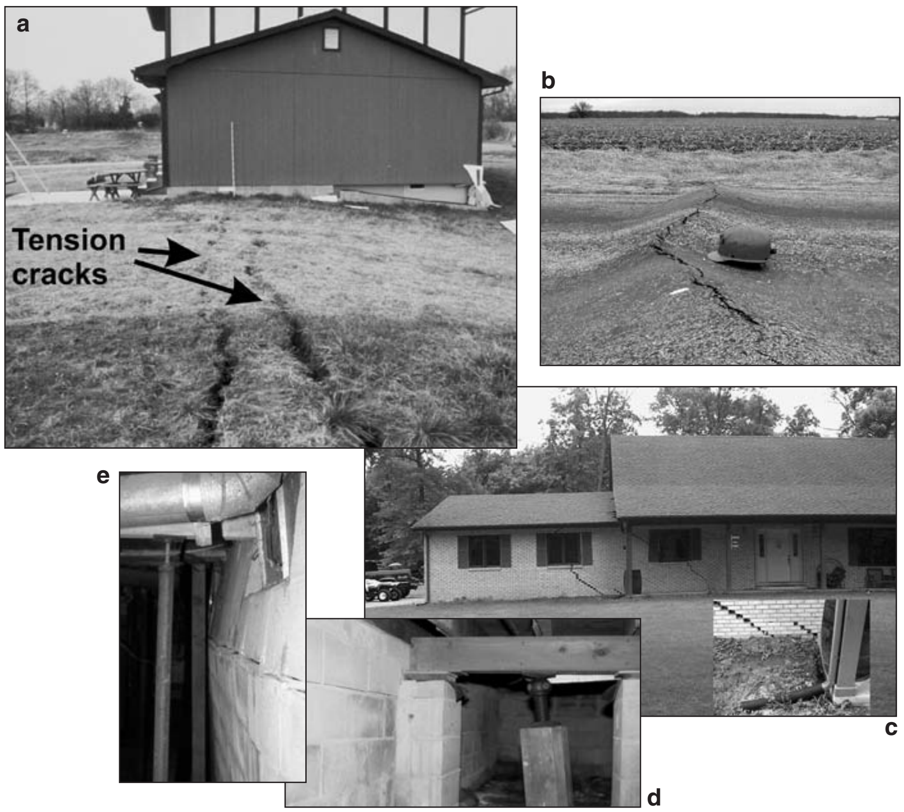
State of Illinois
Rod. R. Blagojevich, Governor
Illinois Department of Natural Resources
Illinois State Geological Survey

Mine Subsidence in Illinois: Facts for Homeowners

Robert A. Bauer

Circular 569   2006

Illinois Department of Natural Resources
1905-2005 ISGS Illinois State Geological Survey



Front Cover: *(a) Tension cracks formed in the ground surface extending through a home; the foundation has settled at the house corner closer to center of sag. (b) Compression ridges formed in a road as the result of ground movement (compression) associated with coal mine subsidence. (c) The brick-sided house in the tension zone shows downward bending (compare roof lines). The left side of the home is closest to the sag center and has dropped down. Insert: ground has pulled away from the porch toward the sag center (left). (d) Settlement of main beam caused by construction problems. (e) This basement damage was unrelated to mine subsidence. It was caused from decades of seasonal wetting and drying of soils, which built up pressure against the basement foundation walls. With each cycle, dryness allows fine grains of soil to fall into the gap between the soil and the foundation wall. When moisture returns, the soil expands, increasing pressure until the wall fails and is pushed inward.*

Released by the authority of the State of Illinois   10M - 8/06

Mine Subsidence in Illinois: Facts for Homeowners

Robert A. Bauer

Circular 569 2006

Illinois Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
William W. Shilts, Chief
615 E. Peabody Drive
Champaign, Illinois 61820-6964
217-333-4747
www.isgs.uiuc.edu

Preface

About 840,000 acres of Illinois land have been undermined for coal and other minerals. About 178,000 acres of residential and other built-up land in Illinois lie close to underground mines and may be susceptible to subsidence. The number of underground coal mines in Illinois has been estimated at 5,500. Maps exist for about 2,600. In 1991, it was estimated that about 320,000 housing units in the state were built over or adjacent to underground mines. Statewide, this number is likely to increase as cities continue to expand outward over mined-out areas.

Subsidence of the surface above abandoned coal mines is uncommon, but homeowners should be aware of nearby mining and the causes and consequences of subsidence. The information provided in this publication should enable homeowners to make a more educated decision as to whether they need to insure their homes against possible mine subsidence damage.

The Illinois State Geological Survey (ISGS) and Illinois Department of Natural Resources, Office of Mines and Minerals (OMM), are on a continual search for missing mine maps. If individuals are aware of any sources of old mine maps, please contact the ISGS or OMM to allow the maps to be copied.

Help for Homeowners

The ISGS has prepared this publication in order to provide information to Illinois homeowners concerned with or experiencing subsidence problems associated with past mining activity. Common damages and problems associated with subsidence are described. Some information is included about problems frequently mistaken as being related to subsidence. Detailed advice is provided as to what to do when subsidence problems are suspected and what help is available for property owners faced with these kinds of problems. Links are provided to other mine information such as maps that will assist the prospective property developer or buyer to avoid known mined-out areas and subsidence problems.

CONTENTS

TABLES

FIGURES

Mine Subsidence in Illinois

Signs of Subsidence

Cracks suddenly appear in the foundation and walls or ceilings, then widen and grow. The ground around the house also starts to crack and lower. Popping and snapping can be heard as the house shifts. Doors and windows stick, jam, or break. Parts of the house tilt, and doors swing open or closed. The chimney, porch, or steps separate from the rest of the house. Water lines break, resulting in dirty tap water, loss of water pressure, and soaked ground. Gas and sewer lines leak.

As subsidence develops, several of these problems are likely to emerge simultaneously within a few days or weeks after onset. Collectively, the damage and ground movements indicate a sense of direction that points to the center of the subsidence event. If only one or two problems occur in a house at random, they may be traced to some cause other than coal mine subsidence.

Underlying Cause

In Illinois, subsidence, or sinking of the land surface, commonly results from underground mining. Soon after the first settlers arrived in Illinois, they developed underground mines to extract coal, lead, zinc, fluorite, shale, claystone, limestone, and dolomite. During the early years, land over mining areas was sparsely populated, and, if the ground settled, homes or other structures were seldom damaged. As towns and cities expanded over mined-out areas, subsidence damage to structures became increasingly common.

In Illinois, the risk of damage to structures has been high enough that a state law, the Mine Subsidence Insurance Act, was passed in 1979 to provide subsidence insurance for homeowners in mining areas. This Act mandates that private insurance carriers include damage coverage as part of the homeowner policy. Amendments to the Act have increased coverage for insured structures from $50,000 (1979) to $350,000 (1990). Mine subsidence insurance in Illinois covers damage caused by underground mining of any solid mineral resource. (More information about the insurance program and the fund is available from the Illinois Mine Subsidence Insurance Fund. See the Contacts for Additional Information section, p. 19.)

Subsidence is possible in any area where any mineral has been mined below the ground surface. One of the state's largest mine subsidence events (700 × 400 feet and 69- to 70-feet deep) took place over a lead-zinc mine near Galena in 1972 (Touseull and Rich 1980). Most mine subsidence in Illinois, however, is related to coal mining, which represents the largest volume extracted and area undermined in the state of any solid commodity. The total acreage where coal mining has occurred (fig. 1) far overshadows the acreage undermined for all other commodities (table 1). A 1991 study showed that about 178,000 acres of residential and other developed areas can be found close to underground mines, and an estimated 320,000 housing units have been built on land over or adjacent to underground mines (Treworgy and Hindman 1991).

Figure 2 shows the extent of underground coal mining in each county. Home insurance policies for residents living in counties with more than 1% of their land undermined have a mine subsidence insurance premium automatically included, as required by the Mine Subsidence Insurance Act of 1979. In these counties, mine subsidence coverage can be declined by signing a waiver.

Geologic Setting

Knowing what geologic (earth) materials lie above and below a coal mine leads to an understanding of how and why subsidence takes place. The ground surface may subside when bedrock or earthen materials fail either above (the roof), within (the coal pillars), or below (the floor) the mine workings.

The term "overburden" refers to all earth materials overlying the mined coal. Overburden includes both the bedrock material and the non-bedrock deposits of sand, silt, clay, and pebbles that are found on top of the bedrock. These upper materials are commonly of glacial origin.

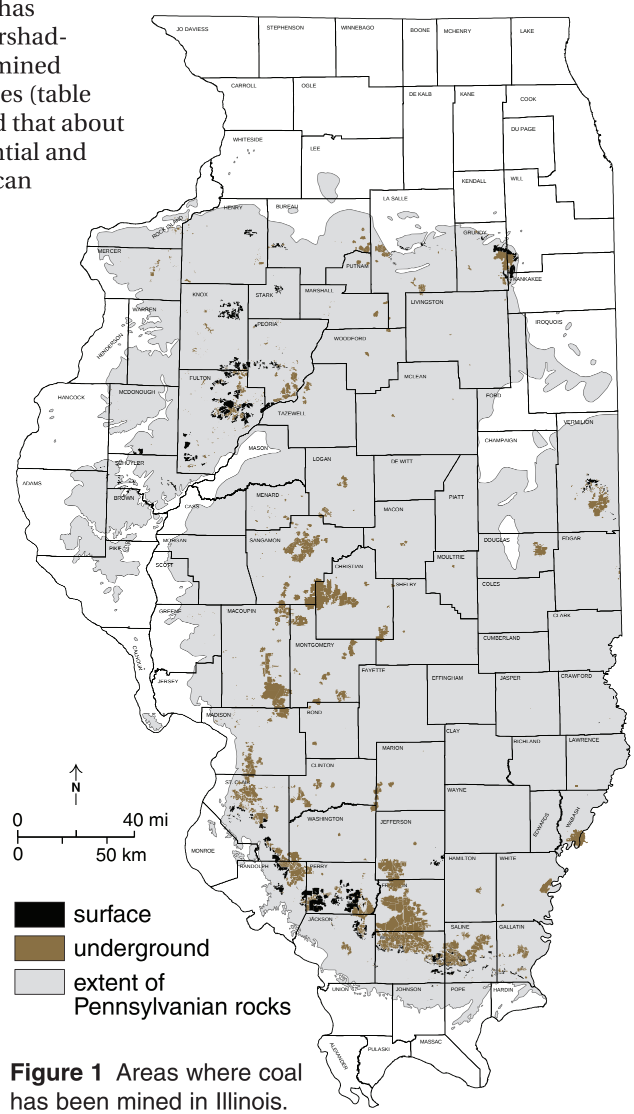


Figure 1 Areas where coal has been mined in Illinois.

From the ground surface downward, first are the windblown silts, called loess, in which Illinois soils have formed. Loess blankets most of the surface of the state. This silt material was blown out of the Mississippi and Illinois River valleys and was deposited across the Illinois land surface. Loess

Table 1 Underground mines producing industrial minerals and metals.

County	Mineral	Mine (no.)	County total
Adams	limestone	4	4
Alexander	ganister	2	6
	tripoli	4	
	clay[1]		
Calhoun	clay	5	5
Carroll	lead	2	2
Cook	dolomite	1	1
Du Page	dolomite		
Greene	limestone	1	1
Hardin	fluorspar[2]	130	131
	lead[2]	1	
	zinc[2]		
Henderson	limestone	1	1
Jackson	clay	1	1
Jo Daviess	lead[3]	93	102
	zinc[3]	9	
Johnson	limestone	1	1
Kane	dolomite	2	2
La Salle	clay	6	8
	limestone	2	
Livingston	clay	1	1
Mc Donough	clay	3	3
Madison	clay	2	4
	limestone	2	
Marshall	clay	1	1
Monroe	limestone	2	2
Pike	limestone	3	3
Pope	fluorspar[4]	51	58
	lead[5]	7	
	zinc[4]		
	barite[4]		
Randolph	limestone	3	3
Rock Island	clay	1	1
Saline	fluorspar[5]	2	2
	lead[5]		
Scott	clay	1	1
Union	clay	12	14
	tripoli	2	
Will	dolomite	2	2

[1] Two of the four tripoli mines also mined clay.
[2] Twenty-nine fluorspar mines also produced lead, ten produced zinc, and four produced lead and zinc.
[3] Fifty-four lead mines also produced zinc.
[4] Twenty-five fluorspar mines also produced lead, three produced zinc, two produced lead and zinc, and one produced barite.
[5] One fluorspar mine also produced lead.

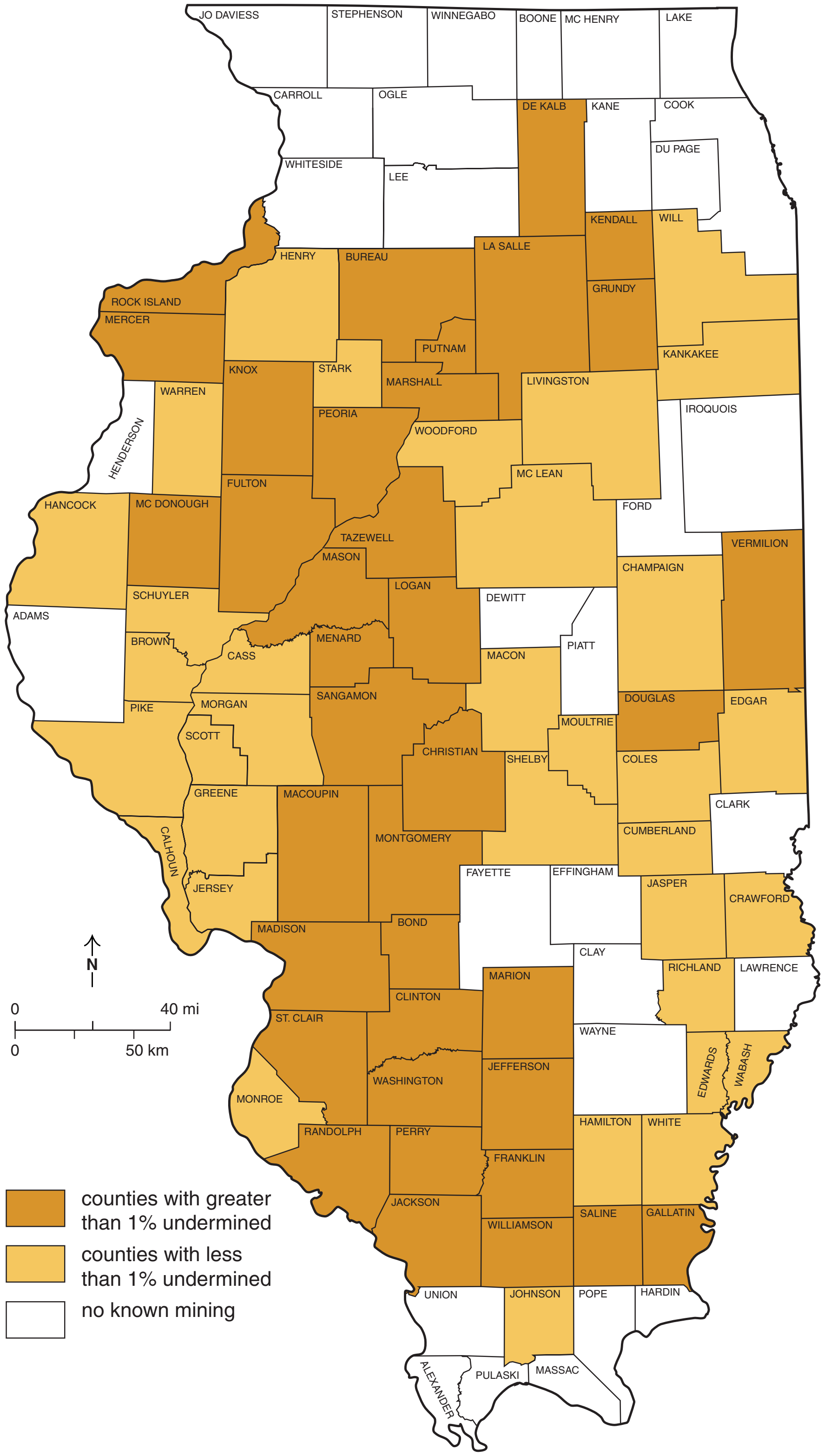


Figure 2 Counties of Illinois undermined for coal. Counties with undermined areas of 1% or more are automatically included in the mine subsidence insurance program.

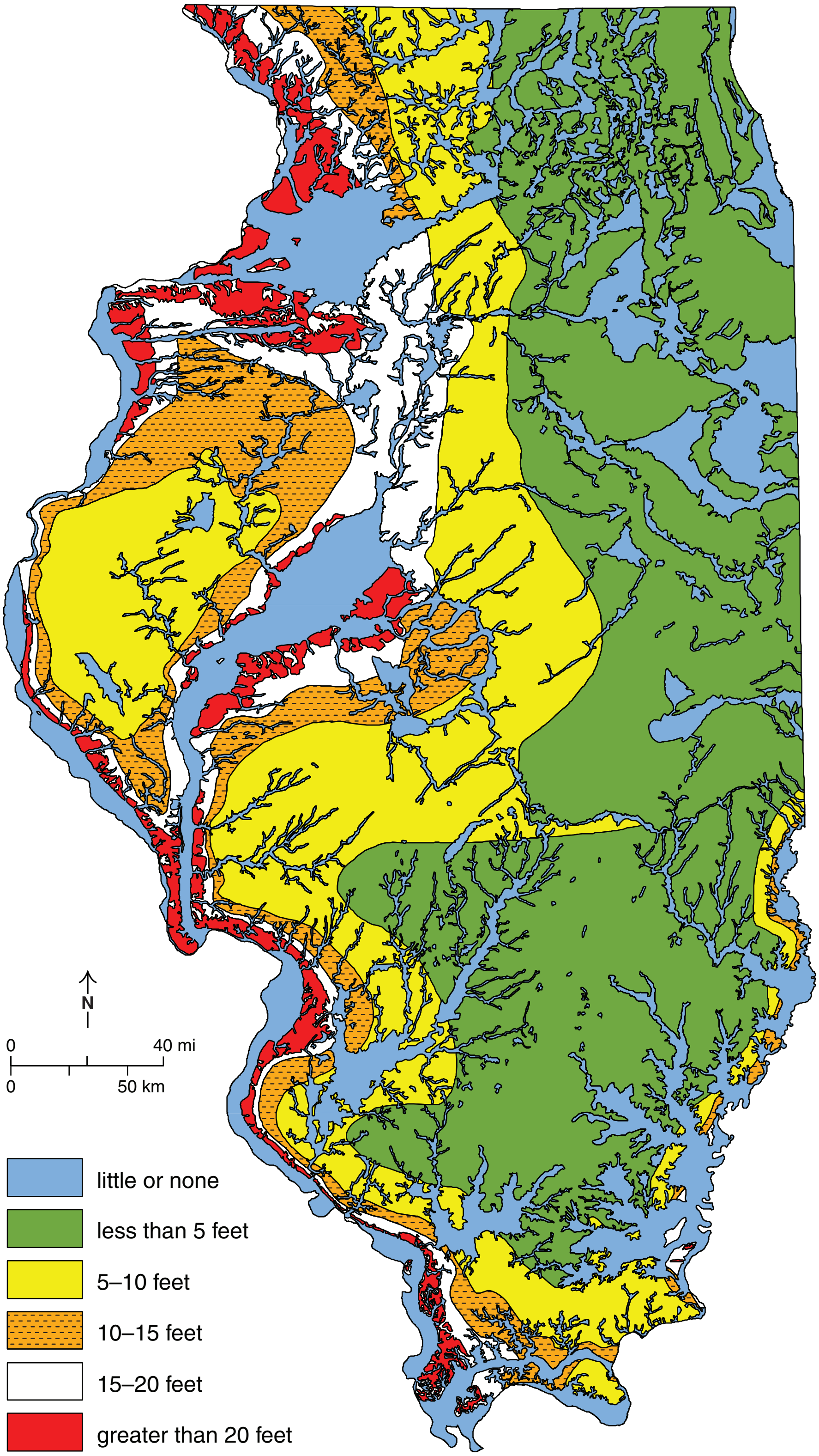


Figure 3 Total loess thickness in Illinois (Fehrenbacher et al. 1986).

ranges from less than 2 feet to about 25 feet thick (fig. 3), except in a part of southwestern Illinois where it may be as much as 100 feet thick near the Mississippi River valley. Below the loess are glacial materials deposited on top of the bedrock. These unconsolidated materials laid down by the moving or melting continental glaciers consist of sand, silt, clay, and gravel. These materials range from less than 10 feet thick to more than 300 feet thick over the areas mined for coal in Illinois. Beneath the glacial deposits is bedrock, the flat-lying or gently dipping layers of shale, coal, claystone, limestone, and sandstone (fig. 4). The layer below most Illinois coals is a soft claystone, also known as underclay.

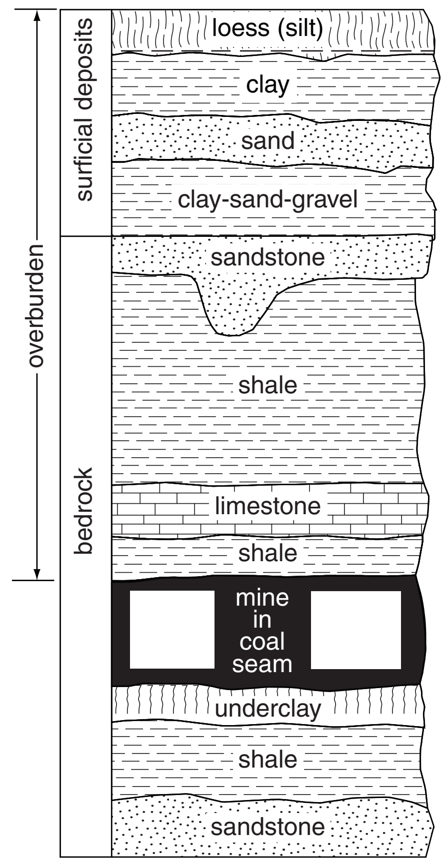


Figure 4 Generalized geologic column showing layers of surficial materials and underlying bedrock layers that are typical of the overburden of many coal mining areas.

Figure 5 Photograph of mining at the face in an early longwall mine. Note the rock support on the right side of photograph. These mines operated from the 1870s to 1951 in fifteen counties. Most were located in the northern counties from Bureau through Will (fig. 2).

Underground Coal Mining Methods

Surface mining, formerly called “strip” mining, accounts for about 15% of the state’s current coal production. Although surface-mined land may settle, that settling is not called subsidence.

Much of Illinois coal lies too deep for surface mining and requires an underground mining operation. Two fundamental underground mining methods are used in Illinois: high-extraction (including longwall) and low-extraction room-and-pillar.

High-Extraction—Planned Subsidence

High-extraction mining methods (figs. 5 and 6) remove almost all of the coal in localized areas, and planned surface subsidence is part of the operation. The surface subsides above the mine within several days or weeks after the coal has been removed. The sinking or subsiding of the overburden over the mined-out area will continue for years. The initial large and rapid ground movements associated with this mining method diminish rapidly after a few months. Once subsidence has decreased to levels that no longer cause damage to structures, the land may be suitable for development.

There have been three main high-extraction mining methods used throughout the history of mining in the state: early longwall, high-extraction retreat, and modern longwall.

In the late1800s and early 1900s, longwall mines (figs. 5 and 6a) were excavated by hand, and workers maintained the haulageways (entryways) by placing stacked rock, wooden props, and rock-filled wooden structures to replace the support lost by the removal of coal. The mine roof and the rest of the overburden’s weight settled onto the stacks of rock and compressed them. When this occurred, a few feet of subsidence resulted at the ground surface over the entire mined area.

Modern high-extraction systems are designed to achieve a high rate of production and maximize resource removal (fig. 6, b–d). The high-extraction retreat method, used from the 1940s through 2002, had miners remove as much coal as possible in an area within a panel until the roof started to collapse. The miners then retreated and formed the next row of pillars. This process was repeated as the miners worked their way out of the panel toward the haulageway. Roof collapse was controlled in those areas by the use of temporary roof supports. In this manner, relatively small areas were allowed to collapse as the miners retreated safely. Eventually, the entire panel was mined out, and the coalescence of collapsed areas caused the ground surface to lower.

In modern longwall mines, workers remove 100% of the coal along a straight working face within defined panels, up to 1 to 2 miles long and about 1,000 feet wide. The mine roof collapses immediately behind the moving roof supports, causing 4 to 6 feet of maximum subsidence on the ground surface over the centerline of the panel. This amounts to 60% to 70% of the mined height of the coal seam plus any roof or floor materials that have been removed along with the coal.

Low-Extraction Room-and-Pillar—Unplanned Subsidence

Using the room-and-pillar system, miners create openings (rooms) as they work. Enough coal is left in the pillars to support the ground surface. In Illinois, this system results in extraction of 40% to 55% of coal resources in modern mines and up to 75% in some older mines.

The design or layout of the rooms has changed through time. The room-and-pillar method that was generally used before the early 1900s was characterized by rooms that varied considerably in length, width, and sometimes direction (fig. 7a, b). To separate production areas (panels) from the main entries and to improve ventilation, mine operators devised the modified room-and-pillar or panel system (fig. 7c). This system provided a more regular configuration of production areas. The production panels were set back from the main entries. Well-defined boundaries were the result of the broad barrier pillars or unmined areas left between adjacent panels and between the panels and the main entries. Two room-and-pillar methods in current usage are the blind room and the checkerboard (figs. 7, d, e). Using the first method, miners bypass every sixth or seventh room of a production area. The unmined area (blind room) functions as a large pillar to support the roof. This method is still used today. The checkerboard system has evenly spaced square pillars in a checkerboard pattern forming very large panels.

Based on current state regulations, room-and-pillar mines in operation after 1983 that do not have planned subsidence approved as part of their operation have to show that they have a stable design. Although these permitting requirements have improved overall mine stability, no one can guarantee that subsidence will not occur above a room-and-pillar mine in the future. In general, if coal has been removed from an area, subsidence of the overlying geologic materials is always a possibility.

Mine Maps

Copies of original mine maps may contain detailed features such as shaft locations (the entrances to a mine), surface facilities, and location and size of coal pillars left in the mine. Original mine maps are used to accurately determine the type of mining performed in each area and to relate the location of mine features to surface structures. Illinois law requires that mining companies file maps and mining information with the State Mine Inspector, Illinois Department of Natural Resources, Office of Mines and Minerals, in Springfield and with the Office of the County Clerk in the county where the mine is located. These two offices are the official repositories for mine maps.

There are an estimated 5,500 underground coal mines in Illinois. Maps exist for about 2,600 of them. The Illinois State Geological Survey and the Illinois Department of Natural Resources, Office of Mines and Minerals, are continually searching for missing mine maps. If persons are aware of any sources of old mine maps, please contact the Survey or Office of Mines and Minerals to allow them to be copied.

Dangers of Abandoned Mines

Abandoned mines are extremely dangerous for a variety of reasons. Many old mines are partly collapsed or unstable, and thus inaccessible. Some are full of water. Others contain poisonous and/or explosive gases or have

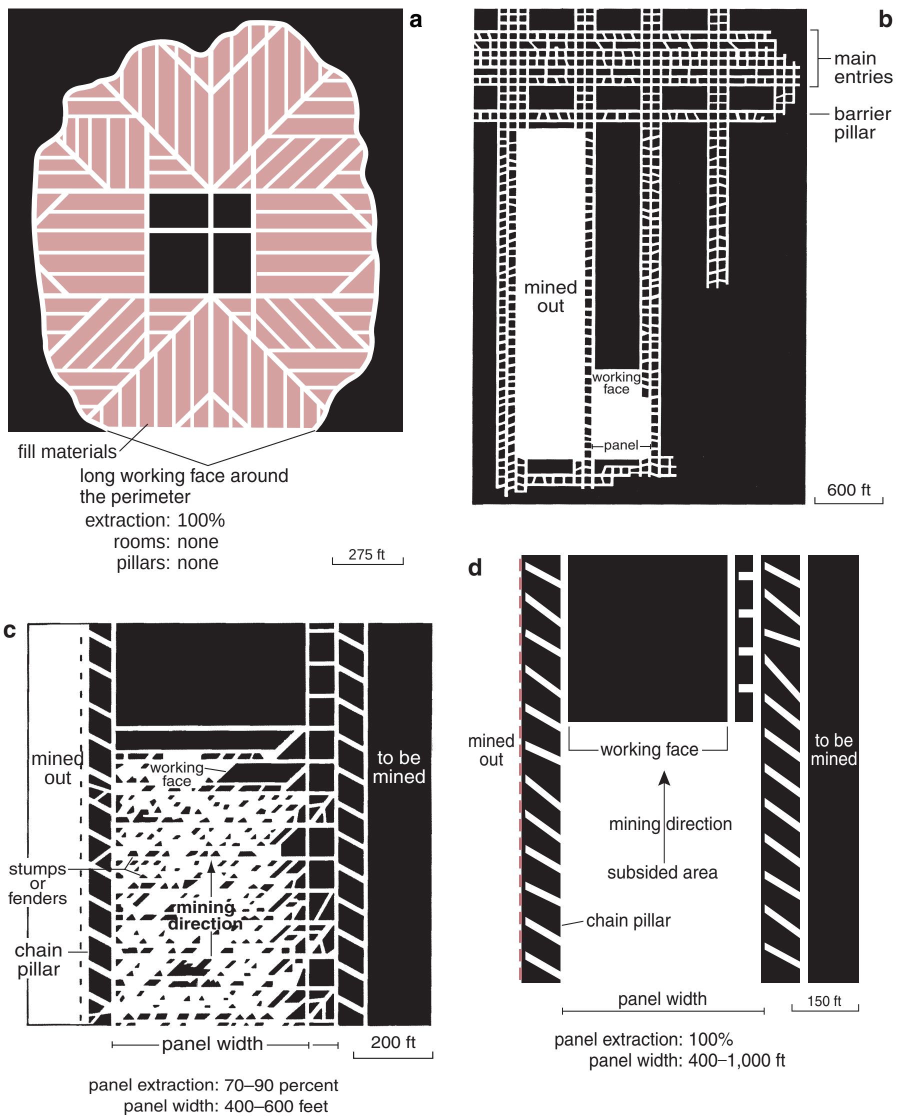


Figure 6 (a) Diagram of an early longwall mine design. Coal was removed starting from the center of the mine (shaft-entrance to mine level) outward along a continuous outside perimeter of the mine. Areas where the coal was removed were backfilled with rock support (see fig. 5) (after Andros 1914a). (b) Diagram of general development plan for modern high-extraction retreat and longwall mine (Hunt 1980). (c) Modern high-extraction retreat method: small stumps of pillars are crushed when roof collapses. Chain pillars may be mined to increase panel width (Hunt 1980). (d) Modern longwall method whereby all coal is removed along a straight mining face, forming a sharply defined panel with no remaining coal support except a row of pillars between panels (after Hunt 1980).

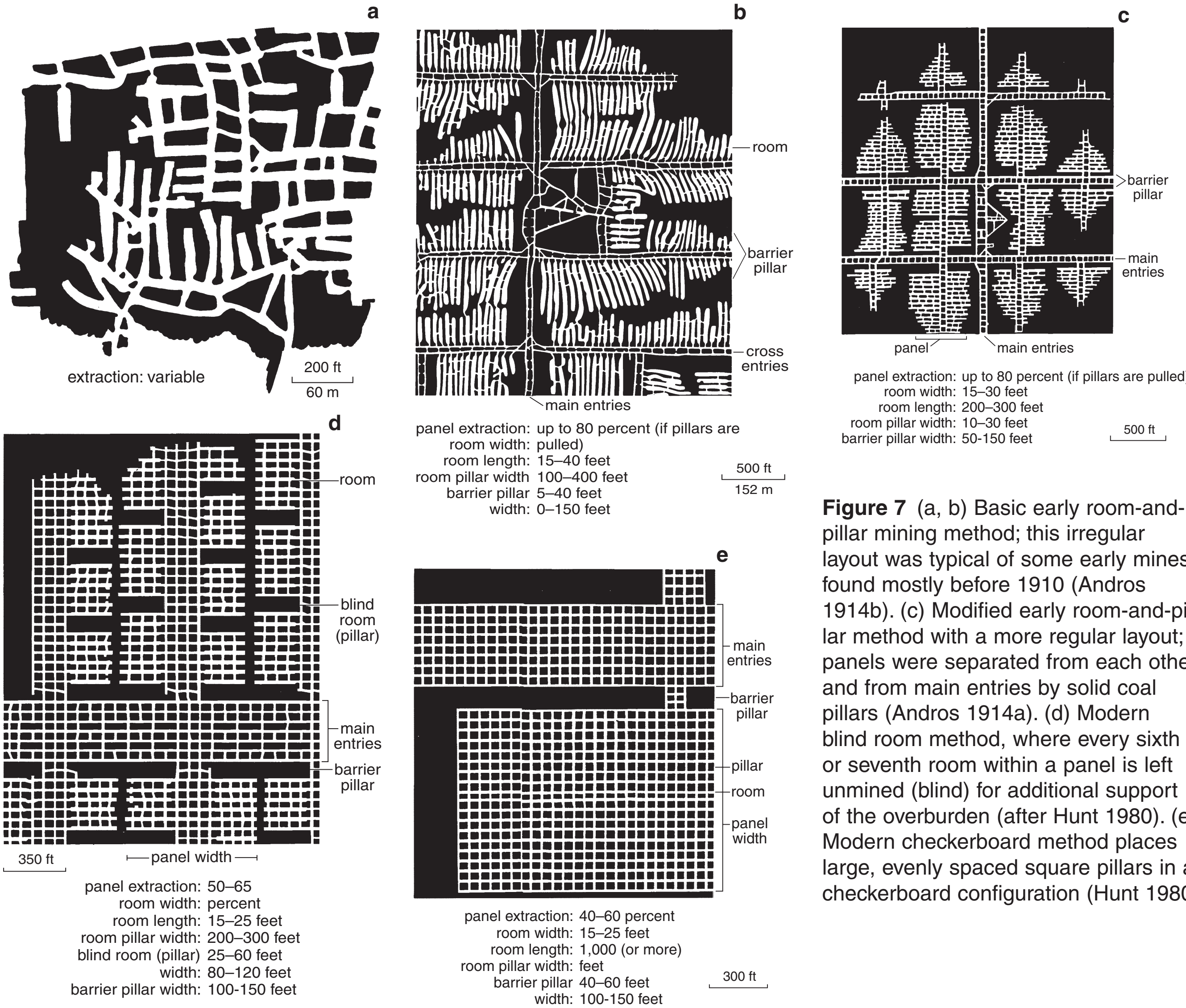


Figure 7 (a, b) Basic early room-and-pillar mining method; this irregular layout was typical of some early mines found mostly before 1910 (Andros 1914b). (c) Modified early room-and-pillar method with a more regular layout; panels were separated from each other and from main entries by solid coal pillars (Andros 1914a). (d) Modern blind room method, where every sixth or seventh room within a panel is left unmined (blind) for additional support of the overburden (after Hunt 1980). (e) Modern checkerboard method places large, evenly spaced square pillars in a checkerboard configuration (Hunt 1980).

too little oxygen to sustain life. Because abandoned mines are so dangerous, mine access requires the approval and supervision of the state mine inspector.

Types of Subsidence

Researchers have learned much about the nature and causes of subsidence by studying ground surface effects, drilling holes down into mines, lowering small television cameras down the holes to view mine conditions, and personally inspecting mines that are still operating and accessible. In Illinois, subsidence of the land surface takes one of two typical forms: pit or sag (trough).

Pit Subsidence

Pits are generally 6 to 8 feet deep and range from 2 to 40 feet in diameter (figs. 8 and 9), although most are less than 16 feet across. Newly formed pits have steep sides with straight or bell-shaped walls.

Pit subsidence mostly occurs over shallow mines that are less than 100 feet deep and where the bedrock over the mine is less than 50 feet thick and composed of weak rock materials such as shale. The pit is produced when the mine roof collapses and the roof fall void works its way up through overlying thin, weak bedrock and surficial layers to the ground surface. Pit subsidence forms very quickly. If the bedrock is only a few feet thick and the surficial deposits are loose, these materials may wash into adjacent mine voids, producing a surface hole deeper than the height of the collapsed mine void.

Sag or Trough Subsidence

Sag subsidence forms a gentle depression over a broad area. Some sags may be as large as a whole mine panel—several hundred feet long and a few hundred feet wide (fig. 10). Several acres of land may be affected. The maximum vertical settlement is gener-

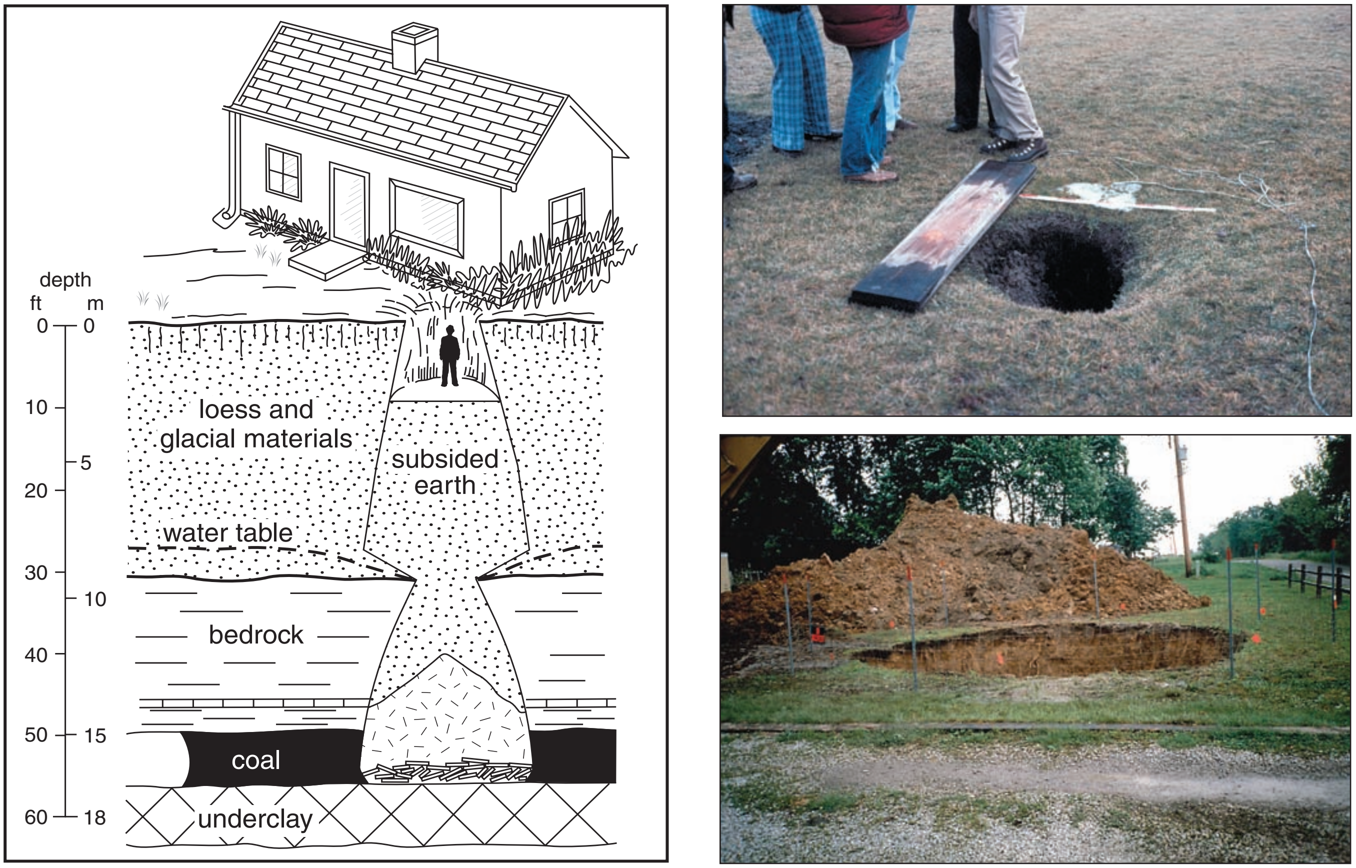


Figure 8 Diagram (Wildanger et al. 1980) and photographs of typical pit subsidence events.

Figure 9 Pit subsidence under the corner of a house from (a) above and (b) below ground.

ally near the center of the depression and is 2 to 4 feet deep (fig. 10).

A major sag may develop suddenly (in a few hours or days) or gradually (over years). The rate of sag development depends on the type of failure in the mine. Sags may originate over places in mines where the coal pillars have disintegrated and collapsed (fig. 11), producing a rapid downward movement at the ground surface or slower downward movements where the coal pillars are being pushed into the relatively soft underclay that forms the floor of most mines (fig. 12). Sags can develop over mines of any depth. The profile in figure 10 shows settlement that took place over 45 weeks.

Tension cracks form as the ground is pulled apart by downward bending of the land near the outside edges of the sag. Generally, the cracks parallel the boundaries of the depression. Near the center of the sag, compression ridges may form as the ground is squeezed by downward bending of the land near the bottom of the sag. Ridges are observed less frequently than tension fractures because the area of compression is much smaller.

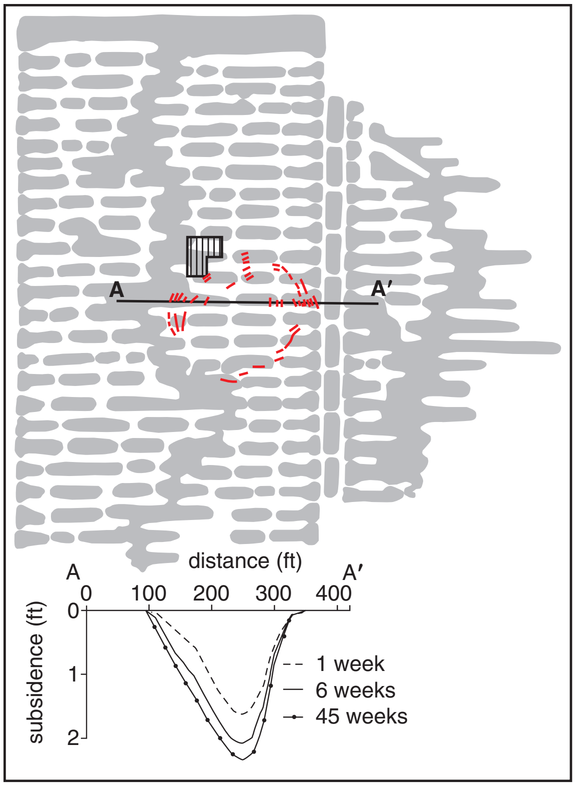


Figure 10 Sag subsidence shown on a map of the underlying mine. Profile A–A′ shows the sag developing. Compression ridges formed near the deepest part of the sag, and tension cracks (red lines) formed around the perimeter. (Data are from Dave Kiesling, Department of Civil Engineering, University of Illinois, personal communication 1981.)

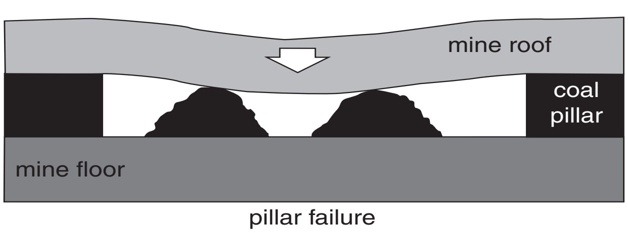


Figure 11 Diagram of a failure of pillars that results in lowering of the ground surface.

Effects of Subsidence: Problems and Solutions

Pit Subsidence

When pits develop, the ground moves primarily in one direction: it drops vertically. Pits commonly appear after heavy rainfalls or snow melts. Water seldom accumulates in the pit. Instead, it drains down into the mine. A common treatment is to fill the pit with clayey soil and to compact the clay as tightly as possible so that its permeability is very low. The idea is to prevent soil from eroding down into the mine by discouraging water from collecting and draining into the mine through the repaired pit subsidence. Many pits have been permanently filled this way.

Structures can be damaged if pit subsidence develops under the corner of a building, the support posts of a foundation, or another critical spot. Otherwise, the probability of a structure being damaged by pit subsidence is low because most pits are relatively small—only a few feet across. If pit subsidence develops under foundation walls, the house may not be affected immediately because the foundation may temporarily bridge the pit (figs. 8 and 9). Left unfilled, the structure (bridge) may become damaged from lack of support.

Homeowners living where pit subsidence is common should periodically inspect crawl spaces and other hidden areas of their homes. When a pit is discovered below a foundation, the pit should be carefully filled so that proper support is again established.

Subsidence pits that are not filled pose a special danger for both people and animals. They are often deep and steep-sided. Anyone who falls in may find it very difficult to get out.

Sag Subsidence

The ground moves in two directions during sag subsidence (figs. 13 and 14). The ground drops vertically and moves horizontally toward the center of the sag. At the surface, the sag may be much broader than the collapsed part of the mine. For example, a failure in a mine 160 feet deep could cause minor surface subsidence more than 70 feet beyond the edge of the collapsed area underground (edge of panel). The deeper the mine, the larger the area affected out over the unmined area. Collapsed areas in abandoned underground mines may occur in only part of a panel or mined-out area (fig. 15).

Sag subsidence produces an orderly pattern of tensile features (tension cracks) surrounding a central area of possible compression features. Mapping the direction of how the cracks pulled apart shows that the movements point toward the center of the sag. Sub-

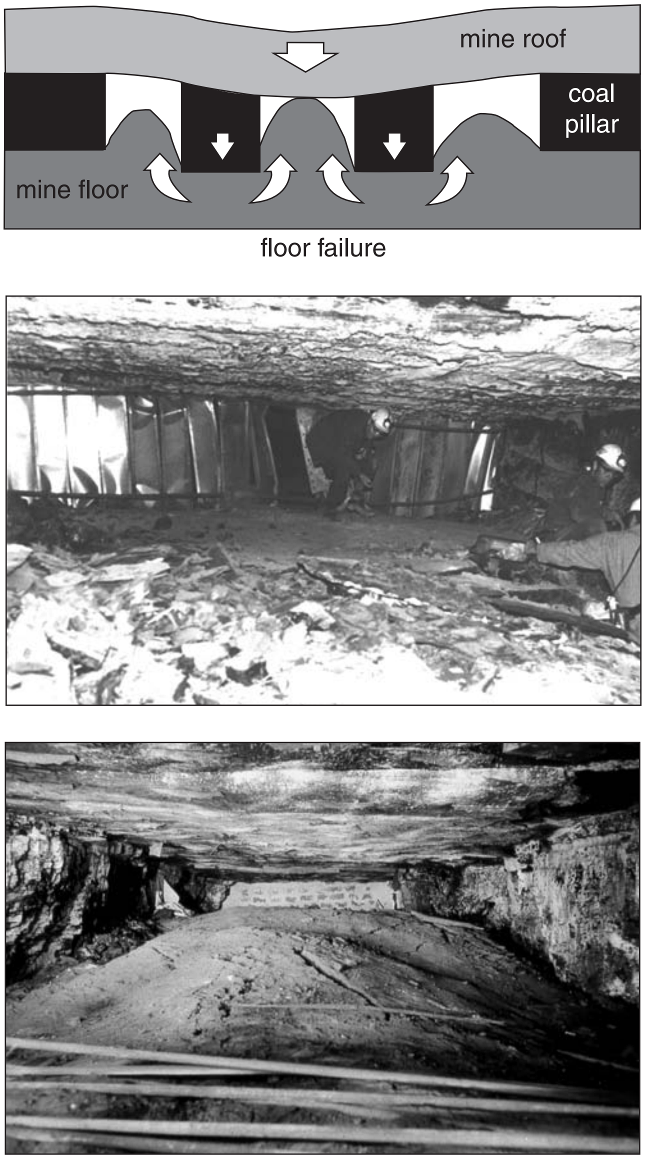


Figure 12 Diagram and photographs of coal pillars being pushed into a soft floor. The claystone material is being squeezed out from under the pillar up into the entryway.

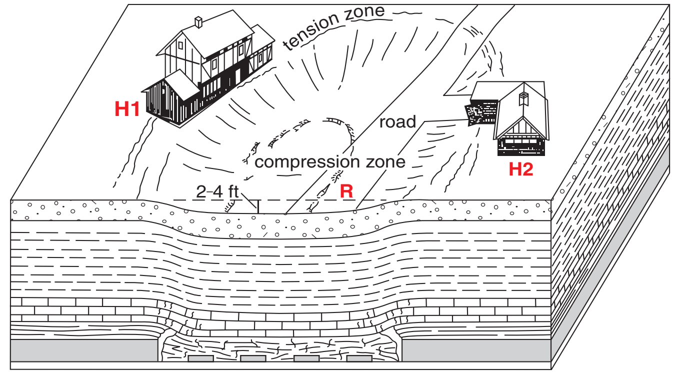


Figure 13 Block diagram of a typical sag subsidence event. The road is in the compression zone (located at R), and asphalt has buckled. The wood frame house (H1) is in the tension zone; the house's foundation has pulled apart and dropped away from the superstructure in one corner. A brick house (H2) in the tension zone shows cracks in walls, ceilings, and floors.

sidence movements are not selective—all structures (buildings, sidewalks, driveways, fences, streets, curbs, etc.) within a sag will be affected and move toward the center of the event.

The type and extent of damage to surface structures relate to their orientation and position within a sag. In the tension zone, the downward-bending movements that develop in the ground may damage buildings and roads as well as driveways, sidewalks, sewer and water pipes, and other utilities. The downward bending of the ground surface causes the soil to crack, forming the tension cracks that pull structures apart. The lowermost portion of the house foundation will be pulled apart where it is in contact with the soil. Houses H1 and H2 (figs. 13 and 14) show cracking and separation caused by tension throughout their structures. Until subsidence has ceased and repairs can be made, house H1 needs to be entirely supported. Damage in house H2 will be restricted mostly to the lowered side, so that only this side may need support.

In the comparatively smaller compression zone, roads (fig. 13, R) may buckle, and foundation walls may be pushed inward. The foundation of any house in the center of the sag would be subjected to horizontal compression. Buildings damaged by compression typically need their foundations rebuilt. They may also need to be leveled due to differential settling.

Repair of Subsidence-Damaged Houses

A house may be built on a slab, on footings with a crawl space, or on a basement. Each type of construction requires a different type of treatment for subsidence damage. Permanent or rigid repairs are not advisable until subsidence-related ground movements have been completed. Premature, rigid repairs may exacerbate damages and may break again, resulting in additional financial loss. Temporary repairs, such as weather proofing or making a door functional, should be flexible and be made to accommodate additional movement. It may be necessary to make temporary repairs several times in cases involving large ground movements. The repair of most structures requires detaching the house from the slab or foundation to relieve stress to the frame and to allow re-leveling. The re-leveling technique is unique to each home in order to account for its damage and structural characteristics.

Houses on slabs Some houses are supported by broad, flat concrete pads called slabs or slab-on-grade construction. Areas around the outside edge of the slab and under other supporting

Figure 14 Photographs illustrating the sag subsidence event and features shown in figure 13. (a) Compression ridges formed in the road (feature R) as the result of ground movement (compression) associated with coal mine subsidence. (b) Tension cracks form in the ground surface extending through a home (feature H1); the foundation has settled at the house corner close to the center of the sag. (c) The brick-sided house (feature H2) in the tension zone shows downward bending (compare roof lines). The left side of the home is closest to the sag center and has dropped down. Insert: Ground has pulled away from the porch toward the sag center (left).

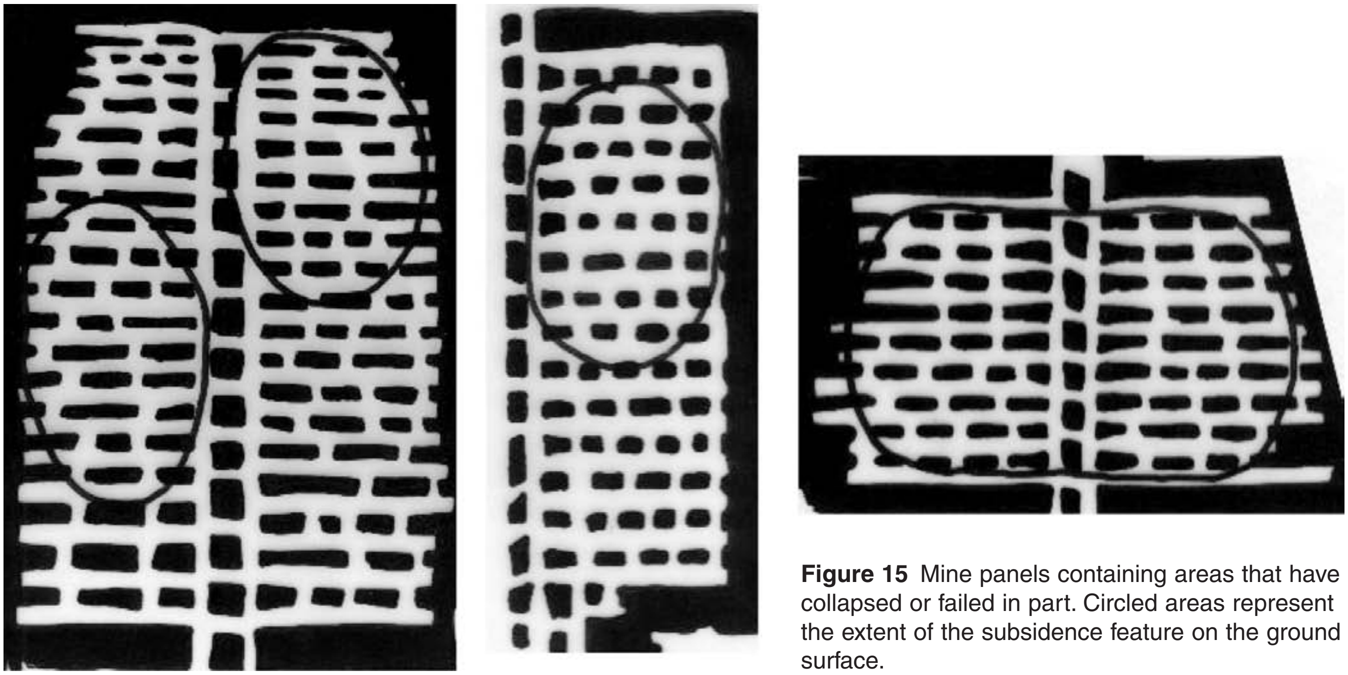


Figure 15 Mine panels containing areas that have collapsed or failed in part. Circled areas represent the extent of the subsidence feature on the ground surface.

interior walls should have foundation walls extending downward from the slab into the soil to below the frost line (where the soil may freeze). The frame of the house is usually attached to the slab with bolts. If subsidence occurs, the slab settles, and the frame is pulled downward.

In many instances, the settlement and resulting damage associated with coal mine subsidence to slab-on-grade homes is sufficient to require leveling the slab and walls as a unit if possible. If not, restoring such a house to a level position may require detaching the house from the slab and raising the frame. Typically, the bolts attaching the frame to the slab can be difficult to find and remove because they are located within the walls. Once the bolt connections are severed, the frame can be raised and leveled, and the walls can be supported until a new foundation can be constructed.

In its raised state, separation between the walls and the floor slab may be sizeable. The home interior may be exposed to the outdoors (fig. 16), which presents security and weatherization problems until a new, level floor is installed. Grading and pouring a new floor cannot be done until subsidence and settling of the ground ends, which may be a year or more. The elevation of the ground around the house can be measured periodically to determine when movement has decreased enough that further damage is no longer expected.

Houses with crawl spaces Some houses are supported by perimeter footings with foundation walls (and interior piers when necessary) so that a crawl space is created between the floor and the ground surface. Bolts attaching the foundation to the wood frame are generally visible and accessible within the crawl space. Once the house is detached from its foundation and support beams are placed under it, the house can be raised to a level position. If foundation walls are constructed of concrete blocks, sections of the wall may be easily removed so that supporting beams can be inserted under the superstructure (frame) of the building (fig. 17). The family can usually continue to occupy the house because the floor is attached to the frame and raised along with it. Typically, temporary steps are constructed to allow access.

Houses with basements In some houses, support is provided by basement walls and, where necessary, interior piers with posts. Subsidence may cause cracks in the basement floors and walls of such houses. If the exterior waterproofing is cracked, water may occasionally enter through the foundation wall.

If basement walls are constructed of concrete blocks or bricks, the blocks or bricks can be easily removed from the walls to allow beams to be inserted under the superstructure (frame) for leveling. Basements with poured concrete walls may present more difficult problems in leveling. For example, basement windows may not be large enough or in the best locations to allow support beams to be brought in and put into position under the frame of the house. Breaking or cutting through poured concrete basement walls can be time consuming and costly. Basements, do, however, allow room for access below the superstructure so that solutions can be devised for each house. Assuming that it is necessary to provide additional support for safety or damage mitigation purposes, the use of the basement as living space can be severely curtailed.

Brick or masonry structures
Houses built with brick exterior siding or other masonry structures will show cosmetic cracks after only small differential movements occur. Large move-

Figure 16 Load-bearing walls of a garage on a slab. The entire superstructure (frame) has been raised to a level position, exposing the interior of the garage. This re-leveling eliminates damaging stresses from differential movements of the foundation and maintains the superstructure level throughout the life of the event.

ments beneath of structures that have full masonry walls may render those structures unstable. A structure with brick or concrete block walls, unlike wood frame walls, generally cannot cantilever or extend over a subsided (lowered) foundation without supplemental support. Expensive remedial measures may be necessary to develop suitable support for heavy masonry structures.

Effects on Utilities and Drainage

Subsidence-related ground movements may also cause damage to water lines, gas lines, sewer lines, telephone lines, electrical wires, and cable TV lines. If utility poles tilt or sink, power and other lines may sag or pull from the poles. In turn, this may drop electrical wires from the poles and create another hazard.

Gas leaks are rare but pose the greatest hazard because an explosion can occur if the gas is allowed to accumulate. If a gas leak is noticed, leave the structure immediately. Do not turn any electrical appliances, including lights, on or off. Phone the local gas utility company or fire department from outside, away from the gas lines and meter, or call from a neighboring property. Flexible piping can be installed between the outside meter and the home to accommodate movements. Water leaks from a

Figure 17 Concrete blocks of a crawl space have been removed to make room to jack the house to a level position. I-beams support the re-leveled house.

broken water main are more common and are usually the first noticeable evidence of major subsidence. Leaking water or sewer pipes cause additional problems by saturating the ground around a foundation or washing soil from under the house, especially in areas with moisture-sensitive soils.

Water can also pond in a sag subsidence event (fig. 18). If any part of a house is in a sag, an attempt should be made to keep water from accumulating around and under it. The ground surrounding the foundation must be kept well drained because excess moisture can cause additional foundation support problems.

Conditions That May Be Mistaken for Mine Subsidence

Soil conditions, tilting floors, support problems, and brick expansion can produce damage that may be mistakenly attributed to mine subsidence (Bauer 1983; Bauer and Van Roosendaal 1992).

Figure 18 Ponding created by sag subsidence. Note the tension cracks around the edge of the depression.

Soils

Shrinking and swelling Moisture-sensitive soils expand when wet and shrink when dry. Many decades of cyclic wetting and drying build up pressure against basement foundation walls as soil and other debris fall into the space between the foundation wall and the dry, shrunken soil. Pressures build until basement walls are pushed inward, forming horizontal cracks that continue across the length of the wall until they propagate downward in a stair-step pattern near the corners. Often these cracks form on all walls but tend to be more severe along the longer, load-bearing walls of rectangular-shaped homes. Typically, these horizontal cracks form a foot or more below the ground surface. If the walls move inward an excessive amount, the floor of the house may drop and tilt (fig. 19).

Reduced load-bearing support of the soil can cause foundations to tilt or sink at the corners (fig. 20). To avoid problems, homeowners should take measures to keep excessive amounts of water away from foundation walls. Downspouts should discharge water several feet from the house. The soil should be built up around the house and graded to slope away from the foundations so that water will then drain away from the house. The cracks produced in foundations by this rotating downward movement of the corner are wide at the top of the foundation and decrease to a nearly hairline crack near the base (footing) of the founda-

Figure 19 Basement damage unrelated to mine subsidence. Damage was caused from decades of seasonal wetting and drying of soils, which built up pressure against the basement foundation walls. With each cycle, dryness allows fine grains of soil to fall into the gap between the soil and the foundation wall. When moisture returns, the soil expands, increasing pressure until the wall fails and is pushed inward.

tion. This pattern is in contrast to that from subsidence, which produces cracking that shows the foundation is being pulled apart at its base where it rests on the soil.

Trees or large shrubs growing near foundations tend to alter soil moisture conditions to a considerable depth. The water contents of the soil can be lowered significantly during a drought when plant roots absorb so much of the available water that the soil shrinks from reduced moisture content. When soil shrinks below the foundation, it may cause plants to sink or tilt outward. When moisture returns, the soils may expand enough that some cracks partially close, only to reopen again during another extremely dry season.

Freezing and thawing As some poorly drained soils freeze and thaw, they expand and contract in a manner similar to that of moisture-sensitive soils (fig. 21). Proper drainage through the use of granular materials (e.g., gravel) can reduce the potential for frost heave. These materials should be used beneath unheated garages, outbuildings, breezeways, driveways, and other structures that are most likely to be affected. Typical signs of heaving are found during extremely cold weather when soil and slabs push upward, causing problems with closing or opening of doors.

Foundation footings that are not installed below the "frost line," where ground freezing may occur during winter, may also see movements in the foundation throughout the year, especially during extreme cold spells. These sections may also heave upward in relation to deeper foundations.

Figure 20 Foundation sinking at the corner of building due to reduced support caused by excessive, repeated moisture changes. Note gutter drainage (arrow) and lack of downspout to channel drainage away from foundation.

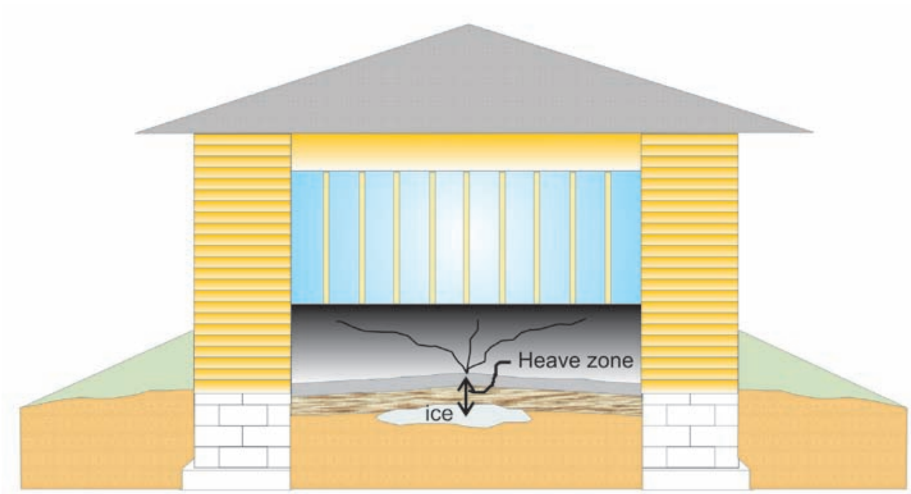


Figure 21 Diagram showing one example of frost heave for a garage floor.

Piping Piping, or subsurface erosion from water washing away fine-grained soil, can occur along broken or separated sewer lines, water lines, old farm tile, and buried downspout extensions (fig. 22). Older drainage systems around the outside base of the foundation—the peripheral drainage system—slowly remove soil particles and lower the ground surface around the house (fig. 23). This removal causes sidewalks, stairs, and patio slabs located along the foundation to drop and tilt toward the house (fig. 24).

When a broken or separated water or sewer line is carrying a high flow, water surges out of the broken pipe and saturates the soil. When the flow is low, water in the saturated soil flows back into the sewer pipe and carries some soil particles with it. This process may excavate a cavity around the line, and the cavity may become large enough to reach the surface, where a hole appears. More often, the piping process slowly lowers the ground surface and causes a depression. A linear depression may occur along the length of the sewer or water line. Piping especially occurs in the highly erodible loess that covers most of the state (fig. 3). Piping depressions are much smaller than subsidence sags and are found near sewer and water lines.

Tilting Floors and Problems with Supports

Vertical intermediate supports for the main beam of a house may sink if they do not rest on properly sized concrete footings. Many times concrete blocks are used in crawl spaces to support the main beam running down the center of the house. Sometimes these blocks are resting directly on the soil, and, because they do not provide enough bearing area, they will sink into the soil. If there is inadequate contact area between a beam and a vertical support, enough weight can be concentrated onto the beam to crush it, thus lowering the floor. Also, if a thick stack of shims has been used between the beam and the vertical support, the shims may compress, lowering the beam (fig. 25). The ends of the main beam should rest on the foundation walls to reduce the likelihood of the beam moving a different amount than the foundation and causing cracks to develop in the walls above this location. Insufficient spacing and floor joist size can result in sagging floors, a condition sometimes mistaken for subsidence.

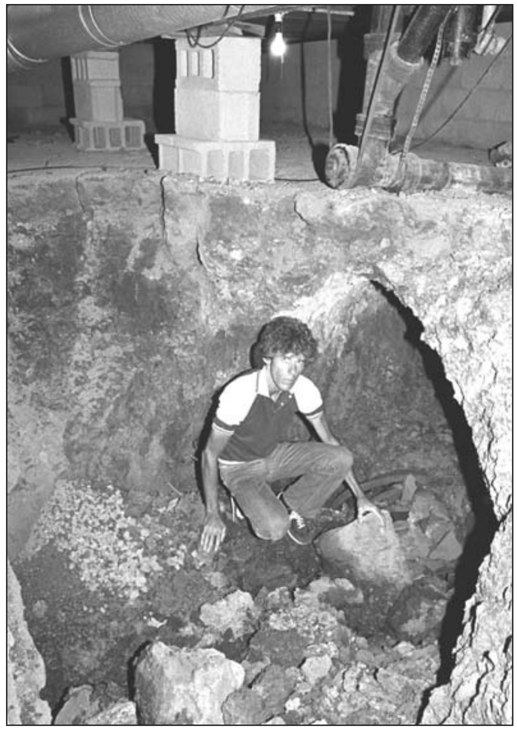


Figure 22 An extreme example of soil piping in a home crawl space. Soil was removed by moving water associated with farm drainage tile. Reproduced by permission of The News-Gazette, Inc. Permission does not imply endorsement by the newspaper. Originally published September 11, 1983.

Brick Expansion

Clay bricks are smallest when they are new. Bricks continue to expand over time. The amount of brick expansion depends on a large number of variables such as temperature of firing, type of clay content, and various brick additives. Some bricks may expand up to 0.1 to 0.2% within four years (Hosking et al., 1966). This expansion may add up to over 1 to 2 inches or more for a 100-foot-long continuous brick wall with no expansion joints (or joints not functioning properly) and stiff mortar. This amount of cumulative movement is enough to be noticeable and generate enough pressure to cause damage.

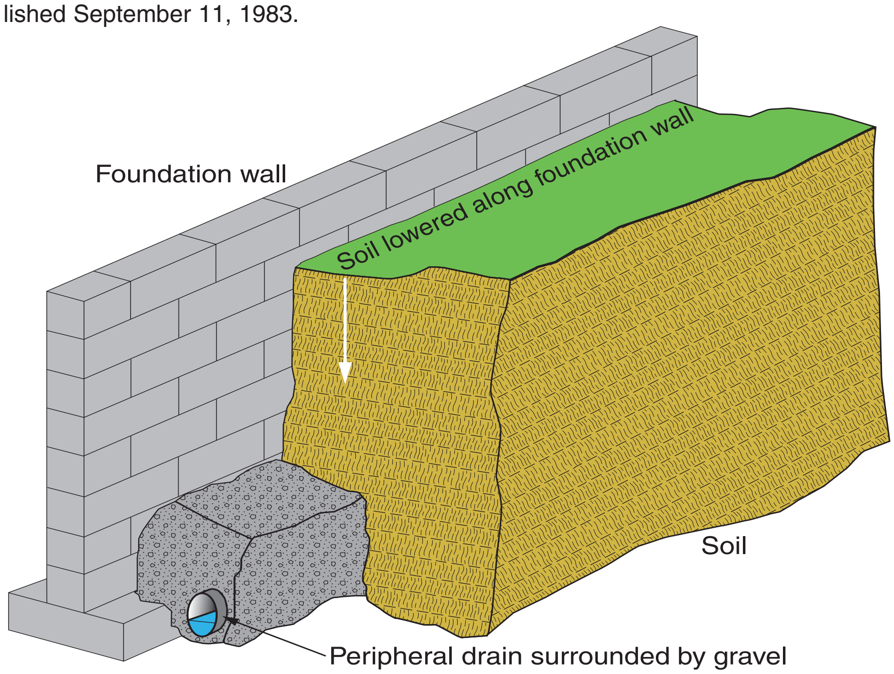


Figure 23 Diagram of a peripheral drainage system around some exterior foundation walls. Over time, the drainage system removes small amounts of soil and lowers the ground surface along the foundation.

Figure 24 A moat-type depression along the foundation wall and lowered sidewalk and patio slabs caused by the kind of peripheral drainage system shown in figure 23.

Figure 25 This main beam is not attached directly to the foundation wall. Because the beam is settling a different amount than the foundation and because some of the thick layers of shims are compressing, cracks have developed in the house above the beam.

This type of damage is commonly associated with long continuous expanses of brick usually found above or below windows or above doors of buildings. Movement increases from none near the center of the brick expanse to the greatest at the edges of the length of the wall (fig. 26). This movement difference occurs because small changes in each brick push adjacent bricks toward the unconfined edge of the wall. Damage is usually at the top of door frames, which move horizontally with the expanding wall in one direction in relation to the bottom of the door frame (fig. 27). This type of movement may result in the brick wall sliding slightly off the foundation at a corner (fig 28); weaker materials in the wall, such as glass blocks, may be crushed (fig. 29), and the sliding wall may become separated from the interior floor slab. To minimize this type of problem, functioning expansion joints should be incorporated into the construction. Expansion joints should be clear of any hard materials that may have fallen in during construction, and pliable caulk should be used to seal the gap.

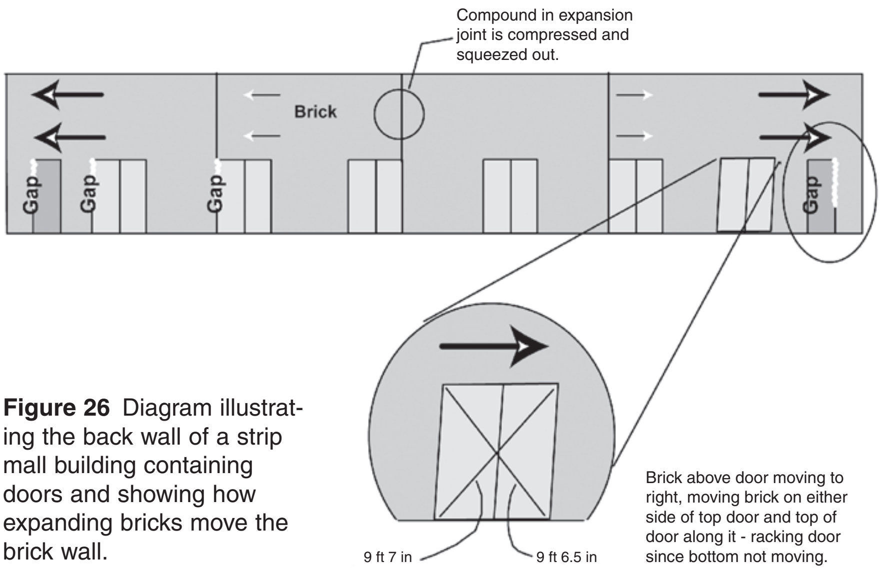


Figure 26 Diagram illustrating the back wall of a strip mall building containing doors and showing how expanding bricks move the brick wall.

Figure 27 The long continuous length of brickwork above the door is expanding, pushing the top of the door frame to the right while the base of the door remains stationary. This movement creates the gap and causes the door to stick while opening and closing.

Disclosure of Previous Mine Subsidence Claims

The Mine Subsidence Disclosure Act of 1989, which became effective on January 1, 1990, allows a buyer to find out if an owner of the property has been paid for mine subsidence damage on the property. The act states that, at the time an agreement to transfer property is made, the owner shall disclose in writing to the buyer and lender all insurance claims paid to the owner for mine subsidence damage on the property.

Property Tax Relief

Some counties offer property tax relief for homes that have been newly damaged by coal mine subsidence. Counties offering tax relief typically require the property owners to protest their taxes and to provide a written report or letter certifying that the damages are subsidence related. Such letters can be obtained from either the Office of Mines and Minerals or the Mine Subsidence Insurance Fund.

Considerations for Mine Subsidence Insurance

The purchase of mine subsidence insurance may be advisable to protect property lying above or near an undermined area or an area soon to be mined.

Homeowners in counties where 1% or more of the land has been undermined (fig. 2) will automatically have subsidence insurance added to their policies when issued. Those individuals refusing coverage will be asked to sign a waiver.

Figure 28 The largest movements are at the edges of the long continuous wall. At this point, the brick wall is being pushed off the foundation.

Insurance agents can describe the mine subsidence insurance program and outline the coverage available. For more information, contact the Illinois Mine Subsidence Insurance Fund headquarters in Chicago. (See Contacts for Additional Information section, p. 19.)

The county clerk's office may be one place to learn about local mining activities. That office may have a map showing general outlines of the underground mines. For general information on coal mines in Illinois, contact the Illinois State Geological Survey in Champaign. The Survey can provide digital copies of original mine maps for some mines. The Survey can also provide county maps (table 2) showing active and abandoned mines and their known extent at a 1:100,000 scale (1 inch on the map represents 1.6 miles on the ground). Township, range, and section lines are included. The county directory of coal mines accompanies each map and lists company names, mine names and numbers, type of mining method used, years operated, coal seam mined, and mine entrance location. Also, some areas have much more detailed outlines of the mines superimposed over topographic maps (1 map inch represents 2,000 feet). The directories that accompany these maps contain more detailed information, such as depth of underground mines, than is available in county directories. Both the county-scale and topographic-scale maps can be viewed on the Illinois State Geological Survey Web site at www.isgs.uiuc.edu/coal sec/coal/index_online pubs_coal.htm.

A report on the state's subsurface operations for minerals other than coal (Cook, unpublished notes, 1979) is on file at the Illinois State Geological Survey library.

Finally, assistance is available from the Illinois Department of Natural Resources, Office of Mines and Minerals, in Springfield. This office is the repository for the original, detailed coal mine maps in the state. The Office of Mines and Minerals also issues mining permits for active and proposed coal mines. All questions concerning active mining and subsidence or mine stability should be directed to the Land Reclamation Division.

What If Mine Subsidence Damage Occurs?

Help is available. Any homeowner with subsidence insurance coverage who suspects property damage due to mine subsidence should immediately call his or her insurance agent, who will have the property examined.

If there are life safety concerns associated with past mining activity, the property owner should contact the Illinois Department of Natural Resources, Office of Mines and Minerals, Abandoned Mined Lands Division. After a brief phone interview, a team can be promptly dispatched to investigate the concerns if warranted and desired by the property owner. If conditions prove to be (1) life threatening and (2) mine related, Abandoned Mined Lands staff will seek federal funds to abate the hazardous conditions. Funds appropriated by the U.S. Congress can be made

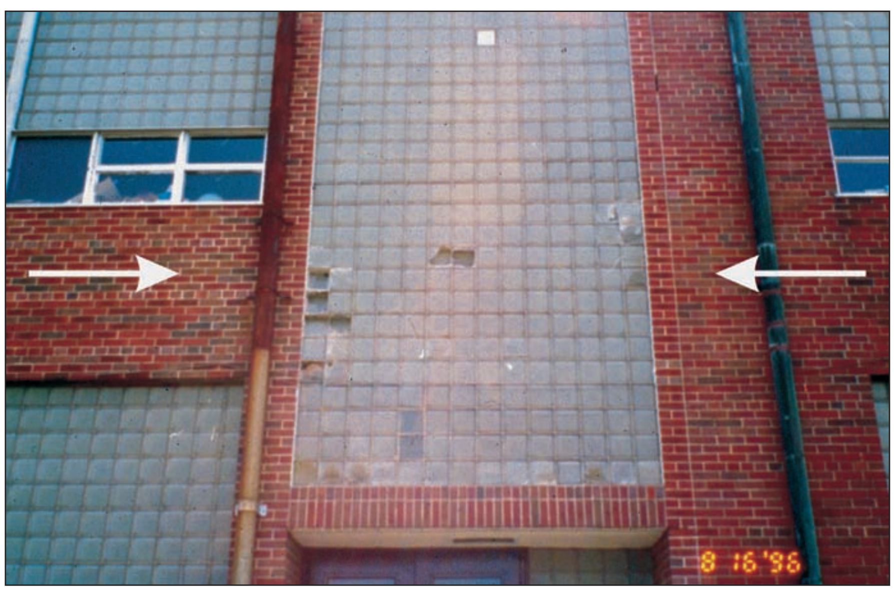


Figure 29 The long, continuous brickwork intersects the vertical glass block wall. Pressures have broken the glass blocks in line with the long continuous expanse of brick work.

Table 2 County maps and directories of Illinois coal mines.

Adams	Jackson	Perry
Bond	Jasper	Pike
Brown	Jefferson	Pope
Bureau	Jersey	Putnam
Calhoun	Johnson	Randolph
Cass	Kankakee	Richland
Champaign	Knox	Rock Island
Christian	La Salle	St. Clair
Clay	Lawrence	Saline (3)[1]
Clinton	Livingston	Sangamon
Coles	Logan	Schuyler
Crawford	McDonough	Scott
Cumberland	McLean	Shelby
Douglas	Macon	Stark
Edgar	Macoupin	Tazewell
Edwards	Madison	Vermilion (2)[2]
Franklin	Marion	Wabash
Fulton	Marshall	Warren
Gallatin (3)[1]	Menard	Washington
Greene	Mercer	White
Grundy	Monroe	Will
Hamilton	Montgomery	Williamson (3)[1]
Hancock	Morgan	Woodford
Hardin	Moultrie	
Henry	Peoria	

[1] Herrin Coal, Springfield Coal, miscellaneous coals.
[2] Danville Coal, Herrin Coal.

available through the Office of Surface Mining Reclamation and Enforcement to be used in abating life-threatening conditions associated with abandoned coal mines. These funds cannot be used for damage repair but are readily available for life protection measures such as providing structural support bracing when necessary, filling of large holes caused by shaft openings or pit type subsidence events, and sealing or venting of dangerous mine gas accumulations. Often the work associated with hazard abatement serves to reduce or control future damages.

If the insurance agent or the Abandoned Mined Lands Reclamation Division finds that a home is not subsiding because of a mine, they may be able to suggest the cause of the problem and, in general, whom to contact. The insurance assessment does not require an investigation into the ultimate cause for the damage; it only determines whether the damage is caused by coal mine subsidence.

Contacts for Additional Information

Illinois Mine Subsidence Insurance Fund
130 E. Randolph Dr., Suite 1130
Chicago, IL 60601-6223
800-433-6743
www.imsif.com

Illinois Department of Natural Resources
Office of Mines and Minerals
Abandoned Mined Lands Reclamation Division
Springfield, IL 62702-1271
217-782-0588

Illinois Department of Natural Resources
Office of Mines and Minerals
Land Reclaimation Division
One Natural Resources Way
Springfield, IL 62702-1271
217-782-6791

Illinois State Geological Survey
615 East Peabody Drive
Champaign, IL 61820-6964
217-333-4747
www.isgs.uiuc.edu

Acknowledgments

This publication is an updated revision of *Mine Subsidence in Illinois: Facts for the Homeowner Considering Insurance,* which was released in 1981 as ISGS Environmental Geology Notes 99 and in 1993 as Environmental Geology 144.

We appreciate the helpful comments provided by peer reviewers: Daniel Barkley, Cheri Chenoweth, Scott Elrick, Robert Gibson, and Dean Spindler.

The Illinois Mine Subsidence Insurance Fund sponsored the reprinting of the original booklet and the printing of the subsequent two updated publications. The distribution of this mine subsidence information for homeowners is largely due to the strong support over several decades of the Fund's recently retired President and CEO, Edmund W. Murphy, and through continued support by the current President and CEO, Randolph J. Beck.

References

Andros, S.O., 1914a, Bulletin 5, Coal mining practice in District I (Longwall): Urbana, Illinois, University of Illinois, Bulletin of Illinois Coal Mining Investigations Cooperative Agreement, v. 1, no. 2, 42 p.

Andros, S.O., 1914b, Bulletin 8, Coal mining practice in District VI (Mines in bed 6 in Franklin, Jackson, Perry, and Williamson Counties): Urbana, Illinois, University of Illinois, Bulletin of Illinois Coal Mining Investigations Cooperative Agreement, v. 1, no. 5, 42 p.

Bauer, R.A., 1983, Damage that may be mistaken for coal-mine subsidence: Proceedings of the Illinois Mining Institute Annual Meeting, October 7–8, 1982, Springfield, Illinois: Illinois State Geological Survey, Reprint 1983E, 7 p.

Bauer, R.A., and D.J. Van Roosendaal, 1992, Monitoring problems: Are we really measuring coal mine subsidence?, *in* S. S. Peng, ed., Proceedings of the Third Workshop on Surface Subsidence Due to Underground Mining, June 1992, Morgantown, WV, p. 332–338.

Cook, W.J., 1979, Non-coal subsurface mines in Illinois: Unpublished notes on open file, Industrial Minerals and Metals Section, Illinois State Geological Survey.

Fehrenbacher, J.B., I.J. Jansen, and K.R. Olson, 1986, Loess thickness and its effect on soils in Illinois: University of Illinois at Urbana-Champaign, College of Agriculture, Agricultural Experiment Station in cooperation with the Soil Conservation Service, U.S. Department of Agriculture, Bulletin 782, 14 p.

Hosking, J.S., W.A. White, and W.E. Parham, 1966, Long-term dimensional changes in Illinois bricks and other clay products: Illinois State Geological Survey, Circular 405, 44 p.

Hunt, S.R., 1980, Surface subsidence due to coal mining in Illinois: University of Illinois at Urbana-Champaign, Ph.D dissertation, 129 p.

Illinois Coal Mine Maps and Directories, 1990, Publications of the Illinois State Geological Survey: Illinois State Geological Survey, p. 121.

Touseull, J., and C. Rich, Jr., 1980, Documentation and analysis of a massive rock failure at the Bautsch Mine, Galena, Illinois: U.S. Bureau of Mines, Report of Investigations 8453, 49 p.

Treworgy, C.G., and C.A. Hindman, 1991, The proximity of underground mines to residential and other built-up areas in Illinois: Illinois State Geological Survey, Environmental Geology 138, 18 p.

Wildanger, E.G., J.W. Mahar, and A. Nieto, 1980, Sinkhole type subsidence over abandoned coal mines in St. David, Illinois: Springfield, Illinois, Abandoned Mined Lands Reclamation Council, 88 p.