OHIO GEOLOGY

GeoFacts No. 15

OHIO DEPARTMENT OF NATURAL RESOURCES • DIVISION OF GEOLOGICAL SURVEY

COAL MINING AND RECLAMATION

Coal has been mined in Ohio since 1800. Mining technology has evolved from pick and shovel to the highly automated, computer-controlled equipment used today. There are two basic types of coal mines: surface mines and underground mines. Since 1800, approximately 3.9 billion tons of coal have been mined in Ohio. This tonnage includes 1.5 billion tons from surface mines and 2.4 billion tons from underground mines. To put this in perspective, imagine a pile of coal more than 20 feet high covering the entire city of Columbus, Ohio.

SURFACE MINING

Surface mining involves removing layers of soil and rock (called *overburden*) above the coal seam and extracting the coal. This method is used where coal seams lie close to Earth's surface. Surface mining in Ohio was first reported in 1810 from a ravine located one mile west of Tallmadge in Summit County. Early surface mining in Ohio consisted of digging coal that outcropped along hillsides, using picks and shovels and in some cases horse-drawn scrapers. The coal and cover material were excavated from the hillside until removal of the cover material became impractical. At this point, coal mining would continue using underground methods.

Mechanized surface mining began in Ohio during the 1880s in conjunction with the construction of railroads. However, surface mining remained minimal until 1914, when large amounts of coal were needed as fuel for World War I. By 1948, surface mining became the dominant method by which coal was produced in Ohio and remained the dominant method until 1995, when more coal was produced in Ohio by underground mining.

Before surface mining can take place, a permit must be obtained from the ODNR Division of Mineral Resources Management. When mining begins, vegetation is removed, and then topsoil and subsoil are removed by bulldozers and earthmovers and stored on the mine site for use in reclamation. Bedrock is loosened by large bulldozers equipped with claw-shaped rip-blades or by blasting. Bulldozers rip up rock, such as shale, that is easily broken. However, more competent rock, such as limestone or well-cemented sandstone, requires blasting. During the blasting process, many closely spaced holes are drilled to a depth that is just above the coal seam. These holes are loaded with explosives and are carefully detonated to only fracture the rock to be excavated. Bulldozers, front-end loaders, and large power shovels or draglines move the loosened bedrock to expose the coal, producing a highwall (a man-made cliff). The overburden is dumped in rows, called *spoil piles*, behind or adjacent to the highwall. Smaller power shovels or front-end loaders load the coal into trucks, which move the coal out of the mine to processing facilities.

The floor of the excavation is called a *pit* or *bench*. Surface mining advances sequentially in a series of benches across the mine site until nearly all the coal has been removed. The bedrock overburden excavated from each pit is used to backfill the preceding pit to its approximate premining contour. Stored subsoil is used to cover the spoil and is in turn covered by topsoil. Finally, the area is revegetated with grasses and/or legumes as required by law.

In Ohio, approximately 80–90 percent of the coal can be recovered by surface mining. The economic limit of surface mining in Ohio is generally a 20:1 ratio of overburden thickness to coal thickness. For example, a 3-feet-thick seam of coal generally can be surface mined economically at an overburden thickness up to 60 feet. Under certain conditions, surface mines in Ohio have used some of the largest surface-mining equipment in the world, including the "Big Muskie" dragline and the "Mountaineer" shovel, producing a highwall up to 200 feet high to mine a 5-feet-thick seam of coal.

UNDERGROUND MINING

There are three types of underground mines, named for the type of opening used to gain access to the coal. *Drift mines* use a horizontal opening to mine coal that occurs above stream level. *Shaft mines* use a vertical opening and *slope mines* use an inclined opening to reach coal at greater depths. Shaft and slope mining have been used to mine coal in Ohio that is over 500 feet below the surface.

Most underground mines in Ohio use the *room-and-pillar* process of mining. A series of rooms are cut into the coal bed and pillars of coal are left for roof support. Wooden timbers and roof bolts are used as additional supports. As room-and-pillar mining advances, a grid-like pattern is formed. Typically, rooms are 20–30 feet wide and up to 400 feet long. Pillars are 20–30 feet wide and 90 feet long. In room-and-pillar mining, generally 50–70 percent of the coal is recovered and the remainder is left as roof support. In Ohio, coal that is less than 3 feet thick has been recovered by underground methods, but normally a coal seam of greater than 4 feet in thickness is required due to economics and technological restraints.

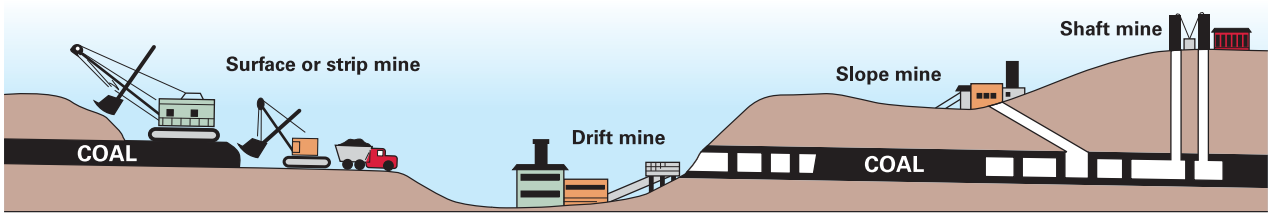
The most common type of room-and-pillar mining is *continuous mining*. In continuous mining, coal is cut by a machine using a rotating cylinder studded with tungsten carbide bits. The coal is then loaded onto a shuttle car or conveyor and carried to the tipple, where it is loaded for shipment.

Another type of underground mining is *longwall mining*, where the coal is mined from one long face. The area to be mined (the longwall) can be up to 14,000 feet long and 800 feet wide. In longwall mining, a machine with a revolving cylinder studded with tungsten carbide bits moves back and forth across the working face, shearing off chunks of coal, while water is sprayed on the coal to minimize the amount of coal dust generated. Just as in continuous mining, the coal falls onto a conveyor system or is loaded onto underground rail cars and carried to the surface. In longwall mining, moveable steel supports hold up the roof over the immediate working area. As the mining machine moves forward, steel roof supports advance with the machine, allowing the roof in the mined-out area behind the supports to collapse in a controlled manner. Nearly 80 percent of the coal can be recovered using this method.

AUGER AND HIGHWALL MINING

Another type of coal mining less common in Ohio is *auger mining*, which combines surface and underground methods. In auger mining, coal is extracted by drilling horizontal holes as far as 500 feet into a seam using screwlike augers, which resemble giant drill bits and are up to 5 feet in diameter. Auger mining is used when it is not feasible to extend a highwall beyond a 20:1 surface-mining limit.

A type of coal mining relatively new in Ohio is *highwall mining*. Openings several feet wide are cut into a coal seam exposed in a



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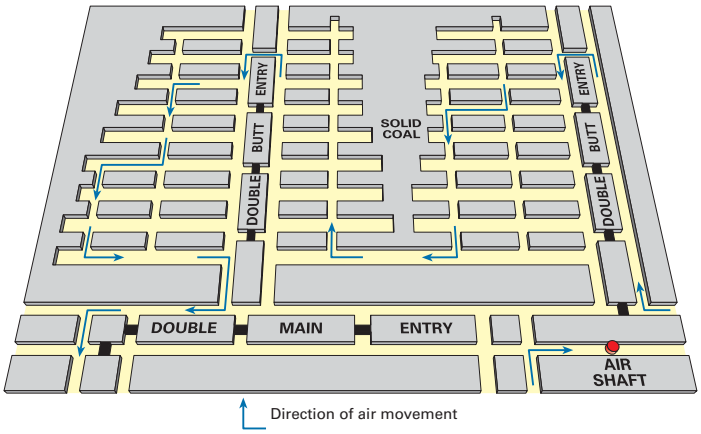

Plan view of idealized double-entry room-and-pillar mine layout (modified from Crowell, 1995, p. 37).

highwall. Roof supports advance with the cutting head and the coal is removed to the rear of the machine by augers. The operator remains safely outside the mine as the cutting head advances underground. Highwall mining can access coal more than 1,500 feet into a hillside, allowing for greater percentage of recovery than auger mining.

EFFECTS OF MINING

By necessity, surface land is disturbed during the process of mining coal. The area of the disturbed land can range in size from a few acres to thousands of acres depending on the availability of the coal resource. The impact of mined land that was not properly reclaimed (before surface mine laws were enacted) can result in environmental degradation due to (1) streams choked by excessive sediment loads, (2) acid mine drainage, and (3) subsidence.

Spoil produced during mining consists of crushed rock, including coal, but it contains no humus, lacks nutrients for plant growth, and has poor moisture retention. Therefore, spoil piles support little to no vegetation and are easily eroded if not reclaimed. Sediment loads of streams fed by eroding spoil piles can be increased by as much as 1,000 times. Thus, these streams can quickly fill with sediment, creating flood conditions and disrupting natural stream flow, which is detrimental to wildlife and groundwater resources.

Nonreclaimed spoil piles often contain pyrite-bearing rock. Pyrite is an iron disulfide (FeS_2) mineral. When it is exposed to oxygen and water, especially in the presence of *Bacillus ferroxidans*, a pyrite-oxidizing bacterium, it produces sulfuric acid ($2H_2SO_4$). Streams carrying acid mine drainage commonly have a reddish or yellowish sediment coating their bottoms. This coating, called *yellow boy*, is an iron sulfate precipitate (Fe_2SO_4). The acid mine drainage added to a stream severely affects aquatic wildlife and may adversely affect the quality of local groundwater aquifers.

Improper underground mining techniques, particularly in historic mines, can lead to surface subsidence (see GeoFacts No. 12). Subsidence can impact homes, business, and infrastructure that have been built over long-abandoned mines. Abandoned underground mines are also a safety concern. When openings (drift, slope, hoisting shaft, and air shaft) are not sealed upon abandonment, these openings become dangerous. People may fall into the mine or use these openings to explore inside the mine; the result can be deadly. The atmosphere in an abandoned underground mine may be unfit or poisonous to breathe and the condition of the roof rock may be so deteriorated that collapse can occur without warning.

RECLAMATION OF MINED LAND

Reclamation is a process of systematically restoring mined land to productive uses. Until 1947, when Ohio's first surface-mining law was passed, surface mining was unregulated and coal companies were not required to restore the land after mining. A few companies performed some reclamation before any law required it, but most companies did not restore mined land because the cost of reclamation was not considered justifiable from a business standpoint. In 1949, the Ohio Division of Reclamation (now the ODNR Division of Mineral Resources Management) was created and charged with administering the new reclamation law. However, Ohio's early surface-mining law was weak in some respects. The initial reclamation law required the posting of a modest reclamation bond of $100–$200 per acre mined and did not require the establishment of successful vegetation on mined lands; therefore, great amounts of fertile topsoil were lost through erosion. Consequently, Ohio's surface-mining law was amended many times and in 1972 became one of the nation's strictest laws regulating active surface mining.

Reclaimed mine lands used for a cattle ranch in Belmont County, Ohio. Photo courtesy of Dickinson Cattle Co.

Before beginning surface mining, a company must specify how topsoil, water conditions, vegetation, wildlife, and archaeological resources will be protected, in addition to outlining how the land will be mined and reclaimed. Also, the company must post a bond to insure that successful land restoration is carried out. Among the many requirements of Ohio's mine law are: (1) restoration of coal-mined land to its approximate original, premining contour, (2) concurrent reclamation, (3) establishment of successful vegetation, which must be monitored for five years before bond monies are fully released to the operator, and (4) repair and/or compensation for damages caused by longwall mining as well as making a premining assessment of structures that may potentially be affected by longwall mining. More detailed information on Ohio mining regulations can be found at **http://minerals.ohiodnr.gov**.

An Ohio coal operator must comply with many regulations, including reclamation of mined lands. Mine planning is essential so that coal mining can be profitable with minimal environmental impact, allowing the restored land to be useful and productive. Innovative post-mined land use in Ohio includes The Wilds wildlife conservation area, thousands of acres of state wildlife areas, and the Dickinson long-horn cattle ranch in eastern Ohio.

FURTHER READING

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• This GeoFacts compiled by Douglas L. Crowell • Revised August 2014 •
The Division of Geological Survey GeoFacts Series is available online at **www.OhioGeology.com**.