Guide to the Geology of the Garden of the Gods Recreation Area, Shawnee National Forest, Saline, Gallatin, Pope, and Hardin Counties, Illinois

Wayne T. Frankie

Geological Science
Field Trip Guidebook 2009B

October 24, 2009
November 14, 2009

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Institute of Natural Resource Sustainability
ILLINOIS STATE GEOLOGICAL SURVEY

__Cover photograph:__ Pounds Sandstone at Garden of the Gods Recreation Area, Shawnee National Forest (photograph by W.T. Frankie).

Acknowledgment The information in this guidebook is adapted from ISGS Field Trip Guidebook 2001A, *Guide to the Geology of Garden of the Gods Area, Gallatin, Hardin, Pope, and Saline Counties, Illinois,* and Field Trip Guidebook 2006B, *Guide to the Geology of Cave-In-Rock Area, Hardin County, Illinois,* both by Wayne T. Frankie and Russell J. Jacobson.

Geological Science Field Trips The Illinois State Geological Survey (ISGS) conducts four 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 Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820-6964 (telephone: 217-244-2414 or 217-333-4747). Guidebooks may also be ordered from the Shop ISGS link at the top of the ISGS home page: http://www.isgs.illinois.edu.

Six U.S. Geological Survey (USGS) 7.5-minute quadrangle maps (Harrisburg, Herod, Karbers Ridge, Rosiclare, Rudement, and Saline Mines) provide coverage for this field trip area.

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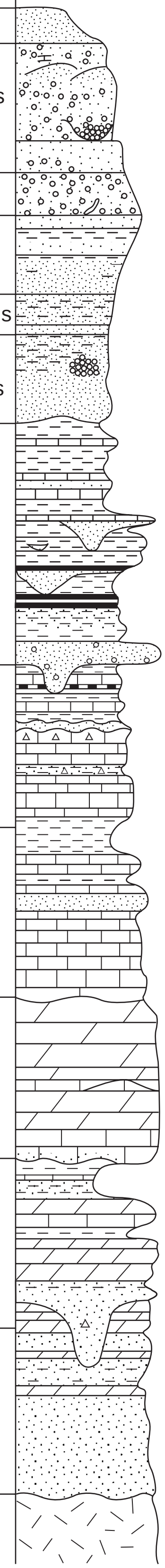
CONTENTS

Era		Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks
CENOZOIC "Recent Life"	Age of Mammals	Quaternary 0–500'	Holocene	10,000	Recent; alluvium in river valleys
			Pleistocene Glacial Age	1.8 m	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
		Tertiary 0–500'	Pliocene	5.3 m	Chert gravel, present in northern, southern, and western Illinois
			Eocene	33.7 m – 54.8 m	Mostly micaceous sand with some silt and clay; present only in southern Illinois
			Paleocene	65 m	Mostly clay, little sand; present only in southern Illinois
MESOZOIC "Middle Life"	Age of Reptiles	Cretaceous 0–300'		144 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")		290 m – 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 the succession of rocks in Illinois.

GARDEN OF THE GODS RECREATION AREA

The Garden of the Gods Recreation Area, located in the Driftless Area of southern Illinois, is one of the most highly faulted and geologically complex areas of Illinois. This area's rugged surface has produced some of the most scenic landscapes in the state, formed mainly by differential erosion of Upper Mississippian and Lower Pennsylvanian age sedimentary strata consisting of alterations of bedrock types between sandstones, limestones, and shales. The 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, landscape, and mineral resources for parts of Gallatin, Hardin, Pope, and Saline Counties, Illinois. Harrisburg, the largest city within the field trip area, is approximately 332 miles south of Chicago, 187 miles southeast of Springfield, 129 miles southeast of East St. Louis, and 81 miles northeast of Cairo.

GEOLOGIC FRAMEWORK

Precambrian Era

Through several billion years of geologic time, the area surrounding the Garden of the Gods Recreation Area 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 deeply enough for geologists to collect samples from these Precambrian rocks of Illinois. 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 in topography to 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 similar to 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 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

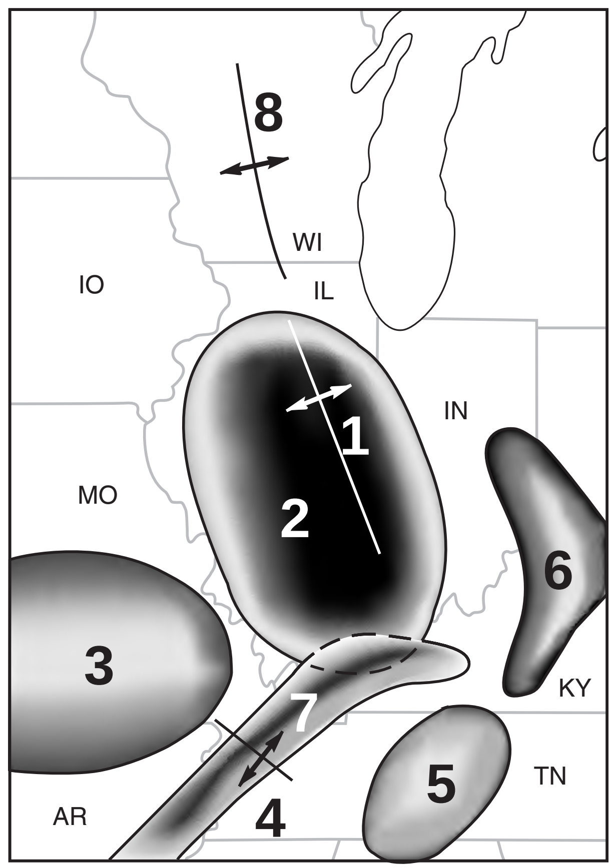


Figure 1 Location of some of the major structures in the Illinois region: (1) La Salle Anticlinorium, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Rough Creek Graben–Reelfoot Rift, and (8) Wisconsin Arch.

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 the formations were present.

Within the field trip area, the depth to the Precambrian basement rocks is significantly offset by the Shawneetown Fault. North of the Shawneetown Fault Zone, where the fault crosses between Gallatin and Saline Counties, the elevation of the top of the Precambrian basement rocks is a little more than 14,000 feet below sea level, and the Paleozoic sedimentary strata deposited on top of the Precambrian total at least 15,000 feet in thickness. Nearby, on the south side of the Shawneetown Fault Zone, the elevation of the top of the Precambrian basement rocks is more than 18,000 feet below sea level, and the Paleozoic sedimentary strata deposited on top of the Precambrian basement are at least 19,000 feet thick. The Paleozoic sedimentary strata in the field trip area range from the 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.

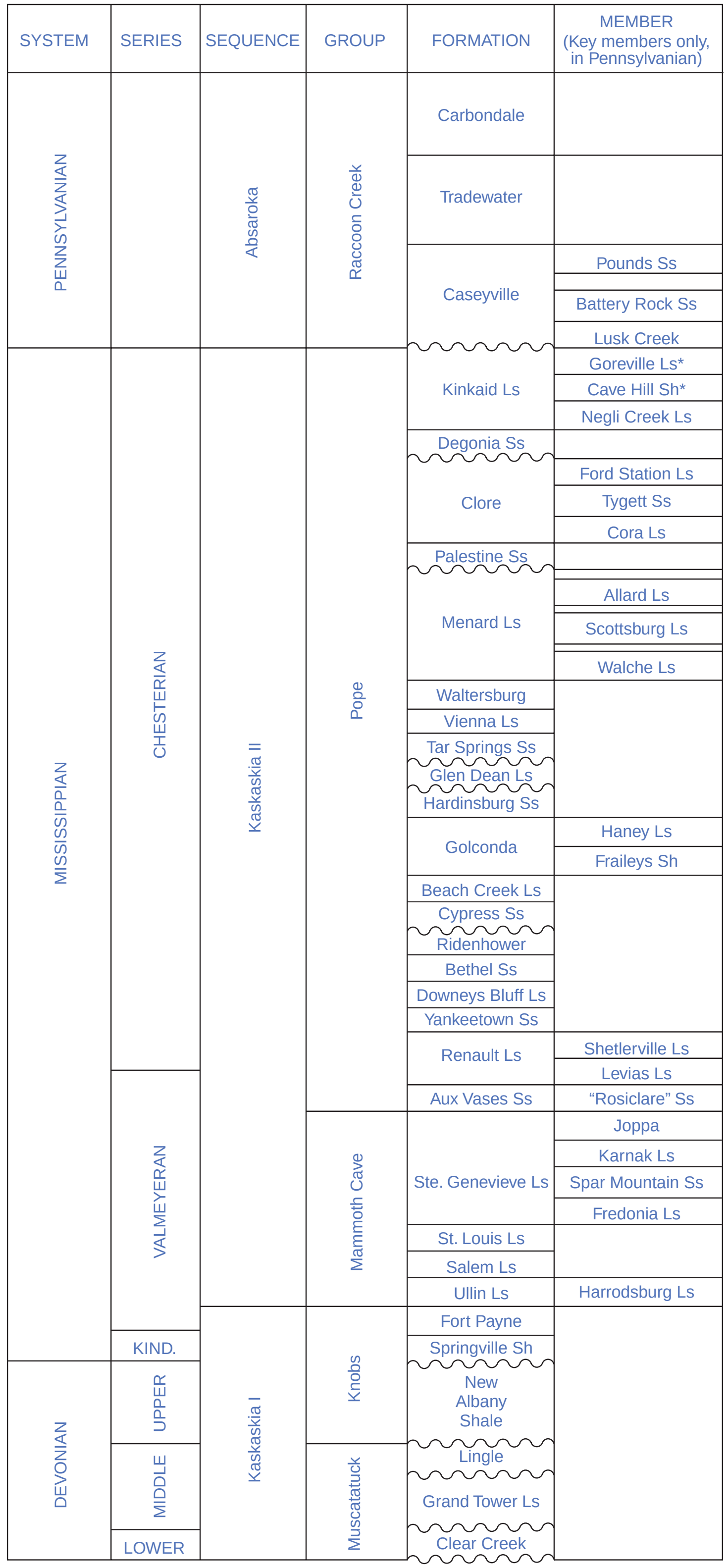


Figure 2 Generalized stratigraphic column of the rock units exposed in field trip area (modified from Baxter et al. 1965 and Kolata 2005). Asterisk indicates unit removed by pre-Pennsylvanian erosion. Abbreviation: KIND., Kinderhookian; Ls, Limestone; Sh, Shale; Ss, Sandstone.

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 part of Illinois and adjacent parts of Indiana and Kentucky sank more rapidly than the areas to the north, allowing a thicker accumulation of sediment. 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.

A sedimentary unit, such as limestone, sandstone, shale, or a combination of these and other rock types, is called a formation when it forms 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, such as Salem Limestone, or St. Louis Limestone, which are usually derived from geographic names and predominant rock types. 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 deposition was virtually continuous. 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 and other kinds of evidence within or at the boundary between the two formations indicate that a significant age difference exists between the lower unit and the overlying unit. This type of contact is called an unconformity. If the beds above and below an unconformity are parallel, the unconformity is called a disconformity. However, if the lower beds were tilted and eroded prior to deposition of overlying beds, the contact is called an angular 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, and therefore no rock record is present in this area. Smaller unconformities that represent shorter time intervals and smaller gaps in the depositional record are also present within the rock 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. 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 that moved through them while they were buried.

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, 360 to 320 million years ago (fig. 2). Mississippian age limestones, shales, and sandstones are exposed around the flanks of Hicks Dome and throughout the southern part of Hardin County. Most of the sediment deposited during this time 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 that was probably similar in size to the Mississippi 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 has 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, Pennsylvanian age bedrock strata consist primarily of sandstone, siltstone, shale, and some thin coals deposited as sediments in the troughs, shallow seas, and swamps between about 320 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 bed-

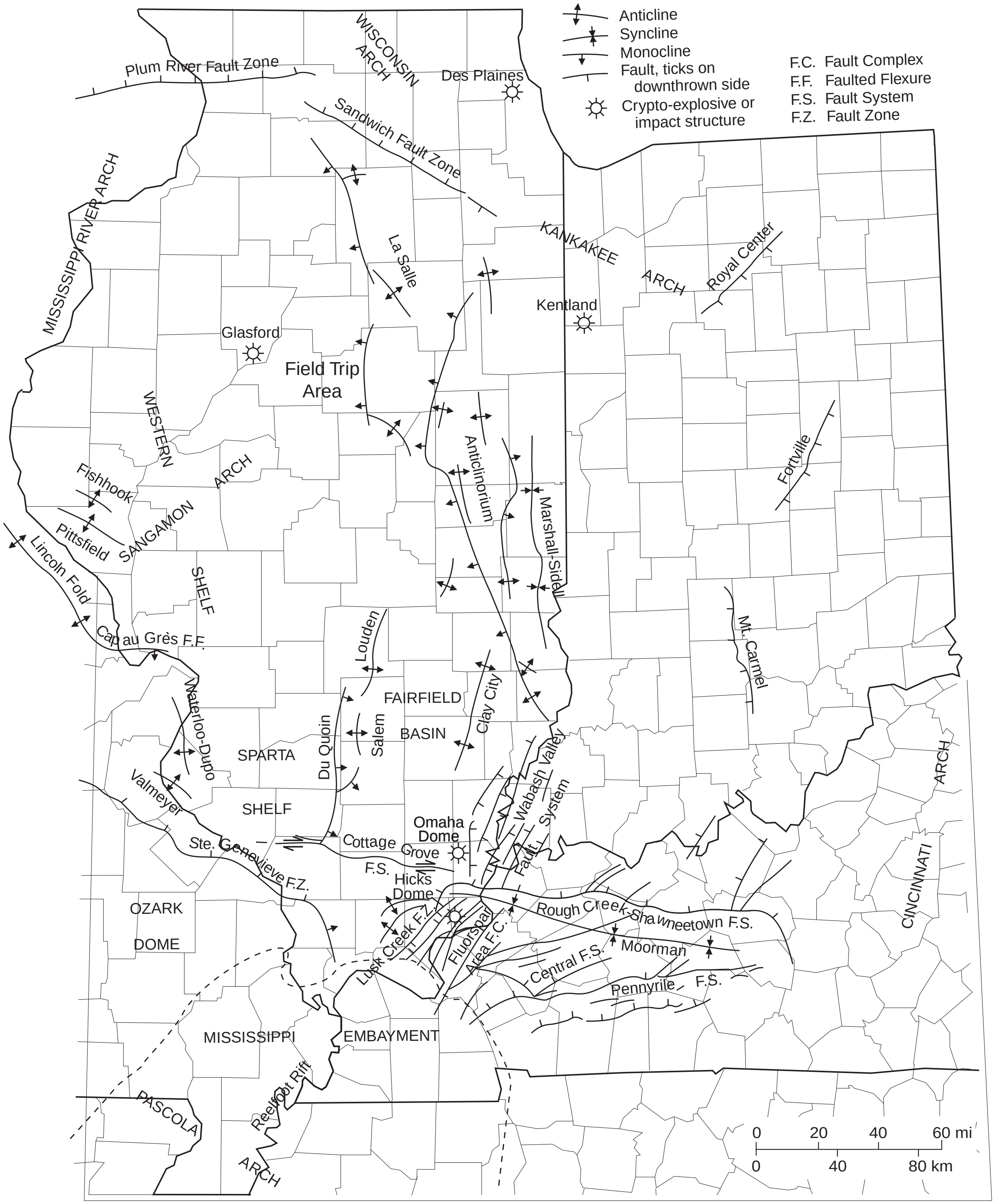


Figure 3 Structural features of Illinois (modified from Buschbach and Kolata 1991).

rock 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 the field trip area 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) and south of the field trip area, within the Rock Creek Graben. Resistant sandstones cap the prominent cliffs and ridges.

Mesozoic Era

During the Mesozoic Era, the rise of the Pascola 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 of southernmost Illinois (fig. 4) shows the distribution of the rock systems of the various geologic time periods as they would appear if the glacial, windblown, and other surface materials were removed.

Younger rocks of the latest Pennsylvanian and perhaps the Permian may have at one time covered the southern portion of Illinois. Mesozoic and Cenozoic rocks (see the generalized geologic column) may 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 rocks of the latest Pennsylvanian and more recent times 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 the repeated advances and melting back of continental glaciers that scoured and scraped the bedrock surface. This glacial erosion and subsequent deposition affected most of the formations exposed at the bedrock surface in Illinois. The final melting of the glaciers left behind the non-lithified deposits in which our modern (Holocene) soil has developed.

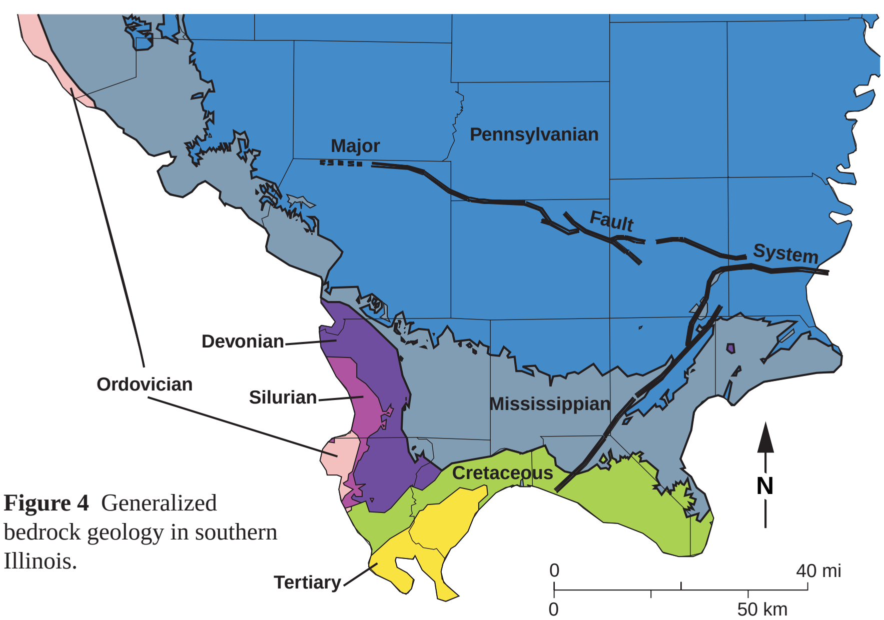


Figure 4 Generalized bedrock geology in southern Illinois.

STRUCTURAL SETTING

The Garden of the Gods field trip area is located in the southeast corner of the Illinois Basin, in southeastern Saline, southwestern Gallatin, northeastern Pope, and northwestern Hardin Counties. The Illinois Basin is the major structural depression between the Ozark Dome and the Cincinnati Arch (fig. 1).

Shawneetown Fault Zone

The Rough Creek-Shawneetown Fault System is located in northeastern Pope, southeastern Saline, and southern Gallatin Counties (fig. 5). The name Shawneetown Fault Zone is applied to the portion of the Rough Creek-Shawneetown Fault System that is in Illinois (fig. 3). The following description of the Shawneetown Fault Zone is modified from that of Nelson (1995).

The Shawneetown Fault Zone enters Illinois just south of Old Shawneetown in Gallatin County and trends westward for about 15 miles. In southeastern Saline County, the fault zone curves sharply to the south-southwest and continues about 12 more miles to Sec-

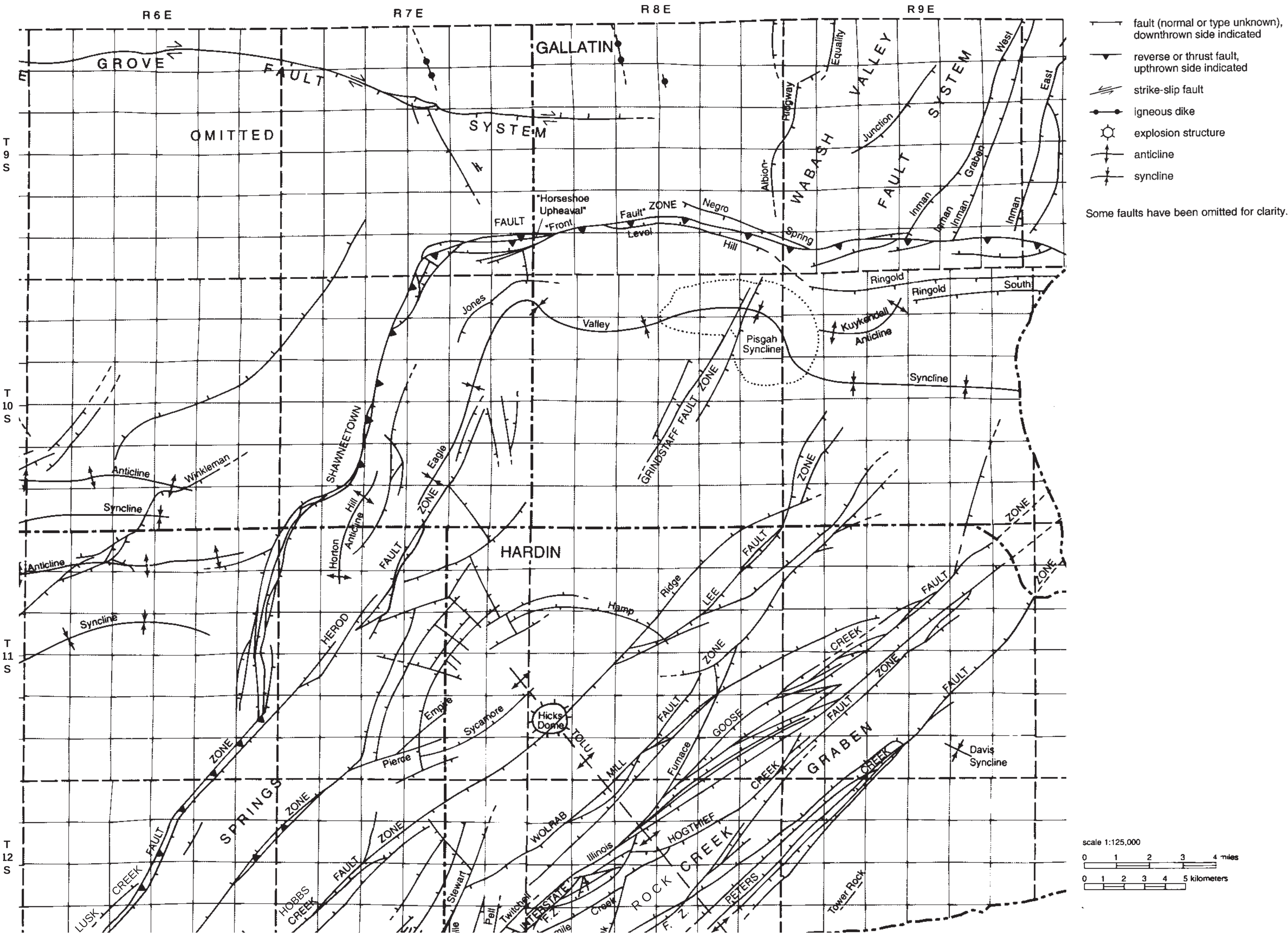


Figure 5 Structural features of southeastern Illinois (modified from Nelson 1995).

tion 25, T11S, R6E, in Pope County, where it intersects the Lusk Creek Fault Zone (fig. 5). Along most of its length, the Shawneetown Fault Zone is well expressed topographically by a range of hills of resistant Lower Pennsylvanian Caseyville Formation south and southeast of the fault zone. These include several of the highest points in southern Illinois: Williams Hill (elevation 1,064 feet), Horton Hill (elevation, 1,000 feet), Wamble Mountain (elevation, 940 feet), Cave Hill (elevation, 923 feet), and High Knob (elevation, 929 feet). The fault zone itself tends to form a strike valley and is concealed by alluvium or glacio-lacustrine deposits in many places.

The fault zone ranges from a few yards wide to as much as 8,000 feet wide. The largest fault in the zone is near the north edge of the east-west–trending part of the zone and exhibits as much as 3,500 feet of vertical separation. This large fault is referred to as the Front Fault, and seismic data indicate that it continues the full length of the Rough Creek–Shawneetown Fault System in Kentucky (fig. 3). Data from wells drilled in this area show this to be a high-angle reverse fault dipping about 70 degrees to the south.

Other faults in the Shawneetown Fault Zone strike subparallel to the Front Fault and have throws measured in hundreds of feet. Some of these join the Front Fault at one or both ends and probably connect with it at depth, but other faults appear to be isolated. In places, the fault zone assumes a braided pattern with interconnected faults outlining a series of polygonal or lens-shaped slices. Most of the smaller faults in the Shawneetown Fault Zone probably are normal faults.

Eagle Valley Syncline

The Eagle Valley Syncline (fig. 6) is the narrow western extension of the Moorman Syncline in Illinois (fig. 3). The syncline is located south of the Shawneetown Fault Zone in southeastern Saline and southern Gallatin Counties (fig. 5). The following description is modified from a description of the syncline by Nelson (1995).

The Eagle Valley Syncline lies immediately south of and trends approximately parallel to the east-west part of the Shawneetown Fault Zone. As defined, the Eagle Valley Syncline is about 15 miles in length, and its width increases from about 6 miles near the west end to about 9 miles at the Ohio River. A fantastic view of the Eagle Valley Syncline can be observed from the Garden of the Gods Observation Trail as you look to the north from the top of Camel Rock. The syncline is abruptly closed off at the west end, where the Shawneetown Fault Zone turns to the southwest. The flanks are marked by rugged hills of resistant lower Pennsylvanian sandstone, whereas the central area is a lowland underlain by easily eroded and younger Pennsylvanian strata of the Carbondale Formation above the Caseyville.

Although displacements on individual faults are large, the net offset across the Shawneetown Fault Zone is small. Pennsylvanian coal beds in the Eagle Valley Syncline south of the fault zone lie at the same or slightly lower elevation as those beds north of the fault zone. However, detailed structural mapping, as measured on the Springfield Coal Member, reveals more than 2,000 feet of relief within the syncline. The axis is sinuous and contains several enclosed depressions. The south limb dips rather uniformly at 5 to 10 degrees; dips on the north limb are much more variable, from less than 10 to 60 degrees (locally steeper).

The north limb of the Eagle Valley Syncline was produced by displacement along the Rough Creek–Shawneetown Fault System. The south west extension of the Eagle Valley Syncline merges with the Herod Fault Zone located along the northwest flank of Hicks Dome (fig. 5).

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, T11S, R8E (figs. 3 and 5). Maximum uplift at its 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 crop out 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 Hicks Dome for a long time. Most think that the structure is related to the period of faulting and igneous activity that took place during Permian time. The breccias, consisting of masses of broken rock, suggest that some sort of explo-

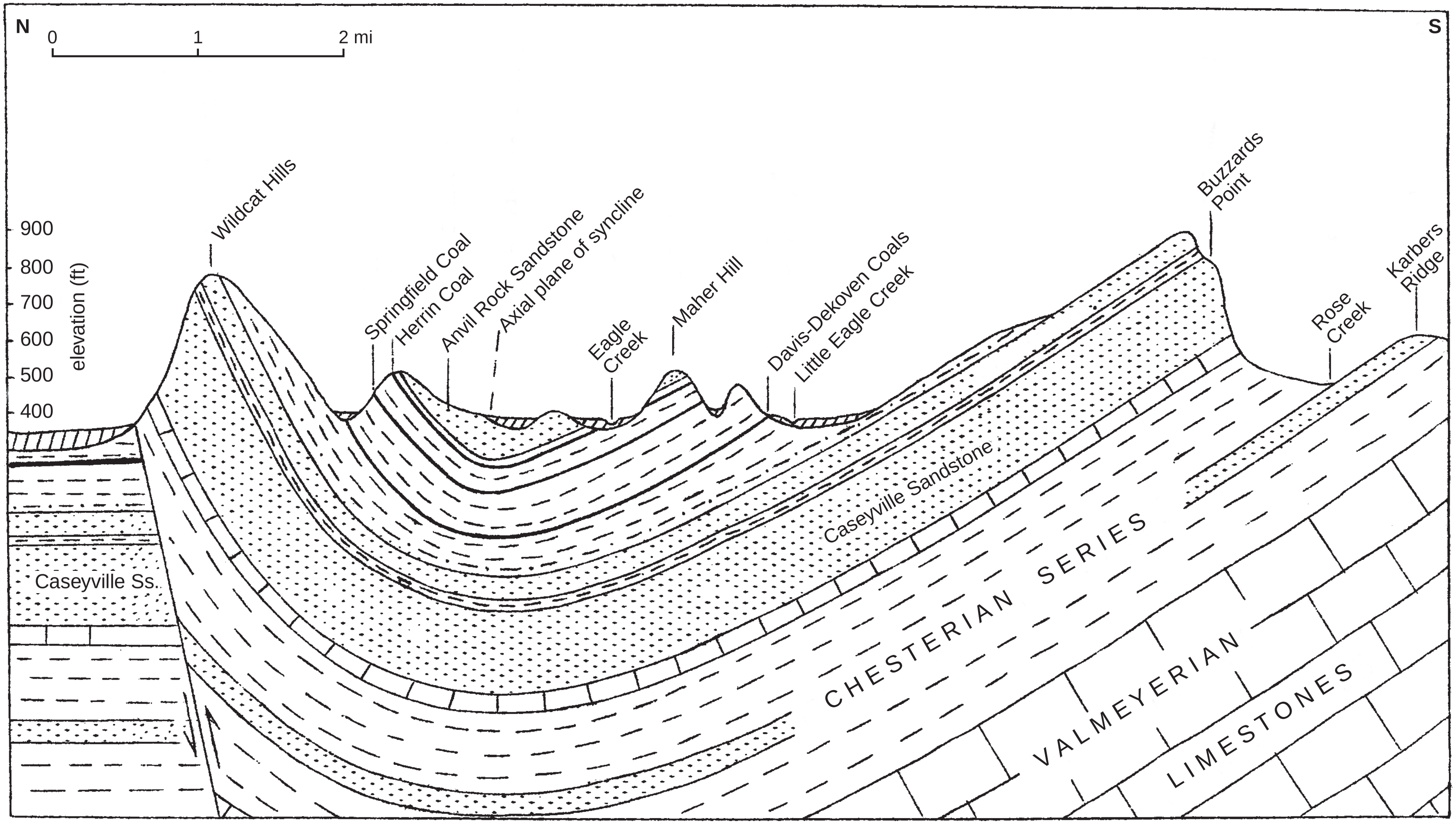


Figure 6 Generalized cross section through Eagle Valley Syncline, from Wildcat Hills just south of Equality to Karbers Ridge near Garden of the Gods Recreation Area. Vertical scale and dips are greatly exaggerated (Frankie and Jacobson 2001).

sive action was involved. The Hicks Dome Breccia (in the vicinity of Hicks Dome), the Hamp Breccia (to the northwest), and the Rose Mine Breccia (to the southeast) consist of angular fragments of sedimentary rocks in a matrix of finely ground sedimentary 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 rooks and minerals (granite, quartz, pyroxene, amphibole, 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 mentioned earlier. Another theory is that the explosion was caused by steam generated from water contained in the sedimentary rocks, which were heated as a result of the intrusion of the igneous dikes (Brett Denny, ISGS, personal communication 2006).

Lamprophyre dikes and explosion breccias, apparently related in origin to Hicks Dome, also occur in the Cave-In-Rock and Rosiclare area; lampryophyre 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 their emplacement about 265 million years ago. Hicks Dome is located approximately 2.5 miles northwest of the Illinois Iron Furnace (Stop 3).

Rock Creek Graben

The major structural feature within the southern and eastern part of the field trip area is the Rock Creek Graben, an elongate downfaulted block extending diagonally across the area from the northeast to the 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 comparison to the complexly faulted strata within the graben 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. The Annabel Lee Fluorspar Mine (Stop 5) is located along the northern boundary of the Rock Creek Graben.

GLACIAL HISTORY

All of the stops within the field trip area lie south of the southernmost extent of the North American continental glaciers. The continental glaciers stopped just north of the Pennsylvanian escarpment near Harrisburg. 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.

Additionally, the loess that mantles the bedrock and glacial drift throughout the field trip area was laid down by the wind during all of the glacial episodes, from the earliest pre-Illinois glacial episode (approximately 1.6 million years ago) to the last glacial episode, the Wisconsin Episode. This yellowish brown silt occurs on the uplands and mantles the glacial drift throughout the field trip area. The loess is generally between 4 and 8 feet thick, but erosion has completely removed it in scattered parts in the Shawnee Hills area of the field trip. Outside the field trip area, the loess thickness generally increases to the west and east toward the Mississippi and Illinois Rivers. The loess, which covers most of Illinois, is up to 15 feet thick along the Illinois River valley and is more than 50 feet thick along the east edge of the Mississippi River valley.

Within the vicinity of the field trip area, north of Harrisburg, glacial drift generally ranges from a few feet to somewhat more than 25 feet thick. Glacial deposits slightly more than 50 feet thick can be found along the preglacial bedrock valley of the Saline River and its tributaries. However, in several localities, bedrock is exposed, and the glacial deposits have been completely removed by erosion.

The sediments that formed the flat topography immediately north of the Shawnee Hills, from Harrisburg east to the Ohio River, are lacustrine deposits of the Equality Formation. These flatlands of the Saline River valley represent the bottom of an old glacial lake (Lake Saline) that once covered this area. In this vicinity, the sediments that accumulated in the lake consist of more than 100 feet of clay, silt, sand, and gravel. Some of these lake sediments probably date from the Illinois glaciation about 200,000 years ago, but most of the sediments were deposited during the melting of the late Wisconsin glaciers from about 20,000 to 10,000 years ago.

Flooding of the lowland areas in southern Illinois and adjacent parts of Indiana and Kentucky was especially extensive during the melting of the large ice mass at the end of the Wisconsin glaciation. 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 and its tributaries. Low areas in the Eagle Valley Syncline to the south were also flooded. At its greatest extent, this lake probably reached an elevation of about 400 feet above sea level.

The former lake bed in the Saline River valley still floods from time to time when the Ohio River rises high enough, and the Pleistocene lake sediments are veneered with sediment of the Recent Epoch. The historic flood of 1937 is thought to have formed a lake approximately the size of the Wisconsinan glacial Lake Saline that existed 13,000 years ago.

GEOMORPHOLOGY

Physiography

Physiography is a general term used to describe landforms; a physiographic province is a region in which the relief or landforms differ markedly from those in adjacent regions. The field trip area is located in two distinctly different physiographic provinces. North of the escarpment formed by the uplifted Pennsylvanian rocks of the Shawnee Hills is the Mt. Vernon Hill Country—a Physiographic Division within the Till Plains Section of the Central Lowland Province (fig. 7). The Till Plains Section is divided into seven distinct divisions in Illinois. The present gross topographic features of the Till Plains Section are largely determined by the underlying preglacial topography. The Central Lowland Province is bordered on the south and west by uplands containing extensive remnants of an older erosional surface. Prior to glaciation, the lowland surface was incised by a drainage system consisting of many deep bedrock valleys. The area south of the Pennsylvanian escarpment is defined as the Shawnee Hills Section of the Interior Low Plateaus Province).

Mt. Vernon Hill Country

Mt. Vernon Hill Country comprises the southern portion of the area covered by the drift sheet left by the Illinois Glacial Episode and the area covered by the glacial deposits of the Wisconsin Episode Equality Formation. The Mt. Vernon Hill Country is characterized by mature topography of low relief with restricted upland prairies and broad alluviated valleys along the larger streams. The covering of glacial sediments is thin, and glacial landforms are essentially absent. The present land surface is primarily a bedrock surface of low relief only slightly modified and subdued by the mantle of glacially deposited material. According to Leighton et al. (1948), an extensive lowland called the “central Illinois peneplain” (a low, nearly featureless, gently undulating land surface) was eroded prior to glaciation into the relatively weak rocks of Pennsylvanian age east and south of the present-day Illinois River. Apparently, just before the advent of glaciation, an extensive system of bedrock valleys was deeply entrenched below the central lowland surface level. As glaciation began, streams probably changed from erosion to aggradation; that is, their channels began to build up and fill in with sediment because the streams did not have sufficient volumes of water to carry and move the increased volumes of sediment. To date, no evidence indicates that the early fills in these preglacial valleys were ever completely flushed out of their channels by succeeding deglaciation meltwater torrents.

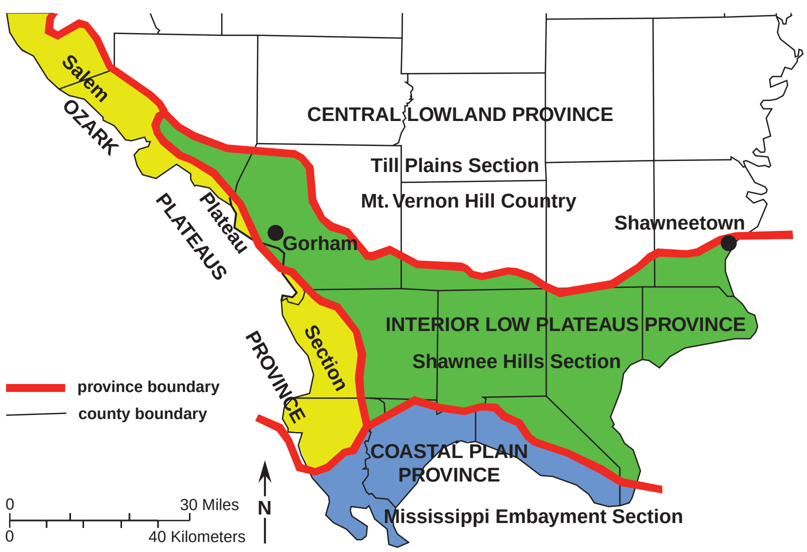


Figure 7 Physiographic Divisions of southern Illinois (modified from Leighton et al. 1948).

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.

Within the Shawnee Hills Section, remnants of a preglacial land surface called the Ozark Plateaus are extensive along the Pennsylvanian escarpment. Locally higher summits on the Pennsylvanian rocks and the lower surfaces on Mississippian rocks indicate a complex erosional history of this preglacial land surface 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, 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 a foundation of its habitats.

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 the Natural Divisions of Illinois because the geologic factors used to determine the Physiographic Divisions were important elements used to define the boundaries of the Natural Divisions. The field trip area is located along the boundary between the Southern Till Plain Division (northern part of the field trip area) and the Shawnee Hills Division (southern part of the field trip area). The geographic area of the Southern Till Plain Division is roughly equivalent to the Mt. Vernon Hill Country physiographic division, and the Shawnee Hills Division is equivalent to the Shawnee Hills Section. The following descriptions of the Natural Divisions are modified from Schwegman (1973).

Southern Till Plain Division

The Southern Till Plain Division encompasses most of the area of dissected Illinois Episode till plain south of the Shelbyville Moraine (Wisconsin Episode terminal moraine) and the Sangamon River and Macoupin Creek watersheds. Both forest and prairie were present at the time of settlement. The soils are relatively poor because of their high clay content and the occurrence of a claypan subsoil in many places. Post oak flatwood forest is characteristic of the division.

Bedrock. The bedrock of the Southern Till Plain Division consists of sandstone, limestone, coal, and shale, which commonly crop out in the eastern and southeastern parts of the division. Bedrock lies near the surface in the Mt. Vernon Hill Country Section.

Glacial History. The Illinoian stage of Pleistocene glaciation reached the southernmost limit of continental glaciation in North America just beyond the limits of this division. The Southern Till Plain Division is entirely covered by Illinoian till.

Topography. The glacial till of the Southern Till Plain Division becomes thinner from north to south. The bedrock of the Mt. Vernon Hill Country Section is near the surface, accounting for the hilly and rolling topography. The Effingham Plain Section is a nearly level to dissected till plain. There are broad floodplains along the major streams, and there are ravines in the bluffs along the stream valleys.

Soils. The soils on the uplands are light colored and strongly developed; internal drainage is poor. They have developed from thin loess and till under both forest and prairie vegetation. Fragipan and claypan layers are characteristic of the upland soils. Some of the prairie soils have a high sodium content and are known locally as "alkaline slicks."

Shawnee Hills Division

The Shawnee Hills Division extends across the southern tip of Illinois from Fountain Bluff (near 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. A number of distinctive plant species are restricted to this division of Illinois.

Bedrock. The Greater Shawnee Hills form a band along the northern edge of the division and consist of massive Pennsylvanian sandstone strata that dip northward toward the Illinois Basin. The Greater Shawnee Hills are 10 miles wide on average and border 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 and zinc, silver, and other metals exist in the eastern part of the Shawnee Hills Division. Iron deposits are found in Hardin County. Hicks Dome, containing an igneous rock core, occurs 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 with 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 about 200 feet lower, on average, than the Greater Shawnee Hills. The Lesser Shawnee Hills have local areas of sinkhole topography.

Soils. The 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. Illinois had long been the principal producer in the country with production centered around Hardin County. 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 the high cost of production forced most of the small producers out of business over time. Fluorite, also known as calcium fluoride (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. Production of fluorspar in 1995 from this company was 48,000 tons, which accounted for 8.5% of the nation's fluorspar requirements. 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.

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

Historically, other minerals produced within the field trip area include limestone and iron ore used as feed for the Illinois Iron Furnaces (Stop 3). Additionally, current mining within the region includes limestone quarries south and east of the field trip area and coal mining northeast of the field trip area.

GUIDE TO THE ROUTE

We will start the trip at the Shawnee National Forest Supervisors Headquarters in Harrisburg, Illinois (SE, SW, NW, Sec. 22, T9S, R6E, 3rd P.M., Harrisburg 7.5-minute Quadrangle, Saline County). Mileage will start at the exit of the parking lot.

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.

Respect 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—you are!
- Stay off 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.

Six U.S. Geological Survey (USGS) 7.5-minute quadrangle maps (Harrisburg, Herod, Karbers Ridge, Rosiclare, Rudement, and Saline Mines) provide coverage for this field trip area.

Miles to next point	Miles from start	
0.0	0.0	Set your odometers to 0.0 at the exit of the parking lot. Exit parking lot and TURN RIGHT onto Illinois Route 145/34.
0.4	0.4	Road begins slight ascent as you enter the community of Pankeyville. This rise in elevation coincides with one of the several small bedrock hills that occur south of Harrisburg. These bedrock hills are part of the Carbondale Formation of Pennsylvanian age sediments. A number of abandoned surface coal mines are located along the southern flanks of most of these bedrock highs. From 1947 to 1949, the Bankston Creek Collieries Company operated a surface (strip) mine immediately south of Pankeyville. The company was mining the Springfield Coal, which is locally known as the Harrisburg coal seam. In addition to the surface mines, the Springfield (Harrisburg) seam has been extensively underground mined in a large area that completely surrounds Harrisburg.
0.7	1.1	T-intersection from the left (Ingram Hill Road). CONTINUE AHEAD.
0.2	1.3	T-intersection from the right (Triple S Road). CONTINUE AHEAD.
0.5	1.8	Road begins descent off the bedrock high on south edge of the community of Pankeyville. The view of the hills to the southeast and straight ahead is the Pennsylvanian escarpment, which forms the northern limit of the Shawnee Hills.
0.2	2.0	Note the flat topography in this area. The flatlands of the Saline River valley represent the bottom of an old glacial slackwater lake (Lake Saline) that once covered this area during the Wisconsin Episode of glaciation. In this vicinity, the sediments that accumulated in the lake

consist of clay, silt, sand, and some gravel. These deposits are part of the Carmi Member of the Equality Formation.

0.5	2.5	Crossroad intersection (Whitesville Road on the left and Butler Road on the right). CONTINUE AHEAD.
0.95	3.45	Crossroad intersection (Pierson Hill Road on the left and Walnut Grove Road on the right). CONTINUE AHEAD.
1.05	4.5	Cross the Saline River. Notice the straight channelized sections of the Saline River to your right and left.
0.2	4.7	Cross the old abandoned course of the Saline River. Notice the meanders to your left. Saline County, established in 1847 from Gallatin County, derived its name from the salt springs that abound in the area. The “Salines” is in reference to the Saline River. Several natural salt springs occur near the river in this area. One of the most famous is Negro Spring, located southeast of Equality and 0.5 miles west of Illinois Route 1 where it crosses the Saline River. The spring is along the south side of the Saline River. Follow Forest Road 1658 immediately south of the bridge over the Saline River.

The following is text from a removed marker on Route 1, south of the Saline River bridge. Source: Illinois State Historical Society (http://www.historyillinois.org).

The United States Salines

Two salt springs in Gallatin County produced brine for one of the earliest salt works west of the Alleghenies. One spring is just southeast of Equality and the other is a short distance (500 ft.) west of this site. The Indians made salt here long before the first settlers appeared. In 1803 the Indians ceded their “great salt spring” to the United States by treaty. Congress refused to sell the salt lands in the public domain but it did authorize the Secretary of the Treasury to lease the lands to individuals at a royalty. The leases required the holder to produce a certain quantity of salt each year or pay a penalty.

Although the Northwest Ordinance prohibited slavery in this area, special territorial laws and constitutional provisions permitted exceptions at these salines. The lessees brought in Negroes as slaves or indentured servants and used them extensively in manufacturing salt. The census of 1820 for Gallatin County listed 239 slaves and servants.

In 1818, as part of the process of making a new state, Congress gave the salines to Illinois but forbade the sale of the land. The State continued to lease the springs and used the revenue to finance part of its operating expenses. Eventually Congress allowed the outright sale of the land. The commercial production of salt continued here until about 1837 when the low price for salt made the expense of extracting it from the brine prohibitive.

0.2	4.9	Enter the community of Mitchellsville.
0.6	5.5	Intersection (Mitchellsville Road). CONTINUE AHEAD. Prepare to turn left and follow Illinois Route 34. Pass the sign indicating Garden of the Gods 16 miles to the left and Lake Glendale 20 miles straight ahead.
0.2	5.7	T-intersection from the left (Illinois Route 34/285N and Illinois Route 145/950E). TURN LEFT. We are following Shawnee Hills on the Ohio National Scenic Byway along this part of the field trip route.
0.7	6.4	Notice the nice view of the Shawnee Hills directly ahead of us.
0.2	6.6	T-intersection from the right (Blackman Hill Road). CONTINUE AHEAD and cross Blackman Creek.

0.5	7.1	T-intersection from the right (Spring Valley Road). CONTINUE AHEAD.
0.3	7.4	Crossroad intersection (Williams Road on the left and Peak Road on the right). CONTINUE AHEAD.
0.3	7.7	T-intersection from the right (Lambert Road). CONTINUE AHEAD. Cross Spring Valley Creek and enter the community of Rudement.
0.4	8.1	Crossroad intersection (Camp Oxford Road on the left and Beech Hollow Road on the right). CONTINUE AHEAD.
0.35	8.45	T-intersection from the right (Sally Hollow Road). CONTINUE AHEAD. Cross unnamed creek. T-intersection from the left, just past the bridge (DeNeal Road/1210E and Illinois Route 34/250N). CONTINUE AHEAD. The road to your left leads to Old Stoneface. Notice that the road begins to rise in elevation. You are leaving the flat topography of the Equality Formation and entering into the northern boundary of the Pennsylvanian escarpment.
1.15	9.6	T-intersection from the left (Wamble Road). CONTINUE AHEAD.
0.4	10.0	Passing over local drainage divide (see route map). Road follows valley cut by Gibbons Creek.
1.35	11.35	Enter Pope County.
0.85	12.2	Pass through Thacker's Gap. During early settlement into this area, Thacker's Gap—"The Gap" as local people call it—allowed access for travelers along the rocky stream bed of Gibbons Creek. The Gap is located between two of the area's highest mountain peaks, Wamble Mountain at an elevation of 940 feet above sea level on the east and Williams Hill at an elevation of 1,064 feet above sea level on the west. Williams Hill is the highest point in southern Illinois and the second highest in Illinois.
0.5	12.7	Outcrop of cross-bedded Pennsylvanian age sandstone, the Battery Rock Member of the Caseyville Formation, on the right with a small cave "rock shelter" at the base of the sandstone bluff. The dilapidated and abandoned building built into the side of the cliff on the right is the former Cliff Side restaurant.
0.2	12.9	T-intersection from the right (Williams Hill Road). CONTINUE AHEAD. The road to the right leads to Williams Hill. Enter the community of Herod.
0.1	13.0	Cross Gibbons Creek and a T-intersection from the left (Grape Hollow Road) just past the bridge. CONTINUE AHEAD. NOTE: The River to River Trail crosses the road at this location.
0.5	13.5	T-intersection from the right (Henry Hicks Road). CONTINUE AHEAD.
1.35	14.85	Enter Hardin County.
0.15	15.0	Cross Rose Creek and prepare to TURN LEFT onto Karbers Ridge Road.
0.2	15.2	T-intersection from the left (Illinois Route 34/025E and Karbers Ridge Road/1065N). TURN LEFT onto Karbers Ridge Road. CAUTION: Large coal-hauling trucks use this road.

0.9	16.1	Great view of the Shawnee Hills to your left. Notice the large sandstone outcrops, along the top of the hills, which form the bluffs at the Garden of the Gods Recreation Area. The Honeycomb Church is on the left.
1.7	17.8	Prepare to turn left.
0.2	18.0	Crossroad intersection (Garden of the Gods Road/250E and Karbers Ridge Road/1180N). TURN LEFT.
0.6	18.6	Cross Rose Creek.
0.5	19.1	Outcrop on the right side of the road. Pennsylvanian age lower Caseyville Formation Lusk Creek Member shales and siltstones can be seen grading upward into the Battery Rock Sandstone.
0.1	19.2	Outcrop of Battery Rock Sandstone on the right side of the road. Prepare to turn left. Enter Gallatin County.
0.2	19.4	T-intersection from the left (Garden of the Gods Road). TURN LEFT. Entrance to Garden of the Gods Recreation Area.
0.6	20.0	Enter Saline County.
0.1	20.1	Small pull-over parking lot on the left. A rock shelter cave is in the Pounds Sandstone bluff on the right.
0.2	20.3	Backpackers' parking lot on the left. CONTINUE AHEAD. Pass the sign indicating observation trail; picnic and camping are straight ahead.
0.25	20.55	River to River Trail crosses the road.
0.1	20.65	Y-intersection (Picnic Road/050N and Garden of the Gods Road/1750E). BEAR LEFT. A sign indicating observation trail is to the left, and picnic ground and campground are to the right. Enter the lower portion of the parking lot and park your vehicles.

STOP 1: Garden of the Gods Recreation Area, Shawnee National Forest (SW, NW, SE, Sec. 36, T10S, R7E, 3rd P.M., Herod 7.5-minute Quadrangle, Saline County). On the day of the field trip, assemble near the south (left) entrance to the Observation Trail located near the middle of the upper parking lot.

0.0	20.65	Leave Stop 1 and retrace your route back to the Y-intersection.
0.3	20.95	YIELD: Y-intersection (Picnic Road/050N and Garden of the Gods Road/1750E). TURN RIGHT onto Garden of the Gods Road.
1.25	22.2	STOP at T-intersection (Garden of the Gods Road and County Highways 17 and 10). TURN RIGHT. Heading toward Karbers Ridge Road. CAUTION: Fast-moving traffic from the left. Road is used by large coal haulage trucks. NOTE: County Hwy. 17 is in Gallatin County to the left, and County Hwy. 10 is in Hardin County to the right.
1.2	23.4	Prepare to stop.

0.2	23.6	STOP. Crossroad intersection (Karbers Ridge Road/1180N and Garden of the Gods Road/250E). TURN LEFT.
0.5	24.1	T-intersection from the right (Forest Road 1700). CONTINUE AHEAD. The road to the right leads to Hicks Dome.
0.9	25.0	T-intersection from the right (Forest Road 1477/400E and Karbers Ridge Road/1175N). CONTINUE AHEAD. The road to the right leads to Illinois Iron Furnace (seven miles). Enter Karbers Ridge.
0.35	25.35	T-intersection from the left (High Knob Road/425E). CONTINUE AHEAD. The road to the left leads to High Knob (two miles), 929 feet above sea level. High Knob offers fantastic scenery from its picnic area and hiking trails. The River to River Trail passes by High Knob.
0.55	25.9	T-intersection from the right (475E). CONTINUE AHEAD.
0.3	26.2	The former Karbers Ridge School is on the left.
0.5	26.7	T-intersection from the right (Cadiz Road/550E and Karbers Ridge Road/1150N). CONTINUE AHEAD.
1.0	27.7	Russell Cemetery on the left.
0.5	28.2	T-intersection from the right (Sparks Hill Road). CONTINUE AHEAD.
0.2	28.4	To the left is a water tower operated by the Hardin County Water Company.
0.4	28.8	Prepare to turn left. Leave Hardin County and enter Gallatin County. NOTE: Karbers Ridge Road is called Pounds Hollow Road in Gallatin County.
0.3	29.1	T-intersection from the left (Forest Road 121). TURN LEFT. Entrance to Rim Rock Recreation Area and the Pounds Escarpment. Hill Cemetery is opposite the entrance.
0.2	29.3	Enter the parking loop of Rim Rock Recreation Area and park your vehicles. This is Stop 2 and lunch. We will eat lunch in the Indian Wall picnic ground.

STOP 2: LUNCH—Rim Rock Recreation Area and the Pounds Escarpment, Shawnee National Forest (NE, SW, SW, Sec. 36, T10S, R8E, 3rd P.M., Karbers Ridge 7.5-minute Quadrangle, Gallatin County).

0.0	29.3	Leave Stop 2 and retrace your route back to Pounds Hollow/Karbers Ridge Road.
0.0	0.0	STOP. T-intersection (Pounds Hollow Road). TURN RIGHT. NOTE: Pounds Hollow Recreation Area is two miles to your left. RESET ODOMETER.
0.7	0.7	Pass Hardin County Water Company tower on the right.
0.2	0.9	T-intersection from the left (Sparks Hill Road). CONTINUE AHEAD.
0.6	1.5	Pass Russell Cemetery on the right.

0.9	2.4	T-intersection from the left (Cadiz Road/550 E and Karbers Ridge Road/1150N). CONTINUE AHEAD.
0.6	3.0	Former Karbers Ridge School on the right.
0.2	3.2	T-intersection from the left (County Road 12/475E). TURN LEFT. This road will take you to Elizabethtown.
1.5	4.7	Cross Big Creek. Outcrop of Mississippian age limestones of the Golconda Group are exposed in the creek.
0.2	4.9	Pass Forest Trail 1461 on the right.
0.6	5.5	Karst pond sinkholes are present on the right and left. The karst topography in this area is developed within the Mississippian age Downeys Bluff Limestone formation.
0.7	6.2	Pass Forest Road 1917 on the right and Central Church just past the forest road.
0.9	7.1	T-intersection from the left (County Road 65/850N and County Road 12/625E). CONTINUE AHEAD.
1.3	8.4	T-intersection from the right (Forest Road 1919). CONTINUE AHEAD.
0.9	9.3	TWO-WAY STOP. Crossroad intersection (County Road 12/Forest Road 1473 and County Road 3). TURN RIGHT.
1.3	10.6	T-intersection from the left (County Road 52A). CONTINUE AHEAD.
0.05	10.65	A break in the levee on the left allows access to Hogthief Creek. The bed load in the creek consists of Mississippian age limestones and cherty gravels from the St. Louis and St. Genevieve Formations. These rocks contain a large number of fossils.
0.25	10.9	T-intersection from the right (County Road 52/ Forest Road 1477). CONTINUE AHEAD.
0.3	11.2	Cross bridge over Big Creek. A local favorite swimming hole is on the left.
0.05	11.25	T-intersection from the left (County Road 12). CONTINUE AHEAD. Follow County Road 52/Forest Road 1477, and TURN RIGHT into Illinois Iron Furnace parking lot.

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

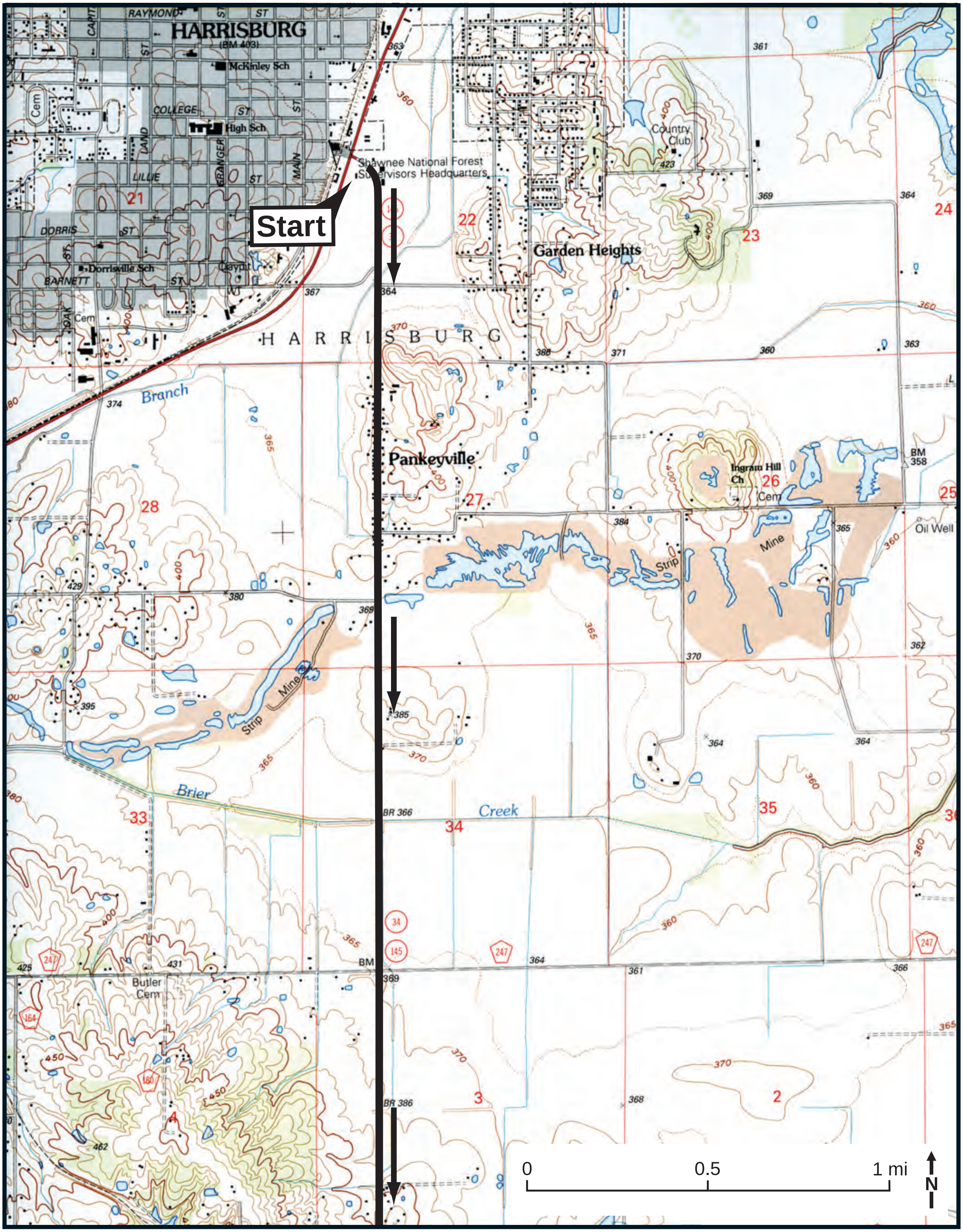
0.0	11.25	Exit parking lot and TURN LEFT.
0.05	11.3	T-intersection from the right (County Road 12). CONTINUE AHEAD.
0.05	11.35	Cross bridge over Big Creek.
0.3	11.65	Entrance to Forest Trail 1764 on the Left. Pull over and park along the road. On the day of the field trip, we will hike 2,000 feet along the forest trail toward the old iron ore pit.

STOP 4: Iron Furnace Fault Zone (NW, NE, NE, Sec. 9, T12S, R8E, 3rd P.M., Rosiclare 7.5-minute Quadrangle, Hardin County).

0.0	11.65	Leave Stop 4 and CONTINUE AHEAD on County Road 12. The road immediately to the left is County Road 52. This road leads to Karbers Ridge.
0.3	11.95	T-intersection from the left (County Road 12/Forest Road 1473). TURN LEFT.
1.3	13.25	TWO-WAY STOP. Crossroad intersection (County Road 12/Forest Road 1473 and County Road 3). CONTINE AHEAD. Historically this intersection was named Pankey's Store.
0.6	13.85	Historic marker for Martha's Blast Furnace on the left.
0.2	14.05	Cross unnamed creek.
0.1	14.15	Abandoned quarry in the Mississippian age St. Louis Formation on the left.
0.2	14.35	T-intersection from the left (County Road 62/700E). CONTINUE AHEAD. Decker Spring is located on the east side of the small unnamed creek 500 feet to the left.
0.35	14.7	Cross Hogthief Creek.
0.05	14.75	T-intersection on the left (County Road 3). TURN LEFT. Historically this intersection was named Jackson's Store. After making the turn, notice the large flat Valley occupied by Hogthief Creek. This creek is classified as an underfit stream. The size of the creek in relationship to the size of the valley is out of proportion. The valley is bounded by two northeast-southwest–trending faults.
2.0	16.75	T-intersection on the left (Forest Road 594). CONTINUE AHEAD.
0.9	17.65	Road curves 90° to the right. Y-intersection on the left (Forest Road 1746). CONTINUE AHEAD.
0.15	17.8	River to River Trail crosses the road. This portion of the trail connects Elizabethtown to the south with Camp Cadiz to the north.
0.2	18.0	Y-intersection (County Road 3 and County Road 67). TURN LEFT. Prepare to immediately TURN RIGHT onto County Road 25.
0.1	18.1	T-intersection on the right (County Road 25). TURN RIGHT. Griffith Cemetery is on the right after making the turn.
1.2	19.3	Pass Forest Trail 1765 on the right.
0.25	19.55	Cross ford.
0.75	20.3	Cross Harrris Creek.
1.15	21.45	Entrance to Anna Bell Lee Mine on the left. On the day of the field trip, we will park along the road.

STOP 5: 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.

0.0	21.45	Leave Stop 5 and CONTINUE AHEAD.
0.5	21.95	STOP. Intersection with Illinois Route 1.
		TURN LEFT, and Route 1 will connect with Illinois Route 13, which will take you to Harrisburg.
		TURN RIGHT, and Illinois Route 1 leads to Cave in Rock.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Shawnee National Forest Supervisors Headquarters
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Garden Heights
Country Club
Dorrisville Sch
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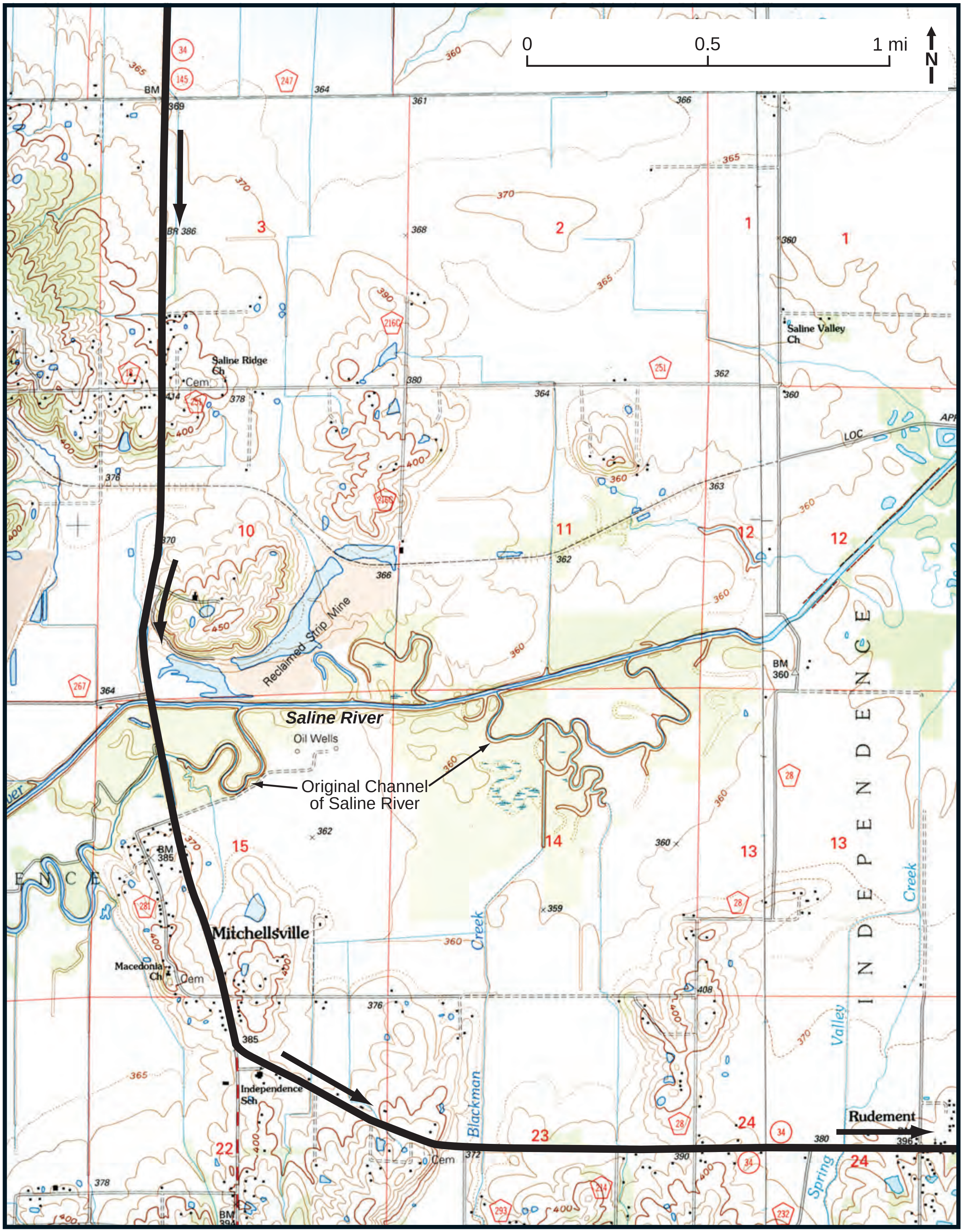
0
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N
Saline Ridge Ch
Cem
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Reclaimed Strip Mine
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Macedonia Ch
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Blackman
Creek
Valley
Spring
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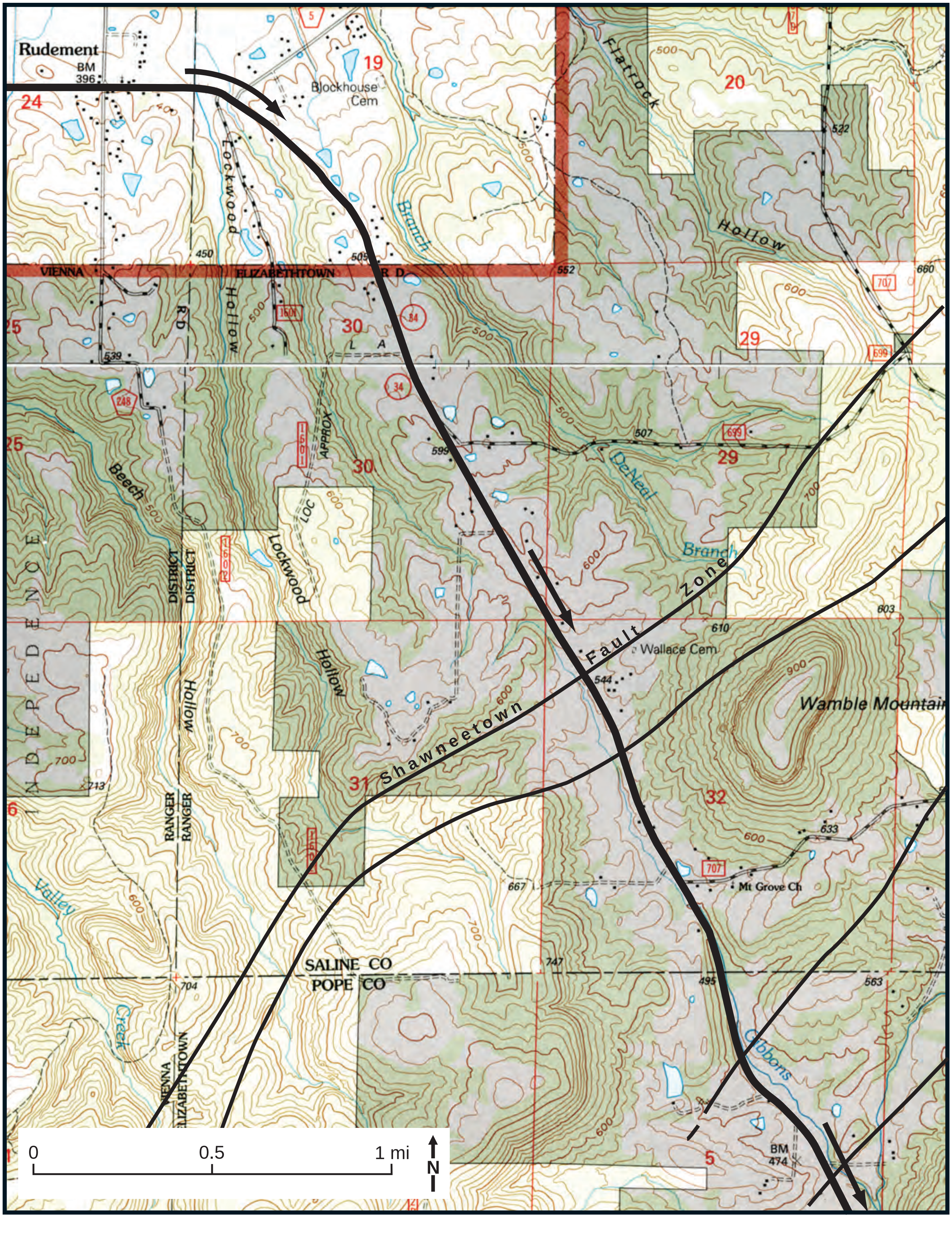
INDEPENDENCE
Rudement


Rudement
BM 396
Blockhouse Cem
Lockwood
Branch
Flatrock
Hollow
VIENNA
ELIZABETHTOWN
R D
Hollow
Beech
APPROX
LOC
Lockwood
DeNeal
Branch
Shawneetown Fault Zone
Wallace Cem
Wamble Mountain
INDEPENDENCE
DISTRICT
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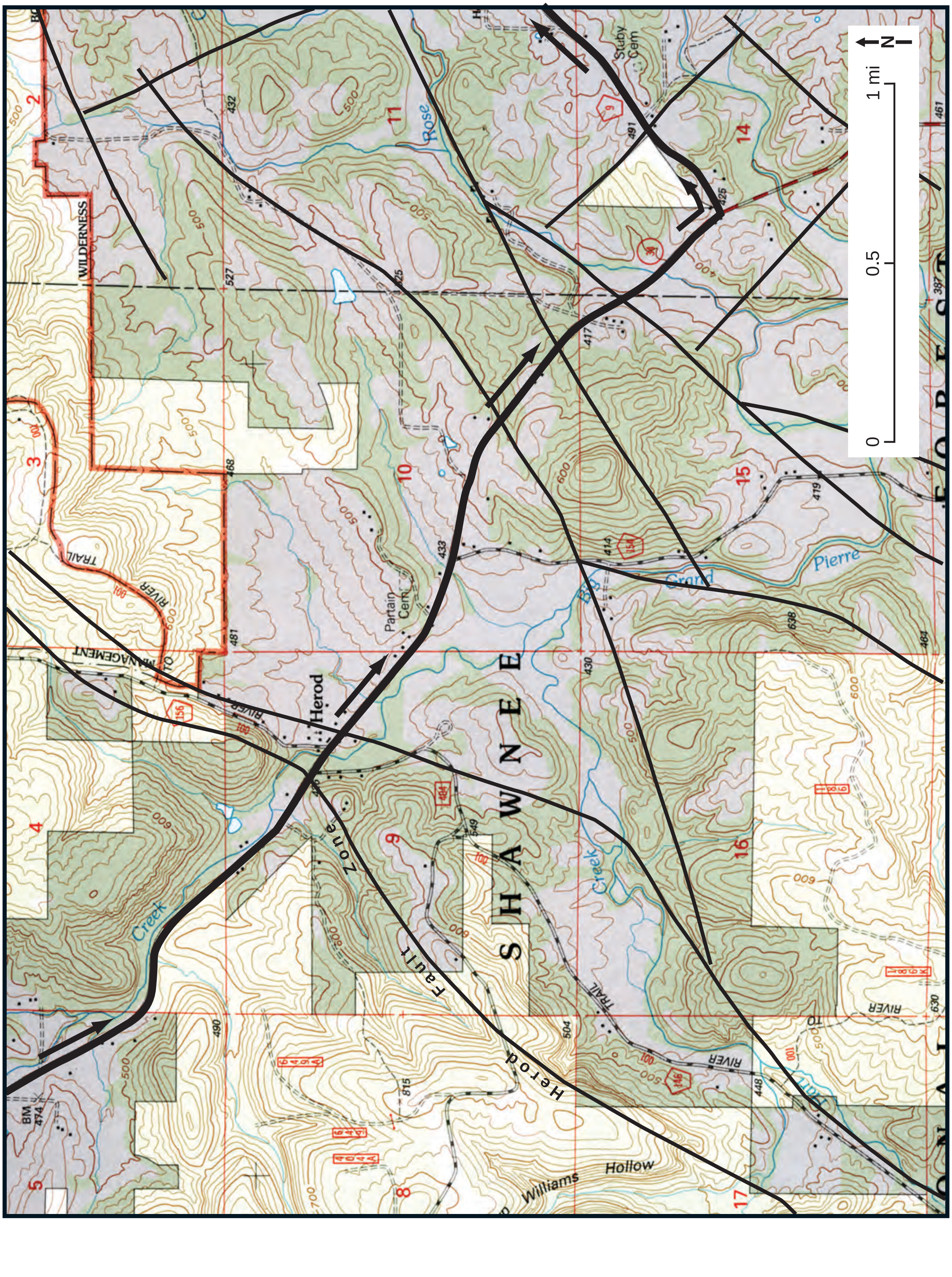
Herod Fault Zone
SHAWNEE
Herod
Partain Cem
Stuby Cem
WILDERNESS
Rose
Grand Pierre
Creek
Williams Hollow
RIVER TO RIVER TRAIL
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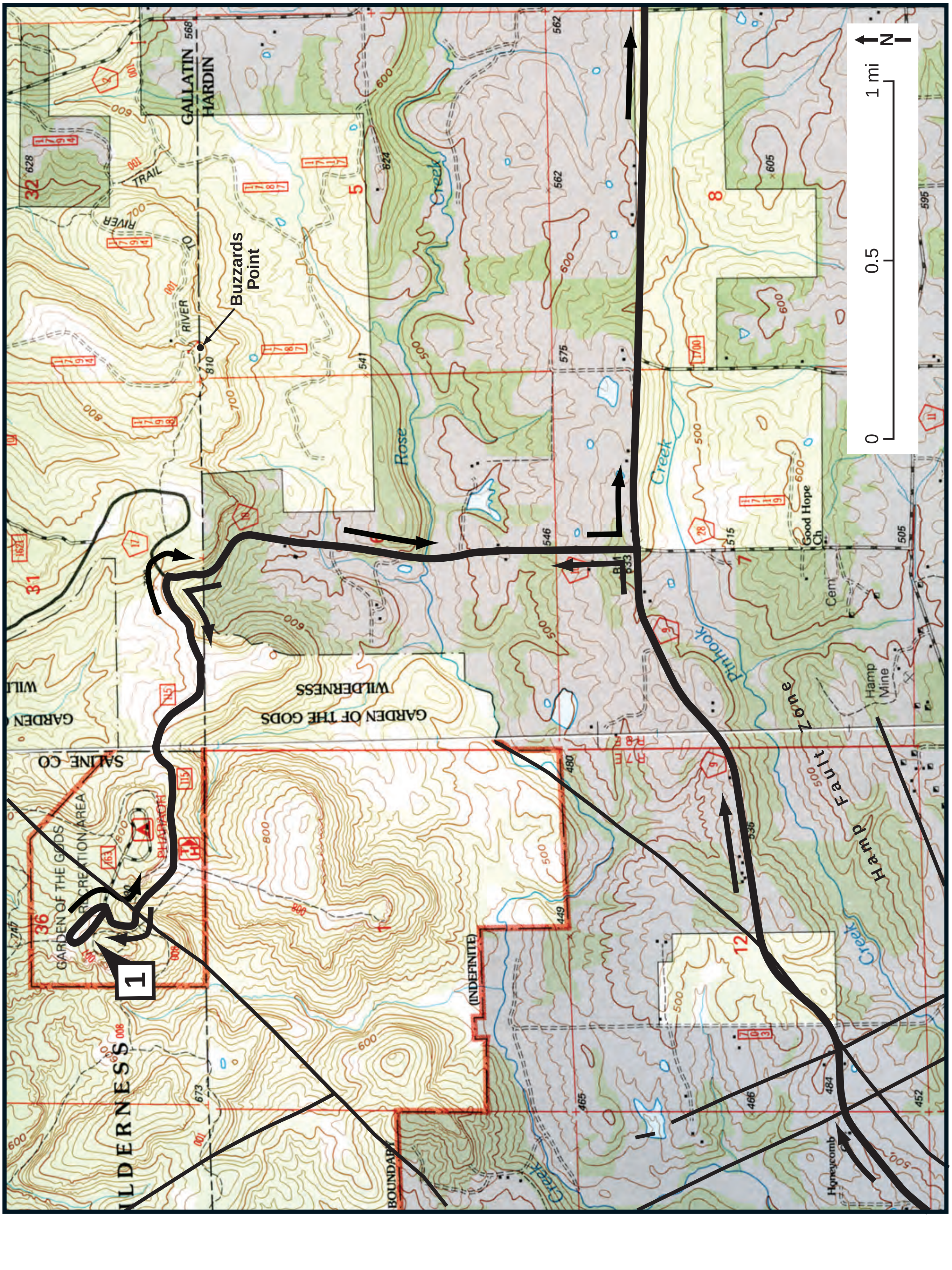

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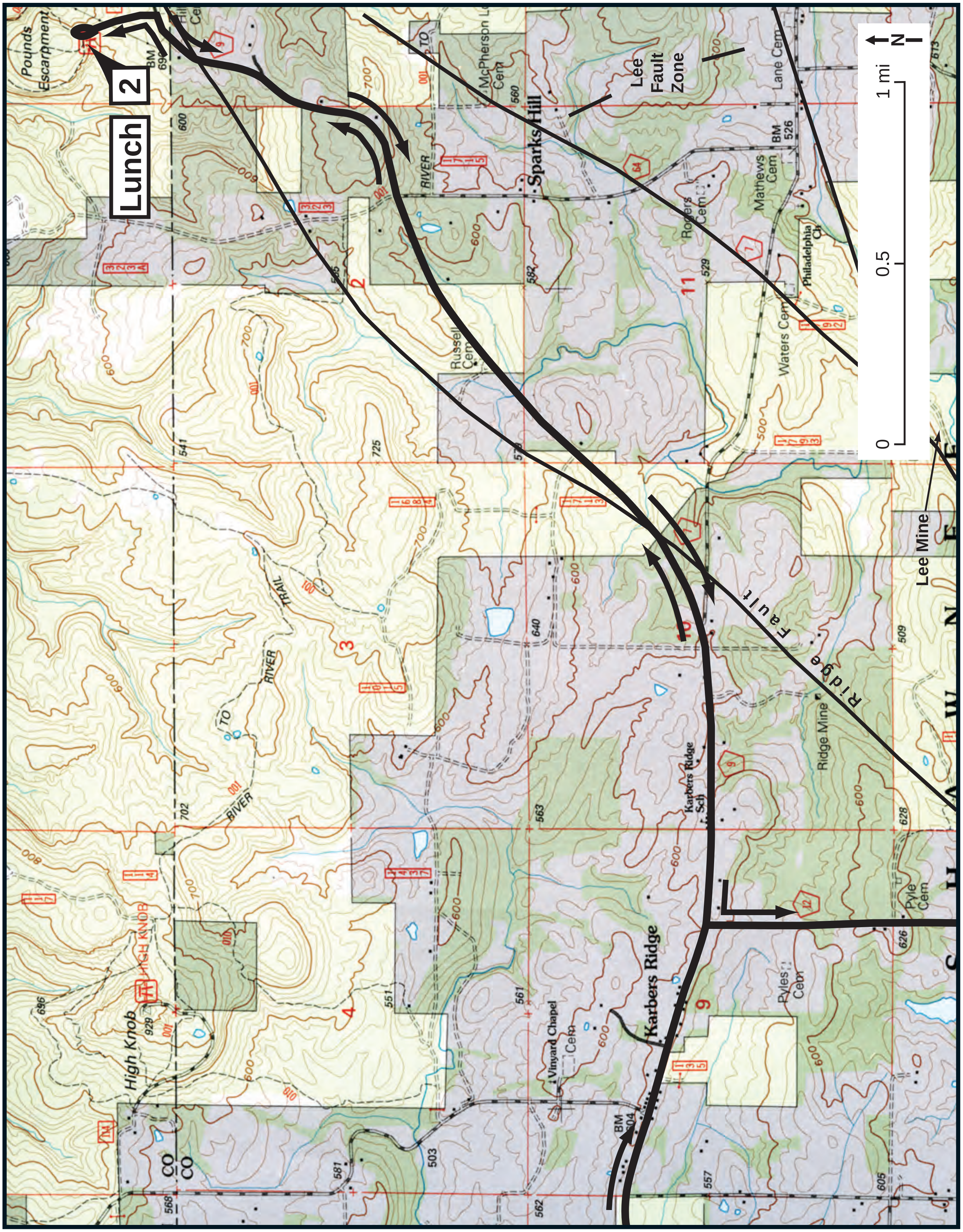
Lunch
2
Pounds Escarpment
Lee Fault Zone
Ridge Fault
Lee Mine
Sparks Hill
Karbers Ridge
High Knob
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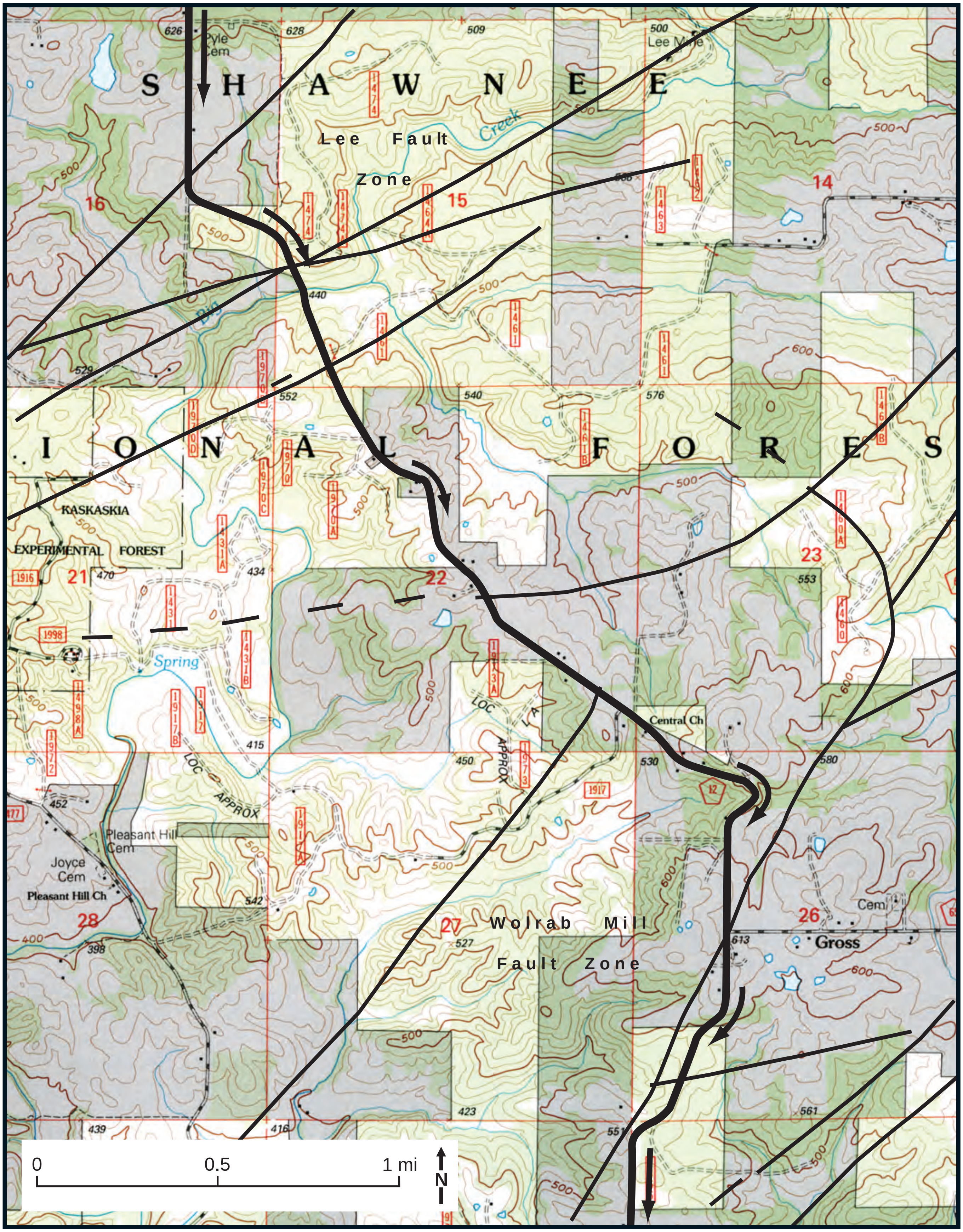
S H A W N E E
I O N A L F O R E S
Lee Fault Zone
Wolrab Mill Fault Zone
KASKASKIA EXPERIMENTAL FOREST
Pyle Cem
Lee Mine
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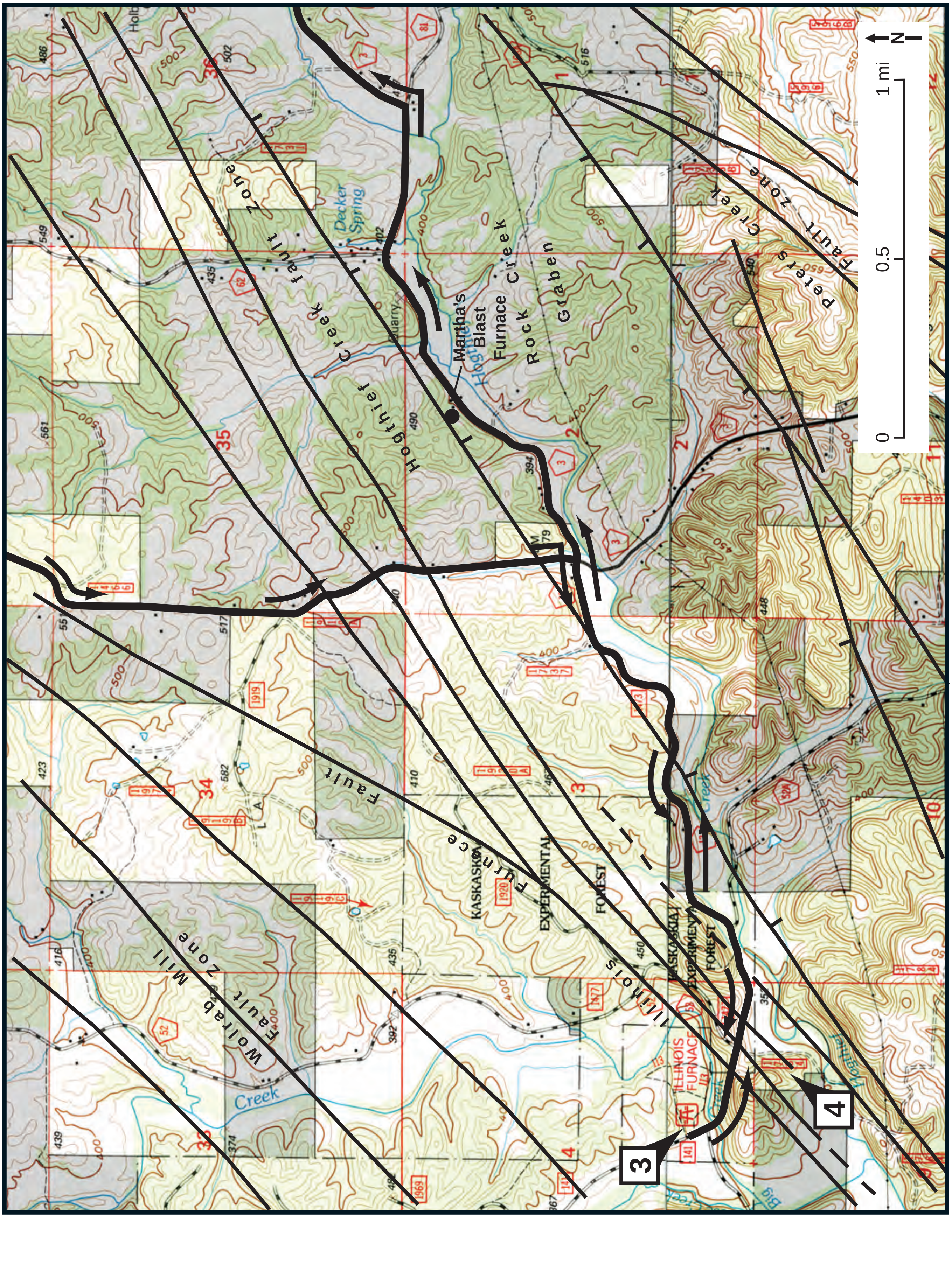

Wolrab Mill Fault Zone
Illinois Furnace Fault
Hogthief Creek Fault Zone
Rock Creek Graben
Peters Creek Fault Zone
Martha's Blast Furnace
Decker Spring
KASKASKIA EXPERIMENTAL FOREST
ILLINOIS FURNACE
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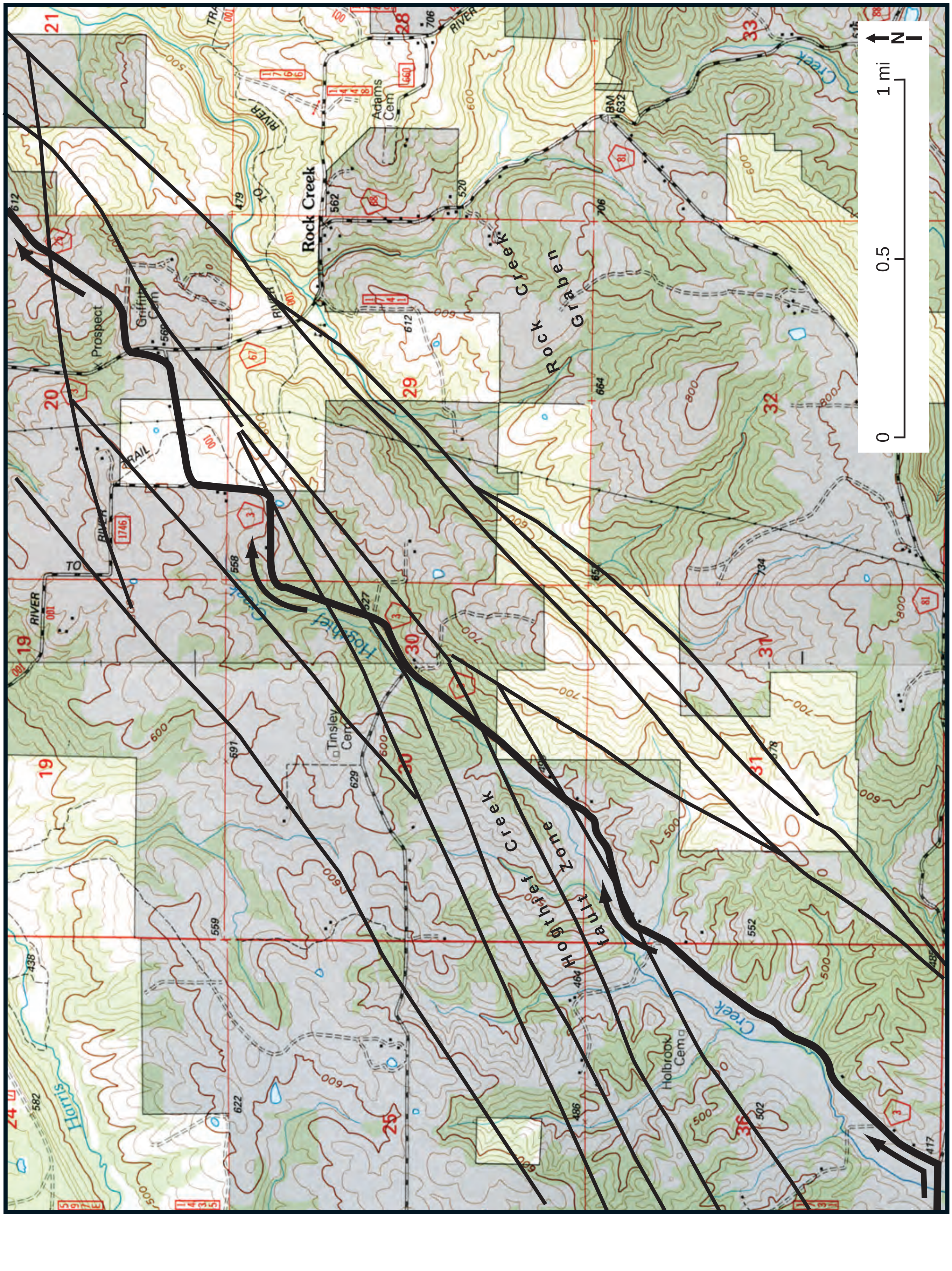
Hogthief Creek Fault Zone
Rock Creek Graben
Rock Creek
Prospect
Griffin Cem
Adams Cem
Tinsley Cem
Holbrook Cem
Hogthief Creek
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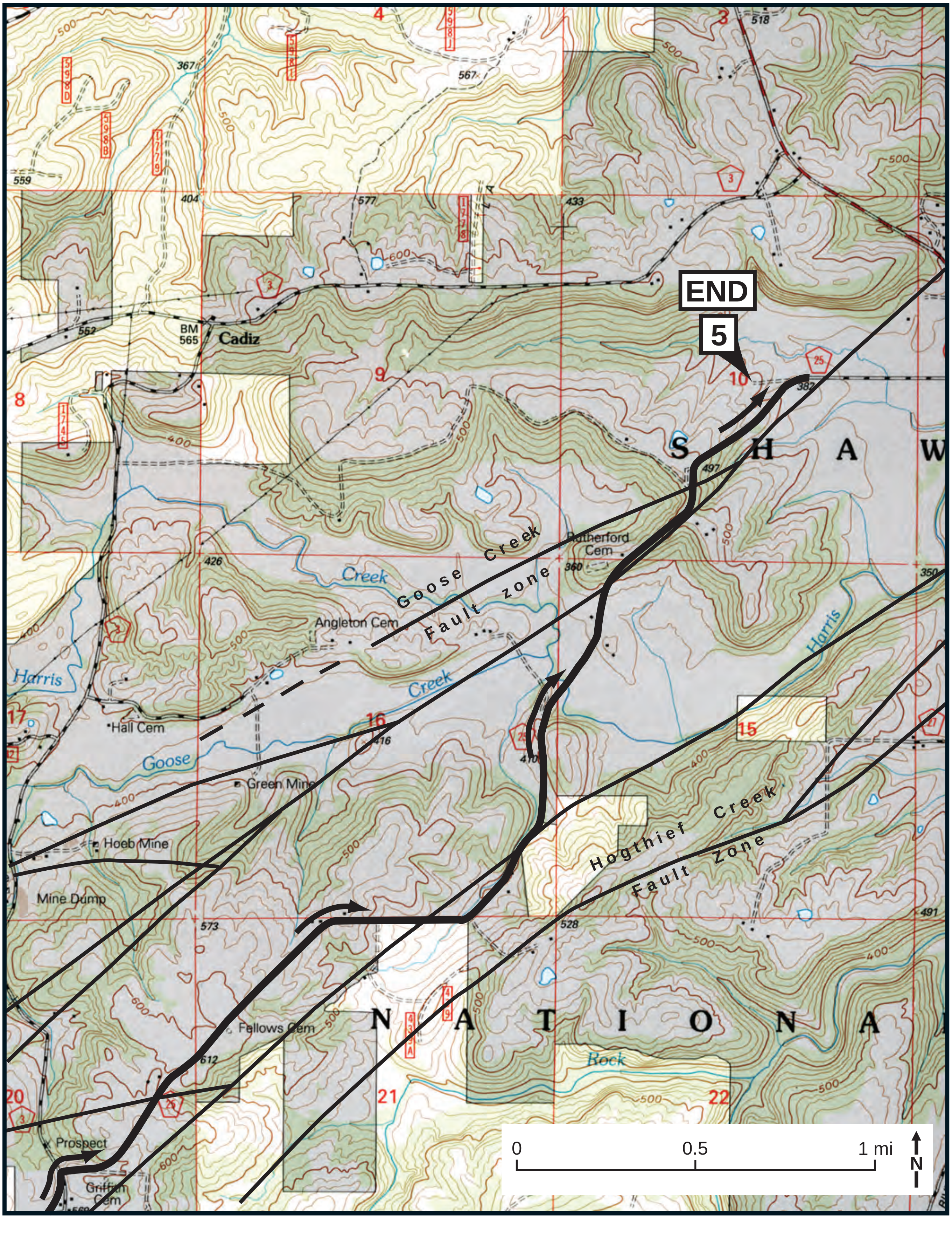
END
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BM
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Goose Creek Fault zone
Hogthief Creek Fault Zone
Rutherford Cem
Angleton Cem
Hall Cem
Green Mine
Hoeb Mine
Mine Dump
Fellows Cem
Prospect
Griffith Cem
Goose Creek
Harris
Rock
S H A W
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STOP DESCRIPTIONS

STOP 1: Garden of the Gods Recreation Area, Shawnee National Forest (SW, NW, SE, Sec. 36, T10S, R7E, 3rd P.M., Herod 7.5-minute Quadrangle, Saline County). On the day of the field trip, assemble near the south (left) entrance to the Observation Trail located near the middle of the upper parking lot.

At Stop 1, we will examine the Pennsylvanian age Pounds Sandstone Member of the Caseyville Formation and discuss the structural history of the region and the development of the Eagle Valley Syncline.

The Garden of the Gods Recreation Area is located in the Shawnee National Forest in southern Illinois. This area is bounded on three sides by the Garden of the Gods Wilderness Area, which was established by an act of Congress in 1990. No motorized vehicles or mechanized equipment is permitted in the 3,300-acre Garden of the Gods Wilderness Area, a relatively undisturbed wilderness area. Visitors are encouraged to “leave no trace” of their visit.

The Garden of the Gods Observation Trail is a one-fourth mile long interpretive trail. It is made of natural flagstone and leads to areas near the bluffs where there are outstanding views of the Shawnee Hills and the Garden of the Gods Wilderness Area. Starting at the south (left) entrance to the Observation Trail you will pass by many interesting rock formations, given names such as Table Rock (fig. 8), Camel Rock, Devil’s Smokestack (fig. 9), and Honeycomb Rock. The Observation Trail has some short, steep grades and a few steps, but as a whole, is not tiring. Caution should be used because there are high cliffs in the area.

Figure 8 Table Rock at Garden of the Gods Recreation Area, Shawnee National Forest. (Photograph by W.T. Frankie.)

Figure 9 Devil’s Smokestack at Garden of the Gods Recreation Area, Shawnee National Forest. (Photograph by W.T. Frankie.)

Geology Tip: Glaciation stopped about 15 miles north of the Shawnee Hills. As a result, you can see a distinct change in topography between the Harrisburg area to the north and this area. The landscapes in the southern tip of the state are very hilly; hence, their name.

The Garden of the Gods Recreation Area provides access the River to River and the Garden of the Gods Wilderness Area trail systems. Users are encouraged to obtain detailed maps before entering the back country. Overnight parking is available at the backpackers’ parking lot.

Geological History

The Shawnee Hills took millions of years to form. The rock formations and cliffs at Garden of the Gods are made of Pennsylvanian age Pounds Sandstone and are about 320 million years old (fig. 10). Long ago, most of Illinois, western Indiana, and western Kentucky were covered by a giant inland sea. For millions of years, great rivers carried sand and mud to the sea where it settled along the shoreline. Over time, the weight of the accumulating sediments and the chemical reactions between the sediments and fluids in them turned the sediments into layers of rock thousands of feet thick.

At Garden of the Gods, the sediment layers now exposed were originally buried about one mile deep. Beneath the Garden of the Gods are still some 20,000 feet of sediments piled on top of the crystalline basement. Eventually uplift raised the land well above sea level. The uplift fractured the bedrock, exposing it to nature's erosive forces. Since that time, windblown sand, rain, and freezing and thawing actions have worn down the layers of sediment, creating the beautiful rock formations at Garden of the Gods. To find out more, read the signs along the Observation Trail.

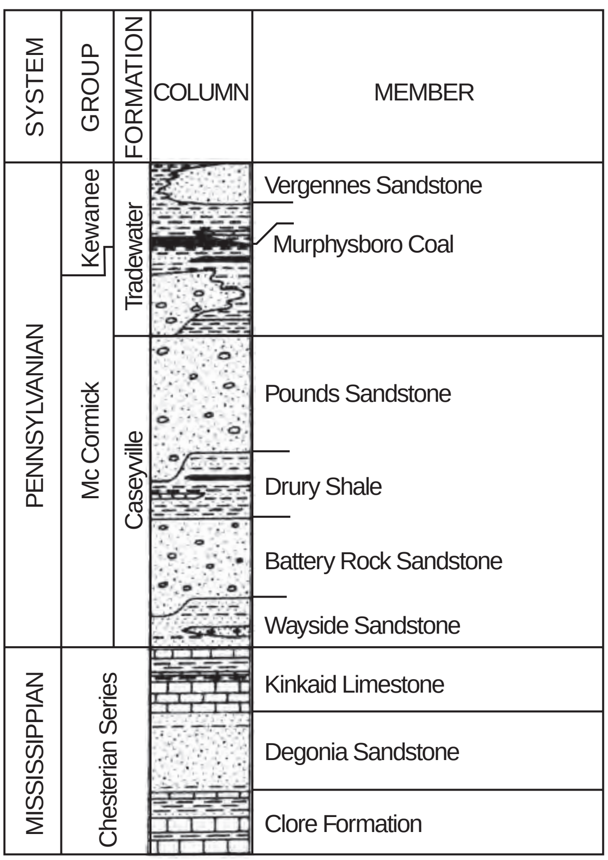

Figure 10 Generalized stratigraphic section of Mississippian and Pennsylvanian stratigraphy in the field trip area.

Garden of the Gods, located on the south limb of the Eagle Valley Syncline, is one of the most scenic areas of Illinois. The rock layers exposed here are part of the Pounds Sandstone Member of the Caseyville Formation. Long periods of erosion of the uplifted southern limb of the syncline has resulted in deeply dissected northward-facing dip slopes (dip is about 10 degrees to the north) and high knobs and ridges that consist of strongly weather-resistant sandstone.

The Pounds Sandstone is a fairly pure, slightly micaceous, quartz sandstone with numerous white rounded quartz pebbles. About 100 feet of sandstone is present in this member throughout much of the area. The sandstones of the Caseyville are very resistant to erosion and, where exposed, are cliff-formers. The sandstones are river channel sands laid down by an ancient Pennsylvanian river system that crossed this part of Illinois from northeast to southwest. A number of sedimentary structures, typically formed by river currents within a delta system building out into and along a shallow continental sea, are well developed in the Pounds Sandstone. These sedimentary structures include wedge-shaped cross-bedding and ripple marks. The purity and coarseness of the sandstone indicate that the currents along the shallow seashore (both river and nearshore currents) were swift and that much of the fine material and softer non-quartz materials were winnowed out before deposition. Other noteworthy sedimentary features of the sandstone at this stop include graded bedding, bimodal sorting of the medium to coarse-grained sandstone containing white quartz pebbles, and Liesegang banding.

The unusual concentric and parallel Liesegang banding of iron oxide-rich layers in sandstone, which is so common in outcrops of the Caseyville, is well displayed along Observation Trail (fig. 11). For this Liesegang banding phenomenon to occur, a fluid containing a salt must be introduced into a colloidal suspension within a porous medium (such as this coarse sandstone). During mixing of the fluid and the colloid, when the dissolved salt reaches a supersaturated level, precipitation occurs at regular intervals, resulting in the banding just described.

From the high sandstone pinnacles at Garden of the Gods, the western part of the Eagle Valley Syncline can be seen. Toward the northwest are areas of disturbed land where the Springfield, Herrin, Davis, and Dekoven Coals (Carbondale Formation, Pennsylvanian) were surface mined (fig. 6). The distinct high ridge that is visible to the north and northwest is the northern limb of the Eagle Valley Syncline.

Liesegang Banding in Sandstones

Figure 11 Liesegang banding. (Photograph by W.T. Frankie.)

The highly convoluted, dark-colored bands that stick out of the surface of some sandstone outcrops in the Caseyville and Tradewater Formations are apparently a near-surface weathering phenomenon. The rings and banding are not observed in fresh samples of these rocks brought up in drill cores.

When these sandstones are exposed on the face of a cliff, groundwater can seep through the rock to the outer surface, carrying dissolved minerals in it. At the surface, as the water evaporates, the mineral concentration in the water increases, ultimately causing the minerals to precipitate out of the solution. The convoluted banding results from the interaction of this groundwater with a colloidal suspension that is already present in the pores of the rock. The bands are zones where the rock grains are more strongly cemented together, and weathering removes the more weakly cemented parts of the rock, leaving the strongly cemented bands standing out from the rock surface.

A colloid is a form of matter in which very fine particles are held suspended in a liquid. (Ordinary gelatin is probably the most familiar colloid.) Ferric iron (iron in its reduced oxidation state; Fe^{2+}) in solution readily forms a colloidal gel as iron hydroxide when the solution is subjected to the right chemical conditions. If the conditions that formed the colloid are then changed by the addition of a new chemical to the solution that surrounds the colloid, the tiny particles suspended in the colloid will start to clump together and form a solid. For reasons that chemists do not yet fully understand, the clumping together of the colloidal particles (called “flocculation”) occurs in bands or rings in the gel, rather than uniformly. The banding apparently forms because slow and non-uniform diffusion of the added chemical into the gelatinous colloidal suspension causes a series of gradients to develop in the concentrations of the flocculating particles. The bands of color commonly observed in agate probably result from similar interactions between colloidal silica and ions dissolved in solutions that interact with the colloid. These phenomena in colloids were first studied and described by a German chemist named Liesegang.

– Jonathan H. Goodwin from Frankie and Jacobson (2001) based on Krauskopf (1967).

A syncline is a fold in which the bedrock layers have been bent downward by compressive forces acting within the Earth’s crust. The strata on both sides or limbs of a syncline dip (tilt) inward toward the axis or lowest part of the fold. Along the axis or central part of an eroded syncline, the youngest folded rocks are exposed. The opposite of a syncline is an anticline, in which the strata are bent upward into an arch.

The Eagle Valley Syncline (fig. 6) is an asymmetrical fold; the strata in the north limb dip more steeply (10 to 25 degrees) than the strata on the south limb (from less than 5 to 10 degrees). The ridges that outline the syncline are formed by the eroded, upturned edges of resistant Lower Pennsylvanian sandstones. These consist principally of the massive sandstones of the Caseyville and Lower Tradewater Formations, which form steep, outward-facing cliffs along their outcrop belt. The top of this erosional escarpment is capped by the Grindstaff Sandstone of the Tradewater Formation. Eagle Valley itself is eroded in the softer shales and shaley sandstones of the upper Tradewater to Carbondale Formations, which overlie the more resistant sandstones. The still younger Anvil Rock Sandstone Member of the Carbondale Formation (which occurs above the Herrin Coal) is also resistant to erosion and forms the low hills in the central part of the valley along the axis of the syncline.

The axis of the syncline plunges (tilts downward) to the east, and thus the syncline is deepest and widest near the Ohio River. The syncline gradually dies out eastward into Kentucky. Near the western end of Eagle Valley, the axis bends sharply to the southwest, and the fold dies out in the vicinity of Herod. As the syncline becomes shallower and narrower westward, the sandstone ridges along its north and south limbs converge toward the axis at the nose of the syncline.

The Shawneetown Fault, a major fracture in the crust, bounds the syncline on the north and west, and faults also border the syncline to the east in Kentucky (figs. 5 and 9). These faults have large vertical displacements ranging from 500 feet to more than 3,500 feet. The Eagle Valley Syncline and the faults in the field trip area are part of a region of intensely disturbed Paleozoic strata that cross southern Illinois and western Kentucky (fig. 5). This region includes the Illinois Fluorspar District, cut by many high-angle faults, such as the one that can be observed at the abandoned Lee Mine at Stop 2.

These features were formed during a major episode of folding and faulting that began at the end of the Pennsylvanian Period about 270 million years ago. This was the time when the Appalachian Mountains were forming along the eastern margin of North America. Another episode of faulting occurred later, during the Cretaceous Period, about 100 million years ago. Recurrent movements along faults in this region have occurred since then, and earthquakes within historic time indicate that movements are still taking place.

STOP 2: LUNCH—Rim Rock Recreation Area and the Pounds Escarpment, Shawnee National Forest (NW, SW, SW, Sec. 36, T10S, R8E, 3rd P.M., Karbers Ridge 7.5-minute Quadrangle, Gallatin County).

Following lunch, we will hike a portion of the trail to examine the flora and geology and to discuss their unique interconnection at the Pounds escarpment.

The Rim Rock Recreation Area and the Pounds Hollow Recreation Area complex contains the Rim Rock National Recreation Trail and a Shawnee National Forest Ecological Area. The Rim Rock National Recreation Trail was constructed in 1962 and 1963 using funds contributed by the Illinois Federation of Women's Clubs. In the early 1980s, the Young Adult Conservation Corps crews replaced the original gravel path with a flagstone walkway. In 1980, the trail was designated as a National Recreation Trail. Rim Rock Trail is within a Shawnee National Forest Ecological Area, an ecosystem relatively unchanged by humans. Evident along the trail are sandstone glades, relict plant associations, and interesting geological formations. Interpretive signs highlight the natural features. Rim Rock is the upper extension of Pounds Hollow, which includes about 230 acres of a designated natural area. This area is managed to protect and preserve archeological features and rare plant communities. Help protect the plant life and other fragile resources by staying on the trail.

The 0.8-mile upper Rim Rock Trail meanders among native hardwoods and a cedar plantation, past the remains of the Old Indian Wall, and along the edge of the Rim Rock Escarpment made up of the Pounds Sandstone Member of the Caseyville Formation (fig. 10) that we also saw at Stop 1. The upper trail takes about one hour to walk and contains steps and some incline slopes. Wheelchair access to the observation deck is possible on the upper trail, with assistance, by going to the left on the upper trail. Steps and slopes of ±8% are encountered along the right portion of the upper trail and along the lower trail. The trail winds around the bluff top and in some places lies close to the edge. Take extreme caution in rainy weather—the trail and deck surfaces may be slippery.

The trail will take you across the Old Indian Wall, past a scenic view of Pounds Hollow Lake, to an observation platform with a breathtaking view of the valley some 70 feet below. A stairway to the valley leads to the Ox-Lot Cave, which is a large rock shelter in the bluff formed of Pounds Sandstone (fig. 12). Near this stairwell is Fat Man's Misery, a narrow passage that goes through the massive sandstone bluffs and boulders.

Stepping Stones Through Time

To early settlers, this formation was known as "the Pounds," an old English term meaning "some sort of enclosure." Throughout time, this natural escarpment and the lush valley below attracted human settlement. For prehistoric peoples, these rock formations provided protection from their neighbors, and the lush valley offered plentiful sources of food and water. After the removal of Native Americans in the 1830s, settlers spread into the interior wilderness. The forest provided an abundant source of wild game and nuts for food and large trees to build log cabins and provide firewood for warmth on cold nights. By the late 1890s, the Pounds Hollow area was purchased by eastern land companies as part of a thriving logging enterprise, after which the land was sold to farmers. By the late 1920s, logging and farming had created an unproductive landscape. In 1936, the Shawnee National Forest acquired this land

Figure 12 Ox-Lot Cave, Rim Rock National Recreation Trail, Shawnee National Forest. (Photograph by W.T. Frankie.)

in an effort to restore the soil and forest. Today's recreationists enjoy the natural beauty of the area, and scientists study its unique features.

Trails

Beaver Trail is on the east side (to the right) of the Pounds escarpment, and Lower Pounds Trail is on the west side of the escarpment. The upper trail is a loop trail with a branch veering off to the left, which follows along the edge of the bluffs, and a branch that is straight ahead, leading up through the Old Indian Wall (fig. 13). Crumbled blocks of sandstone are evident on either side of the path. The following is from a sign near the stone wall:

> Why a defense? Look in front of you. . . . Can you find the remains of the ancient stone wall built by prehistoric Indians about 1,500 years ago? Archeologists believe the inhabitants, members of the Late Woodland culture, used these escarpments as a defense location. They built the wall to block the only accessible route to the top of the bluff. The wall extends almost 150 feet across the bluff top. The height of the wall is unknown, since through time, this wall has crumbled. However, early travelers reported that the walls were 6 feet in height. The stones were gathered from below the bluff, which required considerable effort. Will we be able to reconstruct the story behind the ancient wall? Archeological work has just begun on this significant site. The research will attempt to demonstrate why Late Woodland people were defending themselves.

The Geology of Pounds Hollow from the Observation Platform

The Pounds Sandstone forms these spectacular bluffs. The younger Tradewater Formation underlies the gentler slopes above the sheer cliffs across the valley. These majestic sandstone bluffs began to form as sand and mud were deposited at the shoreline of the shallow sea that covered this area about 320 million years ago. Rivers originating from the Appalachians carried the sediments down to the sea. The land was slowly sinking, and more sand and mud were deposited on top. With time and continued burial, the sand became sandstone, mud became shale, and the peat in the swamps turned to coal.

About 280 million years ago, the land began to rise slowly, and the sea gradually retreated to its present location in the Gulf of Mexico. As this uplift began, geological forces fractured the rocks, creating channels for rainwater runoff. Since then, hundreds of feet of rocks have eroded away, and nature has gradually uncovered these geologic units, carved out Pounds Hollow (the valley below) and its tributary creeks, and sculpted the scenery now exposed at the observation platform.

A stairway at the observation platform leads to the valley floor and Ox-Lot Cave (fig. 12). Near this stairwell is Fat Man's Misery (fig. 14). The observation platform

Figure 13 Old Indian Wall Pounds escarpment, Rim Rock National Recreation Trail, Shawnee National Forest. (Photograph by W.T. Frankie.)

Figure 14 Fat Man's Misery, Rim Rock National Recreation Trail, Shawnee National Forest. (Photograph by W.T. Frankie.)

is located on top of a large block of Pounds Sandstone that has moved westward toward the valley. Fat Man's Misery follows a curvilinear joint/fracture in sandstone trending N35° E.

Ox-Lot Cave provided shelter to many hunters and explorers who passed this way. It was not until loggers entered the hollow that the natural overhang received extensive use. A fence was built around the area to form a corral to keep the oxen, mules, and horses; hence, the name Ox-Lot Cave. The boxed-in spring provided a watering hole for the animals.

A narrow-gauge railroad was built within the hollow to haul cut timber in the area. Oxen dragged the heavy logs to the flatbed cars. The logs were moved to the Saline River and spiked together before being floated down the Ohio River. Logging companies operating in the valley were profitable for a short period from 1902 to 1906. Soon thereafter, the railroad was removed.

Why is there a spring at the base of the Ox-Lot Cave? Rainwater percolates down through the Pounds Sandstone and along fractures to the base of the bluffs. The Drury Shale Member underlies the Pounds Sandstone, and, when water encounters this relatively permeable unit, it begins to flow horizontally along the contact between the underlying shale and overlying sandstone. Joints/fractures concentrate the flow of groundwater. A joint trending S70° E is located near the spring. Can you find other joints in the bluff?

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

On the National Register of Historic Places, the Illinois Iron Furnace allows us 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 City during the Civil War and were used in constructing the Union ironclad 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 only county in Illinois where smelting furnaces for reducing local iron ore deposits were ever built. The Illinois Iron Furnace, one of only two such furnaces in Illinois, was constructed in about 1837 (fig. 15). The hearth and inner walls originally were built of Mississippian sandstone with a lining of firebrick from Ohio. 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 duplicate of the original furnace, the reconstructed furnace certainly is representative of the furnaces built and used during this time.

Figure 15 Illinois Iron Furnace, Hardin County, Illinois. (Photograph by W.T. Frankie.)

The furnace used an ore called limonite that contained more than 80% iron oxides. This material ranged from gravel-sized to much larger. The ore bodies occurred in pockets of comparatively small size in the upper surfaces of the 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, NW, NE ¼ of Sec. 2, T12S, R8E. Martha Furnace was operated from 1548 to 1857 and rapidly deteriorated after its closing.

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

The rustic setting here gives little indication of all of the activity that took place near this operation. Several workers at the furnace charged the furnace 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."

Iron

Iron is a chemical element. It is a strong, hard, heavy gray metal. It is found in meteorites. Iron is also found combined in many mineral compounds in the Earth's crust. Iron rusts easily and can be strongly magnetized. Iron is used to make many things such as gates and railings. Iron is also used to make steel, an even harder, 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.

Furnace Operation: Iron Pigs and Sows and Other Terms

The men who produced charcoal are called "colliers." The "tuyere" 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 pig feeding her piglets. In this area, the site where the charcoal kilns operated was locally known as the "coaling fields."

History of Iron Production

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

Wrought iron was made by first heating a mass of iron ore and charcoal in a forge or furnace using a forced draft of air. This 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, it 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 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 with increased draft from large bellows used to force air through the "charge" (mixture of raw materials). These larger furnaces first freed the molten iron in its upper levels. This 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 to produce steel from iron ore. Steel making still uses blast furnaces that are merely refinements of the furnaces used by the old ironworkers. Improvements in the refinement of molten iron using blasts of air were accomplished by the 1855 Bessemer converter. Since the 1960s, electric arc furnaces have also been producing steel from scrap metal.

STOP 4: Iron Furnace Fault Zone (NW, NE, NE, Sec. 9, T12S, R8E, 3rd P.M., Rosiclare 7.5-minute Quadrangle, Hardin County).

The iron ore used in the furnace was mined from local deposits in the NE¼ of Sec. 9, and the SE¼ of Sec. 3, T12S, R8E, along Hogthief Creek. Other deposits of ore were mined in the NE¼ and NW¼ of Sec. 34, T12S, R8E. Hogthief Creek parallels a major fault. While conducting field work in 2006, an abandoned ore mine was located in the NW, NE, NE¼ of Sec. 9, T12S, R8E (fig. 16). To reach this location, follow Forest Service Road 1784 off County Road 12 and 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. 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 (fig. 17). Recent x-ray refraction analysis of the ore collected in the field has determined that the ore contains both hematite (Fe_2O_3) and goethite (FeO•OH).

Figure 16 Iron ore pit along the Iron Furnace Fault Zone, Hardin County, Illinois. (Photograph by W.T. Frankie.)

Figure 17. Iron ore deposits (limonite) at a historic abandoned pit along the Iron Furnace Fault Zone. Inset images, clockwise from upper left: (1) goethite sample (pencil ore), (2) stalactitic form of goethite, (3) massive variety of limonite and hematite, (4) unusual goethite sample consisting of prismatic crystals exhibiting a radiating pattern that indicates concentric development of the goethite mineral. (Photograph by W.T. Frankie.)

STOP 5: 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.

There will be an opportunity to collect mineral specimens and discuss fluorspar mining in this part of Illinois at the abandoned Annabell Lee Mine (fig. 18). Minerals of 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 its 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 the only one still standing in Illinois. The name of the mine was derived from Edgar Allen Poe's poem of the same name. It may be of interest to know that the Annabel Lee was the last poem written by Poe. I find it ironic that the last mine to operate chose the name Annabel Lee.

Figure 18 Abandoned Annabell Lee Mine, the last fluorite mine to operate in Illinois.

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 the fault is down dropped on the southeast side of the fault. The Mississippian age Palestine Sandstone occurs on the northwest side of the fault, and the Pennsylvanian age Abbott 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 bedded replacement deposits. Underground mining was carried out by a room-and-pillar method. The fluorite ore was produced from the Mississippian age Downeys Bluff Limestone and from the Joppa and Spar Mountain Members of the Ste. Genevieve Limestone (fig. 19). These same horizons are exposed in surface quarries on Spar Mountain, about 4 miles south of here.

At the time, the reason that this mine was one of the last in operation is because Ozark-Mahoning was the only domestic producer of fluorite left. Despite the cheap price of imported ore from Mexico and China, the company was able to keep operations going until 1995 due to its effectiveness in maintaining operations costs by using the equipment, mine structures, and in-house personnel already available in the area. However even this

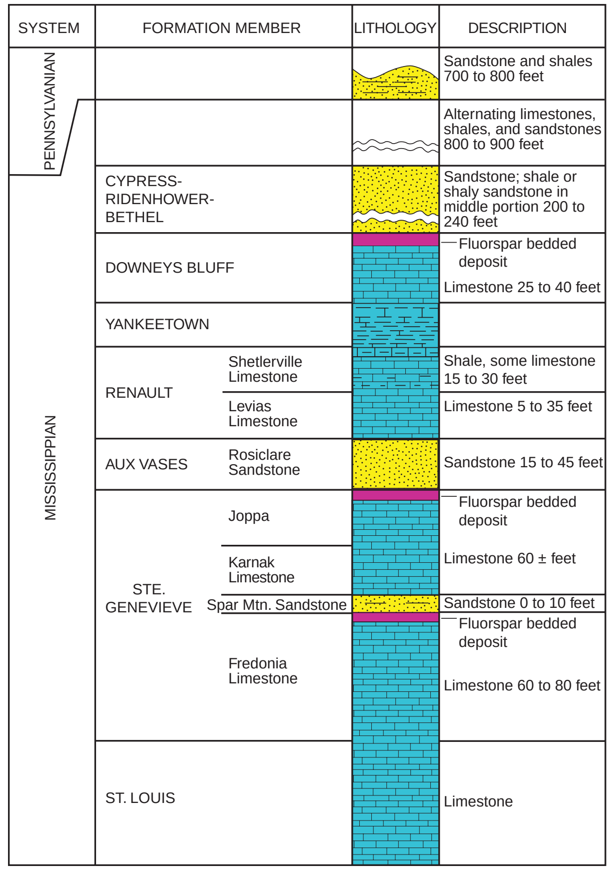

Figure 19 Principal fluorspar-bearing portion of stratigraphic column of the southeastern Illinois Fluorspar District. Black bands represent horizons most favorable for the occurrence of bedded deposits. The most productive parts of vein deposits generally occur below the Rosiclare Sandstone (modified from Bradbury et al. 1968).

mine and another mine, the Number 1 mine, succumbed to the cheap import costs of fluorspar and closed in 1995 as the last mines in the district.

Fluorite Mining

The 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. Fluorite was designated the Illinois state mineral by the 74th General Assembly in July 1965.

Illinois fluorspar occurs almost exclusively in Pope and Hardin Counties (Reinertsen and Masters 1997). 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. 20).

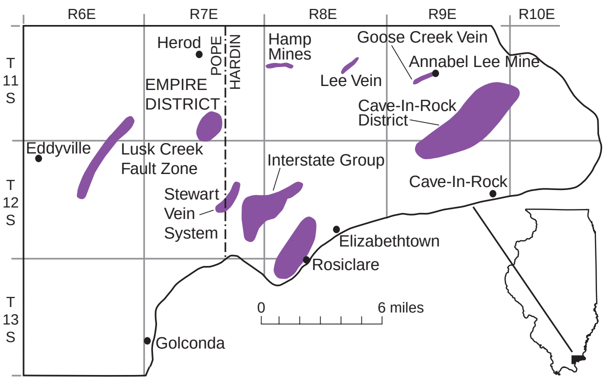

Figure 20 Principal fluorspar mining districts in southeastern Illinois (modified from Bradbury et al. 1968).

Fluorspar, also called fluorite, consists of calcium (51%) and fluorine (49%). Chemically, it is known as calcium fluoride (CaF_2). This glassy mineral is commonly colorless, white, or gray, but much of it is some shade of purple; other colors include pink, blue, green, yellow, and tan. Crystals are characteristically cubic in form, but most fluorspar is massive, consisting of masses of interlocking crystals. The cubic crystals, often associated with crystals of calcite, galena, sphalerite, quartz, and other minerals, are found within pockets of deposits and are highly prized by mineral collectors. 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.

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 mining near Shawneetown may actually have been from the Rosiclare area. Shawneetown may have been used because, during the 1800s, it was the largest town in the area. In 1839, fluorspar and galena (PbS) 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 Fluorspar 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, 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 historically was 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.

Vein Deposits. The primary controlling factor determining the location and extent of mineralization of vein deposits was faulting. Vein deposits occur in steeply inclined, sheet-like deposits as fissure fillings along faults (fig. 21). 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. 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 and 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 n the Rosiclare area have been mined at depths greater than 800 feet.

Vein deposits are best developed in the stronger, more competent limestones and well-cemented sandstones in which adequate open spaces could be maintained along the faults. Weaker rocks, such as shales, sandstones, or shaly limestones, became crushed during faulting and generally filled rather than created openings. The best vein deposits are found in the relatively pure, competent Ste. Genevieve and St. Louis Limestones (fig. 19). Minable vein deposits also occur in competent younger rooks 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.

Bedded Deposits. Bedded fluorspar ores are generally flat-lying, irregular bodies parallel to the bedding of the host limestones (fig. 22). 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 fluorspar simply filled open

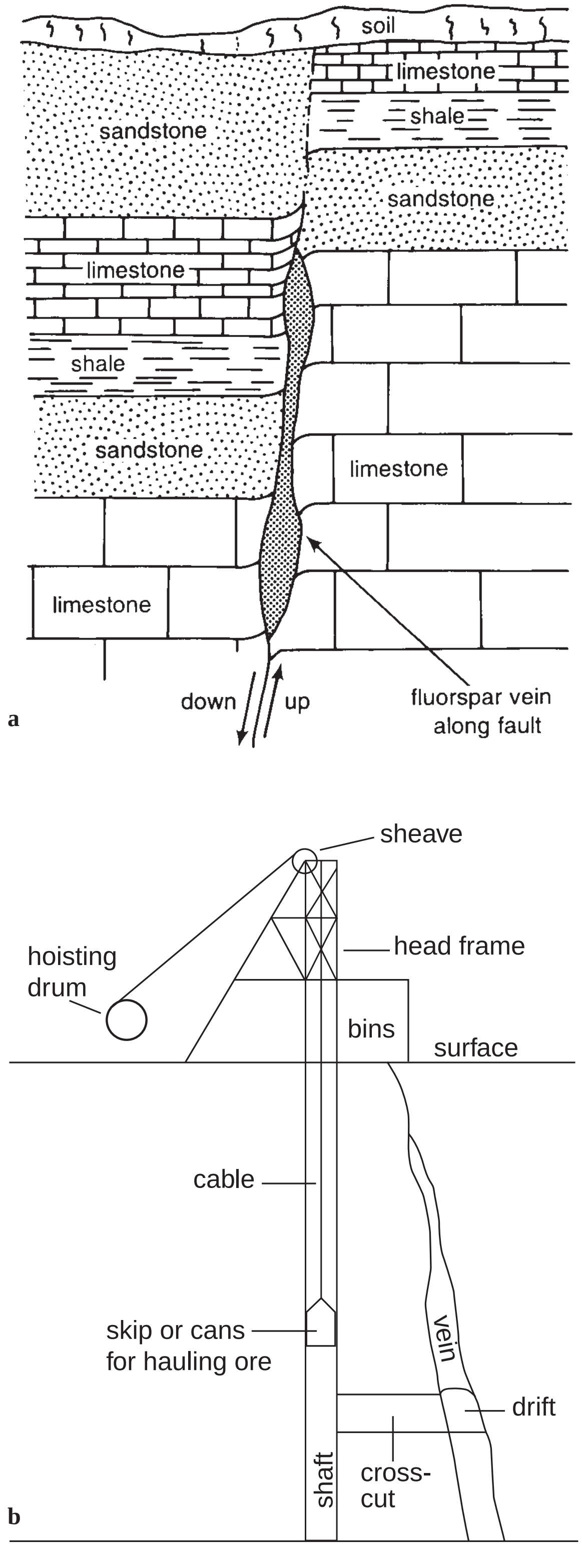

Figure 21 (a) Diagramatic cross section of a fluorspar vein along a fault. The strata on the left side of the fault have moved downward with reference to those on the right. (b) Diagram of mine layout at right angle to the vein showing general relations of surface installations and underground workings to the vein (diagram b modified from Bradbury et al. 1968).

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 generally accepted that the mineralization was deposited by hot, fluorine-hearing, aqueous solutions rising from deep within the Earth's crust. A 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. 19). 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 and fine-grained limestone, characterized by numerous shale partings. Immediately overlying the Joppa is the Rosiclare Sandstone Member of the Aux Vases Sandstone (fig. 19). 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 Limestone. 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 Fredonia Limestone Member of the Ste. Genevieve Limestone (fig. 19). 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 of the Ste. Genevieve Limestone, and the top of the Fredonia Limestone Member of the Ste. Genevieve Limestone. Apparently, the limestone at these levels 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

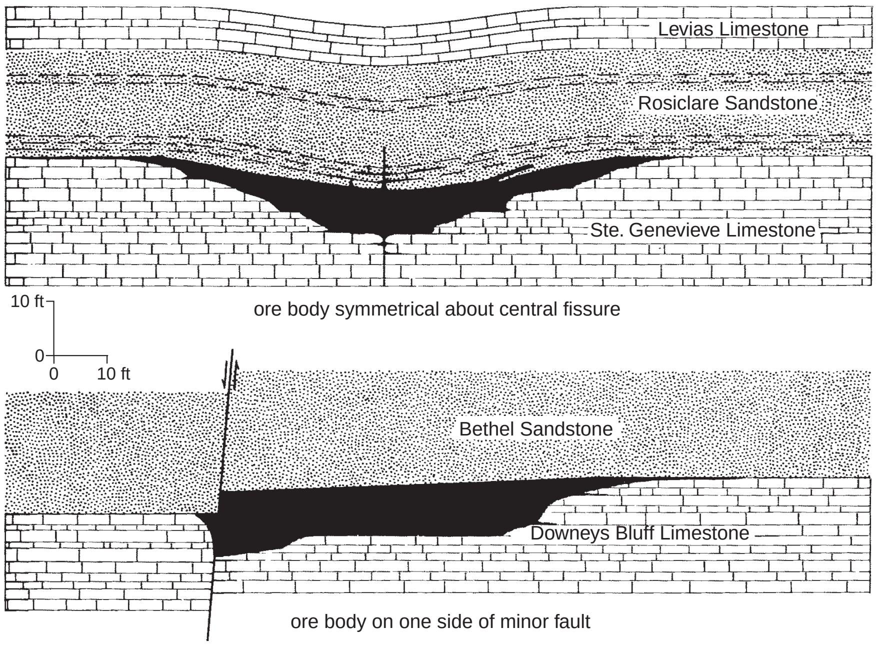

Figure 22 Schematic cross sections of two general types of bedded replacement fluorspar deposits (modified from Bradbury et al. 1968).

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 in limiting the upward movement of the mineralizing solutions.

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 surface 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 upward, 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 channelways 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. 23). 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 Fluorspar 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 along which additional block faulting took place.

Recurrent faulting has occurred 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 (CaF_2) and calcite ($CaCO_3$) are the two chief minerals present in the vein deposits. Minor amounts of

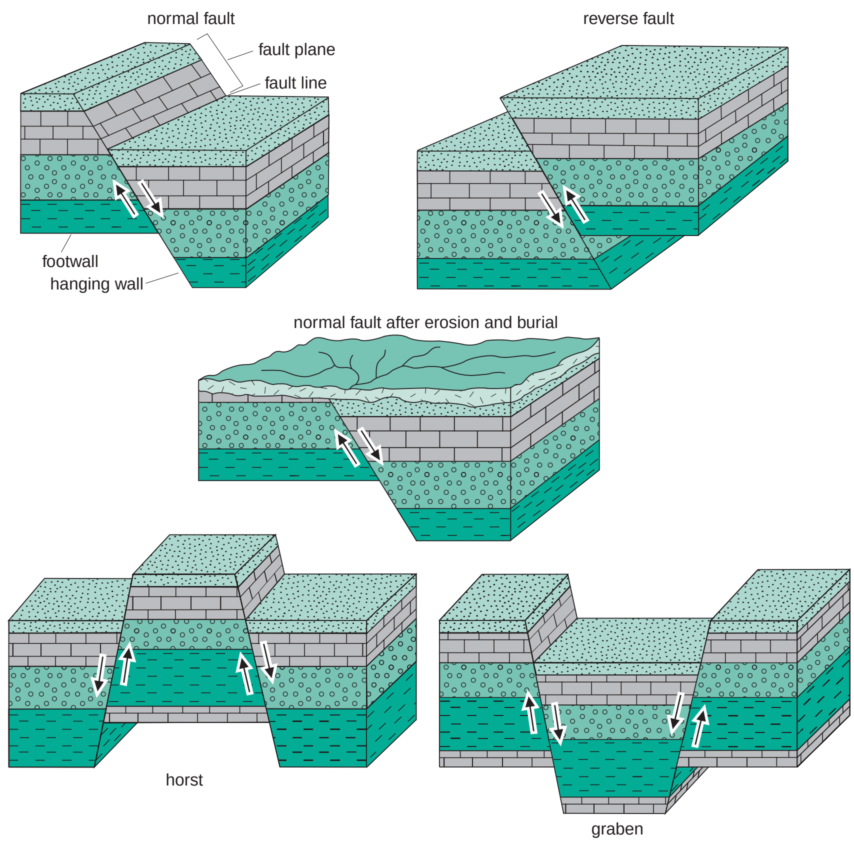

Figure 23 Diagrammatic illustrations of fault types that may be present in the field trip area. A fault is a fracture in the Earth's crust along which there has been relative movement of the opposing blocks. A fault is usually an inclined plane, and when the hanging wall has moved down relative to the 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.

galena (PbS,) sphalerite (ZnS), and barite ($BaSO_4$) also occur. In the bedded replacement 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, chalcopyrite, malachite, marcasite, smithsonite, limonite, gypsum, aragonite, melanterite, stibnite, and sulfur have also been identified in the fluorspar deposits.

Mineralization. In approximate descending order of abundance, primary minerals in vein deposits include calcite, fluorite, quartz, galena, sphalerite, ferroan dolomite, pyrite, marcasite, barite, chalcopyrite, oil, and bitumen. Secondary vein minerals include gypsum, malachite, cuprite, and others. The sequence of mineralization (the order in which the minerals form) is calcite, fluorite, chalcopyrite/pyrite, quartz, calcite, and bitumen.

Industrial Uses. Space does not permit a discussion of the mining, milling, or processing of fluorspar ore. Only brief mention may be made of its uses in industry. 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 consumes 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 (a substance added to a material to make it opaque) in the manufacture of special types of glass and enamels.

End of field trip.

Drive carefully on your way home.

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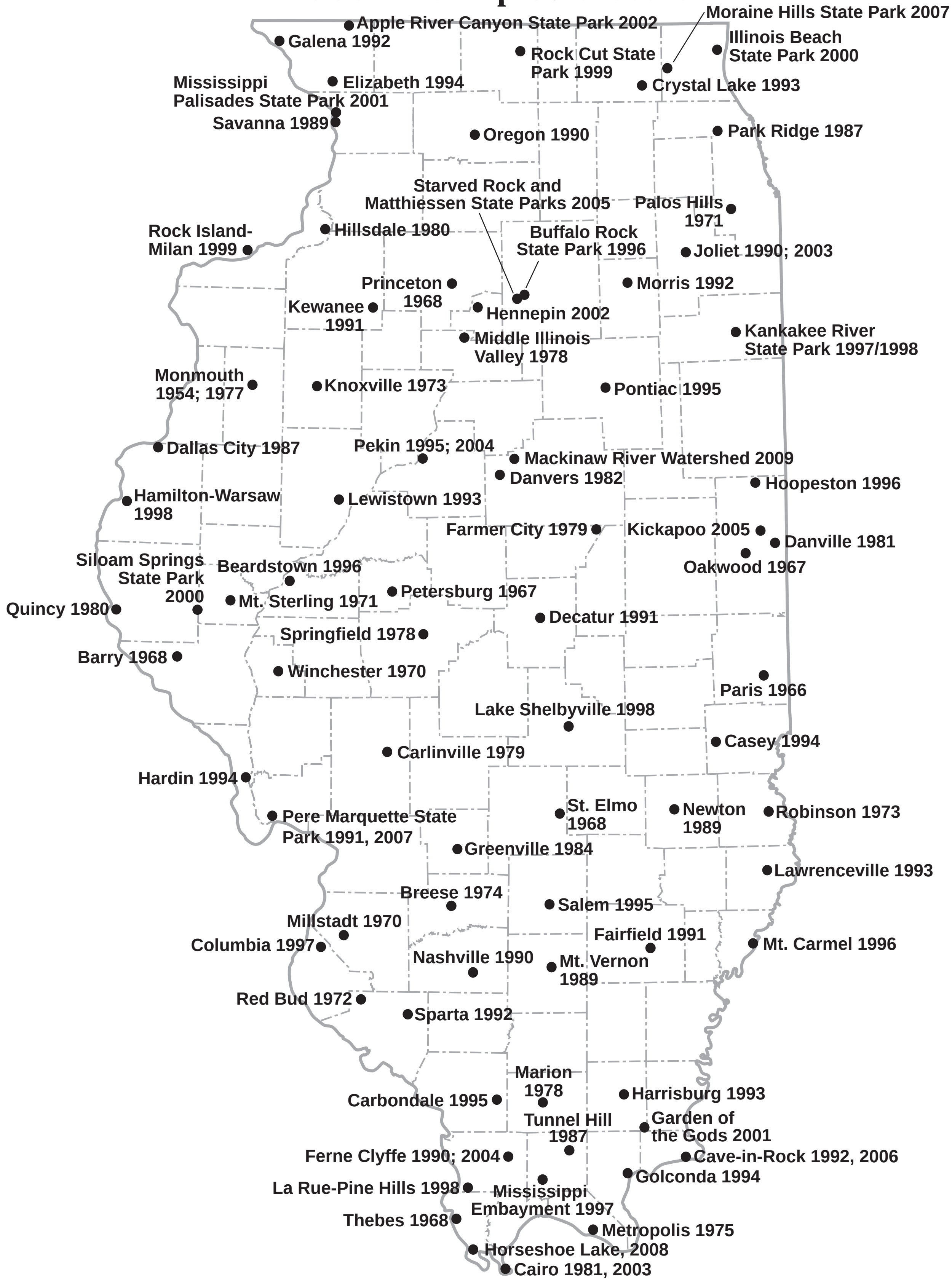

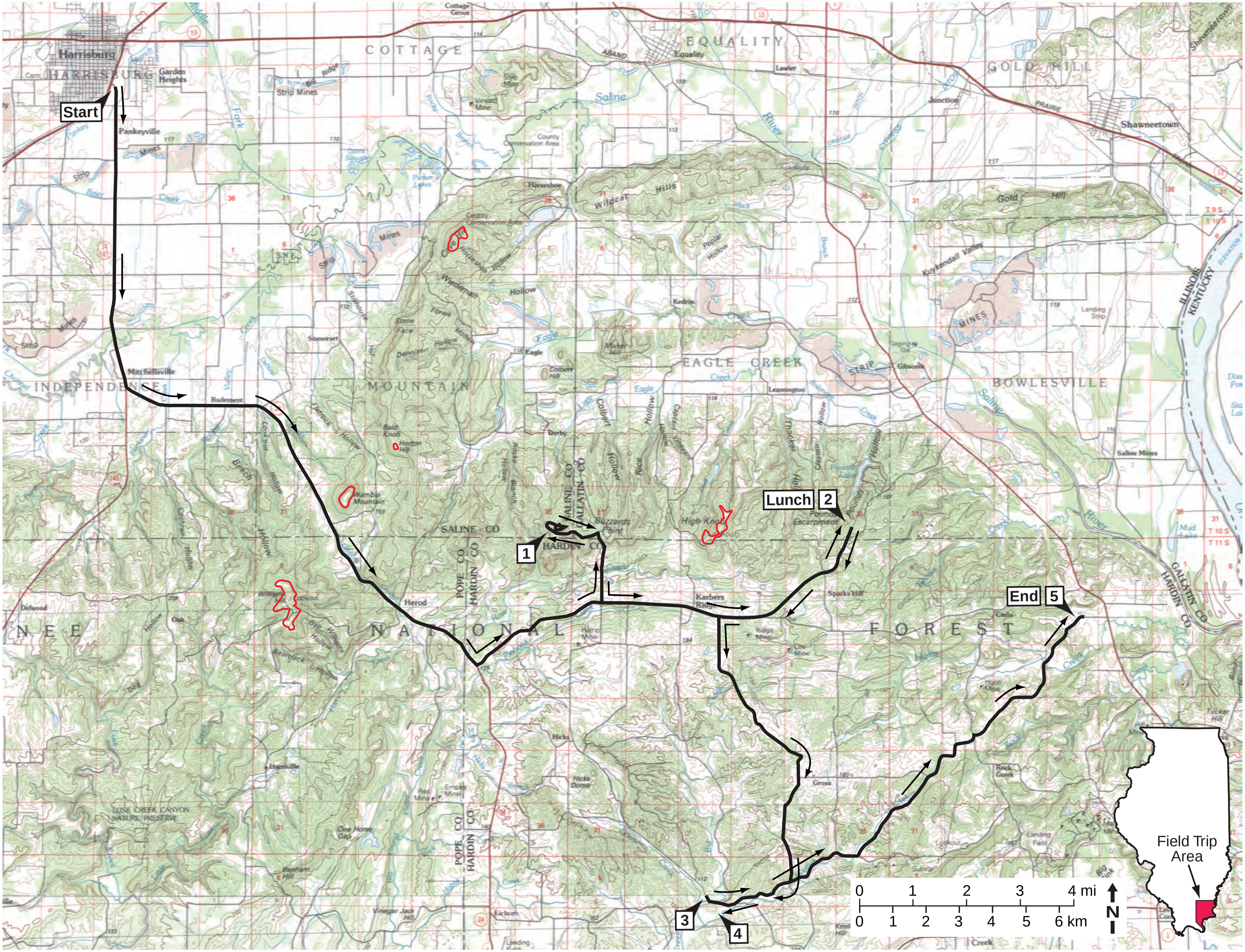

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