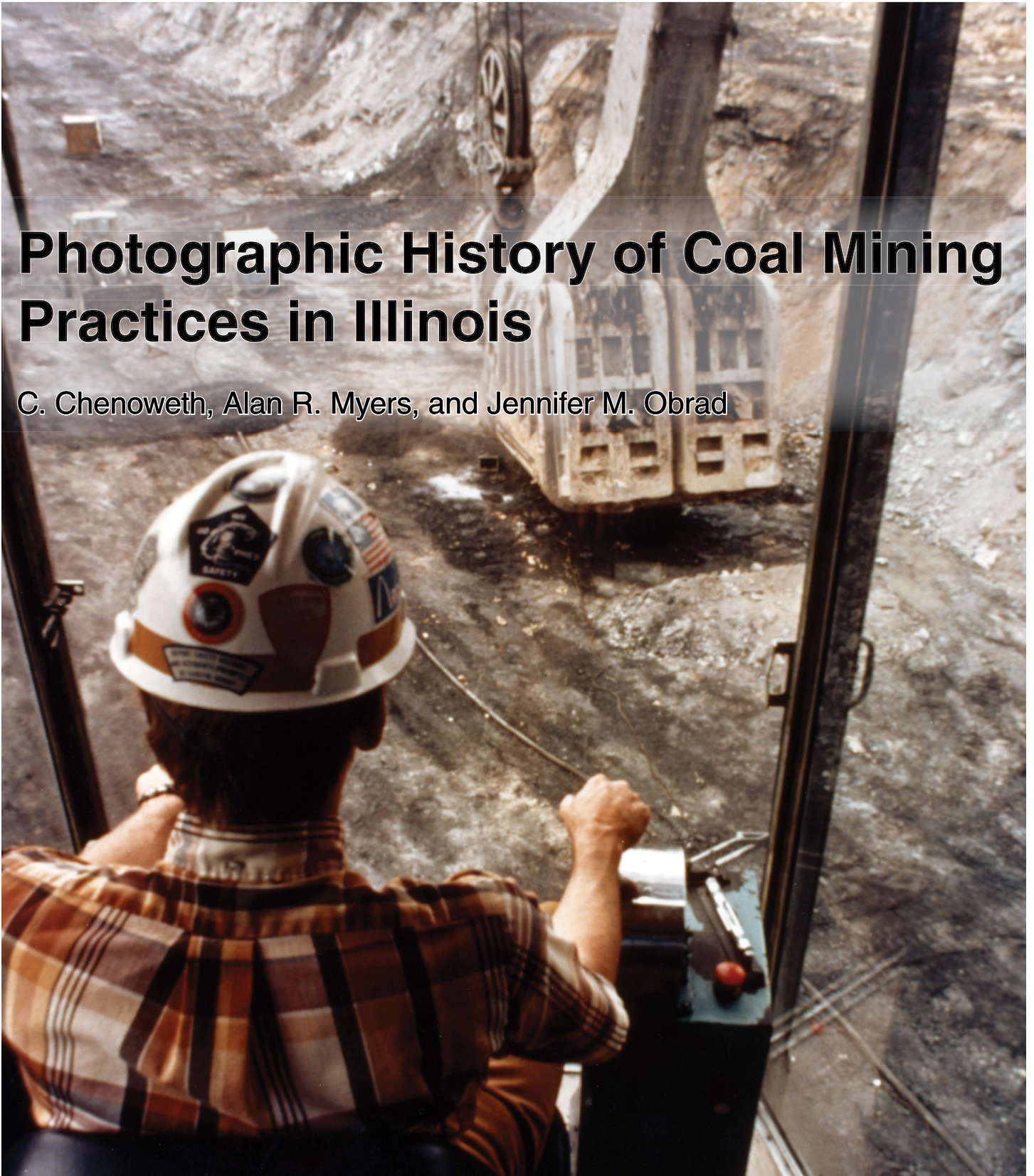




Photographic History of Coal Mining Practices in Illinois

C. Chenoweth, Alan R. Myers, and Jennifer M. Obrad



Circular 572 2008

Cover photo: *Southwestern Illinois Coal Corp., Captain Mine, near Willisville, Perry County. View from the operator's cab of the largest machine to operate on land, the Marion 6360 stripping shovel. The bucket of this machine had a capacity of 180 cubic yards, which would weigh about 300 tons. This is the only bucket that required two doors on the bottom for dumping the material. Each door weighed 15 tons (Haddock 2001). (Photograph source: Illinois State Geological Survey Library collection; card 1476.)*

Acknowledgments

Many of the photographs used in this report are from the photographic collection of the Illinois State Geological Survey (ISGS) Library. Many of these ISGS photographs were taken by ISGS staff or taken from the ISGS Coal Section's mine notes. Other photographs credited to the ISGS may have been taken by coal company personnel and given to the ISGS. Photographers and sources are credited, if known. Thanks are due to the people who took extensive notes about mine operations, which helped substantially in writing the captions for the photographs.

There are some limitations to the collection of photographs shown in this report. Almost all of the photographs are from large shipping mines (mines that shipped their coal to market on the railroads or barges), as is most of the information about mine operations. In 1917, over 56% of the mines produced coal only for small local markets and did not ship coal by railroad. These mines accounted for less than 3% of the total tonnage produced in the state (Andros 1915). Those "unseen miners" should not be forgotten merely because photographs of those mines are not readily available.

Many photographs were collected for the 1992 Illinois Mining Institute Centennial. These include the photographs from Southern Illinois University; Zeigler Coal Company; Robert Fox, retired miner; and others who gave their photographs for this purpose. These photographs were collected and captioned by Heinz Damberger and Jack Simon, ISGS, and Christopher Ledvina, Northeastern Illinois University. In addition, some photographs were from the ISGS Coal Section slide collection, which was organized and contributed to by Heinz Damberger, Jack Simon, Robert Bauer, Philip DeMaris, Dwaine Bergren, John Nelson, William H. Smith, and others at the ISGS throughout the years.

We are especially appreciative to those who gave their time and granted us access to their collections, especially Sue Reichter at the Vermilion County Historical Museum, Dean Spindler of the Illinois Office of Mines and Minerals, and Robert Gibson of the Illinois Department of Natural Resources.

Patrick Schmitz, University of Illinois student assistant, suggested the format of the publication and scanned and cataloged images. Tyler Beemer, University of Illinois student assistant, scanned, identified, and cataloged images. John Nelson, Robert Bauer, and Colin Treworgy, ISGS; and Dean Spindler and Robert Gibson, Office of Mines and Minerals, Illinois Department of Natural Resources, were invaluable in reviewing the text and clarifying the processes shown in the photographs.

This project was funded by the Illinois Department of Natural Resources, Office of Mines and Minerals, Land Reclamation Division, under Contract G2005063.

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Contents

Introduction: Figures 1–2	1
Underground Mining: Figures 3–167	3
Structures	3
Mining Coal by Hand	10
From the Surface to the Working Face	11
Conventional Mining	14
Undercutting	16
Drilling	22
Shooting Coal	24
Wage and Safety Issues Related to Shooting Coal	26
Loading	26
Development of Machine Loading	28
Haulage	36
Animal Haulage	36
Machine Haulage	38
Continuous Mining Machines	46
Haulage Using Continuous Miners	53
Modern Longwall Mining	56
Moving Mined Coal to the Surface	60
From Mine to Market	69
Mine Safety	75
Roof Bolting	75
Explosive Risk: Methane and Rock Dust	89
First Aid and Rescue Teams	96
Surface Mining: Figures 168–283	101
Earliest Surface Mining	101
The Modern Surface Mining Process	102
Earliest Mechanical Shovels in Illinois	103
The Earliest Draglines	105
Fully Revolving Machines	107
Electric Shovels	110
Draglines Reintroduced	118
Productivity of Surface Mining	121
Large Equipment Moves	124
Major Renovations in Stripping Shovel Design	126
Largest Stripping Shovel	142
Decline of Surface Mining	151
Blasting and Explosives Used in Surface Mining	155
Auger Mining	167
Reclamation	173
Conclusion	177
References	177

Introduction: Figures 1-2

Coal was first recognized in Illinois by Louis Joliet and Father Marquette along the Illinois River in 1673. Father Louis Hennepin also noted a coal mine on his 1682 map. However, Howard Eavenson (1942) notes that the word “mine” had a different meaning before 1750 than it does now. At that time, “mine” referred to a deposit, and “pit” was used when the coal was worked, regardless of whether the workings were underground or from an outcrop. Eavenson (1942) cites a 1795 author who said of one Virginia county, “A number of coal mines are in the county, and pits have been opened by many proprietors.”

No records are available to certify the first coal mining in Illinois, but the first known mine was operated by William Boon, who shipped coal from the Big Muddy River in Jackson County to New Orleans sometime between 1809 and 1812 (Figure 1). Coal was found in Gallatin and Saline Counties in 1809 and in Peoria County in 1817. In 1821, a boatload of coal was shipped from the Ottawa area to St. Louis, and the next year, several boatloads were shipped from the Big Muddy River area of Jackson County to New Orleans. Coal for St. Louis was mined in St. Clair County in 1823, and, by 1846, traffic had grown enough to warrant the construction of the first macadam road. Wagons hauled Illinois coal to St. Louis until 1851, when the first railroad in the state was constructed by the Illinois Coal Company from its mine near Caseyville. However, that railroad failed after three years, and the Ohio & Mississippi Railroad Company tore up its track. In the meantime, the Ottawa area mines were developing in order to serve the Chicago market (1838–1841). By the 1850s, the Rock Island and Henry County coal fields were opened, and a slope mine opened near DuQuoin in Perry County. By the 1860s, mining was occurring in Vermilion and Will Counties and, in the St. Louis area, expanding northward to Edwardsville (Eavenson 1942).



ISGS | Undated

Figure 1 This sign, erected by the State of Illinois in 1937, commemorates the first coal mine in Illinois at Big Muddy River outcropping in Jackson County.

Coal has been mined in 76 counties in Illinois (Figure 2). In most of those counties, coal mining began between 1850 and 1860, except where the coal was very deep (such as Franklin County; its the first mine opened in 1904). Records of the Coal Section of the Illinois State Geological Survey

(ISGS) indicate that more than 7,400 mines operated at one time or another within the state's borders. There are more than 30 named coal seams in Illinois (Treworgy et al. 1997), but most of the mining has been in the Herrin or Springfield Coals.

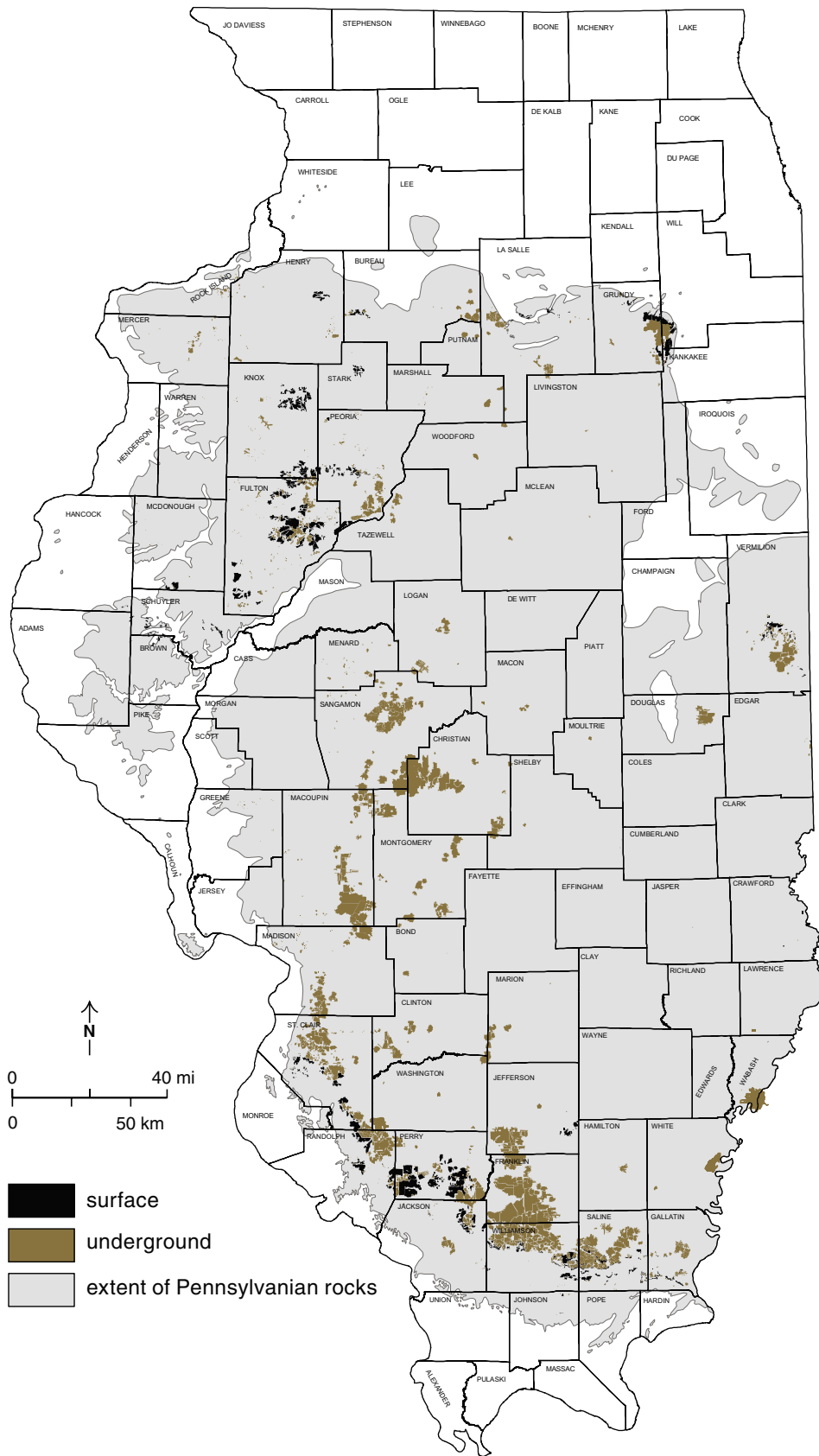


Figure 2 Coal has been mined in 76 Illinois counties.



Courtesy Southern Illinois University | Circa 1895

Figure 3 Mine unknown, Perry County. This mine is probably one of the first in the county (Ledvina et al. 1992). This mine portrait was apparently an important event, as evidenced by its formality. Notice the workers on the balcony-type structure on the left side of the building and at some windows. One of the little girls is holding a doll.



ISGS | Circa 1910

Figure 4 Springfield Colliery Company, Sangamon County. The A-frame structure in the center of the photograph is the headframe, supporting cables from the engine house on the right. The shaft is below the tower. The structure on the left is the tipple, or loading platform, and the sorting shed is above the tipple.

Underground Mining: Figures 3–167

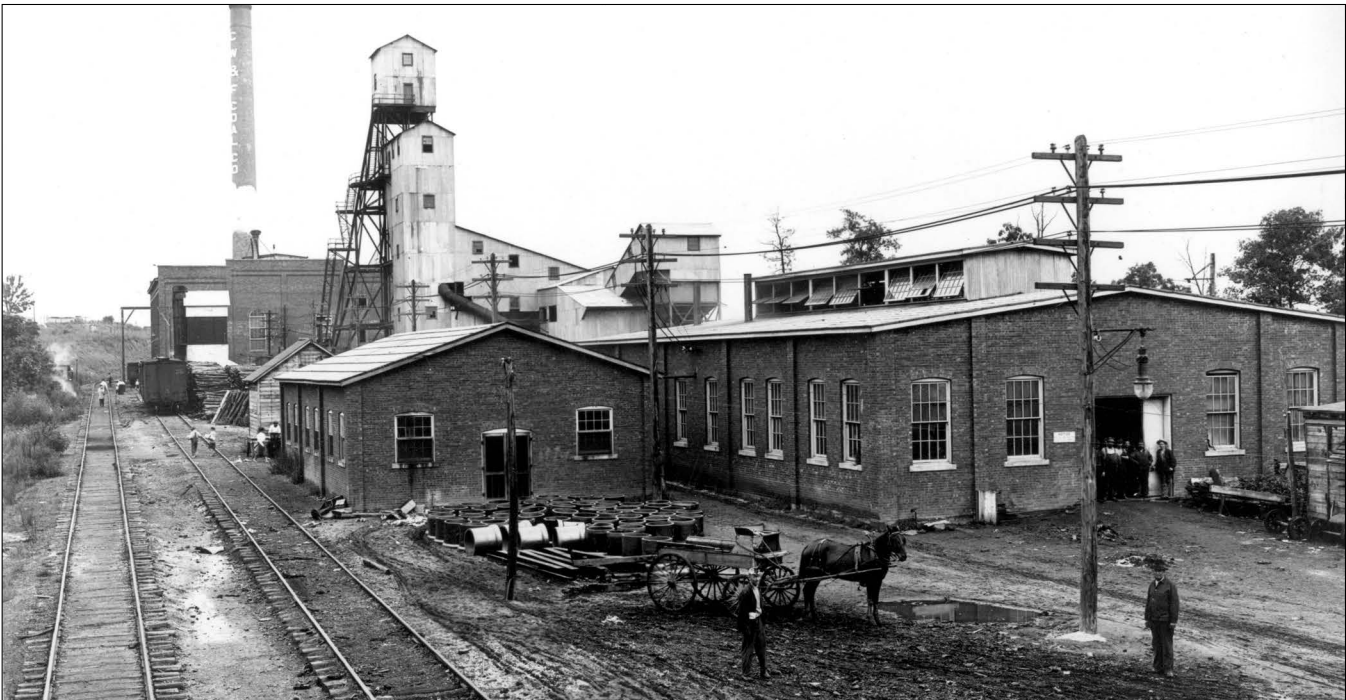
Structures

The extent of an underground mine could not be estimated from the surface. However, most mines required a few buildings on the surface, such as a headframe, to support the cables used to raise and lower the platform or cage down the shaft, a sorting shed, and a loading facility. Later mines also added a wash house for the men.



ISGS | 1914

Figure 5 Old Ben Coal Corporation, No. 11 (or New North) Mine, Franklin County. Mines often constructed railroad spurs that stored the cars for hauling their coal to market. The large A-frame structure (head frame) in the center was the location of the hoist shaft, and the building to the left was the sorting shed and tippel. A pile of timbers to prop the mine roof can be seen in front of the building on the right, which probably contained mine offices, hoisting equipment, and machine shops. This mine was the site of an explosion on Thanksgiving Day in 1917.



Courtesy Southern Illinois University | 1914

Figure 6 Chicago, Wilmington & Franklin Coal Company, Orient No. 1 Mine, Franklin County. A horse-drawn supply wagon is shown at the surface works of this underground mine (Ledvina et al. 1992).



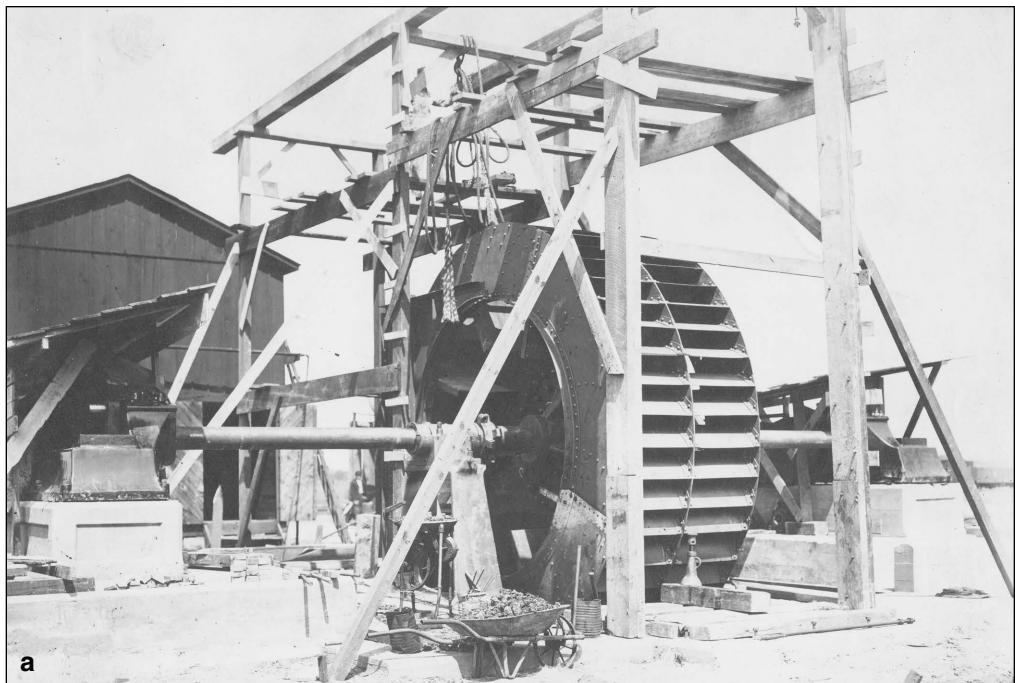
ISGS / 1938

Figure 7 Sahara Coal Company, No. 1 Mine, Saline County. This reinforced concrete head frame was unusual; most were constructed of wood or metal.

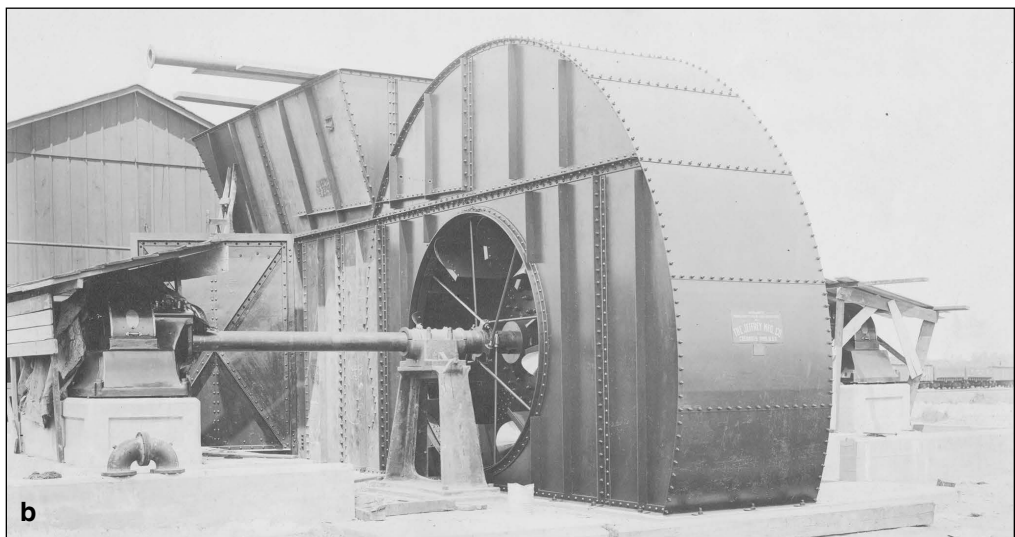


ISGS / 1967

Figure 8 Chicago, Wilmington & Franklin Coal Company, Orient No. 3 Mine, Jefferson County. Loading facilities and preparation plant at Orient No. 3 Mine, the last mine built by Chicago, Wilmington & Franklin Coal Company (Ledvina et al. 1992).



ISGS | Circa 1930–1935



ISGS | Circa 1930–1935



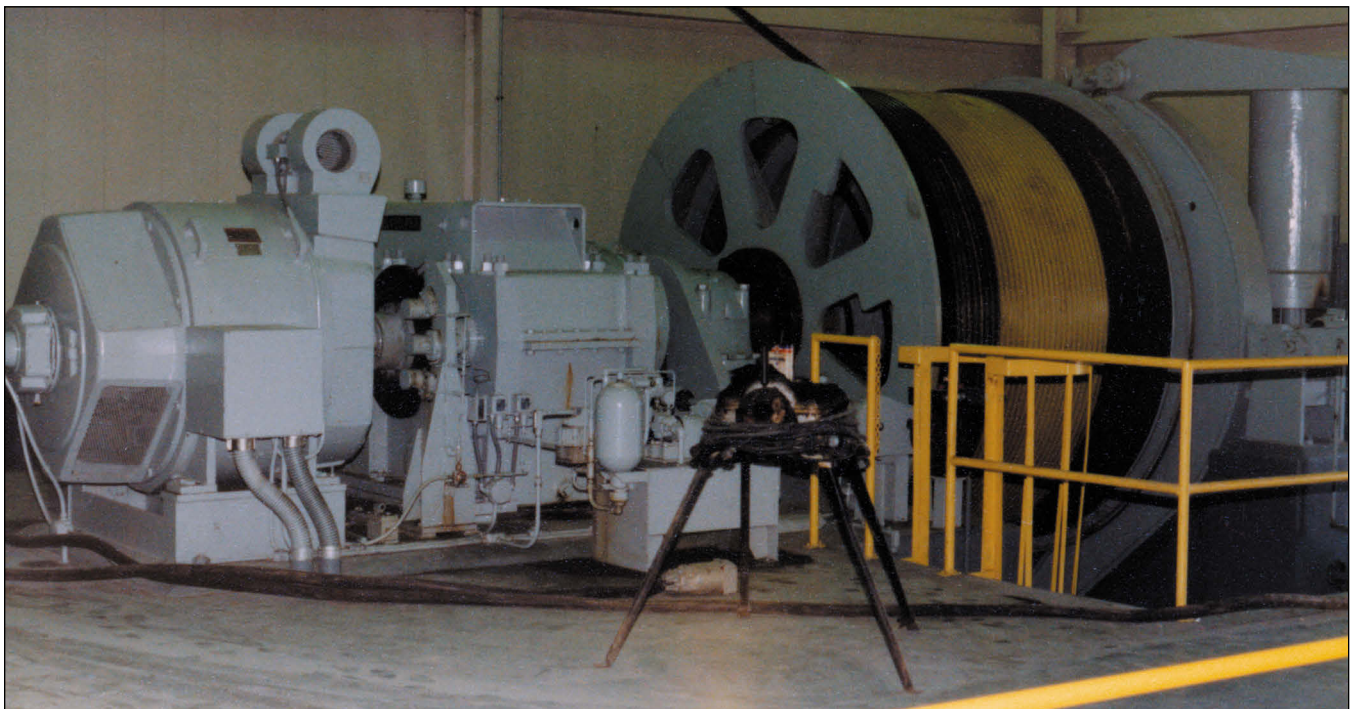
ISGS | Circa 1930–1935

Figure 9 Madison Coal Corporation, No. 9 Mine, near Cambria, Williamson County. Construction of a centrifugal fan is shown. Until the 1950s, centrifugal fans were the mainstay for ventilating underground mines. They were gradually superseded by cheaper, more efficient propeller or turbine fans (Mosgrove 1973). The shaft and explosion door are to the left of the housing in the construction photographs (Ledvina et al. 1992). In case of explosion in the mine, the forces from the explosion would be vented through this door and would be less likely to destroy the fan.



W. John Nelson, ISGS | 1981

Figure 10 Freeman United Coal Company, Orient No. 4 Mine, Williamson County. The head frame for the hoist at the No. 3 Portal for this mine.



W. John Nelson, ISGS | 1981

Figure 11 Freeman United Coal Company, Orient No. 4 Mine, Williamson County. The hoisting engine and cables for the No. 3 Portal for this mine. Earlier versions of hoisting engines are shown in a later part of this report.

Figure 12 Freeman United Coal Company, Orient No. 4 Mine, Williamson County. Wash house at the No. 3 Portal. The use of overhead baskets maximized the use of the floor space of the wash house.



Figure 13 Below: Freeman United Coal Company, Orient No. 4 Mine, Williamson County. The lamp room at the No. 3 Portal, where battery packs for miners' lamps are recharged and available for use. The board (right) is the check board, which indicates which miners are underground. Each miner has a brass tag that is moved from the "out" side to the "in" side when the miner goes underground. This board can be consulted when accidents occur to confirm the number of miners underground. Many mines also require miners to have brass tags riveted to their belts that serve the same purpose as military dog tags.

W. John Nelson, ISGS | 1981

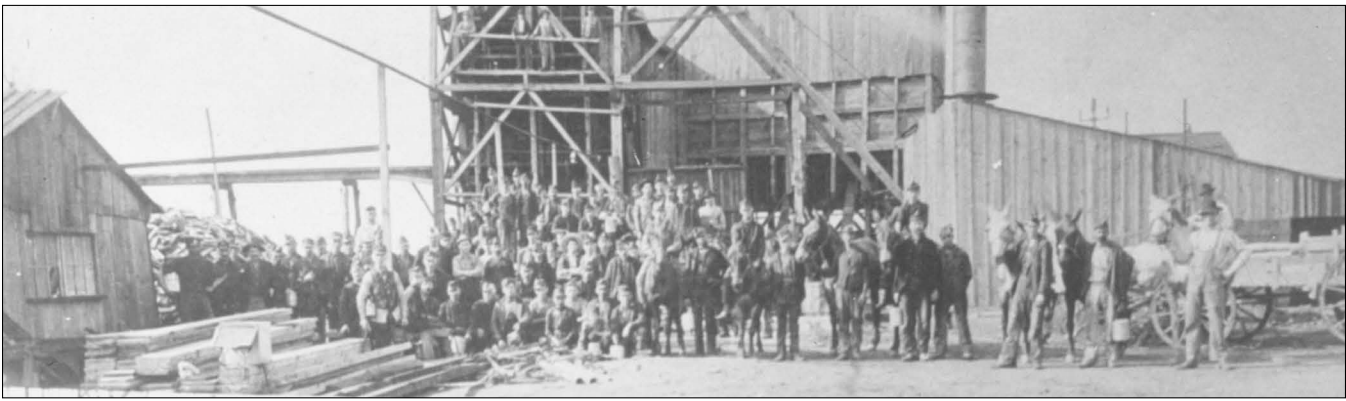


W. John Nelson, ISGS | 1981



Joel Dexter, ISGS | 1995

Figure 14 Kerr-McGee Coal Corporation, Galatia Mine, Saline County (now operated by American Coal Company). The conveyors, silos, and processing plant of modern mines are highly visible at night.



Courtesy Southern Illinois University | 1903

Figure 15 Mifflin Mine (later Pope Mine) in Perry County. This mine was one of the first shaft mines in Illinois to ship coal on the new Illinois Central main line. Opened in 1895, it became the Great Central Mine before closing in 1908 (Ledvina 1992). This photograph includes the drivers and sorting shed workers.

Mining Coal by Hand

The following text is adapted from Greene's (1889) book, *Coal and the Coal Mines*, which described early conditions and practices for the anthracite fields of Pennsylvania. The first to go down into a mine each day was the mine boss, who supervised the mine workings. The fire boss (after 1889, called the mine examiner) was next in authority and also went down before mining began for the day. He had oversight of the ventilating system and issued orders about gas-prone areas. The fire boss had the responsibility to keep the airways maintained; pieces of stoppings,

doors, and brattices often were used as temporary partitions to control mine ventilation.

Miners were employed by the companies as a kind of contractor. Early bituminous mines probably operated similarly to Greene's description of anthracite mines in Pennsylvania. Miners worked two men to a room and split the profits from the coal mined there. Out of those profits, the miners employed laborers. The miners set the props to support the roof. Props were supplied by the mine, and the mine boss inspected the roof and also advised where to add props.

The coal was then undercut, either by hand or by machines powered by compressed air. When a machine was used for undercutting, seven men usually worked three rooms: three contractors or miners, three laborers, and a scraper employed by the company. The miner would then drill holes for the shots. Hand augers were said to take more effort, but were faster than the other common method, using a chisel-type tool to hit the face of the coal repeatedly to make a hole. The holes were about 4.5 feet deep into the coal face, and a special tool was used to clean out the fine coal as the hole got deeper into



Courtesy Southern Illinois University | 1903

Figure 16 Mifflin Mine, Perry County. These are probably the underground workers. Note the soft caps, carbide lamps, and lunch buckets (Ledvina 1992).

the coal face. Miners generally made their own cartridges, buying their black powder from the coal company in 25-pound kegs. After insertion of the cartridge, the hole was tamped full of dust from the floor, while a 5/8-inch thick iron rod called a miner's needle was left in the hole to leave space for the insertion of the squib (a long thin firecracker-like fuse). The miner's needle was removed and the squib was then inserted into the hole. When the fuse on the squib was lit and the flame reached the powder in the squib, the small explosion there pushed the flame back to the cartridge where the real shot was ignited. The laborer then loaded the coal and

cleared the room for the next day's work. When the mine first opened, daily wages for excavating the haulage and airway tunnels were fixed because this specialty work did not go as fast, and the tonnage taken per day was lower than mining in a room. More time was spent setting props and squaring up the sides for these entries that had to last the life of the mine (Greene 1889).

The mines also employed several other laborers, including carpenters, blacksmiths, masons, and track layers. By 1889, some mines had electric lights (Greene 1889), and electric locomotives were uncommon but not unknown.

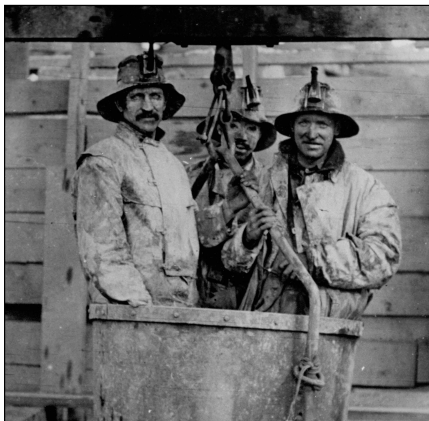
From the Surface to the Working Face

The shaft was constructed to raise and lower personnel, materials, and coal product. Shafts for bituminous mines constructed before 1900 were generally 9 feet wide and 20 feet long, divided into three compartments. The end compartment was the air shaft combined with pumping equipment, and the other two were hoisting shafts, so that empty cars could descend while loaded cars ascended (Greene 1889).



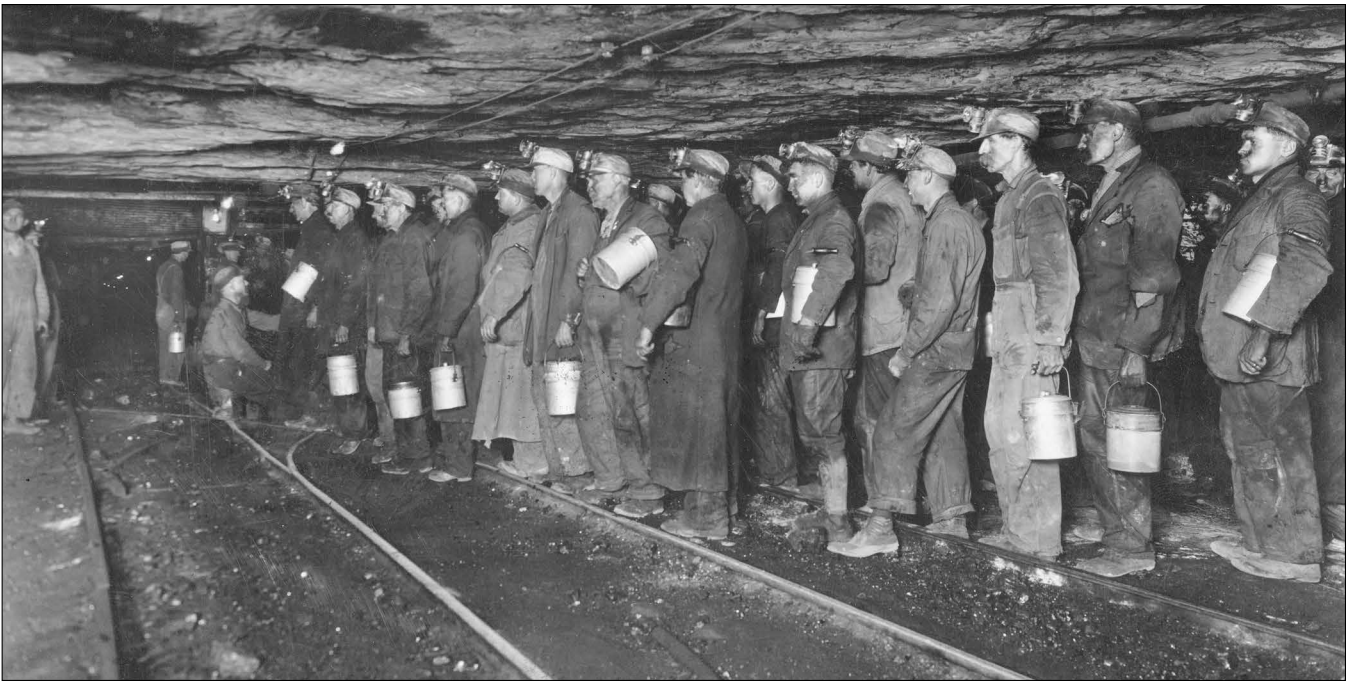
ISGS / Undated

Figure 17 Above: Mine and location unknown. Constructing a shaft was a difficult job without modern equipment. Partitions show separate compartments of the shaft.



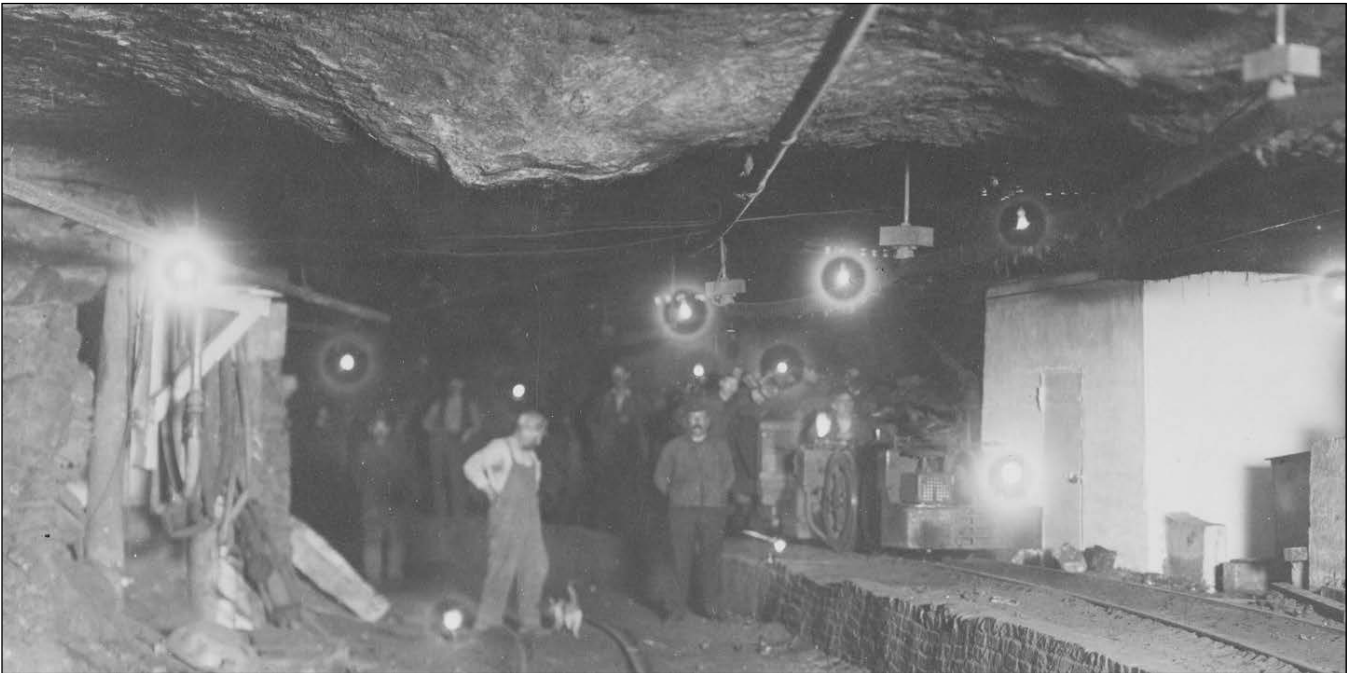
ISGS / 1905

Figure 18 Mine and location unknown. A shaft-sinking bucket was used to lower or raise personnel and to bring excavated soil and rock out of the shaft during its construction (Ledvina et al. 1992).



ISGS | 1920s

Figure 19 O’Gara Coal Company, mine unknown, Saline County. Miners are waiting for a ride to the working face, holding their lunch buckets. The aluminum lunch pail had three compartments; the bottom held water, and the middle and upper compartments held food and chewing tobacco (Crowell 1995).



ISGS | 1920s

Figure 20 Mt. Olive Coal Company, Mine No. 5, Macoupin County. This photograph shows a work area near the shaft bottom. The cat was probably more than a mine pet; where people went, rats were sure to follow. The rats probably came in with the feed and bedding for mules and horses. According to Homer Greene (1889), the rats “take up their quarters in the mine, live, thrive, increase rapidly, and grow to an enormous size. They are much like the wharf rats that infest the wharves of great cities, both in size and ugliness. They are very bold and aggressive, and when attacked will turn on their enemy, whether man or beast, and fight to the death.” Others have said the miners thought the rats were good luck and saved bits of their meals for them because the rats would warn of impending roof falls (Crowell 1995).

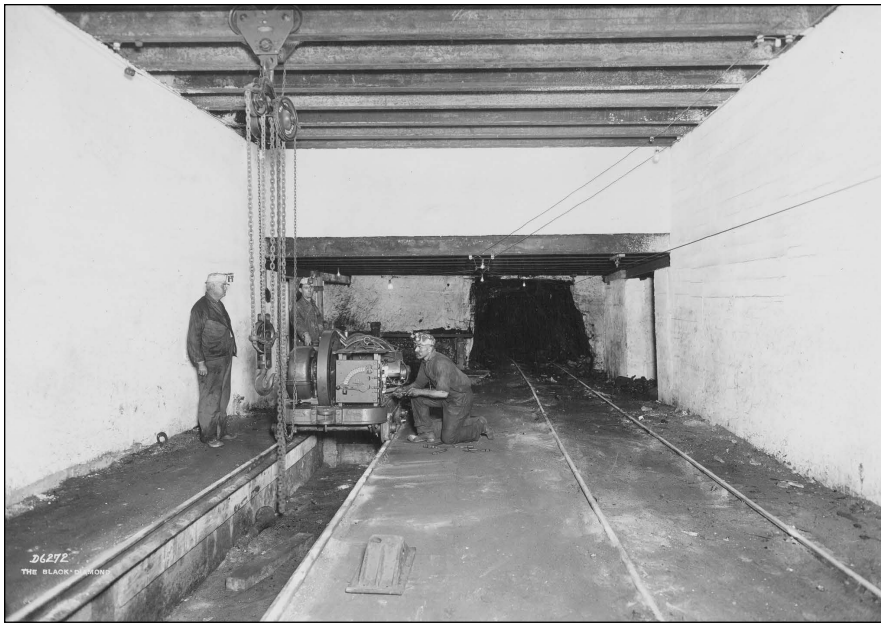


Figure 21 Mine and location unknown. Workers repair a generator in an underground mine. The pit between the tracks is for easier access to the underside of the heavy shuttle cars and locomotives. The block and tackle are necessary to remove engines or to maneuver other heavy items of machinery.

ISGS | Undated



Courtesy Zeigler Coal Company | Circa 1910

Figure 22 Zeigler Coal Company, mine and location unknown. Loaded mantrip departs for working sections. This photograph shows a full shift of miners and bosses ready to leave the shaft area for their working places inside the mine at the start of the shift. Note the open carbide lamps (Ledvina et al. 1992). Electric lamps were available in 1902, but were very heavy and not accepted by many miners (Crowell 1995). John E. Jones (1954), noted for rock dust research, indicated that closed lights of 1917 antagonized labor in a serious way, because the two-candle power lights were too dim to work by and were nicknamed “bug lights.” Later electric cap lamps with over 100-candle power bulbs and battery packs were comparatively light and much more acceptable to the men who had to use them. Such lights weighed about 6 ounces, and the battery pack weighed slightly less than 4 pounds, according to a 1942 advertisement for Wheat Lamp Sales. Flames were then present in the mines only behind the wire mesh of the safety lamp that was used to indicate the presence of methane or the lack of oxygen.

Conventional Mining

Conventional mining was performed in four sequenced steps of undercutting, drilling, shooting, and loading (Morrow 1962). Undercutting the coal face was the removal of the lower part of the seam or the underclay under the coal to create a void for the coal

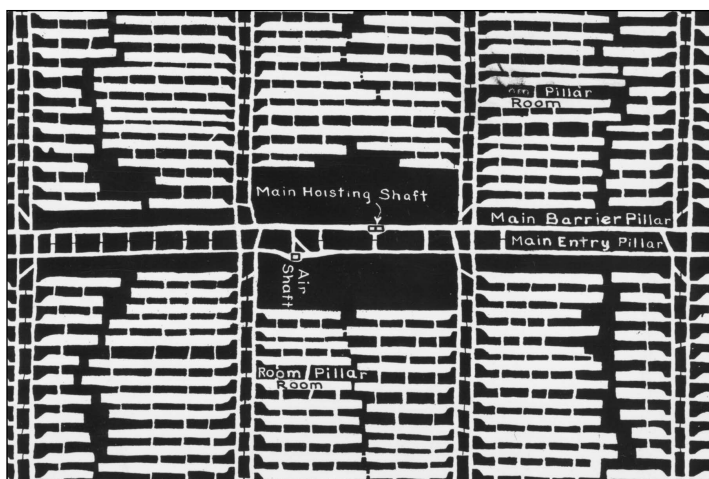
to move into during the blast. This procedure allowed the blast to be smaller and the blasted pieces of coal to be larger. The procedure for blasting the coal from the face with the explosive mixture of potassium nitrate, charcoal, and sulfur—commonly known in the mining industry as black powder—was developed in

Europe in the seventeenth century. The process of undercutting the coal face was developed at the same time. The miner would use a pick to remove the lower part of the seam or the underclay floor to a distance of 3 to 5 feet into the coal face (Morrow 1962). This task was somewhat hazardous because portions of the coal could



Courtesy Vermilion County Museum | Undated

Figure 23 Mine unknown, Vermilion County. These underground workers are gathered for a group photograph with the tools of their trade. Behind them are the timber props used to support the roof.



Andros | 1915

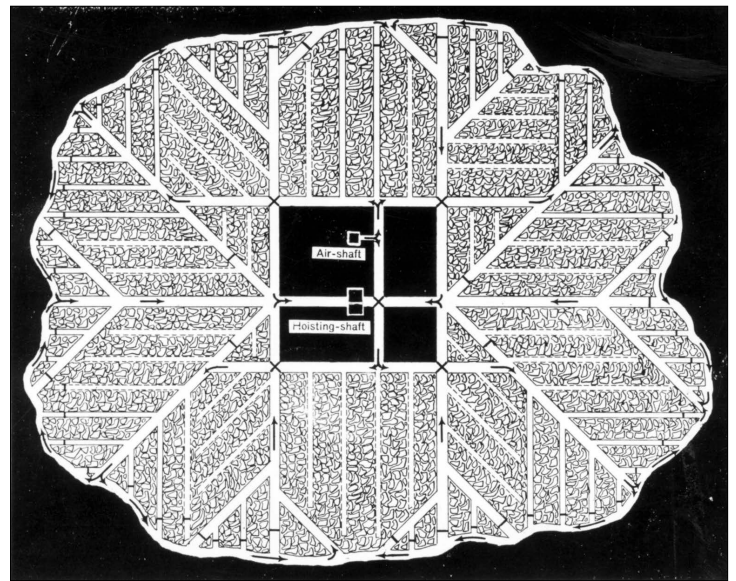
Figure 24 Diagram of old room-and-pillar method (Andros 1915). In this example, mine development left a large block of unmined coal around the main shaft and air shaft. The rooms ranged from 15 to 30 feet wide and 100 to 500 feet long and were characterized by the narrow neck that connected the room with haulage and ventilation entries. The narrow neck was about 6 feet wide, which helped support the roof in that area. The neck was wide enough to set tracks in for haulage but not so wide that it was expensive to seal the room when mining was completed to keep the ventilation current flowing to the active areas of the mine (Andros 1915).



ISGS | 1912

Figure 25 Mine unknown, Grundy or Will County in northeastern Illinois. These miners are undercutting the face of a long-wall mine. The roof is supported by timbers and a rock pack wall (right side).

Figure 26 Diagram of the old longwall mining method (Andros 1915), used in 15 counties in Illinois from 1857 to 1951. In this method, a block of coal around the hoisting shaft, air shaft, and surface buildings was left in place. The undermined area would subside, as all the coal was removed and no standing pillars were left to support the roof and overlying strata. Only haulage routes were supported, so that the coal could be transported back to the shaft. These old longwall mines have maps that show this distinctive pattern, developing out from the center. This type of mining was more commonly used to mine the thinner coals of northern Illinois, which is why Bureau, Grundy, La Salle, and Will Counties are sometimes referred to as “the old longwall district.”



Andros | 1915

fall without warning, and the miner, stooped or laying on his side, was not in a position to scramble quickly out of the way. Drilling made the shot holes for the charges, and shooting was firing the blasting agent to break up the coal and separate it from the face. Shooting the coal without undercutting was termed “shooting off the solid.” Loading involved putting the coal into a coal car, mostly by hand, although mechanical means were experimented with as early as 1890 (Morrow 1962). Until electric haulage was developed, transportation from the working face of the mine was generally by horse or mule.

The process of longwall mining was the same as conventional mining: undercutting, drilling, shooting, and loading the coal. However, the weight of the roof could often be used to break the coal without drilling and shooting.

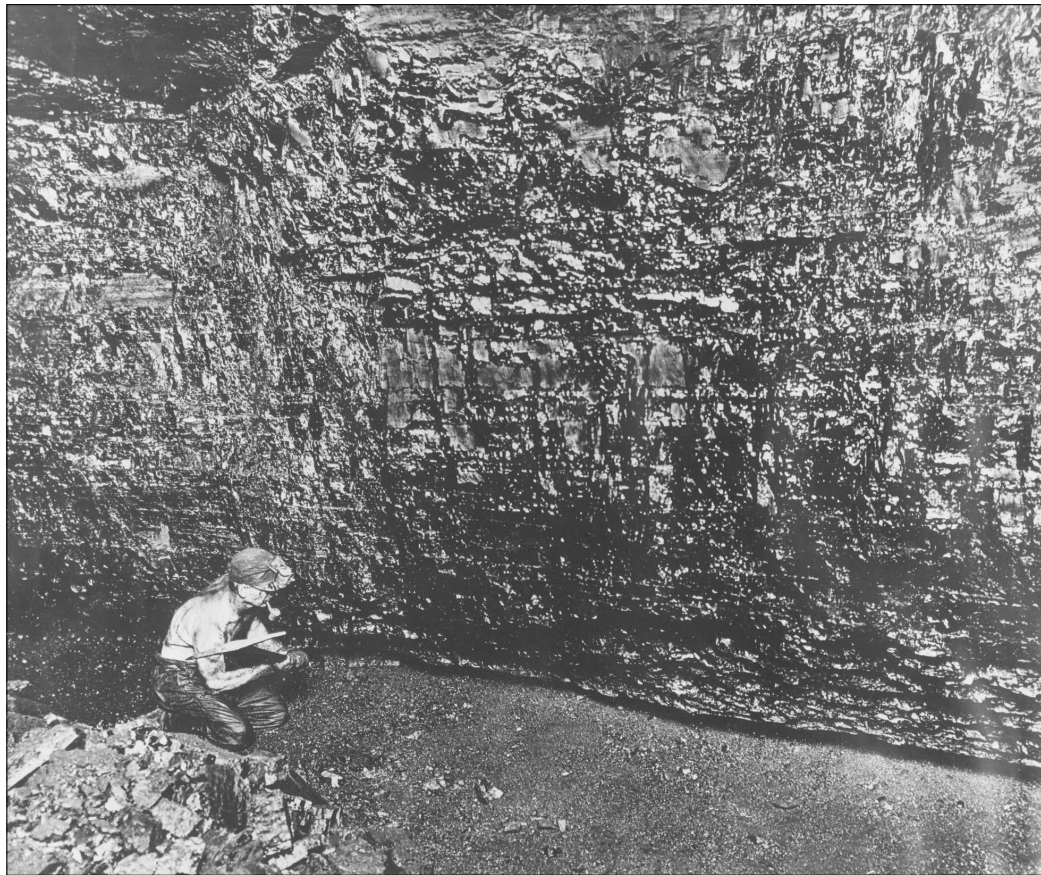
Undercutting Because manual undercutting was slow and laborious,

it was one of the first tasks targeted for mechanization. The first undercutting machine was put to work in a mine in Brazil, Indiana, in 1873. The machine had a 5-hp steam engine (later converted to compressed air) and was mounted on a movable track parallel to the coal face. This machine could undercut 3.5 feet (Eavenson 1942). The next mechanized undercutter, patented in 1876 by Francis Lechner, was a machine powered by compressed air. The machine was 30 inches wide and worked with a rotating square bar set with small bits. When it had cut to the depth of the machine, the machine was pulled back, and a pry bar was used to lever the machine over to another section of the face. Tests in Ohio revealed the machine’s inefficiency. The undercutter often left wedges of coal at the back of the cut so that, after blasting, parts of the coal did not come down off the face, but the machine was an improvement on hand undercutting. In 1887, Jeffrey Manufacturing Company bought the rights to this

machine and modified it, producing an electric version in 1888. A third type of undercutter was invented by J. W. Harrison in 1877. Powered by compressed air, it delivered 180 to 200 blows per minute with a chiseling action. The undercutter was mounted on a sloping wooden platform and was moved along the face with a pry bar to chisel the next part of the face. More than 1,700 Harrisons were sold during the next 20 years. An electric version of this machine was developed, but it did not work as well as the Jeffrey Manufacturing Company design (Morrow 1962). Most of the energy spent compressing the air was wasted as heat so that only 27% of the energy put into the system could be recovered as power to drive the machines (Sperry 1892).

In 1891, Jonas P. Mitchell developed a longwall undercutter that cut continuously from one end of the coal face to the other. The Sullivan Machinery Company bought Mitchell’s patent and hired him to improve his design.

Figure 27 Old Ben Coal Corporation, No. 9 Mine, near West Frankfort, Franklin County. A truly classic photo of a miner with a carbide lamp and corn cob pipe undercutting an amazing thickness of coal. Low-sulfur content, high heating value, and thickness is why the Herrin Coal of Franklin, Williamson, and Jefferson Counties constitutes the “Quality Circle” (Ledvina et al. 1992).



ISGS | Circa 1915

A 1895 modification added a cart behind the cutter to keep it in place under the seam. In 1899, the Sullivan CE came out, an electric undercutter designed for room-and-pillar mines. This machine had to be hauled from room to room and dragged into position. In 1909, Jeffrey Manufacturing

Company came out with a version that operated from the track, and Goodman Manufacturing Company came out with its track-mounted model in 1914 (Morrow 1962).

By 1892, 550,000 square feet had been undercut in Illinois with elec-

tric machines (Sperry 1892), but all of these machines caught on slowly and were not in routine use until the mobile loading machines required faster production during the late 1920s (Morrow 1962).



Figure 28 Mine and location unknown. This undercutter uses a regular chain to work the material under the coal loose. The back of the machine is tilted upward on a block of wood. The photograph is too dark to see the blade, but the machine is similar to the 1899 Sullivan CE shortwall cutter (Morrow 1962).

Courtesy Southern Illinois University | Undated



Figure 29 Mine and location unknown. This undercutter uses a type of gathering chain to rip the material from under the coal. The helper shovels the fine coal shavings away from the face. This machine is similar to the early Jeffrey Manufacturing Company undercutters (Morrow 1962). Note the completed cut to the left of the helper.

ISGS | Undated



ISGS | 1920s

Figure 30 Old Ben Coal Corporation, No. 8 Mine, Franklin County. When the cutting bit of this rail-mounted undercutting machine has dug into the coal the length of the saw portion, it is removed from the coal. Numerous pry bars leverage the machine further along the coal face on the rail.



ISGS | Undated

Figure 31 Mine and location unknown. As the coal is undercut by this rail-mounted undercutter, the visible part of the machine is the frame used to guide and drive the bit into the coal.



Courtesy Zeigler Coal Company | Circa 1915

Figure 32 Bell & Zoller Coal Company, No. 1 Mine, Zeigler, Franklin County. This Joy under-cutting machine was crawler mounted and undercut wide- or narrow-faced rooms. The cutting head swiveled from side to side, which made this machine very versatile. The addition of rubber tires would have made this machine similar to modern cutters (Ledvina et al. 1992).



Courtesy Peabody Coal Company | 1921

Figure 33 Peabody Coal Company, No. 5 Mine, Pawnee, Sangamon County. A vertical shearing machine cuts the coal so that blasting can loosen it from the face more effectively. In mines with a weak roof, top cutting was also done to protect the roof from the effects of the blast (Malesky 1973). The roof in this photograph shows protrusions from the roof, called limestone bosses, which are very hard on bits in coal cutting machines.

Figure 34 Mine and location unknown. This undercutting machine was an advance on previous versions. Although this undercutter required rails, the head rotated so that it could undercut coal to the left, in front, and then on the right side of the machine without laying additional track. Track-mounted machines were made obsolete by machines mounted on rubber tires in 1946 (Morrow 1962).



ISGS | Undated

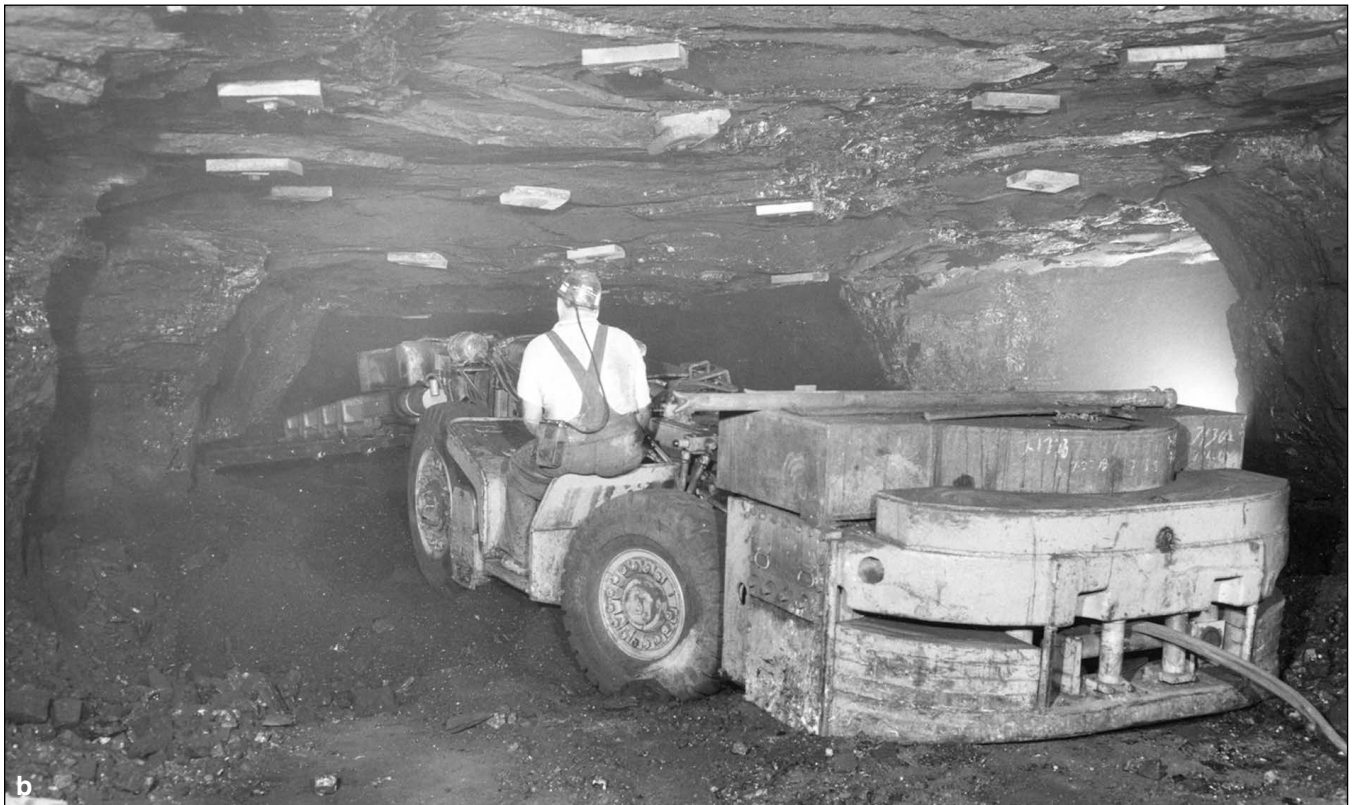


Courtesy Goodman Manufacturing Company | Undated

Figure 35 Mine and location unknown. Mounting the undercutter on rubber-tired wheels made a versatile machine that kept the conventional mining technique feasible after the introduction of continuous mining machines.



Courtesy Peabody Coal Company | Circa 1950s



Courtesy Peabody Coal Company | Circa 1950s

Figure 36 Peabody Coal Company, mine and location unknown. These two cutters are called universal cutters because they could undercut the coal, or the operator could raise the head and top cut between the coal and the roof, or the head could be rotated to make a vertical shearing machine (Goodman Manufacturing Company, undated). Mining machinery was always a big investment, and this versatility bought three machines for the price of one.

Drilling After undercutting the coal, shot holes are drilled for the explosives to be inserted. The shot holes could be drilled with a hand-powered auger-type drill. Drills powered by

air compressors were available before 1890 but not in all mines. Later, post-mounted drills were replaced by independently mobile coal drilling machines. Eventually, automatic

drills mounted on rubber tires vastly improved the speed of this aspect of conventional mining.

Figure 37 Mine and location unknown. This room has been sheared and undercut and is ready to have the shot holes drilled. Undercutting and shearing are done before drilling to take advantage of any irregularities that result from these processes (Malesky 1973).



ISGS | Undated



Courtesy Vermilion County Museum | Undated

Figure 38 Mine and location unknown, probably Vermilion County. Drilling shot holes with a hand-powered auger-type drill. This photograph was probably taken between 1900 and 1915.



Courtesy Zeigler Coal Company | Circa 1930s

Figure 39 Bell & Zoller Coal Company, No. 1 Mine, near Zeigler, Franklin County. In this scene, miners are operating post-mounted coal drills. In conventional mining (mining that breaks coal by blasting), the face required drilling whether chemical explosives or the breaking agents Cardox or Airdox were used.



Courtesy Peabody Coal Company | Circa 1950s

Figure 40 Peabody Coal Company, mine and location unknown. Automatic drills such as the one shown in the photograph vastly improved drilling speed and efficiency.

Shooting Coal By 1867, dynamite and black powder were used extensively to shoot coal from the face (Malesky 1973). Numerous deaths resulted from improperly set shots. In 1906, experimentation to discover a safer explosive began. The U.S. Bureau of Mines approved permissible explosives that were effective, yet safer to handle and detonate. A granular explosive was made that was suitable for dry mines, but moisture caused the granules to deteriorate and lose effectiveness. For damp mines, a gelatinous material of a plastic consistency—formerly used to blast rock—was effective in coal (Malesky 1973). The first permissible explosive used in Illinois was in 1910–1911 in Franklin County, and the use of such explosives became more general after 1915, but never completely replaced black powder. Pelleted powder (black powder pressed into pellet shapes and wrapped in a paper cartridge) became popular around 1929. Pelleted powder was safer than kegs of powder but not as safe as permissible explosives.

Both black powder and pelleted black powder use decreased to almost negligible amounts by 1954 (Schull 1955, p. 60).

Cardox was invented in Illinois by Helmholtz, Farrell, and Crawford (Schull 1955, p. 61). This permissible explosive was liquid carbon dioxide inside a metal casing. During use, a steel disk at the end of the shell was ruptured by an electrical signal, and, as the liquid carbon dioxide under high pressure was released, expansion caused gasification. The released gas acted on the coal in much the same way as the expanding gas from the detonation of black powder. The steel casings were recyclable; they were collected by a service company and recharged (Malesky 1973). The coal was broken at a lower unit pressure than with powder, and more than twice as many holes and charges were required. Compressed air in a similar cartridge was developed during the 1940s (Schull 1955, p. 61). Instead of rupturing a disk, these Airdox cartridges used a piston and valve so

that the cartridges could be set to release the air at a desired pressure (Malesky 1973), triggered by an air-wave impulse through flexible tubing. Because the agent was not explosive, Airdox was called a breaking agent, and the process was breaking instead of shooting or blasting. The process was comparatively slow and displaced coal rather than exploding it. Airdox had a lower working force per unit area than Cardox and required approximately double the number of drill holes (or quadruple the number for permissible explosives). An advantage was that Airdox could be used during the shift with miners in the mine, whereas permissible explosives had to be detonated between shifts with no one in the mine. Chemechol was developed in the early 1950s. This steel-cartridged, permissible explosive used a sudden chemical change to produce the breaking energy. It was detonated with an electric battery and required more drill holes than did permissible explosives (Schull 1955, p. 61).



ISGS | Undated

Figure 41 Mine and location unknown. The room with one shot set into a drilled hole. Shots may be fired one at a time or as multiple shots fired at once. Note the undercut coal face.



Courtesy Southern Illinois University | 1938

Figure 42 Muddy Valley Mining Company, Hallidayboro Mine, Jackson County. When coal was shot with black powder or permissible explosives, the charge had to be primed and tamped into place, and the wires or fuse carefully routed out the hole collar. The end of the hole was then stemmed with some inert material (Ledvina et al. 1992). The box is labeled “Hercules permissible” explosives.

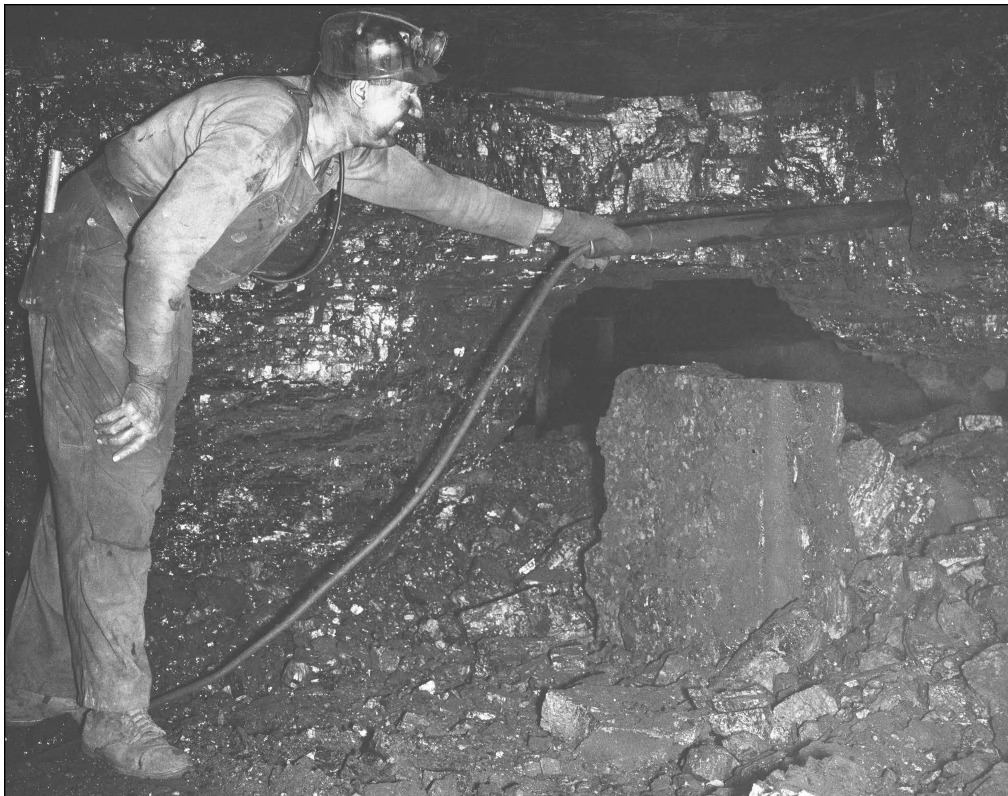
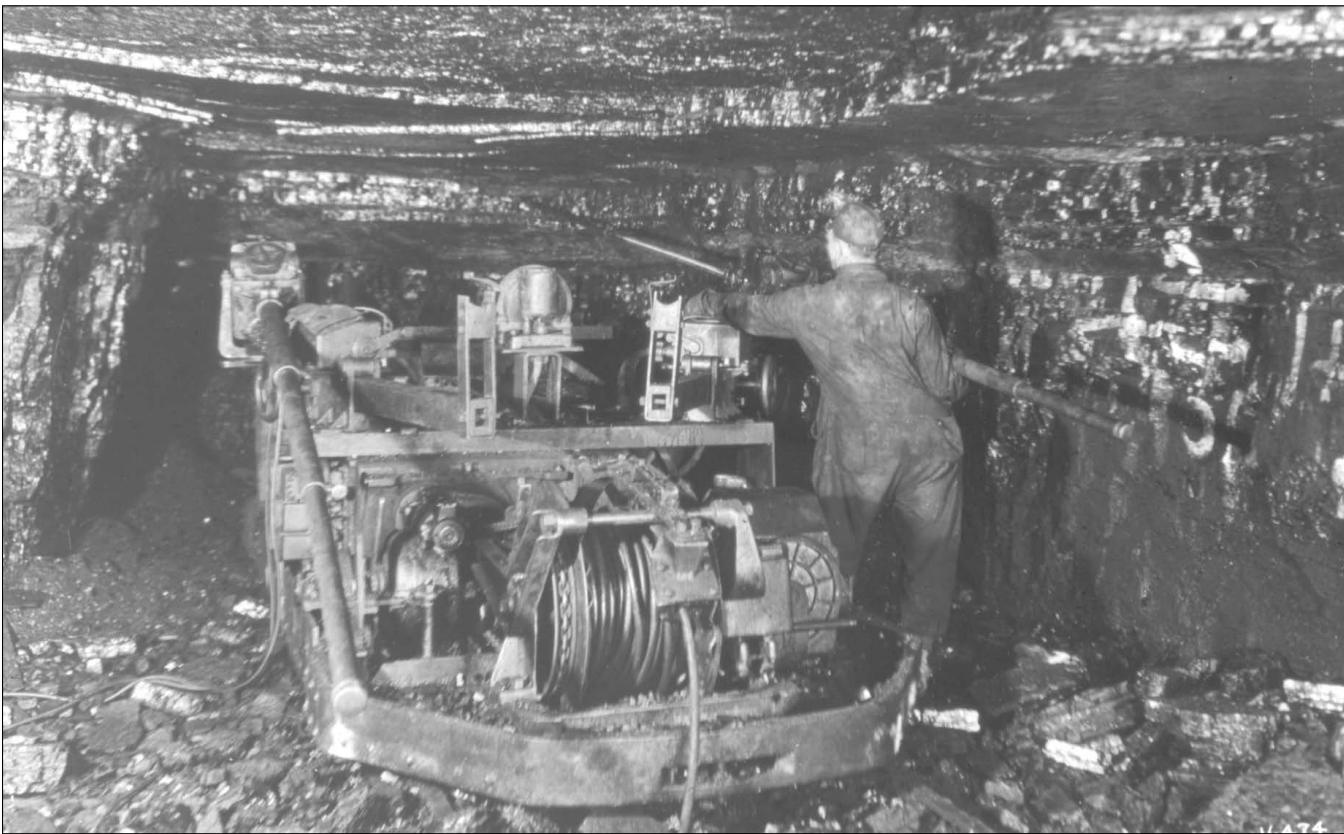


Figure 43 Sahara Coal Company, No. 5 Mine, Saline County. Placing a compressed air shell in a hole in the coal preparatory to shooting the coal. The coal is being shot to open a crosscut with the next entry. The compressed air shells were called Airdox and were much safer than black powder or other explosives used earlier (Ledvina et al. 1992).

ISGS | 1956



ISGS | Undated

Figure 44 Mine and location unknown. This operator and machine are inserting Cardox or Airdox cartridges.

Wage and Safety Issues Related to Shooting Coal In the thin seams of northern Illinois, after a certain area was worked out with the longwall method (Figure 26), the weight of the roof would aid substantially in breaking the coal free from the face. Sparland Coal Company expected to longwall mine the coal in Marshall County without the use of blasting powder. The company offered wages to compensate for the additional cost to the miners for the time before the roof weight came on, paying \$1.20 per ton while powder was required during a time when the regional price was \$0.80 per ton. Perhaps the coal cleavage was poorly developed in this area or the weight of the strata above the coal was less than required for this process to work, but powder continued to be necessary to mine the coal. When the company tried to lower prices to the regional level so that they could sell their coal competitively, the miners reacted to their lower wage by going out on strike. The strike resulted in a gradual wage reduction to the

regional level to allow time for adjustment (Lord 1890).

Nationwide, 1906 saw more than 600 deaths from dust and gas explosions. In response, the U.S. Geological Survey set up the Pittsburgh Testing Station in an attempt to find ways to prevent many of these fatalities (Jones 1954). Illinois had noticed and acted on the problem in 1905 with the passage of the Shot-Firers Act. The Act specified that miners drill shot holes and set the charges, but that the shot firers not set them off until after the mining shift, when the mine was nearly empty. A shot firer could refuse to fire shots that in his judgment appeared to be dangerous. Fatalities caused directly by powder explosives decreased 40% in the three years following the Act compared with those during the three years preceding it (Ross 1908, p. 3). However, the process of setting up a shot does not allow for complete visual examination. As an example, in 1903, before the Shot-Firers Act, six men were killed by an

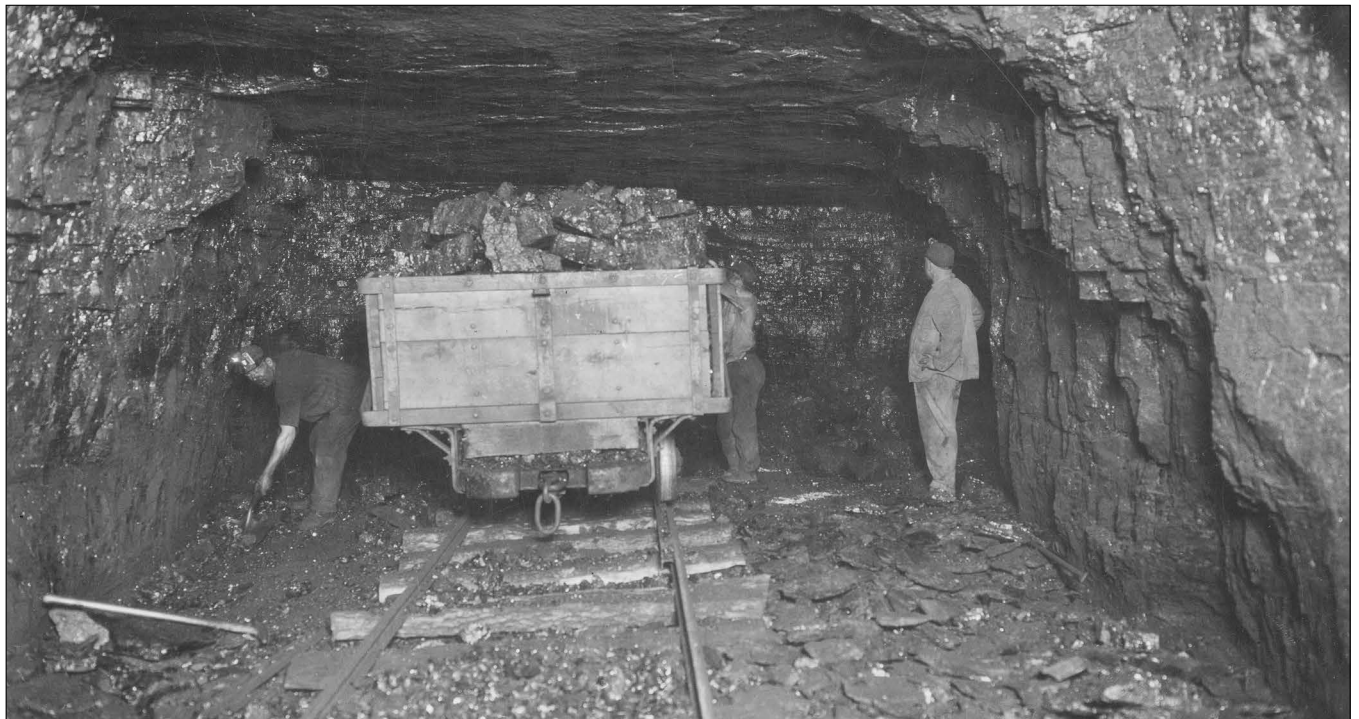
explosion in a mine near Athens. Six shot holes were drilled in the small room, some of them almost through to the room next door, and filled with an estimated 60 pounds of powder. The powder required to shoot the coal down was a fraction of this amount, perhaps 5 to 10 pounds. The men killed in the next room were over 100 feet from the explosion and unaware that improperly drilled holes put them at risk. Additional fatalities occurred because there was no room for expansion and dissipation of the heat, so the flames extended over 500 feet down the haulage entry, killing those in their path. (Taylor 1903). Perhaps the disaster near Athens could have been averted if trained shot firers would have noticed and investigated these inexpertly constructed charges, as was later required by the 1905 law.

Loading Loading the coal was a labor-intensive operation. Many machines were created, even before 1900, to speed the process, but most did not work well under the wide



ISGS | 1920s

Figure 45 Big Creek Coals, Inc., No. 3 Mine, Saline County. The coal face after the coal had been shot down.



ISGS | 1920s

Figure 46 Mine and location unknown. Two men are hand loading the coal car. The man on the far right is most likely a driver waiting for the car to be filled.

range of conditions found in mines. Hand loading was practiced well into the 1920s, even in large, high-production mines.

Development of Machine Loading

The first loading machines were developed before 1900, but most were prototypes or good ideas that worked only in limited circumstances or, for one reason or another, were not marketable to the industry as a whole. In 1890, the Bennett Mine at Lebanon in St. Clair County used a Stanley Header, a machine that had a conveyor. The conveyor is worth mentioning because it is unusual; hand loading was common practice at high production mines for the next 20 years. The first mobile loader in the state was the Hamilton, which used "sweep chains" at the Dewmaine Mine of St. Louis & Big Muddy Coal Company in 1903. Jeffrey Manufacturing Company made entry drivers, which were used as loading machines by Old Ben Coal Company (1914) and Valier Coal Company (1919). The McKinley Entry Driver was adaptable as a loader for Southern Coal, Coke & Mining Company near Belleville (Schull 1955, p. 56–57). Joseph F. Joy developed a wooden, hand-operated loader in 1914. This loader design was tested in a difficult mine in Pennsylvania and modified several times over the next 6 years, but it never worked to the company's satisfaction. Joy thought his loading machine would work quite well in some mines, so he formed Joy Manufacturing Company with the financial backing of John A. Donaldson (the vice president of operations at the mine where the machine was tested) (Morrow 1962).

Track-mounted loaders required a great deal of track construction next to the active face, which sometimes caused delays that more than offset the advantages of machine speed. Many early loaders had gathering arms that fed the coal onto a straight conveyor and required manipulation of the coal cars to load them fully, which contributed to their inefficiency. By 1924, Joy had developed his loader with a rear conveyor that swung 90 degrees to either side of the machine, making it easy to position it over the car. This machine



Courtesy Zeigler Coal Company | 1910

Figure 47 Bell & Zoller Coal Company, Zeigler No. 1 Mine, Franklin County. Hand-loaded cars of coal could be stacked much higher than loading machines could fill the cars. The closely set wheels near the center of the car helped it turn sharp corners in the mine (Greene 1889).

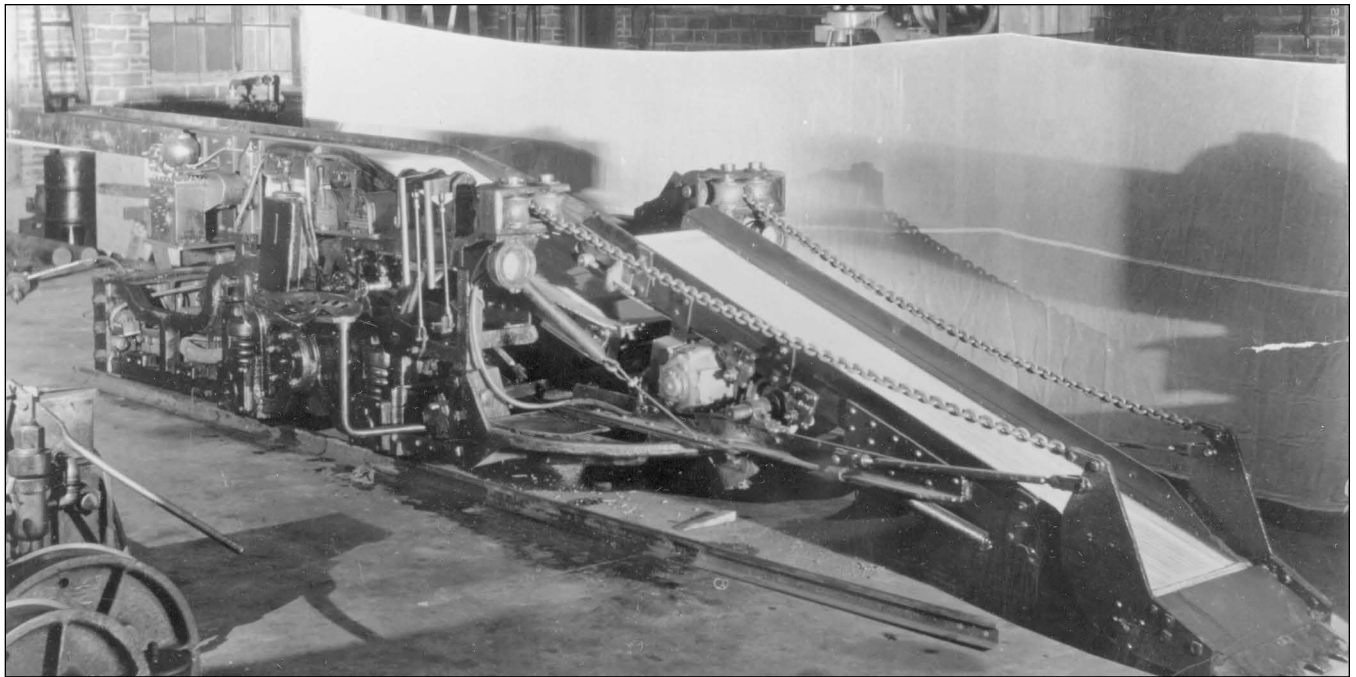
worked satisfactorily, and further modifications were made for special conditions, such as thin seams or narrow rooms with heavy timbering. Joy Manufacturing Company was by no means the only company to produce loading machines that worked well. Goodman Power Shovel, Wilson Chain Loader, Conway Rock Loader, and Sullivan Loader were only a few

of the many competitors in this field. The availability of efficient loading machines helped boost productivity from 1925–1930 (Morrow 1962). In 1927, about 4% of the tonnage produced by shipping mines was mechanically loaded. By 1930, over 50% of coal was mechanically loaded, and, by 1954, the amount reached almost 99% (Schull 1955, p. 58).



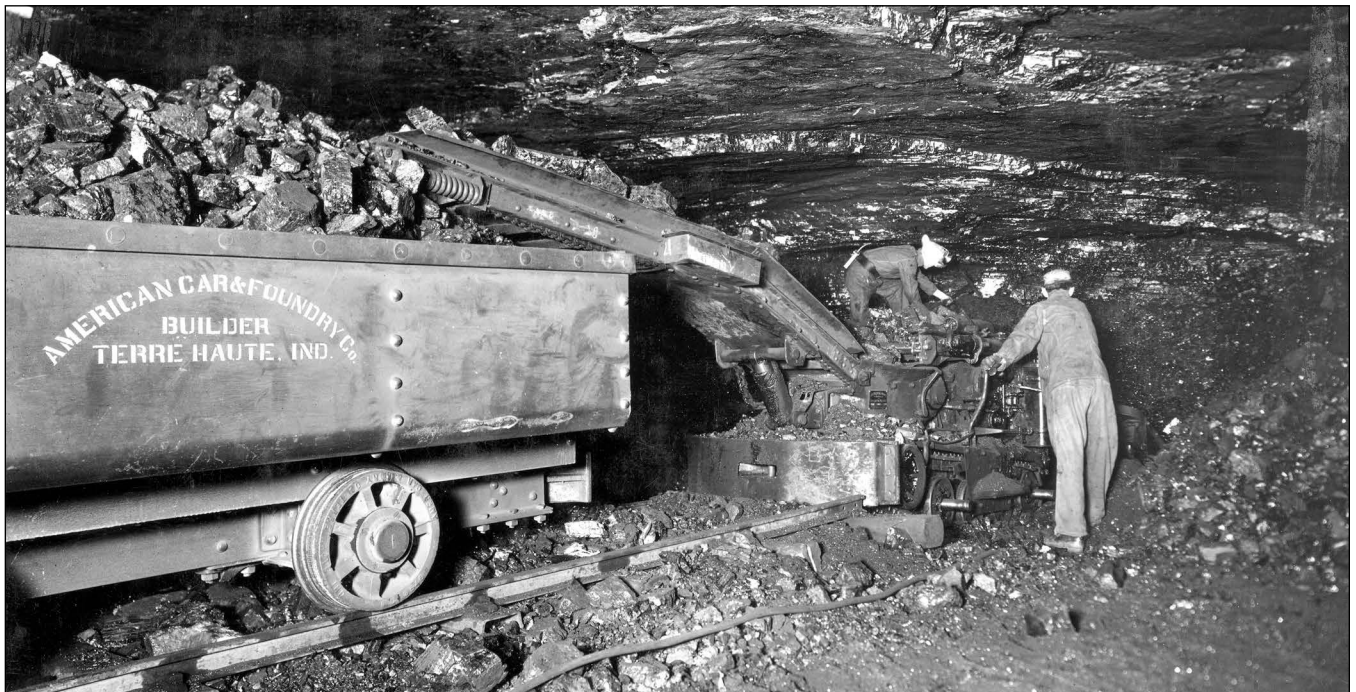
ISGS | Circa 1915

Figure 48 Peabody Coal Company, mine and location unknown. A track-mounted duckbill loading machine is shown (Ledvina et al. 1992).



Courtesy Robert Fox | Circa 1915–1920

Figure 49 Clarkson track-mounted loading machine. This rare machine is shown in the shops of the Clarkson Manufacturing Company (later National Mine Service Company) in Nashville, Illinois. Like most track-mounted loaders, the Clarkson was never very successful and was overshadowed by the Joy crawler loaders. However, the Clarkson helped pave the way for increased mechanization in underground coal mining (Ledvina et al. 1992).



ISGS | Circa 1920

Figure 50 Chicago, Wilmington & Franklin Coal Company, New Orient Mine, Franklin County. The Joy mechanical loader, powered off the trolley using a trailing cable, was versatile, efficient, and reliable. Because it was crawler mounted and not tied to the track, it outperformed hand loading by an incredible margin. These machines became even more efficient when teamed with shuttle cars. Ultimately, they became the loading and conveying portion of continuous mining machines (Ledvina et al. 1992).



ISGS | Circa 1920

Figure 51 Mine and location unknown. Another view of a mechanical loader, probably the same model as shown in Figure 50.



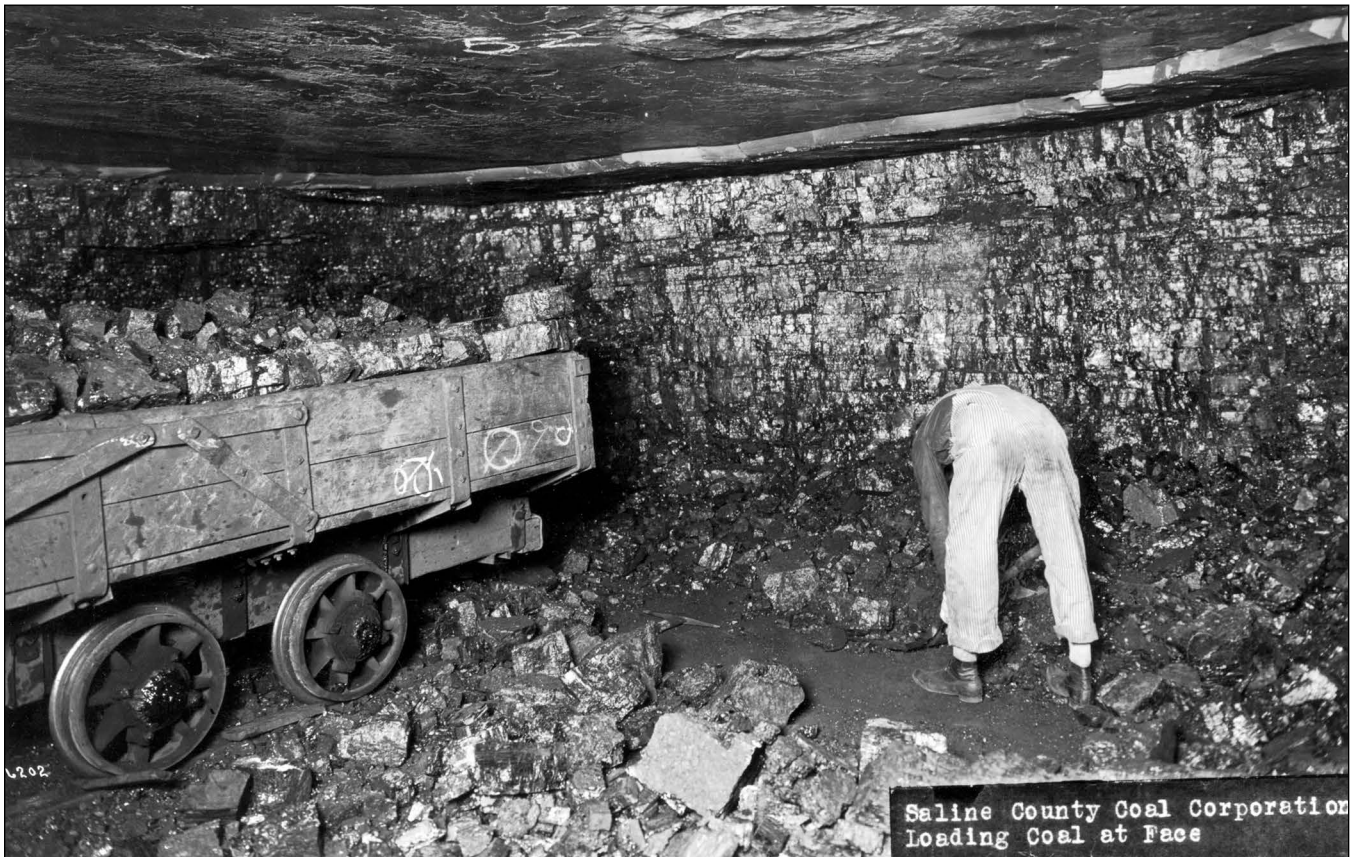
Courtesy Peabody Coal Company | Undated

Figure 52 Peabody Coal Company, mine and location unknown. This duckbill loader is attached to an early conveyor.



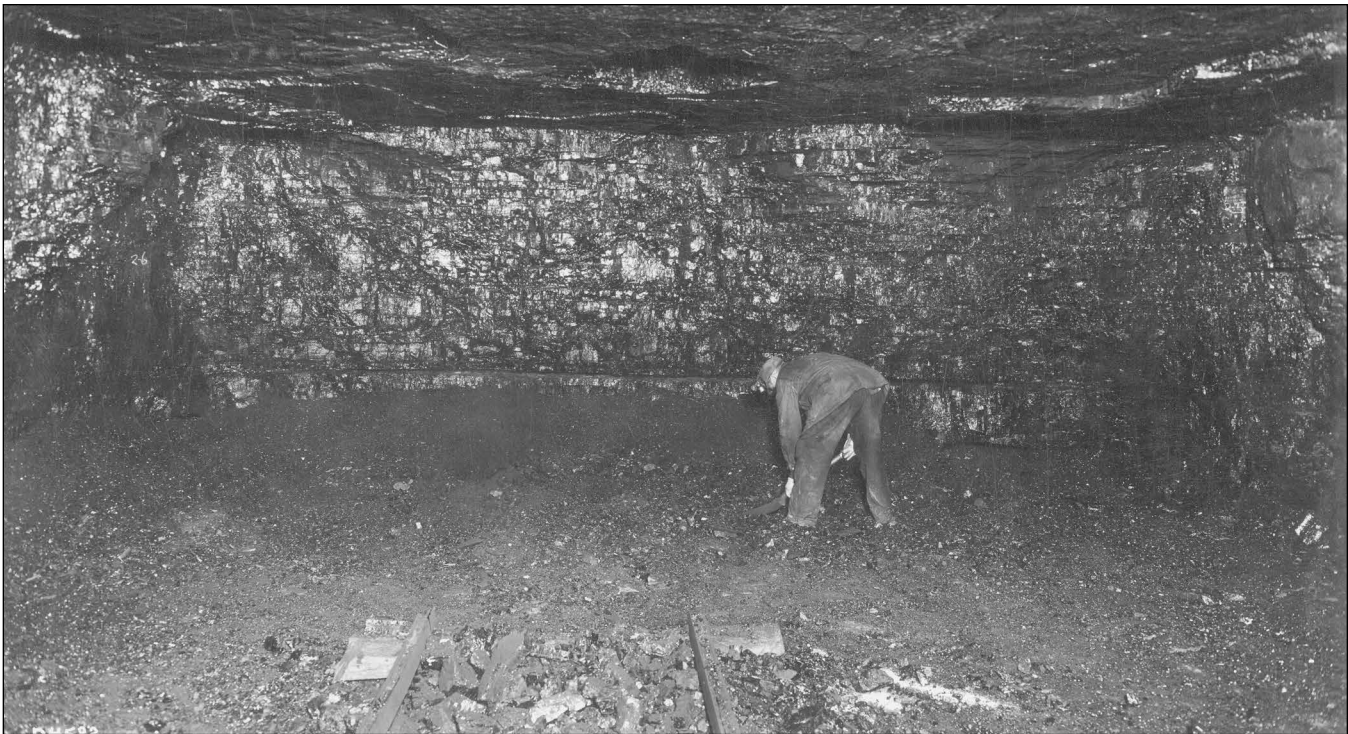
Figure 53 Chicago, Wilmington & Franklin Coal Company, Orient No. 1 Mine, Franklin County. Hand loading coal at the face was a hard and dirty job (Ledvina et al. 1992).

Courtesy Southern Illinois University | 1914



ISGS | Circa 1920

Figure 54 Saline County Coal Corporation, mine unknown, Saline County. A laborer loads the coal into the mine car by hand, a method that was more selective than machine loading, as small pieces could be left at the face (Ledvina et al. 1992).



ISGS | Circa 1920

Figure 55 Mine and location unknown. A laborer cleans up the face in a hand loading mine to prepare the area for the next sequence of undercutting and shooting (Ledvina et al. 1992).



Courtesy Southern Illinois University | Circa 1930

Figure 56 Bell & Zoller Coal Company, No. 2 Mine, Franklin County. An early Joy loader, moving on crawlers, vastly improved maneuverability and underscored the limitations of track haulage at the face (Ledvina et al. 1992).



Courtesy Zeigler Coal Company | Circa 1930–1940

Figure 57 Bell & Zoller Coal Company, No. 2 Mine, near Zeigler, Franklin County. A Joy 11BU loading machine in action. Loading machines grew in size and complexity with increased reliability and greater capacity (Ledvina et al. 1992).

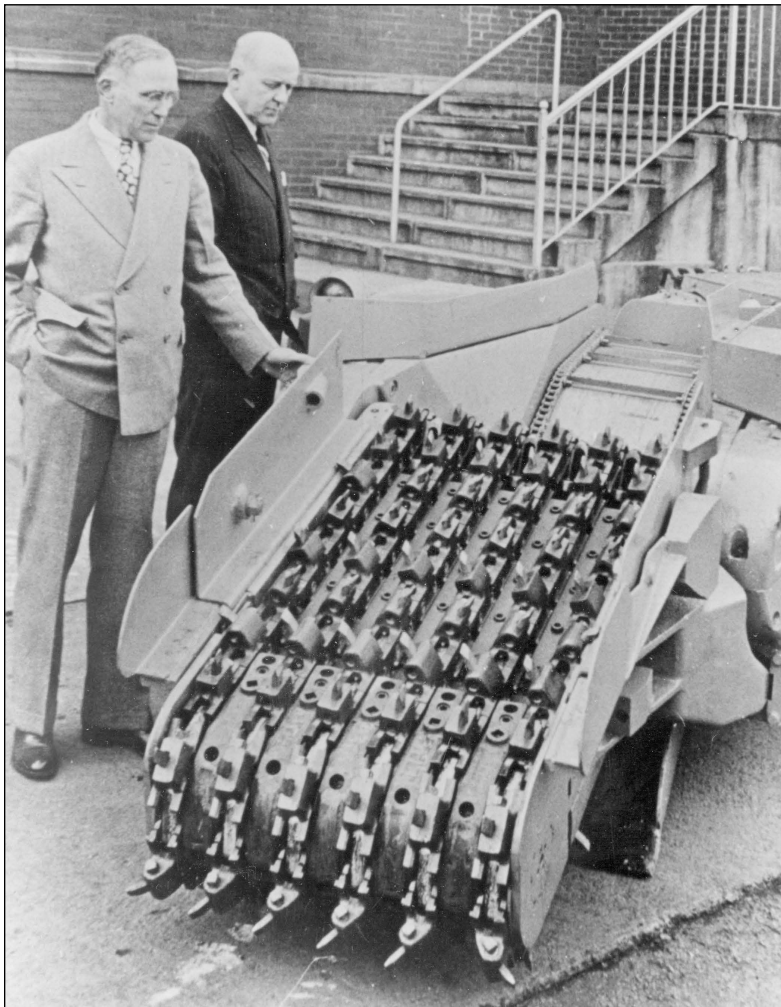


Figure 58 Mine and location unknown. This loading machine was developed in the late 1930s. The make and model are not known.

ISGS | Circa 1937–1939



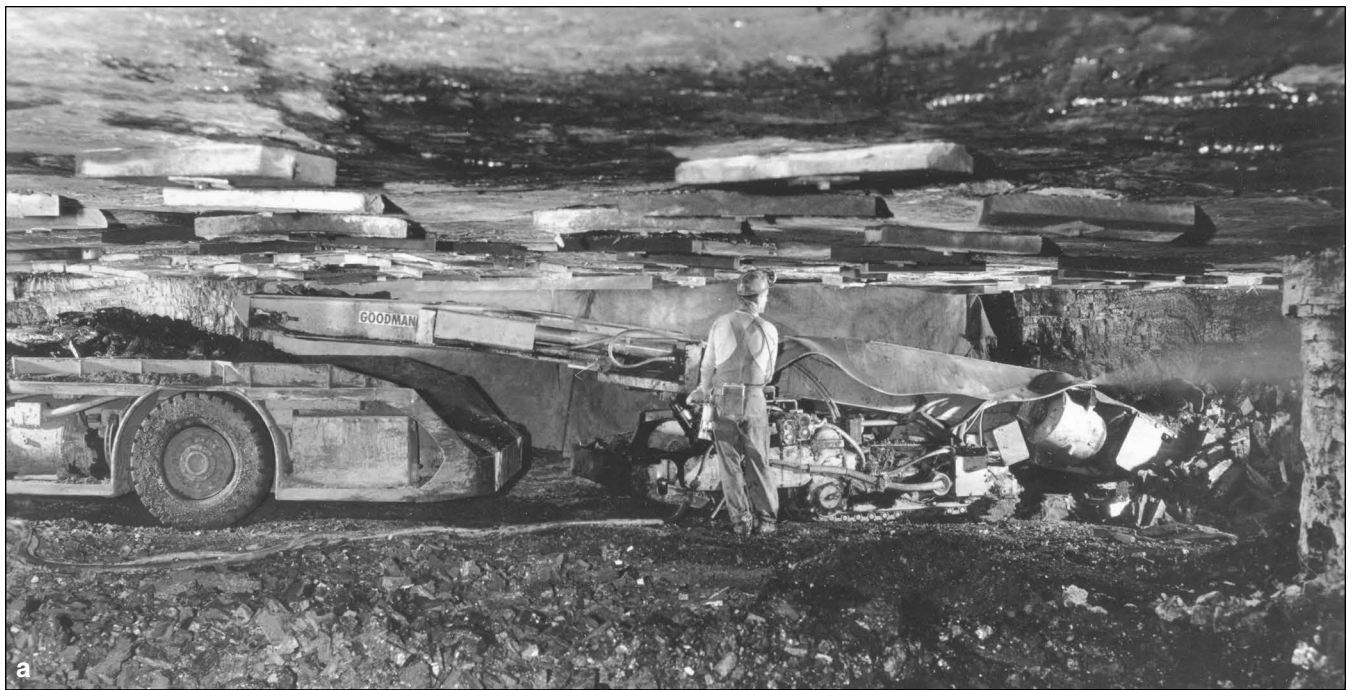
Courtesy Jeffrey Manufacturing Company | Undated

Figure 59 Mine and location unknown. A few roof bolts with metal plates support the roof where this loader is working. The loader has a gathering chain with teeth that brings the coal into the center conveyor and then loads the shuttle car (to the left, mostly out of the photograph). Most loaders could move 10 tons per minute or more, and the capacity of coal movement was limited more by the shuttle cars than by the loader speed (Jeffrey Manufacturing Company undated).



ISGS | 1956

Figure 60 Sahara Coal Company, No. 5 Mine, Saline County. A coal loading machine and operator are shown (Ledvina et al. 1992).



Courtesy Goodman Manufacturing Company | Circa 1960



Courtesy Goodman Manufacturing Company | Undated

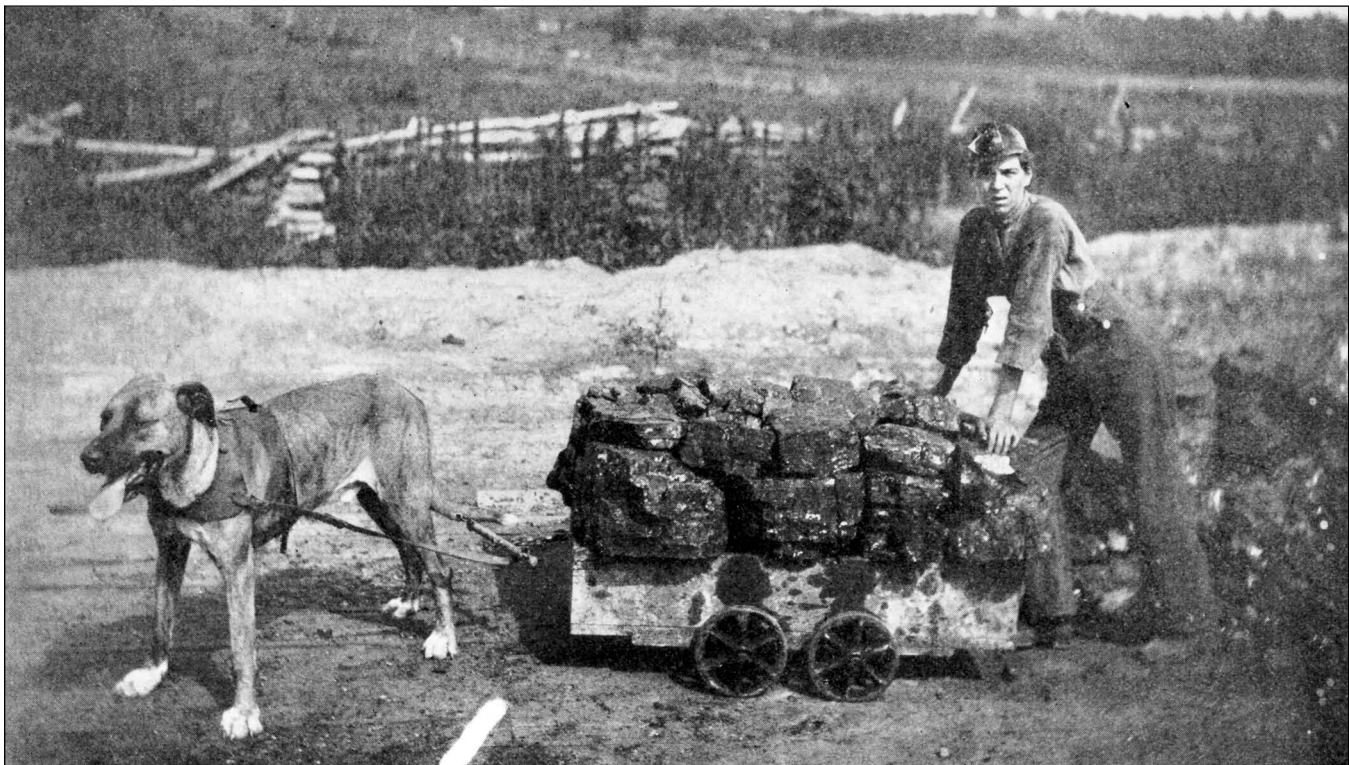
Figure 61 Mine and location unknown. Two types of loading machines are shown for conventional mining units, where the coal is undercut, shot, loaded, and transported. Both loaders are filling shuttle cars. Goodman loaders came as short as 24 inches in overall height for thin seams; the loader could load up to 16 tons per minute (Goodman Manufacturing Company undated). The great advance that made the loaders overwhelmingly acceptable for underground coal mines was making the back of the machine moveable from side to side independent of the front-loading mechanism direction. This advance added speed to the loaders, allowing them to couple without requiring the precise alignment in what was likely a very crowded space. A rear pivot point on the conveyor could swing 45 degrees to either side of the center line (von Stroh 1949). Both machines shown are crawler mounted. The controls are 10 to 13 feet behind the loader head, allowing the operator to stand under a supported roof.

Haulage Generally, coal transportation in an underground mine is broken down into three categories: face haulage, secondary or intermediate haulage, and main haulage (Draper 1973). Face haulage included hand loading a coal car in a room to transport the coal from the face with a mule. Secondary haulage might be a loaded trip of four coal cars pulled by a mule from the active area of the mine to a main haulage line where an electric locomotive collected the cars of several mules to pull a loaded trip of over 30 cars to the shaft bottom. As electricity was extended further through the mine, mules were sometimes replaced by smaller locomotives than those along the main haulage route. These gathering locomotives could pull three to five cars, and the cars may have been loaded in the rooms with an electric loading machine.

Animal Haulage Most mines used horses and mules to haul coal from the face. According to Douglas Crowell (1995), in Ohio, horses were used where the haulage route was 6 feet tall, and mules were used where the clearance was less. Shetland ponies, oxen, and goats were also used. No evidence has been found to indicate oxen or goats were used in Illinois, but much mining history has been obliterated by time. The photographs in this collection do not indicate a great height difference between horses and mules, probably because mule height varies. Where the haulageway was flat, a mule could haul four coal cars, each holding a ton of coal. However, hilly seams lessened the amount of coal a mule could pull. A single mule generally could not pull even one car up an incline of more than 10 degrees (Greene 1889).

Although rare, dogs were used in a few mines in Illinois, as recorded for three

mines near Colchester in McDonough County between 1902 and 1905. The coal in this area was thin, between 2.5 and 3 feet thick, and using larger animals would have required excavating roof and floor material and hauling them from the mine, resulting in a higher mining cost per ton of coal. The Rippetoe & Rundle Mine used about half (15 of 31) of the mining dogs reported for the county. James Taylor, the state inspector for this district, noted the behavior of one of the dogs. When the dog reached the summit of the hill, it jumped into the empty coal car and rode down the hill with the driver. When the lowest spot was reached, the dog jumped out and pulled the car up the grade to the work place, all without instruction from the driver (Taylor 1903). Because of the special attention paid to dog haulage in the *Coal Report*, the practice appears to have been uncommon or perhaps an experiment that was discontinued after 1905.



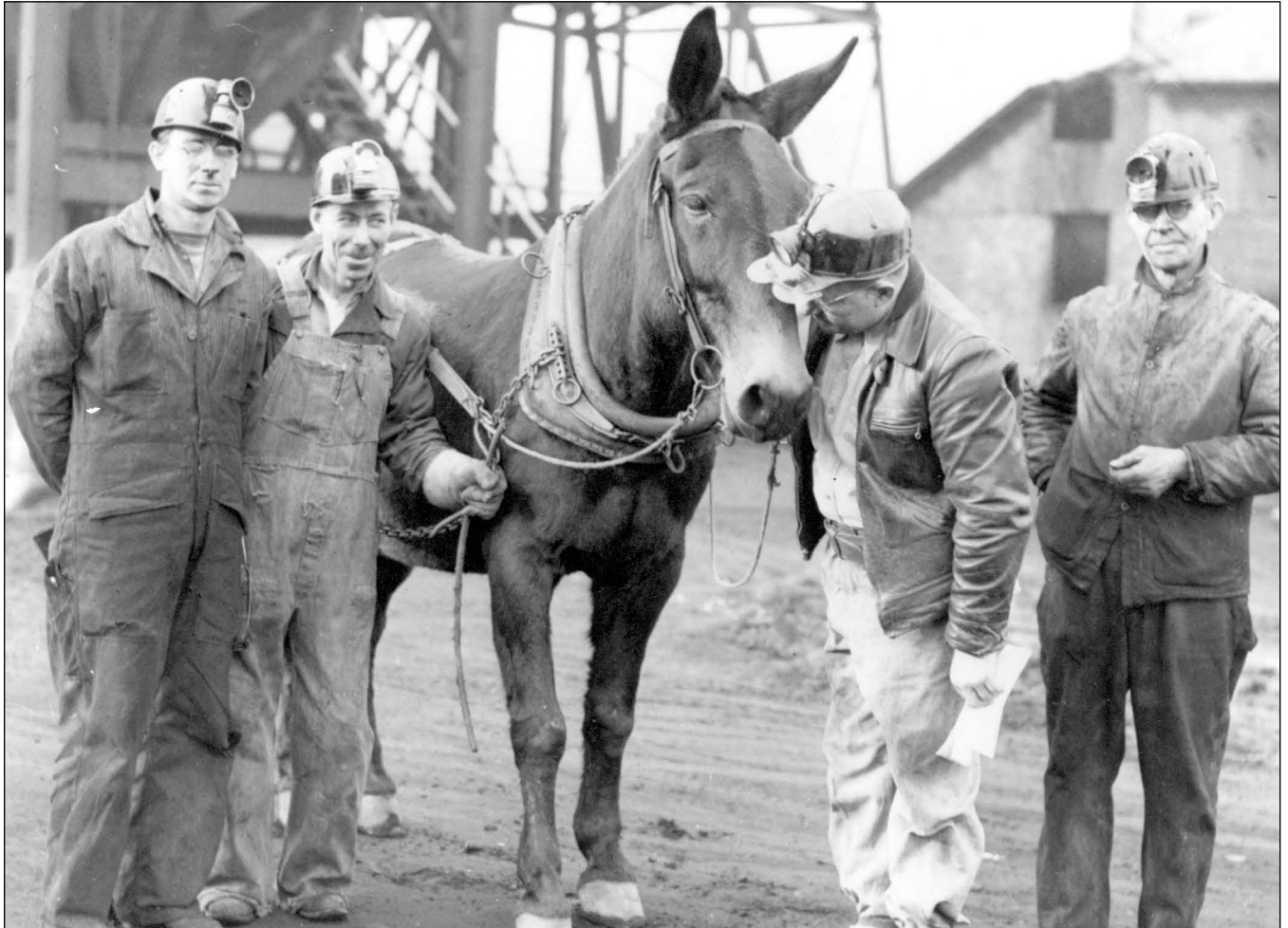
Photograph by James Taylor, Mine Inspector, Illinois Bureau of Labor Statistics | 1903

Figure 62 Mine unknown, near Colchester, McDonough County. Dogs were used for haulage for a few years in McDonough County.



Figure 63 Mine and location unknown. This driver is placing a wedge to prevent the loaded car on the track from rolling. In many mechanized mines, horses and mules were used to haul the coal cars to a main haulage route to make a train, or "trip," of loaded cars to be taken to the hoist shaft (Ledvina et al. 1992).

ISGS | Circa 1915



Courtesy Zeigler Coal Company | Undated

Figure 64 Zeigler Coal Company, mine and location unknown. This mule may have been the last to be taken out of service at the mine. Most mines were mechanized in the 1940s. With mechanization, the face of mining changed. In 1923, there were 103,576 employees in shipping mines. By 1950, that number had dropped to 31,067, a drop of 60%; production fell only 25%, mostly because of changing markets (C. Treworgy, unpublished).

In early mining operations, one innovation that replaced animals at secondary and main haulageways involved the use of endless rope powered by a steam engine outside the mine (Draper 1973). In some mines, main-and-tail rope systems used the weight of loaded cars to pull empty cars on an inclined plane (Greene 1889). This system required double tracks and could cost approximately twice as much as electrification, partially because of high maintenance costs (Sperry 1892, Flood 1942). Both of these rope systems were somewhat inflexible once installed, and mules were still required to haul the coal to the rope system. These rope systems are classified as mechanical haulage (Beltz 1946).

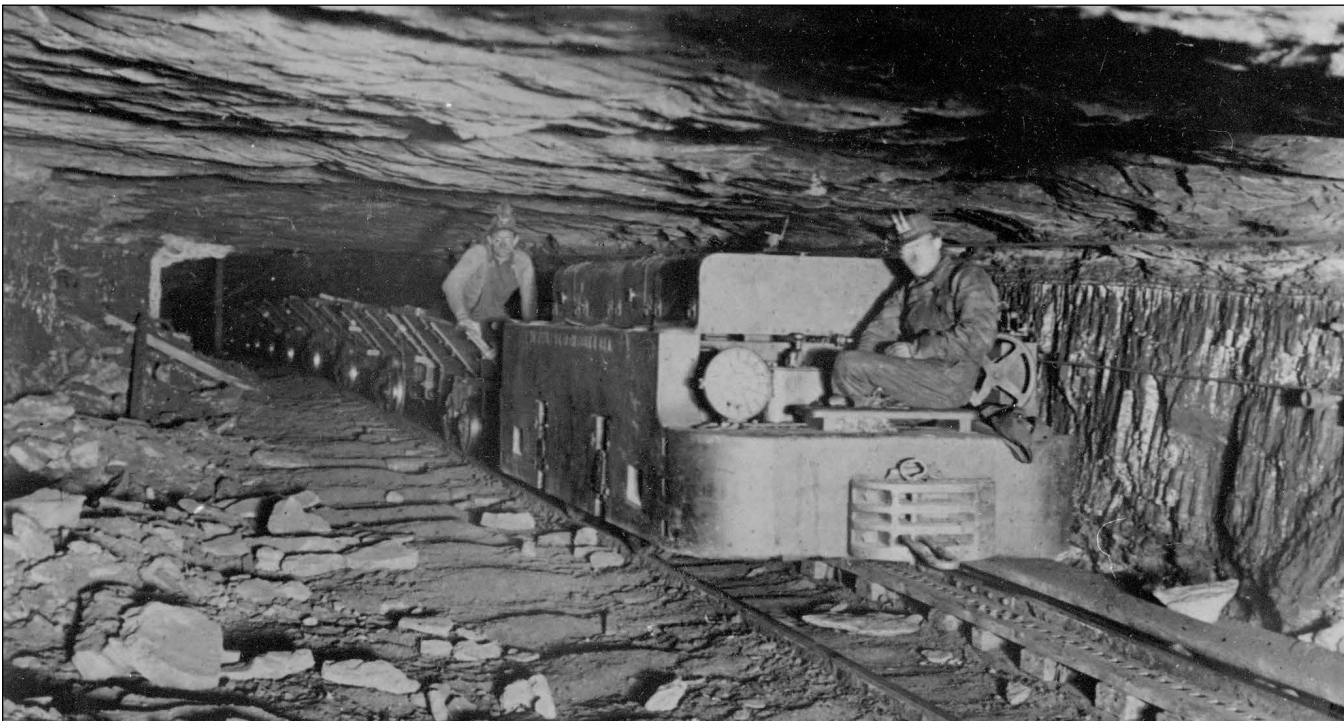
Machine Haulage Compressed-air locomotives were introduced during the early 1880s (Morrow 1962). The large mines tried specially designed steam locomotives or locomotives powered by steam with high-pressure, compressed air reservoirs for main

haulage (Beltz 1946). High production required electric locomotives, which were first developed in Germany in 1883 (Draper 1973). The first electric locomotive in the United States was tested in a Pennsylvania anthracite mine in 1887. To negotiate the sharp turns in the tracks designed for animal haulage, these early locomotives had a short wheel base, which limited their size and weight until Elmer Sperry came up with an ingenious gearing innovation that allowed each set of axles to pivot around the midpoint of the locomotive. Frank Sprague further advanced locomotive design by giving each axle a motor (instead of a motor centered on a fixed axle) so that each set of wheels had a power source. This innovation enabled locomotives to cope with the uneven tracks in coal mines (Beltz 1946).

These main haulage locomotives were a vast improvement over mules. The Chicago, Wilmington & Vermilion No. 3 Mine in Streator had a 6,800-foot

round-trip haulage route, parts of which had a 3% grade. After conversion to electric haulage in 1891–1892, a trip of 37 pit cars (each about 2 tons gross weight) was run in less than 9 minutes. This production of 600 tons per day formerly required 20 mules and 20 drivers (Sperry 1892).

The natural chain of events led to development of the gathering locomotive about 1903 (Morrow 1962). This 4- to 8-ton, two-motor locomotive had an automatic cable reel that allowed access to the portions of a mine without electricity. The automatic reeling system would reel up extra cable as the gathering locomotive approached the wire (Beltz 1946). This trailing cable had poor insulation and was easily damaged. Although electric storage batteries were developed in 1892, they did not become practical for mine usage until about 1910. Battery-powered gathering locomotives were popular between 1912 and 1924. Although slower than their electric counterparts, the battery-powered



ISGS | 1915

Figure 65 Mine and location unknown. As with all facets of mining, mechanization was an evolutionary process. This 30-ton rail locomotive is battery-powered, an unusual style of motor not commonly used in Illinois. Using a center gear, the locomotive meshes with the toothed center rail, enabling it to negotiate very steep grades or run on wet track with no loss of traction (Ledvina et al. 1992). The locomotive also could operate as a simple traction locomotive using only the wheels. The use of these machines was discontinued before World War I because of high maintenance costs (Beltz 1946).

gathering locomotives were just as productive if the haulageway gradients were not too steep. Many were still in use in 1946, especially in gassy mines, but they were supplanted by cable reel locomotives when rubber-clad cable was introduced, mostly because the cable reel locomotives

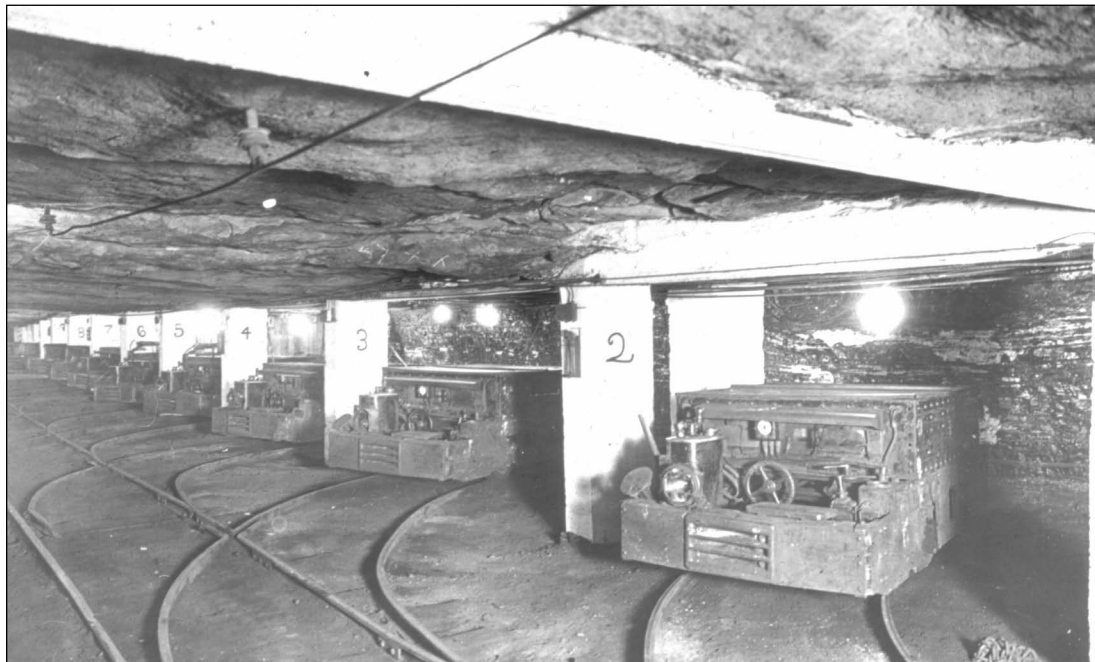
allowed larger and heavier cars that were beyond battery power capability to be run off the trolley. The gathering locomotives pulled their load at about 6 mph, and the more powerful main haulage locomotives worked at 8 mph (Beltz 1946).

The basic design of locomotives stabilized during the period from 1915 to 1917. The period from 1920 to 1930 saw only refinements. Most of these machines were still working 30 years later (Beltz 1946).



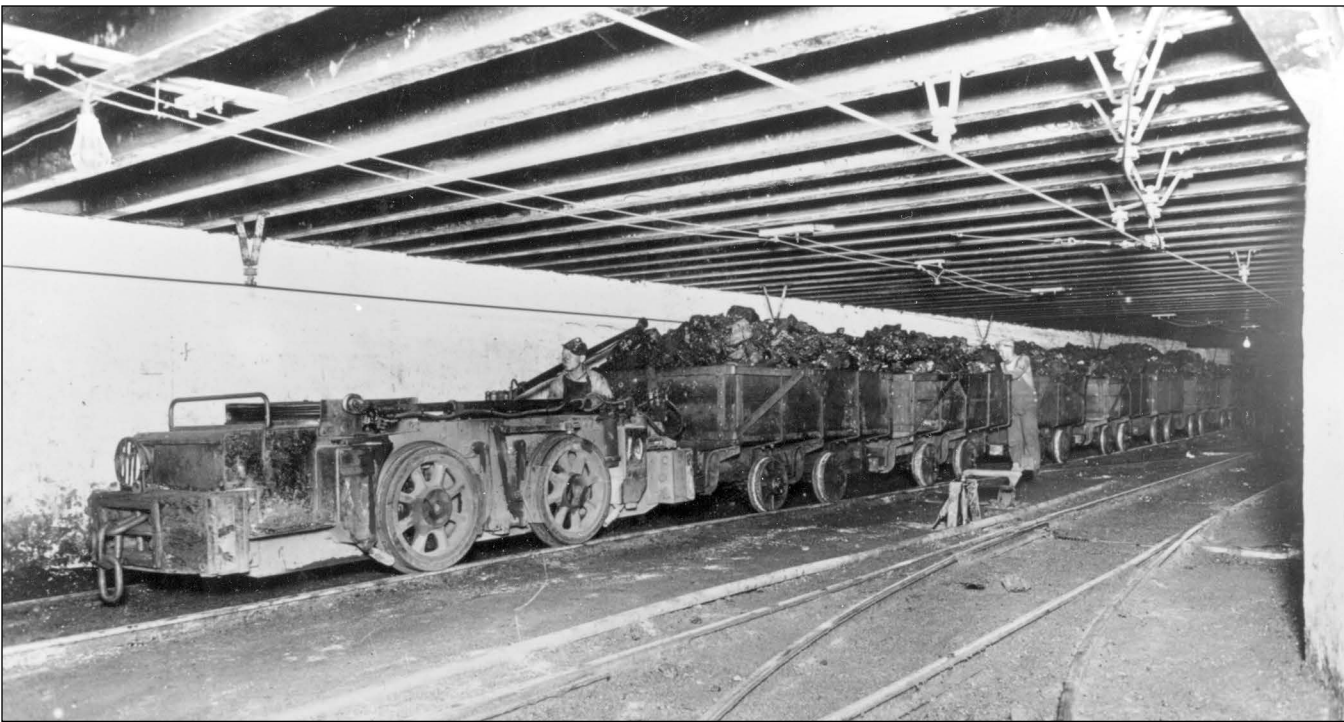
ISGS | Circa 1920s

Figure 66 Madison Coal Corporation, No. 12 Mine, Williamson County. An underground motor barn and charging station. This mine probably used battery-powered locomotives for track haulage rather than trolley power (Ledvina et al. 1992).



ISGS | Circa 1920s

Figure 67 Mine and location unknown. An underground motor barn in a mine that used trolley wires to power the locomotives. The live electric wire is shown suspended from the insulators attached to the mine roof above the straight portion of track.



ISGS / Circa 1925

Figure 68 Peabody Coal Company, mine and location unknown. A loaded trip of cars makes its way to the shaft bottom. Track haulage, shown here, was common in Illinois into the 1950s and was largely replaced by belt haulage (Ledvina et al. 1992).



ISGS / Undated

Figure 69 Mine and location unknown. An electrical trolley engine with a loaded trip of coal cars, operator, and assistant. The connection to the trolley wire is by a spring-loaded pole. An uneven roadbed could shake the pole loose from the connection (W. John Nelson, personal communication).



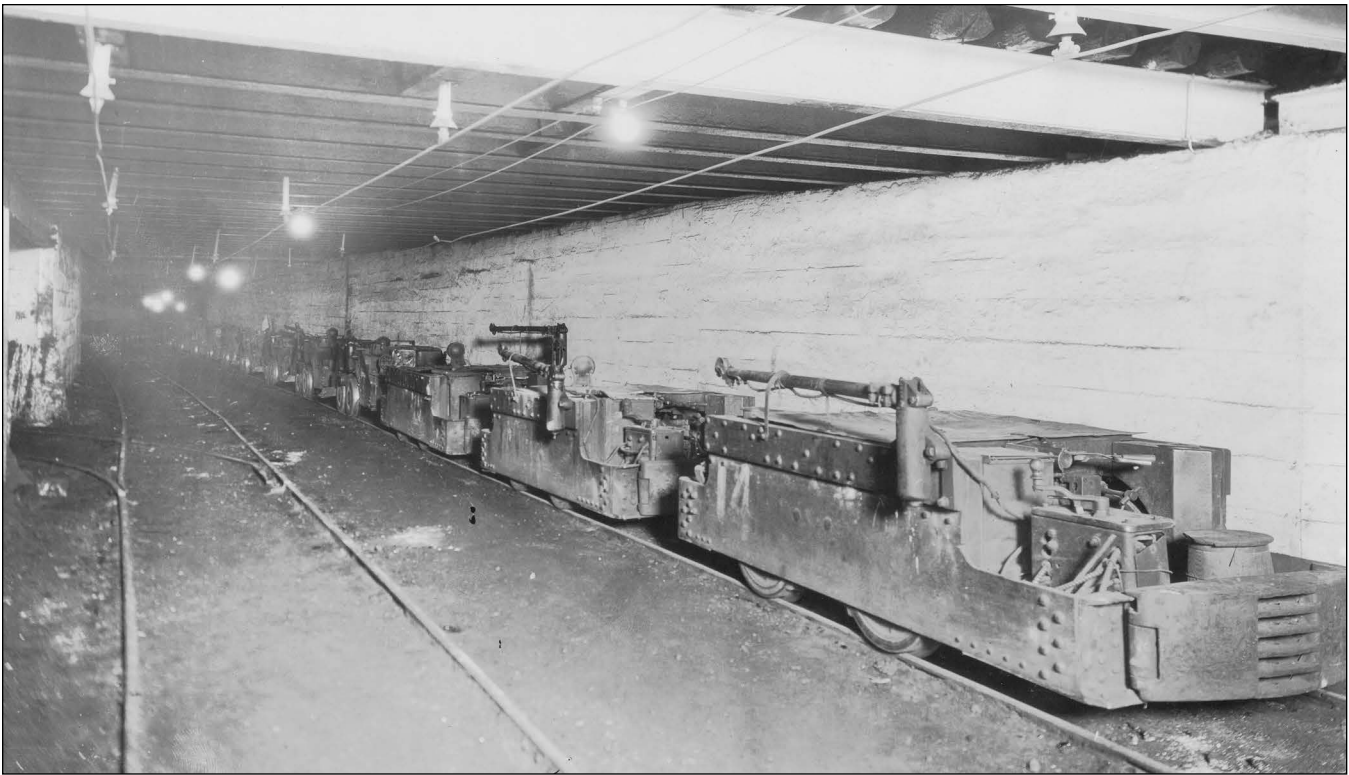
Figure 70 Bell & Zoller Coal Company, No. 2 Mine, near Zeigler, Franklin County. Trolley phones used a high-frequency carrier to conduct a signal through the trolley wire, thus providing communication throughout the mine. Here the motorman is speaking to the dispatcher from a 15-ton locomotive (Ledvina et al. 1992).

Courtesy Zeigler Coal Company | 1951



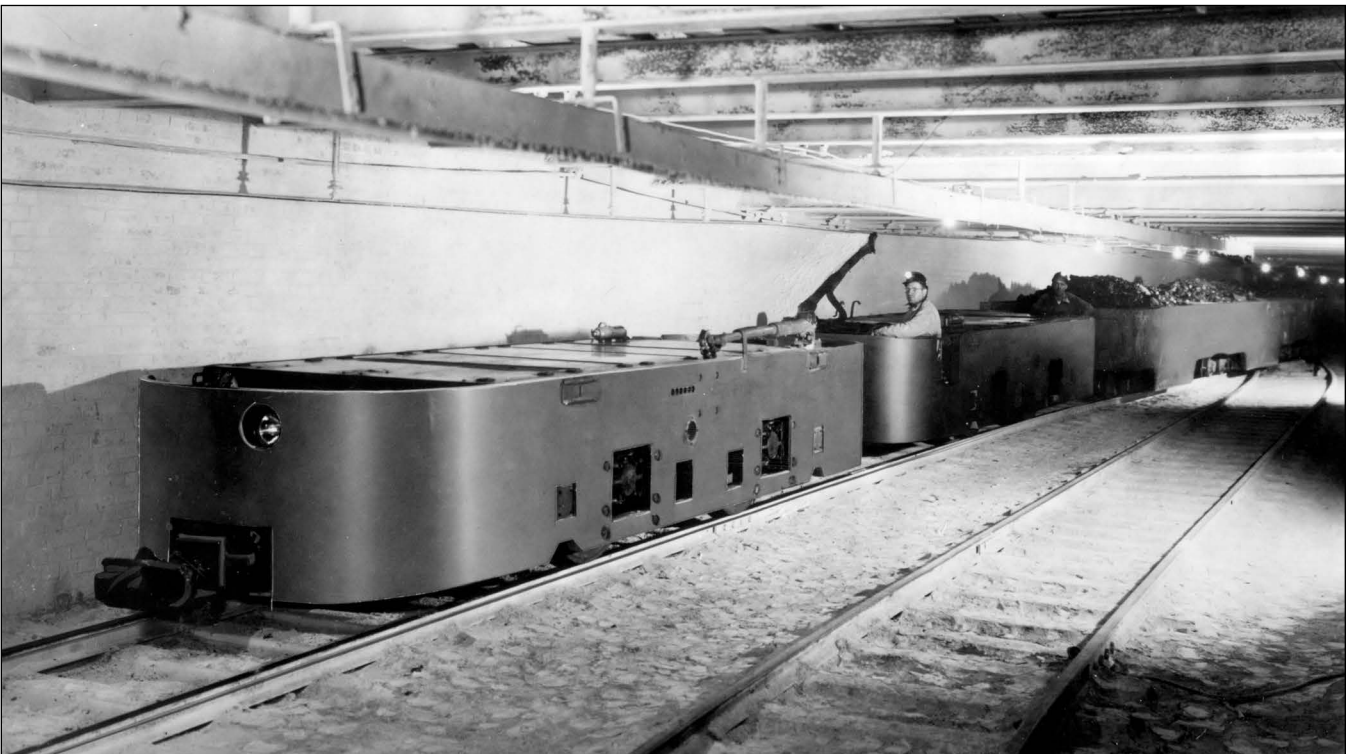
Courtesy Zeigler Coal Company | 1951

Figure 71 Bell & Zoller Coal Company, No. 2 Mine, near Zeigler, Franklin County. Main line motor hauling a loaded trip of mine cars to the shaft bottom. The motorman is in front and is assisted by a trip rider. The dispatcher is at left (Ledvina et al. 1992).



ISGS / Circa 1920s

Figure 72 Big Creek Coals, Inc., No. 3 Mine, Saline County. Haulage locomotives are shown at the shaft bottom. Live electric wires powered the locomotives.



Courtesy Jeffrey Manufacturing Company | Undated

Figure 73 Mine and location unknown. These Jeffrey electric locomotives operated in tandem to pull a heavier load than one locomotive could pull alone.



ISGS | Circa 1955

Figure 74 Mine and location unknown. A coal transfer point for secondary haulage in a mine is shown.



ISGS | 1956

Figure 75 Sahara Coal Company, No. 5 Mine, Saline County. The operator is discharging coal from the shuttle buggy into the transfer pickup to the left that, in turn, loads coal on the rubber belt (Ledvina et al. 1992).



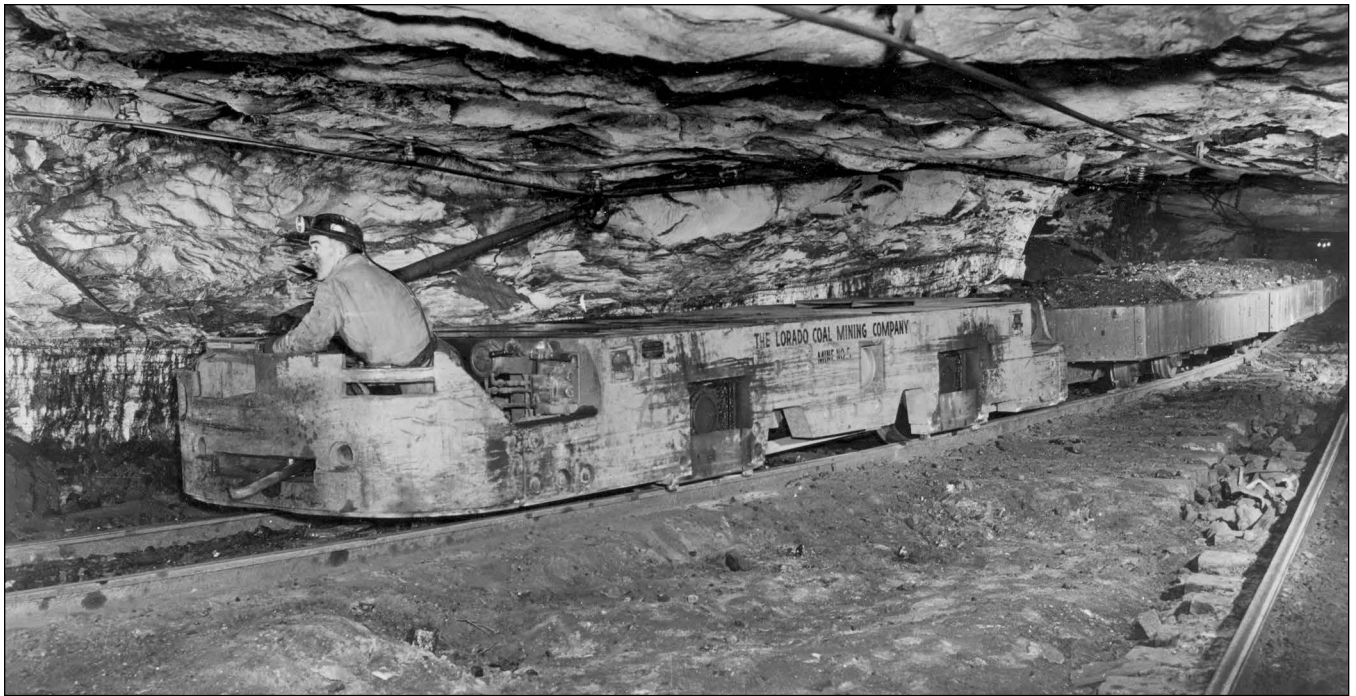
ISGS / 1956

Figure 76 Sahara Coal Company, No. 5 Mine, Saline County. Shuttle buggy (mostly off picture at the right) discharging coal into a company designed transfer pickup (a redesigned loading machine) that transfers coal from the discharging buggy onto the rubber belt (Ledvina et al. 1992).



ISGS / 1956

Figure 77 Sahara Coal Company, No. 5 Mine, Saline County. Coal is transferred from a rubber panel belt to coal cars for haulage to the shaft bottom, a hybrid system used before belt haulage totally replaced track haulage. A moveable baffle prevents coal spillage between cars (Ledvina et al. 1992).



Courtesy Goodman Manufacturing / Undated

Figure 78 Mine and location unknown. Main haulage, which is haulage to the main shaft or out of the mine to the preparation plant or tippie, can be accomplished with either locomotives pulling trips of loaded cars or with a conveyor belt. In large underground mines, combination systems were utilized.



ISGS / Circa 1950s

Figure 79 H.C. Frick Coke Company, Bunsen Mine, Vermilion County. This belt conveyor is part of a system 4.5 miles long. It can move 9,000 tons a day, which is typical of a belt this size. The trend in mining has always been to take staged operations and make them continuous. Belt haulage is a prime example of this concept (Ledvina et al. 1992).

Continuous Mining Machines

To improve both productivity and mining safety, continuous mining machines were designed to use bits rather than explosives to mine coal in a continuous process. A loader was an integral part of the machine. The first continuous miners were cumbersome, but were a considerable advance over the existing technology. They were considered to be less expensive to maintain than the three separate machines (undercutter, drill, and loader) used in conventional methods (Eubanks 1950). Because production from the continuous mining machines was high, fewer active faces were required to produce the tonnage required to meet contracts. They may have remained uneconomical because of low labor rates (von Stroh 1949).

There are three types of continuous mining machines: (1) the boring type, which breaks coal by a scrap-

ing action of an arm against the face and is distinctive for creating entries with curved side walls; (2) the ripper type, which breaks coal with a sawing action of cutter chains and makes particularly good squared cuts for entries and ribs; and (3) the milling type, which cuts the coal with a cutting head made of bit wheels that pick at the face (Shroder 1973). The boring-type continuous miner is shown in Figures 82, 83, 85, 86, and 90, the ripper type in Figure 81, and a milling type in Figures 87, 88, and 89).

The earliest known continuous miner, the English Channel machine, powered by compressed air, tunneled 70 feet per day in 1870. The Hoadley-Knight continuous mining machine emerged in 1912, but the Hoadley-Knight machine ground the coal so fine that most of the product could not be marketed. The McKinley Entry Driver was a successful continuous miner that could mine 3 to 5 tons per minute and is known to have operated

in the New Orient Mine for almost 30 years, starting in the early 1920s. The Jeffrey Manufacturing Company came out with its Entry Driver in the mid-1920s. This machine used an undercutter with shear bars on the side so that its bits could easily remove the coal by working up and down the face.

Efforts to improve continuous mining machines focused on producing flexible machines that could handle uneven or rolling bottoms, mine at a high rate (1 to 2 tons or more per minute), produce coarse coal (many of the first designs ground the coal to powder), load all the mined coal, minimize coal dust production, and operate with low maintenance (Cunningham 1961). Dust production was minimized by adding water spray nozzles to the machine. This feature did not stop the production of dust but did prevent it from becoming an explosion hazard.



Courtesy Jeffrey Manufacturing Company | Undated

Figure 80 Mine and location unknown. A Jeffrey Colmol-type continuous miner is shown. The cutting heads, called breaker arms, are shown in the left foreground. Below the breaker arms are gathering chains that collect the coal to the center of the machine where it is conveyed behind the machine. At that point, a conveyor belt system or shuttle car can transport the coal from the face. The cutting head can move straight ahead, but also to the left and right for greater versatility. These machines came in a variety of heights to mine thin or thick coal (Jeffrey Manufacturing Company undated). The Colmol produced less dust than did other continuous miners because the bit consisted of a drilling portion and a breaking portion (Phillips 1950).

To convert to continuous mining from conventional units, a company had to make several adjustments. Haulage rates had to be improved to keep up with the production, which proved

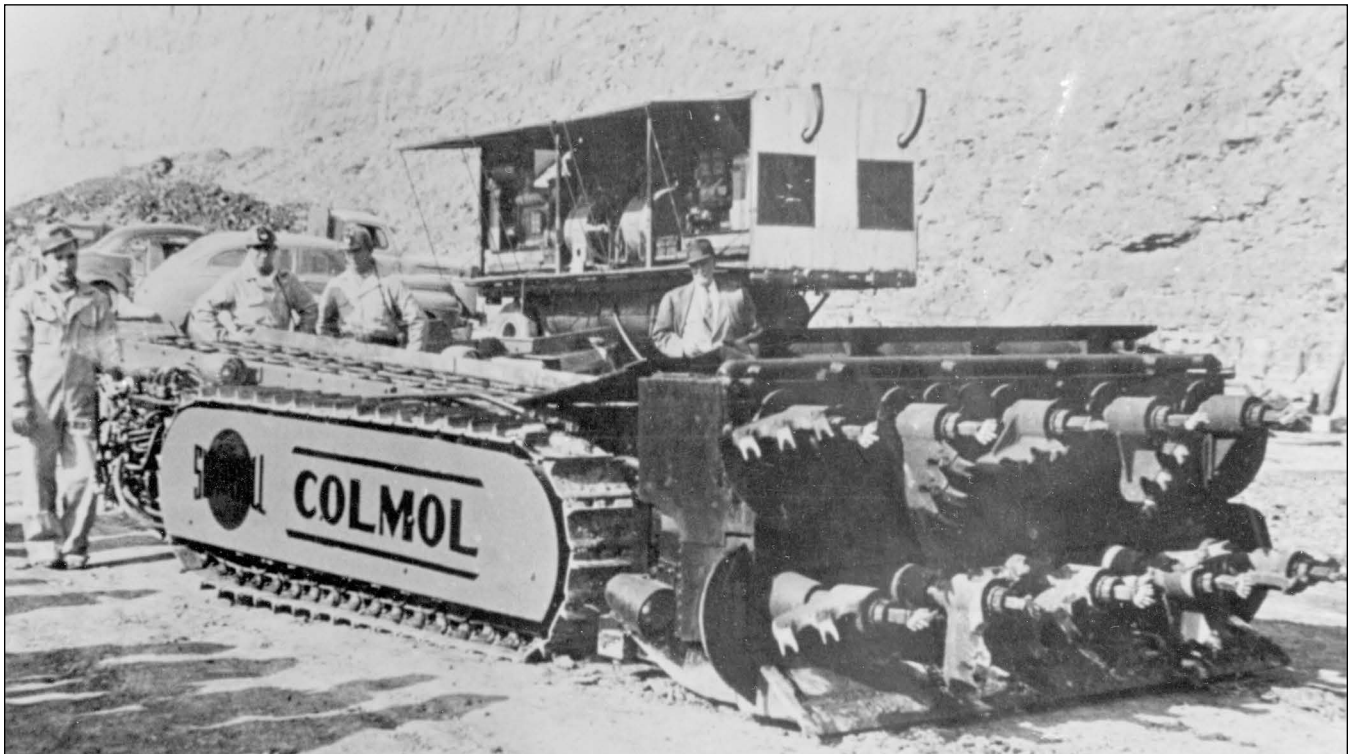
to be difficult. The extension of roof support and ventilation also had to be adapted to the new rate of advance. Although conventional units could get by on low voltage, the continuous

miner's productivity was substantially reduced by power limitations. Occasional peaks of 200 kW were required for 30-second periods (Eubanks 1950).



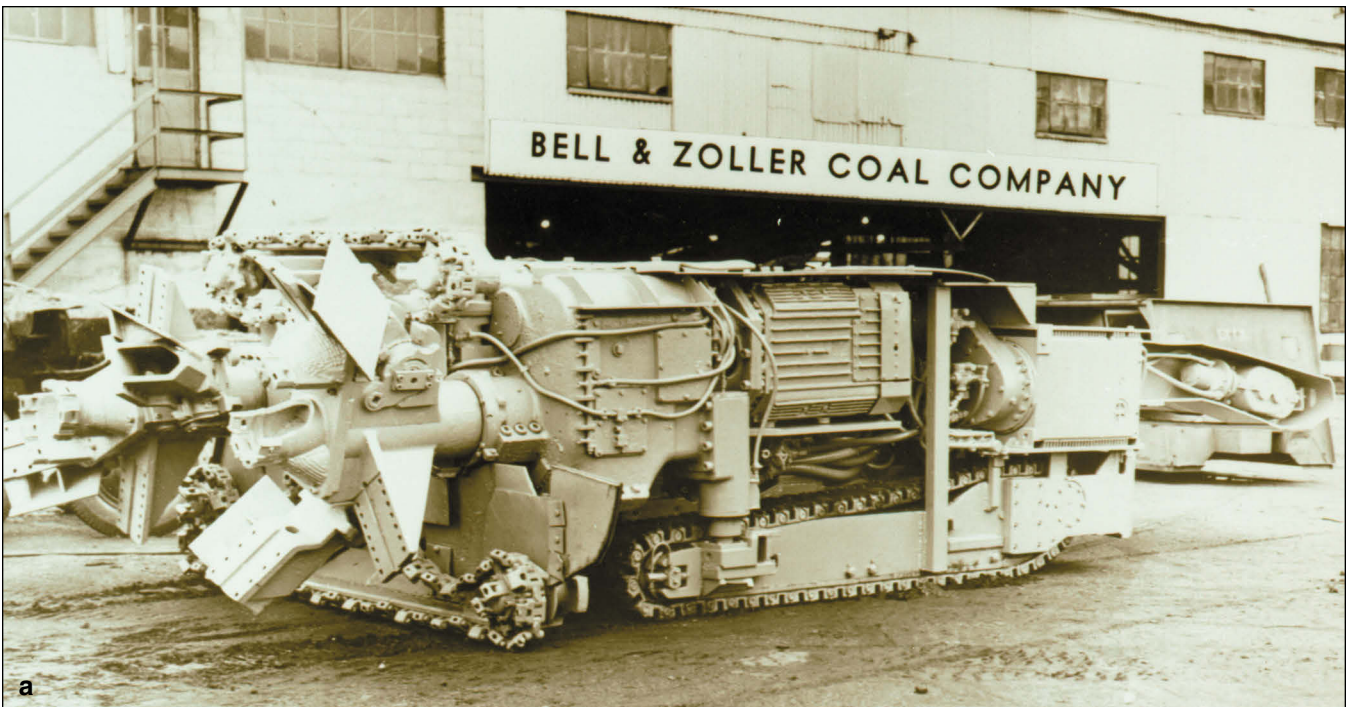
Figure 81 Bell & Zoller Coal Company, No. 3 Mine, near Zeigler, Franklin County. The Joy 1-JCM chain ripper continuous miner shown here shares many parts with a Joy loader, except for the swivel on the crawler section. Modern continuous miners use a drum cutter and lack the swivel feature. This machine could cut 5.5- to 10-foot thick coal and could load at the rate of 5 tons per minute (Ledvina et al. 1992).

Courtesy Zeigler Coal Company | Circa 1945–1949



ISGS | Circa 1950

Figure 82 Location unknown, perhaps manufacturer publicity photo. The Colmol was a variant of the boring type continuous miner. This model was known as the Fairchild Miner and operated mostly in thin coal in the eastern United States (Ledvina et al. 1992).

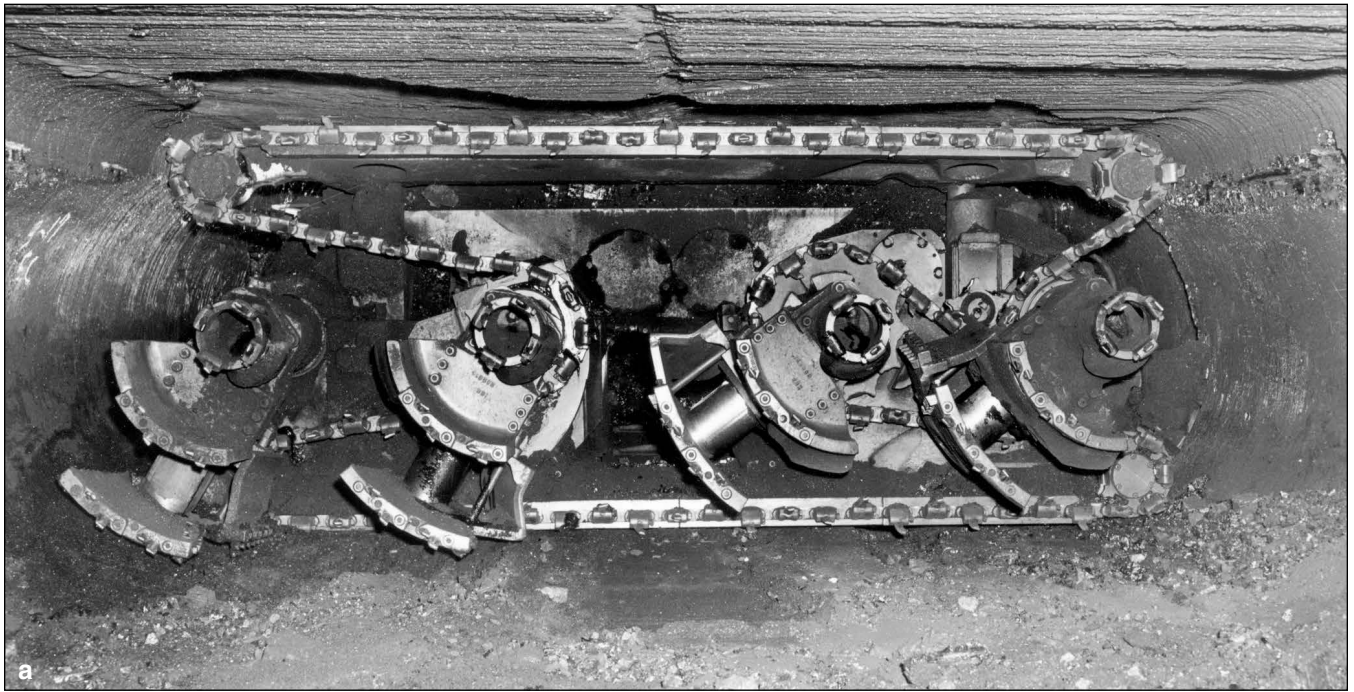


Courtesy Zeigler Coal Company | Circa 1953



Courtesy Zeigler Coal Company | Circa 1953

Figure 83 Bell & Zoller Coal Company, No. 3 Mine, Franklin County. The Goodman boring machine is shown. This machine, the Marietta Miner, and the WABCO borer were three continuous miners that provided long and reliable service. These machines were developed mostly in Illinois and were the most commonly used continuous miners through the 1950s and 1960s. The rotors shown in the top photograph (a) needed to be supplemented by a trim chain to cut the triangles of coal left by their rotation. The rotors and chain were collapsed during tramming (traveling without cutting coal) and extended at the face. These machines also had a fixed cutting height, which was a serious drawback. They cut an entry with curved side walls that provided excellent roof support, could mine in excess of 10 tons per minute, and were rugged and reliable. However, the drum-type continuous miner replaced them in the 1970s (Ledvina et al. 1992).

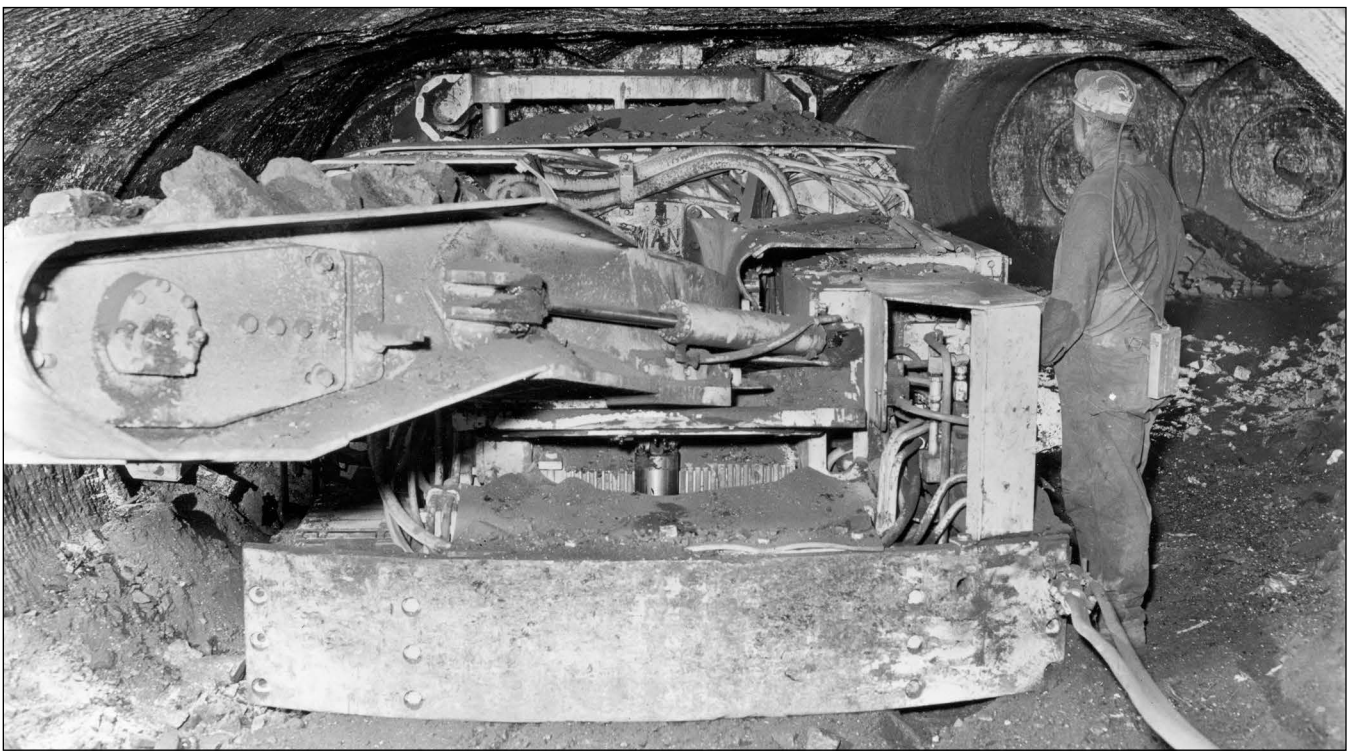


Courtesy Goodman Manufacturing Company | Undated



Courtesy Goodman Manufacturing Company | Undated

Figure 84 Mine and location unknown. Two views of a boring-type continuous miner. As shown, the miner cuts a curved side wall entry, which provides stability to the roof. These machines had some height adjustment capabilities. This machine had four cutting heads, and each head made an inner circle on the central axis; two outer cutting arms had easily replaceable tapered shank cutter bits. In thicker coal, an extension was added so that three cutting arms were attached outside the inner revolving axis. The distance between the rotary cutting arms could also be telescoped in discrete increments to adjust the machine to any variation in seam height. The top and bottom cutter bars could be moved independently. The miner weighed between 40 and 50 tons and had a capacity of 8 tons per minute. The cutting element could be tilted vertically or sideways or raised or lowered to compensate for seam irregularities (Goodman Manufacturing Company undated). Photograph (b) shows the end of the tail conveyor where coal would come out during mining.



Courtesy Goodman Manufacturing | Undated

Figure 85 Mine and location unknown. This is another Goodman boring-type continuous miner. The machine leaves a pattern of circles from the rotating cutting arms on the unmined coal, shown in the upper right portion of the photograph. This small contact area produces a high percentage of coal in large pieces (Goodman Manufacturing Company undated). Early continuous mining machines produced too much dust and fine coal, which could not be sold.



Courtesy Jeffrey Manufacturing | Undated

Figure 86 Mine and location unknown. A Jeffrey Manufacturing Company boring-type continuous miner. Coal is shunted back by the operator on a conveyor for transport to the main haulage.



Courtesy Zeigler Coal Company | Circa 1970

Figure 87 Mine and location unknown. Lee Norse hard head continuous miner. The Joy loading machine was eventually fitted with a series of chains or a drum to cut coal also. The drum design predominated, and the result is the truly modern continuous miner shown here. Drum-type continuous miners may have extendable or fixed width cutting heads or, in some cases, oscillating heads. This is a fixed-width type; hence, the name “hard head” (Ledvina et al. 1992).



Courtesy Peabody Coal Company | Circa 1970s

Figure 88 Peabody Coal Company, Marissa Mine, Washington County. This milling-type continuous miner could raise and lower the cutting head while mining the coal and so could mine varying seam heights and coal where the thickness varied.



ISGS / 1981

Figure 89 Freeman United Coal Company, Orient No. 4 Mine, Williamson County. A milling-type continuous miner is pictured here.



ISGS / 1982

Figure 90 Old Ben Coal Corporation, No. 21 Mine, Franklin County. This Marietta boring-type continuous miner cuts a curved side wall entry. The height of the entry is determined by the height of the machine. This machine is parked in an entry mined with a ripper-type continuous miner, shown by the rectangular profile of the entry (Ledvina et al. 1992).

Haulage Using Continuous Miners

By definition, a continuous miner cuts coal continuously. Design problems with the machines were worked out in the 1940s, but other aspects of mining also had to be addressed, including ventilation, rock dusting, and roof bolting that advanced at the same rate (2 to 4 feet per minute) as the mining machine (von Stroh 1949). However, the biggest obstacle was achieving haulage rates sufficient to handle production.

The most successful haulage method utilized two shuttle cars. This method worked best for thick seams where larger-capacity shuttle cars could be used. Early continuous miners cut at a rate of 1 to 2 tons per minute, so, depending on shuttle size, only 3.5 to 7 minutes were available for the shuttles to get to the secondary haulage point, unload, and return for the next load. The two-car system was flexible and portable (it could follow the miner to the next active face easily), but was initially expensive (two shuttle cars cost about \$25,000 in 1950)

and had high maintenance costs. There was also the risk of operational problems. The water used to control coal dust during continuous mining could muddy the mine floor and slow or completely mire the shuttle cars (Cunningham 1950).

Another method was to use a combination of equipment. The continuous miner was used to break the coal from the face, and a loading machine with one shuttle car was used to take the coal to the intermediate haulage point. This method made the mining machine completely independent of the coal transportation system and was therefore more flexible than the system using two shuttle cars. However, a loading machine was more expensive than a shuttle car, and maintenance costs increased because of the additional machine. The operational problem was the same because the loader also could become mired in wet underclay (Cunningham 1951).

A third method was to have the continuous miner discharge to a duckbill

loader with added sideboards to form a hopper. The duckbill loader discharged to a shaker conveyor. A lightweight steel alloy conveyor with quick acting clamps (rather than bolts) made an extendable unit that could follow the advance of the continuous miner. The extensions were needed two to four times a shift and could be added in about 10 minutes. The cost of this system was less than half that of the other two systems, and there was no shuttle car to get bogged down in soft underclay. However, this system did not work in a mine with medium or steep grades, as strong inclines greatly reduced the conveyor capacity. This system also did not move to another face easily (Cunningham 1951).

Development of more versatile conveyors solved some of these problems, and some mines continued to work with shuttle cars. As with many coal mining obstacles, solutions were often dependent on the conditions at individual mines.



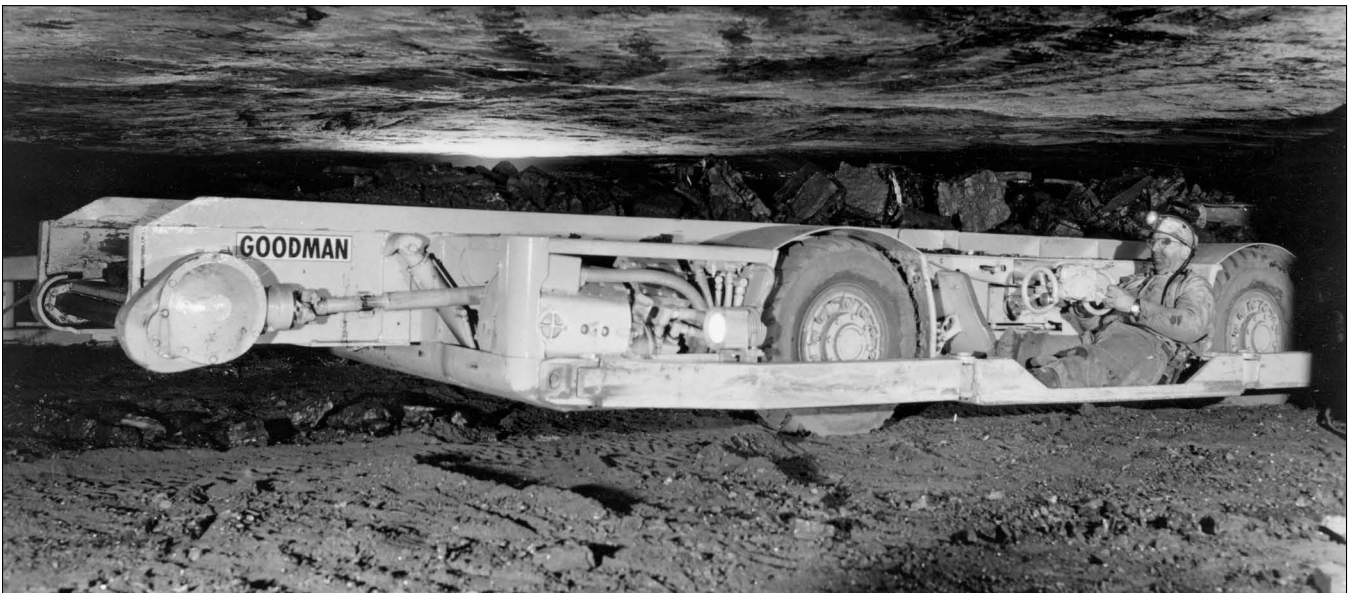
Courtesy Zeigler Coal Company | Circa 1955

Figure 91 Bell & Zoller Coal Company, No. 3 Mine, Zeigler, Franklin County. This shuttle car or buggy is being loaded behind a boring-type continuous miner. The tail (conveyor) of the miner is discharging coal into the shuttle car. The boring machine was pioneered mostly by Old Ben Coal Corporation, but contributions were made by Freeman United and Zeigler Coal Companies as well. The last boring machines were taken out of service in the mid-1980s (Ledvina et al. 1992).



Courtesy Goodman Manufacturing Company | Undated

Figure 92 Mine and location unknown. Shuttle cars transported coal from the face to the secondary haulage location or collection point. The driver could face either direction with this centrally located steering wheel and dual driver seats. The conveyor for unloading is shown on the left. Many shuttle cars were electric and had to return by the same route while avoiding running over their own cable. Most were available in either AC or DC models. Turning radius and maneuverability were important factors in shuttle car efficiency (Goodman Manufacturing Company undated).



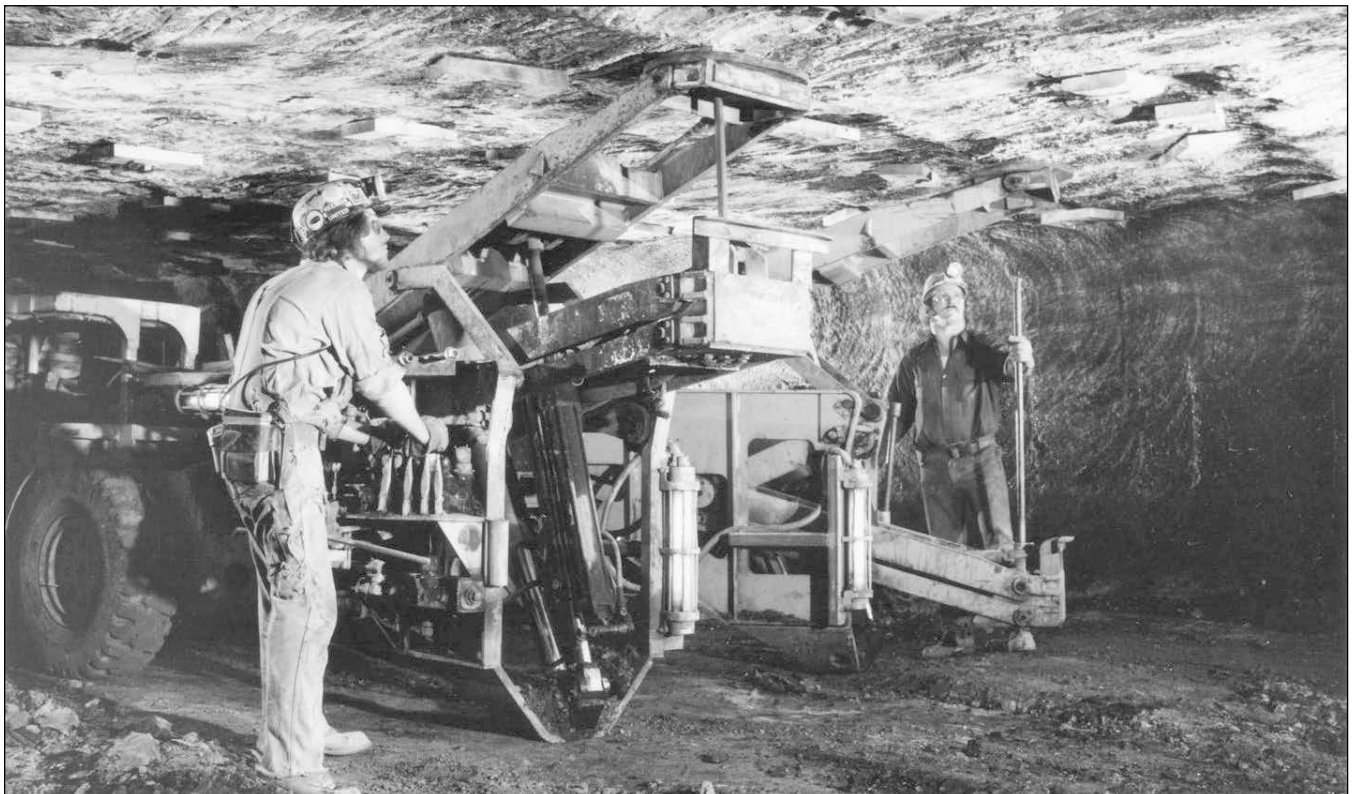
Courtesy Goodman Manufacturing Company | Undated

Figure 93 Mine and location unknown. Shuttle cars could be designed for low coal, the term miners use for thin seams. Shuttle cars such as this one could hold up to 4 tons (depending on width) and yet be only 27 inches tall. The higher the capacity of the car, the fewer trips to the secondary haulage site were required, and the higher the production per shift. Shuttle cars could travel up to 5.5 mph when empty, but generally speeds averaged closer to 3 mph (Goodman Manufacturing Company undated). The shuttle car has a conveyor running down the length of the vehicle to aid in unloading, one end of which can be seen on the left side of the photograph. On the return journey with an empty shuttle buggy, the driver moves to the seat opposite his current position. The driver, not the machine, turns around.



ISGS | Circa 1980–1985

Figure 94 Mine and location unknown. Articulated shuttle car used for coal haulage from the continuous miner to the conveyor belt for transport out of the mine.



Courtesy Peabody Coal Company | Circa 1970s

Figure 95 Peabody Coal Company, Marissa Mine, Washington County. Roof bolting in a mine with continuous mining machines required some automatic processes by the bolting machine, such as loading the bolts into position to be inserted into the hole in the roof, to keep up with mining advance. Note the hydraulic jacks supporting the roof during the bolting process. Roof bolting is discussed in more detail beginning on page 75.

Modern Longwall Mining Labor costs continued to increase after 1960. To cover the increasing costs, mining had to produce more coal per shift. Since room-and-pillar mining leaves approximately 50% of the coal in the ground in the form of pillars, one way to produce more coal was to eliminate the pillars. The longwall method had been modernized in Europe with new machines and methods of roof support.

From 1962 to 1973, there were 10 longwall “faces” in Illinois that were not able to be mined economically. Most had roof control problems at the cutting face. Another problem occurred when the feet of the support pushed into weak mine floors. These longwall mining attempts by Old Ben Coal Corporation and Freeman Coal Mining Company used chock hydraulic supports (see Figure 98). The use of shield-type supports starting in 1976 provided a much smaller area of support of the roof right at the face and also had a much larger area of support on the floor. These support changes overcame the soft floor and roof control problems, allowing five times the rate of coal production compared with that of continuous mining machine sections (Cavinder 1982).



Figure 96 Old Ben Coal Corporation, mine and location unknown. The cutting bit of a drum shearer longwall installation is shown in this photograph. The coal is to the left, and the unit advances to the left after the cutter travels the length of the panel. The mined coal drops to a chain conveyor, where it is transported to the secondary conveyor haulage and then to the main conveyor.

ISGS | Late 1970s

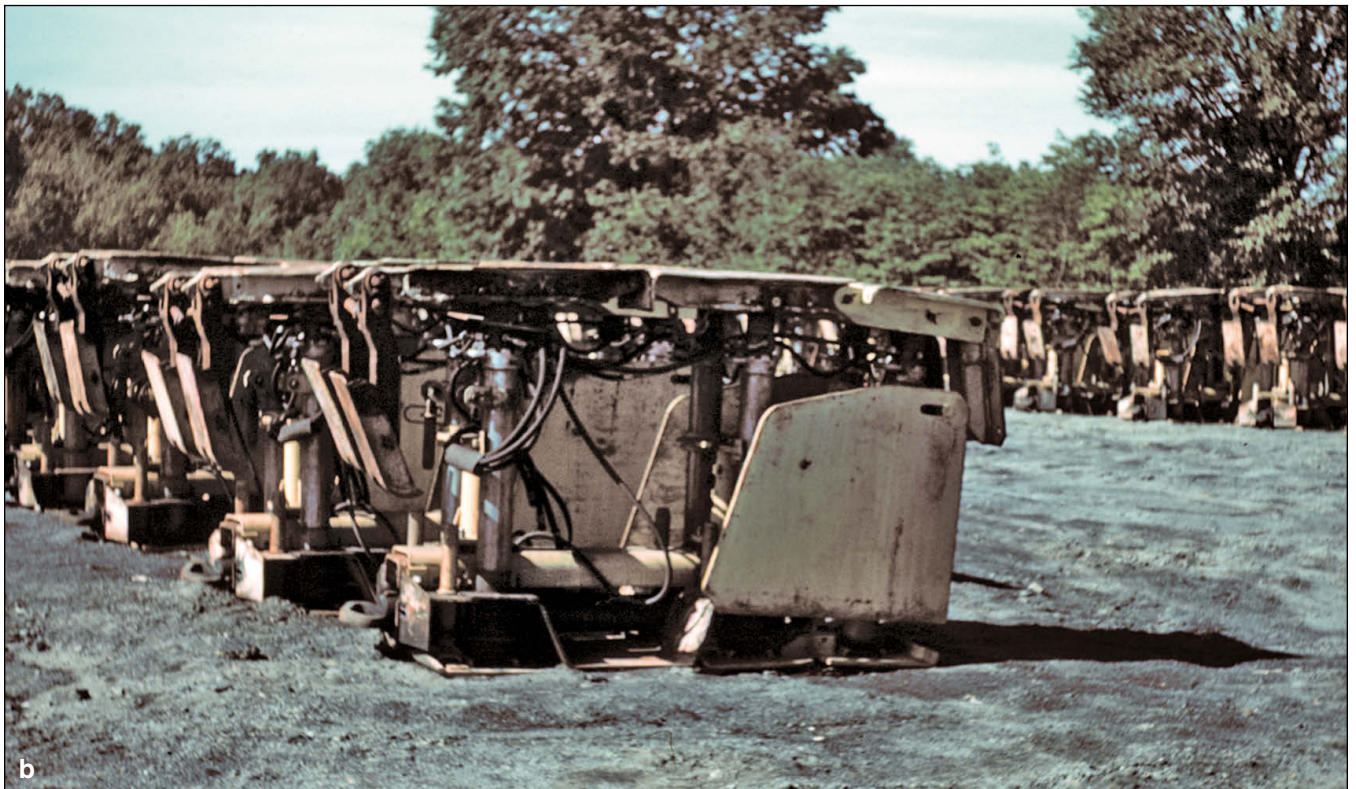


Figure 97 Old Ben Coal Corporation, mine and location unknown. The roof shields support the roof as the cutting drum mines the coal to the right. The longwall unit then advances to the right after one pass of the drum shearer. The roof behind the unit is allowed to collapse as the unit moves forward.

ISGS | Late 1970s



ISGS | Undated



ISGS | Undated

Figure 98 Mine and location unknown. (a) The chock-type roof support for a longwall mine, shown before installation. (b) Support units are placed side by side to control the roof over the longwall cutting machine and conveyor.



Joel Dexter, ISGS | 1995

Figure 99 Kerr-McGee Coal Corporation, Galatia Mine, Saline County. Modern longwall mining is much safer for the operators who stand under the hydraulic roof shields so that rock falls are not the hazard in the longwall panel that they are in the room-and-pillar segment of the mine.



ISGS | Undated

Figure 100 Old Ben Coal Corporation, mine and location unknown. The cutting bit and roof shields of a longwall installation. The coal face is to the right.



Figure 101 Old Ben Coal Corporation, mine and location unknown. Longwall mining units require access to the coal that must be developed using continuous mining machines. These rock-dusted entries are also used for haulage and ventilation.

ISGS / Undated



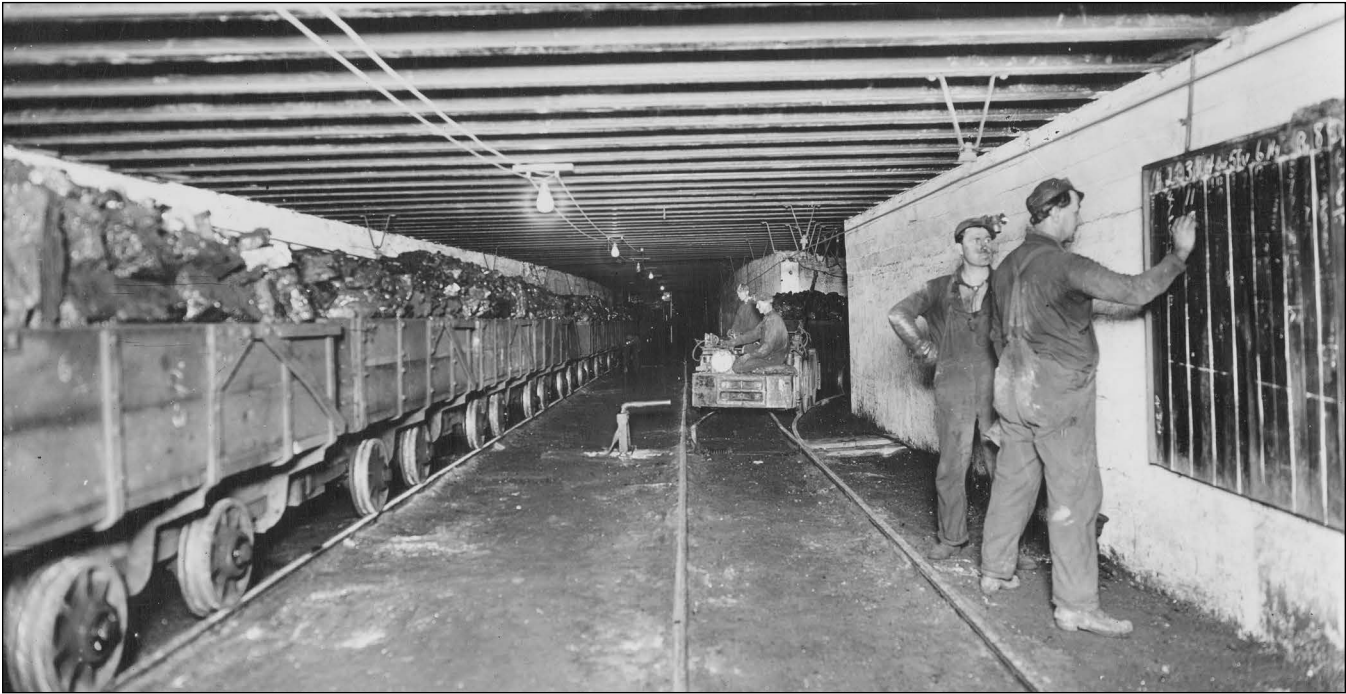
ISGS / Undated

Figure 102 Old Ben Coal Corporation, mine and location unknown. This end of the longwall face shows the side of the shield supports.

Moving Mined Coal to the Surface
Coal cars were collected from all the active working places in a mine into long trains of cars headed for the shaft

bottom. Many mines concentrated on hoisting these cars quickly and efficiently. In some mines, conveyor belts were used to take the coal throughout

the mine up to the surface. In other mines, many cars were dumped into a larger container, which was then hoisted to the surface.



ISGS | Circa 1920s

Figure 103 Peabody Coal Company, mine and location unknown. Loaded trip of hand-loaded cars passing check station near shaft bottom. Checkers keep track of passing cars on the loaded track (left) and empty track (right) (Ledvina et al. 1992).



ISGS | Circa 1920s

Figure 104 Big Creek Coals, Inc., No. 3 Mine, Saline County. Loaded cars at shaft bottom. Note the live electric wires above the cars.



ISGS | Circa 1920s

Figure 105 Big Creek Coals, Inc., No. 4 Mine, Saline County. Early conveyor systems had wooden sides to keep the coal on the belt. Later conveyors had shaker systems that distributed the load more evenly and a trough shape that kept the coal in the center of the belt.



Courtesy Goodman Manufacturing Company | Circa 1960

Figure 106 Mine and location unknown. Conveyor systems such as this one could be miles long and led directly to the main shaft or up the slope to the preparation plant. Later systems were developed that were mobile and could be attached directly to the continuous miner (Ledvina et al. 1992).

Figure 107 Mine and location unknown. These men are weighing and recording the coal production prior to hoisting or dumping the coal. This mine appears to have a rotary dump similar to that shown in Figure 109.

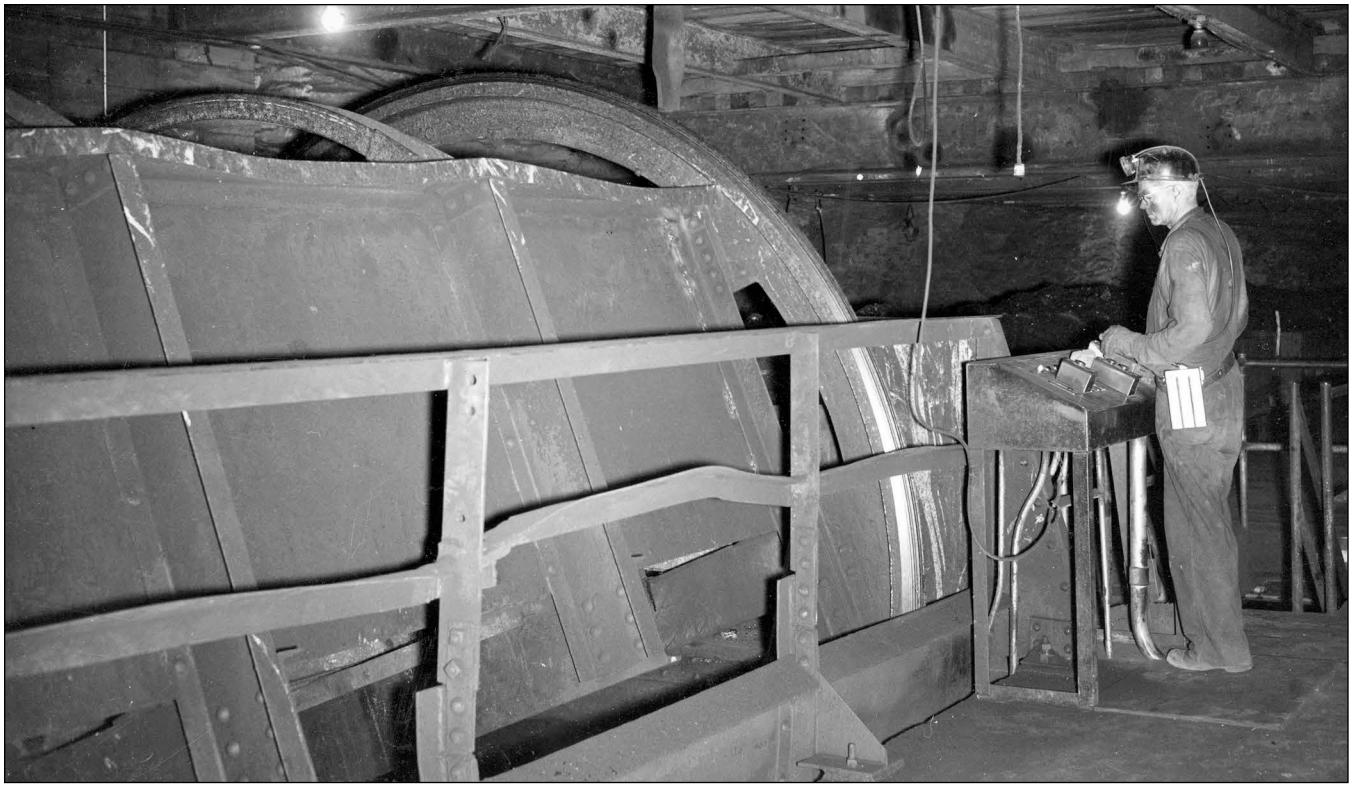


ISGS | Undated



Courtesy Southern Illinois University | Circa 1924

Figure 108 Chicago, Wilmington & Franklin Coal Company, Orient No. 2 Mine, Franklin County. Rotary car dump. In mines of this vintage, cars were often hoisted directly and dumped on top. In this mine, a rotary dumper emptied the cars into a bin, and the coal was then hoisted by “skips”—large open cars or buckets (Ledvina et al. 1992).



ISGS / 1956

Figure 109 Sahara Coal Company, No. 5 Mine, Saline County. An underground rotary dump weighs and dumps coal cars into an underground hopper. From that point, the coal is fed onto a belt line that carries the coal up a slope entry into the preparation plant (Ledvina et al. 1992).



Figure 110 Mine and location unknown. Each car could be maneuvered into the shaft by one man; each car had a man at the front ready to push the empty car off the hoist cage and the loaded car onto the hoist cage. It was critical to keep this area open and free of roof falls. The highly reinforced arch shape is the most stable configuration for roof support.

ISGS / Undated



ISGS | Circa 1921–1931

Figure 111 Madison Coal Corporation, No. 12 Mine, near Cambria, Williamson County. The shaft bottom showing automatic caging equipment. The levers near the track block the wheels of the next car once one is on the hoisting platform. After the first car is past the second set of levers, the hoisting platform is released and raised up for dumping.



ISGS | Circa 1921–1931

Figure 112 Madison Coal Corporation, No. 12 Mine, near Cambria, Williamson County. A view of the mine bottom on the empty side, seen from the shaft.



ISGS | 1921

Figure 113 Big Creek Coals, Inc., No. 4 Mine, Saline County. This shaft bottom is 500 feet below the surface and is constructed of concrete. Mine cars loaded with coal are automatically caged and hoisted; the coal is emptied in 30 seconds. The round trip for each car is 3 minutes (Ledvina et al. 1992). The sign translating the signals is shown in detail on the following page.

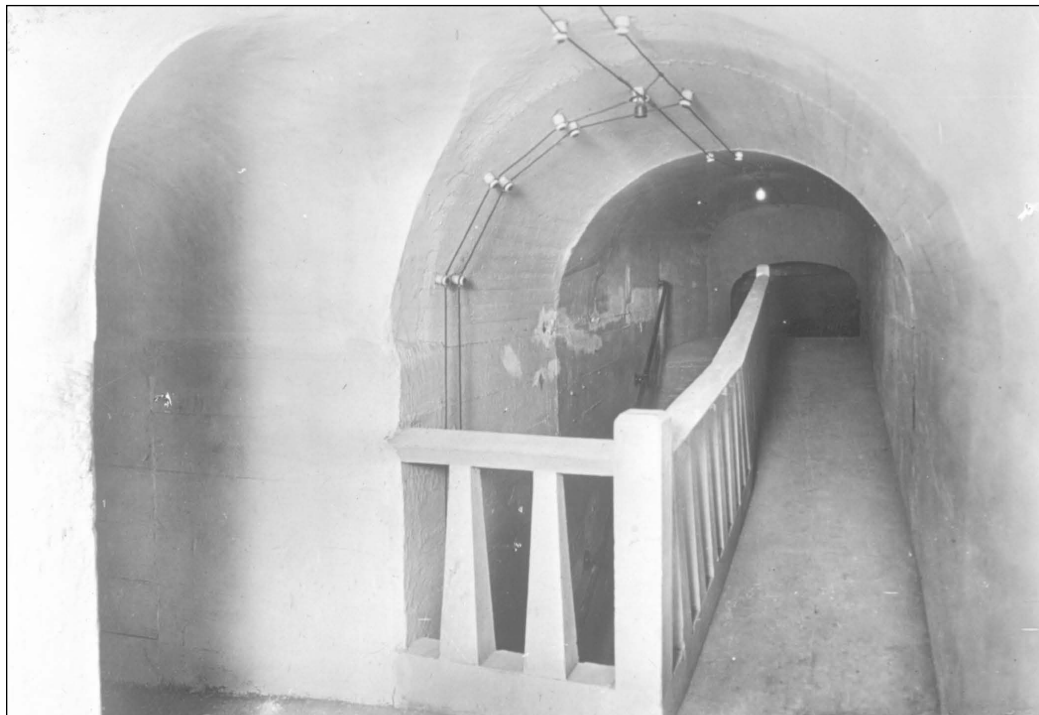


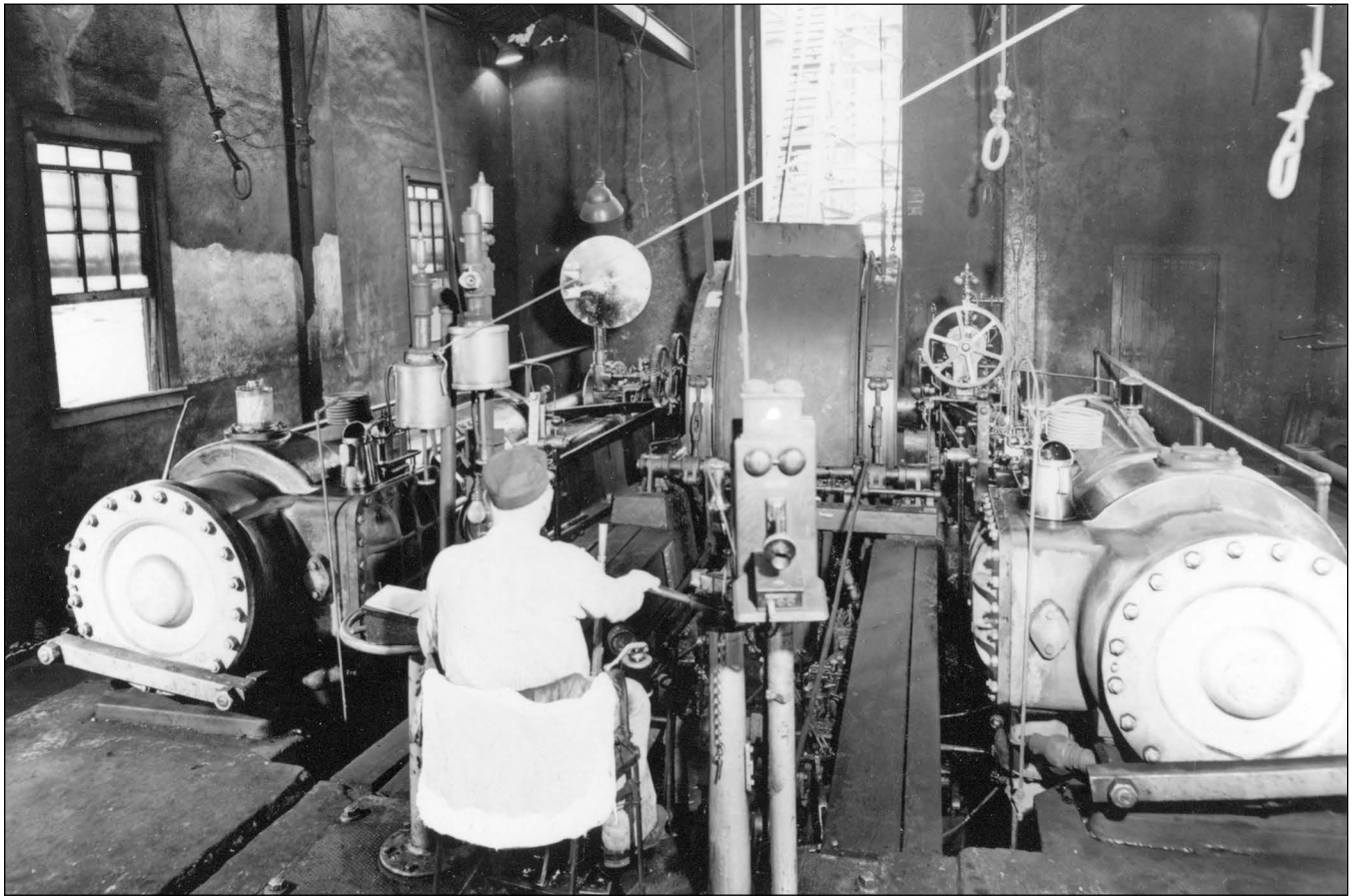
Figure 114 Big Creek Coals, Inc., No. 4 Mine, Saline County. This staircase is shown from the shaft bottom, at the level of the mine.

ISGS | 1921



ISGS | 1921

Figure 115 Big Creek Coals, Inc., No. 4 Mine, Saline County. Detail from Figure 113 on the previous page. The signal bell and codes for the bell are shown. Only the most succinct of messages could be given. The hoisting engineer on the surface would signal that the cage was about to be lowered, or the cagers at the shaft bottom could signal to the hoisting engineer to raise the cage. Later communication developments did add a margin of safety; several deaths resulted from confusion about these hoisting signals.



Courtesy Zeigler Coal Company | 1915

Figure 116 Bell & Zoller Coal Company, No. 1 Mine, near Zeigler, Franklin County. This dual-cylinder hoist operated the twin cages hauling coal cars in the 400-foot-deep shaft. These early steam hoists generally outperformed their modern electric counterparts (Ledvina et al. 1992). The man operating the engines is the hoisting engineer, who was in charge of raising and lowering the cage. The headframe is visible through the gap in the wall in front of the engineer. The headframe is the housing for the cable that raises and lowers the shaft mechanism, controlled at the surface.



Figure 117 Chicago, Wilmington & Franklin Coal Company, New Orient Mine or Orient No. 2 Mine, Franklin County. Main hoist driven by two 2000 DC (direct current) motors (Ledvina et al. 1992). Note the hoisting cable going out the opening in the wall to the headframe to raise and lower the cage in the shaft.

ISGS | Circa 1924

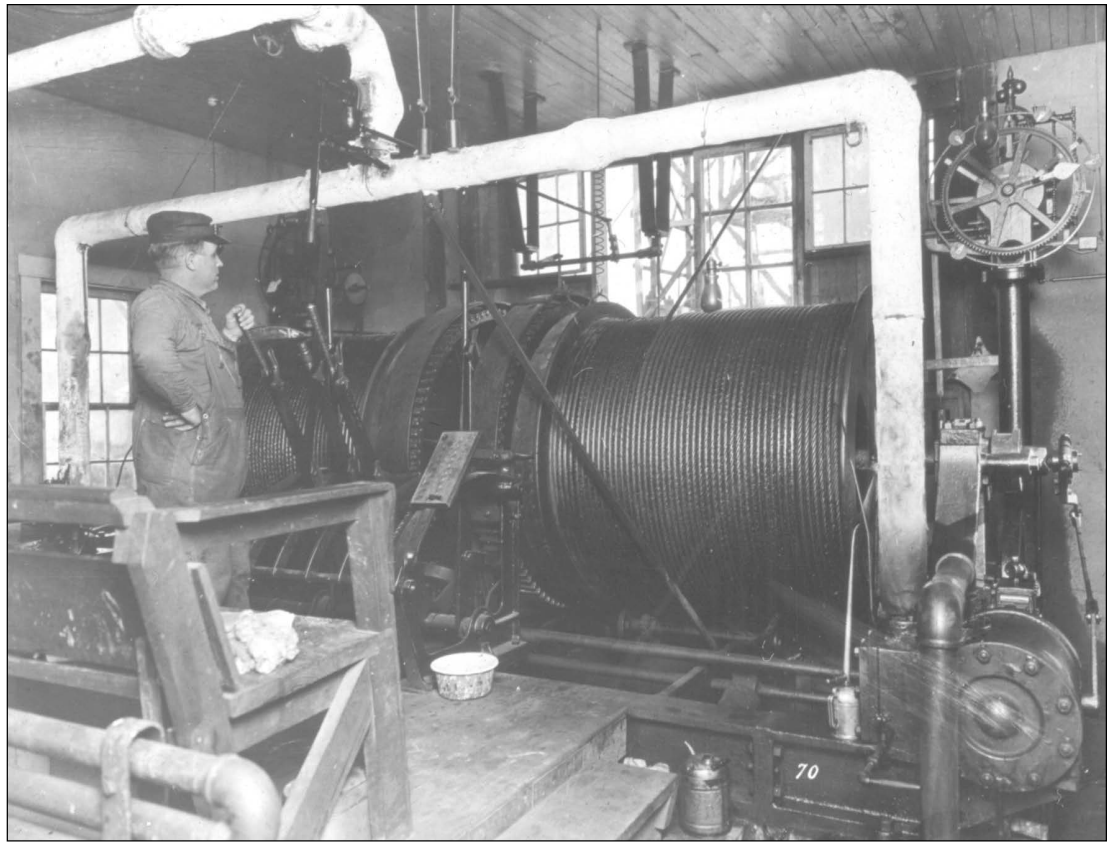


Figure 118 Mine and location unknown. A steam hoisting apparatus for the shaft.

ISGS | Undated

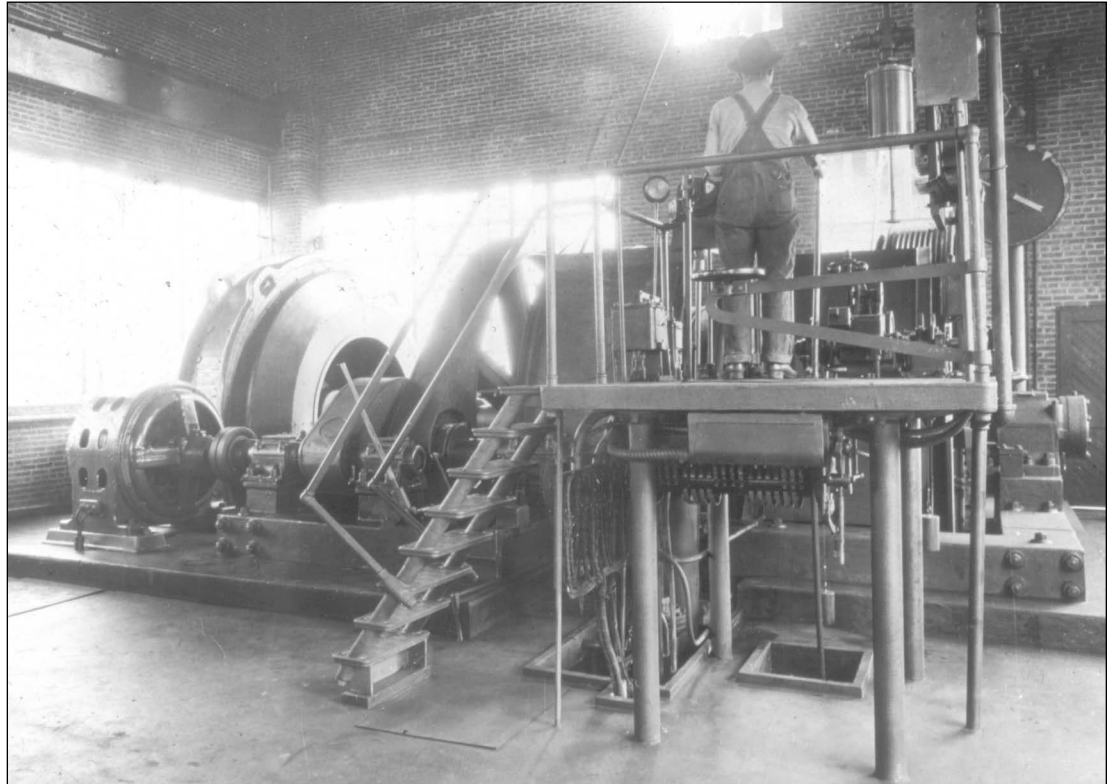
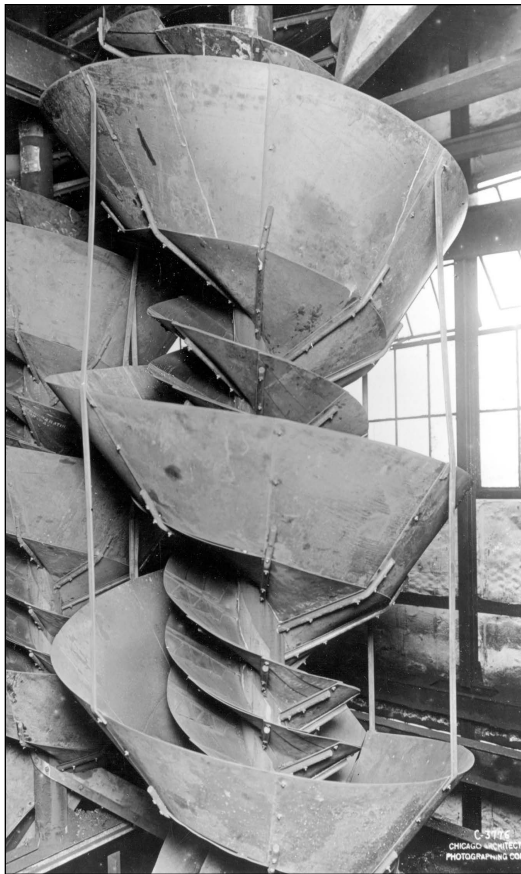


Figure 119 Mine and location unknown. An electric hoisting apparatus.

ISGS | Undated

From Mine to Market Once the coal had been mined and brought to the surface, it had to be cleaned and sorted for market. Cleaning removes impurities such as pyrite nodules or pieces of the shale roof that have adhered to the coal. Sorting gives a product of fairly uniform size that will burn more evenly.

Figures 126–130 show the marketing and shipping of coal. Although most often transported by rail cars, coal was barged to some locations, and local coal retailers filled the needs of smaller retail home customers.



ISGS | Circa 1920

Figure 120 Old Ben Coal Corporation, No. 8 Mine, Franklin County. Spiral separators were ideal for cleaning fine coal. Automating this cleaning procedure meant more coal could be sold, as the quality could be guaranteed to be within certain parameters. Prior to 1900, most of the fine coal was left in the mine, sold for roadbed material, or piled beside the tippie, the apparatus that loaded or emptied the cars (Ledvina et al. 1992).



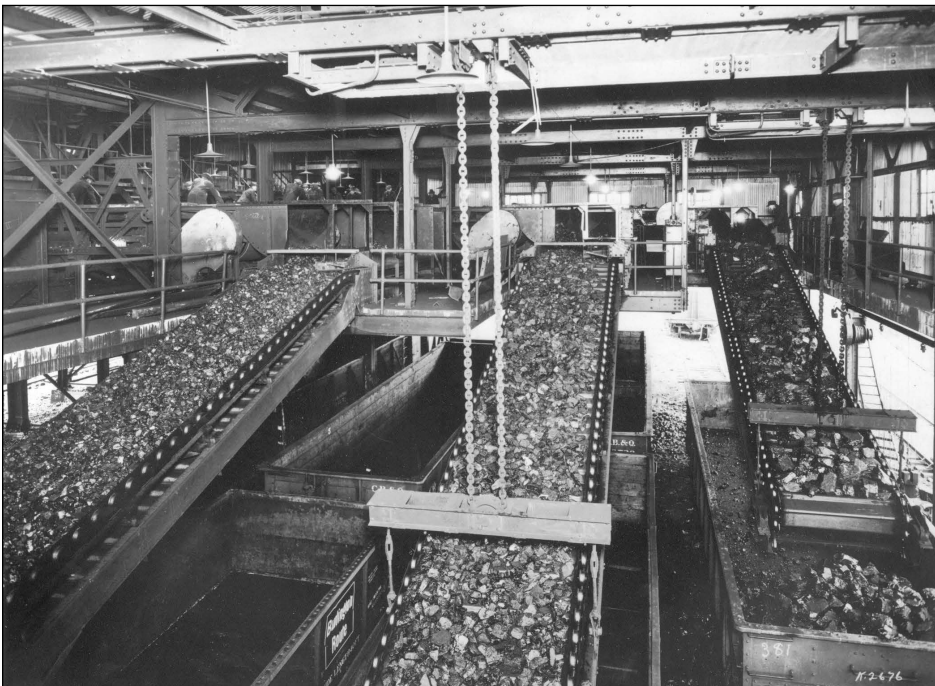
ISGS | Circa 1920s

Figure 121 Harrisburg Coal Company, mine unknown, Saline County. When shaker screens were introduced for sizing coals and the miners were paid only for the coal above a certain size, labor relations sometimes became acrimonious.



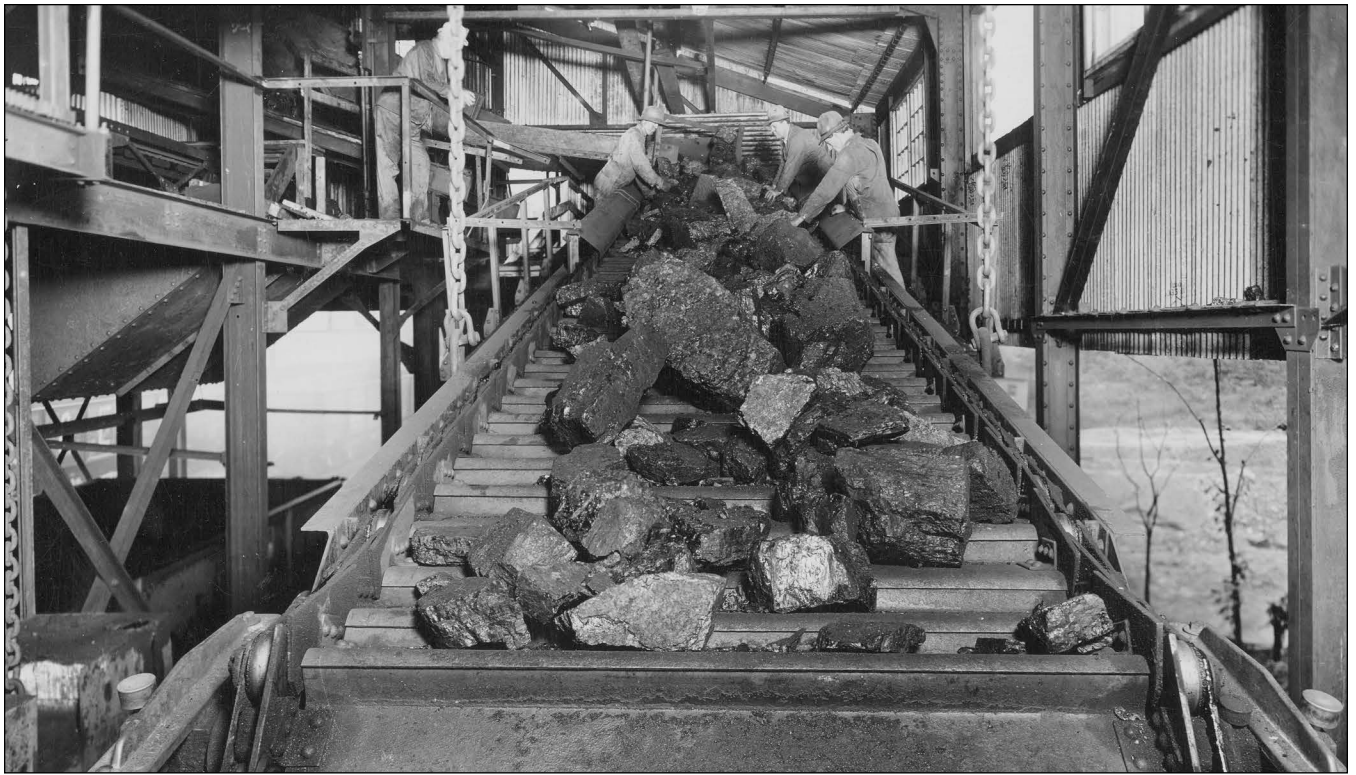
ISGS | Circa 1920

Figure 122 Chicago, Wilmington & Franklin Coal Company, Orient No. 2 Mine, near West Frankfort, Franklin County. Picking tables show the intermediate stage between grinding and loading coal into rail cars. Nothing topped hand-picking for removing roof shale from lump coal (Ledvina et al. 1992).



Courtesy Southern Illinois University | Circa 1920

Figure 123 Chicago, Wilmington & Franklin Coal Company, Orient No. 2 Mine, near West Frankfort, Franklin County. Belt booms load sized coal into railcars. Modern market demands usually do not require such a variety of sizes. Lump coal is on the right, egg in the middle, and nut or stoker size on the left (Ledvina et al. 1992). The men who are working as sorters can be seen in the upper left of the photograph. Open to the weather, the area would have been a very cold workplace in the winter.



ISGS / Circa 1920s

Figure 124 Mine and location unknown. Workers are hand-picking lump coal on the railroad car loading boom (Ledvina et al. 1992).



ISGS / Undated

Figure 125 Mine and location unknown. The end product of the sorting process was clean coal of uniform sizes. Each size had a different market (Ledvina et al. 1992).

Figure 126 Rudolph & Herbert Ice & Fuel Company, probably in St. Louis, Missouri. In the 1940s, a now obsolete destination for coal was the coal, ice, and fuel dealer. Brand recognition was important to home heating customers, and coal companies often sprinkled scatter tags made of plastic, metal, wood, or paper into their coal (Ledvina et al. 1992).



Courtesy Zeigler Coal Company | Circa 1940

Figure 127 The Illinois River was an important transportation route to ship coal to Chicago. The C. & I. M. Railroad coal loading dock at Havana, Illinois.



ISGS | Undated



ISGS | Undated

Figure 128 A coal barge is being pushed along the Illinois River near Pekin.



ISGS | Circa 1949

Figure 129 Illinois Power Company, Havana Plant, on the Illinois River, Mason County. Since the early days of Illinois mining, the end market for coal has changed from predominantly domestic and industrial to utility consumption. Today, most Illinois coal feeds power plants such as this one. Note the barges delivering coal to the plant.



ISGS / 1945

Figure 130 This photograph was taken from a bridge at Henry, Illinois, during the period of heaviest ice. The tug is pulling eight barges.

Mine Safety

The coal industry was always concerned about the fatality and injury rate. Although legislation seems, in hindsight, to have lagged behind the need, individual coal companies took proactive measures to address the problem.

Roof Bolting Before roof bolting, approximately 50% of all accidents in mines were the result of the fall of the roof or the face coal (Pitts 1939). In addition to causing injuries to miners, roof falls cause additional expense to clear haulage and ventilation routes. In the competitive economic arena that coal has always operated in, the additional time spent hauling material that does not generate cash flow can be a significant factor in a mine's economic health. Therefore, both safety and economics dictated the monitoring of roof conditions.

Coal is generally formed in a depositional sequence of rocks called a

cyclothem, an alternating sequence of coal and its associated underclay, shale, limestone, and sandstone. For a more thorough discussion of cyclothem and depositional history of coal and associated rocks, see GeoNote 2, Depositional History of the Pennsylvanian Rocks in Illinois (available free for download from the ISGS Web site). The immediate seam above the coal is generally shale. Often a thin (0 to 3 feet) black shale is overlain by a thicker layer of gray shale, or the gray shale may directly overlie the coal. In extremely good conditions, a limestone is directly over the coal or separated from the coal by a thin shale. Limestone, if sufficiently thick, makes a good solid roof. Shale varies, depending on how well the layers adhere to each other. Often a variety of light gray shale called clod was the immediate mine roof and tended to come down with the coal, but the collapse was more of an annoyance than a hazard. Other shales made a good roof, but the expo-

sure to changing temperature and humidity of the air used to ventilate the mine caused the shale to weather and caused the layers to lose their adhesion. If the coal seams were thick enough, 1 or 2 feet of coal would be left to prevent this weathering (Pitts 1939).

Wooden props or timbers were first used to support the roof in coal mines. Placement was the miner's decision, with guidance from the mine manager. These timbers could degrade in as little as two years, and steel beams were later used to supplement the wood, especially in the haulage ways and ventilation entries (Crowell 1995). The first known roof bolting was in Germany in 1918 (Gaddy 1973). In the United States, St. Joseph Lead Company in Missouri bolted its mine roof in 1943. Almost immediately, Consolidated Coal Company adopted the practice (1944), followed shortly afterward by coal mines in Alabama and Kentucky (Gaddy 1973).



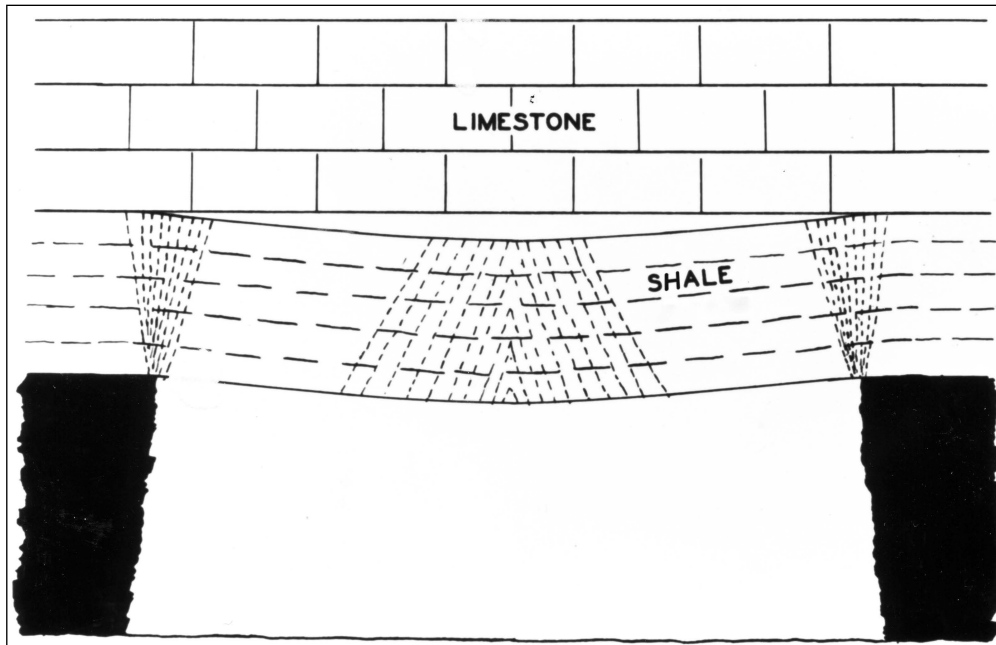
ISGS | 1974

Figure 131 Peabody Coal Company, No. 10 Mine, Christian County. This roof fall shows about 3 feet of thin beds of sandstone interbedded with thin bands of shale, which kept the sandstone layers from adhering to each other. Below the sandstone is a layer of limestone that varied from 6 to 18 inches. About 3 feet of black shale was between the coal and limestone.



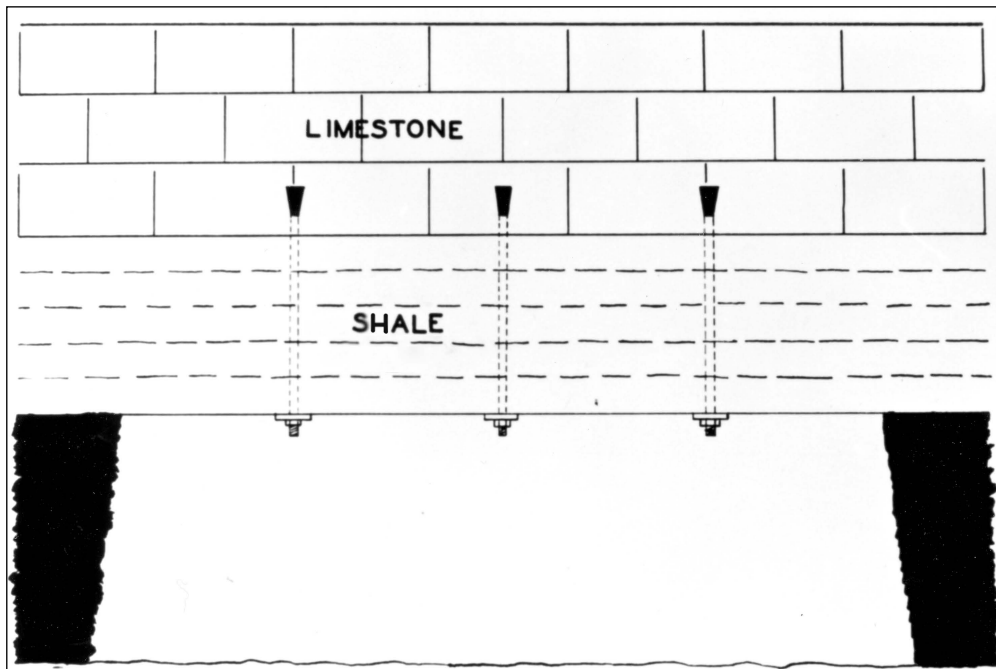
Courtesy Consolidated Coal Company | Circa 1946

Figure 132 Consolidated Coal Company, No. 7 Mine, near Staunton, Macoupin County. This roof fall is probably a gray shale. Note the closely spaced timbering used to support the roof over the haulage route (Ledvina 1992).



Illinois Mining Institute Proceedings | 1948

Figure 133 This illustration by C.C. Conway, Chief Engineer of Consolidated Coal Company, exaggerates the stresses in shale once the coal has been removed, but shows why a shale roof tends to come down. The individual layers in shale allow the rock layers to slide somewhat and act as several layers rather than a uniform block. The illustration also simplifies conditions, since most shales have slips and joints and other factors that allow individual blocks to come away from the roof rock. Unlike steel, shale does not have uniform elasticity, and the illustrated stresses are merely the most likely places for the roof to fail, not the only blocks likely to come away from the roof (Conway 1948).



Illinois Mining Institute Proceedings | 1948

Figure 144 Ideally, roof bolts anchor in a limestone above the shale, which aids holding the layers of shale together and supports the shale. Roof bolts were to support the roof immediately in front of the working face, and timber supports were to be added when mining advanced. Conway did not mean to exchange timbering with roof bolting but to supplement the timbering to make the working face safer for the miners. Timbering was generally put in 16 or more feet behind the working face, and roof bolts were inserted within 1 foot of the working face (before undercutting and shooting the coal at the face) (Conway 1948).

Figure 135 Two mechanical roof bolts or anchors used in Consolidated No. 7 Mine near Staunton, Macoupin County. The bolt in the upper right of the photograph is the type ordinarily used in the lead mines. The anchor in the lower left is an expansion bolt used in coal mines. It would have used a wood plate at the bottom to support a wider area of the roof (Ledvina et al. 1992). The wedge widens the gap in the upper portion of the expansion bolt when the nut is tightened and causes the upper portion of the bolt to tightly fill the drill hole. A disadvantage of this design was that the hole had to be drilled a precise length in order for the wedge to be driven into the gap to expand the bolt casing. This type of bolt was replaced with one that had an expanding shell (Gaddy 1973). In extremely poor shale, C.C. Conway recommended using a wood platform spanning two roof bolts (Conway 1948).



Illinois Mining Institute Proceedings | 1948



Courtesy Consolidated Coal Company | 1946

Figure 136 Consolidated Coal Company, No. 7 Mine, near Staunton, Macoupin County. Roof bolting combined with timbering, with half-sawn timbers bolted to the roof, provided support across the span of the entry or room (Ledvina et al. 1992).

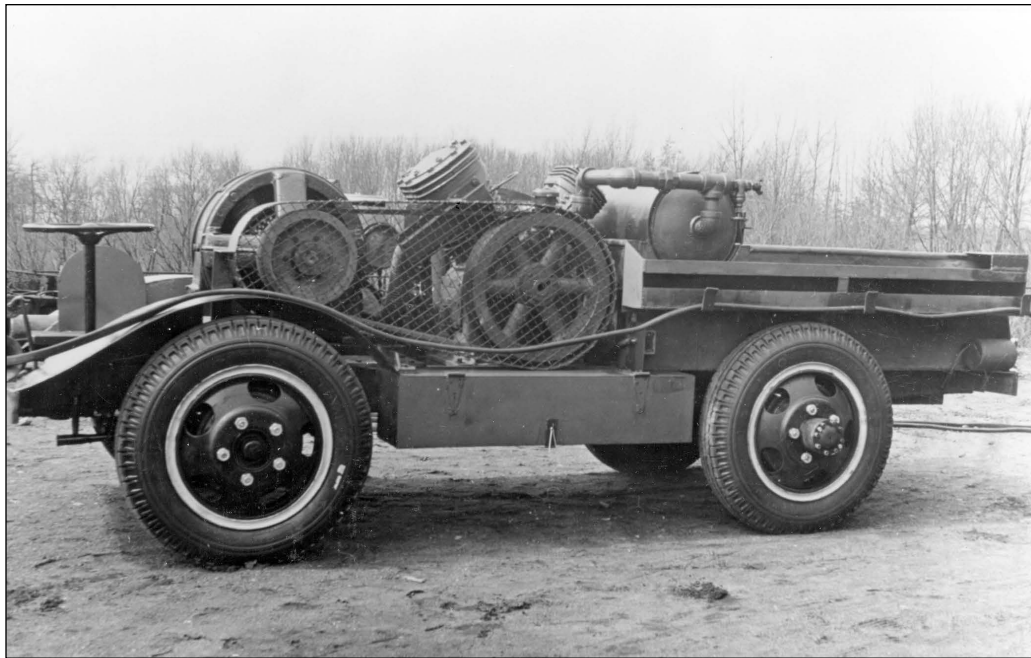


Figure 137 Consolidated Coal Company, No. 7 Mine, near Staunton, Macoupin County. This truck was used for roof bolting and carried an air compressor for the drill. The truck bed could carry 8-foot timbers and roof bolts. This drill truck was built in the mine's shop and was powered by a trailing cable. The men with this truck followed immediately after the loader, before any other face preparation. These operators bolted the roof over the most recent coal removal area and set props (timbers) under the preceding 8-foot cut (Conway 1948).

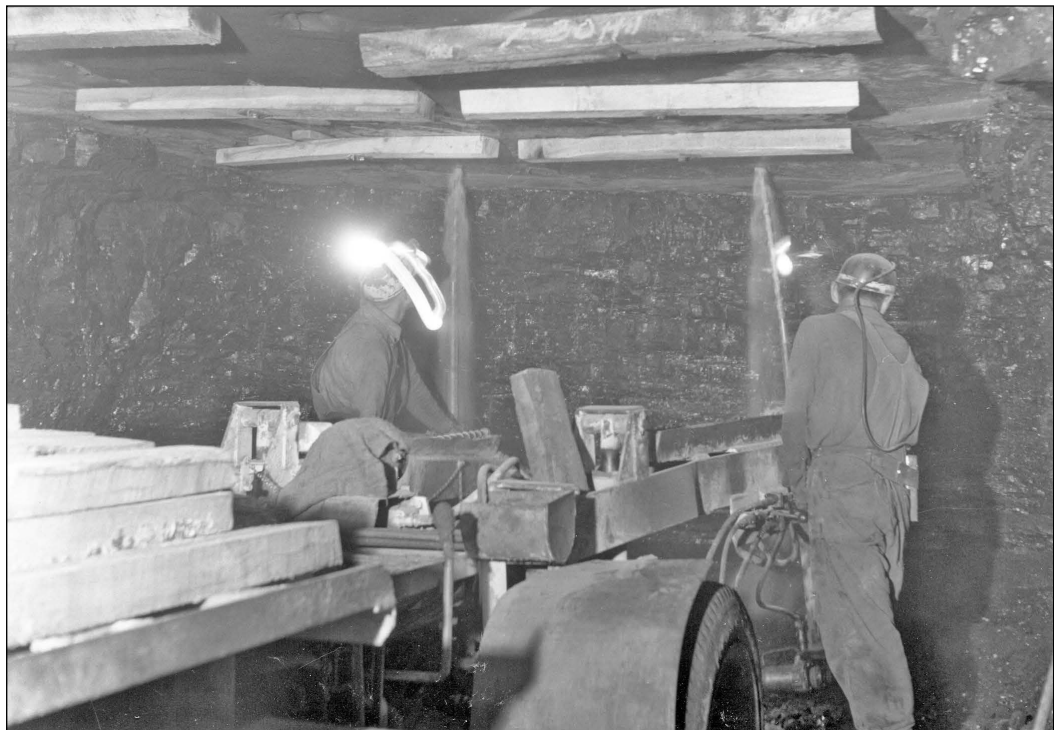
Courtesy Consolidated Coal Company | 1946



ISGS | 1974

Figure 138 Peabody Coal Company, No. 10 Mine, in Christian County. The black shale roof required heavy bolting because of the closely spaced joints (fractures) in the shale. As the roof-bolting process matured, resin-anchored head rebar roof bolts became the most commonly used in U.S. coal mines, followed by standard mechanical roof bolts (Scott 1989). Specialty bolts are used less frequently, and such bolts are generally mechanically anchored bolts that have resin enhancements in the fixtures (Scott 1989).

Figure 139 Union Colliery Corporation, New Kathleen Mine, Perry County. This dual-boom roof bolter, developed by Union Colliery Corporation, allowed the operators to work farther behind the drills, under supported roof (Ledvina et al. 1992).

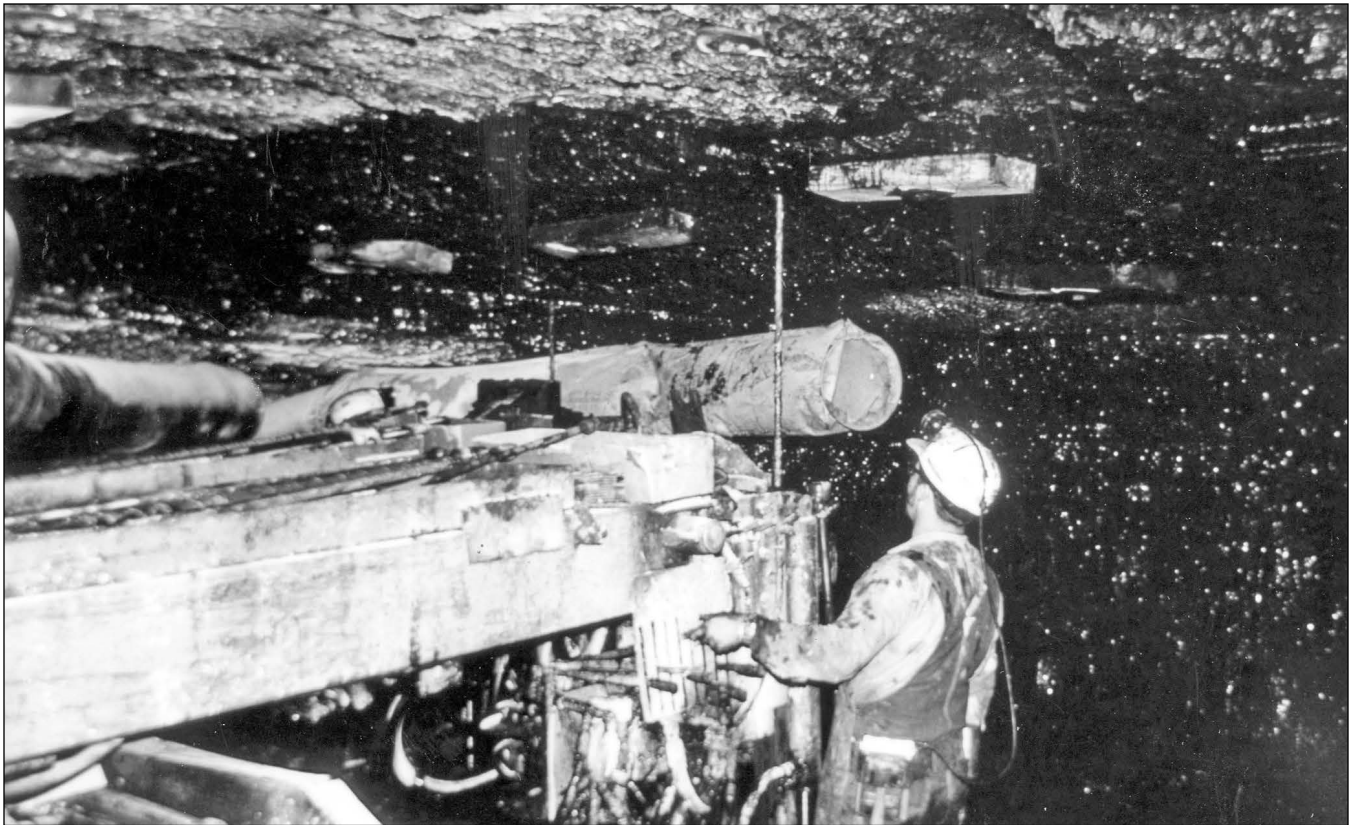


ISGS | Circa 1950

Figure 140 Bell & Zoller Coal Company, No. 3 Mine, near Zeigler, Franklin County. This photograph shows an early dual-boom machine. The operators of this machine work close to unsupported roof. The curved side walls indicate that a boring-type continuous miner excavated this room, and speed was essential to keep up with the advance rate of the mining machine.



Courtesy Zeigler Coal Company | Circa 1955



ISGS | 1975

Figure 141 Inland Steel Coal Company, near Sesser, Franklin County. In thick coals with a poor roof, 1.5 to 2 feet of top coal is left to help support the roof, as shown in this photograph. In older mines, the top coal was sometimes mined on retreat just before a room was abandoned. This mine generally used 6-foot standard roof bolts and used resin bolts only in areas with bad roof (ISGS Coal Section mine notes).



Courtesy Jeffrey Manufacturing Company | Circa 1960

Figure 142 Mine and location unknown. The later roof bolting machines, such as this Jeffrey Model 261 in the 1950s, included an extendable boom (retracted in photograph) and remote operation (Ledvina et al. 1992).

Figure 143 Peabody Coal Company, No. 10 Mine, Christian County. Timbering, steel I-beam, and roof bolting combined to keep this entry and haulage route open. The pillar outlines are characteristic of those used for conventional mining, where the coal is undercut and then shot down with permissible explosives (Ledvina et al. 1992). The white appearance of the pillars and roof is caused by rock dust.

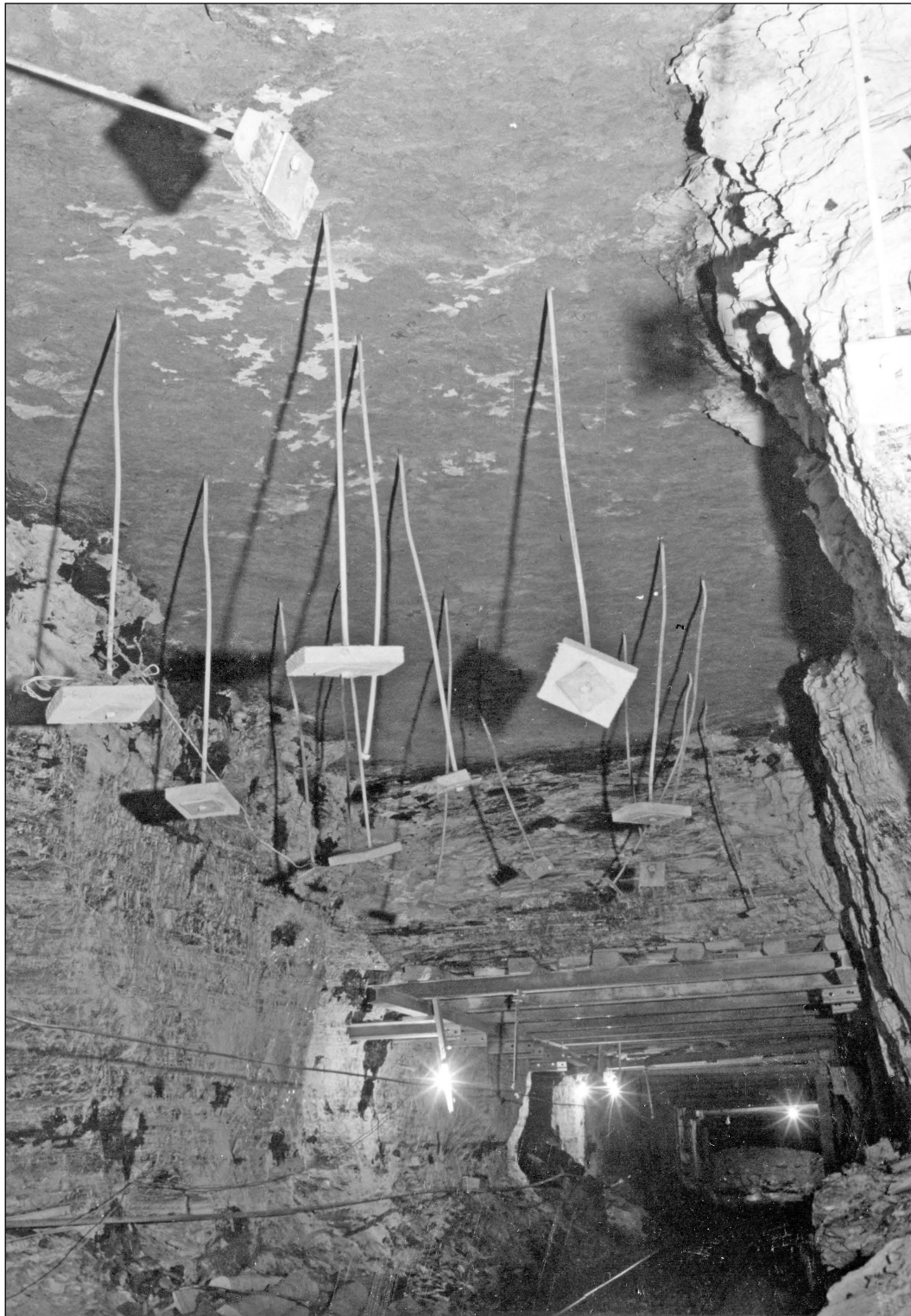


ISGS | Undated



ISGS | Undated

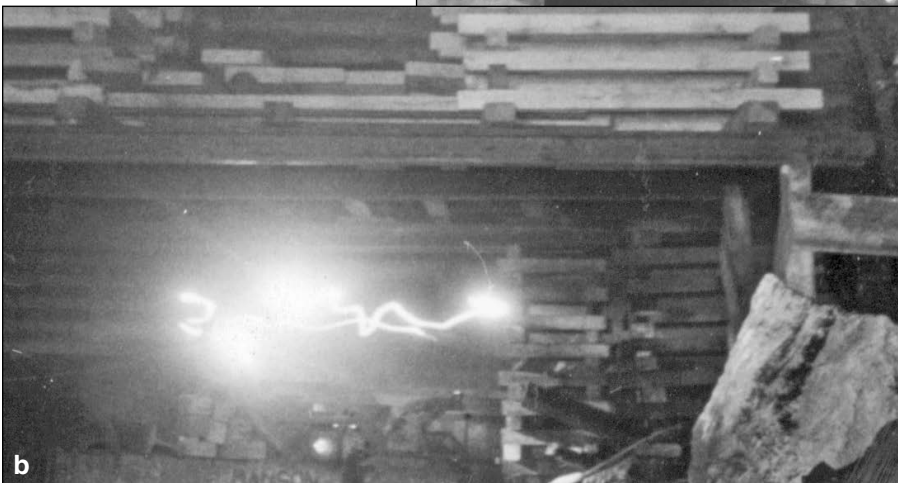
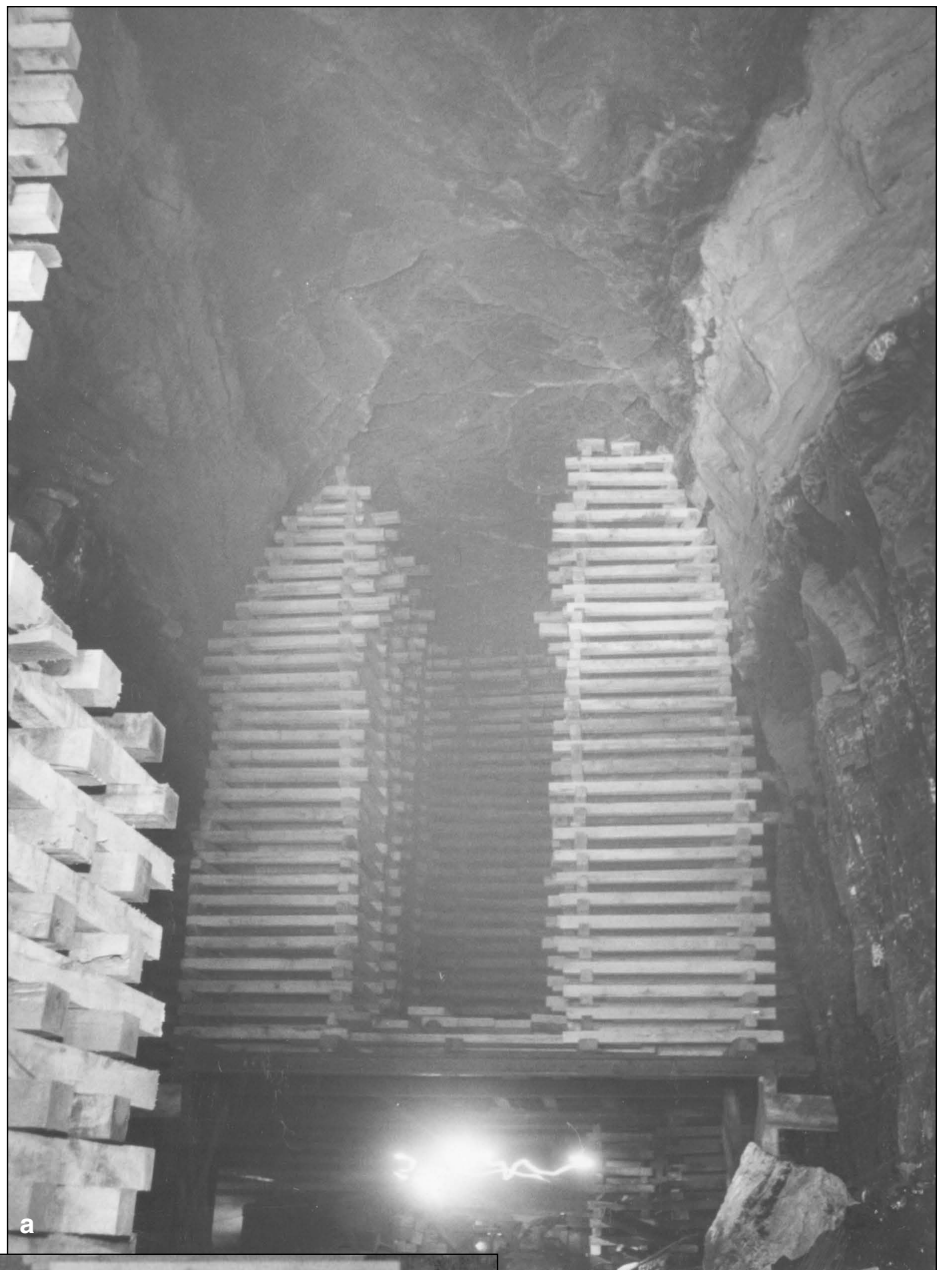
Figure 144 Hillsboro Mine, Montgomery County. Even when the roof has been bolted, weathering, jointing, and other stresses can combine to cause slabs of the roof to come down (Pitts 1939).



ISGS / 1960

Figure 145 Freeman Coal Mining Company, Crown No. 1 Mine, near Farmersville, Montgomery County. These roof bolts are still anchored in the limestone after the coal fell or was shot away. Note the trolley wire hanging below. This photograph was taken from near the shaft bottom, and 2 feet of top coal was left to support the roof. Above the coal was 4 feet of shale. The roof failed despite being bolted, probably because of the moisture in the air weathering the shale even though the top coal was left as protection. The remainder of the shale was shot down to save clean-up costs and slowing of coal haulage in this vital part of the mine. Beyond the roof fall, steel beams support timbers that in turn support the shale.

Figure 146 Peabody Coal Company, No. 10 Mine, Christian County. (a) These stacked timbers are called “cribbing.” The roof fall shown here was about 35 feet high, and the coal here was up to 13 feet thick. (b) The enlarged portion shows the steel I-beams that support the cribbing and the size of one of the blocks that has fallen from the roof (ISGS Coal Section mine notes).



ISGS | 1974



ISGS / 1974

Figure 147 Peabody Coal Company, No. 10 Mine, Christian County. Cribbing was used here to stabilize an area sensitive to roof falls, a major haulage route. Steel and wood are used to construct a frame for shuttle cars to drive under and to support the cribbing that in turn supports the roof (Coal Section mine notes).



Courtesy Vermilion County Museum / Undated

Figure 148 V-Day Coal Company, V-Day Mine, near Danville, Vermilion County. Metal plates at the base of the bolts provide support instead of the more common wood blocks. These metal plates are generally used in areas of good roof conditions.

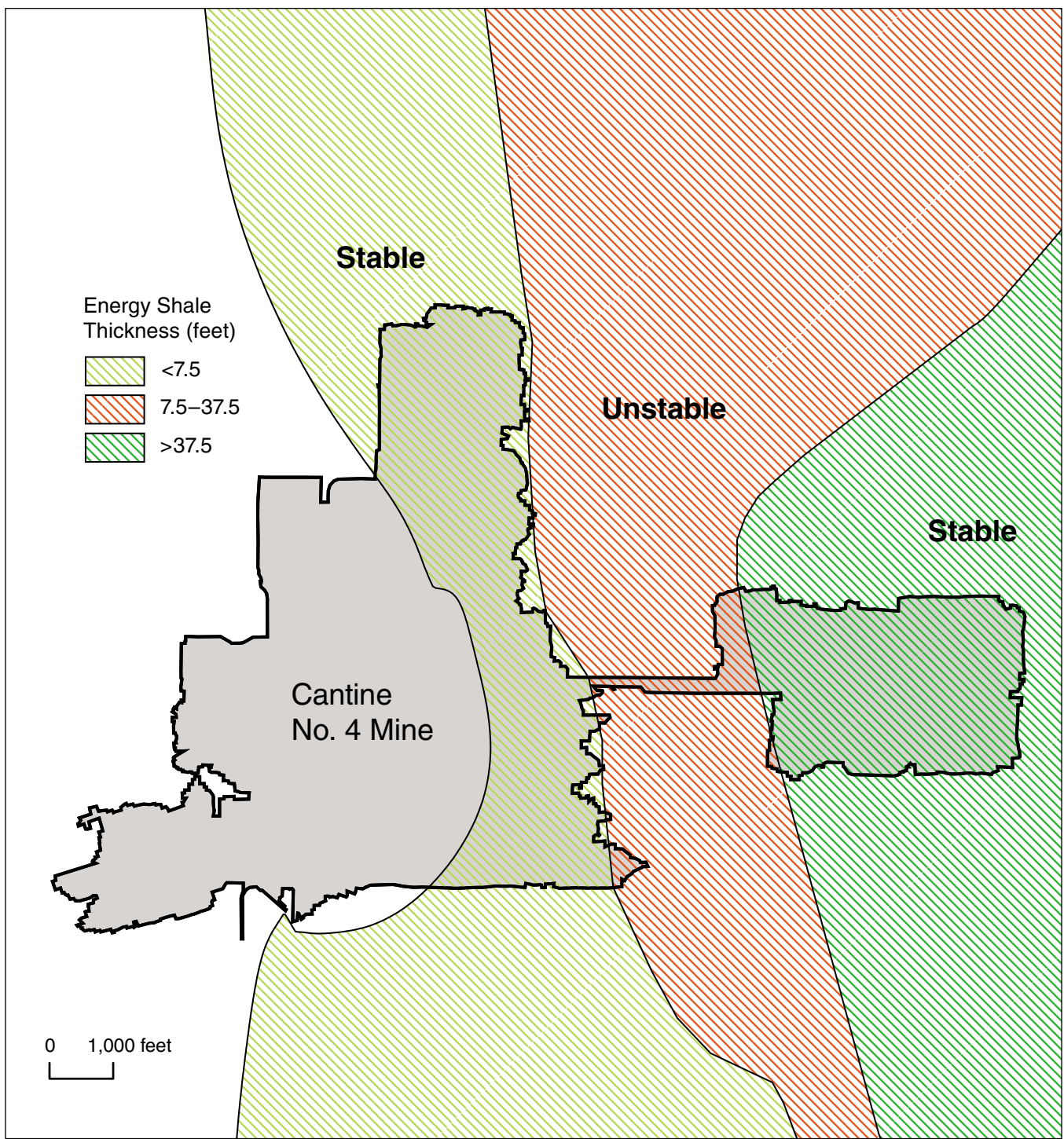


Figure 149 Lumaghi Coal Company, Cantine No. 4 Mine, Madison County. This generalized map of the Energy Shale, superimposed on the mine outline, illustrates the effect of the shale on mine operations. Although the Energy Shale can form a stable mine roof in southern and eastern Illinois, it does not support itself well where it is thin (Treworgy et al. 2000). If thin enough, the shale can be pulled down or bolted to the overlying Brereton Limestone, but, where it thickens, the limestone may be absent or too far above the coal to anchor the bolts. Where thick, the shale is more stable and comes down less readily (Treworgy et al. 1996). As the map shows, mining stopped when the original western section of the mine reached the 7.5-foot thickness contour. In order to continue mining its reserves, the company drove a heavily supported haulage tunnel through the coal until it reached an area where the Energy Shale was thick enough to form a stable mine roof.



Figure 150 Mine and location unknown. This sloping entry used bolted planks to support the roof above a haulage route.

ISGS | Undated

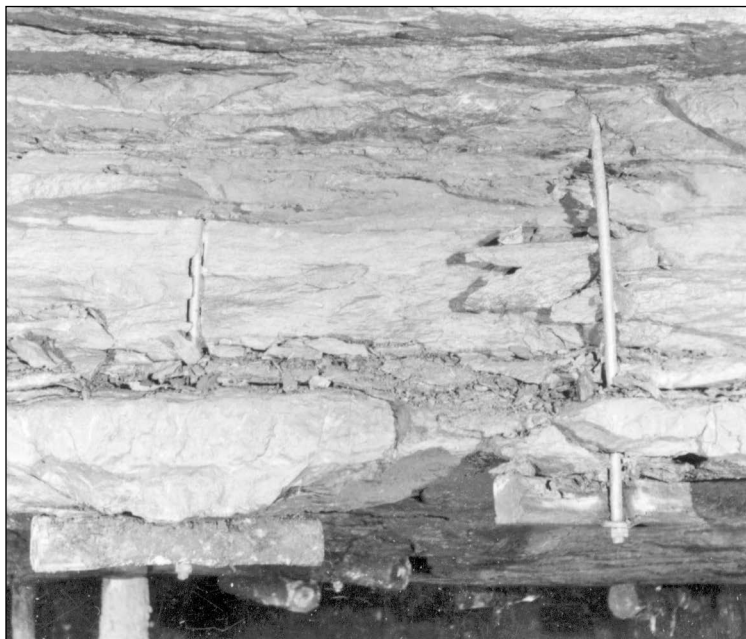


Figure 151 Belle Valley Coal Company, St. Clair County. These bolts are probably anchored in the upper limestone. A line of bolts may have served as “breaker” line, and the roof behind the fall may have held because the lower limestone was up to 2 feet thick.

ISGS | Undated

Figure 152 Bluff Coal Company, St. Clair County. The roof in this area is 3 feet of black shale that required heavy timbering, but generally came down anyway. Above the shale, in the photograph foreground, the lower surface of the limestone was relatively smooth.



ISGS | Undated

Figure 153 Freeman Coal Company, Crown Mine, Montgomery County. Near the coal hoist bottom, the combined use of bolts and steel bar supports can be seen.



ISGS | Undated

Explosive Risk: Methane and Rock Dust A large explosion occurred on Thanksgiving evening in 1917 in Old Ben No. 11 Mine (near Christopher in Franklin County), and 17 men were killed. Because of the holiday, only 25% of the normal evening shift was working; the normal day shift was 600 men. This explosion triggered exploration of explosion prevention methods by John E. Jones (then a state inspector of mines for that district) and D.W. Buchanan, president of Old Ben Coal Corporation, in conjunction with the U.S. Bureau of Mines (Jones 1954).

Methane (CH_4) is present in the joints and bedding planes of coal and is sometimes present in the rocks above and/or below the seam. Methane is explosive when it makes up between 5% and 15% of the air; above 15%,

there is not enough oxygen to propagate an explosion. Below 5%, there is not enough methane to fuel an explosion except in the presence of fine coal dust (Jones 1954).

Safety lamps were invented by Sir Humphrey Davy in 1815. Using a wire mesh of 28 wires to the inch around the flame prevented the ignition of methane on the other side of the wire mesh. Other types of safety lamps were developed, and four brands were in common use by 1890. These lamps could be used in gassy mines, and experienced users could detect the presence of methane at a concentration less than 1% (Greene 1889).

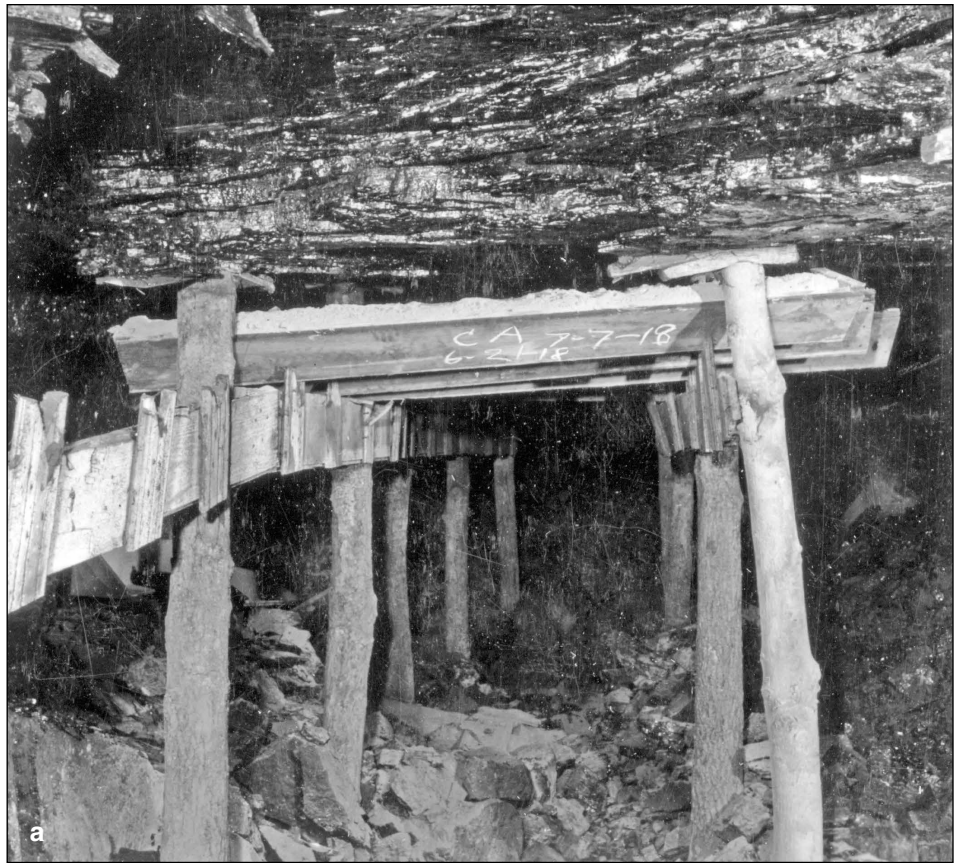
Coal dust had already been recognized as a contributing agent in coal mine explosions by adding a fuel to the mine air that could turn a spark

into a flame. This property had been recognized by the early 1800s in coal mine explosions in Great Britain. European mines distributed rock dust between the rails of their mines, dispersing it with a branch tied to the end car of each loaded trip (Schull 1954). The U. S. Bureau of Mines established an experimental mine near Bruceton, Pennsylvania, and successfully demonstrated methods to prevent explosions (Jones 1938). Rock dusting did not become common practice, partially because methods of application were not efficient. John E. Jones tried various methods of installations that would disperse rock dust throughout the mine during an explosion. He tried his methods on Old Ben No. 11 Mine, which was very dry. The methods did not work in other mines that had more moisture, since the rock dust



Courtesy Zeigler Coal Company | Circa 1940–1948

Figure 154 Bell & Zoller Coal Company, mine unknown, near Zeigler, Franklin County. A safety engineer and state mine inspector are shown taking air velocity measurements. The volume of air flow is then calibrated using the cross-sectional area of the entry where the velocity measurement is taken (Jones 1942).



Courtesy Old Ben Coal Corporation | 1918



Courtesy Old Ben Coal Corporation | 1918

Figure 155 Old Ben Coal Corporation, No. 11 Mine, near Valier and Christopher, Franklin County. These photographs show one of the first types of rock dust barriers created by John E. Jones as safety engineer for Old Ben Coal Corporation. An explosion through this location would blow the rock dust into the air, diluting the coal dust and stopping the coal dust from adding fuel to the explosion. Jones and D.W. Buchanan, president of Old Ben Coal Corporation, had to make their own dust, since fertilizer lime was too coarse. They constructed a mill to grind the roof shale from the mine (Jones 1938).

could cake and not disperse with an explosion; the fine coal particles were swept up and added to the combustible mixture. In a mine explosion, a strong rush of air precedes the flames, which fill the entries. People can avoid the flames by laying face-down in the passage at the first sign of the rush of air. One such explosion occurred in 1921, and the survivors said that, when the explosion reached the rock dust, the “flame broke into millions of sparks and then extinguished.” (Jones 1954)



Courtesy Old Ben Coal Corporation | 1920



Courtesy Old Ben Coal Corporation | 1920

Figure 156 Old Ben Coal Corporation, No. 15 Mine, near West Frankfort, Franklin County. Another approach to rock dust safety that Buchanan and Jones tried was to fill wire baskets with dust. The force of an explosion would knock the dust out of the baskets and disperse it to quench the flame. In a humid mine, the dust might not disperse as predicted (Ledvina et al. 1992).



Courtesy Old Ben Coal Corporation | Circa 1920

Figure 157 Old Ben Coal Corporation, No. 15 Mine, Franklin County. These rock dust baskets have a vane that, when the explosion gust arrives, opens the bottom of the basket and deploys more rock dust quickly. These installations were placed every 10 feet on alternate sides of the entry (Jones 1938). Note that the roof and ribs (pillars) have a coating of rock dust as well. A rock-dusting machine with a high-pressure hose had been developed by 1918, but it required tracks. Because the tracks were pulled up in the abandoned portion of mines, this machine could only rock dust the active portion of the mine. Rock dust needed to be reapplied two to four times a year because coal dust would accumulate on top of the rock dust, and normal rib (wall) rashing (spalling) and small roof falls would erode the rock dust from some areas (Jones 1942).



Courtesy Old Ben Coal Corporation | Circa 1920



a

Courtesy Old Ben Coal Corporation | Circa 1920



b

Courtesy Old Ben Coal Corporation | Circa 1920

Figure 158 Old Ben Coal Corporation, No. 11 Mine, Franklin County. Obsolete rock dust installation constructed under the direction of John E. Jones. Rock dust was molded in a metal container and placed on a solid platform. This rock dust remained powdery after several years, but this method only worked in dry mines such as No. 11. As rock dusting became more common (about 1928), limestone quarries and lead mines produced rock dust in 100- and 80-pound bags. But by 1938, only 10% of bituminous mines were routinely rock dusting (Jones 1938).



Courtesy Old Ben Coal Corporation | Circa 1920



Courtesy Old Ben Coal Corporation | Circa 1920

Figure 159 Old Ben Coal Corporation, No. 15 Mine, Franklin County. Quarries began producing 50-pound bags of rock dust, which decreased the labor of installation. Even so, a mine required thousands of bags. The bags were constructed with a small gauge wire that would rip the paper and allow the dust to be dispersed. (a) The center bag has been tripped by hand, but, in an explosion, the air gust would trip the hanging vane, removing the support so that the bag would rip and disperse dust from the barrier above the entry. (b) The platform base would then drop, causing the wire to rip the bag and disperse the dust (Jones 1938).



Courtesy Old Ben Coal Corporation | Circa 1952

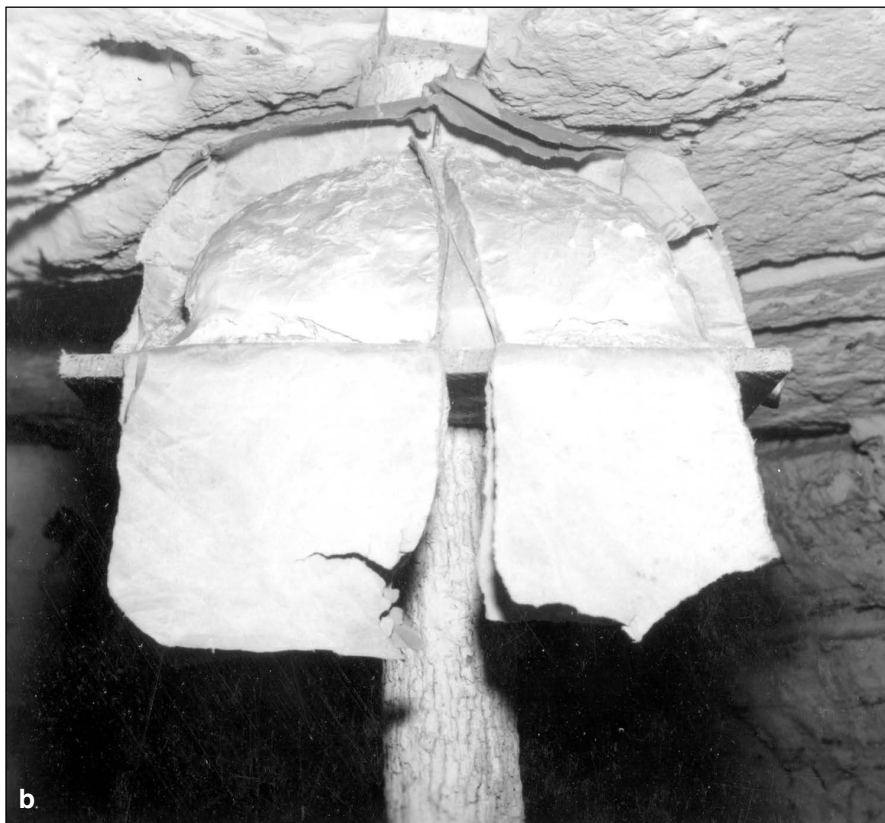


Figure 160 Old Ben Coal Corporation, No. 15 Mine, near West Frankfort, Franklin County. Rock dust installations on platforms. The bag in photograph (a) was tripped by hand (Ledvina et al. 1992).

Courtesy Old Ben Coal Corporation | Circa 1952



Courtesy Old Ben Coal Corporation | Circa 1952

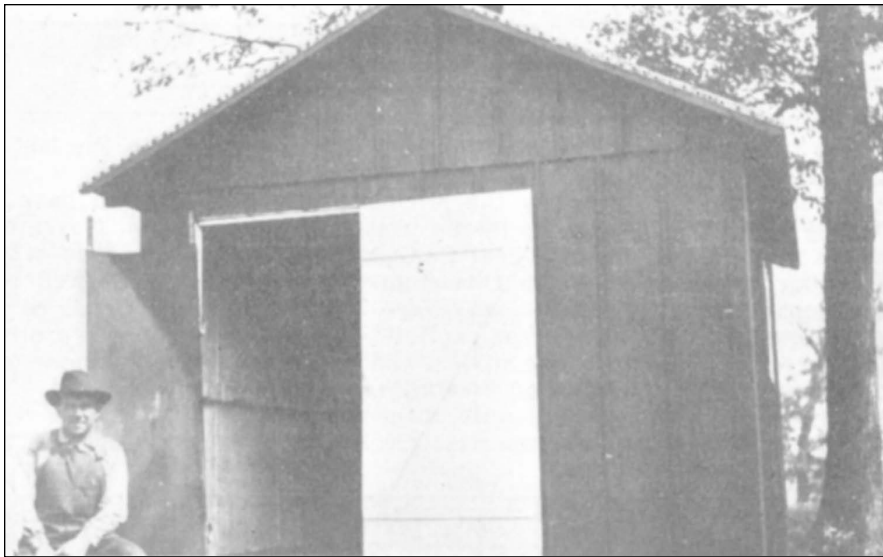
Figure 161 Old Ben Coal Corporation, mine unknown, Franklin County. These concrete blocks make a permanent seal for abandoned parts of an underground mine. The bags containing rock dust are designed to rupture if the seal is blown out by an explosion.

First Aid and Rescue Teams The Cherry Mine disaster, a mine fire that resulted in 256 deaths, in 1910 spurred legislators to pass an act establishing coal mine rescue stations. Three stations were established in the state: the northern station at LaSalle, a central station at Springfield, and a southern station at Benton. The Chicago, Milwaukee, and St. Paul Railroad and the Northwestern Railroad each donated a railroad car to take training throughout the state, and the State supplied another car. Each two-week visit supplied free training in helmet work with the current breathing

apparatus and first aid. In 1914, substations were established at Herrin, Harrisburg (later moved to Eldorado), and DuQuoin. The railroad cars were decommissioned in 1915, and instruction was given by traveling trainers. At that time, the rescue stations were to select teams of five miners who would practice at least two hours a week and be paid for that practice. In 1917, the Mine Rescue Commission was abolished, and the administration of the law was put under the Department of Mines and Minerals, Division of Mine Rescue and First Aid. In 1927, mine rescue and fire fighting stations were

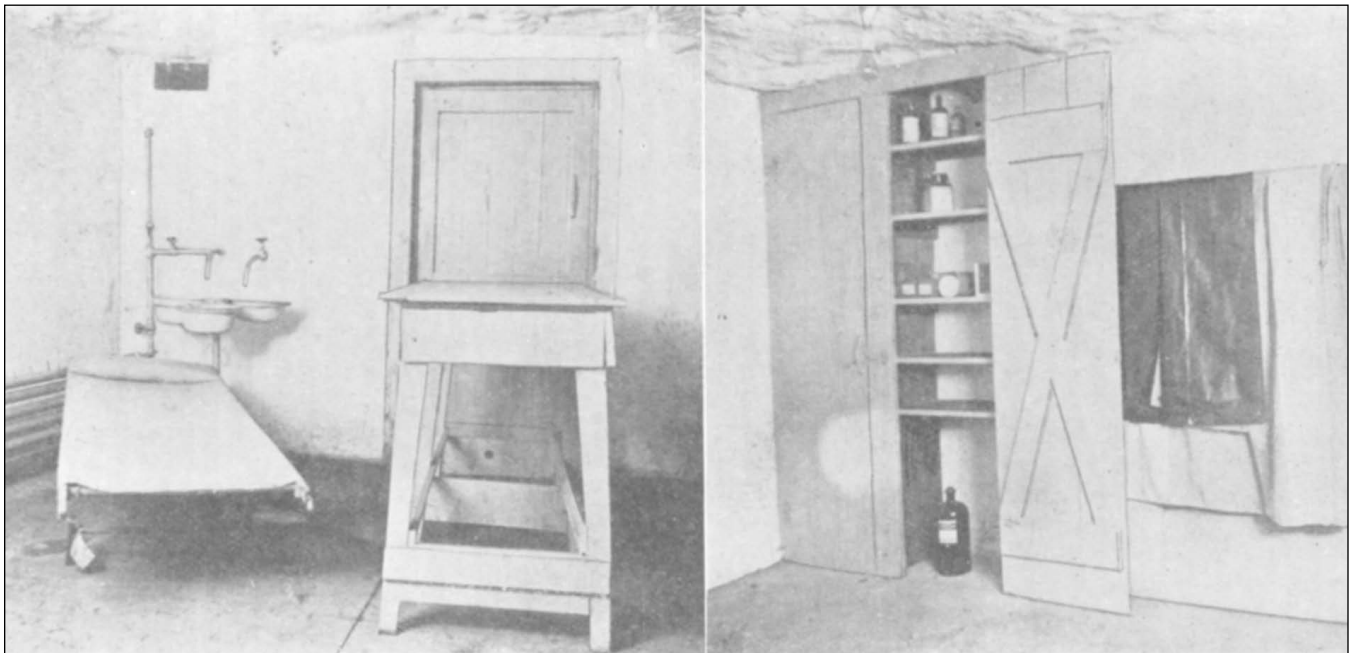
established at Belleville and Johnston City. In 1939, the Johnston City station was decommissioned, and a station was established at Benld. In 1947, three mobile rescue units were constructed, each with equipment for five rescue crews (Schull 1955, p. 238–243).

The first mine rescue competition was in 1912, and the competitions continue to this day. The usefulness of such teamwork and on-site teams is clear, since the travel time from the state rescue stations was time-consuming.



Twenty-Ninth Annual Coal Report, Illinois Bureau of Labor Statistics | 1910

Figure 162 Bunsen Coal Company, Vermilion County. The Bunsen Coal Company erected emergency hospitals, such as the one shown, at all four of their mines during the 1909–1910 fiscal year. These emergency hospitals were equipped with first aid equipment, and some employees were trained in first aid. These may not have been the first on-site aid stations in the state, but they were the first noted in the *Coal Reports*. Previously, injured miners were brought to the blacksmith shop or the engine room to await the arrival of medical help (Ross 1911, 1910 *Coal Report*, p. 343). During the 1909–1910 fiscal year, 35 men were injured in mines in Vermilion County, and 11 died.



Thirty-First Annual Coal Report, Illinois Bureau of Labor Statistics | 1912

Figure 163 Donk Brothers Coal & Coke Company, No. 1 Mine, Madison County. This hospital is thought to have been the first underground hospital in the state. Built of concrete and steam-heated to 90°F, it was furnished with an operating table and electric lights. Stretchers, blankets, and first aid appliances were stored there (Bolt 1913, 1912 *Coal Report*, p. 327).



a

INTERIOR FIRST AID HOUSE
MINE NO. 10
E 7817

ISGS / Circa 1920

Figure 164 Sahara Coal Company, No. 10 Mine, Saline County. (a) The interior of a mine's first aid house is shown, with an exam chair, hospital beds, and rescue equipment of the times. The box near the radiator can be taken on rescue missions underground and contains breathing apparatus for smoky or gassy conditions. It is clear that this first aid station is a showpiece, a place of pride for the mine to show off. It reflects the utilitarian purpose of the space but is not devoid of ornamentation. The radiator includes decorative elements. The blankets are not plain, but plaids. Money and thought were put into this first aid station to make it a comfortable, home-like place for the injured. (b) The enlargement of a portion of photograph (a) shows the shade for the light that reflects the miners' renowned patriotism with stars and stripes. The photograph is of President Woodrow Wilson.



b



Figure 165 Madison Coal Corporation, No. 9 Mine, Williamson County. Most mines had to rely on the state rescue teams sited at strategic positions in the mine inspection districts of the state. Madison Coal Corporation trained its own rescue team and had helmets, oxygen tanks, and other apparatus on site in 1912. The photograph shows the team with its equipment (Ledvina et al. 1992). Between the first two breathing apparatus boxes on the left is a closed light, or safety lamp, which was safe for work in mines with gas.

ISGS / 1913



Figure 166 Madison Coal Corporation, No. 9 Mine, Williamson County. The rescue team is shown wearing rescue gear. The boxes were carried on the backs of rescuers and probably filtered carbon dioxide and carbon monoxide out of smoky air. The man in the center of the front row is the only one with gear that would have allowed him to breath in a gassy mine. The electric cap lights of this time were very poor and produced only two-candle power or less of illumination (Jones 1954). The man on the left in the back row is holding the safety lamp.

ISGS / 1913



ISGS | Circa 1920

Figure 167 Madison Coal Corp., No. 12 Mine, near Cambria, Williamson County. A mine rescue team practices its skills. International competitions were held in the 1920s, and the competitions helped hone skills. This team had the latest equipment and medical gear.

Surface Coal Mining: Figures 168–283

Earliest Surface Mining

The first surface (strip) mines in Illinois were small operations, generally mining very shallow coal by surface methods for personal use. The first commercial surface mining in Illinois was attempted by the company Kirkland, Blankey and Graves near Danville (Vermilion County) in 1866, using the method shown in Figure 168 (Sheley 1935). In the 1870s, Michael Kelly began surface mining near Danville with horse-drawn scrapers to remove the overburden from the coal (Sheley 1935). These early surface-mining operations generally stripped off overburden during the summer months and mined the coal during the winter (Sheley 1935).

Mechanization of surface mining began with machines developed for other industries. The first steam excavator was developed in England in 1796 and in the United States in 1805 by Oliver Evans, but dry land excavating devices were not in demand until the beginning of railroad and canal construction during the 1830s (Williamson and Myers 1955). By 1842, steam-powered shovels developed by William Smith Otis and restricted to the use of his partners could replace the work of 60 to 120 men and complete construction jobs at lower cost and in less time than other companies. After the expiration of the original patent and its extension in 1860, railroads became the major purchasers of steam shovels. Although the original machine had standard gauge railroad wheels, it had to be dismantled, transported by rail car, and reas-

sembled at each work site because it was so wide. When H. T. Stock of Ohio coupled the steam shovel with a standard rail car in 1877, the portability of the design was a distinct advantage (Williamson and Myers 1955).

Steam-powered shovels were first used for coal mining in Kansas in 1877, but the shovel's boom was too short to handle the 12-foot-thick overburden (Hollingsworth 1963). Later, steam shovels were used to remove overburden from coal in Pennsylvania. Consolidated Coal Company of St. Louis leased coal rights in the Missionfield District near Danville in 1885, and steam shovels were then brought to Illinois (Bottomley 1944). Many of the important developments in early shovels were developed for the Missionfield District near Danville.



Courtesy Vermilion County Museum | Circa 1890

Figure 168 A typical early mine. Coal is dug out along the outcrop with picks and shovels, loaded into wagons, and hauled to market or used for heating in homes close to the mine. Surface mining by this method was practiced for more than 100 years, from the earliest mining in the 1830s.

The Modern Surface Mining Process

Figure 169 shows an Illinois surface mining scene that was typical of mining from the 1930s to the 1960s. All of the unmined material on top of the coal, including topsoil, is known as overburden. The unmined wall in a surface mine is the highwall. Overburden material is taken from the highwall and is moved to an area that has already been mined. This excavated material is known as the spoil pile (or just spoil). The loading shovel (lower center, Figure 169) digs and loads coal into trucks or railroad cars for transport out of the mine. Bucket size is optimized to load the haulage vehicles with the fewest cycles. A cycle

is the circuit the shovel makes in loading the bucket, swinging around, and emptying the bucket. The stripping shovel (shown behind the loading shovel) is sitting on the exposed coal seam, removing the rock and soil on top of the coal (the overburden). Its bucket (or dipper) has teeth that dig into the rock face and load the bucket; then the machine swivels, and the bucket's load is dumped onto the spoil pile. The dragline, perched on the spoil pile, fills its bucket by dragging the bucket toward the machine to fill it and then swings around and empties the bucket further behind the machine. The stripping shovel empties its bucket at about its maximum height as the dragline moves material back to make room for the

shovel to transfer more material to the spoil pile. Draglines often worked in conjunction with shovels in this manner, or the dragline worked on the highwall, where it removed the upper one-third of the overburden and the stripping shovel removed the lower two-thirds (Shorthouse 1942). This process enabled the mining operation to access deeper coal with a smaller stripping shovel than the mine might require for its deepest part. By 1970, draglines often worked without stripping shovels, because the dragline could more easily remove discrete zones of overburden material, as needed for reclamation regulations (C.G. Treworgy, personal communication).



Courtesy Vermillion County Museum | Undated

Figure 169 An Illinois surface mining scene that was typical of mining from the 1920s to the 1960s.

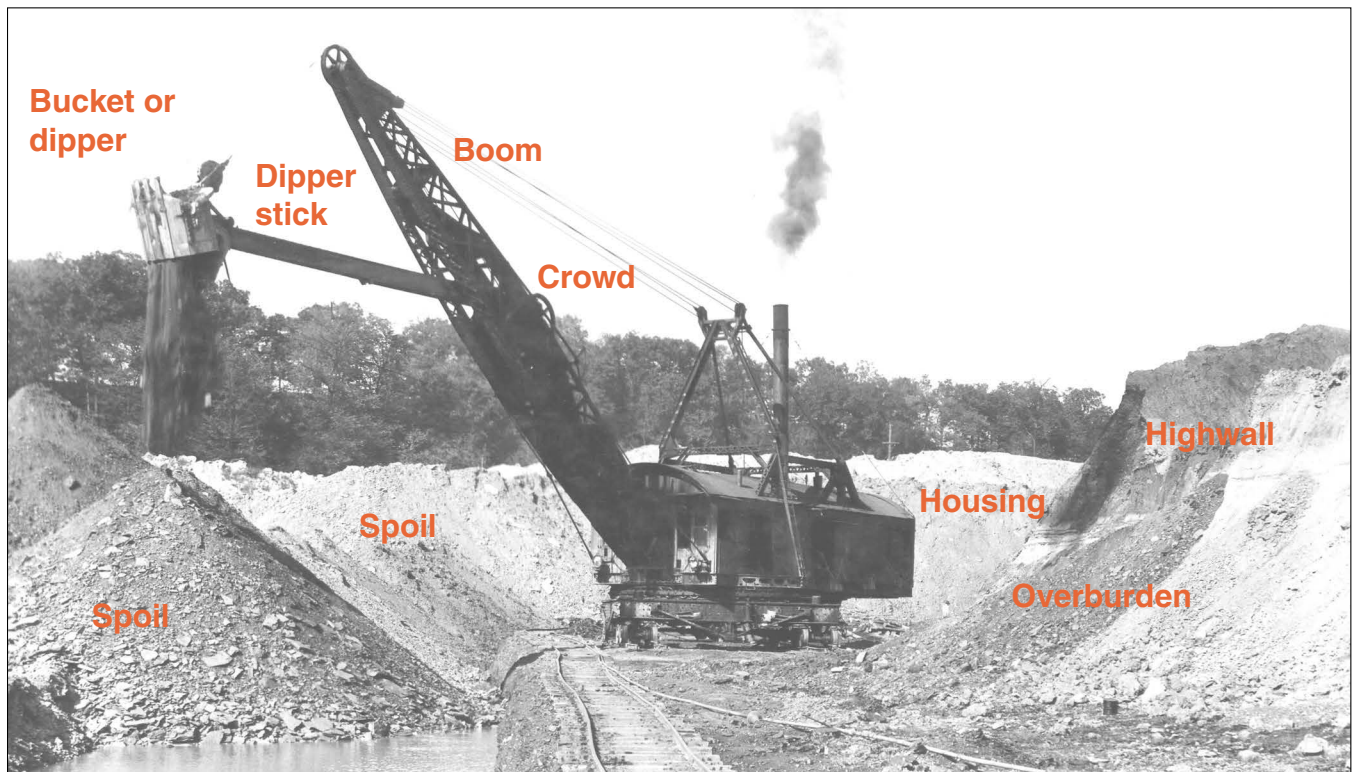
Figure 170 shows an early stripping shovel. The boom projects from the shovel housing that covers the power source, whether steam, as in this case, or later electric, gas, or diesel engines. The boom design was engineered to support the weight and stresses of digging. Solid iron and steel booms were constructed, but derrick frameworks provided the combination of strength and light weight of most of these machines. Cables, chains, or wire ropes looped over the top of the boom to lift the bucket. The bucket teeth enabled more effective digging and could be replaced when broken or worn. Bucket capacity was measured in cubic yards. Before 1930, buckets were made of cast steel (Williamson and Myers 1955) or riveted plates of steel. After 1928, improvements were made by substituting stronger steel alloys (Hollingsworth 1963) and by welding instead of riveting the pieces (Williamson and Myers 1955), and bucket sizes increased dramatically. The bucket is attached to the machine by the dipper stick, which has its pivot point about halfway up the boom. This pivot point is the site of

the crowd, the motors and wire ropes that provide horizontal thrust into the highwall just before the scooping process begins, when the bucket is raised along the highwall. Later innovations on the crowd location enabled further weight reduction for the front end of the shovel. This shovel (shown in Figure 170) had railroad-type wheels that require a set of tracks for mobility. Some leveling of the roadway had to be done before ties and tracks were laid, and only a short segment of track was laid at a time to support the shovel's weight. The shovel's track was extended when the shovel was moved and the track behind the machine was dismantled. The earliest shovels had wheels but often required the work of a block and tackle to actually move, as the weight of the shovel caused the wheels to sink into the underlying material.

Earliest Mechanical Shovels in Illinois

Wallace & Wright of Indiana was experienced in dredging and drainage work and was awarded the contract

from Consolidated Coal Company to strip the overburden off the coal in the Missionfield District near Danville in 1885. Although many mines had operated in the Missionfield District before 1885 and surface mines were operating in other areas, this was the first large-scale surface-mining operation in the state. Wallace & Wright purchased a dredge (minus the hull) from the Marion Steam Shovel Company of Marion, Ohio, and erected the dredge on a wood frame supported by wheels to make a dry land dredge. The steam engine was a single cylinder (Bottomley 1944) and hoisted a $\frac{3}{4}$ -cubic yard dipper (Bottomley 1944) on a 50-foot boom (Hollingsworth 1963). This machine could remove up to 35 feet of overburden (Hollingsworth 1963). The machine was moved with a block and tackle, as the wheels were fastened rigidly to the frame. Negotiating curves was a slow process. Because the machine could dig forward only, Wallace & Wright chose a circular path of operation, making a spiral from the outside of the circle to the inside (Sheley 1935, Bottomley 1944). The dumping range

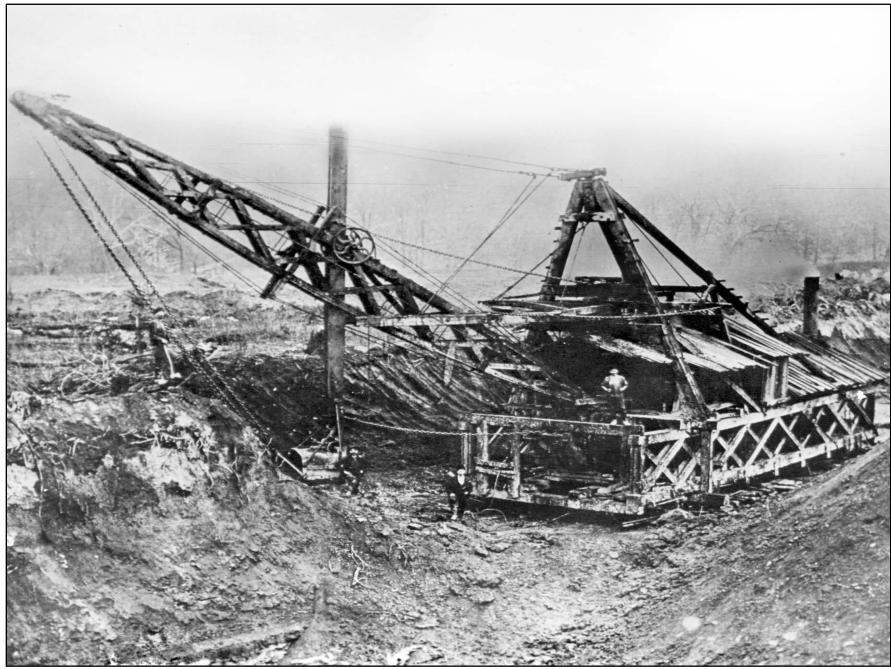


Courtesy Vermilion County Museum | 1922

Figure 170 A 1920s stripping shovel.

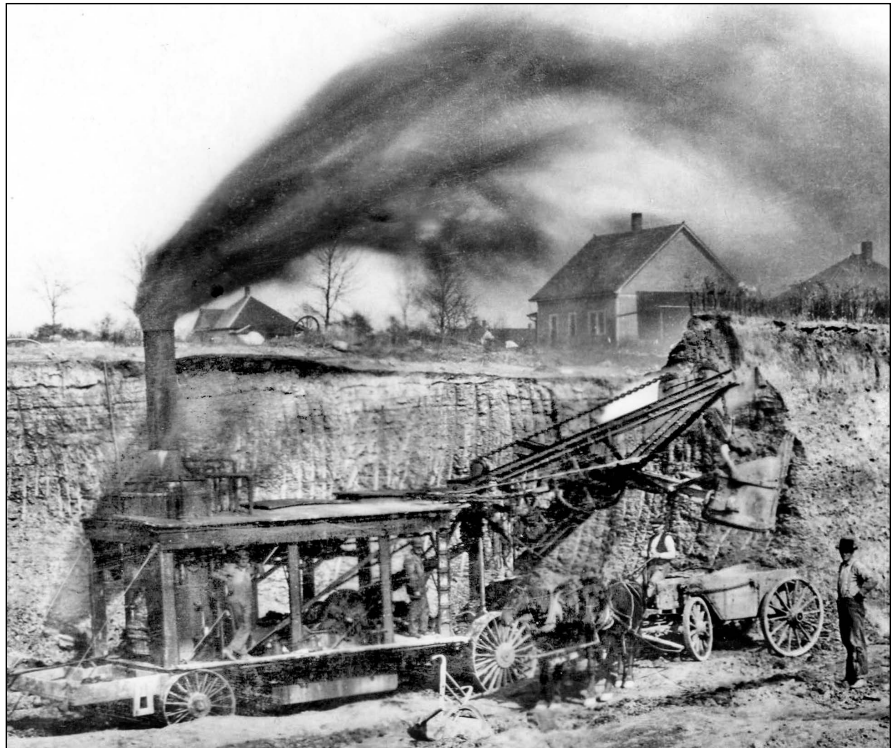
was limited, only 20 feet away from the machine, so the waste banks often covered up the coal face. Coal was loaded by hand. The machine was slow and the cut was narrow, and a second shovel was installed to meet the coal contract. The new shovel had a 1/4-cubic yard bucket, and later a third machine with a 1/2-cubic yard dipper and a 65 foot boom was installed (Bottomley 1944). In 1888, Consolidated Coal Company took over operation of the machines, and the machines were abandoned as worn out in 1890 (Hollingsworth 1963).

Surface mining in Illinois was hindered by thick overburden (Hollingsworth 1963). In Kentucky and other states, more coal was available at shallow depths (Hollingsworth 1963). The shallowest Illinois coal was mined early on, and shovel designers tried to make machines that were versatile enough to move in a surface mine pit and that were capable of removing over 15 feet of various types of overburden. The overburden making up the highwall in Figure 172 is very likely all glacially deposited material, mostly clay with varying amounts of sand and gravel, along with perhaps some soft shales. Many shales weather readily and can degrade if moisture seeps slowly through the glacial materials. Mechanical shovels can gouge out such materials. Harder, more firmly cemented rocks, such as sandstones or limestones, would have been beyond the capabilities of early machine shovels unless the rocks were broken into rubble by explosives in a process called "shooting" the overburden. In many places, shooting the overburden was done to speed its removal and to save wear on the very expensive large stripping shovels, even when they were capable of removing the overburden as it existed in place.



Courtesy Vermilion County Museum | 1885

Figure 171 Missionfield Mine, west of Danville, Vermilion County. This very early stripping shovel was steam-powered. The wooden frame supports dredge machinery, making what is essentially a dry-land dredge.



Courtesy Vermilion County Museum | Circa 1910

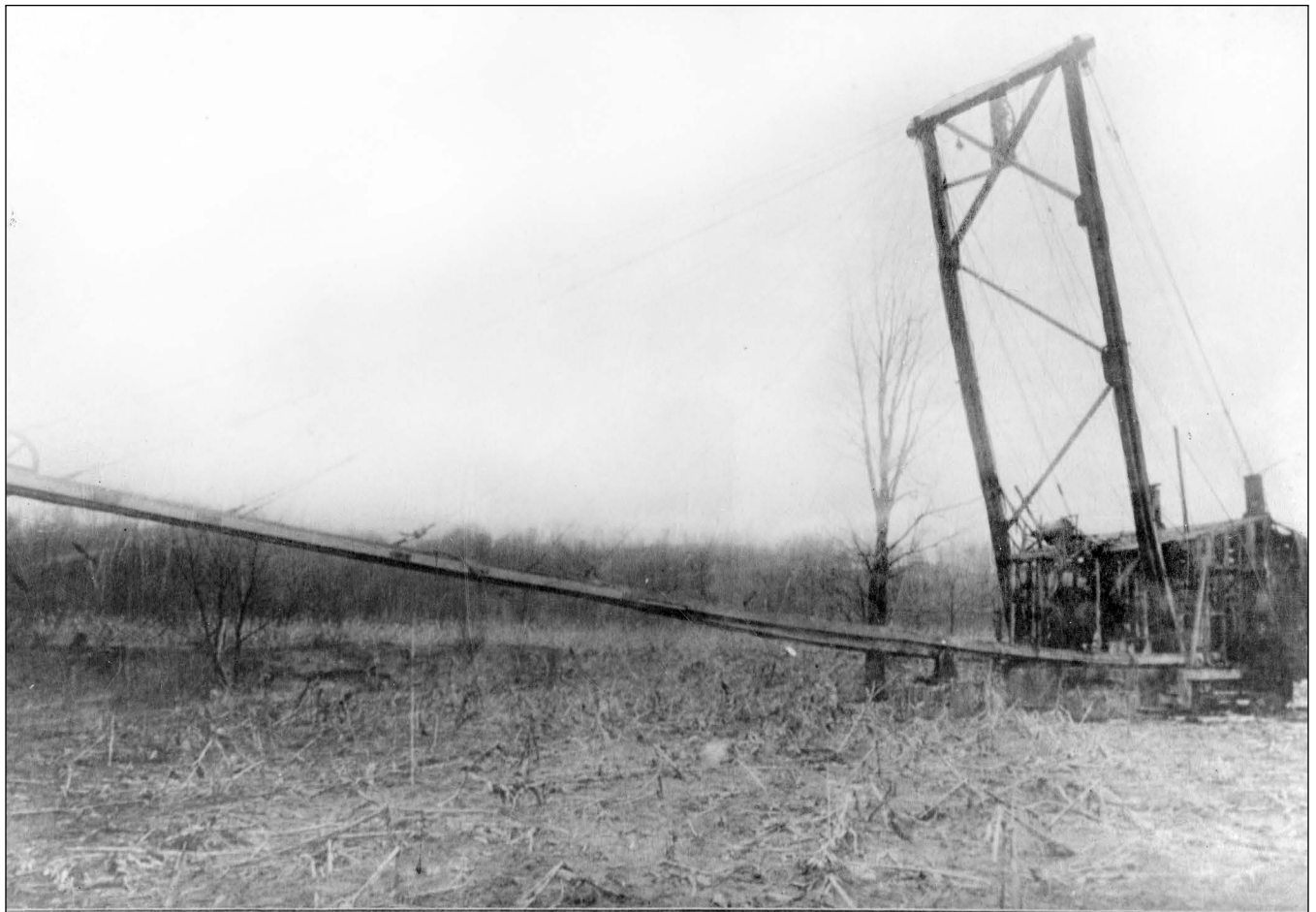
Figure 172 Mine unknown, Missionfield District, Vermilion County. A very early steam shovel removing overburden.

The Earliest Draglines

In 1890, Butler Brothers began using three self-propelling draglines with bucket capacity of $\frac{3}{4}$ cubic yard, $\frac{7}{8}$ cubic foot, and 1 cubic yard and with 80-foot booms (Hollingsworth 1963). An early dragline is shown in Figure 173. The bucket was pulled toward the machine to fill it and then taken out to the farthest length of the boom and dumped (Hollingsworth 1963). These buckets were open on both ends but had teeth on the end that was pulled toward the machine (Bottomley 1944). The draglines worked above the pit on one edge of the bank and were on rails. The ties supporting the rails had to be very closely spaced because the ground was soft, and the machine would sink otherwise (Bottomley 1944). Because the boom did not swing from side to side (Hollingsworth

1963), the machine had to be moved frequently to keep it supplied with overburden. It made 20-foot cuts, and the waste could be piled far enough from the coal so that the active face was not covered. After the first cut, the waste could be deposited into the previously mined section of the pit. Floods in the Butler Brothers pit caused the work site to be moved, and one machine was abandoned. One of the remaining draglines was used for stripping overburden and the other for loading coal into gondolas that carried coal to the tippie. In this manner, production from surface mining increased dramatically so that over 1,000 tons a day were mined. With an experienced operator, over three complete cycles (filling the bucket, moving it to the dump location, and emptying) could be completed in a minute (Bottomley 1944).

However, these machines were only capable of digging unconsolidated overburden (soil and glacial till) and were retired when shale was encountered in the pit. Then Butler Brothers replaced these draglines with one that had a 125-foot boom (Hollingsworth 1963) supported by a 60-foot gantry (Bottomley 1944) and three buckets (2 cubic yards each)—one for rock, one for soil, and one for coal (Hollingsworth 1963). The machine was very heavy, and the expense of providing adequate support of the highwall and blasting the overburden resulted in the abandonment (Bottomley 1944) of this machine in 1907 (Hollingsworth 1963). Draglines were not commonly used in coal mining again until the late 1920s.



Courtesy Vermilion County Museum | Circa 1890

Figure 173 Mine uncertain, near Danville, Vermilion County. This very early dragline has a nearly horizontal boom.



Courtesy Vermilion County Museum | Circa 1903–1910

Figure 174 Fairmount Quarry, Vermilion County. This Marion Model 73 steam shovel is working in a gravel pit. The chain that controls the bucket, the short massive boom and dipper stick, and the 180-degree rotation allowed on the rail-mounted foundation are similar to the earliest coal mining steam shovels in use since 1877. A steam-powered locomotive is probably just out of the picture on the left (indicated by the vast amount of black smoke in that portion of the picture). The pit cars are emptied by tipping them to the side. The end car has a hoist mechanism to aid the process. The size and strength of pit cars increased to keep pace with shovel developments so that the same number of cars were kept occupied (Phelps 1973).

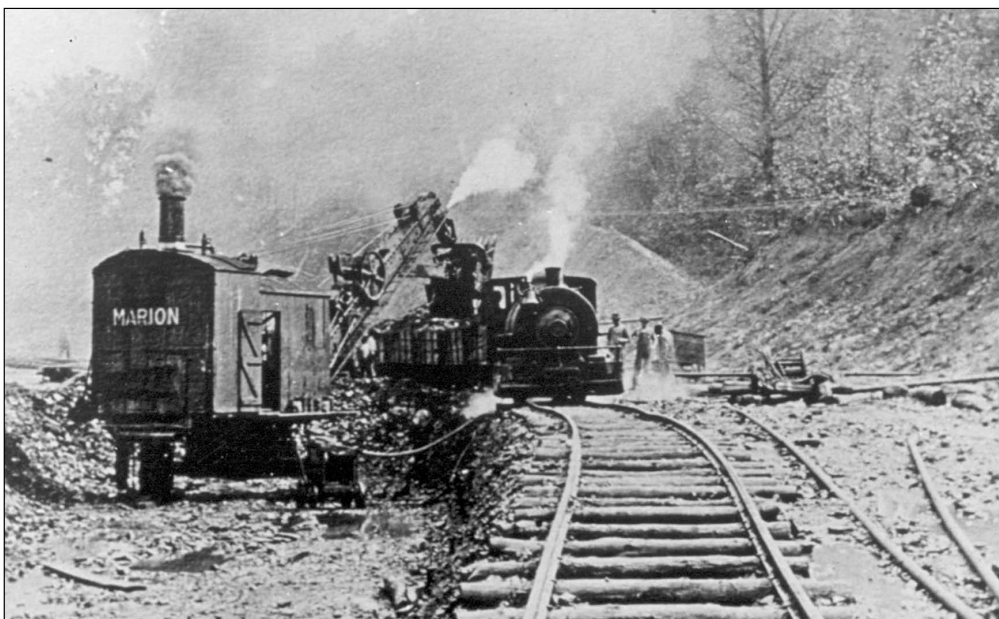


Figure 175 An early steam stripping operation at an unidentified mine. The rail-mounted Marion shovel is loading coal onto cars pulled by a steam locomotive.

ISGS | Circa 1910

Fully Revolving Machines

Fully revolving machines were pioneered in 1884 in England by Whitaker & Sons. In 1886 in the United States, John Howe of Osgood Dredge Company developed a fully revolving machine for a brick yard. The idea of a fully revolving machine remained dormant until 1895, when it was resurrected and successfully implemented for dock loading. Both Vulcan Iron Works and Marion Steam Shovel Company developed fully revolving coal shovels in 1907, mainly for 1½ cubic yard capacity or less. The size limitations kept these machines from replacing railroad-type shovels, but the advantages were immediately apparent. A fully revolving shovel allowed a longer boom because the

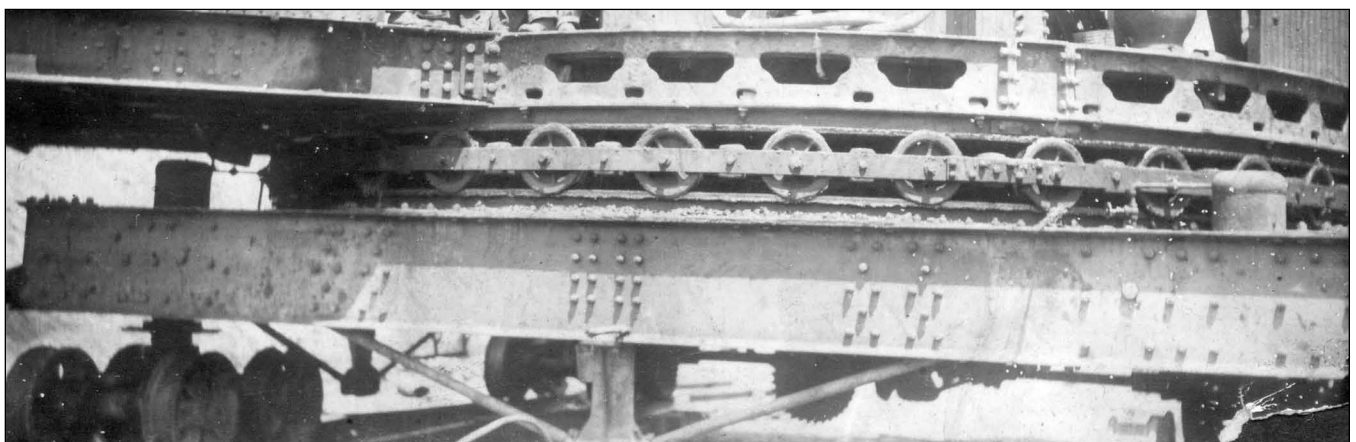
platform counterbalanced the additional weight. This design allowed the machine to pick up and move the tracks as it advanced, which allowed the machine crew to be decreased from six to eight men down to three. The revolving shovel eliminated the constant twisting of the hoist chain; wire rope, which cost about one-third as much but had a similar life span, could be used instead (Williamson and Myer 1955). The Marion Model 250 shovel was the first fully revolving stripping shovel designed for removing overburden from coal. Designed by Grant Holmes and W. G. Hartshorn of Mission Field Coal Company, and built by the Marion Steam Shovel Company in 1911, this 150-ton steam shovel had a 3½-yard bucket on a 65-foot boom and a 40-foot dipper

stick. Hydraulic jacks on each corner leveled the machine so that its weight was distributed evenly. Four four-wheeled bogies (Figure 177) ran on railroad tracks, which provided mobility. This shovel could strip 20 to 30 feet of overburden and was the largest machine in the world at the time. With the advent of this machine, the New Enterprise Coal Company began surface mining in Williamson County in southern Illinois (Bottomley 1944). Bucyrus came out with two fully revolving strippers, the 124-ton Bucyrus 150-B, with a 60-foot boom and 2½-yard bucket, and the 182-ton Bucyrus 175-B, with a 75-foot boom and 3½-yard bucket. The 150-B ran on rail wheels and could handle 10 to 35 feet of overburden (Williamson and Myer 1944).



Figure 176 Mission Mining Company, Missionfield Mine, Vermilion County. The Marion Model 250 is shown removing overburden west of Danville.

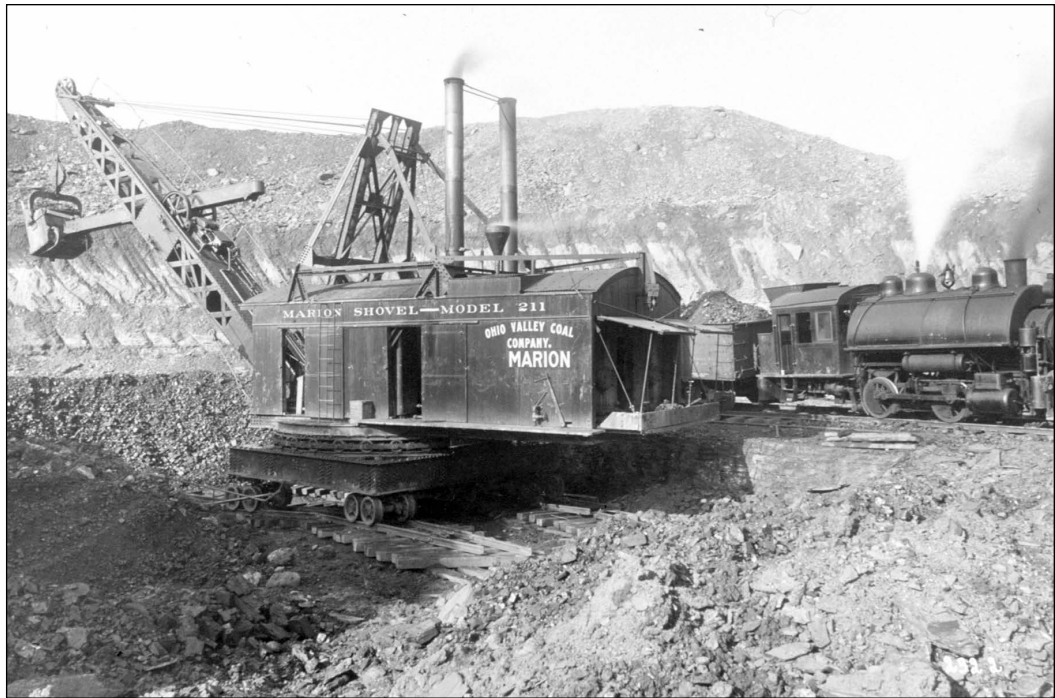
Courtesy Vermilion County Museum | Circa 1911–1914



Courtesy Vermilion County Museum | Circa 1911–1914

Figure 177 Mission Mining Company, Missionfield Mine west of Danville, Vermilion County. This view shows details of the Marion 250 with four-wheeled bogies (one set seen in lower left corner) on railroad tracks and the revolving platform of the steam shovel mechanism.

Figure 178 Ohio Valley Coal Company, Ohio. This Marion Model 211 steam shovel utilized a 2-cubic yard bucket and had 360-degree rotation of the dipper and boom. Mobility was provided by two sets of parallel tracks, both with a high density of ties to provide support for the machine, which had an operating weight of 95 tons (Historical Construction Equipment Association 2002). This photograph is the clearest illustration of the short railroad segments used for early steam shovels.



Courtesy Marion Shovel Company | 1914



Courtesy Vermilion County Museum | Circa 1912–1915

Figure 179 Mine unknown, probably located in Vermilion County. This Marion 270 steam shovel shares many aspects with the Marion 250: a fully revolving shovel with four four-wheeled bogies for mobility. The 5-cubic yard bucket (Historical Construction Equipment Association 2002) was larger and the 90-foot boom longer than the Model 250 (Hollingsworth 1963).



Figure 180 Danville area, Vermillion County. Hand loading was preferable in some mines even when small steam shovels were available. Some coal seams have two or more benches separated by bands of shale, and it was more efficient to leave that shale in the pit. Hand loading of the coals could contribute to the cleaning process by saving time and labor in the sorting sheds.

ISGS | Circa 1914



Courtesy Vermillion County Museum | Circa 1919–1921

Figure 181 Mission Mining Company, west of Danville, Vermillion County. This Marion 300 steam shovel had a 6-cubic yard bucket and weighed 350 tons (Historical Construction Equipment Association 2002).

Electric Shovels

Vulcan Shovel Company pioneered electric shovels in 1899 and electric revolving shovel excavators in 1908, but they were not in common use until the 1920s. Electric drives became more common after 1915, which eliminated problems of bad boiler feed and frozen pipelines (Sherwood 1943, Williamson and Myers 1955). Achieving a similar working cycle to steam power required a Ward-Leonard control, a motor generator set that took alternating current from the utility lines and delivered direct current to the hoist, swing, and crowd motors. With the Ward-Leonard control, the driving motors worked at a nearly constant rotating force (torque), regardless of speed, and

automatically adjusted motor speed to resistance so that the motors slowed down when heavy loads were encountered. The swing and hoisting motors could also be used to brake their motions, when they would act as generators, pumping power back into the electrical system. This improvement on circuit breakers and clutches of the early electrical systems was substantial. High voltage was delivered to the pit by cables stretched along the highwall (Williamson and Myers 1955). Cables came in 1,000-foot lengths, and portable sleds (shown below, right) carrying fuse boxes served to join the cables and connect the laterals to the pit (Bottomley 1944). The first electric-powered shovel in Illinois was in the Black Servant Mine

near Elkhaville (Jackson County) in 1921 (Bottomley 1944).

Applying the gasoline-powered internal combustion engine to excavating shovels was difficult, mostly because of insufficient power transfer to the thrusting motor that crowds the bucket into the highwall. The Bucyrus Company overcame this problem with a patented device consisting of rope-wound drums, which allowed the dipper to be controlled as well as one powered by steam, even allowing the dipper to be shaken to loosen sticky material adhering to the bucket. Bucyrus also constructed the first diesel-powered shovel. Sales of diesel shovels were hindered by the cost, which was 50% higher than steam-powered shovels and 20% higher



Courtesy Vermilion County Museum | Circa 1919–1921

Figure 182 Kehota Mining Company, Redfield, Ohio. The Marion 300E was one of the early electric shovels. This may be the same model used in the Black Servant Mine in Jackson County.



Figure 183 This photograph shows a power sled with fuse boxes. The sled was used to convey power to a stripping shovel.

Courtesy Vermilion County Museum | Undated

than gasoline-powered engines (Williamson and Myers 1955). Advantages of the use of internal combustion engines instead of electricity included the wide availability of fuel. Also, the engines stalled when overloaded,

which avoided damaging the machine (Williamson and Myers 1955). However, the power could not be used to brake the various motions, and, in difficult digging conditions, the engines slowed and the power dropped off

rapidly. Another formidable obstacle was the operator's lack of familiarity and ability to maintain, adjust, and repair the machine in the field.



Courtesy Vermilion County Museum | Circa 1919–1921

Figure 184 Location unknown, probably in Vermilion County. (a) This photograph is a rare shot of a steam shovel without a housing so that all the works are visible. The steam tank was in a horizontal configuration; these tanks generally were vertical. The shovel was supported on hydraulic jacks to keep the machine level, and the shovel revolved fully to remove overburden (left side of the photograph) and deposit it (right side of the photograph). Shovels increased about fourfold in size between 1912 and 1927 (Williamson and Myers 1955). Equalizing devices were incorporated into design modifications to enable the huge excavators to operate on uneven surfaces. Marion Shovel Company used hydraulic jacks at the corners of the undercarriage, whereas Bucyrus Company's solution was a patented equalizing beam that provided three-point suspension (Williamson and Myers 1955). (b) Enlargement of the suspension and steam tank of the steam shovel.

Figure 185 Digging for the foundation of the Harding Hotel in Marion, Ohio. The Marion 21 shovel had a $\frac{3}{4}$ -cubic yard bucket that was very popular and was offered with steam, gasoline, or electric power. More than 800 were sold between 1919 and 1927 (Historical Construction Equipment Association 2002). These shovels were likely used in Illinois coal mines for loading coal.



Courtesy Marion Shovel Company | 1920s



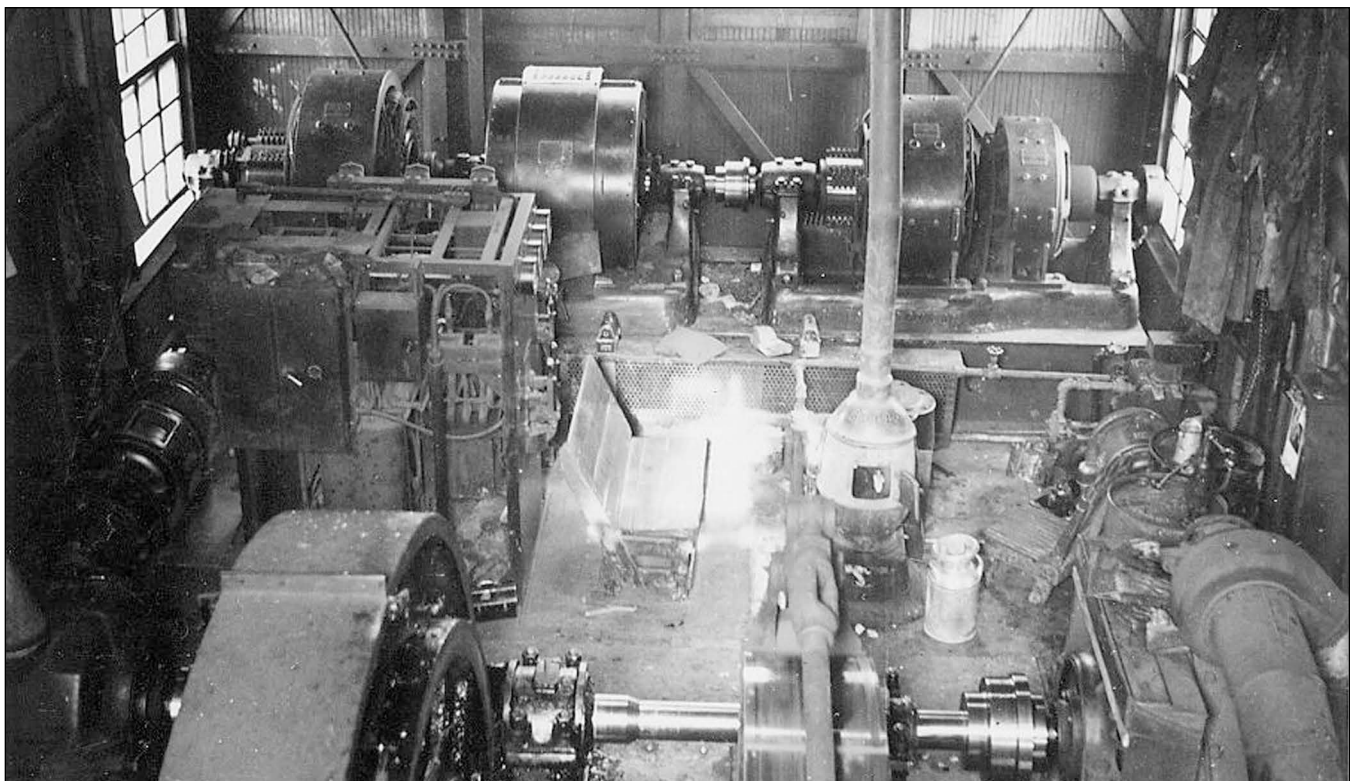
Courtesy Vermilion County Museum | 1922

Figure 186 Mission Mining Company, west of Danville, Vermilion County. This Marion 300 steam shovel shows the depth of overburden that could be removed with these new large shovels.



Courtesy Vermilion County Museum | Undated

Figure 187 Mine and location unknown. Slope stability of the highwall is an important factor in surface mining. In this instance, the highwall has slumped, and the small resulting landslide has pushed the steam shovel against the spoil pile.



Courtesy Wilmington Public Library, Charles I. Raworth Album | Undated

Figure 188 Mine and location unknown. The interior of an electric stripping shovel or large dragline.

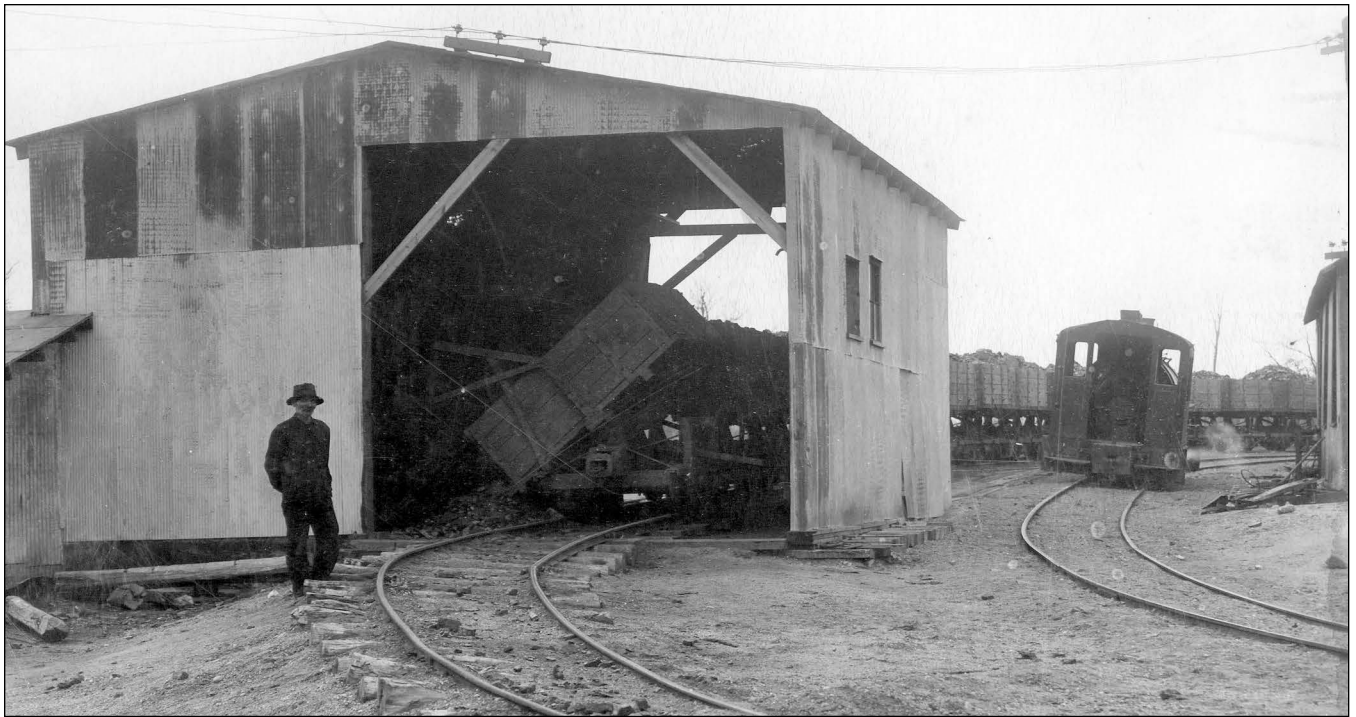


ISGS | Circa 1925



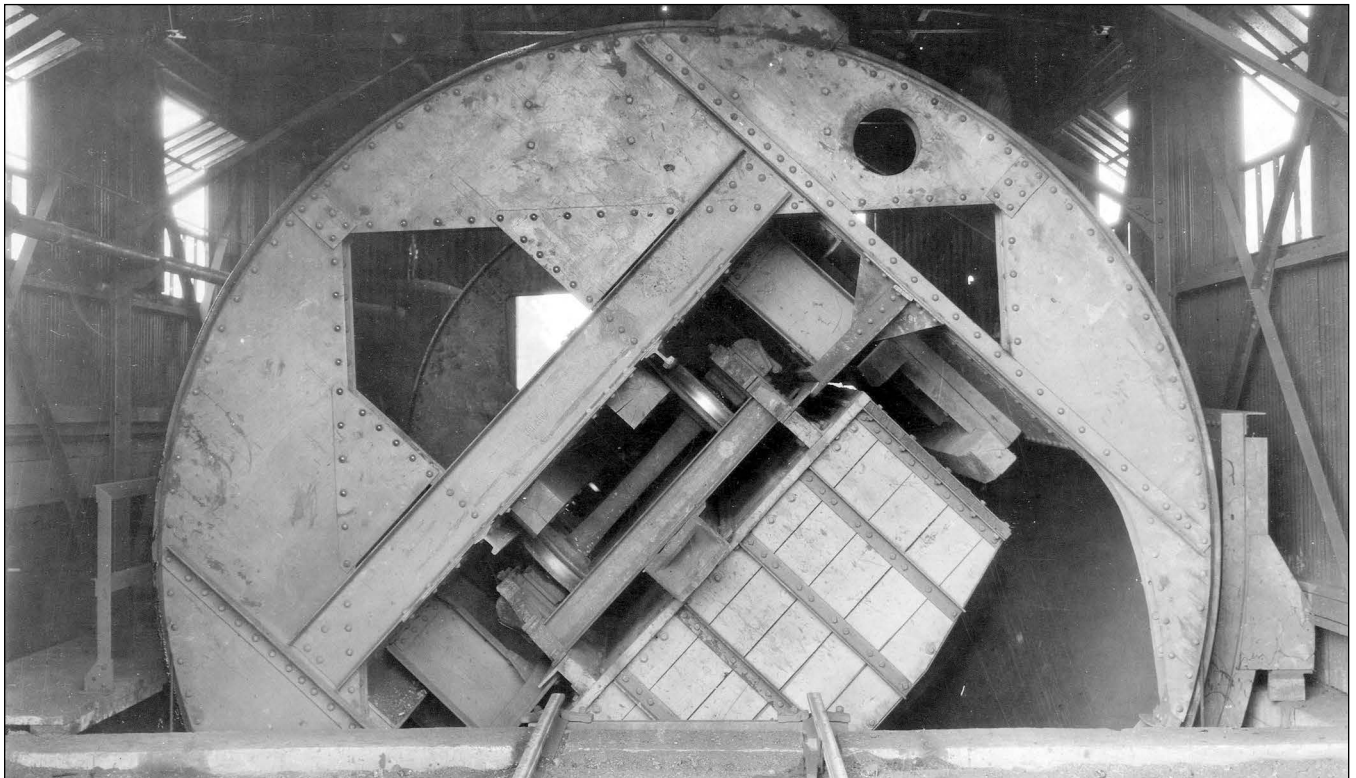
ISGS | Circa 1925

Figure 189 Black Servant Coal Company, Jackson County. Western Dump Cars made these side-emptying rail cars that efficiently dumped coal into a grating, where a conveyor could take the coal to the preparation plant for picking (removal of shale and pyrite impurities) and sorting (grading by size) before being shipped out.



Courtesy Vermilion County Museum | Undated

Figure 190 Mine and location unknown, probably Vermilion County. At this mine, the coal cars were emptied inside a shed. These cars had a mechanism underneath that hoisted one side of the car to dump out of the opposite side.



Courtesy Vermilion County Museum | Undated

Figure 191 Mine and location unknown, probably Vermilion County. These coal cars were constructed without a hoisting device underneath, and a rotary dump turned the entire car over to unload the coal. These rotary dumps were also utilized in underground mines.



ISGS | Circa 1925

Figure 192 Black Servant Coal Company, Jackson County. The Marion 350E had an 8-cubic yard bucket and a 90-foot boom, weighing in at 560 tons (Historical Construction Equipment Association 2002). The shovel shown is rail-mounted, but this model was the first that Marion fitted with crawlers (Bottomley 1944).



Courtesy Pam Cookus | Circa 1926–1930

Figure 193 Electric Shovel Coal Corporation, Staunton Mine, Vermilion County. A Marion Type 490 shovel with a 2¼-cubic yard bucket (Historical Construction Equipment Association 2002) is shown on crawlers. The underframe of the shovels had to be reinforced to mount them because less attention was given to the preparation of the roadway for a crawler-mounted shovel. The design for the underframe was made more rigid to compensate for the unequal weight distribution, and the depth of the underframe was increased (Sherwood 1943).



Courtesy Vermilion County Museum | Circa 1925–1935



Courtesy Vermilion County Museum | Circa 1935–1945

Figure 194 Harmattan Mine, northwest of Danville, Vermilion County. These two photographs are splendid examples of an explosion on film. Both pictures illustrate shooting the coal with dynamite. Coal has many joints and cleavage planes that allow it to readily break into smaller pieces. The goal of shooting coal with small charges of dynamite is to break the coal seam into evenly sized blocks of coal that can be easily loaded into railroad cars or trucks. Poorly spaced shots or an incorrect amount of explosives can result in too many fine particles or in coal pieces too large to fit in the loader's dipper.

Draglines Reintroduced

Draglines had not been used in Illinois since the Butler Brothers abandoned their machines in the early 1900s (Hollingsworth 1963), but the thick overburden in Illinois made draglines more practical than they were in Kentucky or Missouri, which had more shallow coal (Hollingsworth 1963). The poor reputation of draglines centered around the belief that a dragline required excessive shooting costs for proper preparation of the material (Bottomley 1944). Operators found that when the overburden was over 50 feet thick, a dragline and shovel working in tandem was more efficient than a shovel working alone (Williamson and Myers 1955). Figure 195 shows a small dragline (on the left, sitting on the spoil pile) in east-central Illinois. Draglines were often used in this manner, shifting material from the spoil pile further away from the working part of the pit so that the shovel could continue to deposit spoil onto the pile in deep pits. In 1928, two 10-cubic yard bucket draglines were introduced to southern Illinois at the United Electric Coal Company mine

at DuQuoin (Bottomley 1944), and a similar dragline (Figure 197) was installed in northern Illinois the same year.

The revolving dragline required a stronger base than a revolving shovel did. Although a shovel can dig anything short of solid rock and dump it either a short distance away or into a transporting vehicle, a dragline's long boom transports soft material to a permanent site. The swinging strains on the machine are higher, and the base must be more stable than a stripping shovel's base (Williamson and Myers 1955). Walking draglines, introduced to coal mining during the early 1930s, had several advantages to crawler-mounted draglines, including lower bearing pressures. Walking draglines rested on a circular base while working and had a walking device for propelling. Originally designed and built by the Monighan Company of Chicago for levee work on the Mississippi River, these machines had a lower initial cost for the equivalent range and bucket size than did crawler-mounted draglines. When the dragline was working, the

weight rested entirely on the circular base, which distributed the weight more evenly than the crawlers did. This characteristic allowed the heavy machine to rest on any surface that would bear a man's weight during excavation (Williamson and Myers 1955). The walking device, developed by Oscar J. Martinson in 1913, was a pair of pontoon-like "shoes" attached to cams in the revolving portion of the dragline. These "shoes" were drawn up while the machine worked and then were lowered to slightly lift the machine during movement. Complicated cams and piston arrangements tilted the base of the machine, raising it off the ground at an angle. At no time during the stride were the entire base and weight of the machine off the ground. The base slid in the direction of movement and gently lowered to the resting position to prepare for another stride (Williamson and Myers 1955). For a more complete description of this process, diagrams of three types of walking mechanisms are included in Keith Haddock's (2001) *Extreme Mining Machines, Stripping Shovels and Walking Draglines*.



Courtesy Vermilion County Museum | Circa 1928–1930

Figure 195 Mine unknown, probably in Vermilion County. A large rail-mounted steam shovel transfers spoil up the highwall. A smaller machine up on the spoil pile, a small crawler-mounted Marion Model 37 dragline, moves that spoil further away in a continuing effort to access deeper coal.



ISGS | 1928

Figure 196 Northern Illinois Coal Corporation, Northern Mine, Will County. The Marion 5480E electric shovel was crawler-mounted and had a 12-cubic yard bucket (Hollingsworth 1963) and weighed 975 tons (Historical Construction Equipment Association 2002). This machine also featured a three-part hoist, inside dipper stick, and rack and pinion crowd. At about this time, Bucyrus constructed Model 750-B, which had twin hoist ropes on the dipper. This model helped eliminate an old shovel problem, when one side of a dipper caught on a rock or hard spot and twisted the front end, cracking the dipper stick or warping the boom (Hollingsworth 1963). The rails extending from the rear portion of the housing are for an internal crane that aided maintenance and repairs. Doors in the back could be opened to bring in equipment (Historical Construction Equipment Association 2002).



ISGS | 1928

Figure 197 Northern Illinois Coal Corporation, Northern Mine, near Wilmington, Will County. This crawler-mounted Marion 360 Electric dragline is stripping overburden in the opening year of the Northern Mine. The 6-cubic yard dragline was used in conjunction with the Marion 5480E shovel to remove overburden (Ledvina et al. 1992).



Courtesy Vermilion County Museum | Circa 1929

Figure 198 United Electric Company, Fidelity No. 11 Mine, Perry County. (a) The Marion 5600 shovel was another advance in large machines, breaking records when it was introduced in 1929. Note the car parked in the bucket, enlarged in (b), and the rivets on the dipper stick. This was the only Type 5600 built, and it had a 15-cubic yard bucket and weighed 1,550 tons (Historical Construction Equipment Association 2002).

Productivity of Surface Mining

According to Williamson and Myers (1955):

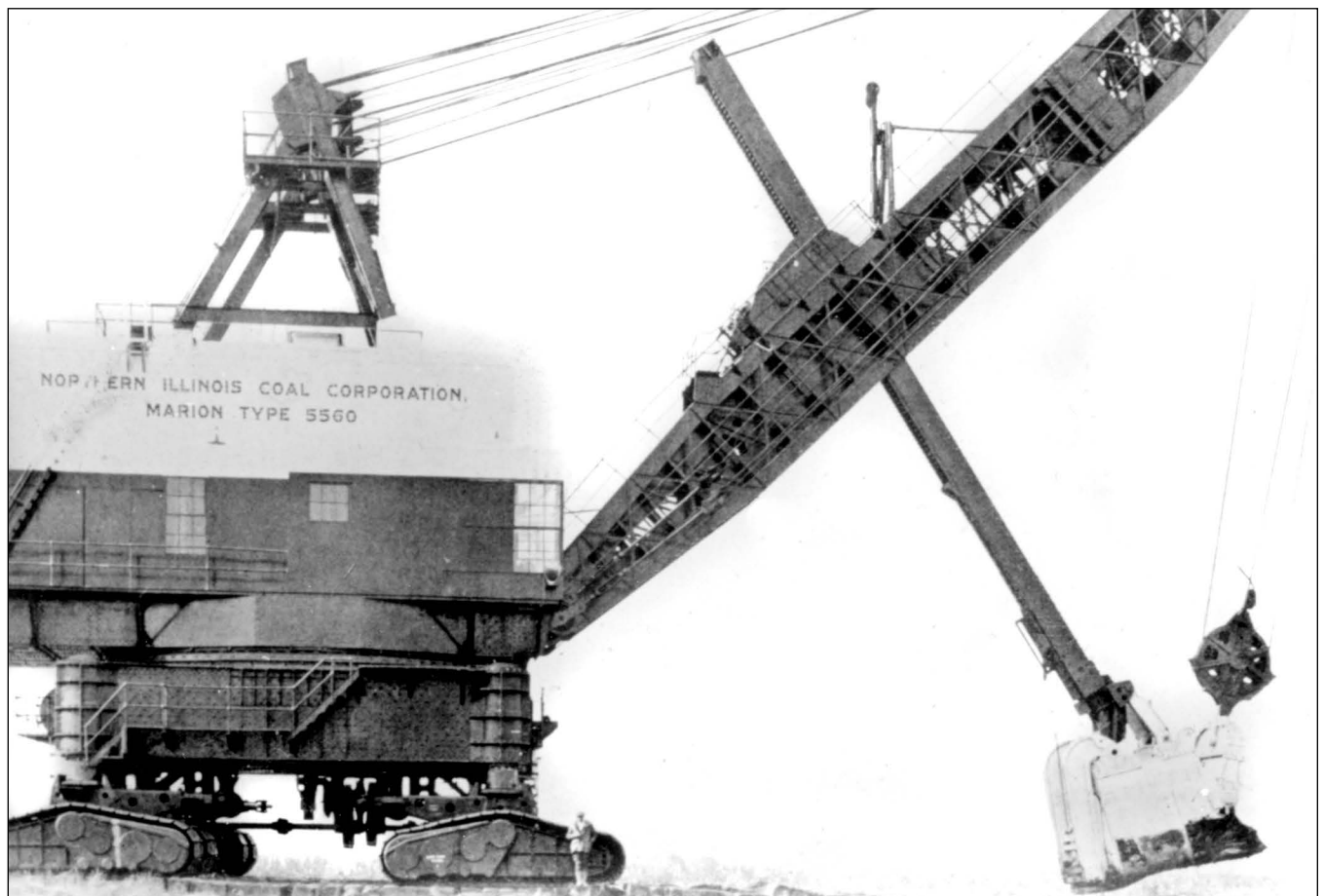
Undoubtedly the most noteworthy application of these large [surface mining] machines was in strip mining of bituminous coal. Between 1914 and 1927 the tonnage of coal produced by such mines expanded fourteen fold, while the output from underground bituminous mines rose only by about one fifth. During the same period, the average production per man-day at power-strip mines in the Nation's six main coal stripping states increased from 5 tons to 13.8 tons, while the average tonnage per man in the underground bituminous mines in the same coal fields rose only from 3.7 tons to 4.9 tons—an

improvement of 176 per cent in stripping operations as compared to 32 per cent in underground mining.

One large contribution to the massive growth in productivity was the crawler mountings that replaced rail mountings for large shovel mobility. The caterpillar traction mounting was feasible as early as 1912 for even the largest machines, but it added about 40% to the cost, and customers were unwilling to pay for the special equipment. The situation changed when Southern Phosphate Corporation ordered the crawler mountings on a Bucyrus 320-B, a 340-ton excavator with a 90-foot boom and an 8-cubic yard bucket (Williamson and Myers 1955). The 1925 cost for this machine with rail mountings was \$99,000, and an identical machine with the crawler mountings was \$137,000. Crawler

effectiveness was demonstrated when turns and position changes were shown to be reduced from 2 days to under 3 hours, saving 15% to 25% in operating time. Labor costs were cut also, as two to four pit men were eliminated, because rails and ties were no longer required. By 1927, most new strippers were mounted on crawlers (Williamson and Myers 1955).

Although the upper limit on the size of surface-mining machines had not been reached in 1927, underground machines were always limited to the height of the coal seam. The sheer size of the stripping shovels also contributed to increased productivity between 1914 and 1927. The 1914 shovels had a bucket capacity of 1 cubic yard or less; by 1927, bucket size had increased to 6 cubic yards and more, which uncovered more coal faster.



ISGS | Circa 1935

Figure 199 Northern Illinois Coal Corporation, near Wilmington, Will County. The Marion 5560 shovel, with a man standing next to it for scale, had a 32-cubic yard bucket (Sheley 1935). During the 1930s, steel alloys and aluminum were used, and the dippers were welded rather than cast, which made them lighter and stronger.



Courtesy Vermilion County Museum | 1935

Figure 200 Kedas Mine near Danville, Vermilion County. Even with the appearance of such large machines, smaller mines continued to operate as they had in the 1920s. The truck is a 1934 Ford. This photograph shows safety hazards that would never be allowed in a pit today, including the ladder on the highwall to exit the pit and the draped cable across the pit that is either an electric cable or a water sump hose.



Courtesy Vermilion County Museum | Circa 1917–1930

Figure 201 United Electric Coal Company, Vermilion County. A larger shovel in the background (only the boom and dipper stick are visible above the loading shovel) removes overburden while this shovel is used for loading.



ISGS | Circa 1936

Figure 202 Little Sister Coal Company, Little Sister Mine, near St. David, Fulton County. Bucyrus-Erie 5-cubic yard 85-B loading shovel (Williamson and Myers 1955) and Caterpillar Diesel bulldozer with Bucyrus-Erie blade working in tandem.



ISGS | Circa 1936

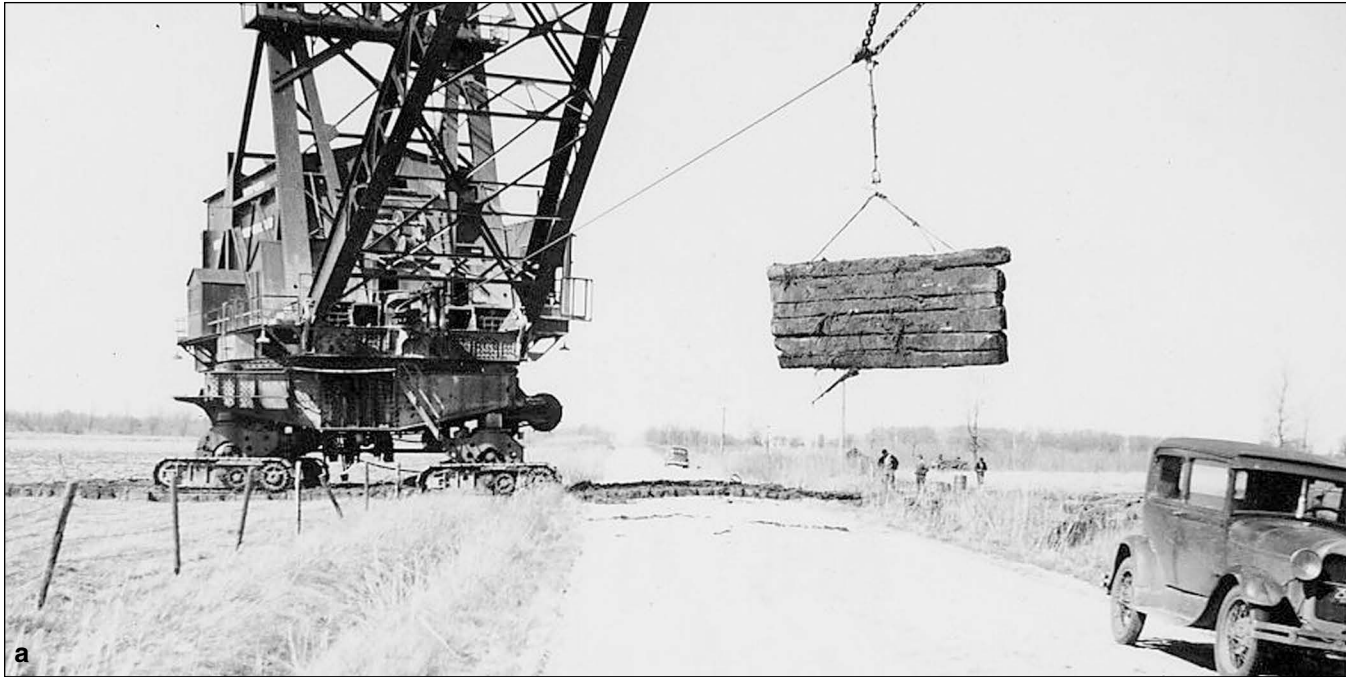
Figure 203 Mine and location unknown. A Marion 4101 loading shovel is shown loading coal into a Euclid hauling truck. A.B. McLaren of Pyramid Coal Corporation (near Marion in Williamson County) introduced truck haulage from the pit to the preparation plant in 1935 (Bottomley 1944).

Large Equipment Moves

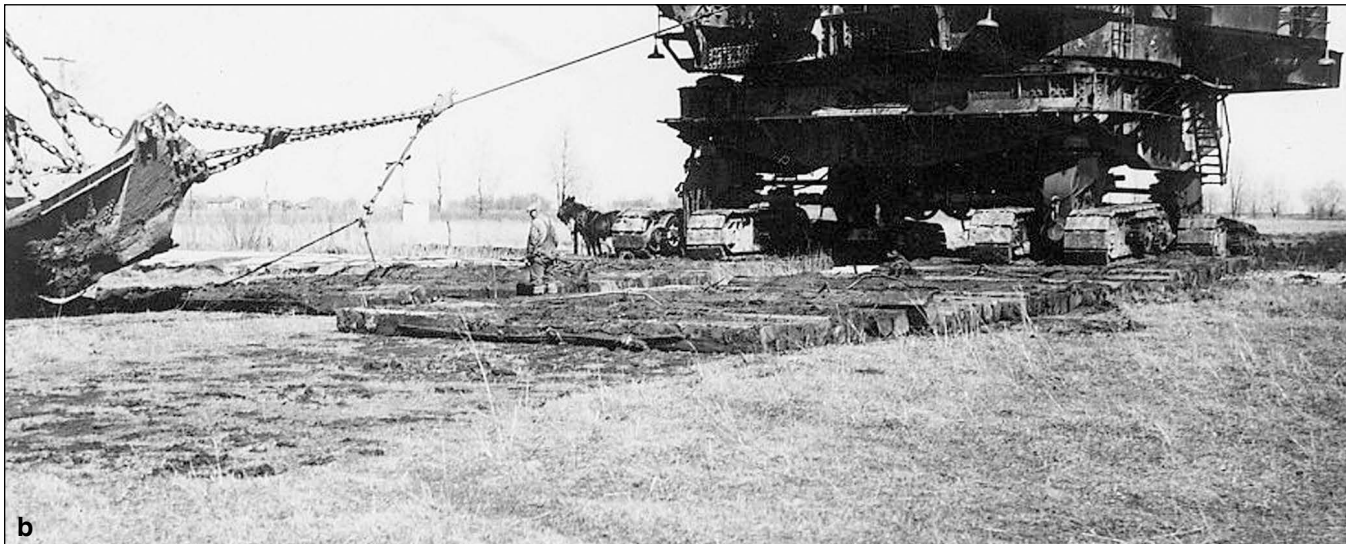
Large draglines and shovels that are constructed on site are considered life-of-mine machines, meaning they are intended to work in one mine until that mine closes, but moves of over 20 miles have been made under the machine's own power (Haddock 2001). Moving such large machines

any distance presents logistical problems that must be overcome. To move across a highway or county road requires closing the road and constructing a protective layer of dirt and gravel (usually about 6 feet thick) to protect the highway surface from cracking under the concentrated weight of the shovel or dragline (Haddock 2001). Often power lines

must be shut down and lowered or cut to let the machine through. If such a machine is sold, it is generally dismantled in the reverse order of construction. Dismantling requires a large area near the machine for these pieces to be stored until they are shipped; shipping can require more than 200 railroad cars (Haddock 2001).



Courtesy Wilmington Public Library, Charles I. Raworth Album | 1938



Courtesy Wilmington Public Library, Charles I. Raworth Album | 1938

Figure 204 Northern Illinois Coal Corporation, Northern Mine, Will County. The Marion 5480 dragline, weighing about 975 tons (Historical Construction Equipment Association 2002), could carry and lay down timbers to protect the roads and fields from the compression of this enormous weight. The timbers would distribute the weight to a larger area than the crawlers that supported the machine.



Courtesy Wilmington Public Library, Charles I. Raworth Album | 1938

Figure 205 Northern Illinois Coal Corporation, Northern Mine, Will County. The condition of the timbers after the dragline has passed over them shows that the weight is still enough to crush them and compress the soil under the machine.

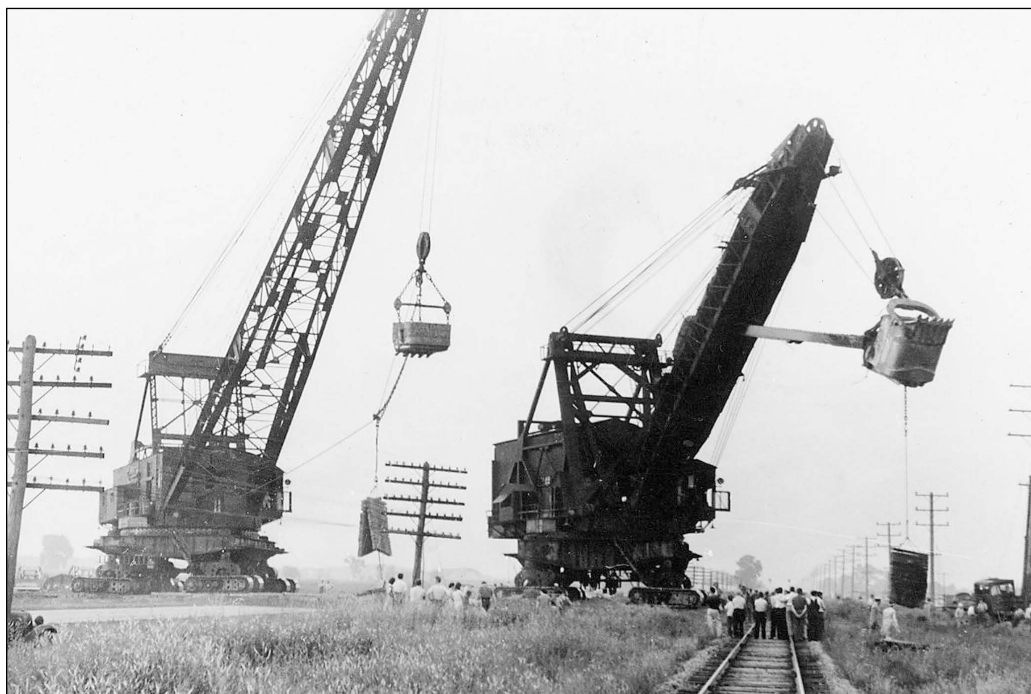


Figure 206 Northern Illinois Coal Corporation, Northern Mine, Will County. This photograph shows a more complicated equipment move, as a stripping shovel and dragline must cross numerous telephone and power lines, a railroad, and Illinois Route 53 between Godley and Braidwood. Between 2 and 3 feet of dirt and gravel beneath the timbers protect the highway surface.

Courtesy Wilmington Public Library, Charles I. Raworth Album | 1941

Major Renovations in Stripping Shovel Design

By 1935, Bucyrus-Erie had made some major renovations to their shovels, many of which are shown on the 950-B stripping shovel. A weight working in the tower at the back end of the revolving frame (in the elevator-type construction) stored energy when the dipper was lowered and added its weight to the pull of the motor when the dipper was excavating the bank. By saving mechanical power in this fashion, more work could be done with smaller electric motors (Hollingsworth 1963). This counterbalanced hoist design had been tested with Bucyrus' 750-B since 1928, but the 12-cubic yard buckets (Williamson and Myers 1955, Hollingsworth 1963) were much smaller than the 30-cubic yard welded buckets on the 950-B (Hollingsworth 1963). The welded buckets (Hollingsworth 1963) were made of steel alloys or aluminum and were stronger and lighter than riveted or cast iron buckets (Williamson and Myers 1955). This new shovel had a total working weight of about 1,550 tons (Sherwood 1943). The welded (Hollingsworth 1963) boom was over 100 feet long (Sherwood 1943) and, as with the bucket, was stronger and lighter than a riveted boom. This shovel could dump at a height of 75 feet and a distance of 115 feet from the center of rotation (Sherwood 1943), which allowed mining in deeper pits, making deeper coal accessible to surface mining techniques. The crowd machinery that thrusts the bucket into the highwall was moved onto the roof of the machine housing (Hollingsworth 1963). This change reduced the front end weight and made much larger bucket sizes practical (Sherwood 1943). This configuration is called a knee-action crowd, because the dipper handle functions much as a knee joint in a leg. The dipper handle was tubular (Hollingsworth 1963) and slid easily in the saddle block portion of the boom, which permitted the dipper handle to swivel without resistance instead of cracking

(Sherwood 1943). The twin rope hoisting mechanism (Figure 207) also was developed for the Bucyrus 750-B to counter the problem of cracked dipper sticks and warped booms when the bucket was twisted by encountering a

rock or hard spot as it was digging up the highwall of the pit (Hollingsworth 1963). Marion Shovel Company also developed a machine of this type, the Model 5560, which had an 18-cubic yard bucket (Haddock 2001).



ISGS | Circa 1937

Figure 207 United Electric Coal Company, Buckheart Mine, Fulton County. The Bucyrus-Erie 950-B was a workhorse shovel that was included in many mine plans.



Courtesy Vermilion County Museum | 1940

Figure 208 Fairview Collieries Corporation, Flamingo Mine, Fulton County. Bucyrus-Erie 950-B stripping shovel shown at work. This photograph shows the counterbalanced hoist mechanism at the rear of the housing very clearly.



ISGS | Circa 1940

Figure 209 Little John Coal Company, No. 5 Mine, Knox County. A Bucyrus-Erie 85-B loading shovel shown in the pit with a large Bucyrus-Erie shovel in the background, probably a 950-B.



ISGS | Circa 1940

Figure 210 Sahara Coal Company, No. 6 Mine, Saline County. A Bucyrus-Erie 950-B has emptied a load onto the spoil pile.



ISGS | Circa 1955

Figure 211 Stonefort Coal Corporation, Will Scarlet Mine, Saline or Williamson County. This Bucyrus-Erie 1050-B was specially designed for the Will Scarlet Mine and two-seam mining. The boom was lengthened from 113 feet to 133 feet, and the bucket size reduced from 36 cubic yards to 26 cubic yards (Dukes 1955). These modifications were needed so that the shovel could make one pass, removing 20 to 50 feet of overburden from the Dekoven Coal to the side and then removing 6 to 17 feet of overburden from the Davis Coal in front of the machine.



Courtesy Vermilion County Museum | 1944

Figure 212 United Electric Coal Company, Cuba Mine, Fulton County. This is the first wheel excavator, pioneered by Frank F. Kolbe of United Electric Coal Company. Kolbe wanted an economical method of moving a great volume of soil and shale and depositing it far enough away to prevent the spoil pile from sliding back into the pit (Hollingsworth 1963). This wheel excavator could deposit to a spoil pile 400 feet away. Bucyrus built the upper portion, which was attached to a Marion dragline base. The machine weighed about 1,000 tons and had an output of 1,000 cubic yards of material per hour. This volume is about five times that of the Marion dragline model that the base was taken from (United Electric Coal Companies 1949).



Figure 213 Truax-Traer Coal Company, Burning Star Mine, near Elkhartville, Jackson County. This photograph shows most of the important elements of a stripping operation. The overburden is removed with the large shovel visible in the distance (a Bucyrus-Erie 320-B, a 340-ton excavator with a 90-foot boom and an 8-cubic yard bucket) (Williamson and Myers 1955). The coal is moved by the smaller shovel into waiting railcars. The highwall or "face" is to the left, and the men and track are standing on the coal seam. Trucks replaced railcars in more modern surface-mining operations.

ISGS | Circa 1946

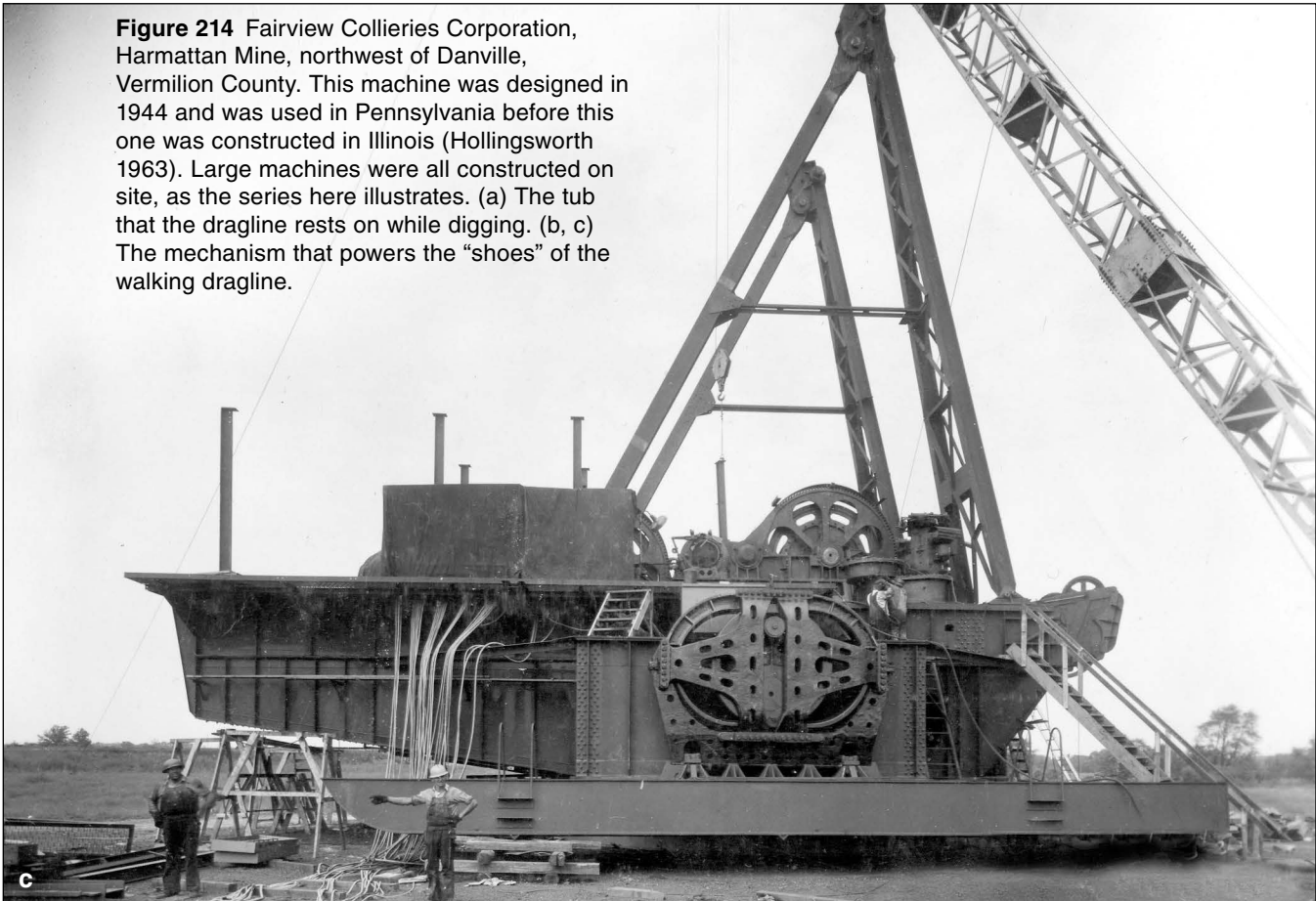


Courtesy Vermilion County Museum | July 1948



Courtesy Vermilion County Museum | August 1948

Figure 214 Fairview Collieries Corporation, Harmattan Mine, northwest of Danville, Vermilion County. This machine was designed in 1944 and was used in Pennsylvania before this one was constructed in Illinois (Hollingsworth 1963). Large machines were all constructed on site, as the series here illustrates. (a) The tub that the dragline rests on while digging. (b, c) The mechanism that powers the “shoes” of the walking dragline.



Courtesy Vermilion County Museum | September 1948



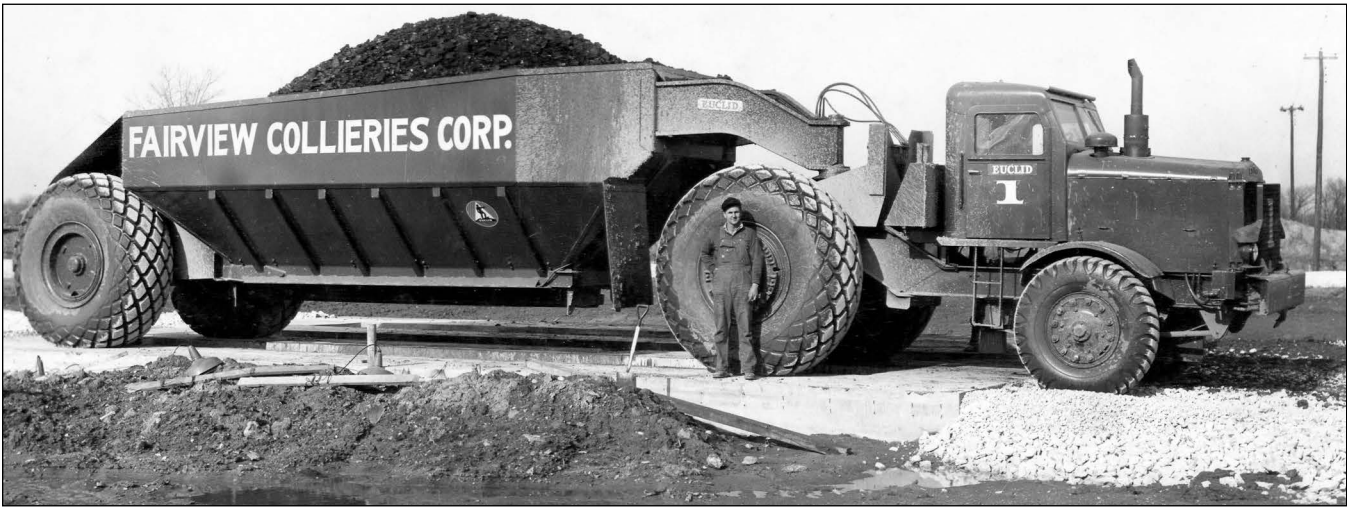
Courtesy Vermilion County Museum | October 1948

Figure 215 Fairview Collieries Corporation, Harmattan Mine, Vermilion County. The final stage of construction is to attach the boom and the bucket to the boom. Steel towers with wire rope guide lines are erected to enable raising the boom to its position against the dragline housing. To show the scale of the machine, a man is barely visible standing on the upper gantry of the boom.



Courtesy Vermilion County Museum | 1949

Figure 216 Fairview Collieries Corporation, Harmattan Mine, Vermilion County. This Bucyrus-Erie 1150 walking dragline from 1949 has a 25-cubic yard bucket on a 180-foot boom (Hollingsworth 1963). An advertisement for the machine offered a version with a 250-foot boom, although with a smaller bucket size.



Courtesy Vermilion County Museum | 1949

Figure 217 Fairview Collieries Corporation, Harmattan Mine, Vermilion County. This 1949 Euclid coal hauler illustrates one of the reasons that truck haulage gradually replaced rail haulage from the pit to the tippie or preparation plant. Rails were not required, and the labor force could be reduced. Cost for materials was also lowered, as timbers and rails were not required. By 1944, 30-ton truck-trailer units were common, and 50-ton trailers were installed at some pits (Bottomley 1944).



Courtesy Vermilion County Museum | 1949

Figure 218 Fairview Collieries Corporation, Harmattan Mine, Vermilion County. A Marion Type 4121 shovel fills a Euclid coal hauler. This shovel was the only Marion loading shovel with a knee-action crowd (Historical Construction Equipment Association 2002).



Figure 219 Little Sister Coal Corporation, Little Sister Mine, Fulton County. This Marion 5561 stripping shovel towers over the pit. The shovel had a 35-cubic yard bucket and weighed 1,675 tons. This shovel, introduced in 1940, was the first Marion shovel with the knee-action crowd (Historical Construction Equipment Association 2002).

ISGS | 1949



Figure 220 (below) Truax-Traer Coal Company, Burning Star Mine, near DeSoto, Jackson County. This Bucyrus-Erie walking dragline, probably an 1150-B, deposits spoil from the highwall to the other side of the pit (Ledvina et al. 1992). The 20-cubic yard bucket on a boom about 200 feet long did its job very well. This machine weighed 1,265 tons (Haddock 2001).

ISGS | 1951



ISGS / 1956

Figure 221 Saxton Coal Company, Newcastle Mine, Saline County. Draglines were used here instead of large stripping shovels to mine two seams in a bench operation. The upper seam is the Dekoven Coal, which is about 20 feet above the Davis Coal in this pit (Ledvina et al. 1992). The dragline in the center of the photograph is resting on the Dekoven Coal, and the shovel in the lower left is working from the top of the Davis Coal.



ISGS / 1956

Figure 222 R.C. Jennings Coal Company, Johnson County. Small operations are often called truck-and-shovel operations. They rarely have large stripping equipment, so these operations can move easily from one small parcel of land to another. The sale of coal from a small parcel is not sufficient to purchase a large stripping shovel. Large reserves and large parcels are required for the big equipment.



Courtesy Vermilion County Museum | Undated

Figure 223 Mine unknown, perhaps Harmattan Mine, Vermilion County. This photograph shows the typical configuration of surface mines in the latter half of the twentieth century. The dragline on the spoil pile rehandled the spoil so that the piles did not slide back into the pit as the shovel added material. A bulldozer cleaned the top of the coal and sometimes aided the loading shovel.



ISGS | Undated

ISGS | Circa 1958

Figure 224 Peabody Coal Company, River King Mine, near Freeburg, St. Clair County. This Marion 5760 electric stripping shovel, “Big Paul, the King of Spades,” built in 1958, was the first of three similar giant excavators to be owned or operated by Peabody Coal Company. The last, a Bucyrus-Erie 3850-B, with a 115-cubic yard bucket on a 210-foot boom, was taken out of service during the summer of 1992 when River King’s reserves were depleted. Big Paul’s 140-foot boom could load 100 tons of overburden and move it one city block away (Sheley 1935) onto a 100-foot high spoil heap. For support and mobility, this machine used four sets of dual crawlers that were connected to the frame with massive hydraulic jacks to make certain the load was dispersed equally in a horizontal direction. The enlarged portion (b) shows the hydraulic jacks and the crawlers that supported Big Paul’s 2,750-ton weight. The operator’s elevator (c) was standard on large shovels after 1956. First introduced on “The Mountaineer,” Marion’s first 5760, the elevator was in the center pin and allowed access to the moving upper deck from the stationary lower deck while the shovel was working (Haddock 2001).



ISGS | Circa 1958

Figure 225 Peabody Coal Company, River King Mine, near Freeburg, St. Clair County. According to a Marion press release, the bucket capacity for the 5760 shovel was 70 cubic yards. The man in the bucket is probably about 6 feet tall.

Figure 226 Peabody Coal Company, River King Mine, near Freeburg, St. Clair County. The loading and hauling process at the River King Mine had to avoid damaging the electrical cables of the machines. (a) One method of supporting the cable over a haulageway is shown. The Marion 5760 shovel, Big Paul, is shown behind the truck. (b) A view from the same mine, showing the rotary drilling rig on the highwall to the left making holes to insert explosives for blasting overburden.



ISGS | Circa 1958



ISGS | Circa 1958



ISGS | Circa 1958

Figure 227 Peabody Coal Company, River King Mine, near Freeburg, St. Clair County. Bucyrus-Erie 50-R rotary drilling rig making holes for explosives to shoot the overburden. The Marion 5760 stripping shovel was certainly capable of removing loose shales in situ, but even thin sandstones or limestones might have damaged the teeth on the bucket and would have slowed the process and required maintenance. The economics of surface mining required the large shovels to have the most efficient cycle of load-rotate-dump in order to move the large amounts of overburden quickly. The 50-R drilled 12-inch diameter holes (Hollingsworth 1963) that enabled better bank preparation that was vital to the large buckets. The right side of the photograph also shows the characteristic spoil pile pattern created by the wheel excavator (left, background).



ISGS | Circa 1957

Figure 228 United Electric Coal Company, Fidelity No. 11 Mine, DuQuoin, Perry County. Kolbe wheel excavator, Model W-3. Wheel excavators, first used in northeastern Illinois, are especially good at removing unconsolidated overburden or soft shales in a continuous process (as opposed to initial placement by shovel and reworking with a dragline to move the spoil back so that the shovel can deposit more). The excavators lend themselves well to reclamation laws, which specify that soil horizons must be removed individually and later replaced in the same sequence (Ledvina et al. 1992).



a

ISGS | Circa 1958



b

Figure 229 Peabody Coal Company, River King Mine, near Freeburg, St. Clair County. This is a view of the same mine shown in Figure 227, but from the other end of the pit. This Bucyrus-Erie wheel excavator is removing the unconsolidated overburden and depositing it far behind the active face of mining, which prevents the waste material from sliding back down into the pit onto the coal that is being removed. The detail shown in the enlargement (b) illustrates the supporting framework for this massive machine.



ISGS | Circa 1958

Figure 230 Peabody Coal Company, River King Mine, near Freeburg, St. Clair County. (a) The cutting head of the excavating wheel is shown. The previous cut can be seen above the head, but it is weathered, and the debris has slumped so that the characteristic curved excavation marks are not easily discernible. (b) A bulldozer working in conjunction with the bucket wheel excavator makes an efficient machine even more so.



ISGS | Circa 1958

Largest Stripping Shovel

In 1965, a unique Marion 6360 stripping shovel was engineered specifically for the Captain Mine. This shovel weighed 15,000 tons (Historical Construction Equipment Association 2002) and was the heaviest machine of any kind to move on land under its own power, even though the top speed was ¼ mile per hour. The weight of the machine dictated the design of the crawlers that supported it. The pressure of the machine on the ground had to be 60 pounds per square inch or less under the crawler pads, which meant that the individual crawler pads had to be 10 feet wide, and each weighed 3.25 tons. The dual pair of crawler mechanisms were 45 feet long and 16 feet high and required 336 crawler pads (Haddock 2001). The clearance under “The Captain”

stripping shovel allowed trucks to pass underneath, which saved the company the cost of construction of another ramp at the end of each pit. This 250-foot-high shovel had a 215-foot boom and a 200-foot dumping radius. The 180-cubic yard bucket could hoist 300 tons of material. This bucket was the only bucket to have two doors on the bottom for dumping, and each door weighed 15 tons. The Captain mined in a bench operation. It sat on the lower seam and dug 90 feet of overburden off the upper coal to the side of the shovel. The machine then dug in front of itself to remove another 25 feet of overburden from the lower coal, allowing both seams to be mined in one pass, as had been done in the Will Scarlet Mine in the 1950s. When the overburden became too thick, the world’s largest bucket wheel excavator, the Bucyrus-Erie

5872-WX, was installed in the same pit. The mine operated three other stripping shovels (capacities of 25, 40, and 65 cubic yards), seven draglines (capacity up to 100 cubic yards), four bucket wheel excavators, five coal loading shovels, 35 bulldozers, 13 scrapers, and 23 haul trucks (Haddock 2001). The Captain suffered an electrical fire in 1991 and was later scrapped (Historical Construction Equipment Association 2002). The size record stands. The second-largest machine was the Bucyrus-Erie 4250-W, a walking dragline named “Big Muskie,” which weighed 14,500 tons (Historical Construction Equipment Association 2002). This dragline had a 220-cubic yard bucket and could hoist 550 tons (Haddock 2001). This machine was owned by Central Ohio Coal Company.



ISGS / 1967

Figure 231 Southwestern Illinois Coal Corporation, Captain Mine, near Willisville, Perry County. “The Captain,” a Marion 6360 stripping shovel, broke all records for size when it was built in 1965. The Captain still holds the record as the heaviest land machine that travels under its own power.



ISGS / 1967

Figure 232 Southwestern Illinois Coal Corporation, Captain Mine, near Willisville, Perry County. This 240-cubic yard truck is being filled by a Marion loading shovel. Cabs in both front and back of the truck mean that the awkward vehicle does not have to be turned around, which could save considerable time in the confines of a narrow pit or loading facility.



Figure 233 Southwestern Illinois Coal Corporation, Captain Mine, near Willisville, Perry County. The head of the O & K (Orenstein & Koppel) wheel excavator is shown.

ISGS / Undated



Figure 234 Peabody Coal Company, River King Mine, near Freeburg, St. Clair County. This Bucyrus-Erie 3850-B stripping shovel was a heavier version of the same model constructed for Peabody's Sinclair Mine in Kentucky. It had a 200-foot boom for a 140-cubic yard bucket and weighed 9,350 tons. The parts came from the Bucyrus-Erie plant in South Milwaukee on 300 railcars. When the shovel was decommissioned in 1992, the operator, Jim Paglia, was the same man who began its career in August 1964 (Haddock 2001).

ISGS | Circa 1965



Figure 235 Midland Electric Coal Company, Elm Mine, near Victoria, Knox County. The shovel in the background is a Marion 5760 with a 60-cubic yard bucket (Historical Construction Equipment Association 2002). This model is the same as the famous shovel, "The Mountaineer," which operated in Ohio and had a 65-cubic yard bucket. The Mountaineer, built in 1955, had the first elevator for the operators (Haddock 2001). This safety feature was installed on all large shovels afterward so personnel could get to the revolving upper frame from the stationary lower frame without accident.

Heinz Damberger, ISGS | 1969



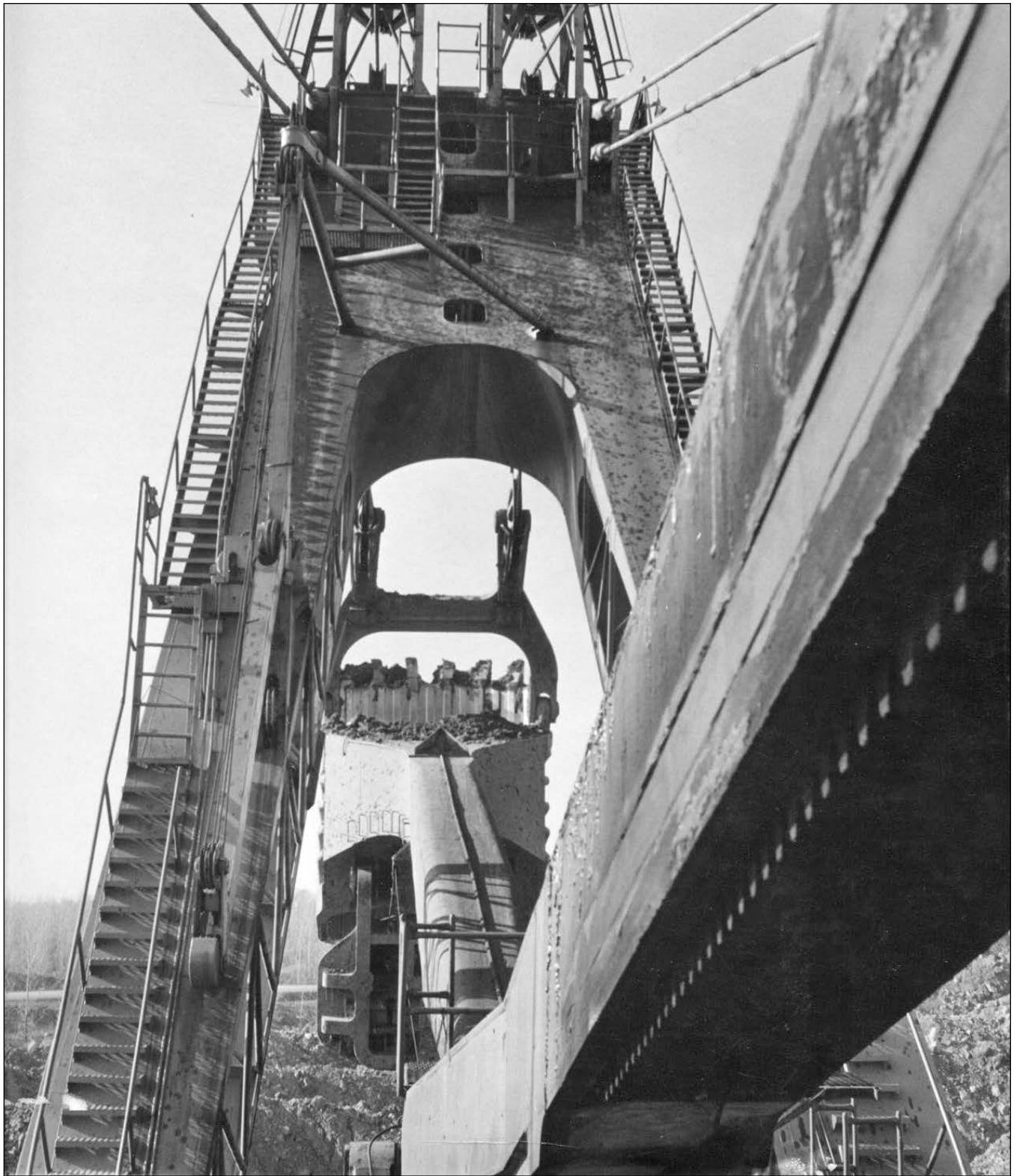
Courtesy Peabody Energy | Undated

Figure 236 Peabody Energy, mine and location unknown. This view is from the end of the boom of a large shovel.



Courtesy Peabody Energy | Undated

Figure 237 Peabody Energy, mine and location unknown. Coal mines often work 24 hours a day, 7 days a week. Surface mines are no exception. This photograph also shows the brackets used for handholds and footholds for maintenance on the bucket or dipper stick.



Courtesy Peabody Energy | Undated

Figure 238 Peabody Energy, mine and location unknown. The booms of large shovels and draglines (Marion shovel boom shown) must be accessible to maintenance crews. This is accomplished with stairs and ladders of various types.

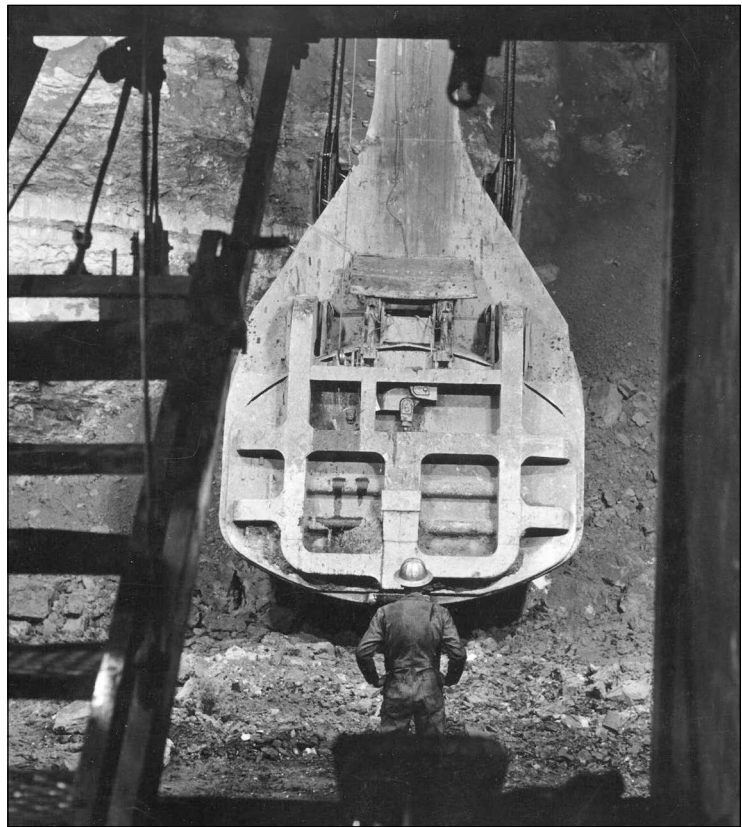
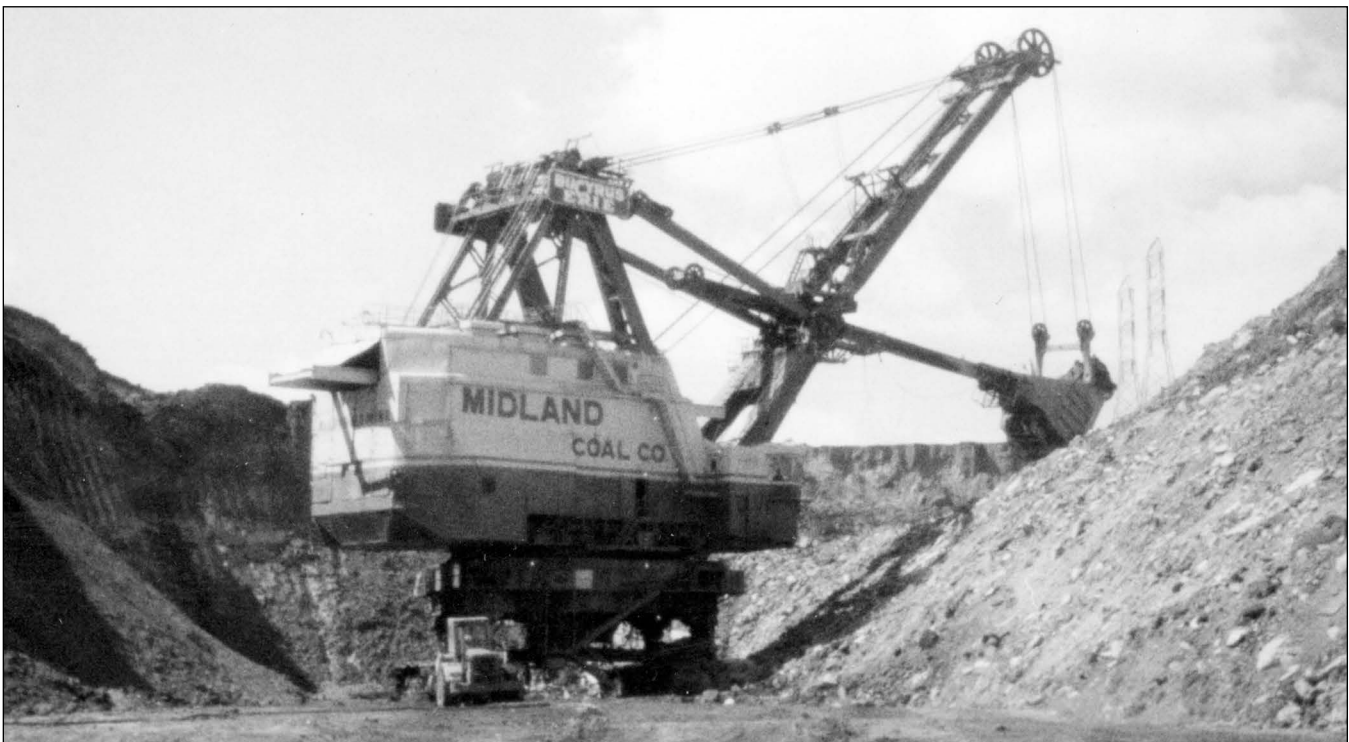


Figure 239 Peabody Energy, mine and location unknown. This view is from inside the shovel housing, showing the bucket door and its massive hinges.

Courtesy Peabody Energy | Undated



W. John Nelson, ISGS | 1976

Figure 240 Midland Coal Company, Mecco Mine, near Victoria, Knox County. The Bucyrus-Erie 1650-B shovel had a 145-foot boom and was sold with bucket sizes ranging from 55 to 70 cubic yards (Hollingsworth 1963). This shovel was probably built between 1956 and 1962. It weighed 2,100 tons (Williamson and Myers 1955).



a

W. John Nelson, ISGS | 1977



b

John T. Popp, ISGS | 1977

Figure 241 Consolidation Coal Company, Burning Star No. 5 Mine, Jackson County. (a,b) The Bucyrus-Erie 2570 dragline named “Big Muddy” had a 110-cubic yard bucket and a 330-foot boom. Note how close to the edge of the highwall these draglines work when the material under them is stable.



W. John Nelson, ISGS | 1976

Figure 242 Peabody Coal Company, Will Scarlet Mine, Saline County. This Bucyrus-Erie 1450-W dragline, with an operating weight of 2,916 tons, broke the size record for large draglines when it was introduced in 1963 (Haddock 2001).



Figure 243 Southwestern Illinois Coal Corporation, Captain Mine, Perry County. This P&H 25-cubic yard shovel has twin dipper sticks to stabilize the bucket and keep it from twisting rather than the double hoisting rope system of larger shovels. The dual ropes here only hoist at the center of the bucket.

ISGS | 1979

Decline of Surface Mining

The total number of surface mines in Illinois has been declining for a long while. In 1970, 35 of 64 operating mines were surface mines, producing 51% of the tonnage. By 2000, only one-third of the mines in Illinois were surface (6 of 18), and they produced only 12% of the tonnage. The reasons for this change are complex and varied, but the depletion of low-cost reserves is one factor—much of the “easy” coal, the relatively thick coal that was shallowly buried, has already been

mined. Another factor was the Surface Mine Reclamation Act of 1978, which greatly reduced the cost advantage that surface mining had over underground mining.

In general, recent surface mines are smaller than older mines and cover less area and use smaller, more versatile machines rather than two or three large pieces of equipment. Only two of the surface mines produced over 1,000,000 tons in 2000, the Wildcat Hills Mine in Gallatin County (1,244,915 tons) and Jader No. 4 Mine

(later I-1 Surface Mine) in Saline County (1,387,384 tons). Although surface mining is more economical than underground mining, public attitudes have resulted in some areas of the state having an unfavorable political climate for surface mining. The stringent safety, health, and reclamation laws are more affordable for large mining companies, which are not attracted to the smaller reserve blocks that hold much of the remaining surface-minable coal in Illinois.



ISGS | 1979

Figure 244 Southwestern Illinois Coal Corporation, Streamline Mine, near Percy, Randolph County. Here is an 18-story tall walking dragline, a Marion 8200. This dragline weighed 4,450 tons and could manage a 65- to 95-cubic yard bucket (Historical Construction Equipment Association 2002), depending on the type of material to be excavated. The dragline used electrical power (7,000 horsepower) equivalent to the needs of a city of 15,000 people (Ledvina et al. 1992).



ISGS | 1981

Figure 245 Amax Coal Company, Delta Mine, near Crab Orchard, Williamson County. A Bucyrus-Erie 1450-W walking dragline removing overburden. Amax reported that this machine had a 250-foot boom with a 60-cubic yard bucket.



ISGS | 1981

Figure 246 Amax Coal Company, Delta Mine, near Harco, Williamson County. A Bucyrus-Erie 3270-W walking dragline under construction towers over the surrounding countryside. The boom, still horizontal and supported by earth at this point of assembly, was 330 feet long. When the dragline was completed, the bucket held 176 cubic yards. The completed machine weighed 8,750 tons. Amax purchased the only two of these machines made, and they are still the second largest draglines ever built (Haddock 2001).



Steve Danner, ISGS | 1983

Figure 247 Arch of Illinois, Inc., Captain Mine, near Willisville, Perry County. “The Captain,” a Marion 6360 stripping shovel, was still working after 18 years.



Steve Danner, ISGS | 1983

Figure 248 Arch of Illinois, Inc., Captain Mine, near Willisville, Perry County. A Page walking dragline with a 40-cubic yard bucket removing overburden.



Steve Danner, ISGS | 1983

Figure 249 Arch of Illinois, Inc., Captain Mine, Perry County. This Bucyrus-Erie Model 2570-W dragline had a 105-cubic yard bucket on a 325-foot boom. Bucyrus-Erie sold 27 of this model after it was introduced in 1973 and later upgraded the model to a super dragline, designated by the WS extension, with larger buckets and longer booms (Haddock 2001).



Figure 250 Arch of Illinois, Inc., Captain Mine, Perry County. This rig is drilling holes to shoot the overburden to the Springfield Coal after the Herrin Coal has been mined.

Steve Danner, ISGS | 1983

Blasting and Explosives Used in Surface Mining

The type of excavation machine dictates the amount of fragmentation of the overburden material that is required to work the machine to its optimum capacity. Blasting procedures, such as hole spacing and hole diameter for the explosives, are governed by the amount of fragmentation required and the type of overburden. Holes for the explosives may be drilled vertically from the top of the highwall down into the overburden or horizontally from the pit into the highwall. Other factors in the choice of horizontal or vertical drilling for blasting include the stability of the slope of the highwall, the depth of overburden, the width of the pit, and the degree of pit congestion with equipment for coal and overburden removal. If the pit is large and not congested with other equipment, horizontal drilling may be more efficient because no road building is required and the drilling depth is less. Vertical drilling may be more effective and efficient when the pit traffic is high or the overburden is thick. Explosive energy follows the

path of least resistance, and the upper portion of the highwall may not break properly with horizontal drilling (Phelps 1973).

Dynamite and other high explosives were used in early surface mining to shoot the highwall, preparing the overburden for faster loading by draglines and shovels. Liquid oxygen absorbed in carbon (LOX) was developed about 1927 as an effective, inexpensive and safer substitute for dynamite. However, LOX was highly flammable and sensitive to impact. The even less expensive ANFO (ammonium nitrate mixed with fuel oil) was so effective that most operators switched eagerly to that new blasting agent (Malesky 1973). The ANFO was much safer, was more easily prepared, and would not detonate without a primer. For extremely hard formations, high-velocity explosives are required to get greater fragmentation. Aluminum slurry mix, gelatin explosives, or dynamite may be used for a thick limestone bed (Phelps 1973).

Packaged ANFO is generally used with horizontal drill holes, whereas

for vertical drill holes the ANFO is mixed and loaded on site. Blasting caps and detonating fuses are used to set off the ANFO with an initial detonation velocity in excess of 16,000 feet per second; a lower-order detonation would produce a burning action rather than an explosive action. Vibration is reduced with the use of millisecond delay lines in the fuse. Slight delays between hole detonation also results in better fragmentation of the material because it provides room for expansion needed by the subsequent shots. A well-designed series of hole placement, delay lines, and charges can result in a method of blasting sometimes termed "cast blasting," where much of the overburden is moved by the force of the explosions to the other side of the pit, reducing the amount the shovel or dragline must move. If several hard layers are present in the overburden, the explosives can be "deck loaded"; that is, a charge is placed in each hard layer (such as limestone), and the remainder of the hole is tamped (filled) with dirt (Phelps 1973).



Steve Danner, ISGS | 1983

Figure 251 Arch of Illinois, Inc., Captain Mine, near Willisville, Perry County. Horizontal drill holes were often used to shoot the overburden from the coal in Illinois surface mining. At the Captain Mine, these holes were drilled 60 feet into the highwall about 3 feet above the Herrin Coal, ordinarily in the Brereton Limestone.



Steve Danner, ISGS | 1983

Figure 252 Arch of Illinois, Inc., Captain Mine, near Willisville, Perry County. This photograph shows the hydraulic-powered dozer attachment that loads ANFO into horizontal drill holes.



Steve Danner, ISGS | 1983

Figure 253 Arch of Illinois, Inc., Captain Mine, near Willisville, Perry County. Tubes of prepackaged ANFO for shooting overburden were brought to the pit, ready to install into horizontal drill holes.



Steve Danner, ISGS | 1983

Figure 254 Arch of Illinois, Inc., Captain Mine, near Willisville, Perry County. Bucket wheel excavators were useful for reclamation because they could remove discrete layers of soil or subsoil and deposit it a much greater distance from the highwall than draglines or shovels could, which reduced the cost of reclamation. However, bucket wheel excavators could only be used for overburden that had very few rocks because rocks damaged the buckets and conveyors.



Steve Danner, ISGS | 1983

Figure 255 Arch of Illinois, Inc., Captain Mine, near Willisville, Perry County. This conveyor transported subsoil dug by the bucket wheel excavator. These Weserhütte conveyors transferred material from the wheel excavator to the around-pit conveyor system. The belt for the around-pit conveyor was almost 2 miles long.



Figure 256 Arch of Illinois, Inc., Captain Mine, near Willisville, Perry County. The O & K wheel excavator moves forward and takes a semicircular “bite” out of the subsoil or glacial drift. The material is then transferred to the Weserhütte conveyor to be evenly deposited onto the around-pit conveyor belt system.

Courtesy Dean Spindler, Illinois Department of Natural Resources | Circa 1980–1984



Courtesy Dean Spindler, Illinois Department of Natural Resources | Circa 1980–1984

Figure 257 Arch of Illinois, Inc., Captain Mine, near Willisville, Perry County. The large shovel in the center of the photograph is “The Captain.” This photograph shows how reclamation was an integral part of the mining plan. The wheel excavator prepares an area to be mined by removing the subsoil and glacial deposits. These deposits are then transported with the around-pit conveyor to the reclamation area above the shovel (upper right). This efficient technique was developed by the previous owners of the Captain Mine, Southwestern Illinois Coal Company, which practiced reclamation in the 1930s, long before it was required by law.



Courtesy Robert Dunker, Illinois Department of Natural Resources | Circa 1980–1984

Figure 258 Arch of Illinois, Inc., Captain Mine, near Willisville, Perry County. The conveyor shows a part of the around-pit conveyor, unique in Illinois, returning empty to the wheel excavator. The belt could travel at 950 feet per minute.



Figure 259 Arch of Illinois, Inc., Captain Mine, near Willisville, Perry County. The Weserhütte conveyors transferred material from the around-pit conveyor to the Mitsubishi conveyor spreader. In this photograph, the Mitsubishi conveyor is stockpiling topsoil.

Courtesy Dean Spindler, Illinois Department of Natural Resources | Circa 1980–1984



Steve Danner, ISGS | 1983

Figure 260 Arch of Illinois, Inc., Captain Mine, near Willisville, Perry County. The Mitsubishi conveyor spreader swung slowly from side to side, depositing the subsoil in an arc onto the rock spoil. Very little grading was required before the topsoil was deposited on top of the subsoil.



Steve Danner, ISGS | 1983

Figure 261 Arch of Illinois, Inc., Captain Mine, near Willisville, Perry County. The Captain Mine generally used 120- to 150-ton capacity haulage trucks, such as this Rimpull hauler.



Heinz Damberger, ISGS | 1989

Figure 262 Freeman United Coal Companies, Industry Mine, McDonough County. This 2,000-ton bucket wheel excavator removed subsoil and deposited it directly onto the rock spoil pile for reclamation. The Industry Mine collected the topsoil into piles with bulldozers and scrapers and moved the topsoil piles with the bucket wheel excavator as well. This process avoided excessive rehandling of the topsoil material. In 1993, yields on reclaimed prime farm land exceeded requirements. This bucket wheel excavator was still operating in 2003 and was the last operating bucket wheel excavator in the United States. At the far right, a vertical drill made holes for blasting on the part of the highwall that had subsoil removed.



Scott Elrick, ISGS | 2003

Figure 263 Freeman United Coal Companies, Industry Mine, McDonough County. This Bucyrus-Erie 1050-B stripping shovel had a 45-cubic yard bucket and was purchased in 1960 (Haddock 2001). This shovel was the last operating stripping shovel in Illinois. The mine closed the month after this photograph was taken. Parts of the bucket wheel excavator can be seen behind the shovel.



Alan Myers, ISGS | 2004

Figure 264 Vigo Coal Company, Wabash County. In current surface mining, the machines used look like machines at any construction site —shovels, trucks, and bulldozers. The equipment on the highwall is removing overburden without the aid of giant stripping shovels and draglines. The Caterpillar D11R in the foreground has a bulldozer blade on the front, and the rear has a tool to rip the coal into large blocks.

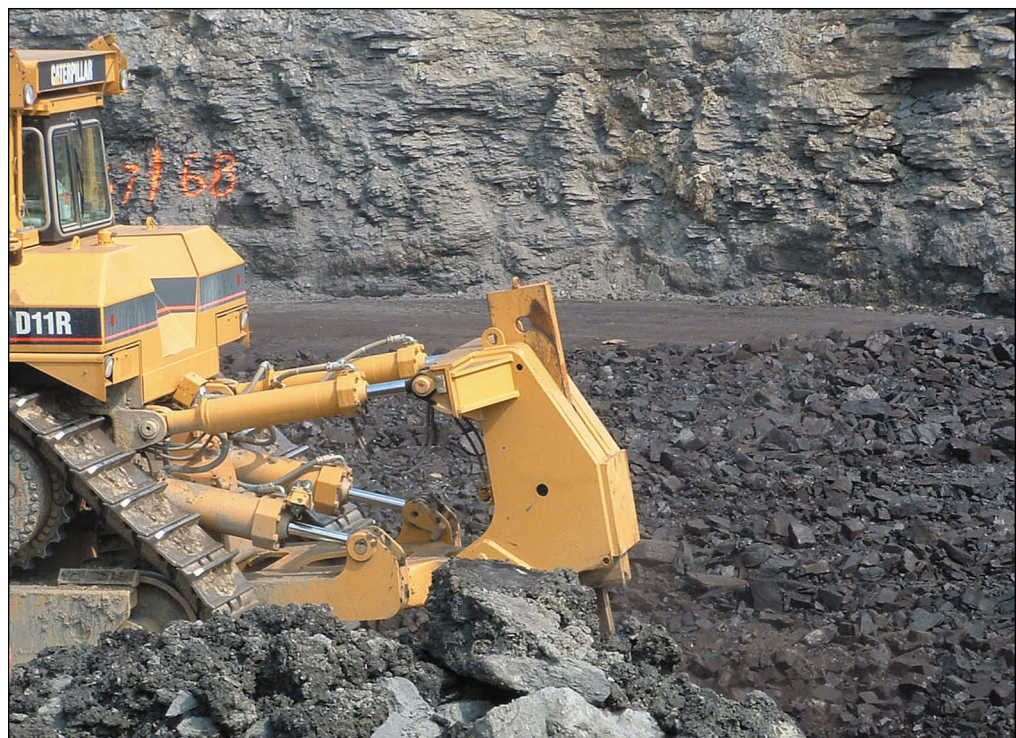


Figure 265 Vigo Coal Company, Wabash County. This Caterpillar D11R ripper attachment works like a chisel plow, breaking the coal into blocks suitable for loading. Explosives are not required to break the coal up in an operation with these machines.

Alan Myers, ISGS | 2004



Alan Myers, ISGS | 2004



Alan Myers, ISGS | 2004

Figure 266 Vigo Coal Company, Wabash County. (a) The blocks of Friendville Coal are shown after the machines have broken them away from the seam. This is the only location in the state where this coal has been mined. (b) A large Rudd haul truck is used to transport coal in truck-and-shovel operations.



a

Alan Myers, ISGS | 2004

Figure 267 Vigo Coal Company, Wabash County. (a) This caterpillar wheel loader is one of three types used at this mine. (b, c) The Rudd-Hitachi EX1100 loader has a versatile bucket that swings 180 degrees.



b

Alan Myers, ISGS | 2004



c

Alan Myers, ISGS | 2004



Alan Myers, ISGS | 2004



Alan Myers, ISGS | 2004

Figure 268 Vigo Coal Company, Wabash County. The Hitachi EX3500 loading shovel in the background (a) has a novel method of dumping, lifting the bucket away from its base (b). The protective canopy on the haul truck is also shown (b). In the rush to load, the shovel operator may overshoot the bed of the truck, but with the reinforced canopy above the truck operator, any damage is minimized.



Alan Myers, ISGS | 2004



Alan Myers, ISGS | 2004

Figure 269 Vigo Coal Company, Wabash County. Construction and maintenance of haulage roads out of the pit is a major enterprise. The slope is dictated by the power of the trucks; switchbacks are inserted so that no segment will exceed the allowable slope.



a

ISGS | 1956

Auger Mining

After surface mining to the point where overburden removal is uneconomical, a small amount of coal can be mined with the use of augers. Auger mining was pioneered in 1947 in West Virginia (Poindexter 1955). Auger mining can be cost effective because the haulage ways already exist from the previous surface mining (Guthrie 1952). Figure 270a shows the cutter head that precedes the auger into the hole and cuts the mined coal away from the surrounding coal. This process also breaks the coal up so that the auger can push the mined coal back to the surface to be shipped. The augers are produced in 6-foot lengths that can be easily transported and fastened end-to-end so that coal can be churned out of the ground for a horizontal depth of 280 feet (Guthrie 1952). A 200-foot cutting depth with a 38-inch diameter cutting head yields about 64 tons of coal (Bullock 1955). Coal recovery with augers generally averages only 35% of the coal left in the highwall. The low cost of production is the major factor in favor of augering (Phelps 1973).



b

ISGS | 1956

Figure 270 Richardson Coal Corporation, No. 1 Mine, near Leamington, Gallatin County. Auger mining in progress.



ISGS | 1976



ISGS | 1976

Figure 271 Lee Coal Company, Vermilion County. As photographs (a) and (b) show, little change in auger mining equipment occurred during the twenty years separating this operation from that shown in Figure 270.



a

Alan Myers, ISGS | 2004

Figure 272 Illinois Fuels Company, LLC, I-1 Underground Mine, Saline County. The most common manner of accessing deep coal off the highwall in Illinois was to open a drift mine and work the coal in the usual underground mining pattern. The corrugated metal arches shown in the photographs protect people and equipment near the opening from rocks falling from the highwall. Photograph (b) shows the conveyor carrying the mined coal out of the mine.



b

Alan Myers, ISGS | 2004



Alan Myers, ISGS | 2004



Alan Myers, ISGS | 2004

Figure 273 Illinois Fuels Company, LLC, I-1 Underground Mine, Saline County. Drift mines go directly into the coal from the surface without the need for a shaft to get down to the level of the coal. (a) The timbers on the left support steel I-beams that in turn support the roof. The machine shown in photograph (b) is a scoop tram, similar to a front end loader. This low-profile vehicle has an open bucket on the front, with a ram to aid unloading by pushing the coal out the front again when it is stopped at a coal transfer point. Other techniques for underground mining are described more fully in the previous section of this report.



Courtesy Dean Spindler, Illinois Department of Natural Resources | 2004



Courtesy Dean Spindler, Illinois Department of Natural Resources | 2004

Figure 274 Knight Hawk Coal, LLC, Creek Paum Mine, Jackson County. The Superior Highwall Miner deploys a continuous miner up to 1,000 feet into the highwall of a surface mine while the operators work above ground (Schafer 2002). Conveyors attached to the continuous mining machine carry the coal to the surface. (a) The entire miner is shown. The reel on the left contains the hose reel assembly, which holds electric power and methane sensor cables. Behind the machine are stacks of pushbeams that attach directly behind the continuous miner. The pushbeams have an internal pair of 18-inch augers to shift the coal to the conveyor belt (shown at right), which protects the coal from out-of-seam dilution, such as shale falling from the roof into the mined coal. (b) The interlocking portion of the pushbeams; this portion requires a forklift working with the highwall miner.



Courtesy Dean Spindler, DNR | 2004

Figure 275 Knight Hawk Coal, LLC, Creek Paum Mine, Jackson County. The ripping-type continuous miner portion of the Superior Highwall Miner progressing into the seam. A chain conveyor in the center of the cutting head gathers the coal and sends it back to the augers in the pushbeams.



Courtesy Robert D. Gibson, DNR | 2004

Figure 276 Mine and location unknown, Ohio. This photograph shows the distinctive rectangular opening made by the ripping-type continuous miner. The Superior Highwall Miner precisely monitors position to keep the continuous miner properly aligned so that the designated pillar width is left between excavated rooms.

Reclamation

Many early mines in the Missionfield District flooded because of their proximity to the Vermilion River. If the cost was too high, or the company had already mined most of the coal, the pit was abandoned. At that time there were no laws requiring reclamation, or cleanup, and sometimes the machines were left in place and allowed to rust. The Open Cut Land Reclamation Act was passed in 1961 after 30 years of attempts by the state legislature. Illinois produced 85% of the total surface-mined coal in the United States at that time and was the only state with no reclamation regulations; Indiana had been operating under regulations for 20 years. Approximately 60% of the surface-mined land was voluntarily reclaimed, but the remainder was

a “black eye on the entire industry” (Weber 1962). This reclamation act went into effect in 1962, thus initiating a permitting process for all surface mines with more than 10 feet of overburden, whether the mined material was clay, limestone, gravel, or coal. Permits were required for mining, and a valid reclamation plan had to be provided. The mine operator could choose the type of subsequent land use, but ridges and peaks had to be graded so that they were a minimum of 10 to 15 feet wide, and the land was to be seeded. Reclamation was administered by the Department of Conservation to ensure compliance. The Act did not include provisions for refusing a permit to mine once the requisite bonds and fees were supplied (Weber 1962). In 1968, the Surface Mined Land Reclamation Act added a buffer zone between the

mine boundary and roads and buildings. A more thorough overhaul of reclamation regulations was instituted in 1971 with the Illinois Surface Mined Land Conservation and Reclamation Act. This act required the public filing of reclamation plans with the county clerk, a waiting period, and public hearings before mining permits could be granted. This Act was amended in 1975 to include requirements for soil productivity, so that soils capable of supporting row crops had to be restored to that capability. A federal act soon followed that allowed an exemption: soils that were capable of but had not historically been in use for row crop production did not have to be restored to prime farmland capability (Illinois Department of Natural Resources, Office of Mines and Minerals, undated).



Courtesy Vermilion County Museum | Undated

Figure 277 Missionfield District, perhaps Kickapoo State Park, Vermilion County. A shovel is shown abandoned in an old surface mine.

Differences in state and federal mining regulations were reconciled in 1980 with a new Surface Coal Mining Land Conservation and Reclamation Act that was approved by the U.S. Department of Interior. This Act required monthly inspections at all active mine sites and spot inspections from the Federal Office of Surface Mining, Reclamation and Enforcement. Operators also had to comply with the Clean Air Act, Clean Water Act, Federal Coal Mine Health and

Safety Act, Endangered Species Act, Resource Conservation and Recovery Act, and many other legislative initiatives. This regulatory program is administered by the Illinois Department of Natural Resources, Office of Mines and Minerals. The present permitting process is more rigorous and requires a pre-mining inventory that includes, but is not limited to, gathering data on surface and groundwater quality; soil

type, depth, and quality; existing land uses; major plant communities; physical and chemical properties of the strata including the coal seam; and archeological sites. Reclamation plans must be included in the request for a permit to mine along with bonds and fees. Permits may be denied. Provisions for public notifications and hearings are spelled out (Illinois Department of Natural Resources, Office of Mines and Minerals, undated).

Figure 278 Mine and location unknown. This 1960 spoil pile shows the appearance of unreclaimed surface-mined lands before reclamation laws took effect. Current laws require that overburden be graded within 180 days of coal removal and that no more than four ungraded spoil ridges should exist behind the active pit (Illinois Department of Natural Resources, Office of Mines and Minerals, undated).



ISGS | 1960

Figure 279 Freeman United Coal Company, Crown No. 1 Mine refuse pile, Montgomery County. Grader and bulldozer smooth out an area under reclamation. Graders and scrapers are necessary tools for removing and stockpiling topsoil and subsoil and for dispersing these soil materials during the reclamation process.



Courtesy Abandoned Mined Lands Reclamation Council | 1992



Courtesy Southern Illinois University | 1980

Figure 280 Mine and location unknown. Planting trees by hand in reclaimed land. Reclamation plans and post-mining land use must be approved before the permit to mine coal is approved.



Figure 281 Arch of Illinois, Captain Mine, Perry County. With the new reclamation laws, coal companies required scrapers, bulldozers, and other equipment suitable for handling the soil layers and the more agricultural post-mining phase, as they had to show three years of productivity for prime farm land comparable to pre-mining productivity (Illinois Department of Natural Resources, Office of Mines and Minerals, undated).

Courtesy Southern Illinois University | 1986



Courtesy Abandoned Mined Lands Reclamation Council | 1990

Figure 282 Amax Coal Company, Sunspot Mine, Fulton County. Top soil and subsoil are replaced in their natural order in reclaiming mined land. To prevent soil erosion and re-establish soil structure and porosity, wheat or oats are planted, followed by a grass and legume mix (Illinois Department of Natural Resources, Office of Mines and Minerals, undated).



Courtesy Southern Illinois University | 1986

Figure 283 Black Betty Coal Company, Indiana. Row crops established in reclaimed land. The full bond posted by the mining company is not released until the land is capable of supporting the approved land use. In the case of high-capability prime farm land, the topsoil must be a minimum of 8 inches thick, and productivity is compared to a yield at a high level of management (Illinois Department of Natural Resources, Office of Mines and Minerals, undated).

Conclusion

Old mining photographs are intriguing to many people. Most are more than memorabilia. These historic mining photos contain clues to the process and often to the age of the photograph. Most were taken for a reason, either pride in new technology or to record a benchmark of a larger shovel, faster transport of workers to the face instead of walking, or safer methods to support a roof. The process of mining coal has changed very little over the last 100 years—it's just that machines now do most of the things that were done by hand. When the process is understood, most of the photographs take on new meaning. The viewer then knows what happened before the photograph was taken and what likely would happen afterward. Most of the people who worked with the older machines are gone, either retired, deceased, or otherwise unavailable. This document was made to record as much as is known about these photographs and to make them available to others.

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