Mined-Land Rehabilitation

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To my lovely wife Linda and to three beautiful children, Dwight, Andrea, and Brent, for undying love and support. To my parents who introduced me to God's creation and taught me to be a good steward of the land.

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PROLOGUE

The Need to Rehabilitate

In 1973, a critical dilemma faced the United States in the form of an oil embargo imposed by the Arab oil-producing nations. Americans suddenly found themselves sitting in long lines to purchase gasoline for their automobiles. Many service station operators closed at noon and did not bother to open their doors on weekends. There was talk of rationing by the federal government of fuel purchases, as was done during World War II. California's rationing system obliged those with even-numbered license plates to make purchases on even-numbered dates. Since that time, the cost of fuel from all sources has multiplied many times over, inflating the cost of all goods and services—not only in our own nation, but throughout the world.

Solar greenhouses, solar homes, wood burning stoves, and fuel-efficient automobiles have become a status symbol. Our life-style now calls for lower winter temperatures, higher summer temperatures, 10-speed bicycles, and comfortable shoes. The desperate search for energy-related minerals has had its effect, not only on the nation's social structure, but on the economy and the environment as well.

In Gillette, Wyoming, the hub of the vast, coal-bearing Powder River Basin, the population—in 1980 at 15,600—is expected to rise some 28 percent in the next two years. By 1990, the city should double with a potential influx of 10,000 new workers. These workers will help man 12 new coal mines, 5 uranium operations, a power plant, and a synthetic fuels plant.[1]

Wyoming is the nation's third-fastest-growing state. Its population growth exceeds by far the state's ability to construct an adequate urban structure in which new citizens can find housing, education, and recreation. With additional population comes the need for roads, water supplies, and quality sewage treatment systems. "Homesteaders" are already living in tents in the Wyoming desert, moving back and forth between federal land and railroad right-of-way as officials drive them away. People sleep in their cars, moving from street to street in the cities of Green River and Evanston. In Rawlins, a man paid $350 in the summer of 1979 for a renovated chicken coop.[2]

In Littleton, Colorado, a Denver suburb, the main steet is closed to automobile traffic for up to five hours a day to allow coal trains to pass. Typically, a three bedroom house in Denver that sold six years ago for $35,000 will sell today for $105,000.[3] Some 3,000 oil companies of various sizes have offices in Denver. Its ever-growing skyline is reflective of these figures.

In July 1980, in Moab, Utah, some 500 people gathered in a city park for a rally where they listened to the national anthem on automobile stereos as the American Legion raised the American flag. Following speeches by three of the county's commissioners critical of federal land policy, the commissioners climbed aboard a bulldozer and proceeded to cut a destructive 200 yard-long swath through a proposed Bureau of Land Management wilderness area.[4] This action was part of what has come to be known as the "sagebrush rebellion," an attempt to wrestle the land away from federal government control.

In July 1981, the *Rainbow Warrior,* a converted trawler owned by a group of environmentalists called "Greenpeace," set sail from Boston to an off-shore drilling site near Cape Cod where a 12-story Shell oil rig had begun drilling after six years of delay and controversy. Greenpeace, concerned about potential pollution and oil spills, placed bumper stickers on the rig and left to continue its battle in court.[5]

Tales go on and on that outline the story of the conflict between environmentalists and industrialists—between mineral extraction and environmental and social integrity. However, one basic objective lies before us—we must produce as much energy as possible with a minimum impact on the environment. It is unrealistic to imagine the United States abandoning its commitment for self-sufficiency in energy production. We are simply too industrialized to swing in the other direction. Even agricultural products are dependent on fuel sources in the field as well as transport to our markets. It is equally unrealistic to imagine the mining and drilling companies removing the various minerals without some damage to the environment occurring. The challenge before us is by no means going to be easy. We must ensure that adequate rehabilitation standards are enforced.

The checks and balances that emerge in the conflict between such groups as Greenpeace, the Sierra Club, and the Audubon Society, and the oil and mining companies should be maintained in order to reach an acceptible mean. To turn the public lands over to the extracting industries without supervision could be disastrous. The *Wichita Eagle and Beacon* quotes Paul Driessen of the Rocky Mountain Oil and Gas Association stating that "wilderness areas, wildlife refuges, and parts of Yellowstone and other national parks should be opened to oil exploration."[6]

As our nation continues its desperate quest for energy self-sufficiency, the conflict between mineral extraction and the environment will broaden. What is badly needed is a realistic set of guidelines that will allow the mining and petroleum companies the latitude needed to remove the resource but with enough control that ensures proper rehabilitation. We also need thresholds or limitations on where oil or coal should be taken and where it should not be taken. I am not, quite frankly, anxious to see oil rigs or draglines sitting at the foot of the Tetons—no matter how desperate we get for oil and coal. Some things are just too sacred.

A careful balance must be maintained between the various forces of nature in our ecosystem. An area that has been disturbed must be rehabilitated as quickly as possible to ensure the balance of natural systems. This is especially critical in the arid and semiarid regions of the West where the balance is so intricate and sensitive. Success in this venture requires that the techniques of rehabilitation be studied and utilized.

A distinction should be made between the terms *restoration, reclamation,* and *rehabilitation.*

Restoration implies that the conditions of the site prior to the time of disturbance will be replicated after the action that disturbs the land is terminated. *Reclamation* implies that the site is habitable by organisms that were originally present or by others that are similar to the original inhabitants. *Rehabilitation* implies that the land will be returned to a form and level of productivity that conforms with a prior land use plan, including a stable ecological state that does not contribute substantially to environmental deterioration and that is consistent with surrounding aesthetic values.[7]

In western areas, complete restoration is rarely, if ever, possible. Reclamation and rehabilitation primarily depend on the goals set by society, which in turn are determined by what society wants and needs from its natural resources, by the physical and ecological conditions of the site, and the economic and social trade-offs involved in supplying those wants and needs.

Rehabilitation specialists, in order to be effective, need to have a knowledge of state and federal laws that relate to surface disturbances, mining and drilling processes, erosion and sedimentation control techniques, and revegetative processes. This book is meant to be an introduction to those topics considered to be basic to rehabilitation. It serves as the beginning of an educational process. The seed planted here, the author hopes, will someday blossom into a life of quality for all the living to enjoy—as well as those future generations that may benefit from our labors.

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MINING PROCEDURES

1
Basic Mining Principles

INTRODUCTION

For thousands of years, man has been fascinated by gems and precious metals. Although some have appeared on the earth's surface, most have had to be reached by digging into the soil to remove the object or the ore. It has been estimated that mineral resources are unevenly distributed in only about 1 percent of the earth's crust.[1]

Mined products are used in our daily lives to a greater extent than most of us realize. Baking soda, for example, is mined from the desert floor in Wyoming. Our life-style and the nation's economy is dependent on the success of mining operations. Because of recent energy crises, the production of coal has taken on a renewed importance. Most of the discussions in this book, therefore, are primarily related to the mining and rehabilitation of coal lands.

Clements reports that the total United States has coal reserves of approximately 434 billion short tons that are economically and legally available.[2] With energy conservation, this reserve should supply the nation's needs for several decades. Nevertheless, even with a stable per capita use of fossil fuel, these energy sources are limited over time because of population growth. The Arab oil embargo of 1973 illustrates the fact that energy is both limited and expensive. Our dependence on domestic reserves for energy sources places a new demand on mineral-laden landscapes. The rates of natural, geological, and biological processes that replenish these resources are infinitesimally small when compared to consumption rates.

An understanding of rehabilitation processes must be preceded by a basic knowledge of mining principles. All the methods currently employed to remove minerals will not be discussed in this chapter, rather, only those methods having a significant impact on the earth's surface.

DEFINITIONS

Coal

Coal is classified into three types including *lignite, bituminous,* and *anthracite.* Each has unique characteristics, but can be evaluated most readily by its ability to produce energy. The content of coal relevant to its energy-producing potential can be expressed in terms of percentages of fixed carbon, volatiles, and water. Coals are rated according to the *fuel ratio,* which is the ratio of fixed carbon to volatile matter. Volatiles burn in the form of gas and produce a long, smoky flame. Fixed carbon produces a hot, smokeless flame. The anthracite coals have a high fuel ratio, bituminous, moderate, and lignite, low.

Lignite, often called *brown coal,* is extremely soft with a fibrous texture. In terms of geologic time, the lignite coals are not well developed. Bituminous coal, or *soft coal,* has evolved over a longer period of time than lignite. It has generally been buried deeper and thus, is more compressed. This accounts for the lower percentage of water contained in bituminous when compared to lignite.

Anthracitic coals have been compressed under tremendous weight for long periods of time. The coal is very hard and glassy in appearance. While anthracite is very valuable and of high quality, it is rare. Most of the reserves are found only in eastern Pennsylvania.

Bituminous coals are the most abundant and sometimes occur in extremely deep formations called *seams*. Those that can be economically mined vary from a few inches to over 60 feet in thickness.

Mining

The mining of coal employs two general methods—underground and surface—which will be discussed later in the chapter. In the process of mining, however, it should be noted that all the topsoil, rock, and other strata that lie above the coal seam, called *overburden,* must be removed. Once the overburden has been removed, it is usually placed in piles called *spoils*. Following the removal operations, the coal is then cleaned and milled to a consistent quality and texture. The residue from this milling process is stacked in piles that are known as *tailings*.

Not all coals are economically available for recovery. The feasibility of mining any given coal site is determined by the ratio of overburden to the thickness of the coal seam. The amount of overburden that lies over the coal is an indication of the expenses to be incurred in mining. The thickness of the coal seam is an indication of the expected profit. Other considerations should be taken into account such as the seam's *inclination* or the angle of slope in the formation. All the natural resources that affect the recovery of the coal will play a role in the economic feasibility of mining as well.

MINING PROVINCES

There is a wide range of differences throughout the United States in topography, geology, and mining techniques. For the purposes of discussing these differences, the United States has been divided into six mining provinces (shown in Figure 1.1), including:

A. Eastern province
B. Interior province
C. Gulf province
D. Northern Great Plains province
E. Rocky Mountains province
F. Pacific province

The variation in natural conditions from region to region creates the need to address mining methods and rehabilitation techniques that are unique to each.

The eastern province is characterized by rolling hills and steep slopes. Mining methods include contour and modified contour methods of removal. The interior and Gulf provinces possess generally flat terrain and thick overburdens. The methods most employed in these regions include box-cut and area stripping. The topography of the northern Great Plains, Rocky Mountains, and Pacific provinces varies from flat to mountainous. In these areas shallow overburdens and thick deposits are typically removed by area strip and open-pit mining methods. Underground mining can occur in all regions but has not been used in recent years to the extent of surface mining methods.

MINING METHODS

Underground Mining

Coal seams are usually locked between sedimentary types of rock formations. Therefore, the seams are usually relatively flat and extend horizontally or with some degree of incline because of geological uplift. In coal seams that lie deep below

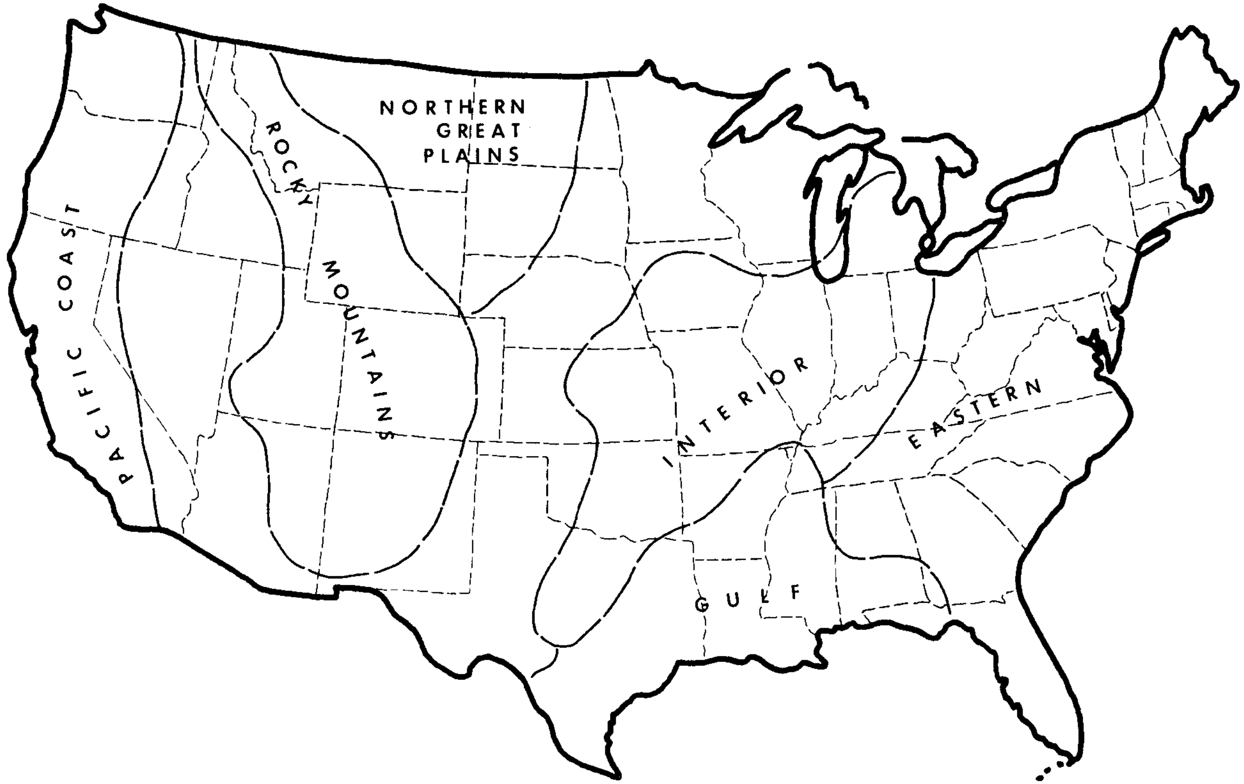

Figure 1.1. The six mining provinces of the United States (Adapted from Bureau of Mines).

the earth's surface, vertical shafts are constructed as an initial means to get to the seam. The coal is mined by extension of horizontal *drifts* or tunnels projected into the face of the seam. In mountainous terrain where the seam is exposed to the mountainside, the drifts can be driven directly into the formation.

Two basic methods are employed to remove the coal in the underground mine. The first is known as the *room-and-pillar* method in which approximately one-half of the coal is left in place as support pillars. The second method of underground mining is the long-wall system. In long-wall mining, all of the coal seam is removed centripetually inward from a large circle. A large block of coal is left to support the shaft. In this system, the roof above the excavated area is allowed to settle as coal is removed.

In mining other types of minerals, especially some ores, the desired material flows along a *vein* embedded in igneous rock formations. Veins run horizontally, vertically, and in branches. Therefore, the underground mining must follow the vein. In mining for gold in the Rocky Mountains, the miners' tunnels may go to the left or right, or up and down to follow the lode wherever it may go. In most cases, the rock material excavated to get to the mineral is dumped at the entrance to the mine.

Surface Mining

Surface mining, also called strip mining, is employed whenever the coal seam has relatively shallow overburden, or when it outcrops along the hillside. There are four basic methods of strip mining including *area strip, contour strip, open pit,* and *mountaintop removal.*

Area Strip Mining. Area strip mining occurs over large geographical areas typical of the interior and northern Great Plains provinces. It is characteristically used in areas with flat terrain, shallow overburdens, and thick seams. The mines require giant earth-moving equipment and must operate several years to justify the cost of the equipment.

The area strip method begins with an initial trench known as a *box cut.* The box cut exposes the seam to be removed. The excavated overburden is stockpiled to the side and will not be used to backfill until the mine is nearly completed. Successive parallel cuts are made, with the overburden cast into the box cut previously made (see Figure 1.2). The last cut leaves an exposed highwall and a deep trench until the rehabilitation process begins. The spoil piles are a parallel series of long peaks and valleys. Occasionally the seams occur in several layers separated by rock material known as *parting.* All the seams can be removed in each cut provided the seam is thick enough to justify the effort to get to it.

The process of mining with the area strip method begins with the removal of vegetation and topsoil located above the overburden. In some cases, where the vegetation is sparse, it is removed with the topsoil. The overburden is then blasted with an explosive charge, which fragments the material for ease of removal. The trenches and spoil banks are recontoured as the rehabilitation process begins. After the topsoil is spread, the mined area is then revegetated. This description of the process

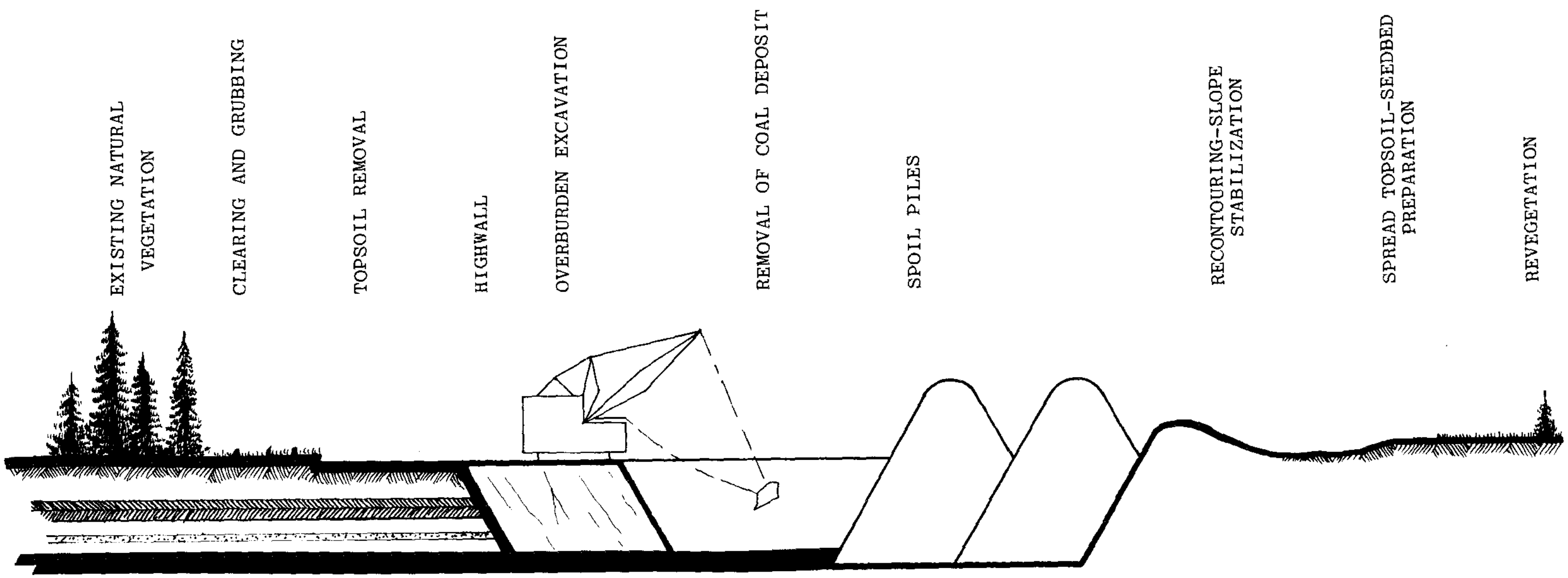

Figure 1.2. Area strip method of mining.

is offered in its most simplistic form. Considerations relative to soil chemistry, surface manipulation, and revegetation problems complicate the work in reality.

Conventional Contour Strip Mining. Contour strip mining is normally used in areas where the topography is rolling or mountainous. This method of surface mining establishes an initial cut into a hillside where an outcrop of coal or mineral seam occurs (see Figure 1.3). The *cut,* or excavation, continues along the hillside and resembles a contour line—hence the name of the method. The overburden in this method is cast on the downhill side in a variety of ways which will be discussed later. Once the overburden has been removed, the exposed, flat slope on which the seam lies is known as a *bench* or *shelf*. The bench is bordered on the downhill side by a spoil pile and on the uphill side by an exposed highwall up to 100 feet in height. The exposed highwalls and spoil piles destroy the vegetation and create tremendous visual intrusions on the landscape. Contour strip mining, for this reason, has been subject to quite a bit of criticism for environmental destruction.

The contour strip mining method buries the overburden of high quality beneath successive layers of low-quality overburden. The exposed overburden is often high in acidity and can produce disastrous pollution problems whenever it is exposed to high winds or heavy rains. With the highwall on one side and the spoil pile on the other, surface water often becomes entrapped. During heavy rains, these pools of stagnant water are more apt to enter the watershed and flow toward streams. Doyle indicates that there is an estimated 25,000 miles of contour bench in Appalachia. Of this figure, some 1,700 miles are affected by massive landslides.[3]

Open-pit Mining. Open-pit mines are essentially the opposite of contour mining in configuration. The open-pit mine has benches that are arranged in spirals or as levels with connecting ramps. The benches range in width from 25 to 125 feet. Safety considerations and the types of equipment employed in

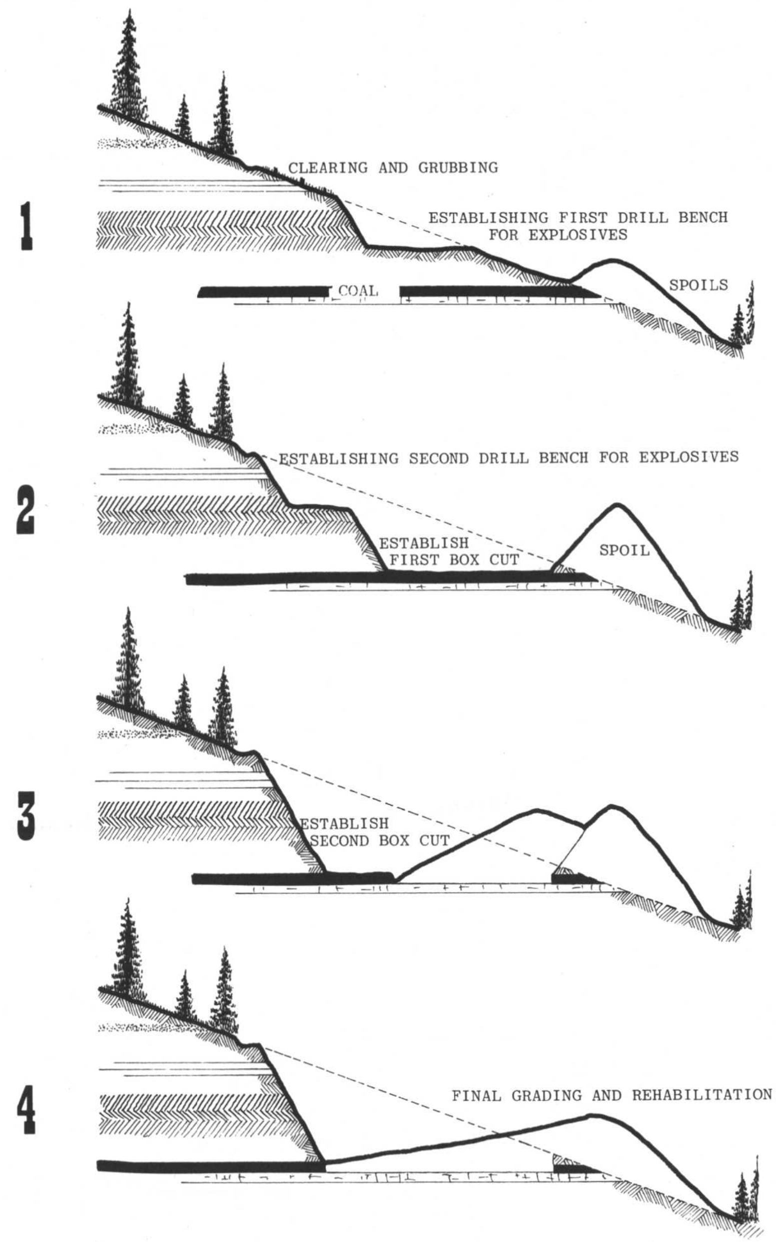

Figure 1.3. Conventional contour strip method of mining.

the mine are the determining factors in bench width. The length and gradient of the bench faces and working slopes are determined mostly by the type of rock formation found in the area. The impact of these operations can be overwhelming in scale. Ore production at a Utah open-pit copper mine approximates 100,000 metric tons per day.[4]

In open-pit mining, the non-ore material is stockpiled around the outside edges of the mine. Only when coal is found in extremely thick seams is the method used. Other forms of mining coal are generally more efficient. The open-pit mine is illustrated in Figure 1.4.

Mountaintop Removal. Mountaintop removal is a method of mining that removes the entire top of a mountain to expose a seam or mineral deposit (see Figure 1.5). It is basically the same method of area strip mining that has been adapted to mountainous or hilly terrain. In utilizing this method, a mining company is able to recover nearly 100 percent of the coal deposit. Excess overburden that cannot be retained on the site is placed in nearby valleys and depressions or on ridges.

This process begins initially with a box cut that is made parallel to the mountain ridge. A barrier at least 15 feet wide is left between the pit floor and the outslope. The barrier helps retain surface drainage and serves as an anchor for spoil piles. Overburden from the initial cut is removed and placed as described above. Overburden from successive cuts is placed in the previously excavated pit.

Chironis describes several distinct advantages that the mountaintop removal method offers, including: (1) No steep downslopes are created by the dumping of spoils; (2) highwalls are completely eliminated; (3) total resource recovery is realized; (4) rugged mountains are transformed into rolling hills and may be capable to future development; and (5) because of near total recovery, the site will not experience future mining disturbances.[5] The main disadvantage of this method is the impact of placing the overburden in the nearby valleys or *head-of-hollow* fills (see Figure 1.6).

The head-of-hollow fill is essentially a procedure whereby excess spoils are placed in nearby narrow, v-shaped, steep-sided hollows. The slopes created by this filling are then terraced to prevent erosion. Natural surface drainage is retained by employing a French drain of natural rock placed in layers on top of the original stripped surface. Downslopes are crown terraced and seeded every twenty feet to prevent erosion. The top of the entire fill is also crowned toward the highwall, if one exists.[6]

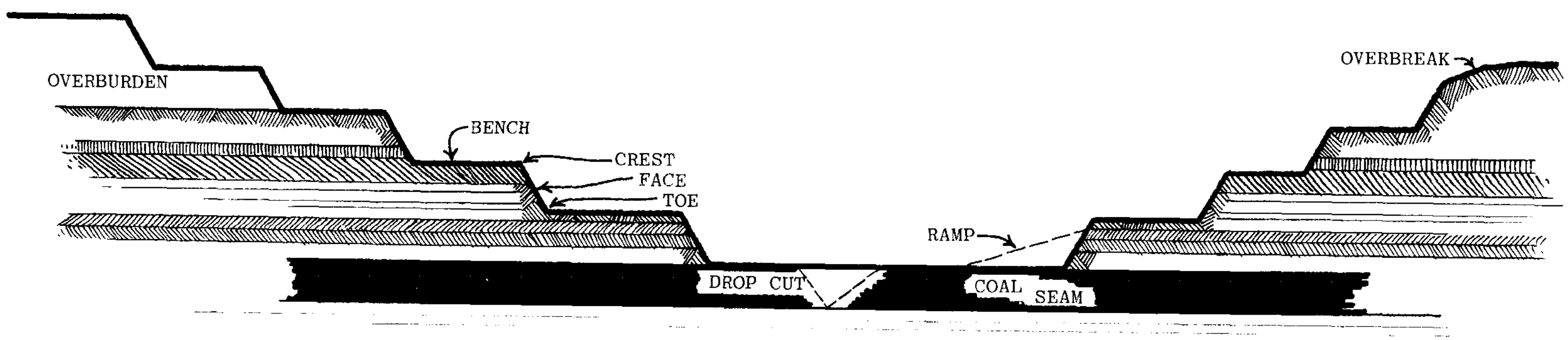

Figure 1.4. Open-pit method of mining (From Peters, W. C., *Exploration and Mining Geology*, New York: John Wiley, 1978).