Coal Mining Methods

Underground Mining

Longwall & Room and Pillar Mining

Longwall mining and room-and-pillar mining are the two basic methods of mining coal underground, with room-and-pillar being the traditional method in the United States. Both methods are well suited to extracting the relatively flat coalbeds (or coal seams) typical of the United States. Although widely used in other countries, longwall mining has only recently become important in the United States, its share of total underground coal production having grown from less than 5 percent before 1980 to about half in 2007. More than 85 longwalls operate in the United States, most of them in the Appalachian region.

In principle, longwall mining is quite simple (Fig. 1). A coalbed is blocked out into a panel averaging nearly 800 feet in width, 7000 feet in length, and 7 feet in height, by excavating passageways around its perimeter. A panel of this size contains more than 1 million short tons of coal, up to 80% of which will be recovered. In the extraction process, numerous pillars of coal are left untouched in certain parts of the mine in order to support the overlying strata. The mined-out area is allowed to collapse, generally causing some surface subsidence.

Extraction by longwall mining is an almost continuous operation involving the use of self-advancing hydraulic roof supports, a sophisticated coal-shearing machine, and an armored conveyor paralleling the coal face. Working under the movable roof supports, the shearing machine rides on the conveyor as it cuts and spills coal onto the conveyor for transport out of the mine. When the shearer has traversed the full length of the coal face, it reverses direction and travels back along the face taking the next cut. As the shearer passes each roof support, the support is moved closer to the newly cut face. The steel canopies of the roof supports protect the workers and equipment located along the face, while the roof is allowed to collapse behind the supports as they are advanced. Extraction continues in this manner until the entire panel of coal is removed.

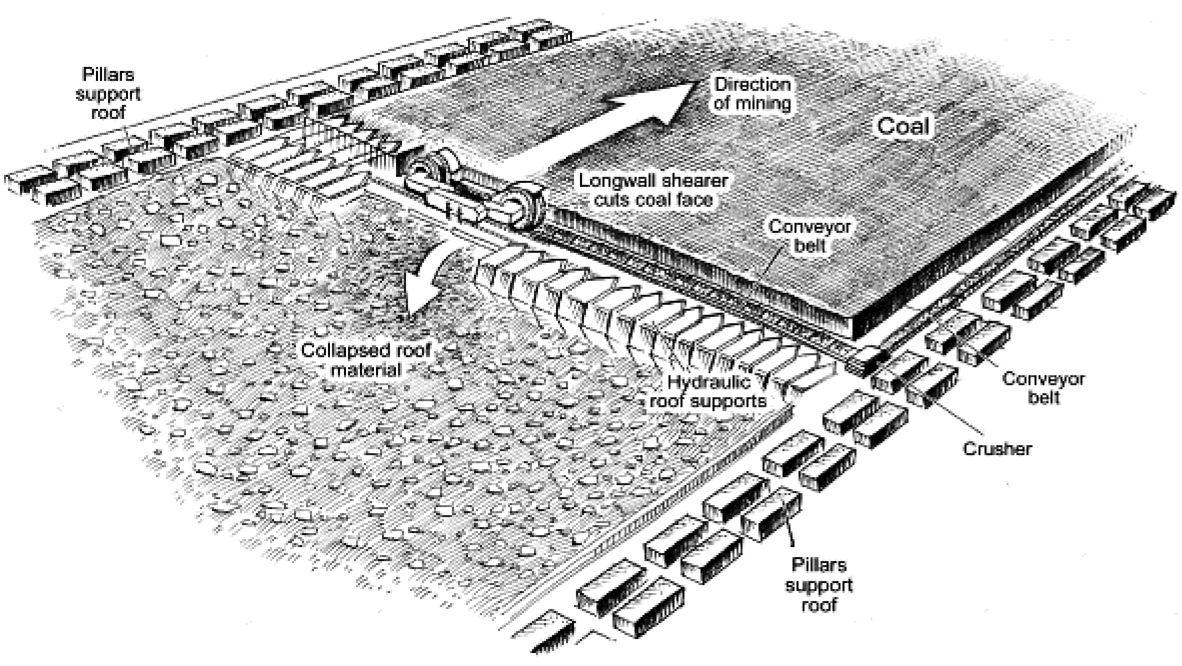

Fig. 1: Longwall Mining

Other underground coal mines are laid out in a checkerboard of rooms and pillars (Fig. 2), and the mining operation involves cyclical, step by-step mining sequences. The rooms are the empty areas from which coal has been mined, and the pillars are blocks of coal (generally 40 to 80 feet on a side) left to support the mine roof. Room-and-pillar mining generally is limited to depths of about 1,000 feet because at greater depths larger pillars are needed, resulting in smaller coal recovery (typically 60% of the coal in the affected area).

In "conventional" room-and-pillar mining, production occurs in five steps: mechanically undercutting the coalbed, drilling holes into the bed for explosives, blasting the coal, loading the broken coal into shuttle cars for delivery to a conveyor, and then bolting the mine roof in the excavated area.

To provide a steady flow of coal in a room-and-pillar mine, several stages of mining occur simultaneously in different rooms. A final phase of mining termed "retreat mining" may be performed to recover additional coal by extracting pillars and allowing the roof to fall.

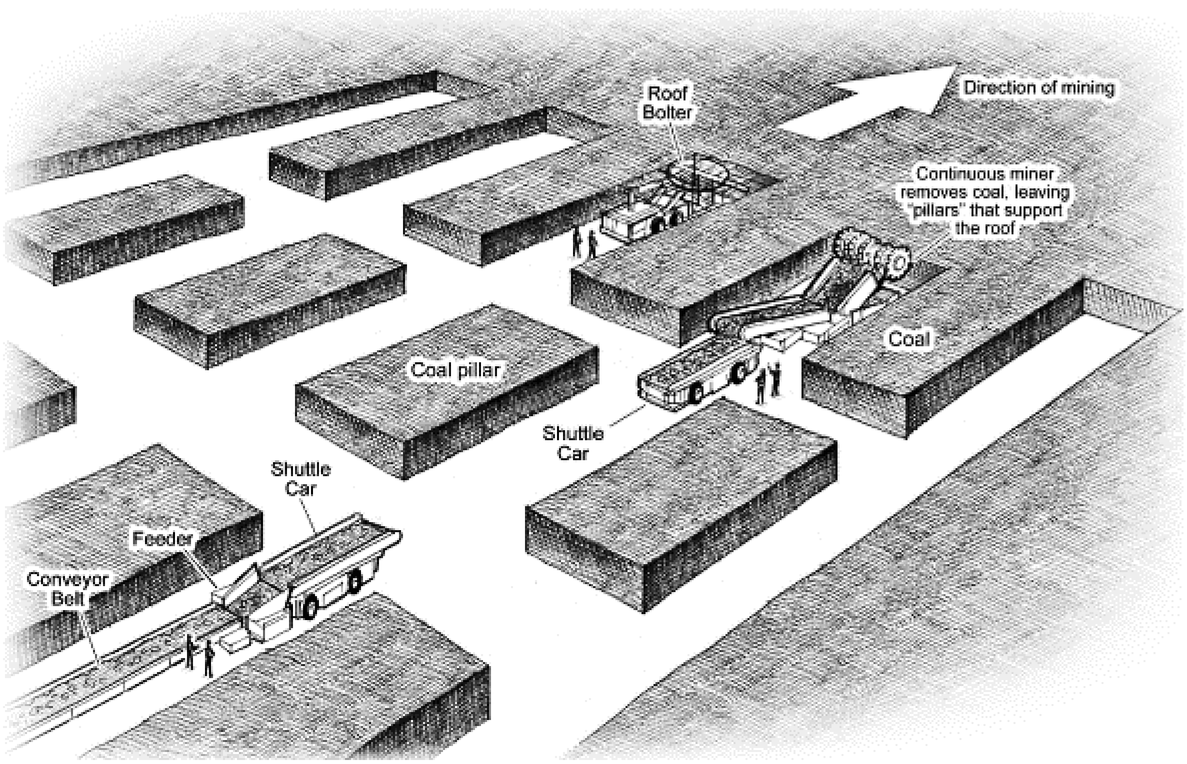

Fig. 2: Room and Pillar Mining

The "continuous" version of room-and pillar mining is the most common, representing more than half of all underground production. In this method, a continuous mining machine excavates the coal and loads it onto a conveyor or shuttle car in a single step. Despite the term "continuous," the machine operates only part of the working time, because after mining advances about 20 feet, the machine is withdrawn from the face so that roof bolts can be installed to bond the strata and prevent caving.

However, this is a complex procedure that requires additional planning.

Advantages of Longwall Mining

Longwall mining is a very efficient coal producing technique. Longwall productivity is potentially higher than that of room-and-pillar mining, because longwall mining is basically a continuous operation requiring fewer workers and allowing a high rate of production to be sustained. The amount of coal recovered is also high, currently averaging 57 percent nationwide but substantially higher in some mines. Room-and-pillar recovery rates are usually lower, but they may approach longwall recoveries if retreat mining is employed.

The longwall system also concentrates miners and equipment in fewer working sections, which makes the mine easier to manage. Safety improves through better roof control and a reduction in the use of moving equipment. This method eliminates roof bolting at the working face to support the mine roof, and it minimizes the need for dusting mine passages with inert material to prevent coal dust explosions. It involves no blasting, with its consequent dangers. It also recovers more coal from deeper coalbeds than does room-and-pillar mining. The coal haulage system is simpler, ventilation is better controlled, and subsidence of the surface is more predictable. Overall, longwall mining offers more opportunities for automation.

Disadvantages of Longwall Mining

Longwall mining's chief drawback is high capital costs. Costs for equipment and installation are substantially higher than for room-and-pillar mining. Longwall mines need continuous mining machines (similar to those used in room-and-pillar mines) to block out panels of coal. Plus, longwall mines need the specialized longwall, with its rugged and very expensive shields, cutters, and conveyors. A large initial capital outlay is required, and there is little immediate return from coal production (apart from the small amounts of coal produced during the development of accessways and the first coal panel. The large front-end investment and deferred revenue generally restrict users of longwall technology to large coal companies.

Longwall mining is also complex, with many moving parts, all of which must operate as an integrated system. Failure of one part can disrupt the entire operation, delaying production and causing contractual difficulties.

Longwall mining also requires a well-maintained ventilation system because of the large amounts of dust and methane produced. Dust levels often exceed the maximum allowable limit despite the use of advanced dust-control technology. A temporary variance may be required while dust levels are reduced by modifying the coal-cutting sequence or by increasing the air flow across the face.

Geologic Limitations

Not all coalbeds are suitable for longwall mining. The technique works best in coalbeds that are extensive, fairly flat-lying, generally uniform in thickness, and free of discontinuities, such as large faults or other geologic features that could interfere with continuous coal extraction. The mine floor must provide a firm base for the moveable roof supports used in longwall mining. Large aquifers should not overlie the coalbed. Oil and gas wells that penetrate the mine are problematic, because pillars of coal must be left to protect the wells.

Ideally, the strata overlying the coalbed should cave behind the roof supports soon after the coal is extracted. If the strata hang up and break into large blocks, the high stresses placed on the roof supports may lock them in place and interfere with their operation. When large sections of hard-to-cave roof strata eventually fall, dangerous working conditions can occur due to violent air blasts, ground vibrations, and related conditions.

On the other hand, certain geologic conditions strongly favor longwall mining over room-and-pillar mining. In particular, coalbeds deeper than 1000 feet typically must be extracted using longwall mining. Room-and-pillar mining generally is not economical at such depths because the very large pillars are required to support the roof, which significantly reduces the amount of coal that can be recovered. Longwall mining is well suited to deep coalbeds because there is no need to support the roof. In fact, the roof in deep mines is less likely to hang up, thereby reducing the stress on the roof supports.

Development of a Longwall Operation

The first step in the development, or preparation, of a panel of coal for longwall mining involves the use of continuous mining machines to dig entries, or passageways, on three sides of a panel, starting from the main entries of the mine. Development work generally requires 9 to 12 months, depending on the size of the panel. A small amount of coal is produced during this stage, because entries are excavated through the coalbed, using room-and-pillar techniques. Development work also provides a means for exploring the area to be mined for potentially troublesome geologic conditions. In areas with a history of geologic problems or large variations in coalbed thickness, the panel may be explored prior to development by drilling from the surface.

The Federal Coal Mine Health and Safety Act of 1969 requires that mine entries consist of at least three parallel passageways (three-entry systems), so that if one is accidentally blocked the others afford a means of escape; at least one provides an airway for mine ventilation. However, the Act allows a mining company to use two passageways (two-entry systems) if the safety of its mining plan is approved by the U.S. Mine Safety and Health Administration. Two-entry systems have been approved for use in several western coal mines because they provide better ground stability than the three-entry systems previously used.[2]

In longwall mines, two sets of entries called "panel entries" (or "gate entries"), one on each side of the panel of coal to be mined, are driven from the main mine entries to the end of the panel. They are then connected at the back of the panel by another set of entries.

Each entry is about 20 feet wide and 6 feet high. Entries are connected at regular intervals by crosscuts, which are dug to allow workers and equipment to pass between adjacent entries. The entries next to the panel that are used to transport miners, coal, and supplies are the "headgate" entries (or "headentry"). On the opposite side of the panel are the "tailgate entries" ("tailentry"), used mainly as an airway in ventilating the mine. Due to the parallel layout of longwall panels, the headgate entries become the tailgate entries of the next panel to be mined. The entries at the back of the panel, where extraction begins, are "bleeder entries" that provide continuity in the mine ventilation system.

Within the entries are un-mined parts of the coalbed called "chain pillars" that are left to support time overlying strata. They measure 20 to 150 feet in width and 40 to 20 feet in length, depending on mining conditions. Additional support is provided by roof bolting. Optimizing pillar design for both safely and economics is a key part of planning longwall mines. Miners working in the entries are not protected by powered supports as they are at the face and are exposed to greater roof-fall hazards. Thus, pillar design is a key to preserving safety in this area. On the other hand, pillars that are too large can be expensive and wasteful because the coal locked up in them is seldom recovered and is a lost resource. In addition to the chain pillars in the entries, large "barrier pillars" (200 to 500 feet on a side) are left at both ends of the panel to provide roof support and to separate unmined and mined out panels. A "setup room" is excavated next to the barrier pillar at the rear of the panel to provide space for assembling the longwall equipment.

Extraction by Longwall Mining

After the longwall panel has been blocked out by entries, it is mined out on retreat: extraction begins from the farthest end of the panel and proceeds toward the main entries (toward the mine entrance). This technique contrasts with the "advance" system, common in Europe, in which mining progresses away from the main haulageway toward the far end of the panel. Although advance longwall mining produces large amounts of coal from the onset, the method has disadvantages. Development of the entries on each side of the panel must continue simultaneously with the advance of the longwall face, "deadwork" is required to keep entries open through caved ground ("gob") behind the area extracted, and mine ventilation is more complex than with the retreat method. The advance system was tried in U.S. coalfields, but it was abandoned because of roof failures and poor production. The current trend in European coal mines is toward the greater use of retreat longwall mining.

The longwall mining system comprises three basic equipment components – movable roof supports, a coal extraction machine that moves back and forth across the coal face, and an armored conveyor at the coal face. Almost all movable roof supports in use today are shields, the most stable in a succession of roof support designs. A shield consists of a canopy, a caving shield that prevents rock fragments from getting into the working area, and two to four hydraulically operated legs set on a base. Today's shields typically can support 600 to 800 tons of rock. More than 100 shields, set side by side, are required for a single longwall panel. Apart from supporting the roof, the shields provide 10 to 15 feet of space for miners and equipment to work. As the coal is removed and the face advances, a system of controls and hydraulic cylinders snake both the shields and the conveyor forward. The roof of the mined out section is allowed to collapse behind the shields, forming gob.

Surface Mining

When coal seams are near the surface, it may be economical to extract the coal using open cut (also referred to as open cast or open pit) mining methods. Strip mining is typically used for coal. Strip mining exposes the coal by the advancement of a moving open pit or strip. The earth above the coal is known as overburden. A strip of overburden next to the previously mined strip is usually drilled. The drill holes are filled with explosives and blasted. The overburden is then removed using large earthmoving equipment such as draglines, shovels and trucks, excavator and trucks, or bucket-wheels and conveyors. This overburden is put into the previously mined (and now empty) strip. When all the overburden is removed, the underlying coal seam will be exposed as a strip known as a 'block'. Coal in the block may be drilled and blasted (if hard) or ripped (if soft or friable), and loaded on to trucks or conveyors for transport to a crushing or washing plant. Once all coal is gone from the current strip, a new strip is created next to it.

Open cast coal mining recovers a greater proportion (up to 90 percent) of the coal deposit than underground methods. Globally, about 40 percent of coal is produced by surface mining. Surface mining accounts for around 80 percent of Australia’s production and two-thirds of production in the United States. Opencast coal mines can cover many square kilometers.

Mountaintop removal is a form of surface mining that involves scraping off the topmost portion of a mountain to expose the underlying coal. It has been used in Appalachia for more than 30 years. It is highly controversial because of the drastic changes in topography, the creation of hollow fills (valleys filled with mining debris), the covering of streams, and the disruption of ecosystems.

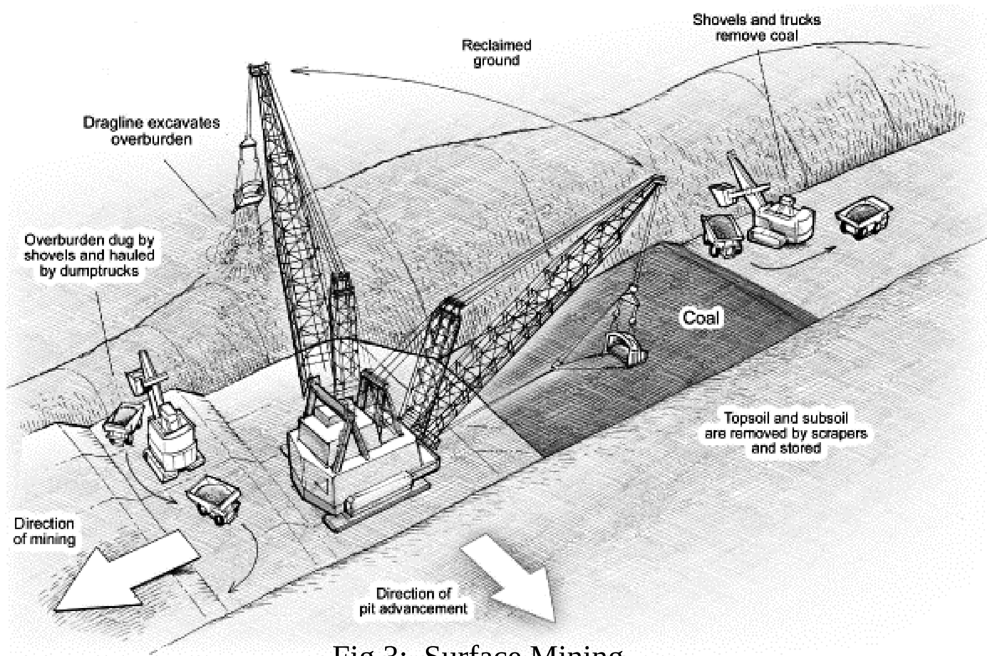

Fig.3: Surface Mining

Sources

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http://en.wikipedia.org/wiki/Coal_mining