



# Guide to the Geology of Cave-In-Rock Area, Hardin County, Illinois

Wayne T. Frankie and Russell J. Jacobson



Field Trip Guidebook 2006B

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**Cover photo:** *Cave-In-Rock, Cave-In-Rock State Park, Hardin County, view from the Ohio River. (Photograph by W. T. Frankie.)*

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**Geological Science Field Trips** The Geoscience Education and Outreach Unit of the Illinois State Geological Survey (ISGS) conducts four free tours each year to acquaint the public with the rocks, mineral resources, and landscapes of various regions of the state and the geological processes that have led to their origin. Each trip is an all-day excursion through one or more Illinois counties. Frequent stops are made to explore interesting phenomena, explain the processes that shape our environment, discuss principles of earth science, and collect rocks and fossils. People of all ages and interests are welcome. The trips are especially helpful to teachers who prepare earth science units. Grade school students are welcome, but each must be accompanied by a parent or guardian. High school science classes should be supervised by at least one adult for every ten students.

The inside back cover shows a list of guidebooks of earlier field trips. Guidebooks may be obtained by contacting the Geoscience Education and Outreach Section, Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820-6964. Telephone: 217- 244-2427 or 333-4747. This information is on the ISGS home page: <http://www.isgs.uiuc.edu>.

Five USGS 7.5-Minute Quadrangle maps (Cave-In-Rock, Dekoven, Karbers Ridge, Rosiclare, and Saline Mines) provide coverage for this field trip area.



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# **Guide to the Geology of Cave-In-Rock Area, Hardin County, Illinois**

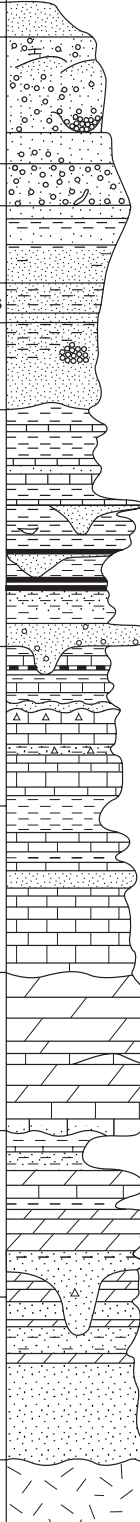
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Era	Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks	
CENOZOIC "Recent Life"	Age of Mammals	Holocene	10,000	Recent; alluvium in river valleys	
		Quaternary 0-500'		Glacial till, glacial outwash, gravel, sand, silt, lake deposits of clay and silt; wind deposits of loess and sand dunes. Deposits cover nearly all of state except northwest corner and southern tip	
		Pliocene	1.8 m 5.3 m 33.7 m	Chert gravel, present in northern, southern, and western Illinois	
		Tertiary 0-500'		Mostly micaceous sand with some silt and clay; present only in southern Illinois	
		Paleocene	54.8 m 65 m	Mostly clay, little sand; present only in southern Illinois	
MESOZOIC "Middle Life"	Age of Reptiles	Cretaceous 0-300'	144 m 290 m	Mostly sand, some thin beds of clay, and, locally, gravel; present only in southern and western Illinois	
PALEOZOIC "Ancient Life"	Age of Amphibians and Early Plants	Pennsylvanian 0-3,000' ("Coal Measures")	323 m	Largely shale and sandstone with beds of coal, limestone, and clay	
		Mississippian 0-3,500'	354 m	Black and gray shale at base, middle zone of thick limestone that grades to siltstone chert, and shale; upper zone of interbedded sandstone, shale, and limestone	
	Age of Fishes	Devonian 0-1,500'	417 m	Thick limestone, minor sandstones, and shales; largely chert and cherty limestone in southern Illinois; black shale at top	
	Age of Invertebrates	Silurian 0-1,000'	443 m	Principally dolomite and limestone	
		Ordovician 500-2,000'	490 m	Largely dolomite and limestone but contains sandstone, shale, and siltstone formations	
		Cambrian 1,500-3,000'	543 m	Chiefly sandstones with some dolomite and shale; exposed only in small areas in north-central Illinois	
		Precambrian		Igneous and metamorphic rocks; known in Illinois only from deep wells	

Generalized geologic column showing succession of rocks in Illinois.

# CAVE-IN-ROCK AREA

The Cave-In-Rock Area, located in the driftless area of southern Illinois, is one of the most highly faulted and geologically complex areas of the state. This area's rugged surface has produced some of the state's most scenic landscapes, mainly due to differential erosion of Upper Mississippian and Lower Pennsylvanian age sedimentary bedrock strata of sandstones, limestones, and shales. The bluffs and ridges are generally underlain by resistant rocks, usually sandstones, and the valleys are underlain by relatively softer limestones and shales. Numerous faults cut across the strata and in part control the development of the ridges and valleys. This geological science field trip will acquaint you with the *geology*<sup>1</sup>, landscape, and mineral resources for part of Hardin County, Illinois.

## GEOLOGIC FRAMEWORK

### Precambrian Era

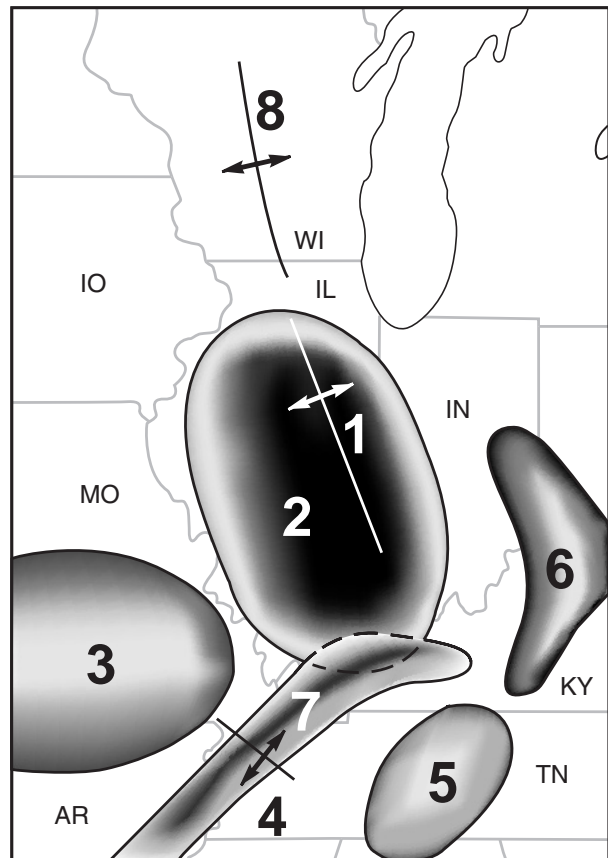
Through several billion years of geologic time, the Cave-In-Rock area of Hardin County has undergone many changes (see the rock succession column, facing page). The oldest rocks beneath the field trip area belong to the ancient Precambrian *basement complex*. We know relatively little about these rocks from direct observations because they are not exposed at the surface anywhere in Illinois. Only about 35 drill holes have reached deep enough for geologists to collect samples from these Precambrian rocks. From these samples, however, we know that these ancient rocks consist mostly of granitic and rhyolitic *igneous*, and possibly *metamorphic*, crystalline rocks formed about 1.5 to 1.0 billion years ago. From about 1 billion to about 0.6 billion years ago, these Precambrian rocks were exposed at the surface. During this time, they were deeply weathered and eroded and formed a barren landscape that was probably quite similar to the topography of the present Missouri Ozarks. We have no rock record in Illinois for the long interval of *weathering* and erosion that lasted from the time the Precambrian rocks were formed until the first Cambrian age *sediments* accumulated, but that interval is almost as long as the time from the beginning of the Cambrian Period to the present.

Because geologists cannot see the Precambrian basement rocks in Illinois except as cuttings and cores from boreholes, they must use other techniques, such as measurements of Earth's gravitational and magnetic

fields and seismic exploration to map out the regional characteristics of the basement complex. Such evidence indicates that in southernmost Illinois, near what is now the historic Kentucky-Illinois Fluorspar Mining District, *rift* valleys like those in east Africa formed as movement of crustal plates (plate *tectonics*) began to rip apart the Precambrian North American continent. These rift valleys in the midcontinent region are referred to as the Rough Creek Graben and the Reelfoot Rift (fig. 1).

### Paleozoic Era

After the beginning of the Paleozoic *Era*, about 520 million years ago during the late Cambrian *Period*, the rifting stopped, and the hilly Precambrian landscape



**Figure 1** Location of some of the major structures in the Illinois region: (1) La Salle Anticlinorium, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Rough Creek Graben–Reelfoot Rift, and (8) Wisconsin Arch.

<sup>1</sup> Terms in italics (except for Latin names) are defined in the glossary at the back of the guidebook. Also, please note: although all present localities have only recently appeared within the geologic time frame, the present names of places and geologic features are used because they provide clear reference points for describing the ancient landscape.



began to sink slowly on a broad regional scale, allowing the invasion of a shallow sea from the south and southwest. During the 280 million years of the Paleozoic Era, the subsiding area that is now called the Illinois Basin continued to accumulate sediments that were deposited in the shallow seas that repeatedly covered it. The region continued to sink until at least 20,000 feet of sedimentary strata were deposited in the deepest part of the Basin, located in the Rough Creek Graben area of southeastern Illinois and Western Kentucky. At various times during this era, the seas withdrew, and deposits were weathered and eroded. As a result, there are some gaps in the sedimentary record in Illinois.

In the field trip area, *bedrock* strata range in age from more than 520 million years old (the Cambrian Period) to less than 320 million years old (the Pennsylvanian Period). Figure 2 shows the succession of rock strata a drill bit would penetrate in this area if the rock record were complete and all *formations* were present. Within the field trip area, the thickness of the Paleozoic sedimentary strata deposited on top of the Precambrian is at least 13,000 feet, ranging from deeply buried rocks of Late Cambrian age (about 523 million years old) to surface exposures of Early Pennsylvanian age (about 315 million years' old).

## DEPOSITIONAL HISTORY

As noted previously, the Rough Creek Graben and the Reelfoot Rift (figs. 1 and 3) were formed by tectonic activity that began in the latter part of the Precambrian Era and continued until the Late Cambrian. Toward the end of the Cambrian, rifting ended, and the whole region began to subside, allowing shallow seas to cover the land.

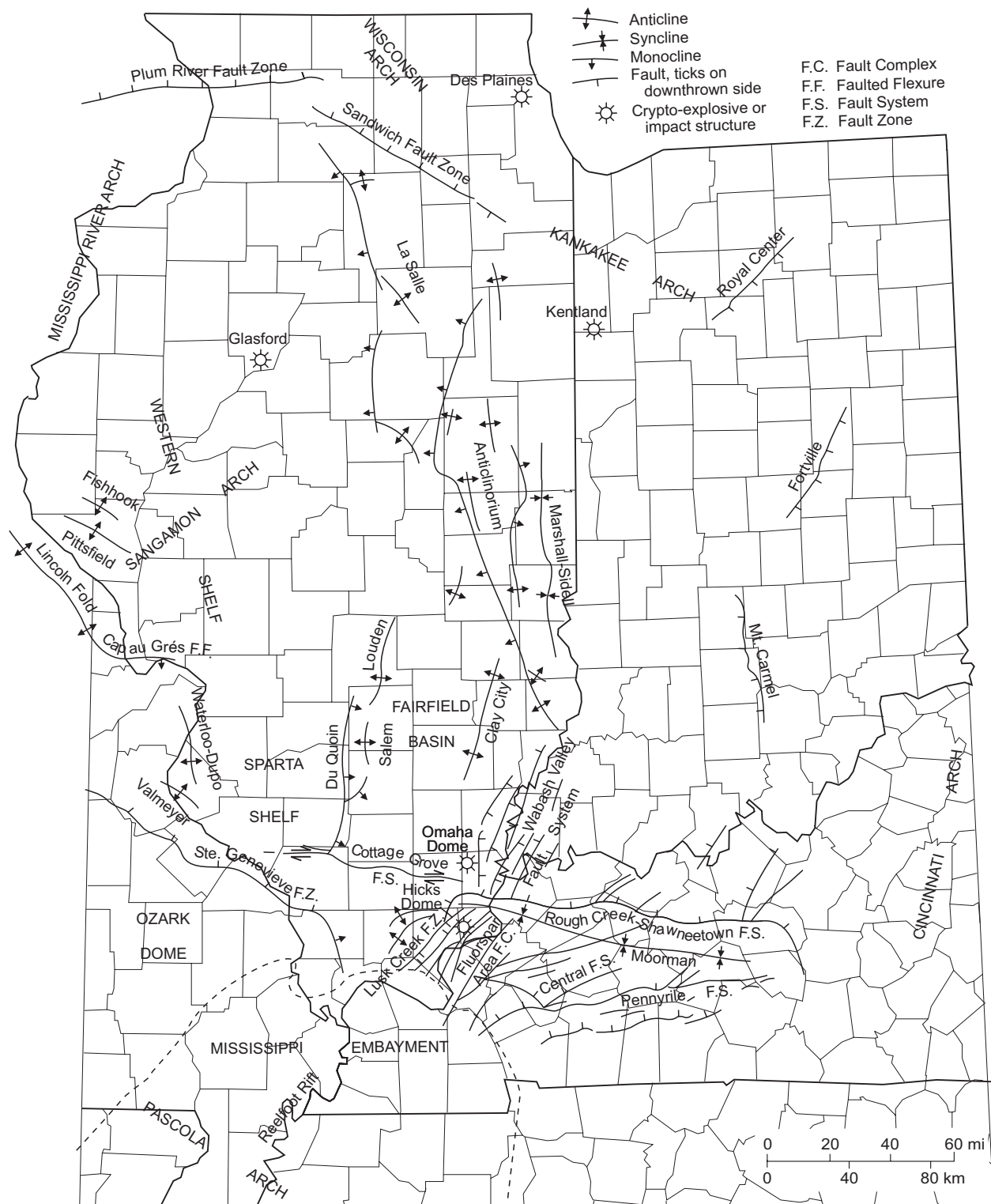
### Paleozoic Era

From the Late Cambrian to the end of the Paleozoic Era, sediments continued to accumulate in the shallow seas that repeatedly covered Illinois and adjacent states. These inland seas connected with the open ocean to the south during much of the Paleozoic, and the area that is now southern Illinois was an embayment. The southern

SYSTEM	SERIES	MEGA-GROUP	GROUP	FORMATION	MEMBER (Key members only, in Pennsylvanian)
PENNSYLVANIAN			Raccoon Creek	Tradewater	Murray Bluff
					Finnie
					Grindstaff
					Pounds
				Caseyville	Battery Rock
					Lusk
					Goreville*
					Cave Hill*
					Negli Creek
				Kinkaid	
MISSISSIPPIAN	CHESTERIAN	Pope		Degonia	
				Clore	Ford Station
					Tygett
					Cora
				Palestine	
				Menard	Allard
					Scottsburg
					Walche
				Waltersburg	
				Vienna	
				Tar Springs	
				Glen Dean	
				Hardinsburg	
			Golconda	Haney	
				Fraileys	
				Beach Creek	
			West Baden	Cypress	
				Ridenhower	
				Bethel	
			Cedar Bluff	Downeys bluff	
				Yankeetown	
				Renaults	Shetlerville
					Levias
					Rosiclare
				Aux Vases	Joppa
				Ste. Genevieve	Karnak
					Spar Mountain
					Fredonia
				St. Louis	
				Salem	
				Harrodsburg	
				Fort Payne	
				Springville	
DEVONIAN	UPPER	Knobs	New Albany		
	MIDDLE	Hunton		Lingle	
				Grand Tower	
	LOWER			Clear Creek	

**Figure 2** Generalized stratigraphic column of the field trip area (modified from Baxter et al. 1965). Asterisk indicates unit removed by pre-Pennsylvanian erosion





**Figure 3** Structural features of Illinois (modified from Buschbach and Kolata 1991).

part of Illinois and adjacent parts of Indiana and Kentucky sank more rapidly than the areas to the north, allowing sediment to accumulate more thickly. During the Paleozoic and Mesozoic, the Earth's thin crust was periodically flexed and warped in places as stresses built up in response to the tectonic forces associated with the collision of continental and oceanic plates and mountain building. These movements caused repeated invasions and withdrawals of the seas across the region. The former sea floors were thus periodically exposed to erosion, which removed some sediments from the rock record.

Sedimentary units, such as limestone, sandstone, shale, or combinations of these and other rock types are called formations. A formation is a persistent body of rocks that has easily recognizable top and bottom boundaries, is thick enough to be readily traceable in the field, and is sufficiently widespread to be represented on a map. Most formations have formal names derived from geographic locations and predominant rock types, such as the Salem Limestone. In cases where no single rock type is characteristic, the word formation becomes a part of the name, such as Caseyville Formation.

Many of the formations have conformable contacts—that is, no significant interruption in deposition occurred as one formation was succeeded by another. In some instances, even though the composition and appearance of the rocks change significantly at the contact between two formations, the *fossils* in the rocks and the relationships between the rocks at the contact indicate that the deposition was virtually continuous. In contrast, in other places, the top of the lower formation was at least partially eroded before deposition of the next formation began. In these instances, fossils or other kinds of evidence within or at the boundary between the two formations indicate that a significant age difference between the lower unit and the overlying unit. This type of contact is called an *unconformity*.

Unconformities occur throughout the Paleozoic rock record, and major unconformities are shown in the generalized stratigraphic column in figure 2 as wavy lines. Each unconformity represents an extended interval of time during which a considerable thickness of rock that is present in nearby regions was either eroded or never deposited in this area; therefore, no rock record is present in this area. Smaller unconformities represent shorter time intervals and thus smaller gaps in the depositional record.

**Devonian Period.** The oldest rocks exposed in this area are Early Devonian limestones that formed from sediments deposited in the embayment that encompassed present-day Illinois about 390 million years ago (fig. 2).

Erosion has left these rocks poorly exposed at the apex of Hicks Dome (fig. 3). Younger Devonian strata occur on the flanks of the structure. Some of these rocks have become *silicified* and *cherty* through the addition of silica from subterranean solutions.

**Mississippian Period.** Relatively low-lying lands adjacent to the Illinois embayment generally did not contribute large volumes of terrestrial sediment to the seas covering the region during Mississippian time, 354 to 323 million years ago (fig. 2). Mississippian age limestones, shales, and sandstones are exposed around the flanks of Hicks Dome and throughout southern Hardin County. Most of this sediment consisted of either locally precipitated carbonates or muds and sands eroded from areas far to the northeast; the muds and sands were transported here by a large river system probably similar in size to the modern Ohio River.

Near the close of the Mississippian Period, gentle arching of the rocks in eastern Illinois initiated the development of the La Salle Anticlinorium (figs. 1 and 3). This complex structure includes smaller structures such as domes, *anticlines*, and *synclines* superimposed on the broad upwarp of the anticlinorium. Further gradual arching continued through the Pennsylvanian Period. Because the youngest Pennsylvanian strata are absent from the area of the anticlinorium (either because they were not deposited or because they were eroded), we cannot determine just when folding ceased—perhaps by the end of the Pennsylvanian or during the Permian Period a little later, near the close of the Paleozoic Era.

**Pennsylvanian Period.** In the field trip area, bedrock *strata* of early Pennsylvanian age consist primarily of sandstone, siltstone, shale, and some thin coals deposited as sediments in the troughs, shallow seas, and swamps between about 323 and 315 million years ago (fig. 2).

The thickness of Pennsylvanian strata is highly variable in the field trip area because these are the youngest bedrock strata present and the area has been highly faulted and eroded. This Pennsylvanian section, from the highest exposed strata down to the basal unconformity, is approximately 1,250 feet thick (Baxter 1963), but only an aggregate thickness of about 600 feet of the section is exposed in outcrops. The Pennsylvanian strata occur along the northern part of Hardin County and within the Rock Creek Graben. Resistant sandstones cap the prominent cliffs and ridges.

## Mesozoic Era

During the Mesozoic Era, the rise of the Paskola Arch (figs. 1 and 3) in southeastern Missouri and western Tennessee produced a structural barrier that helped

form the current shape of the Illinois *Basin* by closing off the embayment and separating it from the open sea to the south. The Illinois *Basin* is a broad, subsided region covering much of Illinois, southwestern Indiana, and western Kentucky (fig. 1). Development of the Pascola Arch, in conjunction with the earlier sinking of the deeper portion of the Basin north of the Pascola Arch in southern Illinois, gave the Basin its present asymmetrical, spoon-shaped configuration. The geologic map (fig. 4) shows the distribution of the rock systems of the various geologic time periods as they would appear if all the glacial, windblown, and surface materials were removed.

Younger rocks of the latest Pennsylvanian and perhaps the Permian may have at one time covered the entire southern portion of Illinois. Mesozoic and Cenozoic rocks (see the generalized geologic column) might also have been present here. Indirect evidence, based on the stage of development (rank) of coal deposits and the generation and maturation of petroleum from source rocks, indicates that perhaps as much as 7,000 feet of latest Pennsylvanian and younger rocks once covered southern Illinois. During the more than 240 million years since the end of the Paleozoic Era (and before the onset of *glaciation* 1 to 2 million years ago), several thousands of feet of strata may have been eroded. Nearly all traces of any post-Pennsylvanian bedrock that may have been present in Illinois were removed. During this extended period of erosion, deep valleys were carved into the gently tilted bedrock formations. Later, the topographic *relief* was reduced by repeated advances and melting back of continental *glaciers* that scoured and scraped the bedrock surface. This glacial erosion affected all the formations exposed at the bed-

rock surface in Illinois. The final melting of the glaciers left behind the non-lithified deposits in which our Modern (Holocene) soil has developed.

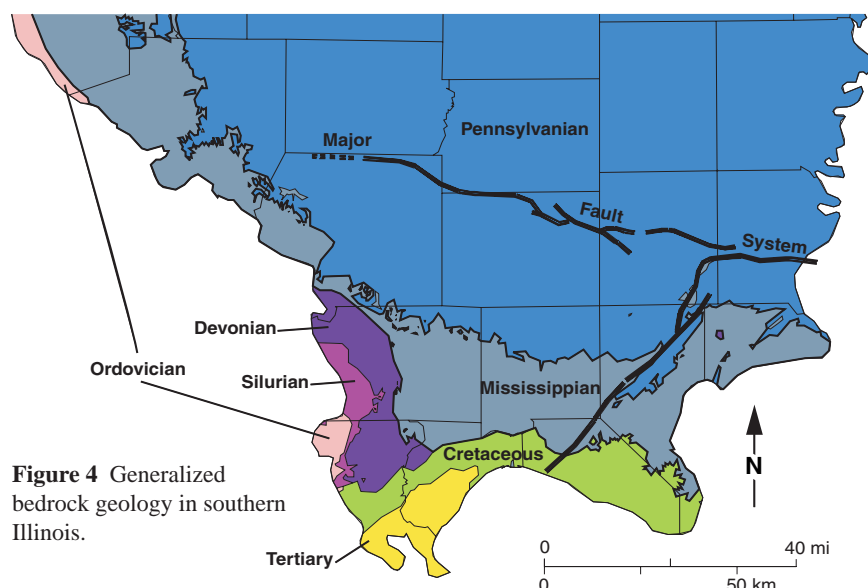
## STRUCTURAL SETTING

### Hicks Dome

Hicks Dome (a *cryptovolcanic* feature) is an elliptical uplift of about 100 square miles; the long axis is oriented toward the northwest. The center of the dome is located in the SW, NE, SE, SE quarter of Sec. 24, T15S, R7E (figs. 3 and 5). Maximum uplift at the dome's apex is estimated to be about 4,000 feet. Erosion has truncated the structure and exposed limestone and chert of Middle and Early Devonian age at the center. Younger Devonian, Mississippian, and Pennsylvanian formations are exposed around the flanks. The beds dip away from the apex in all directions, the steepest dips occurring on the northwest. The New Albany Shale occupies a depression between the Devonian limestone and chert of the central high area and the resistant, cherty limestone of the Fort Payne Formation, which forms a prominent encircling ridge. The circular outcrop pattern of the younger Mississippian formations is interrupted on the southeast by a large southwest-trending fault that is downthrown to the southeast. Two other major southwest-trending faults cut across the structure near the apex. On three sides, the dome is rimmed by a discontinuous system of curved faults. At least five igneous dikes and four patches of brecciated rock, up to 200 feet in diameter, occur within the central area.

Geologists have puzzled over the origin of Hick's Dome for a long time. Most think that the structure is related to the period of faulting and igneous activity that took

place in Permian time. The *breccias*, consisting of masses of broken rock, suggest that some sort of explosive action was involved. The Hicks Dome Breccia (found in the vicinity of Hicks Dome), the Hamp Breccia, just to the northwest), and the Rose Mine Breccia (to the southeast) consist of angular fragments of sedimentary rocks in a matrix of finely grained igneous rock. Other breccia in the Fluorspar District, such as the Sparks Hill Breccia 6 miles to the northeast and the Grants Intrusive 2 miles to the south, also contain fragments of igneous rocks and minerals (granite, quartz, pyroxene, am-



**Figure 4** Generalized bedrock geology in southern Illinois.

phibole, apatite, mica, and feldspar) that strongly indicate a deep-seated origin. Drilling of the Hamp Breccia showed sedimentary strata that were intensely brecciated to a depth of at least 3,000 feet in rocks of Ordovician age. The form of the breccia in the subsurface is not definitely known, but the oval shapes in outcrop and the drilling data indicate that they may be pipe-like features. The doming and brecciation of the strata may have been caused by the relatively sudden release of gases that had accumulated at the top of a large body of magma. Another theory is that the explosion was caused by steam generated from water contained in the sedimentary rocks that were heated as a result of the intrusion of the igneous *dikes* (Weller 1920, 1952).

*Lamprophyre* dikes and explosion breccias, apparently related in origin to Hicks Dome, also occur in the Cave-In-Rock and Rosiclare area. Lamprophyre is a dark coarse-grained igneous rock of iron-magnesian minerals, formed deep within the earth. These dikes and breccias are thought to have formed during a period of intense crustal deformation when the strata were also broken by numerous faults. Radiometric dating of the igneous dikes has indicated a Permian age for their emplacement about 265 million years ago.

## Rock Creek Graben

The major structural feature within the field trip area is Rock Creek Graben, an elongate downfaulted block extending diagonally across the area from northeast to southwest (fig. 5). Regionally, the bedrock strata are tilted gently toward the northeast, although anomalous local dips are very common because of the great number of faults in the area. Southeast of the Rock Creek Graben, the strata are cut by few faults in contrast to the complexly faulted strata within and the area located northwest of the graben. A large area of these relatively unfaulted rocks, principally in the vicinity of Cave-In-Rock, exhibits markedly less rugged terrain than is found elsewhere in the field trip area. A rolling landscape with numerous sinkholes, characteristic of karst topography, has developed upon the thick middle Mississippian limestones occurring there. Hicks Dome is located approximately 2.5 miles northwest of the Illinois Iron Furnace (Stop 5).

## GLACIAL HISTORY

The North American continental glaciers stopped approximately 25 miles northwest of Cave-In-Rock, near Eldorado. However, meltwater floods from the glaciers contributed to deposition of clay, silt, sand, and gravel within the Ohio River valley and the lower reaches of the major streams in the field trip area, leading to the formation of several high level terraces. In addition,

*loess* occurs on the uplands and mantles the bedrock. This deposit of yellowish brown silt was laid down by the wind during all of the glacial episodes, from the earliest pre-Illinois glacial episode (approximately 1.8 million years ago) to the last glacial episode, the Wisconsin Episode (which occurred approximately 25,000 to 13,500 years ago). The loess is generally between 4 and 8 feet thick and is generally thicker closer to the Ohio River, where thick alluvial deposits were a major source of the fine material. Erosion has completely removed the loess in scattered areas within the uplifted Shawnee Hills area of the field trip. The thickness of the loess increases to the west toward the Mississippi and Illinois Rivers. Loess, which covers most of Illinois, is up to 15 feet thick along the Illinois River valley and more than 50 feet thick along the east edge of the Mississippi River valley.

## GEOMORPHOLOGY

### Physiography

Physiography is a general term used for describing landforms; a physiographic province is a region in which the relief or landforms differs markedly from those in adjacent regions. The field trip area is located within the Shawnee Hills Section of the Interior Low Plateaus Province (fig. 6).

### Shawnee Hills Section

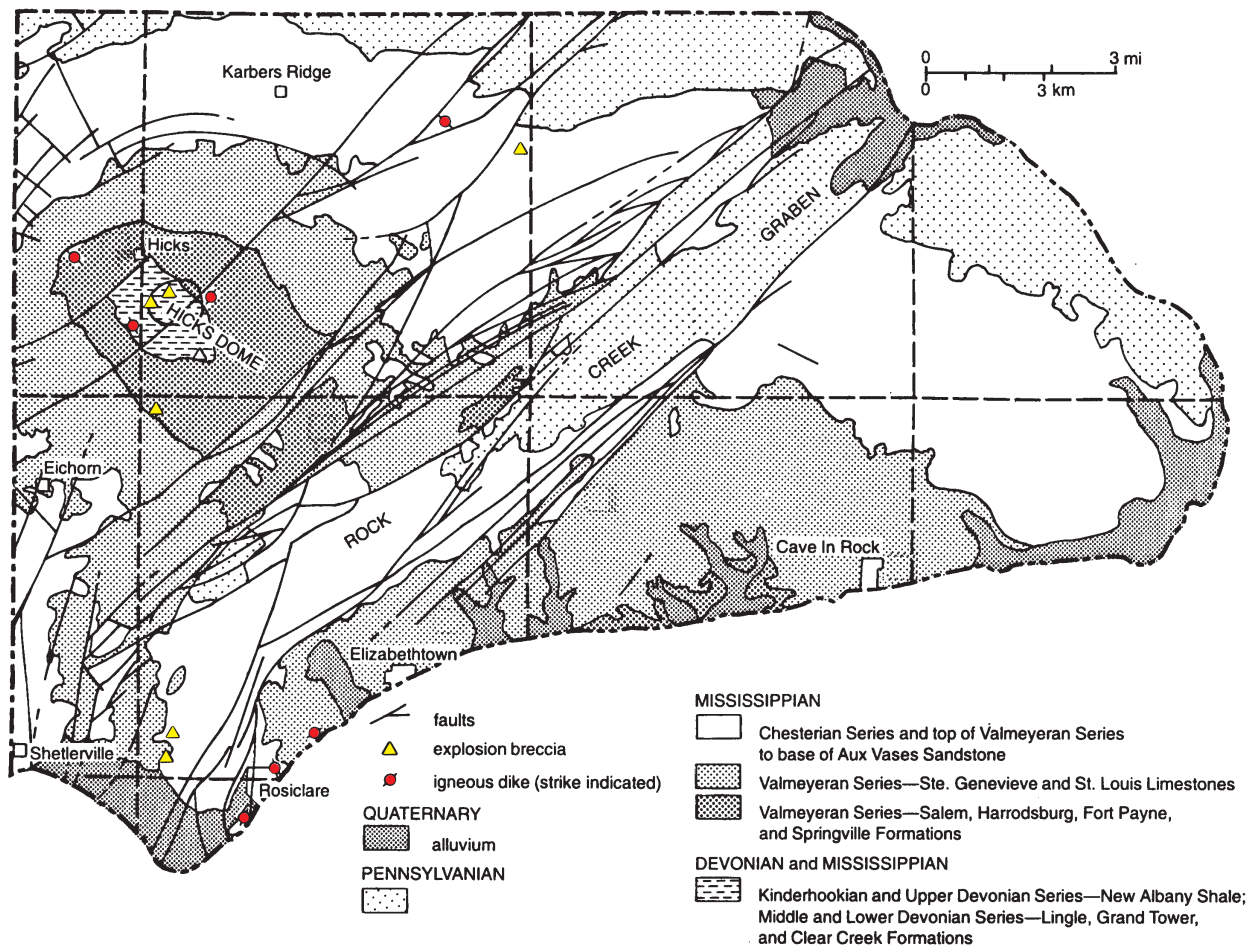
The Shawnee Hills Section includes a complex dissected upland underlain by Mississippian and Pennsylvanian bedrock of varied lithology. It is located along the southern rim of the Illinois Basin, with a *cuesta* (a ridge with a gentle slope on one side and a steep slope on the other) of lower Pennsylvanian rocks generally forming its northern margin and its southern part comprising a dissected plateau underlain largely by Mississippian rocks.

In the Shawnee Hills Section, remnants of a preglacial land surface called the Ozark Plateaus are extensive along the Pennsylvanian *escarpment* (a long, more or less continuous cliff or steep slope facing in one general direction, generally marking the outcrop of a resistant layer of rocks). Locally higher summits and some lower surfaces on Mississippian rocks indicate a complex erosional history that continued during all of the glacial episodes.

## NATURAL DIVISIONS AND GEOLOGY

Topography influences the diversity of plants and animals (biota) of Illinois by strongly influencing the diversity of habitats. Geological processes form, shape,



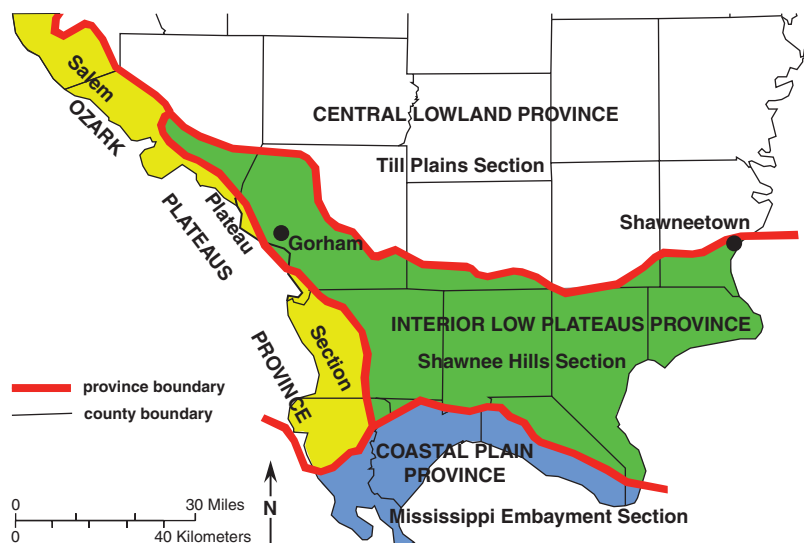


**Figure 5** Surficial geology of Hardin County (modified from Reinertsen 1992).

and create the topography on all of the Earth's surface. Specifically, geology determines the composition of the parent material of soils, and geological processes form soils through the weathering of parent materials. Thus, the geology of a region is the foundation of its habitats.

## Natural Divisions

Natural Divisions are distinguished according to differences in significant aspects of topography, glacial history, bedrock geology, soils, aquatic habitats, and distribution of plants and animals (flora and fauna). A strong relationship exists between the Physiographic Divisions of Illinois and Natural Divisions of Illinois because the geologic factors used to determine



**Figure 6** Physiographic Divisions of southern Illinois (modified from Leighton et al. 1948).

the Physiographic Divisions were important elements used to define the boundaries of the Natural Divisions. The field trip area is located in the Shawnee Hills Division. The following descriptions are modified from Schwegman (1973).

### Shawnee Hills Division

The Shawnee Hills Division extends across the southern tip of Illinois from Fountain Bluff (Gorham) on the Mississippi River to the Shawneetown Hills near the mouth of the Wabash River. This unglaciated hill country is characterized by a high east-west escarpment of sandstone cliffs forming the Greater Shawnee Hills Section and a series of lower hills underlain by limestone and sandstone known as the Lesser Shawnee Hills Section. Originally this division was mostly forested, and considerable forest remains to the present time. There are a number of distinctive plant species restricted to this division of Illinois.

**Bedrock.** The Greater Shawnee Hills Section forms a band along the northern edge of the division and consist of massive Pennsylvanian sandstone strata that dip northward toward the Illinois Basin. The range of hills averages 10 miles wide and borders the Lesser Shawnee Hills to the south. The Lesser Shawnee Hills are underlain by Mississippian limestone and sandstone, and sinkholes and caves are locally common features. Mineralized faults containing fluorspar, sphalerite, and other metals exist in the eastern part of the Shawnee Hills Division. Iron deposits are found in Hardin County. There is a dome, Hicks Dome, containing an igneous rock core in western Hardin County, and outcrops of igneous rock occur in the Lesser Shawnee Hills Section.

**Topography.** The topography of the Shawnee Hills Division is very rugged, containing many bluffs and ravines. The north slopes of the Greater Shawnee Hills Section are relatively gentle, but the south slopes consist of many escarpments, cliffs, and overhanging bluffs. Streams have eroded canyons in the sandstone. The Lesser Shawnee Hills are, on average, about 200 feet lower than the Greater Shawnee Hills. The Lesser Shawnee Hills have local areas of sinkhole topography.

**Soils.** The area soils are derived mainly from loess. Narrow bands of moderately developed deep loess soils occur along the Mississippi River in Jackson County and along the Ohio River in eastern Hardin County; however, most of the soils are derived from thinner loess and are strongly developed. Claypan and fragipan layers are frequent.

## NATURAL RESOURCES

### Mineral Production

**Fluorspar.** The field trip lies within the heart of the historic Illinois-Kentucky Fluorspar District. The first recorded fluorspar mining in Illinois was in 1842 when a small operation was started in Hardin County, where, for over a century, production continued. Illinois was long the principal producer in the country. In the early days, fluorspar output came from numerous mines ranging from those producing only a few hundred tons per year to those producing tens of thousands of tons annually. The extremely competitive conditions and high cost of production forced most of the small producers out of business over time. Fluorite, or calcium fluoride ( $\text{CaF}_2$ ), was designated the state mineral by the 74th General Assembly in July 1965.

**Last Mine to Close.** In 1995, Ozark-Mahoning Co., a subsidiary of the Pennsylvania-based Elf Atochem North America Inc., was the nation's only fluorspar producer, generating 48,000, or 8.5%, of the nation's fluorspar requirements that year. Elf Atochem North America announced the closure of its two mines and a flotation plant in Hardin County in late 1995 and laid off 103 workers effective January 31, 1996. The reasons given for the shutdown were depletion of reserves at active mines and competition from China. Ozark-Mahoning was the last active fluorspar mining company in the country and had been in operation in southern Illinois since late 1938. Hastie Mining and Trucking Co., a local quarry company, leased Ozark-Mahoning's mineral drying and bagging facilities to process fluorspar purchased from the National Defense Stockpile. With the closure of Ozark-Mahoning Company's operations, the United States ended 153 years of fluorspar mining.

**Other Minerals Produced.** In addition to fluorite, barite, copper, lead, silver, and zinc (sphalerite) concentrates were recovered as co-products of fluorspar processing in Illinois. Fluosilicic acid, a by-product, was also recovered from fluorspar processing. Fluosilicic acid was used primarily in the aluminum industry for making aluminum fluoride and in water fluoridation, either directly or after processing to sodium silicofluoride.

**2005 Mineral Statistics.** The statistical information for fluorspar given in this section was obtained from the U.S. Geological Survey's *2005 Minerals Yearbook: Fluorspar* (<http://minerals.usgs.gov/minerals/pubs/commodity/fluorspar/fluormyb05.pdf>). For additional

information, contact U.S. Geological Survey commodity specialist, M. Michael Miller (telephone: 703-648-7716, Fax: 703-648-7757, e-mail: mmiller1@usgs.gov).

There was no mine production of fluorspar in the United States in 2005. The bulk of the nation's demand was supplied by imports, although that supply was supplemented by sales of material from the National Defense Stockpile and by small amounts of by-product synthetic fluorspar produced from industrial waste streams.

Fluorspar is used directly or indirectly to manufacture products such as aluminum, gasoline, insulating foams, plastics, refrigerants, steel, and uranium fuel. Most fluorspar consumption and trade involve either acid grade (also called acidspar), which is greater than 97% calcium fluoride ( $\text{CaF}_2$ ), or subacid grade, which is 97% or less  $\text{CaF}_2$ . Subacid grade includes metallurgical and ceramic grades and is commonly called metallurgical grade or metspar.

During 2005, the National Defense Stockpile Center sold about 10,400 metric tons of acid grade and about 57,300 tons of metallurgical grade fluorspar. Hastie Mining Co. in Cave-In-Rock, Illinois; Oxbow Carbon and Minerals LLC in Aurora, Indiana; and Seaforth Mineral & Ore Co., Inc. in East Liverpool, Ohio, screened and dried metallurgical and acid-grade fluorspar. These materials were either purchased from the National Defense Stockpile or imported from Mexico.

In 2005, imports of fluorspar increased by 5% over 2004 imports. The leading suppliers of fluorspar to the United States were China (67%), Mexico (14%), South Africa (12%), and Mongolia (7%). The average unit value, including cost, insurance, and freight, was \$202 per ton for acid grade and \$93 per ton for metallurgical grade.



# GUIDE TO THE ROUTE

We'll start the trip at Cave-In-Rock State Park, in the main parking lot located immediately past the park entrance, on the right (SW, SW, SE, Sec. 13, T12S, R9E, 3rd P.M., Cave-In-Rock 7.5-minute Quadrangle, Hardin County). Mileage will start at the entrance/exit to the park.

You must travel in the caravan. Please drive with headlights on while in the caravan. Drive safely, but stay as close as you can to the car in front of you. Please obey all traffic signs. If the road crossing is protected by an Illinois State Geological Survey (ISGS) vehicle with flashing lights and flags, please obey the signals of the ISGS staff directing traffic. When we stop, park as close as possible to the car in front of you and turn off your lights.

**Private Property** Some stops on the field trip are on private property. The owners have graciously given us permission to visit on the day of the field trip only. Please conduct yourselves as guests and obey all instructions from the trip leaders. So that we may be welcome to return on future field trips, follow these simple rules of courtesy:

- Do not litter the area.
- Do not climb on fences.
- Leave all gates as you found them.
- Treat public property as if you were the owner—which you are!
- Stay off of all mining equipment.
- Parents must closely supervise their children at all times.

When using this booklet for another field trip with your students, a youth group, or family, remember that you must get permission from property owners or their agents before entering private property. No trespassing, please.

Five USGS 7.5-Minute Quadrangle maps (Cave-In-Rock, Dekoven, Karbers Ridge, Rosiclare, and Saline Mines) provide coverage for this field trip area.

Please Note: A large number of the roads and intersections are unmarked. Special attention with regard to the mileages and the route maps will help individuals conducting their own field trips.

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**STOP 1. Cave-In-Rock State Park** (SW, SW, SE, Sec. 13, T12S, R9E, 3rd P.M., Cave-In-Rock 7.5-minute Quadrangle, Hardin County). On the day of the field trip, climb the stairs from the lower parking lot towards Shelter No. 3 and then follow the stairs down to the cave in the rock.

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Miles to next point	Miles from start	
0.0	0.0	Exit parking lot and TURN LEFT onto East Park Avenue. Set your odometers to 0.0 at the Park's entrance/exit.
0.1	0.1	Road curves to the right and becomes Broadway Street.
0.05	0.15	TURN LEFT onto East Main Street.
0.1	0.25	STOP (two-way). TURN LEFT onto Route 1 (south), head toward the ferry, and TURN RIGHT into the parking lot.

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**STOP 2. Cave-In-Rock Ferry** (SW, SE, SW, Sec. 13, T12S, R9E, 3rd P.M., Cave-In-Rock 7.5-minute Quadrangle, Hardin County). On the day of the field trip, we will board the ferry on foot to cross the Ohio River.

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0.1	0.35	Exit parking lot and TURN LEFT onto Route 1 (north).
0.05	0.4	On the left are two historical signs, erected in 2003 by the State of Illinois. A summary of their content follows.  Meriwether Lewis, William Clark, and about 20 men passed this place during fall 1803 on their famous journey westward. Cave-In-Rock was well-known to European explores as early as 1729. Its location was noted in journals and diaries of travelers and on maps used by Lewis and Clark. Late in the eighteenth century, the cave was the habitat for robbers and thieves. These malefactors included Samuel Mason and the Harpe Brothers. Knowing of the cave's history, Lewis and Clark would have approached this point with caution. The explorers continued on to Fort Massac.
0.05	0.45	TURN LEFT onto West Clay Street (390N/County Road 101). This road is part of the Ohio River Scenic Byway and is locally known as Tower Rock Road. The Illinois portion of the Ohio River Scenic Byway extends from Cairo, Illinois, northward to New Haven where Illinois Route 146 crosses the Indiana state line. Visit <a href="http://www.ohioriverscenicbyway.com">http://www.ohioriverscenicbyway.com</a> for more information on the 188-mile Ohio River Scenic Byway.
0.4	0.85	T-intersection from the left. Unmarked. CONTINUE AHEAD.
1.55	2.4	View of Ohio River and campground to the left.
0.35	2.75	Cross unnamed creek. Round Spring is located immediately on the north side of road and adjacent to the east bank of the creek. Round Spring is aptly named; the spring forms a small circular pool encircled by trees. The water flowing from Round Spring is most likely an underground outlet for Big Sink (see route map).
1.75	4.5	Prepare to TURN LEFT.
0.15	4.65	T-intersection from the left (National Forest Road 575). TURN LEFT onto Tower Rock access road.
0.50	5.15	T-intersection from the right (entrance to campground). CONTINUE AHEAD toward picnic ground and boat launch.
0.15	5.3	TURN RIGHT and follow one-way loop road.
0.1	5.4	Boat launch. Park on the far right side of the road.

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**STOP 3. Tower Rock** (NW, NE, SW, Sec. 21, T12S, R9E, 3rd P.M., Cave-In-Rock 7.5-minute Quad-range, Hardin County). The trail leading to the top of Tower Rock is located north of the boat launch. The trail is 1/8 mile long.

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0.0	5.4	Leave Stop 3 and retrace the route back to the main road.
0.85	6.25	STOP (one-way). T-intersection (390N). TURN LEFT.
0.85	7.1	Cross right fork of Peters Creek. T-intersection from the right, just past bridge. CONTINUE AHEAD. Road to the right leads to Peters Creek Junction.
0.4	7.5	Outcrop on the right.
0.05	7.55	Cross Peter Creek. Note the small narrow valley cut into the resistant bedrock by Peter's Creek.
0.75	8.3	Karst depression on the left. An indication of carbonate bedrock immediately below the surface of the land.
0.5	8.8	Cross small unnamed creek. Note that the valley cut by this creek is wider than that cut by Peter's Creek, suggesting that the bedrock here is less resistant than the bedrock along Peter Creek.
0.55	9.35	STOP (one-way). T-intersection (Illinois Route 146). TURN LEFT.
0.25	9.6	T-intersection from the right (Basset Road). CONTINUE AHEAD. Hardin County K-12 school on the right.
0.25	9.85	Cross Hosick Creek.
0.50	10.35	T-intersection from the left (unmarked). CONTINUE AHEAD.
0.40	10.75	T-intersection from the right (Basset Road). Shawnee National Forest, Elizabethtown Ranger Station located to the right. Enter Elizabethtown, county seat of Hardin County (population 350).
0.65	11.4	STOP (four-way). Intersection of Main Street and First Street. CONTINUE AHEAD. The historic Rose Hotel is located to the left. The Rose Hotel is the oldest operating hotel in Illinois. This National Historic Site was built in 1812, during a period when river boats lined the Ohio River. For more information on the Rose Hotel, visit <a href="http://www.rosehotelbb.com">http://www.rosehotelbb.com</a> or call 618-287-2872.
0.7	12.1	Cross Big Creek. Local faults controlled the erosional development of Big Creek.
0.4	12.5	T-intersection from the left. CONTINUE AHEAD. Illinois Department of Transportation facilities and the Ohio River loading docks operated by the Hastie Company are located to the left.
1.1	13.6	Pass salvage yard on the right. Prepare to turn left.

0.3	13.9	Crossroad intersection (Illinois Route 146 and Illinois Route 34). TURN LEFT onto Illinois Route 34, heading toward Rosiclare 2 miles ahead. County Road 12 is to the right.
0.7	14.6	Crossroad intersection (Three-Mile Creek Road). CONTINUE AHEAD.
0.75	15.35	T-intersection from the right (Lower Greenville Road). CONTINUE AHEAD. Enter Rosiclare (population 1,400).
0.3	15.65	T-intersection from the left (Hillside Road). CONTINUE AHEAD. The Hastie Company fluo-rite processing plant is located to the left.
0.35	16.0	End of Illinois Route 34. Road curves to the right and then immediately to the left and be-comes Main Street. Prepare to turn right.
0.1	16.1	Entrance to The American Fluorite Museum on the right. TURN RIGHT.

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**STOP 4. The American Fluorite Museum** (SW, SW, SE, Sec. 32, T12S, R8E, 3rd P.M., Rosiclare 7.5-minute Quadrangle, Hardin County). The museum is located on the former site of the Rosiclare Lead and Fluorspar Mining Company.

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0.1	16.2	Exit The American Fluorite Museum. TURN LEFT onto Main Street. The road curves to the right and then immediately to the left and becomes Illinois Route 34.
0.7	16.9	T-intersection from the left (Lower Greenville Road). CONTINUE AHEAD.
0.75	17.65	Crossroad intersection (Three-Mile Creek Road). CONTINUE AHEAD.
0.75	18.4	STOP (two-way). Crossroad intersection (Illinois Route 146/34 and County Road 12). CON-TINUE AHEAD. <b>CAUTION: Traffic from the right and left do not stop.</b>
0.4	18.8	Outcrop of Mississippian age Menard Limestone on the left on the south side of the hill. From road level upward, the exposure consists of thin- to medium-bedded limestones separated by thin shale overlain by thick limestone beds. The units exposed exhibit well-developed karst solution features.
0.1	18.9	A northwest- to southeast-trending fault cuts across this area on the north side of the hill. Evidence of the fault is indicated by the abrupt changes in the nature of the bedrock, from massive thick-bedded Menard Limestone on the south side of the fault to thin-bedded Menard Limestone on the north side of the fault.
0.2	19.1	Outcrop of Menard Limestone on the right.
0.3	19.4	Cross a northeast- to southwest-trending fault. The Mississippian age Clore Formation is on the north side of the fault, and the Mississippian age Tar Springs Sandstone is on the south side of the fault. No outcrops are exposed along the fault at this location. The limestone on the right is rip rap, placed there to control erosion.
0.7	20.1	Outcrop of Mississippian age Clore Formation on the left. From road level upward, the expo-sure consists of thin bedded shaley limestones of the Tygett Member of the Clore Formation overlain by thick carbonate beds of the Ford Station Limestone Member of the Clore Forma-

tion. The beds are dipping approximately 8 degrees to the west. A series of three northeast to southwest faults cross this area.

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| 0.2  | 20.3  | Good exposure of a fault within the Clore Formation on the left. Beds adjacent to the fault exhibit high-angle dips. The beds on the south side of the fault have apparent dips to the north, and the beds on the north side of the fault have apparent dips to the south. This relationship demonstrates deformation of beds along a fault with significant vertical movement. True dip is approximately 27 degrees to the northwest.   |
| 0.25 | 20.55 | Outcrop of Mississippian age, Salem Limestone (approximately 15 feet exposed) overlain by St. Louis Limestone (approximately 10 feet exposed) on both sides of the road. From road level upward, the exposure consists of thick-bedded cherty carbonate beds of the Salem Limestone, overlain by thin-bedded limestones of the St. Louis Limestone. The contact is sharp between the Salem and the St. Louis Limestones. The Salem Limestone contains abundant zones of fossil corals. Beds dip 7 degrees to the west. The outcrop contains numerous joints, and mineralization along the joints consists of calcite; an occasional small amount of fluorite encrusts the calcite. This relationship demonstrates that the first mineralization was by calcite followed by fluorite. This relationship is the same as observed in the mineralized veins within the fluorite mines. |
| 0.65 | 21.2  | T-intersection from the left. CONTINUE AHEAD.  |
| 0.65 | 21.85 | Cross Goose Creek. Flow is to the right, where Goose Creek empties into Big Creek. The road parallels Big Creek after crossing the bridge. Big Creek cuts across a highly faulted area, which controlled erosional development. Big Creek flows southward and empties into the Ohio River.   |
| 0.15 | 22.0  | Approaching T-intersection. PREPARE TO STOP.   |
| 0.1  | 22.1  | STOP. T-intersection. (Forest Service Road 141). TURN LEFT and immediately TURN RIGHT into the Illinois Iron Furnace parking lot.  |

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**STOP 5. LUNCH. Illinois Iron Furnace** (NE, SW, SE, Sec. 4, T12S, R8E, 3rd P.M., Rosiclare 7.5-minute Quadrangle, Hardin County).

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| 0.1  | 22.2  | Leave Stop 5. Exit parking lot and TURN LEFT.  |
| 0.05 | 22.25 | T-intersection from the right. CONTINUE AHEAD and cross Big Creek. The locally famous “ol’ swimmin hole” is on your right.   |
| 0.25 | 22.5  | T-intersection from the left (unmarked County Road 52/National Forest Road 1477). CONTINUE AHEAD. The road to the right will take you to Karbers Ridge Road, which leads to the Garden of the Gods.                  |
| 0.15 | 22.65 | Y-intersection (County Road 12 to the left and County Road 52A to the Right). BEAR RIGHT onto County Road 52A.   |
| 0.35 | 23.0  | <b>CAUTION: Narrow bridge.</b> Road curves to the right. Immediately cross Hog Thief Creek, and road immediately curves to the left. Hogthief Creek parallels a major fault. Flow is to the right, toward Big Creek. |

1.1	24.1	T-intersection from the right (National Forest Road 1736). CONTINUE AHEAD. Lake Tecumseh and Woopie Cat Lakes to the right 1 mile.
0.4	24.5	Prepare to stop.
0.15	24.65	STOP (one-way). T-intersection (County Road 3 and County Road 52A). TURN RIGHT onto County Road 3. Note the iron-rich red soil along the road's shoulders.
0.2	24.85	Outcrop of Mississippian age Hardinsburg Sandstone on the right.
1.15	26.0	Y-intersection from the left (Basset Road) unmarked intersection. TURN LEFT. <b>CAUTION: Sharp turn.</b> Just before crossing Hosick Creek, on the left is the former site of the one-room Basset School.
0.2	26.2	Cross Hosick Creek. Flow is to the right. Hosick Creek empties directly into the Ohio River.
0.3	26.5	Hardin County K-12 School on the left. Prepare to stop.
0.05	26.55	STOP (one-way). T-intersection (Illinois Route 146). TURN LEFT.
0.2	26.75	T-intersection from the right (Tower Rock Road). CONTINUE AHEAD. Tower Rock is 4 miles to the right.
0.65	27.4	Outcrop of Valmeyeran (Middle Mississippian) Ste. Genevieve and St. Louis Limestones on the right and left side of the road. CONTINUE AHEAD.

This following information is modified from the 1992 geological science field trip (Reinertsen 1992). It is included here for use with future field trips with smaller numbers of participants.

This exposure (although slightly overgrown) contains the contact between the Ste. Genevieve and the St. Louis Limestones. The deeply pitted solution cavities in the upper surface of the exposure contain residual red clay, derived from weathering of the limestone.

The St. Louis is predominantly a cherty, brownish gray, fine-grained limestone, but it contains some beds of fossiliferous limestone, dolomitic limestone, and oolitic limestone. It ranges from 350 to 400 feet thick in the field trip area. In the upper part, exposed here, the St. Louis is oolitic and contains numerous large chert nodules, which weather brown and have smooth outer boundaries. The limestone exhibits slight fluorspar mineralization.

The overlying Ste. Genevieve Limestone is 140 to 160 feet thick and consists of relatively chert-free limestone of variable character, including medium to light gray, oolitic limestone that is diagnostic of the formation. Interbedded with the oolitic limestone are beds of crystalline, fossiliferous limestone and fine-grained, dense, almost lithographic limestone. Several lenticular, sandy layers, sub-Rosiclare sandstones, occur at various intervals within the formation. The Ste. Genevieve is divided, in ascending order, into four members: the Fredonia Limestone, the Spar Mountain Sandstone, the Karnak Limestone, and the Joppa Member.

The lowermost Fredonia Limestone is exposed here above the St. Louis Limestone. The contact between the St. Louis and the Ste. Genevieve is conformable (non-erosional). Although the contact is gradational, the change from slightly oolitic, fine-grained limestone to extremely oolitic, coarser-grained limestone can be seen here. A small, weathered re-entrant (a slight notch formed in weaker materials) marks the approximate contact at the base of the Fredonia. The Fredonia contains little chert and is markedly cross-bedded. The underlying St. Louis is highly cherty and massive.

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| 0.3  | 27.7  | The road parallels the northeast-southwest–trending Peter Creek Fault Zone.                                       |
| 0.3  | 28.0  | Church of Christ on the right.  |
| 0.7  | 28.7  | Abandoned Rest Area on the left. CONTINUE AHEAD.  |
| 0.05 | 28.75 | Cross Peters Creek. The development of stream erosion along the upper reaches of Peter Creek is fault controlled. |

This following information is modified from the 1992 geological science field trip (Reinertsen 1992). It is included here for use with future field trips with smaller numbers of participants. Please note that most of the exposure is overgrown.

The formations exposed in the road cut on the right, after crossing Peters Creek, are the Mississippian age, Chesterian Series, Bethel Sandstone and the Downeys Bluff Limestone. The Bethel is a light gray, fine- to medium-grained sandstone that weathers tan. The Downeys Bluff consists principally of gray to brownish gray, fossiliferous, oolitic limestone, which can be seen near the east end of the road cut, south of the highway.

The exposure occurs in a narrow, downfaulted block (graben) within the Peters Creek Fault Zone and affords an excellent opportunity to observe the effects of faulting close up. The fault that bounds the graben on the northwest passes along the east edge of Peters Creek.

The fault that bounds it on the southeast passes about 300 yards east of the road cut, beyond the dip in the highway. Along these faults in this vicinity, the Bethel and the Downeys Bluff have been faulted against the older Ste. Genevieve and St. Louis Limestones.

Within the graben, a small fault cuts across and passes through the road cut near the east end. It is a normal fault, downthrown on the northwest side. The Bethel has been faulted against the Downeys Bluff. The steep northwestward tilt of the sandstone is the result of drag (friction) during faulting that bent the beds upward along the fault plane. The fault is not a clean break, but consists of a zone of intensely fractured and crushed rock.

Fine-grained, clayey material, containing angular fragments of sandstone, occurs beneath the sandstone. This material, a fault gouge, was formed by grinding action along the fault. In some places it has been shoved up into the sandstone. The gouge is light brownish gray with greenish and reddish patches caused by mixing with shale of the same colors from the top part of the Downeys Bluff.

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| 0.85 | 29.6 | T-intersection (Peters Creek Junction) from the right (925E and 550N). CONTINUE AHEAD. The road to the right leads to Tower Rock.  |
| 1.1  | 30.7 | T-intersection from the left. (1025E) Unmarked intersection. CONTINUE AHEAD.   |
| 0.5  | 31.2 | Crossroad intersection (1075E and 590N). CONTINUE AHEAD. The large depression in the landscape ahead is Big Sink.  |
| 0.5  | 31.7 | Crossroad intersection (1125E and 590N). Entrance to Hastie Quarry on the left. CONTINUE AHEAD.  |
| 0.5  | 32.2 | Cross middle of Big Sink, where two no passing zone signs are located. Big Sink is a broad, treeless, flat area. During extended heavy rainfalls, the sink floods and forms a lake. Water level in the sink also rises during times of high flood water in the Ohio River. View of quarry operations in bluffs to the left. The bluffs form a portion of the Mississippian cuesta. This fea- |



ture is a ridge with a gentle, north-sloping upper surface and a steep, southward-facing cliff or escarpment.

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| 1.1  | 33.3  | Prepare to Stop. Approaching T-intersection. Karst topography to the right.   |
| 0.3  | 33.6  | STOP (one-way). Loves Corner Junction (State Route 1 and State Route 146). TURN LEFT onto Route 1 North.  |
| 0.1  | 33.7  | Martin Marietta, Hardin County Plant No. 2 located on the left. Currently inactive, this facility manufactured and bagged powdered limestone for use in underground coal mines. The powdered lime was sprayed on the walls to minimize coal dust and lessen the chance of a coal dust explosion.  |
| 0.3  | 34.0  | Prepare to turn right.  |
| 0.1  | 34.1  | T-intersection from the right (Lamb Road, County Road 116/Country Road 650N). TURN RIGHT.   |
| 0.5  | 34.6  | Smyrna Cemetery on the left.  |
| 0.05 | 34.65 | Entrance to Shawnee Stone on the right. This operation is quarrying thin-bedded sandstone along a small creek for use as flagstone. These thin-bedded sandstones are part of the Mississippian age Ridenhower Formation.  |
| 1.0  | 35.65 | Large white house on the left, formerly the old Potter Church. A cemetery is located immediately north of the house.  |
| 0.15 | 35.8  | Cross Haney Creek.  |
| 0.3  | 36.1  | T-intersection from the right (County Road 110A). CONTINUE AHEAD.   |
| 1.1  | 37.2  | Outcrop on the right, thick-bedded limestone of the Mississippian age Glen Dean Limestone.  |
| 0.2  | 37.4  | Outcrop on the right, thin-bedded sandstone of the Mississippian age Tar Springs Sandstone.   |
| 0.1  | 37.5  | Cross Haney Creek.  |
| 0.05 | 37.55 | STOP (one-way). T-intersection, unmarked (County Road 116 to the left, and County Road 75 to the right). TURN RIGHT onto County Road 75. We are now following part of the River-to-River Trail, which starts at Battery Rock.   |
| 0.55 | 38.1  | Y-intersection (820N and 1635E). BEAR LEFT onto County Road 75 and cross unnamed creek. <b>CAUTION: narrow one-way bridge.</b> This is a spring-fed creek. The spring is located 1,600 feet to the left and upstream. The spring is flowing from the Mississippian age Menard Limestone.  |
| 0.1  | 38.2  | Outcrop of Menard Limestone within the creek on the right. These units include thin- to medium-bedded limestone overlain by thick-bedded dark gray limestone. Both units are fossiliferous. The beds dip between 5 to 6 degrees to the northeast.   |
| 0.1  | 38.3  | Contact between the Mississippian age Menard Limestone and the overlying Mississippian age Palestine Sandstone. A great example of karstic erosion within the Menard Limestone is found just below the contact. Good fossil collecting within a zone of thin-bedded limestone and shale units approximately 6 feet below the top of the Menard Limestone. |

0.25	38.55	Y-intersection, unmarked (County Road 1548 to the left and County Road 75/ National Forest Road 102 to the right). BEAR RIGHT. <b>CAUTION: Narrow unimproved road, but marked as suitable for passenger cars.</b>
0.3	38.85	Road enters into a large flat gravel parking lot. <b>CAUTION: The remaining portion of the road leading to Battery Rock is marked as suitable for high-clearance vehicles only.</b> On the day of the field trip, anyone driving an extremely low-clearance vehicle should park here and hitch a ride with someone in a high-clearance vehicle. A small outcrop of Pennsylvanian age siltstones and sandstones belonging to the lower basal unit of the Caseyville Formation occurs on the north side of the parking lot. The siltstones and sandstones contain both limonite and hematite staining and include layers of liesengang banding. The bedrock is overlain by a windblown loess deposit.
0.05	38.9	Former location of Battery Rock School on the right just past the parking lot
0.4	39.3	Great view to the left of Sturgeon Hill, elevation 595 feet above sea level.
0.2	39.5	End of road. Park in the large grassy area to the right or in the loop road at the end of the road. We will hike to Battery Rock from this point.

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**STOP 6. Battery Rock** (SE, NE, SE, Sec. 27, T11S, R10E, 3rd P.M., Dekoven 7.5-minute Quadrangle, Hardin County). From the large grassy area follow Trail 102 marked with a blue “I.” At approximately 400 paces (2,000 feet), the trail forks. A small pond is located on the left, the northwest corner of the fork in the trail. Follow the left fork (Trail 102B) for approximately 370 paces (1,850 feet) downhill to where the trail opens up onto exposed bedrock of the Pennsylvania age Battery Rock Sandstone. Follow the trail down the bedrock spillway to a rock shelter formed in the bluffs and the Ohio River. **CAUTION: The spillway is extremely slippery when wet.** Total round trip is 1.5 miles.

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0.05	39.55	Leave Stop 6 and retrace the route back to the County Road 75.
0.6	40.15	Enter large flat gravel parking lot.
0.3	40.45	STOP ( <b>CAUTION: No sign</b> ). T-intersection, unmarked (County Road 1548 to the right). CONTINUE AHEAD on County Road 75.
0.45	40.9	Cross unnamed creek and STOP on other side of the bridge. Y-intersection (820N and 1635E). BEAR RIGHT onto County Road 75, heading toward Lamb Junction.
0.55	41.45	T-intersection from the left, unmarked (County Road 116 to the left and straight ahead. End of County Road 75). CONTINUE AHEAD on County Road 116.
0.35	41.8	Enter Lamb Junction. T-intersection from the right, James Town Road (1550E and 840N). CONTINUE AHEAD.
2.0	43.8	Abandoned Minerva No. 1 Fluorspar Mine site to the right. CONTINUE AHEAD.
0.55	44.35	T-intersection from the right, unmarked (County Road 45). CONTINUE AHEAD.
0.15	44.5	STOP (one-way). T-intersection (Illinois Route 1). TURN RIGHT onto Route 1 North. The abandoned Hill Mine, an underground fluorspar mine, is located 1,400 feet directly west of this intersection.

- |      |       |  |
|------|-------|--|
| 0.6  | 45.1  | Cross left fork of Rock Creek.   |
| 0.1  | 45.2  | T-intersection from the left (1005N and 1275E). CONTINUE AHEAD. Mt. Zion Church on the left.   |
| 0.2  | 45.4  | Cross Rock Creek. CONTINUE AHEAD. Notice the large, flat floodplain to the right. Rock Creek flows into the Saline River, which empties into the Ohio River at Saline Landing, located 3 miles to the northeast. The floodplain contains laminated silts and clays of the Equality Formation. Some of these lake sediments probably date from the Illinois glaciation about 200,000 years ago, but most of the sediments were deposited in a slack water lake, which formed during the melting of the Wisconsin glacier from about 20,000 to 10,000 years ago.   |
|      |       | <p>Flooding of the lowland areas in southern Illinois and adjacent parts of Indiana and Kentucky was especially extensive during melting of a large ice mass called the Valparaiso glacier. The Valparaiso glacier represented a major readvance of the Wisconsin glacier, just entering extreme northeastern Illinois about 13,000 years ago. Vast amounts of meltwater poured from the ice front and caused extensive flooding in the Mississippi, Illinois, Wabash, and Ohio River valleys. In this area, a great lake was formed as these floodwaters backed up the Saline River valley, its tributaries, and areas to the south. At its greatest extent, this lake probably reached an elevation of about 400 feet above sea level.</p> <p>The former lake beds in the Saline River valley still flood with Ohio River backwater from time to time, and the Pleistocene lake sediments are veneered with thin alluvium of Recent (Holocene) age. The flood of 1937 is thought to have formed a lake approximately the size of the Wisconsin glacial lake that existed during Valparaiso time.</p> |
| 0.35 | 45.75 | T-intersection from the left (1050N and 1245E). CONTINUE AHEAD.  |
| 0.35 | 46.1  | T-intersection from the right (1075N/ County Road 29). CONTINUE AHEAD.   |
| 0.2  | 46.3  | Outcrop of Pennsylvanian age Abbot Formation sandstone on the right and left side of the road. A northeast-southwest-trending fault crosses the road near the north end of the outcrop. The beds dip 11 degrees to the northwest.  |
| 0.5  | 46.8  | Cross Harris Creek. Prepare to turn left. Initial development of Harris Creek is between two faults within a down dropped block.   |
| 0.05 | 46.85 | T-intersection from the left (1150N/ County Road 25). TURN LEFT. After making the turn, the head frame for the abandoned Annabel Lee mine is visible.  |
| 0.55 | 47.4  | Entrance to the abandoned Annabel Lee Mine to the right, just before the road curves to the left. Pull over to the far right side of the road and park your vehicle.   |

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**STOP 7. Annabel Lee Mine** (Center of Sec. 10, T11S, R9E, 3rd P.M., Saline Mines 7.5-minute Quadrangle, Hardin County). The Annabel Lee is an abandoned fluorspar mine

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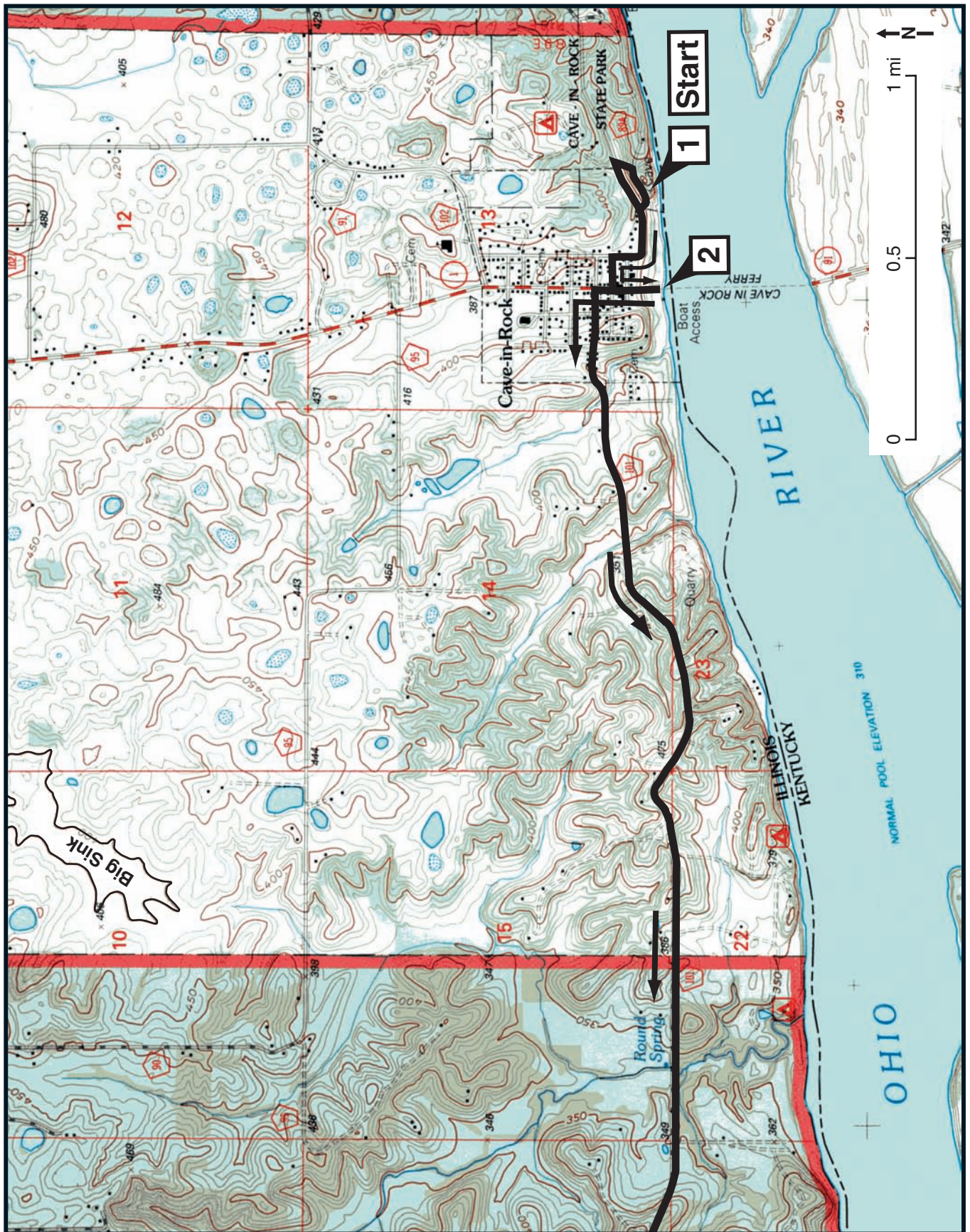
End of trip.

Turn around, and retrace field trip route back to Illinois Route 1.

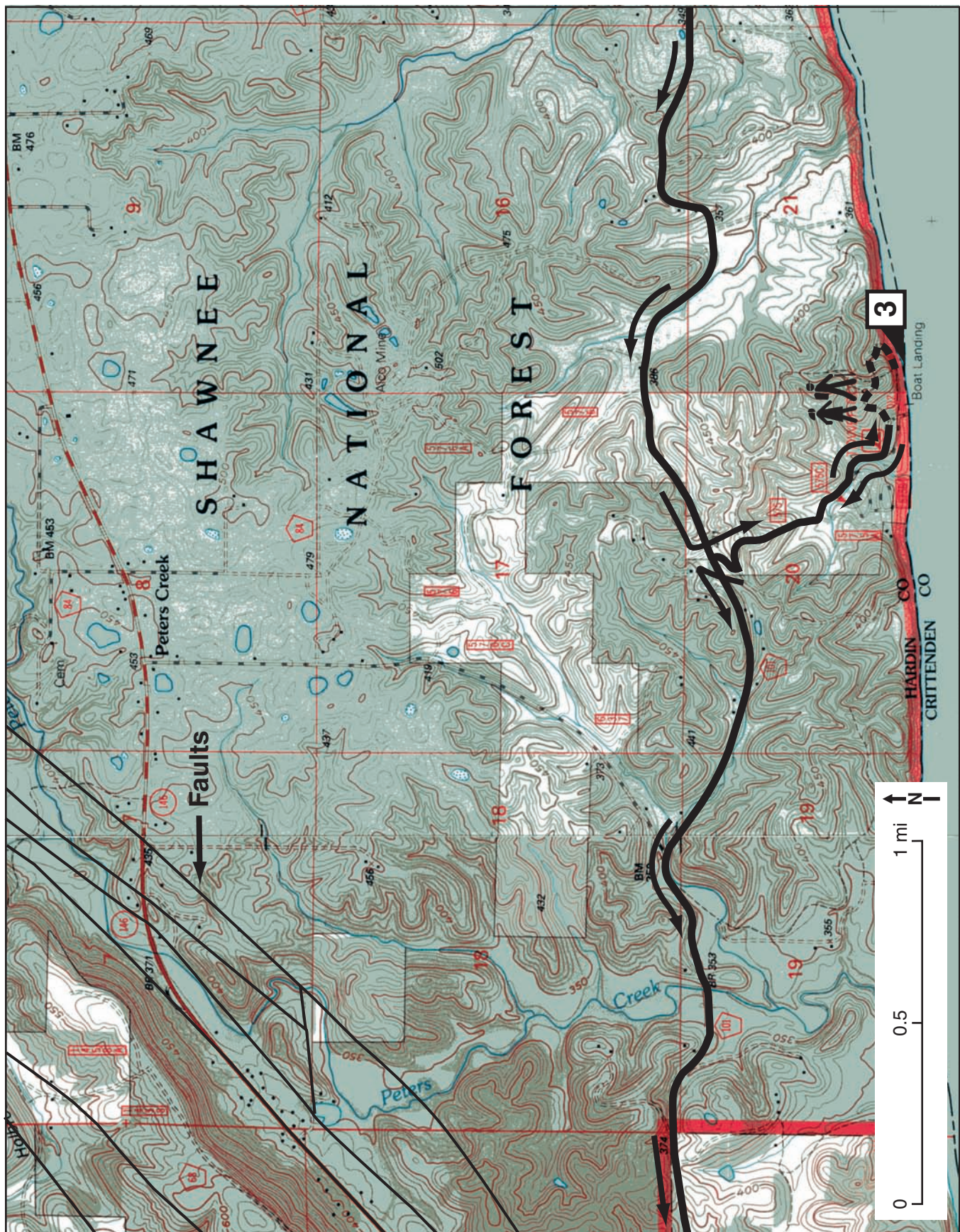
TURN RIGHT onto Illinois Route 1 toward Illinois Route 146 and Cave-In-Rock. Then TURN RIGHT on Illinois Route 146 toward Vienna and Interstate 24.

TURN LEFT onto Illinois Route 1 toward Illinois Route 13. TURN LEFT onto Illinois Route 13 toward Harrisburg, Marion, and Interstate 57.

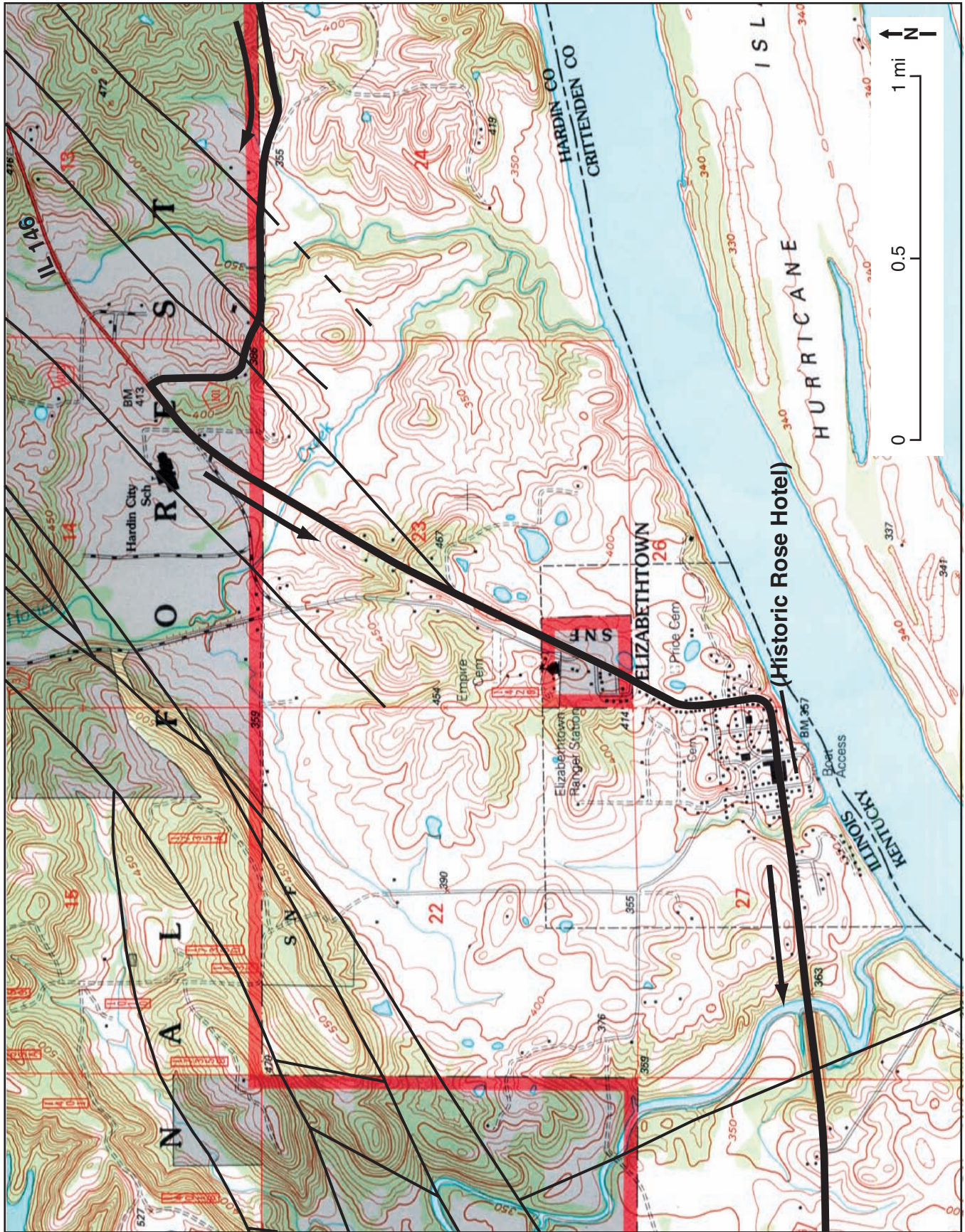




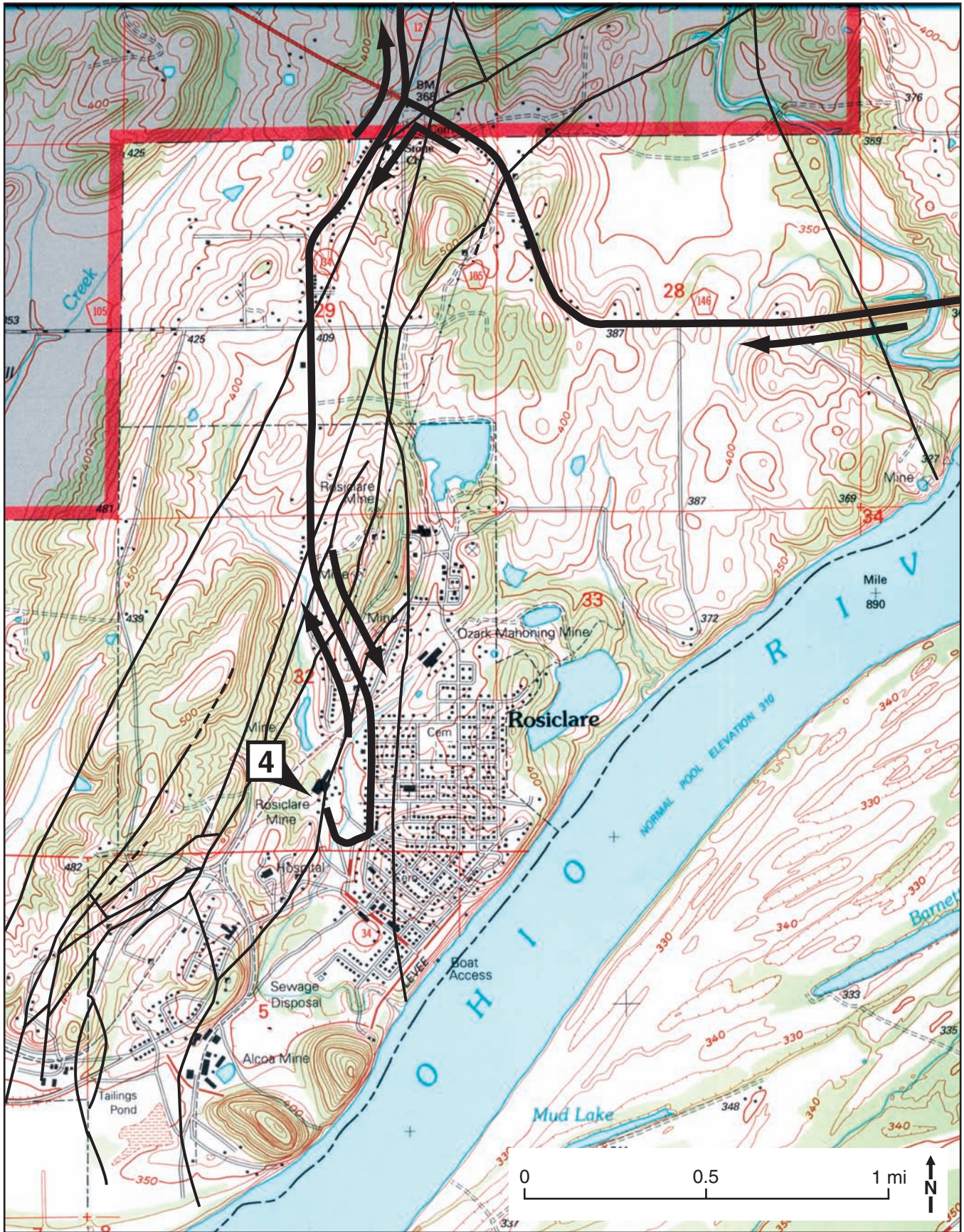




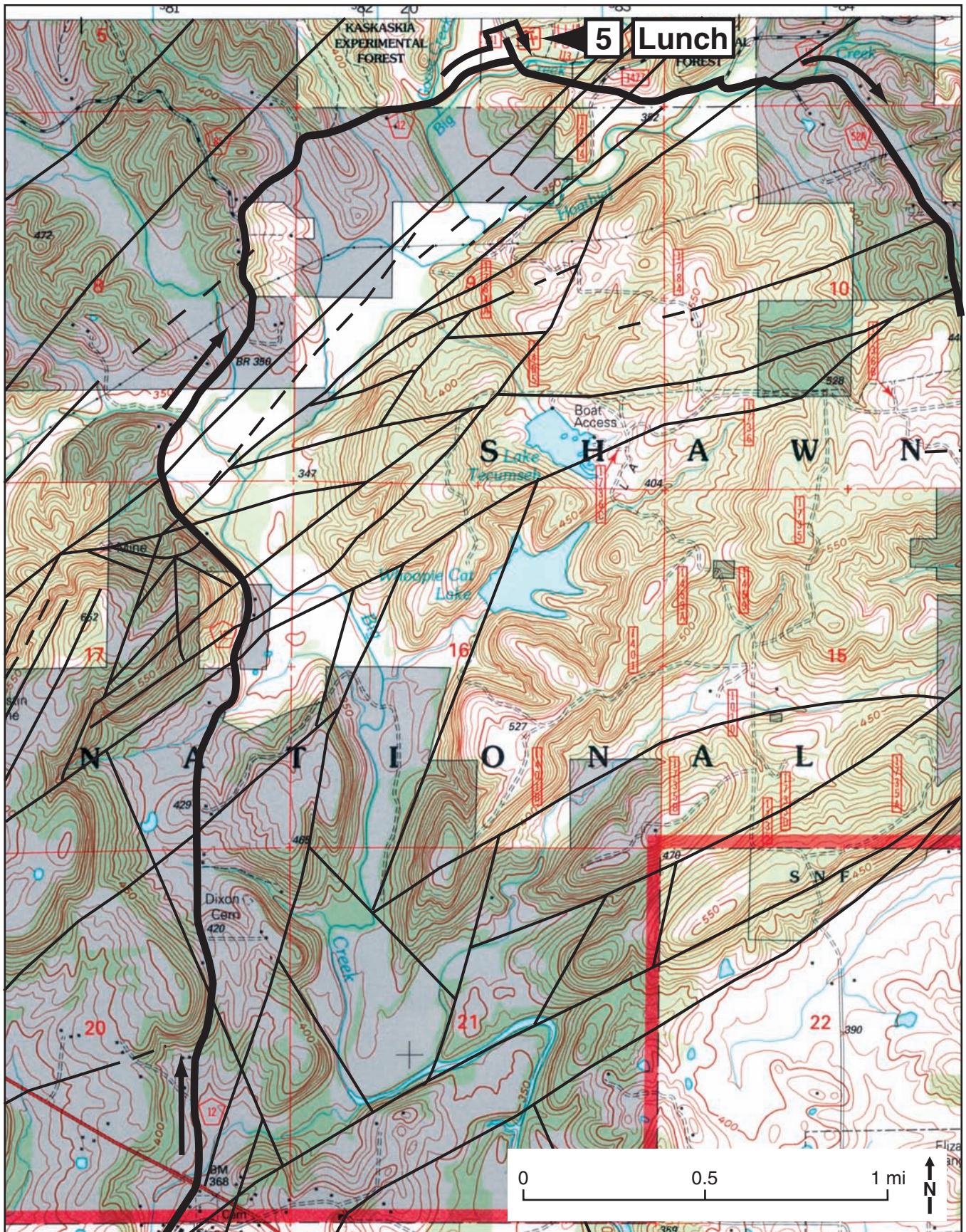




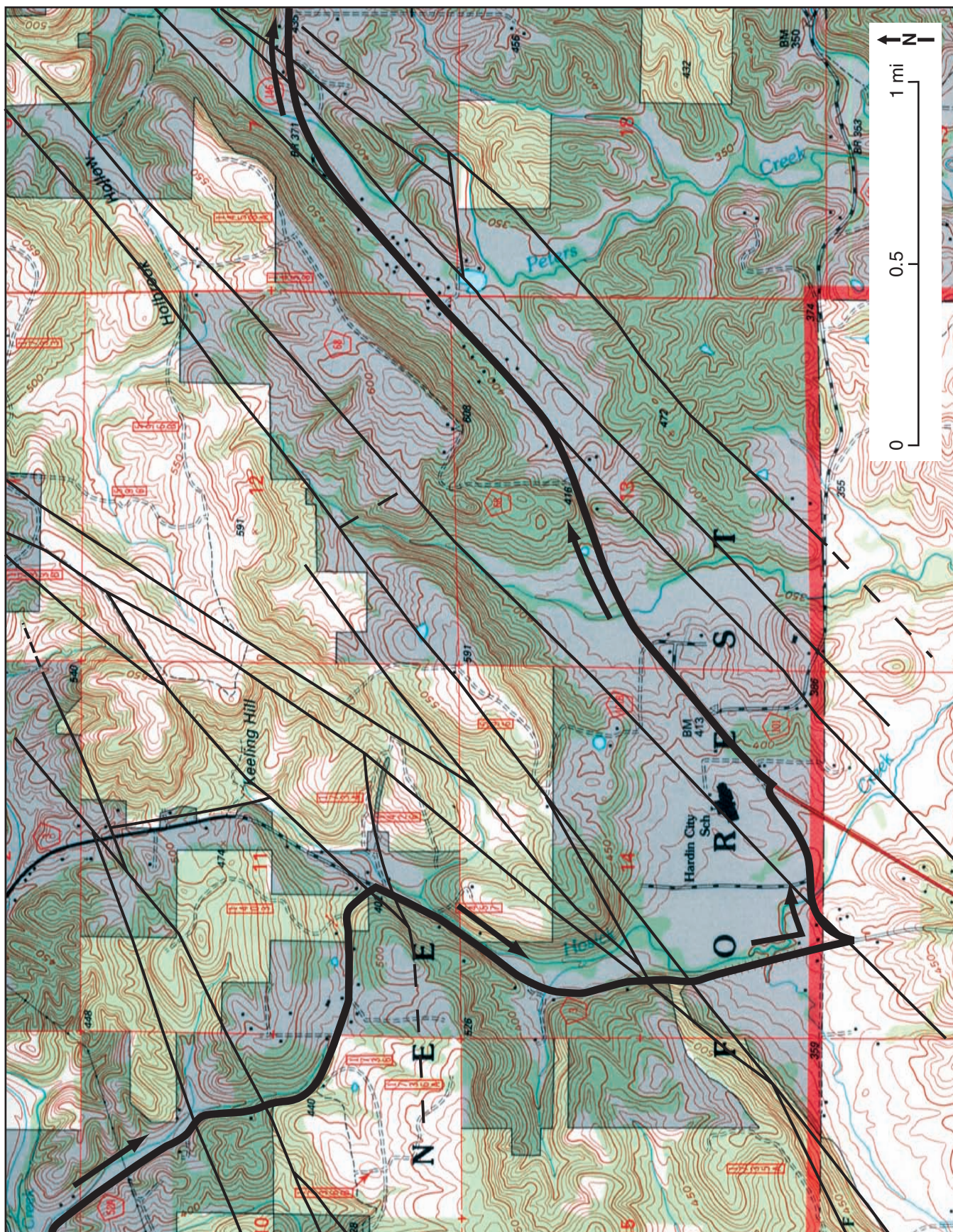




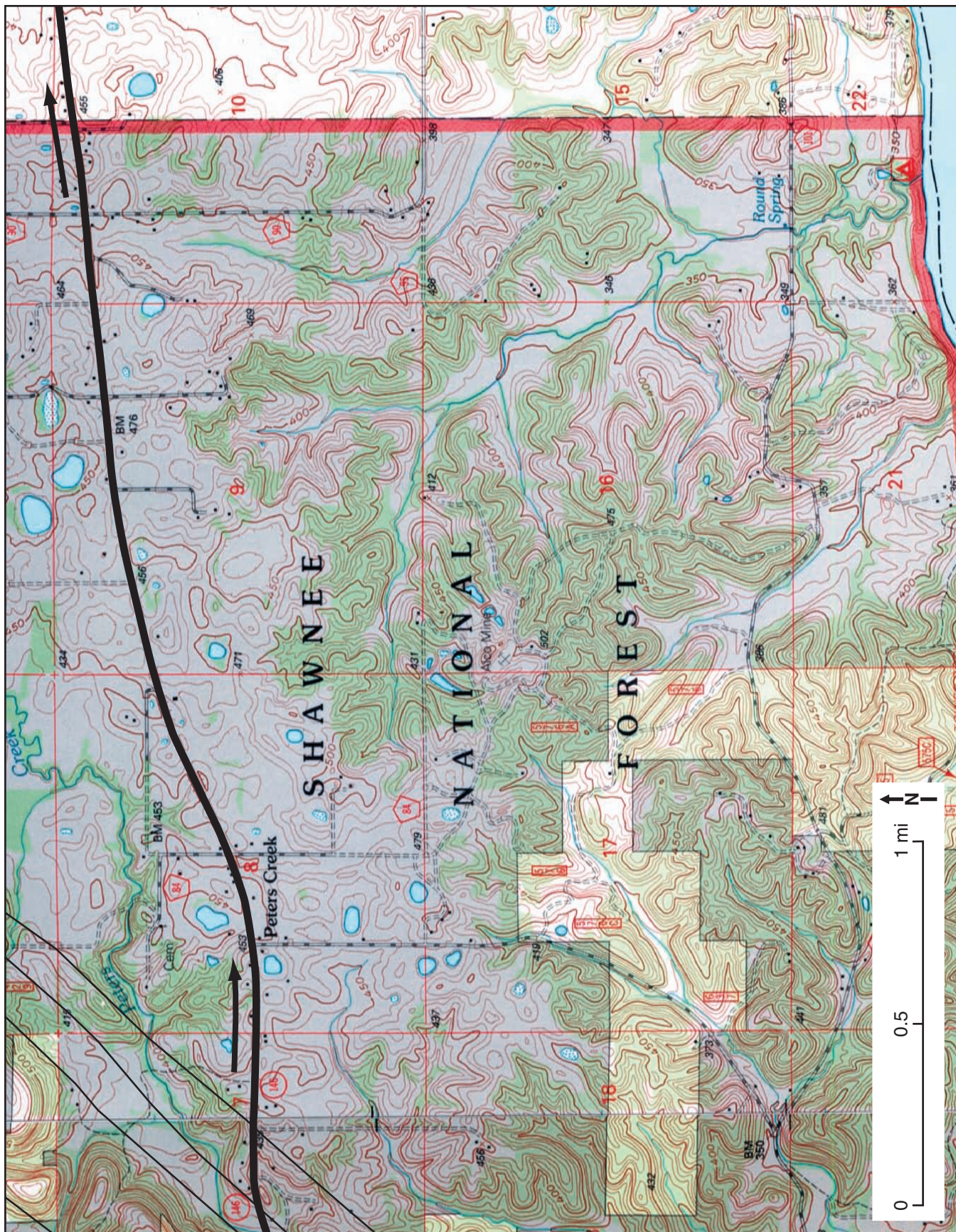




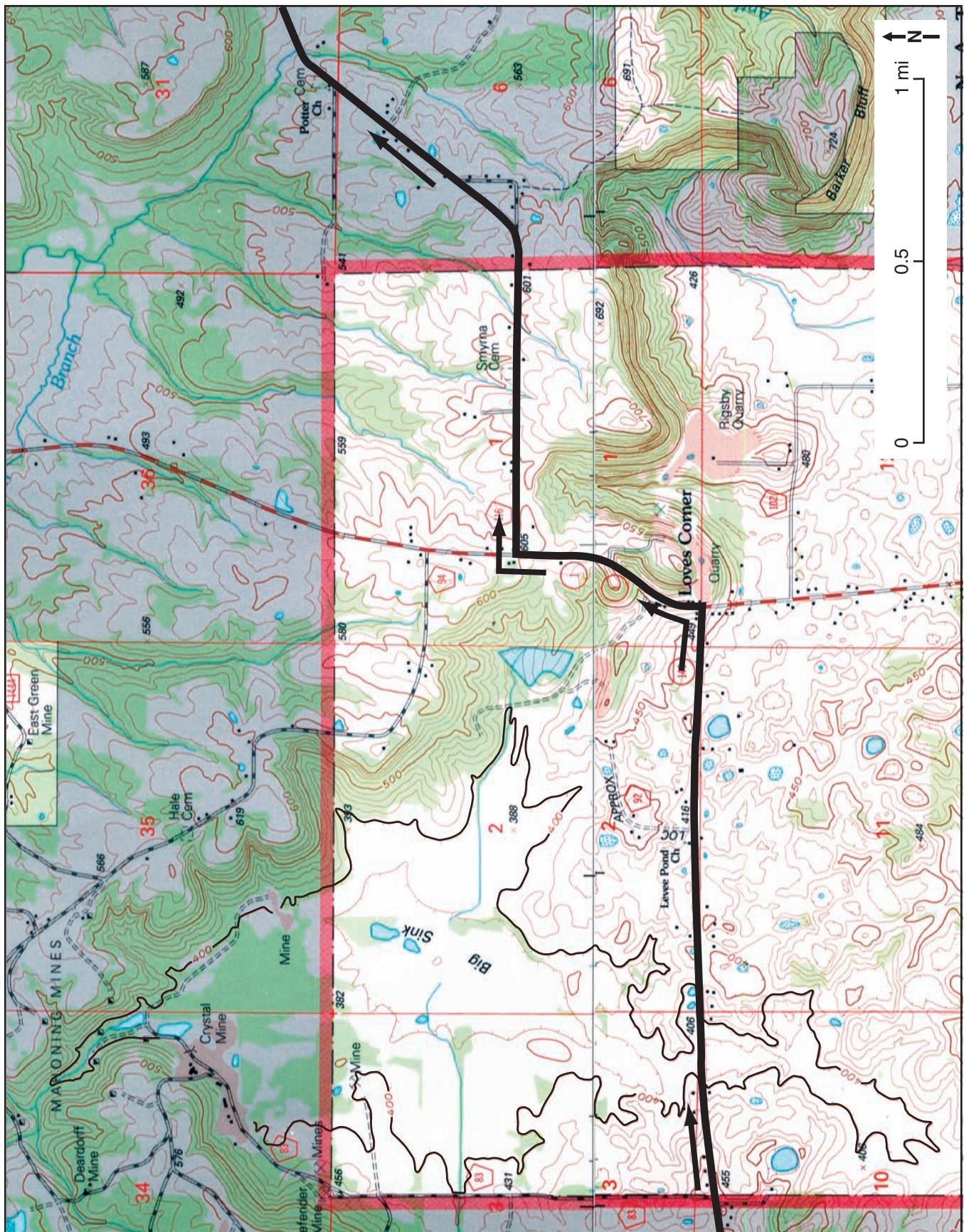








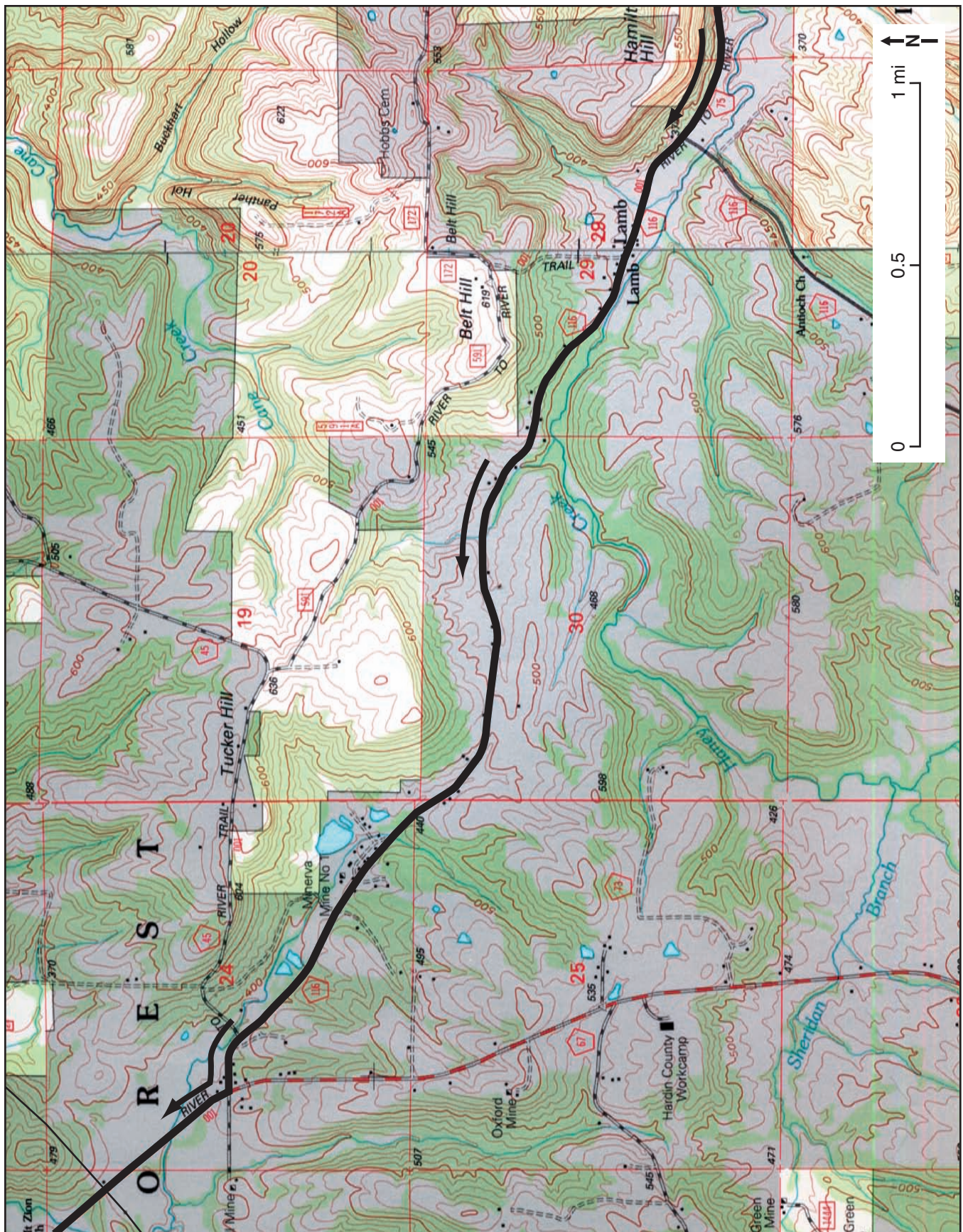




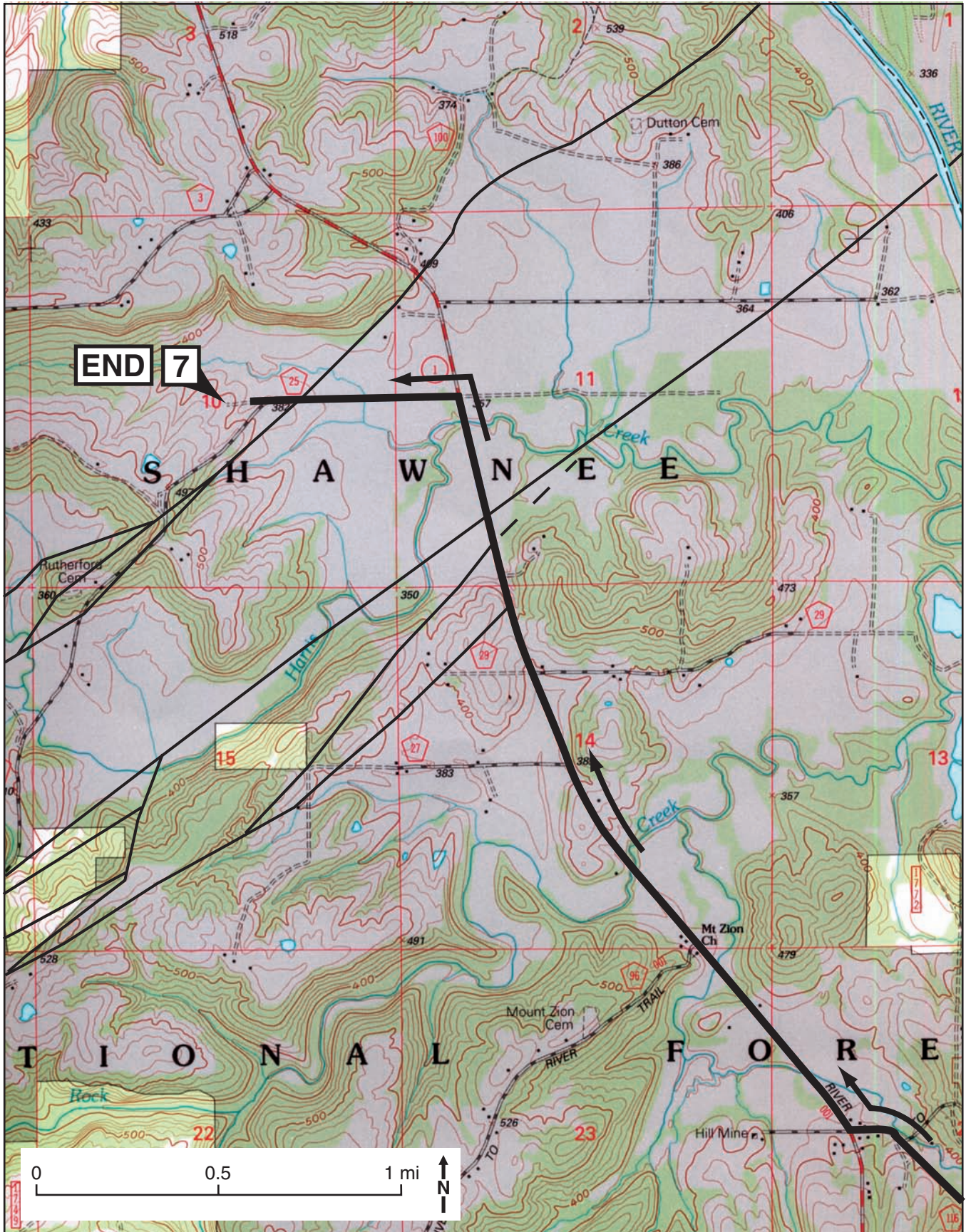














# STOP DESCRIPTIONS

**STOP 1. Cave-In-Rock State Park** (SW, SW, SE, Sec. 13, T12S, R9E, 3rd P.M., Cave-In-Rock 7.5-minute Quadrangle, Hardin County). On the day of the field trip, climb the stairs from the lower parking lot towards Shelter No. 3 and then follow the stairs down to the cave in the rock.

We'll visit the most famous cave in Illinois, Cave-In-Rock (fig. 7). The entrance is just above the river.

**CAUTION: Footing within the cave may be slippery, especially under wet or muddy conditions.**



**Figure 7** Cave-In-Rock, Cave-In-Rock State Park, Hardin County (photograph by W. T. Frankie).

## Legends and Lore

The actual history of this imposing natural phenomenon is colorful and provocative. Imagine yourself as a wiry pirate. Indeed, river pirates and bandits once hung out in the recesses of this cave and used the strategic location for their plunderous benefit. In the words of Illinois historian John W. Allen:

Today only the natural beauty of the historic spot remains, clothed in mystery. In the hollow silence of the cave that echoes the peaceful cooing of doves,

a visitor can let a vivid imagination run riot. But he can dream little that will be beyond what actually happened.

If you want to fit in, and not sound like an outsider, to refer to the cave, use the term “Cave Hole,” for this is the name used by the local residents.

The first European explorer to discover the cave was M. de Lery, who in 1729 called it *Caverne dans le Roc* (“cave in the rock”). Based on this earlier report, Charlevoix located it on a map in his 1744 *History of New France*. The cave was a conspicuous curiosity frequently mentioned by later travelers in diaries and journals. Following the Revolutionary War, this immense recess served as headquarters and stronghold for outlaw bands that preyed upon hapless travelers along the Ohio River. A few of the more infamous outlaws include the pirate Samuel Mason, the Sturdivant Gang, the bandit Logan Belt, and Philip Alston, the counterfeiter.

One of the most ambitious of these ruthless malefactors was Samuel Mason. Once an officer in George Washington's Revolutionary Army, in 1797, under the name of Wilson, he converted the cavern into a tavern which he called “Wilson's Liquor Vault and House of Entertainment.” From this apparently innocent and inviting locale, many a river boatman were given poison while enjoying Mason's hospitality. In order to drum up business, Mason would sometimes dispatch his cohorts upriver to befriend unwary and bewildered travelers with offers of help and guidance. As they neared the cave, these henchmen would disable their boats or force them toward the yawning hollow, where the hapless pilgrims would be robbed, or worse. Few victims lived to tell their story. These river rogues firmly believed in the saying that “dead men tell no tales.” A favorite method of covering up their dirty work was to slit open the body of the murdered traveler, fill it with stones, and sink it out in mid-stream. Mason was eventually forced to flee his hideout at Cave-In-Rock, and afterward he set up shop along the Natchez Trace, once again robbing travelers. The hard-nosed old river pirate was later double-crossed by two members of his own gang at Cave-In-Rock. One of the conspirators was the notorious Wiley (Little) Harpe. The gang beheaded Mason for the reward money.

It's interesting to note that the cave served as a backdrop for a scene in the movie *How The West Was Won*. The scene was a near-accurate portrayal of how, during the eighteenth and nineteenth centuries, ruthless bandits used the cave to lure unsuspecting travelers to an untimely end. However, only a shot of the cave's entrance was used in the movie. The inside of the movie cave was filmed elsewhere. This film editing of two different localities and making them seem like one is called "creative geography." Cave-In-Rock was also used in the Walt Disney movie *Davey Crockett and the River Pirates*.

Following Mason's demise, the cave sheltered the even more notorious Harpe Brothers (Wiley "Little" Harpe and his brother Micajah "Big" Harpe) a pair of killers fleeing execution in Kentucky. The actions of the Harpe Brothers were even too cruel for other outlaws. Legend has it that they would kill for the sheer sport, and lore says that "Big" Harpe killed his own baby son by bashing the infant's head against a tree because his crying irritated him. During their murder spree in 1799, following an incident involving a victim (reported to be female) tied to a blindfolded horse and driven off the cliff above the cave, they were "asked" to leave by members of their own gang. The Harpe Brothers continued their personal reign of thievery and murder in Illinois until they, too, were killed. "Big" Harpe was captured by a posse and criticized his killer for being "a dam poor butcher," as the man was severing the outlaw's head from his shoulders.

By the early 1800s, following the demise of the Mason Gang and the Harpe Brothers, a host of other misfits used the cave. These later outlaws included James Ford, ferryman and gang leader, who would rob his own customers. Other misfits included the counterfeiter John Duff, followed by perhaps the last outlaw to use the cave, another counterfeiter named Sturdeyuant.

The cave was used almost continuously by various criminal gangs until the mid-1830s, when the quickening westward expansion of civilization and the steady growth in the local population and commerce prompted the U.S. Government to take action. By 1834, all outlaws had either been killed or discouraged from further nefarious activities. The cave then became a "safe" refuge for travelers on their way west, or so it has been reported. Throughout the nineteenth century, this remarkable geological feature was an important landmark, prominently displayed on maps from the period. Even today, Cave-In-Rock is still highlighted on many maps and especially travel brochures.

Information used in the preceding Legends and Lore section was combined from a variety of sources includ-

ing the state park brochure, and an old Cave-In-Rock ferry brochure that included a story by Ed Hahey, *St. Louis Post-Dispatch*, dated July 28, 1951. As with most legends, some of the details vary from one source to another. However, they all have some of the historical accounts in common. For more information about the activities of the outlaws, you may be interested in a book written by Otto A. Rothert. *The Outlaws of Cave-In-Rock*, Otto A. Rothert, Cleveland 1924; reprinted 1996 (ISBN 0809320347).

## Geology of the Cave

Cave-In-Rock is developed in the Mississippian age St. Louis Limestone (fig. 2). The St. Louis Limestone is fine grained and contains numerous zones of knobby chert. Upon close examination, the chert nodules can be seen in the bluffs. Native Americans made use of the chert to make arrowheads, scrapers, and other primitive tools. A large number of chert flakes were discovered on top of the bluffs during construction of the lodges in the park. The large accumulation of chert flakes are an indication that Native Americans spent a considerable amount of time in this area working the chert. The shaping of chert into tools is called knapping.

The caves, subterranean caverns, and sinkholes created by groundwater dissolving limestone are solutional features typical of areas of karst topography, such as occurs in the vicinity of Cave-In-Rock. The cave has formed in Valmeyeran (middle Mississippian) St. Louis Limestone, which forms the bluffs along the Ohio River in this vicinity. The great size of Cave-In-Rock gives geologists reason to think that it once extended much farther to the south. Erosion by the Ohio River may have removed limestone that contained a larger cavern. The cave probably also extends much farther to the north than its rear wall, which is only about 100 feet from the mouth, and it probably plunges downwards beneath the mud floor at the back of the cave. A ravine in the park, just north of the ridge that contains the cave, has been cut down lower than the present floor of the cave. The cave must bend downward beneath the ravine bottom; otherwise, today's cave would simply be a tunnel through the ridge.

**Development of Karst Topography.** Karst topography develops in areas of fractured or jointed limestone bedrock where the strata are flat-lying or only gently tilted. There must also be ample rainfall and an outlet below the limestone bedrock toward which groundwater can flow. Rainwater charged with carbon dioxide from the atmosphere and humic acids from decaying vegetation percolates downward through the jointed limestone. The water gradually dissolves the limestone and enlarges the joints to form an interconnecting network

of subterranean fissures. More and more of the surface drainage will eventually be diverted into the subsurface, and, if enough time passes without a change in these conditions, some of the fissures will enlarge into great underground caverns, such as the one at Cave-In-Rock State Park.

Some sinkholes form as the roofs of caverns collapse. Other sinkholes are purely solutional features and form by the enlargement of joints from the surface downward. The result of this process is a rolling karst plain, pocked by numerous sinkholes and underlain by cavernous limestone. The area immediately surrounding the town of Cave-In-Rock possesses all of the conditions necessary for the development of karst topography. The area is underlain by a thick section of jointed Valmeyeran (middle Mississippian) limestones (Ste. Genevieve, St. Louis, and Salem), receives ample rainfall (probably more during Pleistocene time), and lies adjacent to the entrenched Ohio River, toward which subsurface upland drainage can move.

**Theories of Cave Origin.** Two main theories have been offered by geologists to explain the formation of caves. The first is that caves are formed mainly above the water table (in the zone of unsaturated bedrock) by the scouring and solutional activity of groundwater (*vadose water*) flowing in subterranean streams. The second theory, more widely accepted by geologists, is that caves form mainly below the water table in the zone of saturated bedrock where groundwater (*phreatic water*) moves slowly under hydrostatic pressure. Recharge from the surface continually supplies fresh water that slowly dissolves the limestone and carries the calcium carbonate away in solution.

Both processes are probably active in the history of most caves, the latter being more important and occurring throughout most of the interval of cave formation, the former occurring at the end. Each case has to be evaluated individually.

Panno and Bourcier (1990) presented a hypothesis for the formation of caves and associated karst features near the southern margins of the Illinois, Michigan, and Appalachian Basins. They noted that the relationships between various features of these basins suggest that Pleistocene glaciations may have induced the discharge of saline waters from the basin margins. The great weight of the glaciers could have resulted in compaction of underlying sediments and in flushing of underly-

ing aquifers as bottom melting of the glaciers occurred in recharge areas of basin aquifers. Pressure-induced upward migration of basin saline waters into near-surface strata caused the saline waters to mix with glacial meltwater and meteoric water and a dissolution of the limestone. Such dissolution would result in the development of horizontal caves and cave systems and vertical phreatic conduits. Panno and Bourcier (1990) noted that, after cave formation, lowering of the water table and exposure of the caves to erosion resulted in further dissolution by vadose mechanisms.

**Origin of Cave-In-Rock.** Evidence supporting the hypothesis that Cave-In-Rock was formed by phreatic water includes the fact that the rock floor of the cave apparently plunges below its present earthen floor. The rock floor at the mouth of the cave is actually higher than it is toward the back. Only groundwater moving upwards under a hydrostatic head (pressure differential) could produce such a feature. Scour features are virtually absent, and the only erosive feature attributable to the action of vadose water is the small central trench in the bottom of the cave.

The cave is not related in origin to the present sinkhole plain to the north, although it is tempting to consider the possibility that the cave connects with the bottom of Big Sink, the largest known sinkhole in Illinois. Evidence against a connection with Big Sink, or with the other sinkholes, includes the fact that the cave is not presently serving as an outlet for groundwater discharge. The present sinkhole plain is probably too small to have supplied enough groundwater to form such a large cavern. The sinkhole plain is probably a Pleistocene feature that began to form less than 1 million years ago and is still undergoing change as groundwater drains toward the Ohio River. Cave-In-Rock is much older than Pleistocene, perhaps forming during Late Tertiary time, probably late in the Pliocene Epoch, which lasted from about 10 million to perhaps 2 million years ago.

At one time during its formation, the cavern probably served as a major conduit for groundwater flowing southward from the highlands in the north. The cavern may have extended many miles southward to an ancient river, tributary to the ancestral Mississippi. However, there is no known evidence in Kentucky to substantiate its presence. The cave must have been slightly longer than it is now, and perhaps it simply discharged upward as a great artesian spring somewhere south of here.



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**STOP 2. Cave-In-Rock Ferry** (SW, SE, SW, Sec. 13, T12S, R9E, 3rd P.M., Cave-In-Rock 7.5-minute Quadrangle, Hardin County). On the day of the field trip, we will board the ferry on foot to cross the Ohio River.

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We will take a ride on the only ferry crossing the Ohio River in Illinois. Unless you have a boat, the only other places to cross the Ohio River, other than the ferry, in this part of Illinois are at Brookport approximately 70 miles to the south or Shawneetown approximately 35 miles to the north. During the early part of the last century, several other ferries operated in this area, including the Berry Ferry at Golconda and the Ford Ferry located north of Cave-In-Rock. In addition, there were ferries operating at Rosiclare, Elizabethtown, and Shawneetown.

Among the later outlaws in the Cave-In-Rock area, some—such as James Ford—worked in an atmosphere of semi-respectability. Ford arrived in about 1803 and

settled on the Kentucky side about 3 miles north of Cave-In-Rock, where he owned and operated Ford's Ferry. He had enough influence on the Kentucky side to have Livingston County maintain a road leading to the crossing. However, he was unsuccessful in having a road constructed at public expense in Illinois, so he built a stretch on his own. The road maintained on each side of the crossing totaled about 20 miles, which was a considerable distance in a roadless region. As a result, Ford's Ferry was able to attract more travelers than other crossings. A gang of outlaws often robbed the travelers along this road or as they were crossing the river, and some of those who escaped identified Ford as the leader of the gang (Haheys 1951). This may have been an early form of road taxation collected by James Ford!

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**STOP 3. Tower Rock** (NW, NE, SW, Sec. 21, T12S, R9E, 3rd P.M., Cave-In-Rock 7.5-minute Quadrangle, Hardin County). The trail leading to the top of Tower Rock is located north of the boat launch. The trail is 1/8 mile long.

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On the day of the field trip, if you are a beachcomber, follow the Ohio River bank north of the boat ramp. Good fossil collecting is within the talus slope below the bluff along the Ohio River. You never know what treasures can be found along the banks of the Ohio River. However, if you have a little mountain man in your blood, follow the 1/8-mile trail to the top of Tower Rock for a fantastic view of the Ohio River valley.

Tower Rock, at an elevation of 500 feet above sea level, is the highest point along the Ohio River in Illinois and is reported to be the highest point along the entire Ohio River (fig. 8).

The stratigraphy of Tower Rock, from the base at the Ohio River's edge, consists of approximately 120 feet of Mississippian age Salem Limestone, overlain by 60 to 80 feet of Mississippian age St. Louis Limestone. The Salem Limestone is typically gray to almost black, argillaceous, foraminiferal calcarenite, whereas the overlying St. Louis Limestone is fine grained and cherty. Several zones of silicified singular horn coral assemblages occur in the upper portion. These horn corals can be seen in the bedrock near the observation platform and along the trail at the top.

During Mississippian time, the midcontinent of North America was a generally low-lying stable platform. Clear, warm, shallow seas entered the Mississippi Valley region, which remained almost continually submerged throughout the Mississippian Period (from about 354 to 323 million years ago). During the middle part of the period, the seas reached far to the north, and



**Figure 8** Tower Rock (photograph by W. T. Frankie).

relatively pure limestones, such as the St. Louis and the Salem Limestones, were deposited over enormous areas. During the latter part of the period, the seas became

more restricted, and the numerous shales and sandstones of the Chesterian Series were deposited.

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**STOP 4. The American Fluorite Museum** (SW, SW, SE, Sec. 32, T12S, R8E, 3rd P.M., Rosiclare 7.5-minute Quadrangle, Hardin County). The museum is located on the former site of the Rosiclare Lead and Fluorspar Mining Company.

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The American Fluorite Museum has generously waived the normal admission fee. If you wish, please make a donation to help the American Fluorite Museum. We will visit the American Fluorite Museum and discover the wonders of fluorspar, the Illinois State Mineral. Inside the museum, you will learn of the history, production, and uses of fluorite. The museum is located on the former site of the Rosiclare Lead and Fluorspar Mining Company.

Through the efforts of many dedicated volunteers, the Museum Board, the Hardin County Historical and Genealogical Society, and interested citizens, The American Fluorite Museum is now open. Museum hours are Friday 1:00 p.m. to 5:00 p.m., Saturday 10:00 a.m. to 5:00 p.m., and Sunday 1:00 p.m. to 5:00 p.m.

The museum features numerous items representing the fluorspar mining industry that have been donated by interested citizens, including ore specimens, mining paraphernalia, and photographs. The reception area offers literature from the Hardin County Rural Development Council, gifts from the Hardin County Hospital Auxiliary, and literature from the Hardin County Historical and Genealogical Society.

Tours are given by special appointment. Contact The American Fluorite Museum, Main Street, P.O. Box 755, Rosiclare, IL 62982 or call 618-285-3513. Admission fees are \$3.00 for adults and \$1.00 for children 6 to 12 years of age.

### **Fluorspar: The Gem of Hardin County**

Fluorspar is the industrial name for the mineral known as "fluorite." The chemical makeup is quite simple: calcium fluoride or  $\text{CaF}_2$ . On a hardness scale of 1 to 10, fluorite is number 4. It also is 3.18 times heavier than the same volume of water and comes in purple, yellow, blue, white, green, and several other less common colors. Fluorite is used as a flux to make steel, glass, and aluminum; to make hydrofluoric acid; and to make ceramic products. It is a primary source of fluorine for

medical and industrial uses. A current major application is the manufacturing of refrigeration gases. The uses for fluorspar are wide ranging and virtually endless.

Major fluorite deposits have been mined commercially in southern Illinois and western Kentucky since the 1800s. Early Native Americans used the brightly colored pieces as jewelry or to make ceremonial carvings. During the 1810s, fluorspar was first used as a flux to help remove the impurities from steel smelting. This was the first serious large-scale use for the mineral, and the area began to boom. Many families created small-scale mining or milling companies to produce fluorspar. Several father-son or brother teams evolved, and, by the turn of the century, hundreds of operations dotted the countryside. As production and uses began to climb, larger companies and investors became interested and moved in; thus, the economy of the area began to flourish. Eventually, Hardin County became the largest fluorspar-producing area in the United States.

The geology of the area was critical to the formation of the fluorspar industry. The entire region is heavily faulted and for the most part has been pushed upward, thus providing opportunities for the deep-seated fluorine-bearing solutions and gases to migrate upward to conditions favorable to make the fluorite deposits. Most of this happened over 200 million years ago (Late Permian). Most of the fluorspar deposits were situated in such a manner that underground mining had to be employed in order to make the operations economic. Some of the mines in the district were worked as deep as 1,300 feet.

The fluorspar industry has been a colorful and important part of the history and lives of many people throughout the area for several generations. The aim of the American Fluorite Museum is to preserve that history for future generations. Fluorspar information is by Eric Livingston, President American Fluorite Museum, modified from The American Fluorspar Museum brochure.

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**STOP 5. Lunch. Illinois Iron Furnace** (NE, SW, SE, Sec. 4, T12S, R8E, 3rd P.M., Rosiclare 7.5-minute Quadrangle, Hardin County).

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Now on the National Register of Historic Places, the Illinois Iron Furnace allows you to step back in time to Civil War days when “pig iron” was smelted in the first charcoal-fired iron furnace in Illinois. Iron ore mined from the nearby hills was mixed with charcoal and smelted down to form “pigs.” These were then shipped to Mounds during the Civil War and were used in constructing the Union Iron Clad boats used to keep the rivers clear during the Civil War. Unwind in this secluded valley where you can picnic, hike, and swim in the “ol’ swimmin hole.”

Hardin County, at one time known for its iron deposits, is the first county in Illinois where smelting furnaces for reducing local iron ore deposits were built. Illinois Furnace, one of only two such furnaces in Hardin County, was constructed in about 1837 (fig. 9). The hearth and inner walls originally were built of Mississippian sandstone with a lining of firebrick. The outer walls were constructed from blocks of dark gray Salem Limestone. The furnace may not have initially functioned properly because it was rebuilt and enlarged in 1856 to a height of 32 feet. The present structure was rebuilt in the mid-1960s by the U.S. Government under the Job Corps Program in an attempt to reproduce the furnace as it appeared in the mid-1800s. The present furnace was

constructed in part from plans that were used to rebuild an Ohio furnace. Although not an exact replica of the original furnace, the reconstructed furnace certainly is representative of the furnaces built and used during this time.

The furnace used an ore called limonite that was reported to contain more than 80% oxides of iron. This material ranged from gravel-sized to much larger. The ore bodies occurred in pockets of various sizes along faults bounded by Mississippian limestones, particularly the St. Louis and Ste. Genevieve. The ore was associated with accumulations of residual clay and, in some cases, with abundant chert. Several pits in these pocket ores operated at one time or another in this vicinity. Early ISGS reports stated that the ore was first burned on log heaps to expel its water content. The roasted ore was then ready for charging the furnace. Two hundred bushels of hardwood charcoal were needed to produce 1 ton of pig iron. Nine tons of pig iron were reportedly produced every 24 hours. The furnace operated from 6 to 9 months each year, depending on the ready availability of iron ore.

The second furnace, Martha Furnace, was smaller and was located about 2.5 miles northeast of here in the SW,



**Figure 9** Historic Illinois Iron Furnace before (above) and after (right) reconstruction. (photograph by W. T. Frankie).





NW, NE quarter of Sec. 2, T12S, R8E. Martha Furnace was operated from 1848 to 1857 and rapidly deteriorated after its closing.

Early ISGS reports state that the furnace closed down in 1861 at the start of the Civil War. However, pig iron reportedly was produced at Illinois Furnace for the Naval Shipyard 50 miles to the southwest at Mound City, where the pig iron was used in constructing the Union Iron Clad boats.

As we look around the rustic setting here, it is hard to imagine all of the activity that took place near this operation. Several workers at the furnace charged it with charcoal and iron ore and then kept it stoked. Others worked the runs from the furnace to the “pig house” where the molds for pig iron had been fashioned out of the ground. Sluice gates were used to divert the molten iron from one full mold to a neighboring empty one. In addition, men dug the ore and loaded it into horse- or mule-drawn wagons that were brought here. There was also quite an industry involved in producing the charcoal needed to fire the furnace. Not only did men fell hardwood timber with axes and hand-drawn saws, they also brought the wood to the charcoal kiln site, stacked the wood for burning, and then transported the finished charcoal to the iron furnace. Once the “pigs” had cooled, they were taken to Elizabethtown for transport on the river.

Rudyard Kipling said it best:

Gold is for the mistress, silver for the maid  
Copper for the craftsman cunning at his trade  
‘Good!’ said the Baron, sitting in his hall  
‘But Iron—cold iron—is master of them all.’

The iron ore used in the furnace was mined from local deposits in the northeast quarter of Sec. 9 and the southeast quarter of Sec. 3, T12S, R8E, along Hogthief Creek. Other deposits of ore were mined in the northeast and northwest quarters of Sec. 34, T12S, R8E. Hogthief Creek parallels a major fault. While conducting field work, an abandoned ore mine was found in the NW/NE/NE quarter of Sec. 9, T12S, R8E. To reach this location, follow Forest Service Road 1784 off County Road 12, and then follow the diamond trail approximately 0.1 miles. The ore body is located along the northeast-southwest-trending Iron Furnace Fault Zone. The Mississippian age Ste Genevieve Limestone is on the south side of the fault, and the Mississippian age St. Louis Limestone is on the north side of the fault. The iron-rich *limonite* (a field term for iron-bearing ore) deposits in the local bedrock may be related to iron-rich hydrothermal fluids that migrated along the faults in this area. Recent analysis of the ore collected in the field by X-ray diffraction has determined that the ore

contains both hematite ( $\text{Fe}_2\text{O}_3$ ) and goethite ( $\text{FeO}\cdot\text{OH}$ ).

## **Furnace Operation: Iron Pigs and Sows**

Some terms that one should know follow. The men who produced charcoal are called “colliers.” The “tuyere” (pronounced twêre) is the opening at the base of the furnace that is used to blow air with force into the blast furnace. The term “pig iron” comes from the shape of the molten material as it flows from the furnace. A central, larger channel is called the “sow,” and perpendicular to the sow are rows of “pigs.” The term “pig iron” was adopted by the workers and became a standardized industry term because it reminded them of a sow feeding her piglets. In this area, the site where the charcoal kilns operated was locally known as the “coal-ing fields.”

## **History of Iron Production**

The exact date when people first discovered how to smelt iron ore and produce usable metal is not known. Archaeologists have found early iron tools in Egypt that were used from about 3,000 B.C. Iron objects of ornamentation were used even earlier. By about 1,000 B.C., the ancient Greeks are known to have used heat treatment techniques to harden their iron weaponry. All iron alloys produced until about the fourteenth century were forms of wrought iron.

Wrought iron was made by first heating a mass of iron ore with charcoal in a forge or furnace using a forced draft of air. This treatment generated enough heat to reduce the iron ore to a hot, glowing, spongy mass of metallic iron filled with slag materials. The slag contained metallic impurities and charcoal ash. This iron sponge was then removed from the furnace and, while still glowing hot, was pounded with heavy sledges to separate the slag impurities and to weld and form the purer mass of iron. The iron produced in this way almost always contained slag particles and other impurities, but occasionally this technique of small batch iron making yielded a true steel product rather than wrought iron. These early iron makers also learned to make steel by reheating wrought iron and charcoal in clay boxes for several days until the iron absorbed enough carbon to become a true hardened steel.

By the end of the fourteenth century, iron furnaces used in smelting were becoming larger, and increased draft from large bellows forced air through the “charge” (mixture of raw materials). These larger furnaces first freed the molten iron in its upper levels. The metallic iron then combined with higher amounts of carbon because of the heated combustion blast produced by the air forced up through the furnace. The product of these

furnaces was pig iron, an alloy that melts at a lower temperature than steel or even wrought iron. Pig iron was then further processed to make steel.

Today, giant steel mills are essential for producing steel from iron ore. Modern blast furnaces are merely refinements of the furnaces used by the old ironworkers. Improvements in the refinement of molten iron with blasts of air was accomplished by the 1855 Bessemer converter. Since the 1960s, electric arc furnaces have also been producing steel from scrap metal.

Iron is a chemical element. It is a strong, hard, heavy gray metal found in meteorites and also as part of many mineral compounds in the Earth's crust. Iron rusts easily and can be magnetized. It is used to make many items, such as gates and railings. Iron is also used to make steel, an even harder and tougher metal compound. Steel is formed by treating molten (melted) iron with intense heat and mixing it (alloying) with carbon. Steel is used to make machines, cars, tools, knives, and many other things.

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**STOP 6. Battery Rock** (SE, NE, SE, Sec. 27, T11S, R10E, 3rd P.M., Dekoven 7.5-minute Quadrangle, Hardin County). From the large grassy area, follow trail 102 marked with a Blue "I." At approximately 400 paces (2,000 feet), the trail forks. A small pond is located on the left, the northwest corner of the fork in the trail. Follow the left fork (marked as 102B) for approximately 370 paces (1,850 feet) downhill to where the trail opens up onto exposed bedrock of the Pennsylvania age Battery Rock Sandstone (fig. 10). Follow the trail down the bedrock spillway to a rock shelter formed in the bluffs and the Ohio River. CAUTION: The spillway is extremely slippery when wet. Total round trip is 1.5 miles.

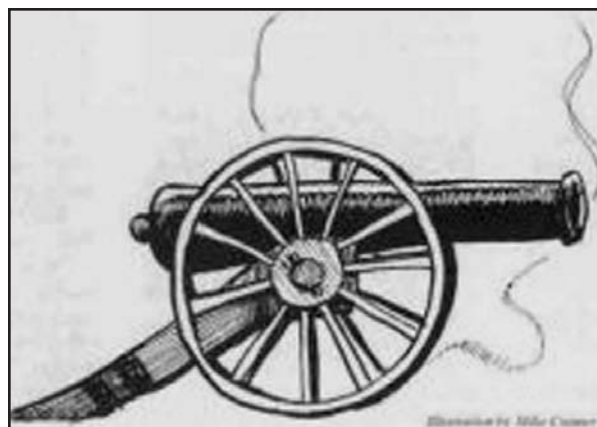
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Battery Rock (fig. 10) is the starting point for the River-to-River Trail, which connects the Ohio River with the Mississippi River. The River-to-River Trail is part of the American Discovery Trail, which covers more than 5,000 miles from Point Reyes National Seashore, Point Reyes, California, to Cape Henlopen State Park at Lewes, Delaware. It connects 6 national scenic trails, 10 national historic trails, 23 national recreational trails, and hundreds of local and regional trails.

Stratigraphy of the Battery Rock area from river level to the top of Sturgeon Hill consists of Pennsylvanian age Battery Rock Sandstone overlain by the Pounds Sandstone. Locally the rocks exposed along the Ohio River dip 5 to 6 degrees to the north.

### How Battery Rock Got Its Name

During the Civil War, Col. Johnson of the Confederate Army was ordered to destroy the Union ships anchored near the bluffs south of where the Saline River flows into the Ohio River. A sandbar (Saline Bar) that formed in the summer months allowed Col. Johnson to cross into Illinois and capture five steamboats. Panicked officials sent more troops to the area, positioning the 87th Illinois Infantry atop what is now known as Battery Rock. The name Battery Rock comes from the battery of cannons that were positioned on top of the bluff to protect the commercial steamers and U.S. Navy war-



ships anchored at the base. Soldiers etched their names into the stone more than a century ago.

### Movie Location

Of interest to western movie buffs, Battery Rock was the site where 15 minutes of the movie *How the West Was Won* were filmed. The scenes filmed at Battery Rock were used to highlight the westward migration of early pioneers along the Ohio River during the early portion of the movie. MGM used a little creative geography. In the movie, the events filmed here were represented as being located somewhere in Ohio.



**Figure 10** Above: Liesegang banding in Battery Rock Sandstone at Battery Rock, Hardin County. Right: Battery Rock. (photographs by W. T. Frankie).

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**STOP 7. Annabel Lee Mine** (Center of Sec. 10, T11S, R9E, 3rd P.M., Saline Mines 7.5-minute Quadrangle, Hardin County). The Annabel Lee is an abandoned fluorspar mine.

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We will have the opportunity to collect some mineral specimens and discuss fluorspar mining in this part of Illinois at the abandoned Annabel Lee Mine (fig. 11). Fluorite, barite, calcite, quartz, sphalerite, and dolomite can be found in the surrounding spoil piles.

The Annabel Lee Mine is located in the northern edge of the Illinois-Kentucky Fluorspar District. This region is a complexly faulted area lying between the Illinois Basin on the north and the Mississippi Embayment to the south. The Illinois portion of the district, with a history of fluorspar mining that dates from 1842, still has unmined deposits of fluorspar and related minerals.

The Annabel Lee mine was the last mine to open (1984) and the last one to close (1995) in the Illinois-Kentucky Fluorite District. It is well known by collectors of fluorite and other minerals as it produced many, many beautiful specimens. The head frame is still present and is the only one still standing in Illinois. The name of the mine was derived from Edgar Allen Poe's poem "Annabel Lee," the last poem written by Poe. I find it somewhat ironic that the last mine to operate chose the name Annabel Lee.

The Annabel Lee Mine is located along a fault trending N50° E to S50° W. This fault forms the northwest boundary of the Rock Creek Graben. The bedrock along











**Figure 11** Annabel Lee, abandoned fluorspar mine (photo by W. T. Frankie).



the fault is downdropped on the southeast side of the fault. The Mississippian age Palestine Sandstone occurs on the northwest side of the fault, and the Pennsylvanian age Tradewater Formation is on the southeast side of the fault. The mine shaft is located on the northwest side of the fault. The mine shaft was sunk to a depth of 996 feet. The Annabel Lee produced fluorite from both vein and bedding replacement type deposits. Mining was carried out by a room-and-pillar method. The fluorite ore was produced from the Mississippian age Downy's Bluff Limestone and from the Joppa and Spar Mountain Members of the Ste. Genevieve Limestone (fig. 12). These same horizons are exposed in surface quarries on Spar Mountain about 4 miles to the south.

The reason the Annabel Lee Mine was one of the last in operation is because Ozark-Mahoning was the last domestic producer of fluorite. Despite the cheap price of imported ore from Mexico and China, the company

SYSTEM	FORMATION	LITHOLOGY	DESCRIPTION
PENNSYLVANIAN			Sandstone and shales 700 to 800 feet
			Alternating limestones, shales, and sandstones 800 to 900 feet
	CYPRESS-RIDENHOWER-BETHEL		Sandstone; shale or shaly sandstone in middle portion 200 to 240 feet
	DOWNEYS BLUFF		Fluorspar bedded deposit
	YANKEETOWN		Limestone 25 to 40 feet
	RENAULT	Shettlerville Limestone	Shale, some limestone 15 to 30 feet
		Levias Limestone Member	Limestone 5 to 35 feet
	AUX VASES	Rosiclare Sandstone Member	Sandstone 15 to 45 feet
	STE. GENEVIEVE	Joppa Member	Fluorspar bedded deposit
		Karnak Limestone Member	limestone 60 feet ±
		Spar Mtn. Mem.	Sandstone 0 to 10 feet
			Fluorspar bedded deposit
MISSISSIPPIAN	Fredonia Limestone		Limestone 60 to 80 feet
	ST. LOUIS		Limestone

**Figure 12** Principal fluorspar-bearing portion of stratigraphic column of the southeastern Illinois Fluorspar District. Black bands represent horizons most favorable for the occurrence of bedded deposits. The most productive parts of vein deposits generally occur below the Rosiclare Sandstone (modified from Bradbury et al. 1968).

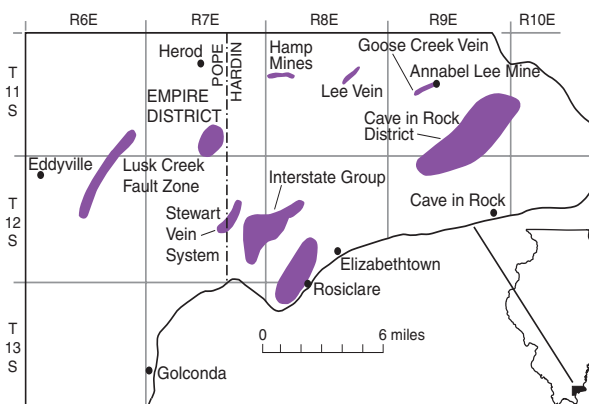
was able to keep operations going until 1995 due to its efficient use of equipment, mine structures, and in-house personal already available in the area. Nevertheless, even this mine succumbed to the cheap import costs of fluorspar and closed in 1995 as the last of two mines in the district.

## Fluorite Mining

This Illinois-Kentucky fluorspar mining region is a complexly faulted area lying between the Illinois Basin on the north and the Mississippi Embayment to the south. Fluorspar from this region was in demand because of its high purity and absence of toxic trace elements often found in imported ore. A large number of fluorite and associated mineral specimens from the Annabel Lee mine are still available and are being offered by several dealers over the Internet. Fluorite was designated Illinois State Mineral by the 74th General Assembly in July 1965 (for additional information about fluorite, see *Geobit 4: Fluorite-Illinois State Mineral*, available for download from the ISGS Web site at <http://www.isgs.uiuc.edu>).

Illinois fluorspar occurs almost exclusively in Pope and Hardin Counties. The main production has come from the Rosiclare vein system and from bedded replacement deposits north of the Cave-In-Rock area. Less significant amounts of fluorspar have been mined from several areas outside these main areas (fig. 13).

The first reported use of Illinois fluorspar was in 1823. Fluorspar mined near Shawneetown, Illinois, was used to manufacture hydrofluoric acid (HF). Note that the early reports of fluorspar being mined near Shawneetown may actually have been referring to fluorspar mined from the Rosiclare area. Shawneetown may have been cited because, during the 1800s, that town was the largest in the area. In 1839, fluorspar and galena (PbS)



**Figure 13** Principal fluorspar mining districts in southeastern Illinois (modified from Bradbury et al. 1968).

were found in a water well sunk southwest of Rosiclare; however, the lead ore (galena) was of most interest. No active mining of lead ore took place in the district until 1842, when a mine opened near Rosiclare. Although small tonnages of galena (the chief mineral sought in the Rosiclare area until 1870) were mined, the large amounts of fluorspar associated with it were cast aside as waste. Many of these old waste dumps later served as valuable sources of fluorspar ore. Fluorspar was historically one of the most important mineral commodities in Illinois. Today, almost 90% of the fluorspar used in the United States is imported.

## Ore Deposits

Ore bodies in the Illinois-Kentucky Fluorspar District are of three general types: (1) bedded deposits formed by selective replacement of limestone strata, (2) fissure-filling or vein deposits along faults and fractures, and (3) residual deposits derived from one of the other types.

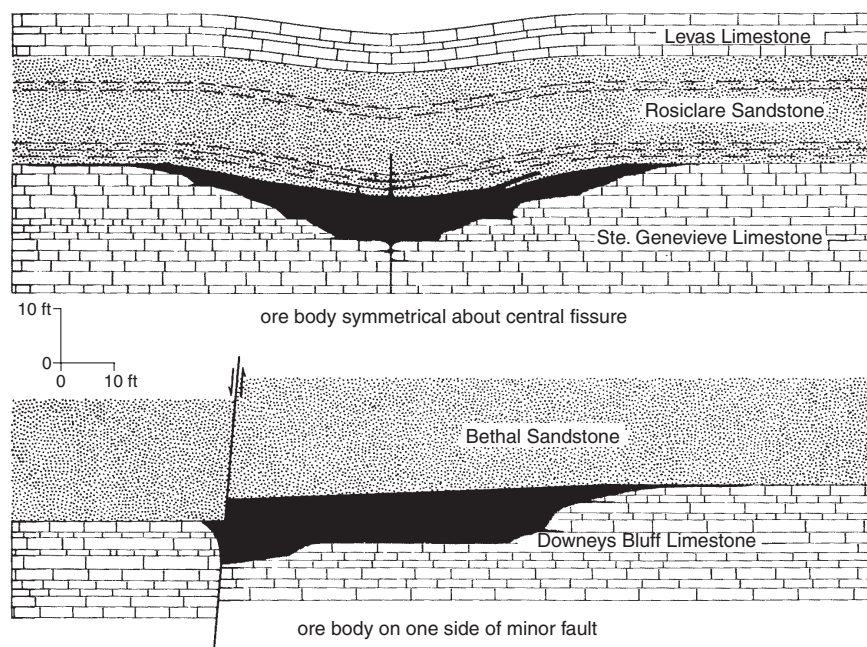
**Bedded Deposits.** Bedded fluorspar ores are generally flat-lying, irregular bodies parallel to the bedding of the host limestones (fig. 14). Typically, the deposits are elongate and range from 200 to more than 2,500 feet in length and from 50 to 300 feet in width. They are commonly 4 to 15 feet thick and wedge out laterally. Unlike the vein deposits, in which the fluorspar simply filled open fissures, the bedded deposits were formed by a chemical reaction between the fluorine-bearing solutions and the limestone. The calcium carbonate of the limestone was changed to calcium fluoride or fluorite. The mineralizing solutions that formed the bedded deposits moved along minor faults and joint-like fractures that had little or no open space to permit deposition. Thus, the solutions spread out laterally along bedding planes within the limestone, perhaps even moving through the pore spaces in coarser-grained parts of the rock. This close contact with the limestone permitted the chemical reaction to take place. The exact origin of the mineralizing solutions that formed the vein and bedded ores has not been completely resolved. However, it is gen-

erally accepted that the mineralization was deposited by hot, fluorine-bearing, aqueous solutions rising from deep within the Earth's crust. Deep-seated magma, related to the formation of Hicks Dome, is the most likely source for the hydrothermal solutions.

The chief horizon of bedded fluorspar in the Illinois Fluorspar District occurs at the top at the Mississippian (Valmeyeran) Ste. Genevieve Formation in the Joppa Member (fig. 12). The Ozark-Mahoning Hill Mine about 2.5 miles southeast of the Annabel Lee mine operated mainly in this horizon. Because of the general northeastward dip of the strata, the Joppa Member in the Hill Mine occurs at a depth of about 900 feet.

The Joppa Member consists of gray, oolitic, fine-grained limestone, characterized by numerous shale partings. Immediately overlying the Joppa is the Rosiclare Sandstone Member of the Aux Vases Sandstone (fig. 12). The Rosiclare consists mainly of tightly cemented, gray or greenish gray, calcareous, fine-grained sandstone. The sandstone is massive to thin-bedded. A few feet of sandy, micaceous, greenish gray shale or siltstone occurs at the base of the lowest sandstone unit, immediately above the Joppa. The bedded ores occur just below the siltstone.

The bedded replacement deposits occur chiefly within a relatively narrow stratigraphic interval from the base of the Bethel Sandstone downward to the top of the Fredo-

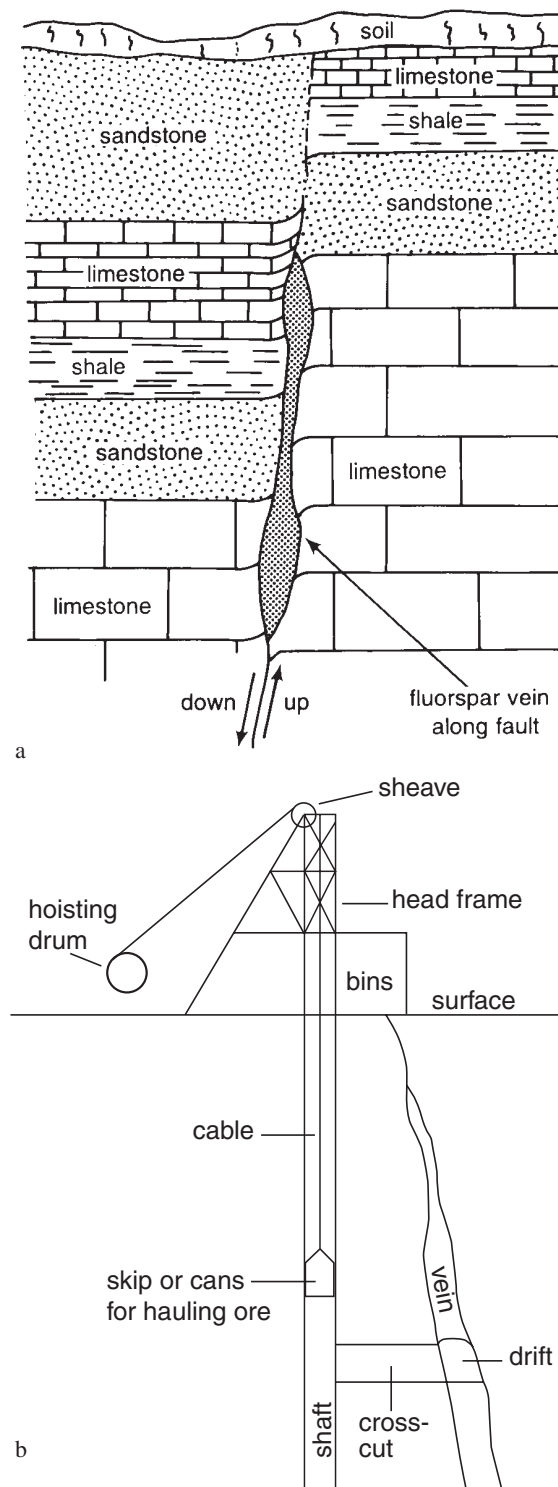


**Figure 14** Schematic cross sections of two general types of bedding-replacement fluorspar deposits (modified from Bradbury et al. 1968).

nia Limestone of the Ste. Genevieve Limestone (fig. 12). The principal deposits are found at three favored positions within this interval: at the top of the Downeys Bluff Limestone, the top of the Joppa Member, and the top of the Fredonia Limestone. The limestone at these levels apparently presented the most favorable conditions (purity, porosity, or fracturing) to allow replacement by fluorite. The lower mineralized zone near the level of the Spar Mountain Sandstone Member is commonly referred to as the "Sub-Rosiclare zone." The heaviest mineralized portions of the two upper zones occur immediately beneath the Bethel and Aux Vases (Rosiclare) Sandstones. These sandstone units are usually tightly cemented, rendering them relatively impervious, which may have been a factor limiting the upward movement of the mineralizing solutions.

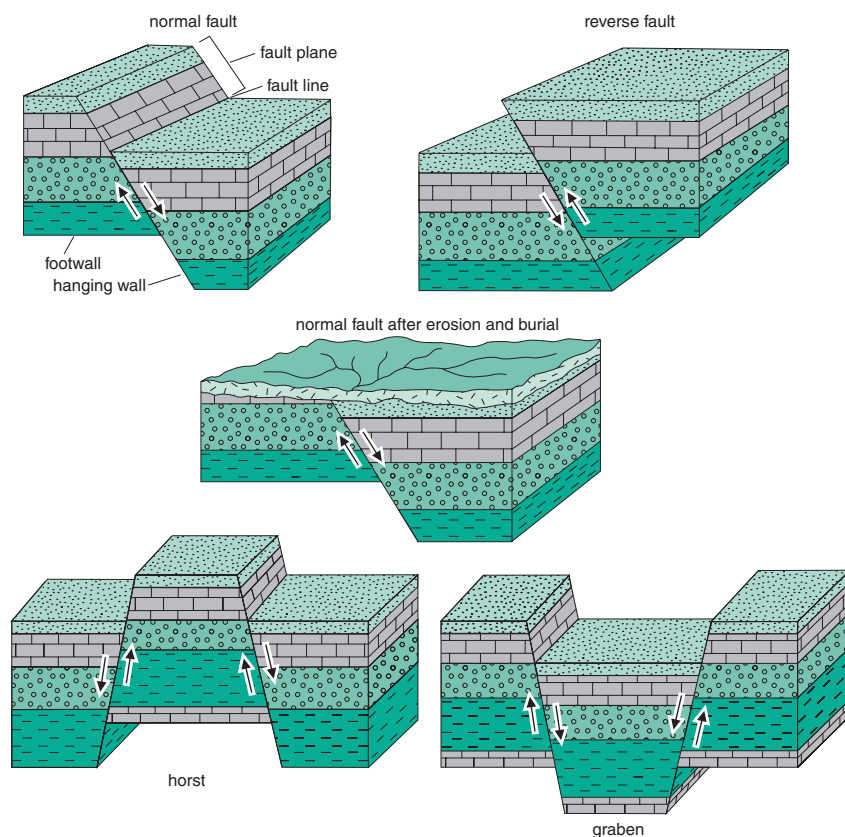
**Vein Deposits.** Faulting is the primary controlling factor determining the location and extent of mineralization of vein deposits. Vein deposits occur in steeply inclined, sheet-like deposits as fissure fillings along faults (fig. 15). A fault is a fracture in the rocks along which relative movement of the opposite sides has taken place. The width and continuity of the vein deposits depend on the size of openings between the fault surfaces in which they were formed. Fault planes (surfaces) are rarely perfectly parallel. Usually, the rock surfaces on either side of a fault are wavy and irregular, preventing a good fit where one side of the fault plane rests against the other. These irregularities caused the opposite walls of the fault planes to be pushed apart, producing the openings in which the fluorspar veins were deposited by mineralizing solutions. As a result, the veins pinch and swell both vertically and laterally. The veins range in thickness from a feather edge to as much as 30 feet. Suitable open spaces existed primarily along faults of moderate movement, commonly 100 to 200 feet. Smaller faults did not have large enough openings, and the grinding and crushing of the wall rock in larger faults did not permit openings to form. Vein deposits in the Rosiclare area have been mined at depths greater than 800 feet.

**Relation to Rock Type.** Vein deposits are best developed in the stronger, more competent limestones and well-cemented sandstones in which adequate open spaces can be maintained along the faults. Weaker rocks, such as shales, sandstones, or shaly limestones, become crushed during faulting and generally fill openings rather than create them. The best vein deposits are found in the relatively pure, competent Ste. Genevieve and St. Louis Limestones (fig. 12). Minalve vein deposits also occur in competent younger rocks of the overlying Chesterian Series, but these ore bodies are limited in size and occurrence because shale beds associated with these strata generally plugged the faults.



**Figure 15** (a) Diagrammatic cross section of fluorspar vein along a fault. The strata on the left side of the fault have moved downward with reference to those on the right. (b) Diagram of mine layout at right angle to the vein showing general relations of surface installations and underground workings to the vein (diagram b, modified from Bradbury et al. 1968).





**Figure 16** Diagrammatic illustrations of fault types that may be present in the field trip area. A fault is a fracture in the earth's crust along which there has been relative movement of the opposing blocks. A fault is usually an inclined plane, and when the hanging wall has moved down relative to the footwall, the fault is a normal fault. When the hanging wall (the block above the plane) has moved up relative to the footwall (the block below the fracture), the fault is a reverse fault.

**Mixed Deposits.** A few of the fluorspar mines operated in both vein and bedded ore deposits. In some vein deposits, certain limestone beds were selectively replaced short distances from the main fissure filling. Such mixed deposits are not common.

**Origin of the Faults.** The sequence and timing of all of the structural events in this complex area of faulting have not been entirely worked out. However, there is general agreement on the occurrence and timing of the major events. At the end of Pennsylvanian time or during early Permian time (about 260 million years ago), the Paleozoic strata of the present Illinois-Kentucky Fluorspar District were arched into a northwest-trending, elongated dome by an enormous rising body of magma (molten rock) generated at great depth. Extensional fractures were formed parallel to the long axis of the dome because of the stretching of the sedimentary strata. Some magma was squeezed into these fractures to form the dark igneous dikes now exposed at the sur-

face in southeastern Illinois and western Kentucky. Radiometric dating of the intrusive dikes places the time of intrusion as Early Permian.

After the magma had begun to crystallize and ceased to push upwards, the area was broken by a second set of fractures oriented northeast-southwest, probably by forces related to those that were forming the Appalachian Mountains (the Alleghenian orogeny) along the eastern margin of the continent. Relaxation of these forces, plus shrinkage of the body of magma as it continued to cool, caused the domed area to collapse into a series of blocks bounded by the northeast-trending fractures. The resulting *normal faults* trended northeast-southwest and became the channel-ways for the fluorine-bearing solutions that were probably derived from the underlying magma body. These same faults also served as sites of deposition for the fluorite vein deposits. Most of the faults are normal, with fault planes inclined at high angles (70 to 80 degrees), but some are reverse faults (fig. 16). Movement along the faults was largely vertical, but, in some

places, there was also horizontal (sideways) movement. The Shawneetown Fault Zone, a large faulted structure in Gallatin and Saline Counties just north of the district, shows evidence of reverse movement of as much as 3,500 feet. The compressive forces that caused this thrusting were probably also responsible for additional movement along the northeast-southwest-trending fractures where additional block faulting took place.

Faulting has recurred throughout the region since Permian time, although these later movements may be unrelated to the earlier period of faulting. Cretaceous and Tertiary strata in extreme southern Illinois and in Kentucky are also cut by faults, and *earthquakes* within recorded history suggest that movements are still taking place. The most recent major earthquakes occurred in southeastern Missouri along the New Madrid Fault in the winter of 1811–1812. Smaller earthquakes have occurred up to the present in several places.

**Mineralogy.** Fluorspar ( $\text{CaF}_2$ ) and calcite ( $\text{CaCO}_3$ ) are the two chief minerals present in the vein deposits. Minor amounts of galena ( $\text{PbS}$ ), sphalerite ( $\text{ZnS}$ ), and barite ( $\text{BaSO}_4$ ) also occur. In the bedded deposits, fluorite is the principal ore mineral, but galena and sphalerite occur locally. Bedded ores commonly consist of alternating bands of coarse- and fine-grained fluorspar. Some banded ores also consist of dark, fine-grained layers of fluorite, forming the so-called “coontail” spar. Rare or small amounts of strontianite, witherite, dolomite, pyrite, ankerite, chalcopryrite, malachite, marcasite, smithsonite, limonite, gypsum, aragonite, melanterite, stibnite, and sulfur have also been identified in the fluorspar deposits. In approximate descending order of abundance, primary minerals in vein deposits include; calcite, fluorite, quartz, galena, sphalerite, ferroan dolomite, pyrite, marcasite, barite, chalcopryrite, oil and bitumen. Secondary vein minerals include; gypsum, malachite, cuprite, and others. The sequence of miner-

alization is calcite, fluorite, chalcopryrite/pyrite, quartz, calcite, and bitumen.

**Industrial Uses.** Space does not permit a discussion of the mining, milling, or processing of fluorspar ore. In industrial uses, Illinois fluorspar concentrate is marketed in three grades: acid (97% pure), ceramic (85 to 96% pure), and metallurgical (60 to 72% pure). More than 60% of the fluorspar consumed in the United States is used by the chemical industry in the manufacture of hydrofluoric acid, the basic chemical for almost all fluorine chemical processes. Fluorine chemicals are used in the manufacture of synthetic cryolite, refrigerants, aerosols, plastics, medicines, high-octane fuels, and a host of other products. The steel industry consumed about 20% of total production in the form of metallurgical spar for use as a fluxing agent in steel and smelting. In the ceramic industry, fluorspar is used as a flux and opacifier in the manufacture of special types of glass and enamels.

## REFERENCES

- Bastin, E. S., 1931, The fluorspar deposits of Hardin and Pope Counties, Illinois: Illinois State Geological Survey, Bulletin 58, 116 p. plus plates.
- Baxter, J. W., and G. A. Desborough, 1965, Areal geology of the Illinois Fluorspar District. Part 2 - Karbers Ridge and Rosiclare Quadrangles: Illinois State Geological Survey, Circular 385, 40 p. plus plates.
- Baxter, J. W., G. A. Desborough, and C. W. Shaw, 1967, Areal geology of the Illinois Fluorspar District. Part 3 - Herod and Shetlerville Quadrangles: Illinois State Geological Survey, Circular 413, 41 p. plus plates.
- Baxter, J. W., P. E. Potter, and F. L. Doyle, 1963, Areal geology of the Illinois Fluorspar District. Part I - Saline Mines, Cave in Rock, Dekoven, and Repton Quadrangles: Illinois State Geological Survey, Circular 342, 43 p. plus plates.
- Bradbury, J. C., G. C. Finger, and R. L. Major, 1968, Fluorspar in Illinois: Illinois State Geological Survey, Circular 420, 64 p.
- Buschbach, T. C., and D. R. Kolata, 1991, Regional setting of the Illinois Basin, in M. W. Leighton, D. R. Kolata, D. F. Oltz, and J. J. Eidel, editors, Interior cratonic basins: Tulsa, Oklahoma, American Association of Petroleum Geologists, Memoir 51, p. 29–55.
- Goldstein, A., 1997, The Illinois-Kentucky Fluorite District: The Mineralogical Record, v. 28, Jan.–Feb., p. 3–25.
- Horberg, C. L., 1950, Bedrock topography of Illinois: Illinois State Geological Survey, Bulletin 73, 111 p.
- Illinois Department of Natural Resources, 2000, Cave-In-Rock (park flyer): Springfield, Illinois, 2 p.
- Leighton, M. M., G. E. Ekblaw, and C. L. Horberg, 1948, Physiographic Divisions of Illinois: Illinois State Geological Survey, Report of Investigations 129, 19 p.
- Leighton, M. W., D. R. Kolata, D. F. Oltz, and J. J. Eidel, editors, 1991, Interior cratonic basins: Tulsa, Oklahoma, American Association of Petroleum Geologists, Memoir 51, 819 p.
- Nelson, J. W., 1995, Structural features in Illinois: Illinois State Geological Survey, Bulletin 100, 144 p. plus plates.
- Panno, S. V., and W. L. Bourcier, 1990, Glaciation and saline-freshwater mixing as a possible cause of cave formation in the eastern midcontinent region of the United States: A conceptual model: *Geology*, v. 18, no. 8, p. 769–772.
- Reinertsen, D. L., 1992, A guide to the geology of the Cave in Rock and Rosiclare area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1992A, 39 p. plus attachments.
- Schwegman, J. E., 1973, Comprehensive Plan for the Illinois Nature Preserve System. Part 2 - Natural Divisions of Illinois: Springfield, Illinois, Illinois Nature Preserves Commission, 32 p.
- United States Geological Survey, 2005, Minerals yearbook: Fluorspar: U.S. Department of the Interior, 11 p.
- United States Geological Survey, 2004, The mineral industry of Illinois, U.S. Department of the Interior, 4 p., plus tables.
- Weller, J. M., R. M. Grogan, and F. E. Tippie, 1952, Geology of the fluorspar deposits of Illinois: Illinois State Geological Survey, Bulletin 76, 147 p. plus plates.
- Weller, S., 1920, The geology of Hardin County: Illinois State Geological Survey, Bulletin 41, 416 p. plus plates.
- Worthen, A. H., and H. Engelmann, 1866, Chapter XIII - Geology of Hardin County, in Geological Survey of Illinois, Volume I, Geology: Springfield, Illinois, State Journal Steam Press, p. 350–375.

## RELATED READINGS

- Baxter, J. W., and J. C. Bradbury, 1989, Illinois-Kentucky Fluorspar Mining District, in J. W. Baxter, J. C. Bradbury, E. B. Kisvarsanyi, P. E. Gerdemann, J. M. Gregg, and P. D. Hagni, eds., Precambrian and Paleozoic geology and ore deposits in the midcontinent region: 28th International Geological Congress Field Trip Guidebook T147: Washington, D.C., American Geophysical Union, p. 3–36.
- Baxter, J. W., J. C. Bradbury, and N. C. Hester, 1973, A geologic excursion to fluorspar mines in Hardin and Pope Counties, Illinois: Illinois State Geological Survey, Guidebook Series 11, 28 p.
- Bonnell, C., 1946, The Illinois Ozarks: Privately published, 156 p.
- Bradbury, J. C., 1959, Barite in the Southern Illinois Fluorspar District: Illinois State Geological Survey, Circular 265, 14 p.
- Cote, W. E., D.L. Reinertsen, and G.M. Wilson, 1967, Elizabethtown-Cave in Rock area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1967 A and F, 20 p. plus attachments.
- Evers, R. A., and L. M. Page, 1977, Some unusual natural areas in Illinois: Champaign, Illinois, Illinois Natural History Survey, Biological Notes 100, 47 p.
- Goldhaber, M. B., and J. J. Eidel, eds., 1992, Mineral resources of the Illinois Basin in the context of basin evolution: Program and Abstracts: Reston, Virginia, U.S. Geological Survey, Open-File Report 92-1, 68 p.
- Griffith, K., and W. Griffith, 1943, Spotlight on Egypt: Guidebook of the scenic and historic places in Egypt, Illinois: Carbondale, Illinois, Egypt Book House, 24 p.
- Grogan, R. M., 1949, Structures due to volume shrinkage in the bedding-replacement fluorspar deposits of southern Illinois: Illinois State Geological Survey, Circular 158, 14 p.
- Haney, S. D., 1976, Shawnee Forest guide to southeastern Illinois, featuring Gallatin, Hardin, Pope and Saline Counties: Flora, Illinois, Martin Printing and Album Co., 120 p.
- Hansel, A. K., and W. H. Johnson, 1996, Quaternary deposits of Illinois. 8½ × 11 inches.
- Harris, S. E., Jr., C. W. Horrell, and D. Irwin, 1977, Exploring the land and rocks of southern Illinois: A geological guide: Carbondale and Edwardsville, Illinois, Southern Illinois University Press, 240 p.
- Kolata, D. R., 2005, Bedrock geology of Illinois: Illinois State Geological Survey, Illinois Map 14, 1:500,000; two sheets.
- Lineback, J. A., et al., 1979, Quaternary deposits of Illinois: Illinois State Geological Survey, 1:500,000.
- Luman, D. E., L. R. Smith, and C. C. Goldsmith, 2003, Illinois surface topography: Illinois State Geological Survey, Illinois Map 11, 1:500,000.
- Lyons, S., 2000, The Shawnee area, An inventory of the region's resources; A product of the Critical Trends Assessment Program: Illinois Department of Natural Resources, Office of Reality and Environmental Planning: Springfield, Illinois, Illinois Department of Natural Resources Clearinghouse, Illinois, 22 p.
- Martin, L. R., 2001, Bibliography and index of Illinois geology 1966–1996: Illinois State Geological Survey, Bulletin 105, 446 p.
- McFall, D., and J. Karnes, eds., 1995, A directory of Illinois Nature Preserves; Volume 2, Northwestern, central and southern Illinois: Springfield, Illinois, Illinois Department of Natural Resources, Division of Natural Heritage, 321 p.
- Nelson, W. J., and D. K. Lumm, 1987, Structural geology of southeastern Illinois and vicinity: Illinois State Geological Survey, Circular 538, 70 p. plus plates.
- Post, S. L., 1997, Hiking Illinois; America's Best Day Hikes Series: Champaign, Illinois, Human Kinetics, 212 p.
- Pryor, W. A., 1956, Groundwater geology in southern Illinois: A preliminary geologic report: Illinois State Geological Survey, Circular 212, 25 p.
- Raasch, G. O., 1948, Cave in Rock area: Illinois State Geological Survey, Earth Science Field Trip Guide Leaflet, 1948A, 7 p.
- Reinertsen, D. L., 1982, A guide to the geology of the Cave in Rock-Rosiclare Area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1982D, 15 p.
- Enjoy southern Illinois: A complete recreational guide: Vienna, Illinois, Cache River Press, 647 p.
- United States Department of Agriculture, U. S. Forest Service, 2002, Shawnee National Forest, 1:126,720. ISBN 1-59351-851-X.
- Voigt, J. W., and R. H. Mohlenbrock, 1956, An Ozark odyssey: Carbondale, Illinois, Southern Illinois University Printing Service, 13 p.
- Willman, H. B., E. Atherton, T. C. Buschbach, C. W. Collinson, J. C. Frye, M. F. Hopkins, J. A. Lineback, and J. A. Simon, 1975, Handbook of Illinois stratigraphy: Illinois State Geological Survey, Bulletin 95, 261 p.
- Willman, H. B., et al., 1967, Geologic map of Illinois: Illinois State Geological Survey, 1:500,000.
- Willman, H. B., and J. C. Frye, 1970, Pleistocene stratigraphy of Illinois: Illinois State Geological Survey, Bulletin 94, 204 p.
- Willman, H. B., J. A. Simon, B. M. Lynch, and V.A. Langenheim, 1968, Bibliography and index of Illinois geology through 1965: Illinois State Geological Survey, Bulletin 92, 373 p.



Wilson, G. M., 1961, Geology merit badge—Fluorspar District, Hardin and Pope Counties: Illinois State Geological Survey, Earth Science Field Trip Guide Leaflet 1961 H, 9 p.

Wilson, G. M., D. L. Reinertsen, and W. E. Cote, 1967, A guide to the geology of the Cave in Rock area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1967A, 20 p. plus attachments.

## GLOSSARY

The following definitions are adapted in whole or in part from several sources. The primary source is R. L. Bates and J. A. Jackson, eds., 1987, Glossary of Geology, 3rd ed.: Alexandria, Virginia, American Geological Institute, 788 p.

**anticline** A convex-upward rock fold in which strata have been bent into an arch; the strata on either side of the core of the arch are inclined in opposite directions away from the axis or crest; the core contains older rocks than does the perimeter of the structure.

**basement complex** The suite of mostly crystalline igneous and/or metamorphic rocks that generally underlies the sedimentary rock sequence

**basin** A topographic or structural low area that generally receives thicker deposits of sediments than adjacent areas; the low areas tend to sink more readily, partly because of the weight of the thicker sediments; the term also denotes an area of relatively deep water adjacent to shallow-water shelf areas.

**bedrock** The solid rock (sedimentary, igneous, or metamorphic) that underlies the unconsolidated surface materials (for example, soil, sand, gravel, glacial till).

**breccia** A coarse-grained, clastic rock composed of angular broken rock fragments held together by a mineral cement or in a fine-grained matrix.

**chert, cherty** A hard, extremely dense dull to semivitreous, microcrystalline or cryptocrystalline sedimentary rock, consisting predominantly of interlocking quartz crystals.

**cryptovolcanic structure** A rock structure produced by concealed volcanic or meteoric activity.

**cuesta** A ridge with a gentle slope on one side and a steep slope on the other.

**dike** A tabular igneous intrusion that cuts across the bedding or foliation of the rock.

**dome** A general term for any smoothly rounded landform or rock mass that roughly resembles the dome of a building.

**era** The unit of geologic time that is next in magnitude beneath an eon; it consists of two or more periods (for example, Paleozoic Era).

**escarpment** A long cliff or relatively steep slope facing in one general direction; produced by differential erosion or faulting.

**formation** The basic rock unit, one distinctive enough to be readily recognizable in the field and widespread and

thick enough to be plotted on a map. Formation describes the strata, such as limestone, sandstone, shale, or combinations of these and other rock types. Formations have formal names, generally derived from the geographic localities where the unit was first recognized and the type of rock described (for example, St. Louis Limestone).

**fossil** Any remains or traces of a once-living plant or animal preserved in rocks (arbitrarily excludes recent remains); any evidence of ancient life. Also used to refer to any object that existed in the geologic past and for which evidence remains (for example, a fossil waterfall).

**geology** The study of planet Earth that is concerned with its origin, composition, and form, its evolution and history, and the processes that acted (and act) upon the Earth to control its historic and present forms.

**glacier** A large, slow-moving mass of ice formed on land by the compaction and recrystallization of snow.

**igneous** Said of a rock or mineral that solidified from molten or partly molten material (magma).

**iron** A chemical element; a strong, hard heavy gray metal found in meteorites and also combined in many mineral compounds in the Earth's crust; it rusts easily and can be magnetized.

**lamprophyre** A dark, coarse-grained igneous rock of iron-magnesian minerals, formed deep within the Earth.

**limonite** A field term for iron-bearing ore.

**loess** (pronounced "luss") A homogenous, unstratified accumulation of silt-sized material deposited by the wind.

**magma** Naturally occurring mobile rock material generated within the Earth and capable of intrusion and extrusion; igneous rocks are thought to be derived from magma; it may or may not contain suspended solids (for example, crystals and rock fragments) or gases.

**metamorphic rock** Any rock derived from pre-existing rocks by mineralogical, chemical, and structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment at depth in Earth's crust (for example, gneisses, schists, marbles, and quartzites).

**period** An interval of geologic time; a division of an era (for example, Cambrian, Jurassic, and Tertiary).

**phreatic water** Water in the zone of saturation, that is, groundwater.

**physiography** The study and classification of the surface

features of Earth on the basis of similarities in geologic structure and the history of geologic changes.

**relief** (a) A term used loosely for the actual physical shape, configuration, or general unevenness of a part of Earth's surface, considered with reference to variations of height and slope or to irregularities of the land surface; the elevations or differences in elevation, considered collectively, of a land surface (frequently confused with topography). (b) The vertical difference in elevation between the hilltops or mountain summits and the lowlands or valleys of a given regional extent. Formed in places where the forces of plate tectonics are beginning to split a continent (for example, East African Rift Valley).

**rift** (a) A narrow cleft, fissure, or other opening in rock made by cracking or splitting; (b) a long, narrow continental trough that is bounded by normal faults—a graben of regional extent.

**room-and-pillar mining method** A method of mining whereby miners create openings (rooms) as they work, leaving enough coal in the pillars to support the ground surface.

**sediment** Solid fragmental matter, either inorganic or organic, that originates from weathering of rocks and is transported and deposited by air, water, or ice or that is accumulated by other natural agents, such as chemical precipitation from solution or secretion from organisms. When deposited, sediment generally forms layers of loose, unconsolidated material (for example, sand, gravel, silt, mud, till, loess, and alluvium).

**sedimentary rock** A rock resulting from the consolidation of loose sediment that has accumulated in layers (for example, sandstone, siltstone, mudstone, and limestone).

**silicification** The introduction of, or replacement by, silica, generally resulting in the formation of fine-grained quartz, chalcedony, or opal, which may fill pores and replace existing minerals.

**silicified** Adjective form of silicification.

**syncline** A convex downward fold in which the strata have been bent to form a trough; the strata on either side of the core of the trough are inclined in opposite directions toward the axis of the fold; the core area of the fold contains the youngest rocks (see also anticline).

**system** A fundamental geologic time-rock unit of worldwide significance; the strata of a system are those deposited during a period of geologic time (for example, rocks formed during the Pennsylvanian Period are included in the Pennsylvanian System).

**tectonic** Pertaining to the global forces that cause folding and faulting of the Earth's crust; also used to classify or describe features or structures formed by the action of those forces.

**tectonics** The branch of geology dealing with the broad architecture of the upper (outer) part of Earth; that is, the major structural or deformational features, their origins, historical evolution, and relationships to each other. It is similar to structural geology, but generally deals with larger features such as whole mountain ranges or continents.

**unconformity** A substantial break or gap in the geologic record where a rock unit is overlain by another that is not next in the stratigraphic succession.

**vadose water** Water of the zone of aeration.

**weathering** The group of processes, both chemical and physical whereby rocks on exposure to the weather change in character and decay and finally crumble into soil.





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