Figure 7. Examples of bar charts illustrating the range of ash and HGI for selected West Virginia coal seams. These charts were developed from our computerized database. (Illustration by Dan Barker)

Figure 6. This graph shows the range of West Virginia coals available with various values of grindability and fixed carbon. For example, a coal having 60% fixed carbon would probably have an HGI of 48 to 95. Sometimes coal specifications conflict, calling for a combination of qualities not normally found in West Virginia. By referring to charts such as this, or by querying our database, we can quickly determine whether a coal user's specifications are feasible. (Illustration by Dan Barker)

Further Reading


Coal Quality Maps of West Virginia: C. J. Smith and others, 1:500,000 scale, 1982-present, covering ash fusion, sulfur, Btu, FSI, fixed carbon, volatile matter, etc. for the State and various seams—please inquire of Coal Section, West Virginia Geological Survey, P. O. Box 879, Morgantown, WV, 26507-0879, 304/594-2331.

*Survey publication. To order, see Contents page.
Fairmont, West Virginia: A Look at Mining, Geology, and Subsidence

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Fairmont isn’t unique in having subsidence problems. But by focusing on this northern West Virginia city, we can examine in detail the relationship between geology and subsidence, and how property owners with this problem can get help.

A Fairmont resident noticed increasing difficulty opening and closing the doors and windows in his house. He also noticed cracks appearing in the brickwork and basement walls. Only after talking to an older neighbor did he discover that his house was built over an abandoned coal mine. Was mine subsidence responsible for his problems?

Where can the Fairmont resident find answers to his questions? The West Virginia Geological Survey is a good place to start. We can tell the homeowner whether or not his home is undermined, how far the mine is below the surface, and explain the geology beneath the home. Other state and federal government agencies investigate suspected mine subsidence and determine if the site qualifies for government assistance. Also, there is now mine subsidence insurance available to West Virginia homeowners.

We’ll look further at assistance available to homeowners later in this article. But first, let’s examine what areas in Fairmont are mined, when the mining took place, and the role that geology has played in mine subsidence.

Mining

Like many West Virginia communities, the history and development of Fairmont have been closely tied to coal mining. The setting is ideal: Fairmont (then called Middletown) was laid out in 1819 right on top of one of the world’s finest coal deposits—the Pittsburgh coal bed (Figure 1). Mining began under Fairmont in the early 1800s, and has long since progressed to the west, leaving

Figure 1. Outcrop of the Pittsburgh coal bed, just north of the Third Street Bridge in Fairmont. (Looking closely, a man can be seen standing in front of the outcrop.) Everest Avenue is below the retaining wall. Virginia Avenue is above the outcrop. The Pittsburgh coal is about seven feet thick here; the top is about 20 feet below Virginia Avenue.

(Photograph by Ray Strawser)
the city to face the problem of abandoned mine voids beneath its streets and homes.

Figure 2 shows where the Pittsburgh coal underlies the city and where it crops out. The shaded portions are where the coal has been deep-mined. Some of the earliest mining took place along the outcrop on Coal Run and Washington Street. These mines were small and maps of their workings were probably never drawn; thus their exact extent is unknown. However, it is possible that most of downtown Fairmont is not undermined, as several holes drilled there have encountered solid coal, not old mine workings.

A Look Beneath the Surface

What does an underground coal mine look like if we could see down through the surface? Fortunately, mine maps exist for the area from First Street to the West Fork River. Figure 3 shows the city streets superimposed over the network of headings and intersecting crosscuts where the coal has been removed, and the intervening coal pillars left for support. The mining depicted here was done from the 1860s to the 1930s. The coal bed is seven to nine feet high, carved out with picks and shovels. Horses, ponies, mules, and later electric motors pulled the coal from the mines.

Geology

Slicing down through the surface of this part of Fairmont, we can see the underlying soil, rock strata, the coal seam, and voids left by mining. This “slice” is what the geologist calls a geologic cross section. Figure 4 is such a section cut on a line from 8th Street to Coal Run along Walnut Avenue (see location on Figure 2). We constructed the section from descriptions of core holes drilled along or near this line. The holes were drilled to determine the condition of the rock strata over the mine workings, to help understand what is happening or may happen to the surface. The maximum thickness of rock and soil over the coal bed and mine workings in this cross section is about 120 feet. The coal bed dips (decreases in elevation) to the northwest, becoming deeper beneath the surface.

The Formation of the Pittsburgh Coal

To better understand mine subsidence in Fairmont, we need to understand the area’s geology: how the coal and rock strata were formed, and what events have shaped the hills.

During the Pennsylvanian geologic period, approximately 290 million years ago, northern
West Virginia was a low-lying delta plain bordering on a shallow inland sea or bay which lay to the northwest. A large northwestward-flowing river deposited considerable amounts of sediment on the edge of the delta. In this way the delta was built out into the sea. Periodically, as sediment built up, the river would shift to an adjacent, lower area and begin building a new lobe or subdelta.
We see different rock types in the cross section. Each type formed in different parts of the delta system, such as the river, its subdeltas, the sea, and flanking areas. These rock types include sandstone, siltstone, shale, mudstone, and limestone. Swamp vegetation grew in wet areas where sedimentation was not taking place. The dead vegetation, preserved in the water, slowly accumulated into a peat deposit which was much later transformed into coal. The peat-forming swamp that would become the Pittsburgh coal grew on a vast, sediment-free site, such as an abandoned subdelta. Because the river shifted back and forth throughout time, as did the sites where the various rock types and coal formed, we now see horizontal and vertical changes in rock types in the cross section.

The burial of each layer of sediment and peat continued for millions of years until uplifting of the land drained the water from the surface. Millions of years and the pressure and heat of deep burial then combined to change the sediments into rock, and the peat into coal. During those same millions of years the streams and rivers eroded the land, carving the hills and valleys we see today around Fairmont.

Lake Monongahela

A much later geologic event also left its imprint on Fairmont. Long after the close of the Pennsylvanian Period, the Ice Age or Pleistocene Epoch began about two million years ago, lasting until just 10,000 years ago. During the Pleistocene, continental ice sheets and glaciers pushed south into neighboring Pennsylvania and Ohio, blocking the northward-flowing Monongahela River and ancient Pittsburgh River. The Pittsburgh River started near New Martinsville and also flowed north. The ice dams created an extensive lake in both river valleys, named Lake Monongahela.

At its maximum depth, the lake covered all the land below 1100 feet elevation, meaning that about 85% of present-day Fairmont was under water. In the Monongahela River valley, the many-fingered lake extended from the ice dams some 40 miles north of Pittsburgh to about 12 miles south of Weston (Figure 5). (See the article The Ice Age In West Virginia, in the 1982 issue of Mountain State Geology.)

The Monongahela River and its tributaries carried sediment into Lake Monongahela, depositing it in the slow-moving water. When the ice sheets retreated, and the lake drained, the sediments were left as higher-level terraces and valley fills. Many areas of present-day Fairmont which lie between 950 and 1100 feet elevation are blanketed by these loose sands, silts, and clays (Figure 6). Our cross section shows the lake terrace sediment to be 11 to 40 feet thick. Other nearby core holes disclose as much as 55 feet. Carbon-14 dates from organic material found in similar sediments in Morgantown indicate that Lake Monongahela was in existence as far back as 39,000 years ago. The role these lake deposits play in Fairmont's mine subsidence today will be seen shortly.

Mine Subsidence

The rock strata above a mined coal bed act as "beams" bridging the mine passages, holding up all the material above them, including buildings on the surface. These rock beams are made up of different materials, are of different sizes and strengths, and have built-in defects. Man-made
beams, such as those of steel, are strong either when compressed or when pulled apart (under tension). Also, a steel beam is elastic, and can flex somewhat under load and rebound if the load is released. In comparison, rocks are strong when compressed, but weak when pulled apart. Once the coal has been mined out from beneath the rock strata, they are under tension. Also, while rocks do have some elasticity, they are brittle under conditions found in a mine roof.

Some rock types are weaker than others. Shales and mudstone form the weakest beams. Both are made up of very small clay particles. Shale beds have clearly defined thin layers (horizontal laminations), in effect being a collection of many thin, weak beams. Mudstones are poorly layered or bedded, and are weak beams. By contrast, the particles in sandstone and limestone beds are well-cemented together and these beds make harder and stronger beams, especially if thick.

All the rock strata are cracked, or fractured. Fractures along which there has been no movement are called joints. These are especially well-developed in sandstone, limestone, and coal beds, and are often regularly spaced. Shale and mudstone beds are not. In addition to joints, fractures with smooth polished surfaces, indicating that movement has taken place along them. All fractures weaken rock beams, just as cracks in a steel beam make it weaker.

Coal beds in a mine roof make poor beams because coal is brittle and highly jointed. Also,
the coal pillars left during mining for roof support are brittle. Eventually they crush under their load of overlying rock, which weighs thousands of tons.

Groundwater flows through fractures in the rocks, which are further weakened as the water enlarges the fractures by erosion and chemical reaction.

The loose sand, silt, and clay left from Lake Monongahela have essentially no strength under tension. Were it not for the intervening bedrock, these sediments would simply fall into the mined-out passages. Also, if a bedrock fracture is open enough, these sediments could be flushed or "piped" through it into a mine void by percolating water from rain, drains, or broken water pipes.

When mining is completed, the rock strata begin falling down from the roof, filling up the passages. Because broken rock takes up more space than the original solid rock, sometimes the mine passages completely fill. Then the rubble has to support the weight of the overlying strata. This causes the rubble to compact and the overlying strata then continue to deform, fracture, and sag until an equilibrium is reached. Mine subsidence occurs when the breaking of the rock

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Figures 8, 9, and 10. Mine subsidence damage to residential buildings. Figures 8 and 9 are in the West End section of Fairmont. Figure 10 is in nearby Barrackville. The tension cracks seen here are typical of external damage from mine subsidence. Other types of damage include cracks in interior walls, cracks and differential settlement of basement floors and walls, bowing and tilting of basement walls, misalignment of doors and windows, and the breaking of utility pipes. Damage begins in foundations and progresses upward, in the same way the rock strata fail.

(PHOTOS BY RAY STONE)