a subsequent development, mine planners can enhance the value of the mined land and help convert it to a use that the public will consider favorable.