CHAPTER 2.—OVERVIEW OF THE UNDERGROUND ENVIRONMENT AND STUDY SETTINGS

This chapter details the perspective from which collected data have been examined. The first part, intended primarily for lay readers, discusses several topics related to mining as an enterprise. Initially, the organizational functioning of a typical large mine will be described. It is the formal structure above a miner that decides the conditions of his or her work. A second point of concern is the technology itself. An underground coal mine is a sociotechnical system, with workers and machines organized in particular ways during production. Third, general conditions and dangers underground will be described in detail. The physical environment of an operation is a powerful factor in the work life of miners. Fourth, a discussion of the process of formal training is given. During this training, a new worker is taught what the organization expects of him or her in the role of safe, productive, coal miner. Next, there are outside organizations that act as significant forces in the workplace. Examples include the Mine Safety and Health Administration (MSHA), State agencies, and the United Mine Workers of America (UMWA). The roles of these entities will also be examined. The second part of this chapter will depict each study site as a concrete setting, so that findings can be interpreted in their proper context.

The Organizational and Technical Nature of Mining

A coal mine is a complex system. It is defined as all parts of a mining plant's property (both underground and surface) that contribute, under one management, to the extraction or handling of coal [American Geological Institute 1997]. As suggested, many functions that must be carried out at an operation are only indirectly related to coal mining and processing. Even the jobs that are directly related tend to be numerous and varied [Wallwork 1981]. According to Palowitch [1982], the chief reason for this sophistication is that "after more than two centuries of exploiting our coal resources, today's coal industry finds itself saddled with a horrendous legacy of human impairments and environmental damages which society demands be corrected." Now, the effects of government regulation are evident in every aspect of the mining industry. Any operation, if it is to survive, must be administered with an eye for social efficiency and accountability.

Long-range planning is needed to ensure that the mine produces coal in a cost-effective manner. One of the first things that must be considered is location and method of access. To extract coal from an underground mine, a coalbed (or "seam") must be reached from the surface. The term "portal" is generally given to any entrance that provides access to a coal mine. In hilly terrain, such as is found in Appalachia, the coal may "outcrop" on a hillside. This allows direct entry to the coal seam via a horizontal tunnel ("drift") opening. At other locations where there is no outcrop, it may be possible to open a "slope" tunnel that angles down from the surface and intersects with the coal seam. If the seam is too deep for a slope to be feasible, a "shaft" must be constructed. This shaft, which may be 20 ft or more in diameter, is opened vertically from the surface to the coalbed and allows access via a large elevator.

During long-range planning there is a general focus on such essentials as equipment type, deployment, utilization, and haulage. Laying out a mine also involves auxiliary factors including ventilation arrangements, roof support plans, power distribution, and communications. All of these planned systems are incorporated into a "projection map" that is developed by a team of technical specialists. This team will include, at various times, mining engineers, electrical engineers, industrial engineers, and company geologists, among others. The mine map serves the same purpose for a person running an operation that an architect's blueprint serves a building contractor. It provides an overview of the project, shows where features should be located, helps management direct crews effectively, and serves as a tool in the planning of everything from maintenance schedules to capital expenditures for major equipment purchases.

Responsibility for translating the long-range plan into day-to-day operations belongs to a mine superintendent. This person is in charge of the overall mine complex, including surface facilities. An assistant superintendent helps the superintendent perform his duties and at some sites oversees all underground operations. At least one general mine foreman reports to the assistant superintendent. This individual directs day-to-day underground operations. For each working shift at the mine, there is at least one shift foreman ("shift boss") who reports to the general mine foreman. The shift boss is in charge of mining-related activities including coal extraction and service work. Each production crew in the mine is placed under the direction of a section foreman ("face boss") who manages mining operations on his or her section and who reports to the shift boss. There are also supervisors who oversee specialized support work underground. These foremen manage (1) maintenance, (2) belt installation, (3) supply activities, and (4) track laying and repair. All of these individuals report to the shift boss or the general mine foreman.

The long-range plan provides structure for a superintendent's short-range planning. If coal is to be mined productively, it must be obtained systematically. This requires the integration of several weekly plans into a smooth limited projection. One of the most important functions of a superintendent and his subordinates is to maintain an effective extraction cycle at the point of production. To do this extraction, plans must incorporate the following factors: (1) a determination of the shift for each section at which coal production will take place, (2) a decision about when the section will be idled so that belt and power moves can be made, (3) the scheduling of regular equipment maintenance, (4) provision for special projects such as the installation of belt head drives, and (5) preparation for any tasks that cannot be accomplished during regular workdays, such as shutting down and repairing the ventilation fan. The better a mine superintendent is at planning for and taking care of all of these details, the more smooth-running and efficient an operation will be.

After entering their portal and reaching the underground workings, a typical production crew will board a self-propelled personnel carrier known as a "mantrip" and travel to their "working section." This is where coal is extracted, and may be miles from the portal. "Working faces" are the individual places on a working section where mining activities take place. Here, sets of parallel tunnels ("entries") are driven through the coal seam following a predetermined plan developed by a mining engineer. Mine entries are 16 to 20 ft wide and as high as the coal seam is thick. The number of entries being mined in a working section varies from 2 to 10 or more depending on many factors. As parallel entries are developed, they are connected by perpendicular tunnels ("crosscuts"). Like entries, crosscuts are also usually 16 to 20 ft wide and as high as the coal seam is thick. Crosscuts, or "breaks" as they are sometimes called, allow workers and equipment to move between and among the entries. The walls of entries and crosscuts are called "ribs," while the ceiling above is called the "roof" or "top." The mine floor is typically called a "bottom."

As coal is mined, a working section advances toward the boundaries of the coal property. This advancement is generally known as "development mining" and follows a "room-and-pillar" mining plan. With a room-and-pillar plan, entries and crosscuts are opened through the seam while large blocks of coal ("pillars") are left in place to help support the mine workings. In the United States, most development mining following a room-and-pillar plan uses "continuous mining" technology. Work crews on a continuous mining section are usually composed of 8 to 10 individuals. A typical crew might consist of (1) one face boss, (2) one continuous miner operator and a helper, (3) two roof bolting machine operators, (4) two shuttle car operators, and (5) one mechanic. These workers perform two operation cycles at the working face that include (1) cutting and loading of coal and (2) support of the mine roof above the entry or crosscut.

With continuous mining, operations progress sequentially at each face on a working section. First, an area from which coal has already been extracted (commonly called a "cut") must have its roof supported. The roof is "bolted" by one or two miners who operate a "roof bolter." The roof bolter is a rubber-tired, electrically powered machine with rotating drill heads. It puts holes in the mine roof. Steel bolts (48 to 96 inches long) are then inserted into these holes and tightened. They bind together layers of rock strata located above the cut. This, in effect, creates a supporting beam between coal pillars and across entries and crosscuts. Thus, the roof is prevented from collapsing. Next, a "continuous miner" is "trammed" into the face. A continuous miner is an electrically powered machine that moves along on crawler tracks similar to bulldozer treads. The machine has a rotating drum ("ripper head") about 10 ft wide and 3 ft in diameter, on which cutting bits are mounted. The ripper head rotates and cuts coal from the face. A pair of mechanical gathering arms, located beneath the ripper head, then sweeps the dislodged coal onto a short conveyor. This conveyor moves the coal to the rear of the machine, where it is dumped into a shuttle car (or "buggy"). A buggy is a rubber-tired electrically powered haulage vehicle that can carry 6 to 10 tons of coal. Usually, two buggies transport coal from the face to a conveyor belt dumping point. From this dumping point on the working section, coal is typically transported out of the mine via a series of conveyor haulage belts. In some mines, however, coal is dumped directly into small rail cars. Groups of these cars, known as "trips," are pulled by electrically powered locomotives to a main underground dumping point. From there, the coal is transported out of the mine via conveyor belt.

Once a mine (or a portion of it) is developed, the development sections may then become "retreat" mining sections. In retreat mining, coal pillars that were originally left in place for support of the mine entries and crosscuts are themselves extracted. The basic approach is to mine in a series of cuts, supporting the roof with timbers, bolts, or a combination of both. As these pillars are removed completely, the mine roof they once supported collapses.

In many large mines, retreat mining has been replaced by longwall mining. To establish a longwall, two parallel continuous miner sections, each consisting of two to four entries, are advanced 5,000 ft or more to a predetermined point. They are then turned and driven toward each other until they join. Once these sections are joined, they have created a large block of coal, 600 to 1,000 ft wide and approximately a mile long, that is known as a longwall "panel." Crews on a longwall mining section are made up of 8 to 10 individuals. A crew might consist of (1) one supervisor, (2) two shearer operators, (3) two shield operators, (4) one headgate operator, (5) one tailgate operator, and (6) one mechanic. These workers run large specialized equipment, which has been dismantled on the most recently mined longwall section, then brought in and set up at the new face. Panel extraction consists of completely removing this large block of coal that was created during the development process. Strata are allowed to cave behind the longwall as coal is mined back in the direction from which the parallel "setup" sections were started.

Longwall mining operations depend on the use of self-advancing hydraulic roof supports called "shields." These are massive overhead steel structures supported by large multistage hydraulic jacks. The jack system allows shields to be raised and lowered mechanically as a face is advanced. Shields are placed side-by-side in a row so that they form a protective canopy along the entire length of the working face. Coal is removed from the face by a rotary drum shearing machine or "shearer." This shearer rides on top of a flexible, segmented conveyor ("pan line") that runs along the face. It is attached to the front of the shields by hydraulic jacks. The shearer has circular cutting heads mounted on long arms that are affixed to each end of its main body frame. A cutting head is equipped with carbide bits arranged in a spiral formation. The head rotates to cut a strip of coal 30 to 40 inches deep from the longwall face as it is moved across the panel. This extracted coal falls onto the pan line for transportation across the face to the panel's belt conveyor. The panel conveyor then moves the coal to the mine's main haulage belt for transport outside.

Fresh air must be supplied to all working areas of a mine. Air is drawn into a mine from the outside by one or more propeller-type, axial-vane fans that may be as large as 8 ft in diameter. These fans can move several hundred thousand cubic feet of air per minute. Entries serve as "intake" (fresh) and "return" (contaminated) aircourses that channel the air through a mine. Intake and return aircourses are separated by concrete block walls ("stoppings") that are built in the crosscuts between entries. Where intake and return aircourses must cross each other, air bridges ("overcasts") are used. Air moving through the mine and sweeping across its working faces carries away smoke, dust, and accumulations of methane gas. The intake and return aircourses also function as escapeways for miners should a fire or other type of emergency occur. Federal mining law requires that underground mines must maintain two separate and distinct travelable passageways designated as escapeways from each working section. At least one of these two escapeways has to be located in fresh air.

While an underground coal mine is in some respects like a factory, the working environment is very different. The only lighting, for instance, comes from miners' battery-operated cap lamps or from localized sources on various equipment. At the face, production crews must contend with work areas that can be dusty, or wet and muddy depending on the amount of water that may be present. These places can also be extremely confined, especially in mines where the seam thickness is not great. To extract coal, miners must operate large machines under such conditions. Outby[1] support personnel are scattered through the labyrinth of underground entries. They are needed to help maintain the many auxiliary subsystems found in the mine. Work done by these miners includes building and maintaining air stoppings, installing supplemental roof supports, cleaning coal spills around or under conveyor haulage belts, moving supplies, maintaining electrical installations, and conducting hazard inspections. Generally, these support workers do their tasks singly or in small crews, usually without direct contact with other miners, supervisors, or the outside world. They also have to deal with poor footing due to uneven or muddy bottom. In sum, all miners must do their jobs in an environment that is harsh and potentially dangerous.

---

[1]"Outby" means away from the working face of the mine. The opposite is "inby," or toward the face.

Mine Dangers

No matter which technical division of labor is being used, miners create a void under the Earth's surface—a void that is potentially deadly, as Palowitch [1982] has illustrated. To reduce the risks associated with mining, all face equipment must meet permissibility standards set forth by MSHA. In addition, all sources of open flame such as matches and cigarette lighters, welding equipment (except in designated areas), and unsealed lights are strictly prohibited. Even in mines where these regulations are rigidly enforced, however, there is still the danger of ignition from steel bits striking rock or pyrites, from sparks caused by slabs of roof falling against metallic surfaces, or from willful violation of the standards and prohibitions.

Increased mechanization and the introduction of greater numbers of electrical machines have resulted in mine fires being ranked just behind explosions as a major cause of mine disasters. Of 877 mine fires that occurred between 1952 and 1970, 351 happened at or near the working face, and the remaining 526 were at various spots throughout the mine. Sixty-nine percent of the fires at or near the face were determined to have had an electrical source [Palowitch 1982]. The origin of fires outby the face were most often frictional ignition of conveyor belts, or spontaneous combustion in abandoned sections of the mine [Kutchta 1978]. A survey of coal mine fire reports conducted by Allen Corp. [1978] showed that the number of fires increased from 28 in 1951 to 184 in 1960, then decreased to 25 in 1977.

However, mine fires are still occurring, sometimes with disastrous consequences. An example is the fire disaster that took place at Emery Mining Co.'s Wilberg operation on December 19, 1984. On that date, company officials informed miners on the Fifth Right longwall panel that the mine would attempt to break a world record for 24-hour longwall production. On second shift, with the record within reach, nine extra workers were sent to the section and eight management people accompanied them to see the record broken. When fire (ignited by a faulty compressor near the intake of Fifth Right) broke out, smoke and carbon monoxide poured in on the 28 people on the section. Unable to don their self-contained self-rescuers (SCSRs), evidently because of lack of adequate training, most of the miners attempted to escape barefaced down either the intake or belt entry. They were quickly overcome, and died. Three miners tried to get out through the tailgate return entry. That entry had been allowed to collapse several weeks before, and the cave-in made it impassable. The miners' bodies were found at the blockage. The last survivor wriggled through a "squeeze" in the bleeders where the roof had caved in and the floor had heaved up. He made it into the clear and walked several hundred feet before being overcome by carbon monoxide poisoning and dying, with an unopened self-contained self-rescuer around his neck [Moore 1987].

There are several system failures implicit in the Wilberg disaster: (1) non-essential personnel were in attendance at a time when workers and equipment were being pushed to break a production record; (2) the faulty air compressor was allowed to run unattended in a nonfireproofed area; (3) at least some of the miners died, not necessarily because there was a fire, but because entries running off the tailgate of the longwall were blocked by a cave-in; (4) firefighting preparedness was inadequate; and (5) the miners were not adequately trained in how, and under what conditions, to employ nonroutine safety skills such as the use of their emergency breathing apparatus.

The Training Process

All persons entering an underground coal mine must be trained. The type of training required, and the amount individuals receive, depends on their status and function in the mining environment. 30 CFR 48 stipulates that each operator of an underground mine must file, for approval by MSHA, a plan that contains programs for (1) training new miners, newly-employed experienced miners, experienced miners assigned to new tasks, (2) annual refresher training, and (3) hazard training for miners and visitors. The course content and minimum hours of instruction for each of these programs vary. It has been argued that U.S. miners may be comparatively poorly trained for many nonroutine events they are likely to encounter. McAteer and Galloway [1980] summed this notion up in a report comparing training in the United Kingdom, West Germany, Poland, Romania, France, Australia, and the United States: "Training and supervisory certification requirements in the United States are less thorough than those of any other nation studied."

New miner training, which is what people receive before reporting to work, prescribes at least 40 hours of instruction in miners' rights under the law, the use of self-rescue and respiratory apparatus, procedures for entering and leaving the mine, transportation and communication, emergency evacuation and barricading, roof and ground control, rock dusting program, hazard recognition, electrical hazards, mine gases, health and safety aspects of assigned tasks, miner health, and an introduction to the specific work environment. Each year, all miners working underground must receive a minimum of 8 hours of annual refresher training that covers many of the topics just listed. All training, in order to comply with 30 CFR, must be given by instructors who have been approved by the Mine Safety and Health Administration, and is expected to be adapted to the mining operations and practices in existence at the company whose workers are being trained.

There is much technical information miners need, not only because of the hostile physical environment they face, but because continuing technological and organizational changes cause new problems in the workplace. An example may be gotten from the use of longwall technology in this country. Wala and Cole [1987] incorporated choices about where to place brattice curtains and take airflow readings into paper-and-pencil simulations of longwall operations. The researchers then administered the simulations to 90 mine workers responsible for making ventilation arrangements during cut-throughs at their respective operations. Nearly one-half of the respondents were shown to have potentially fatal misconceptions about the behavior of airflow during longwall setup procedures.

A factor in miners' lack of proficiency regarding some aspects of their work environment is that instructors often draw upon their stock of knowledge and present discrete bits of information unconnected to any grounding that would make them useful [Briggs and Digman 1980]. At times the training delivered this way may not be very well thought out. An example of this is provided by a segment of the hazard training offered to mine visitors under 30 CFR 48.11. The self-contained self-rescuer (SCSR) instruction traditionally consisted of an SCSR being shown by the mine's safety instructor, who would explain the procedure for putting it on "at the first sign of smoke."

The weakness of this demonstration is apparent, especially when one stops to consider the nature of SCSRs. First, SCSRs are complex closed-circuit breathing devices. Improper use of compressed oxygen rebreathers (one type operates on this principle) can lead to hypoxia and death. SCSRs that generate oxygen chemically are more fool-proof, but still must be handled correctly to be of any benefit in an unbreathable atmosphere. Second, unlike firefighting apparatus or mine rescue gear, which is donned and activated before the wearer goes into danger, an SCSR is meant to be put on under extreme conditions such as fires. From this perspective, it requires little imagination to understand that the intended user should be thoroughly task trained. Yet, it was not until September 1987 that MSHA, citing research begun shortly after the Wilberg disaster [Cole and Vaught 1987; Vaught and Cole 1987], promulgated regulations at 30 CFR 48 and 75 requiring hands-on instruction in the use of self-contained self-rescuers.

Cole et al. [1986], after observing and participating in many training sessions, made several generalizations about how classes are conducted: (1) The most commonly used technique of mine trainers is instruction for the rote learning of information. (2) There is a heavy reliance on the same sets of training films and procedures from year to year. (3) Trainees frequently fail to pay attention to the instruction, devoting their attention to what is going on around them instead. (4) When games are used as teaching devices, they usually focus only on factual recall of information and commonly detract from the content of what is being taught. (5) In many classes, great amounts of time are wasted, in the sense that it is not spent in instruction. (6) Segments of the day's program may degenerate into gripe sessions, with little of a substantive nature being accomplished. In short, the typical miner training class is not always effective.

Outside Organizations and the Mine

The U.S. Department of Interior's Bureau of Mines (USBM)[2] was created in 1910 as a legislative response to a seemingly interminable series of fires and other disasters that touched communities from Franklin, WA, to Belle Ellen, AL, to Wilkes-Barre, PA [Keenan 1963]. Although this was the Federal Government's first venture into mining regulation, it followed legislation enacted by the various coal-producing States by 20 to 30 years [Palowitch 1982]. Moreover, the USBM had no sanctifying authority. Its primary function was to conduct mine safety research and issue reports. Mine disasters have historically driven legislation, however, and following a rash of these disasters in 1940, the U.S. Congress passed the Federal Coal Mine Safety Act, which granted the USBM inspection authority, but only in order to gather and publish information on safety conditions. After a further string of incidents, the U.S. Congress took the next step: in the summer of 1952, the Federal Coal Mine Safety Act of 1952 (Public Law 82-552) was enacted. It contained section 209, which stipulated that USBM inspectors could issue an order of withdrawal from portions of a mine faced with imminent danger [National Research Council 1982].

The Federal Coal Mine Health and Safety Act of 1969 (Public Law 91-173) was the first comprehensive plan to protect "the health and safety of persons working in the coal mining industry of the United States." The Act provided for each underground coal mine to be inspected four times per year. It also set forth an array of interim mandatory safety standards covering roof support, ventilation, combustible materials, electrical equipment, blasting, transportation, and communication, among others. It also set forth a hierarchy of penalties for individual and corporate violations of these standards. On July 1, 1973, the Mining Enforcement and Safety Administration was formed within the U.S. Department of the Interior, but separate from the USBM. The USBM's inspection functions were vested in this new agency.

Federal regulations governing the mining of coal are currently contained in the Federal Mine Safety and Health Act of 1977 (Public Law 95-164). This act was promulgated in the wake of yet another round of disasters including the Sunshine silver mine fire. Perhaps the most significant innovation of the 1977 Act, besides the creation of an enforcement arm with enhanced rule-making and sanctioning capabilities, was the establishment of mandatory health and safety training. For the first time, the Federal Government was taking a proactive approach to removing "acts of God" as explanations of workplace accidents. There has existed, since 1977, a total package of administrative rules, periodic inspections, workforce preparation, and technical assistance. This comprehensive

[2]The safety and health research functions of the former U.S. Bureau of Mines were transferred to the National Institute for Occupational Safety and Health in 1996.

package is aimed at not only correcting, but also preventing health and safety hazards in the Nation's mines.

There is a second level of oversight at underground coal mines. State enforcement agencies station inspectors in districts around the coalfields. Beyond writing citations, some States also provide technical support for mines needing help in achieving and maintaining compliance. Finally, there may be a training and education division whose staff conducts various training and certification programs in the State. West Virginia and Kentucky have the most extensive education and certification programs for rank-and-file miners. For instance, all new miners are required to complete a course of formal instruction followed by an underground orientation, serve an apprenticeship, and pass an examination (oral and/or written) to receive his or her "miner's papers" [McAteer and Galloway 1980]. In essence, State and Federal regulations ensure a regular presence by government officials at an underground mine.

After the National Recovery Act, the United Mine Workers of America managed to insert safety and health provisions into the next several contracts. These included "reasonable" rules for safety and health (1937), union inspection of the mine (1939), establishment of safety committees (1941), clean working conditions (1943), a protective clothing allowance (1945), benefits for long-term injuries (1946), and the right to withdraw for safety and health reasons (1947). During the period of rationalization, however, no new provisions were negotiated. It was not until the 1971 contract that safety and health clauses were again added, largely as a response to specific sections of the 1969 Act [Short 1982]. Generally, there are now contractual provisions stipulating that at each union mine there must be a Mine Health and Safety Committee and a Mine (grievance) Committee.

The United Mine Workers of America has traditionally been a high-profile entity at operations it has organized. Rank-and-file employees at the three mines in this study were all members of the UMWA. Thus, the union was an organizational component that, along with Federal and State bodies, helped to shape the nature of workplaces at these sites. The following section describes each setting in turn, paying special attention to such things as personnel numbers, production figures, and technical layout. These sketches will provide readers a better understanding of the underground environments from which the miners were required to escape.

The Study Settings

Adelaide Mine

Adelaide Mine was an underground operation established in 1903. This mine was opened by six air shafts into the Pittsburgh Coal Seam, which had an average thickness of 72 inches. A total of 327 workers were employed at the operation; 278 worked underground and 49 had jobs on the surface. Coal was mined on five production sections. Three of these conducted development mining and two were on retreat. All working sections used continuous mining technology and the room-and-pillar mining method. Entries were on centers of approximately 70 ft with crosscuts on centers of approximately 90 ft. The mining company ran two production shifts per day, 5 days per week. Average coal output at this operation was just over 4,100 tons per day.

Coal was transported from the sections by 36- and 42-inch belts to an underground storage bunker. It was then loaded into 10-ton mine cars for transportation to a skip hoist. A 10-ton capacity skip hoist was used to raise coal to the surface. There, it was deposited into a raw coal silo to await processing at the mine's preparation plant. Supplies and machinery were lowered into the mine by an equipment hoist. Trolley locomotives were used to haul coal, supplies, and implements inside the mine. Trolley mantrips were used to transport miners to and from the working sections. Three exhausting axial-vane mine fans located on the surface provided ventilation to the workings. Permanent stoppings, overcasts, check curtains, and line brattices were used to control air flow throughout the mine.

Three working sections were located inby the source of combustion at Adelaide Mine. These are shown in figure 2.1.

2 Northwest

The 2 Northwest submains, where the fire occurred, was developed from the Southwest Mains. As development of this section progressed, panels were driven off to the left and connected at the back end of the section with bleeder entries. At the time this fire occurred, mining in 2 Northwest and the two panels driving off it was being done with two sets of face equipment. Machinery included continuous miners, shuttle cars, roof bolting machines, and battery-powered scoop tractors. An axial-vane exhausting mine fan located on the surface at Peterson shaft provided ventilation for all three sections in the 2 Northwest submains area of the mine.

At the mouth of 2 Northwest submains, entries were identified by numbers 1 through 8 (from left to right facing inby). Entries 1, 2, and 8 served as return aircourses, with entries 2 and 8 designated as alternate escapeways. Entries 3, 4, 5, and 7 functioned as intake aircourses, with entry 7 designated as an intake escapeway. The trolley haulage was located in No. 4 entry, with the conveyor belt located in entry No. 6. As the section advanced from Southwest Mains, a ninth entry was added at approximately 2,300 ft inby Southwest Mains. Entry 9 served as a return aircourse and became a designated alternate escapeway. A 10th entry was added to the section at about 4,200 ft inby Southwest Mains. This entry also became a return aircourse and designated alternate escapeway.

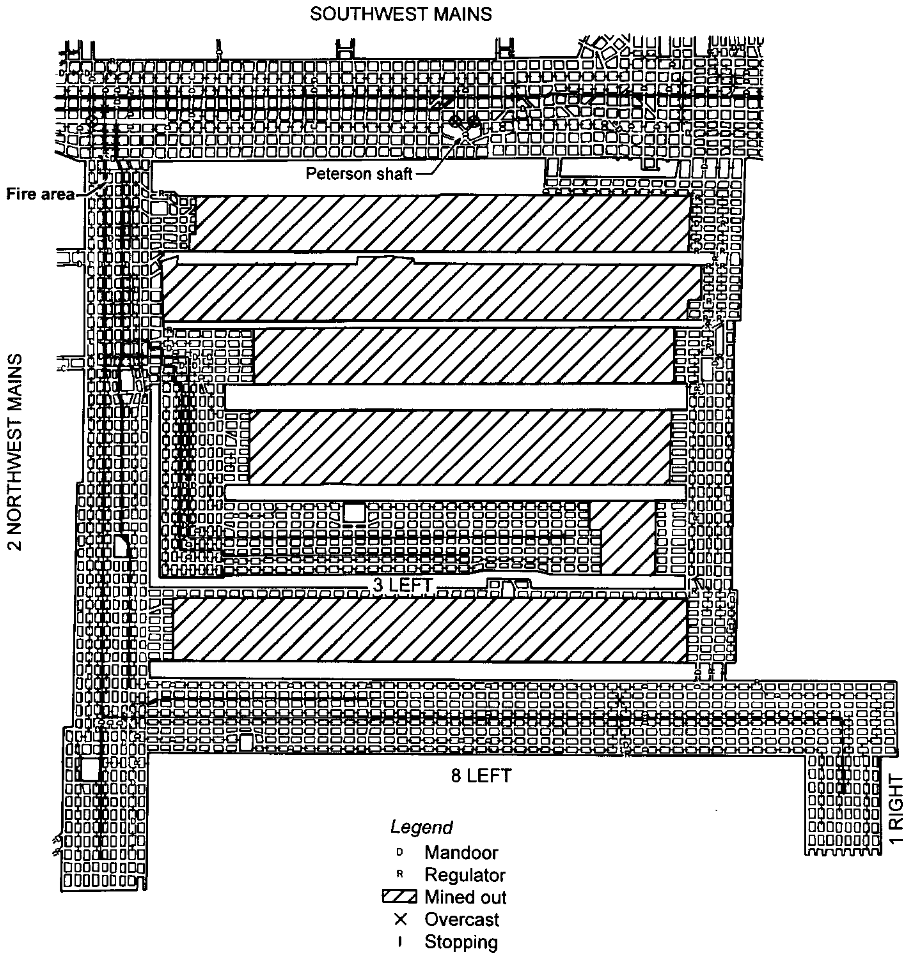

Figure 2.1–The three sections affected by fire at Adelaide Mine.

Because of a limited number of intake aircourses at the mouth of 2 Northwest, and since working sections were being advanced to greater distances from the main ventilating fan at Peterson shaft, mine management requested and received permission to use air from their belt entry also to ventilate the active working places. As part of their approval plan to use belt air for ventilation, the mine was required by MSHA to install a carbon monoxide (CO) monitoring system. This system had to be capable of detecting CO at a level of 1 ppm, using sensors installed in the belt entry every 1,000 to 2,000 ft (depending on air velocity). The system also had to be equipped with audible and visual alarms that activated automatically in the dispatcher's office and at the underground dumper's shanty when one or more sensors detected CO concentrations of 10 ppm or greater. Finally, the approval plan included a provision for elimination of a requirement that the belt and trolley entries be separated with stoppings. Separation of belt and trolley entries was continued in the 2 Northwest and 1 Right sections but was discontinued on 3 Left.

3 Left

At the time of the fire, 3 Left was a retreat section. This panel, consisting of nine entries, had been turned off 2 Northwest and driven approximately 3,500 ft to a point where the section connected with a set of bleeder entries. After all entries had been connected with the bleeders, pillar extraction was started. The section had retreated about 500 ft outby. Entries on this section were numbered 1 through 9, left to right facing inby. Entries 1 and 9 served as return aircourses, with No. 9 entry designated as the alternate escapeway. Entries 2 through 8 functioned as intake aircourses. No. 8 entry was designated as the primary escapeway and was separated from entries 7 and 9 by stoppings. The belt conveyor was located in entry 5, and the trolley haulage was in entry 7. As mentioned earlier, the belt and trolley haulage entries on 3 Left were not separated by stoppings.

1 Right

1 Right off 8 Left was a nine-entry development section that also turned off 2 Northwest submains. The section had been driven approximately 4,800 ft before it was turned 90E to the right. Entries on this section were numbered 1 through 9, left to right facing inby. Entries 1 and 9 served as return aircourses, with No. 9 also serving as the alternate escapeway. Entries 2, 3, 4, 6, 7, and 8 functioned as intake aircourses, with No. 6 designated as the primary escapeway. Trolley haulage was located in No. 3, and the belt conveyor was located in entry 5.

Brownfield Mine

Brownfield Mine was opened by one slope and eight shafts into two underground coal seams, one above the other. Both the Upper Kittanning (or CN) and Lower Kittanning (or B) Seam average 48 to 54 inches thick. At the time of the fire, Brownfield Mine employed 869 workers. Of this number, 804 individuals worked underground and 65 worked at various locations on the surface. There were 17 continuous mining units and 3 longwall sections that produced an average 7,000 tons of coal each day during 3 production shifts. Entries and crosscuts were developed 18 to 20 ft wide and were on centers of from 60 to 120 ft. This operation was ventilated by six axial-vane, exhausting mine fans located on the surface. Underground ventilation was controlled by permanent stoppings, overcasts, regulators, check curtains, and line brattices.

Coal from the faces of working sections was transported by shuttle cars and discharged onto conveyor haulage belts. A series of conveyor belts transported coal from each section to a loading area where it was dumped into mine cars. From this load point, coal was hauled in mine cars to a main rotary dump area underground. From the dump area, coal was taken via conveyor belt out of the mine to a cleaning plant for processing. Supplies and equipment were moved within the mine by rail using trolley locomotives. Trolley mantrips were used to transport miners to and from the working sections. On longwall panel development sections, miners would dismount their rail mantrips at the mouth of the section. They would then board rubber-tired personnel carriers and go to the faces.

6 West Mains

6 West Mains, where the fire occurred, had developed eight entries using continuous mining technology and the room-and-pillar mining method. Entries on 6 West Mains were numbered 1 through 8, left to right facing inby (figure 2.2). Entries 1, 2, and 3 served as return aircourses, with entry 3 designated as the alternate escapeway. Entries 4, 6, 7, and 8 functioned as intake aircourses, with entry No. 4 designated as the primary escapeway. Trolley haulage was located in No. 6, and the conveyor belt was located in No. 5. As coal extraction progressed in this area, longwall development panels were driven off to both the left and right of 6 West. Two of these were situated inby the fire's location.

4 South

The 4 South section was a three-entry longwall development panel that had been advanced approximately 2,000 ft from 6 West Mains. Entry 1 served as the return aircourse for this section and was designated as their alternate escapeway. No. 2 entry was the intake aircourse and functioned as a primary escapeway for the section. A conveyor haulage belt, located in entry 3, was ventilated by a separate split of intake air that moved from the section mouth inby to the belt tailpiece.

5 South

The 5 South section was also a three-entry longwall development panel that had been advanced about 1,000 ft inby from 6 West Mains. On this section, entry 1 served as the intake aircourse and was also the primary escapeway. The conveyor belt was located in entry 2 and was ventilated by a separate split of intake air that moved from the mouth of the section inby to the tailpiece. Entry 3 was the return aircourse and served as a designated alternate escapeway for this section.

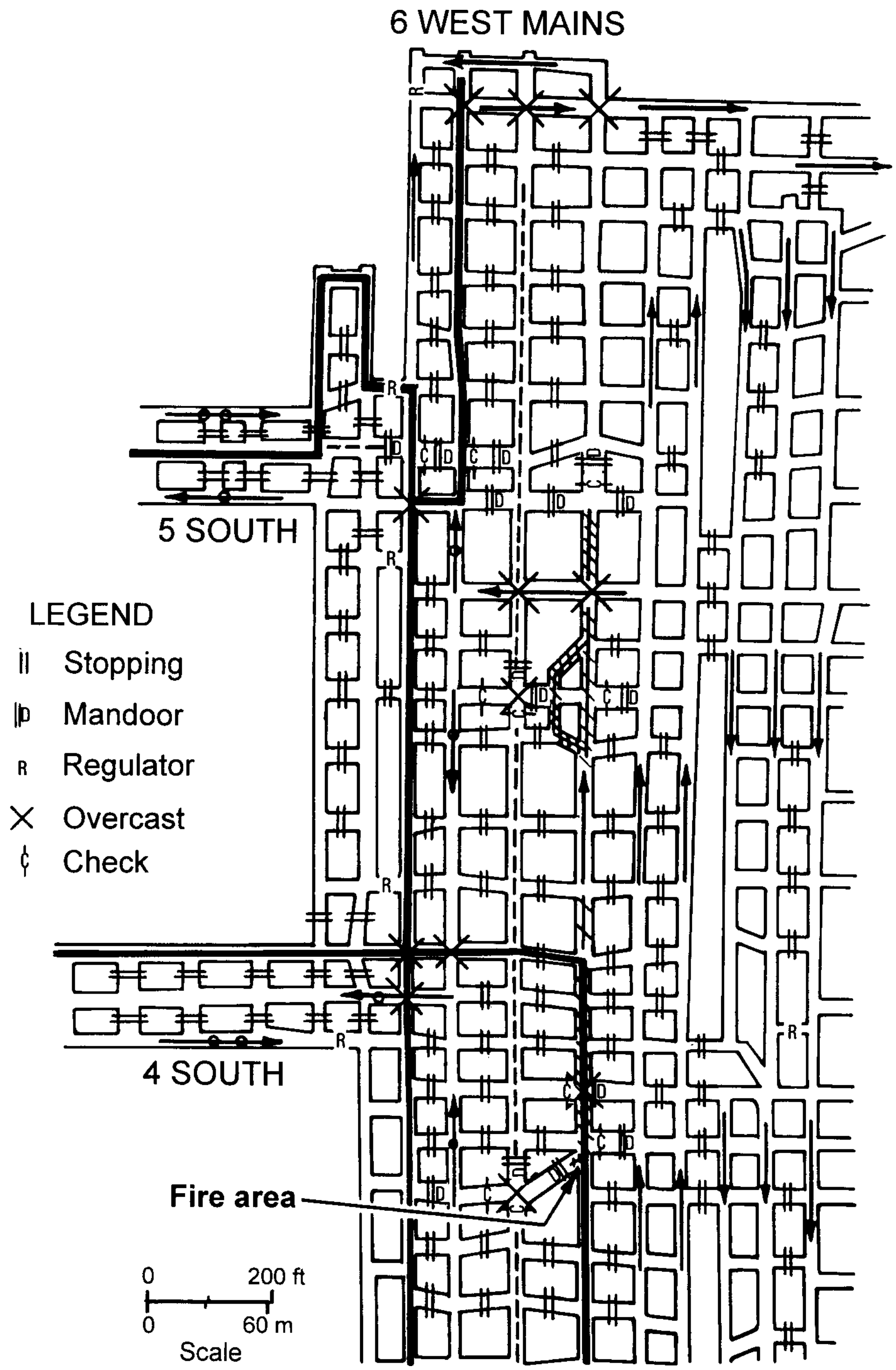

Figure 2.2–Area affected by fire at Brownfield Mine.

Cokedale Mine

Cokedale Mine was originally started in 1944. At the time the Cokedale Mine fire occurred, this operation was opened by one drift and eight shafts into the Pittsburgh Coal Seam. Here, the Pittsburgh Seam averaged 66 inches thick. A total of 408 persons were employed at the mine, 319 working underground on 2 production shifts and 1 maintenance shift per day, 5 days per week. The mine operated seven active sections and had three spare sections. Workers produced an average of 6,500 tons of coal per day. All sections were mined using the room-and-pillar method, with coal extraction being done by continuous miners. Entries and crosscuts were mined to a width of 16 ft. Entries were normally developed on centers of 64 ft, with crosscuts mined on centers of 96 ft.

Coal was transported from the faces by shuttle cars and dumped onto belt conveyors. These conveyor belts transported coal from the sections to underground loading tipples, where the coal was loaded into mine cars. From the tipples, 37- and 50-ton track locomotives transported trips of loaded mine cars to the surface, where coal was then processed at the mine's cleaning plant. Ventilation to the mine was provided by six exhausting axial-vane mine fans located on the surface. Intake air entered at the drift entrance and at seven intake air shafts. Permanent stoppings, overcasts, and undercasts were used to control air flow and provide the required separation between various aircourses. Permanent stoppings were constructed of concrete blocks with mortared joints or blocks plastered on one side. In areas of short production duration, steel panel stoppings were used. Face ventilation was accomplished using auxiliary fans and tubing.

From Cokedale Mine's drift opening (pit mouth), a series of seven or eight entries (main headings) were driven in a westerly direction. The fire at this mine originated in the loaded track entry of these mains (figure 2.3). It started at a point about 6 miles inby the pit mouth and 1,000 ft outby Steiner portal. At the time, entries 1, 2, and 3 were functioning as return aircourses, while entries 6, 7, and 8 served as intakes. Near the fire, entries 4 and 5 were track entries and accommodated Cokedale Mine's main trolley haulage from working sections to the pit mouth. Entries 4 and 5 also served as intake aircourses, and air velocity in these entries exceeded 250 fpm. They were developed before the Federal Coal Mine Health and Safety Act of 1969, which limited air velocity around trolley haulage systems to 250 fpm.

8 Face

The 8 Face section consisted of nine entries and had been developed in the mid-1950s to the left off the main headings. Entries 1 through 4 were intake airways, while entries 5 through 8 served as return aircourses. A series of eight-entry panels were developed to the right of 8 Face. After development, these butt panels were retreated back to 8 Face.

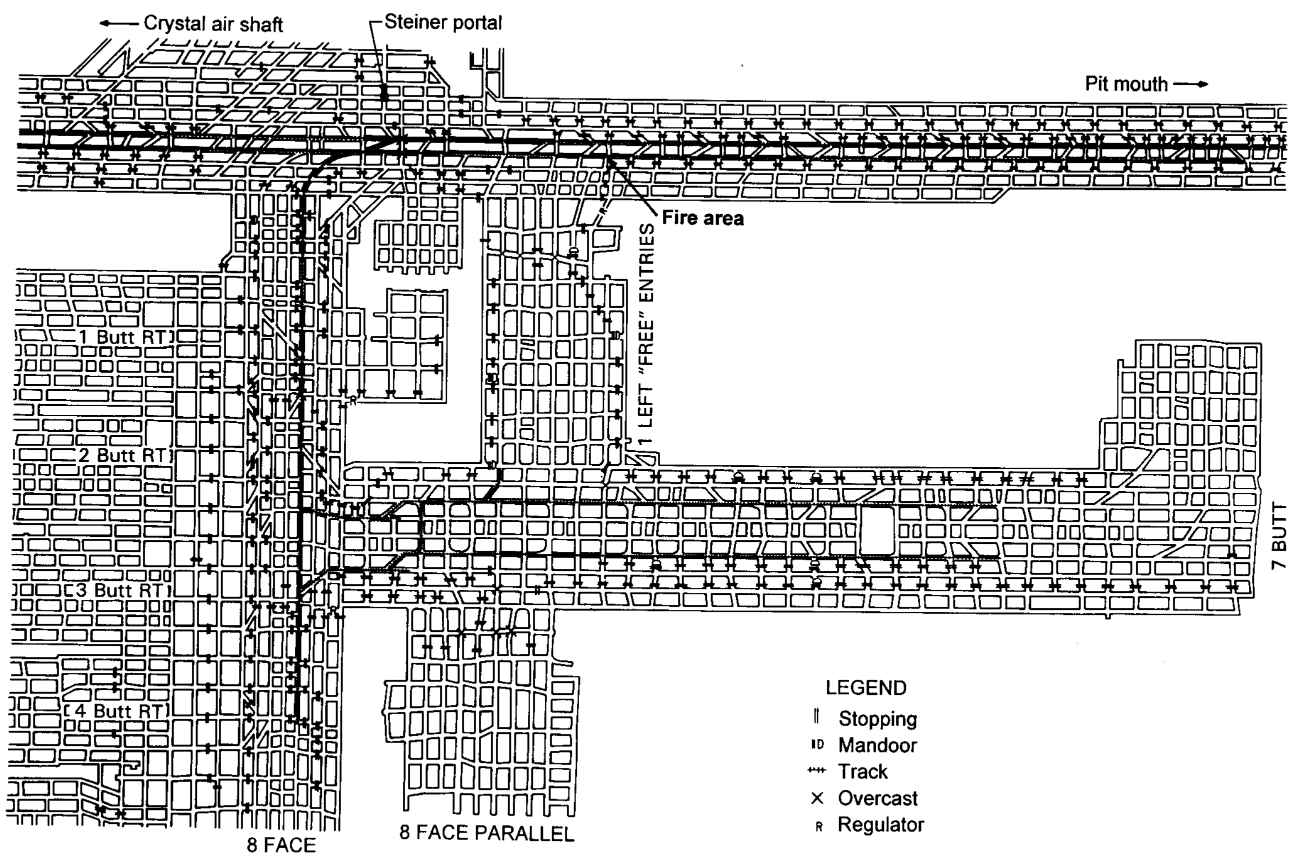

Figure 2.3.–Site of combustion source at Cokedale Mine.

7 Butt

In the late 1980s, a new series of nine entries, known as 7 Butt, were developed to the left of 8 Face about 1,000 ft inby the main headings. These entries were driven some 3,200 ft before the section was turned to the left. In this section, entries 1, 8, and 9 were designated return aircourses, while entries 2 through 7 served as intake aircourses. After 7 Butt had been advanced approximately 1,000 ft, a set of seven entries, known as the 1 Left "free" entries, were driven 90E off 7 Butt and connected with the haulage mains. The purpose for driving this set of entries was to provide more air to the developing sections.

8 Face Parallels

Just outby the 1 Left "free" entries along 7 Butt, a series of nine entries were developed 90E to the right. These entries, known as 8 Face Parallels, were being driven parallel to the old 8 Face entries. For 8 Face Parallels section, the primary (intake) escapeway followed No. 7 entry to its intersection with 7 Butt. The primary escapeway coming out of 7 Butt followed No. 8 entry out to the intersection of 7 Butt and old 8 Face. The old 8 Face entries were developed before the Federal Coal Mine Health and Safety Act of 1969; as a result, the intake escapeway from old 8 Face was routed onto the track entry. The alternate (return) escapeway off 8 Face Parallels followed No. 9 entry to the intersection with 7 Butt. The alternate escapeway off 7 Butt followed No. 9 entry to the intersection with old 8 Face. At this point, the return escapeway crossed over old 8 Face to the right-side return (No. 7 entry) of old 8 Face. The secondary escapeway in old 8 Face followed No. 7 entry to the section mouth. From there, the secondary escapeway followed the left-side return (No. 3 entry) of the main headings to Crystal air shaft.

Discussion

This chapter has depicted an underground coal mine as a well-planned, complex, and regulated system operating in a harsh environment. Additionally, it profiled the three fire settings to be discussed later. Since mines contain numerous pieces of electrical equipment, have various friction sources, and possess an almost inexhaustible supply of fuel, it is not surprising that they sometimes catch fire. Actually, small fires are somewhat common. Those that force an evacuation, however, are nonroutine events. While miners may be highly skilled at their jobs, the task of responding to this type of emergency requires a different set of proficiencies.

Earlier, it was suggested that safety training classes may not always give miners competencies they need to face contingencies in their workplaces. This brings up an interesting point as it relates to fire. Even though mines are potentially dangerous, they are not emergency organizations. Their goal is to extract a product—coal—and to do it profitably. Preparation for an event that may never occur will obviously not be given the same priority in a mine that it would merit on a naval combat vessel, for instance. What, then, is the appropriate way to view behaviors that will be reported in the chapters to follow? Workers at these operations did not display the discipline that well-drilled mine rescue teams would have, but is such an expectation realistic? Perhaps the best way to approach this analysis is to note that some groups responded much more effectively than others and to explore what factors led to such variation. That way, any recommendations for improvement are likely to remain in context, recognizing that mines are not emergency organizations.

References

Allen Corp. [1978]. An annotated bibliography of coal mine fire reports. Alexandria, VA: Allen Corp. of America. U.S. Bureau of Mines contract No. J0275008.

American Geological Institute [1997]. Dictionary of mining, mineral, and related terms. 2nd ed. Alexandria, VA: American Geological Institute.

Briggs G, Digman M [1980]. New miner and annual refresher training stories and examples. Morgantown, WV: West Virginia University, Office of Research and Development.

Cole HP, Vaught C [1987]. Training in the use of the self-contained self-rescuer. In: Mining Applications of Life Support Technology. Pittsburgh, PA: U.S. Department of the Interior, Bureau of Mines, IC 9134, pp. 51-56.

Cole HP, Vaught C, Wasielewski R, Wiehagen W [1986]. Judgment and decision-making in simulated mine emergencies. In: Proceedings of the 13th Annual Training Resources Applied to Mining (Wheeling, WV), pp. 167-178.

Keenan C [1963]. Historical documentation of major coal-mine disasters in the United States not classified as explosions of gas or dust. Washington, DC: U.S. Department of the Interior, Bureau of Mines, Bulletin 616, pp. 1846-1962.

Kutchta J [1978]. Fire protection for mine conveyor belt systems in coal mine fire and explosion protection. In: Coal Mine Fire and Explosion Prevention. Washington, DC: U.S. Department of the Interior, Bureau of Mines, IC 8768, pp. 51-63.

McAteer J, Galloway L [1980]. A comparative study of miners' training and supervisory certification in the coal mines of Great Britain, the Federal Republic of Germany, Poland, Romania, France, Australia, and the United States: the case for Federal certification of supervisors and increased training of miners. West Virginia Law Rev *82*(4):937-1018.

Moore M [1987]. Fire in the intake. United Mine Workers J *98*(7):11-17.

National Research Council [1982]. Toward safer underground coal mines. Washington, DC: National Academy Press.

Palowitch E [1982]. The social efficiency of the coal industry [Dissertation]. Pittsburgh, PA: University of Pittsburgh, pp. v, 73, 80.

Short J [1982]. The role of unions in occupational safety and health [Dissertation]. Salt Lake City, UT: University of Utah, p. 147.

Vaught C, Cole H [1987]. Problems in donning the self-contained self-rescuer. In: Mining Applications of Life Support Technology. Washington, DC: U.S. Department of the Interior, Bureau of Mines, IC 9134, pp. 26-34.

Wala A, Cole H [1987]. Simulations that teach and test critical skills in mine ventilation. In: Mutmansky J, ed. Proceedings of the Third Mine Ventilation Symposium at The Pennsylvania State University. Littleton, CO: Society for Mining, Metallurgy, and Exploration, Inc.

Wallwork G [1981]. Mining administration. In: Crickmer D, Zegeer D, eds. Elements of practical coal mining. 2nd ed. New York, NY: American Institute of Mining, Metallurgical, and Petroleum Engineers, pp. 741-770.