


# Guide to the Geology of the Carbondale Area Jackson, Union and Williamson Counties, Illinois

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Field Trip Guidebook 1995D October 28, 1995

Department of Natural Resources  
ILLINOIS STATE GEOLOGICAL SURVEY



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ILLINOIS STATE GEOLOGICAL SURVEY  
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Champaign, IL 61820-6964

**Cover photo** Saltpeter Cave in bluff of Battery Rock Sandstone, Caseyville Formation  
(photo by W. T. Frankie).

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

A list of guidebooks of earlier field trips for planning class tours and private outings may be obtained by contacting the Educational Extension Unit, Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820. Telephone: (217) 244-2427 or 333-4747.

Seven USGS 7.5-minute topographic quadrangle maps (all available from the ISGS) provide coverage for the area of the field trip: Carbondale, Cobden, Crab Orchard Lake, Lick Creek, Makanda, and Pomona.



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Era	Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks	
CENOZOIC "Recent Life"	Quaternary 0-500'	Holocene	10,000	Recent - alluvium in river valleys	
		Pleistocene Glacial Age		Glacial till, glacial outwash, gravel, sand, silt, lake deposits of clay and silt, loess and sand dunes; covers nearly all of state except northwest corner and southern tip	
	Tertiary 0-500'	Pliocene	1.6 m. 5.3 m. 36.6 m.	Chert gravel, present in northern, southern, and western Illinois	
		Eocene		Mostly micaceous sand with some silt and clay; present only in southern Illinois	
		Paleocene	57.8 m. 66.4 m.	Mostly clay, little sand; present only in southern Illinois	
MESOZOIC "Middle Life"	Cretaceous 0-300'		144 m. 286 m.	Mostly sand, some thin beds of clay and, locally, gravel; present only in southern Illinois	
PALEOZOIC "Ancient Life"	Pennsylvanian 0-3,000' ("Coal Measures")			Largely shale and sandstone with beds of coal, limestone, and clay	
	Mississippian 0-3,500'		320 m.	Block 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	
	Devonian 0-1,500'		360 m.	Thick limestone, minor sandstones and shales; largely chert and cherty limestone in southern Illinois; block shale at top	
	Silurian 0-1,000'		408 m.	Principally dolomite and limestone	
	Ordovician 500-2,000'		438 m.	Largely dolomite and limestone but contains sandstone, shale, and siltstone formations	
	Cambrian 1,500-3,000'		505 m.	Chiefly sandstones with some dolomite and shale; exposed only in small areas in north-central Illinois	
	Precambrian		570 m.	Igneous and metamorphic rocks; known in Illinois only from deep wells	

Generalized geologic column showing succession of rocks in Illinois.



## CARBONDALE AREA

On this geological science field trip, you will have an opportunity to become acquainted with the geology\*, landscape, and mineral resources of parts of Jackson, Williamson, and Union Counties, Illinois. The city of Carbondale is in southwestern Illinois, approximately 330 miles southwest of Chicago, 160 miles south of Springfield, 120 miles southeast of St. Louis, and 60 miles north of Cairo.

### GEOLOGIC FRAMEWORK

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

Geologists seldom see Precambrian rocks in Illinois except as cuttings and cores from drill holes. To determine some of the characteristics of the basement complex, they use various techniques, such as surface mapping, measurements of Earth's gravitational and magnetic fields, and seismic exploration. The evidence indicates that in southernmost Illinois, near what is now the Kentucky–Illinois Fluorspar Mining District, *rift* valleys like those in east Africa formed as movement of crustal plates (plate tectonics) began to rip apart the Precambrian-age North American continent. These rift valleys in the midcontinent region are referred to as the Rough Creek Graben and the Reelfoot Rift (fig. 1).

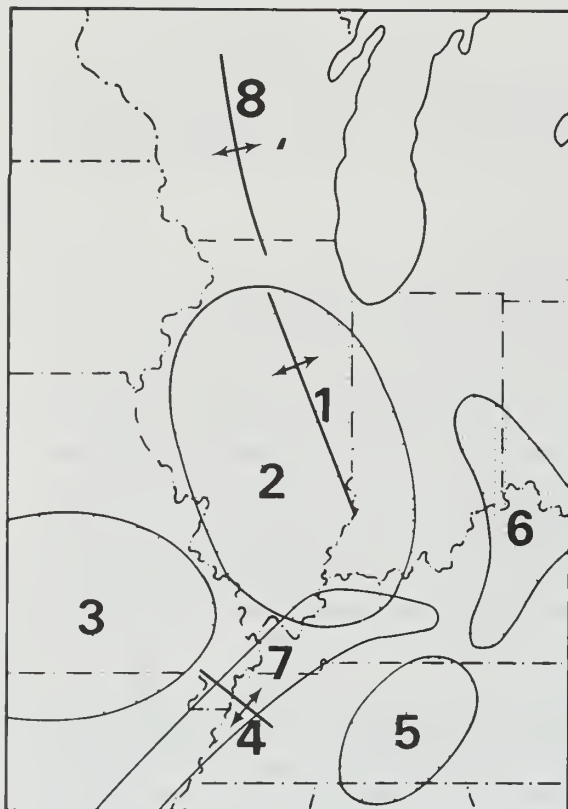
**Paleozoic Era** Near the beginning of the Paleozoic Era about 570 million years ago, the rifting stopped and the hilly Precambrian landscape began to sink slowly on a broad regional scale, and allowed the invasion of a shallow sea from the south and southwest. During the several hundred million years of the Paleozoic Era, the area that is now southern Illinois continued to accumulate sediments deposited in the shallow seas that repeatedly covered it. The region continued to sink until at least 15,000 feet of sedimentary strata were deposited. At 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 from more than 520 million years (the Cambrian *Period*) to less than 290 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 (the oldest formations are at the bottom right of the column).

The elevation of the top of the Precambrian basement rocks in the field trip area range from less than 7,000 feet below sea level in western Jackson and Union Counties to more than 11,000 feet below sea level in eastern Jackson and Union Counties. The Paleozoic sedimentary strata range from about 7,100 feet thick in northwestern Jackson County to about 11,250 feet in the eastern-central portion of Jackson County. In Union and Williamson Counties, the bedrock is exposed and erosion has reduced the thickness of the rocks.

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\*Words in italics are defined in the glossary at the back of the guidebook. Also please note: although all present localities have only recently appeared in the geologic time frame, we use the present names of places and geologic features because they provide clear reference points for describing the ancient landscape.



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

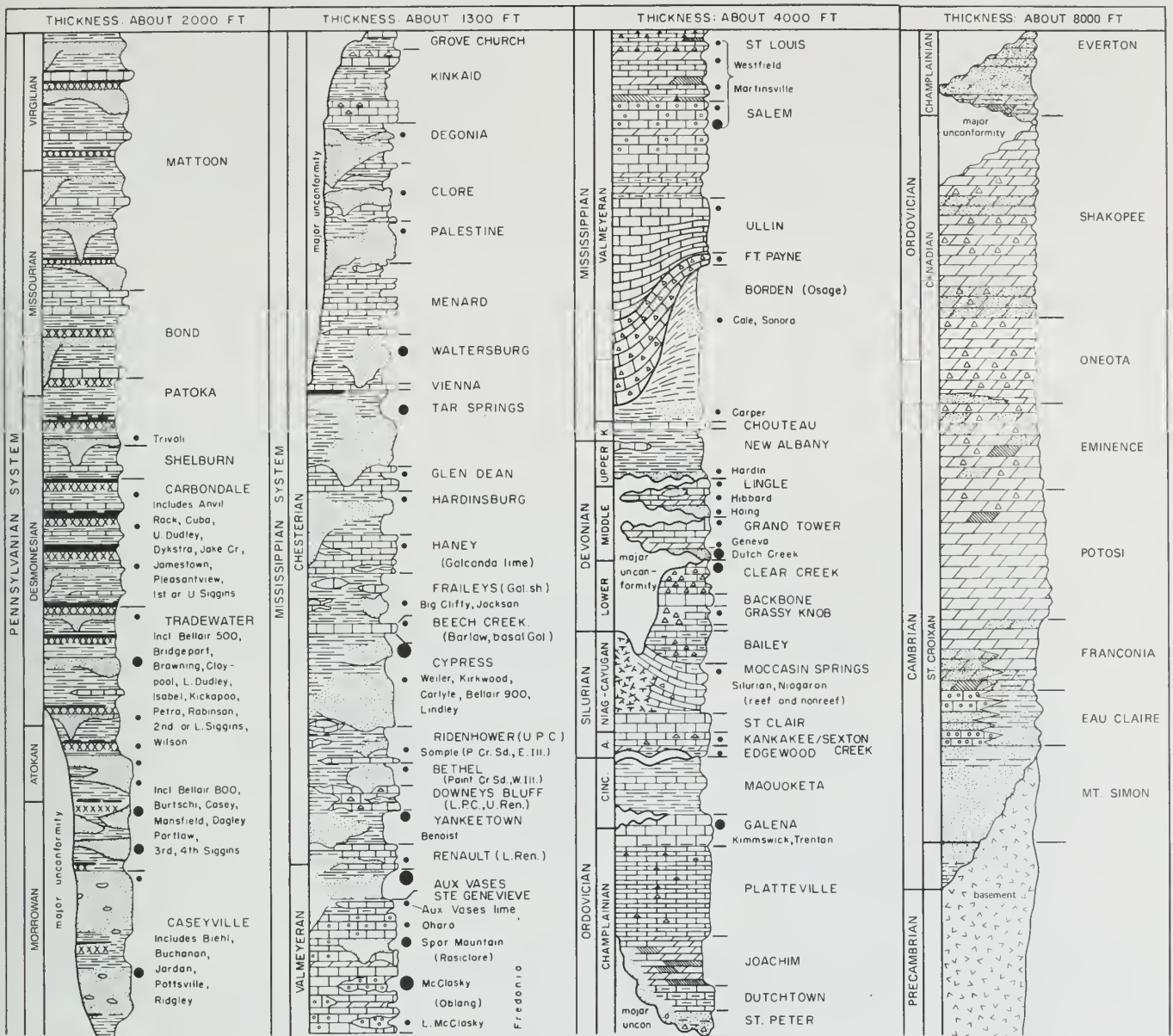
Pennsylvanian-age bedrock strata consisting of shale, siltstone, sandstone, limestone, coal, and underclay were deposited as sediments in shallow seas and swamps between about 320 and 288 million years ago. They are found immediately beneath a cover of glacial deposits in the northern portion of Jackson County and are exposed at the surface in southern Jackson County along the Pennsylvanian *escarpment*. These rocks are exposed in the numerous abandoned coal strip mines, road cuts, and stream cuts. Pennsylvanian strata, although eroded away in southwestern Jackson County, increase in thickness to more than 1,200 feet in northeastern Jackson County. (See *Depositional History of the Pennsylvanian Rocks* in the supplemental reading at the back of this guidebook for a more complete description of these rocks.)

Mississippian-age bedrock strata are found immediately beneath the Pennsylvanian rocks and outcrop in southwestern Jackson County and northern Union County. Rocks exposed within the field trip area are included in the Chesterian Series (Upper Mississippian) and consist of limestones, sandstones, and shales, with the sandstones and shales dominant. These rocks were deposited as sediments in shallow seas between 360 and 320 million years ago. The formations are part of the thick succession of Mississippian strata in the Upper Mississippi River Valley in Illinois that constitute the "type section" for rocks of the Mississippian Period throughout the world. Mississippian strata, although eroded away in extreme southwestern Jackson County, increase in thickness to more than 2,400 feet in eastern Jackson County. (See *Depositional History of the Mississippian Rocks* in the supplemental reading at the back of this guidebook for a more complete description of these rocks.)

### STRUCTURAL AND DEPOSITIONAL HISTORY

As noted previously, the midcontinent rift valleys (the Rough Creek Graben and the Reelfoot Rift, figs. 1 and 3) formed during Precambrian tectonic activity. These valleys became filled with sand and gravel shed from the adjacent uplands as they rose and with limestone deposited in the shallow seas that periodically covered the area.

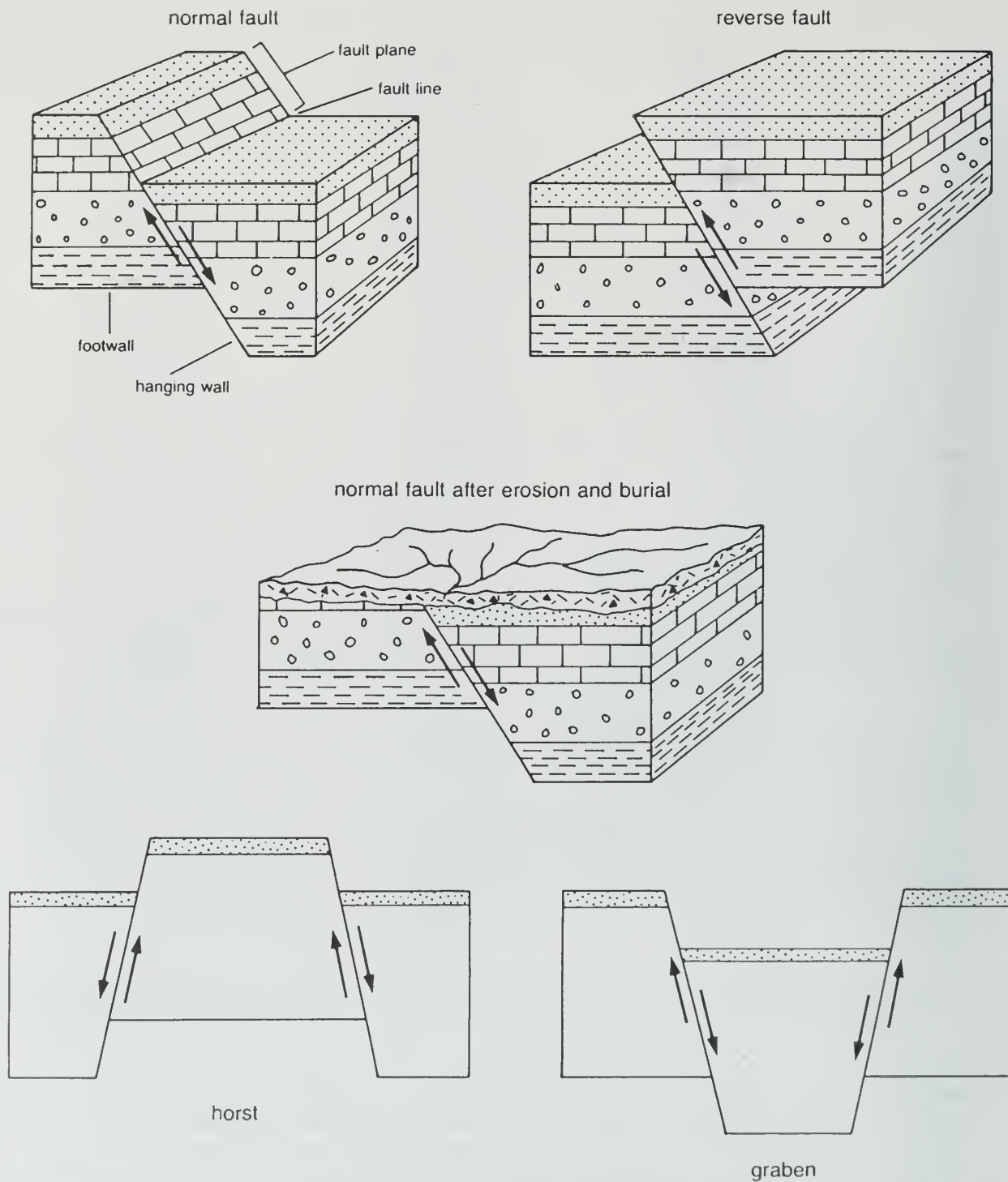




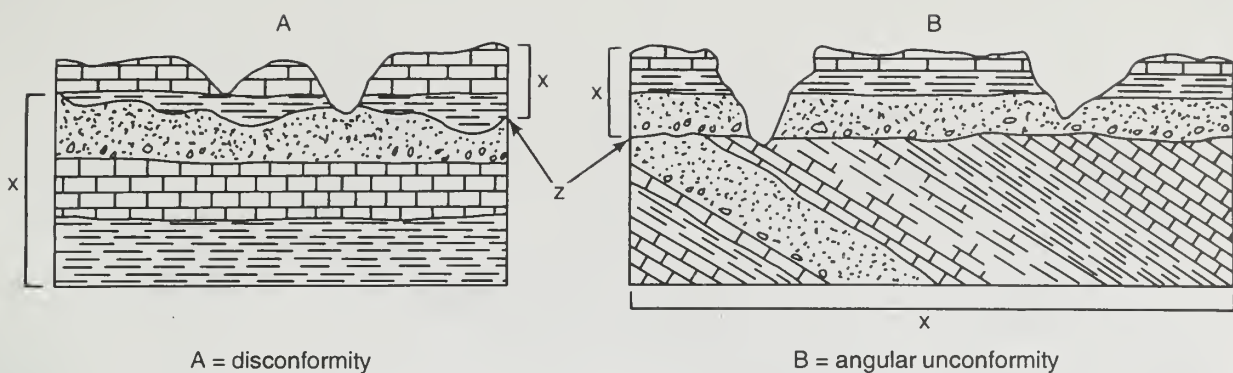
**Figure 2** Generalized stratigraphic column of the field trip area. Black dots indicate oil and gas pay zones (variable vertical scale; from Leighton et al. 1991).

**Paleozoic History** During the Paleozoic Era, sediments accumulated in the shallow seas that 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 like an embayment. The southern part of Illinois and adjacent parts of Indiana and Kentucky sank more rapidly than areas to the north, allowing a greater thickness of sediment to accumulate. Earth's thin crust was periodically flexed and warped as stresses built up in places. These movements caused repeated invasions and withdrawals of the seas across the region. Former sea floors were thus periodically exposed to erosion, which erased some sediments from the rock record.

Many of the sedimentary units, called formations, have conformable contacts that is, no significant interruption in deposition occurred as one formation was succeeded by another (figs. 2 and 4). In some instances, even though the composition and appearance of the rocks change significantly



**Figure 3** Diagrammatic illustrations of fault types that may be present in the field trip area (arrows indicate relative directions of movement on each side of the fault).



**Figure 4** Schematic drawings of (A) a disconformity and (B) an angular unconformity (x represents the conformable rock sequence and z is the plane of unconformity).

at the contact between two formations, the *fossils* in the rocks and the relationships between the rocks at the contact indicate that deposition was continuous. In some places, however, the top of the lower formation was at least partially eroded before deposition of the next formation began. Fossils and other evidence in the two formations indicate that there is a significant age difference between the lower unit and the overlying one. This type of contact is called an *unconformity* (fig. 4). If the beds above and below an unconformity are parallel, the unconformity is called a *disconformity*; if the lower *beds* have been tilted by tectonic forces and eroded before the overlying beds were deposited, the contact is called an angular unconformity. Five major unconformities are shown in the rock columns in figure 2. Each represents an extended interval of time for which there is no rock record. Smaller unconformities also are shown in figure 2 as wavy lines; these generally represent shorter time intervals or more localized events. At these points less material is missing from the record.

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 5). This is a complex structure having smaller structures such as domes, *anticlines*, and *synclines* superimposed on the broad upwarp of the anticlinorium. Gradual arching continued through the Pennsylvanian. 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 know just when movement along the belt ceased—perhaps it was by the end of the Pennsylvanian or during the Permian Period a little later, near the close of the Paleozoic Era.

During the Mesozoic Era, which followed the Paleozoic Era, the rise of the Pascola Arch (fig. 1) in southeastern Missouri and western Tennessee formed 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 deeper parts of the area to the north, gave the basin its present asymmetrical, spoon-shaped configuration (fig. 6). The geologic map (fig. 7) shows the distribution of the rock *systems* of the various geologic time periods as they would appear if all the glacial, windblown, and surface materials were removed.

The Carbondale field trip area is located on the southwestern edge of the Illinois Basin. It is bounded by the Cottage Grove Fault System to the north, the Ste. Genevieve Fault Zone to the south, and the Bodenschatz-Lick Fault Zone to the west (fig. 5). Structural features within the field trip area include the east-west-trending Pomona Fault in southern Jackson County; two north-south-trending faults (Shiloh Church Fault and Bradshaw Creek Fault), both in northern Union County; and the north-east-southwest-trending Saratoga Anticline, also in northern Union County.

Younger rocks of the latest Pennsylvanian and perhaps the Permian (the youngest rock system of the Paleozoic) may at one time have covered the Jackson County area. It is possible that Mesozoic and Cenozoic rocks (see generalized geologic column) could also have been present here.



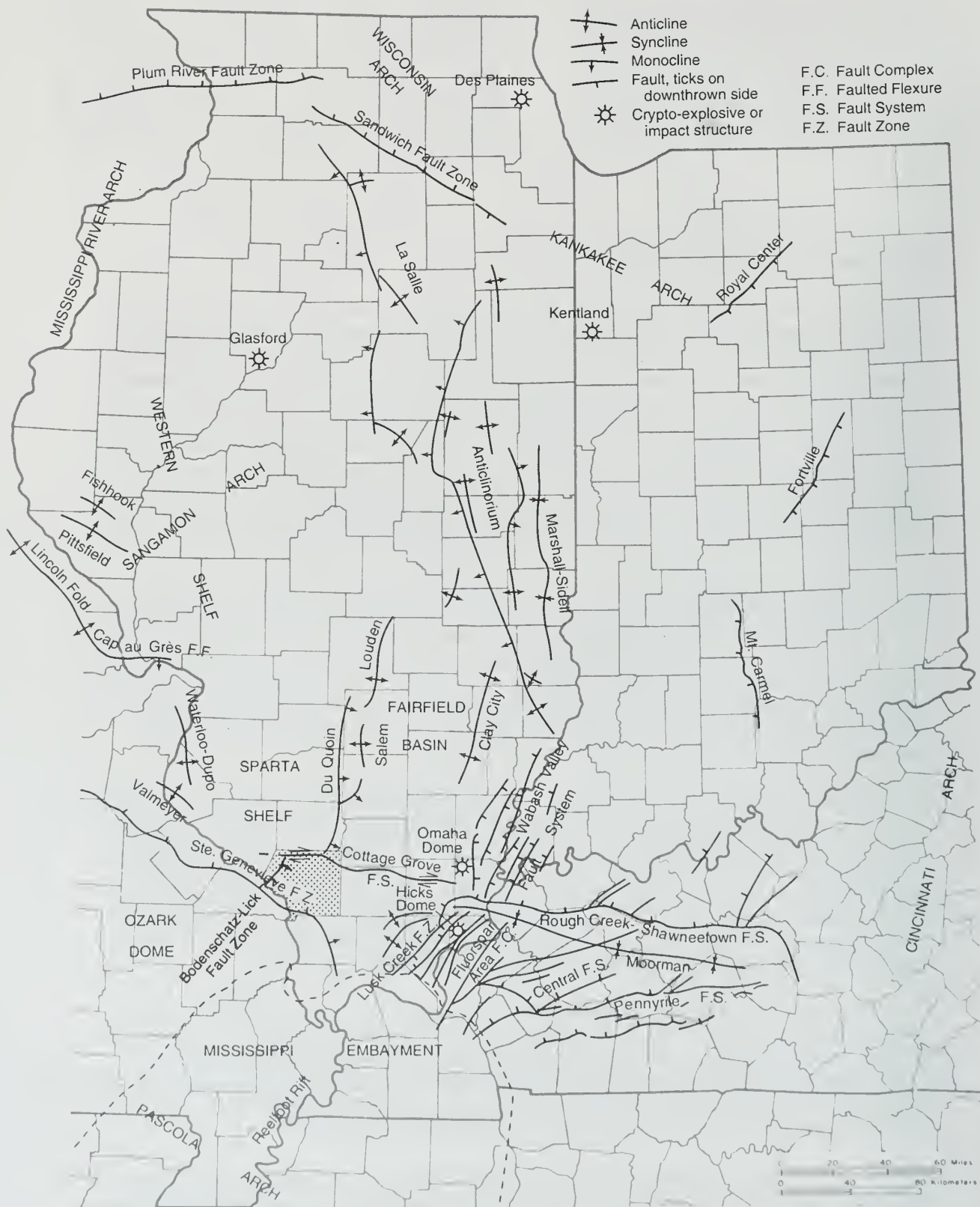
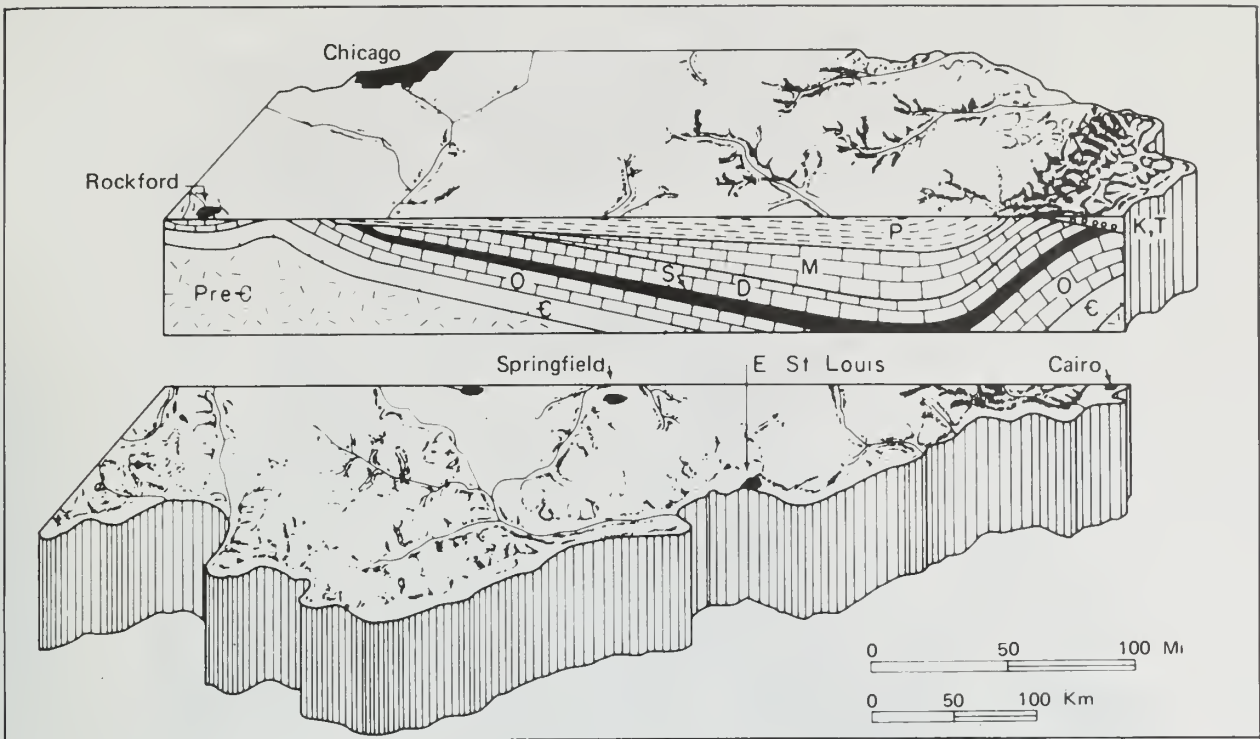


Figure 5 Structural features of Illinois (modified from Buschbach and Kolata 1991).



**Figure 6** Stylized north-south cross section shows the structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks has been greatly exaggerated and younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-Є) granites. They form a depression filled with layers of sedimentary rocks of various ages: Cambrian (Є), Ordovician (O), Silurian (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). Scale is approximate.

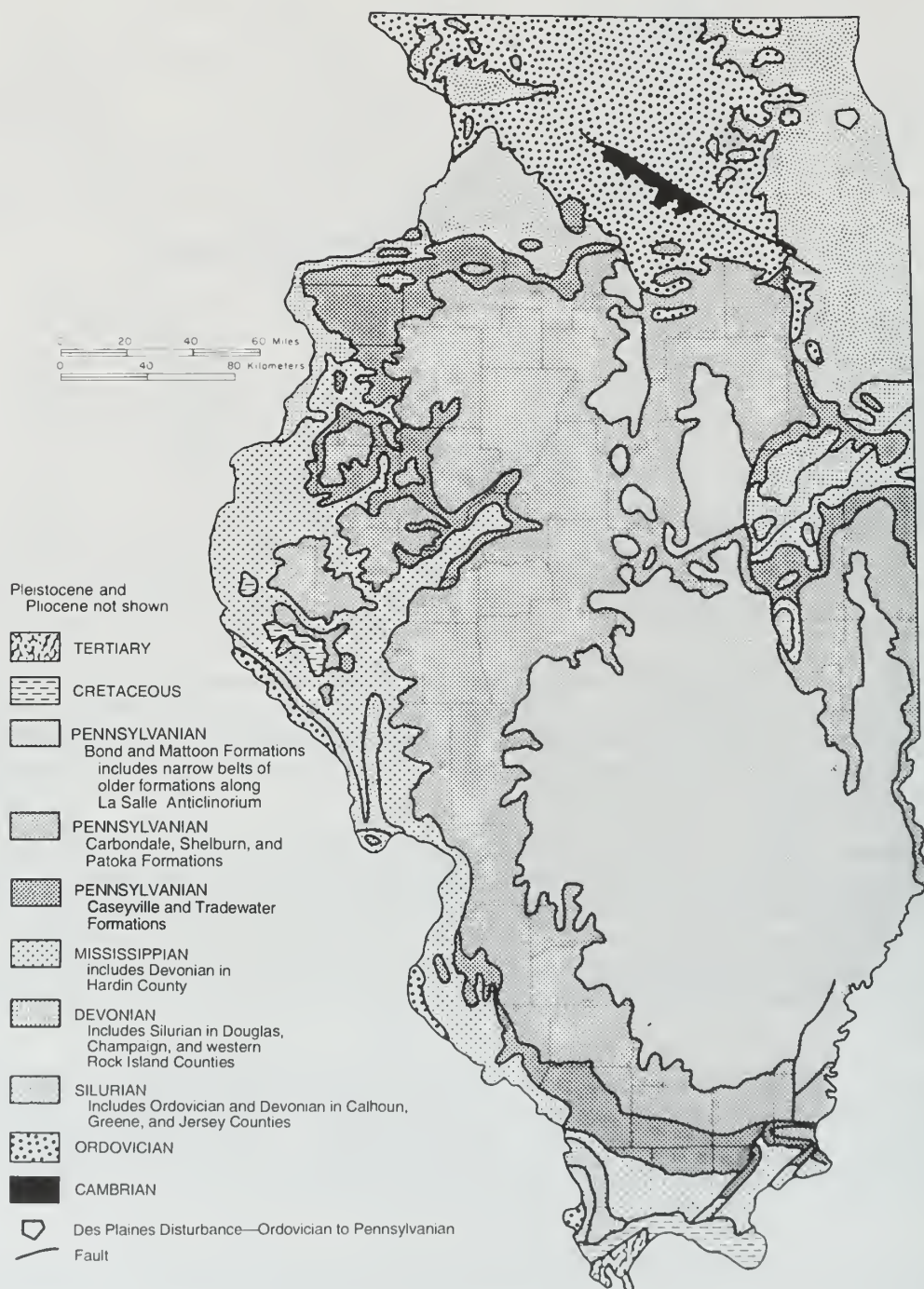
Indirect evidence, based on the stage of development (rank) of coal deposits and the generation and maturation of petroleum from source rocks (Damberger 1971), indicates that perhaps as much as a 1.5-mile-thickness of latest Pennsylvanian and younger rocks once covered southern Illinois. However, during the more than 240 million years since the end of the Paleozoic Era (and before the onset of *glaciation* 1 to 2 million years ago), several thousands of feet of strata may have been eroded. Nearly all traces of any post-Pennsylvanian bedrock that may have been present in Illinois were removed.

During this extended period of erosion, deep valleys were carved into the gently tilted bedrock formations. Later, the topographic *relief* was reduced by repeated advances and melting back of continental *glaciers* that scoured and scraped the bedrock surface. This glacial erosion affected all the formations exposed at the bedrock surface in Illinois. The final melting of the glaciers left behind the nonlithified deposits in which our modern soil has developed.

**Glacial History** A brief general history of glaciation in North America and a description of the deposits commonly left by glaciers may be found in *Pleistocene Glaciations in Illinois* at the back of the guidebook.

Erosion that took place long before the glaciers advanced across the state left a network of deep valleys carved into the bedrock surface (fig. 8). Prior to glaciation, Jackson County and adjacent areas to the north, northeast, and west was drained by a northeast-southwest-trending ancient bedrock valley called the Big Muddy Drainage Basin. After glaciation, a new drainage system and its tributaries reestablished itself along the same trend of the older Big Muddy Drainage Basin.





**Figure 7** Bedrock geology beneath surficial deposits in Illinois.

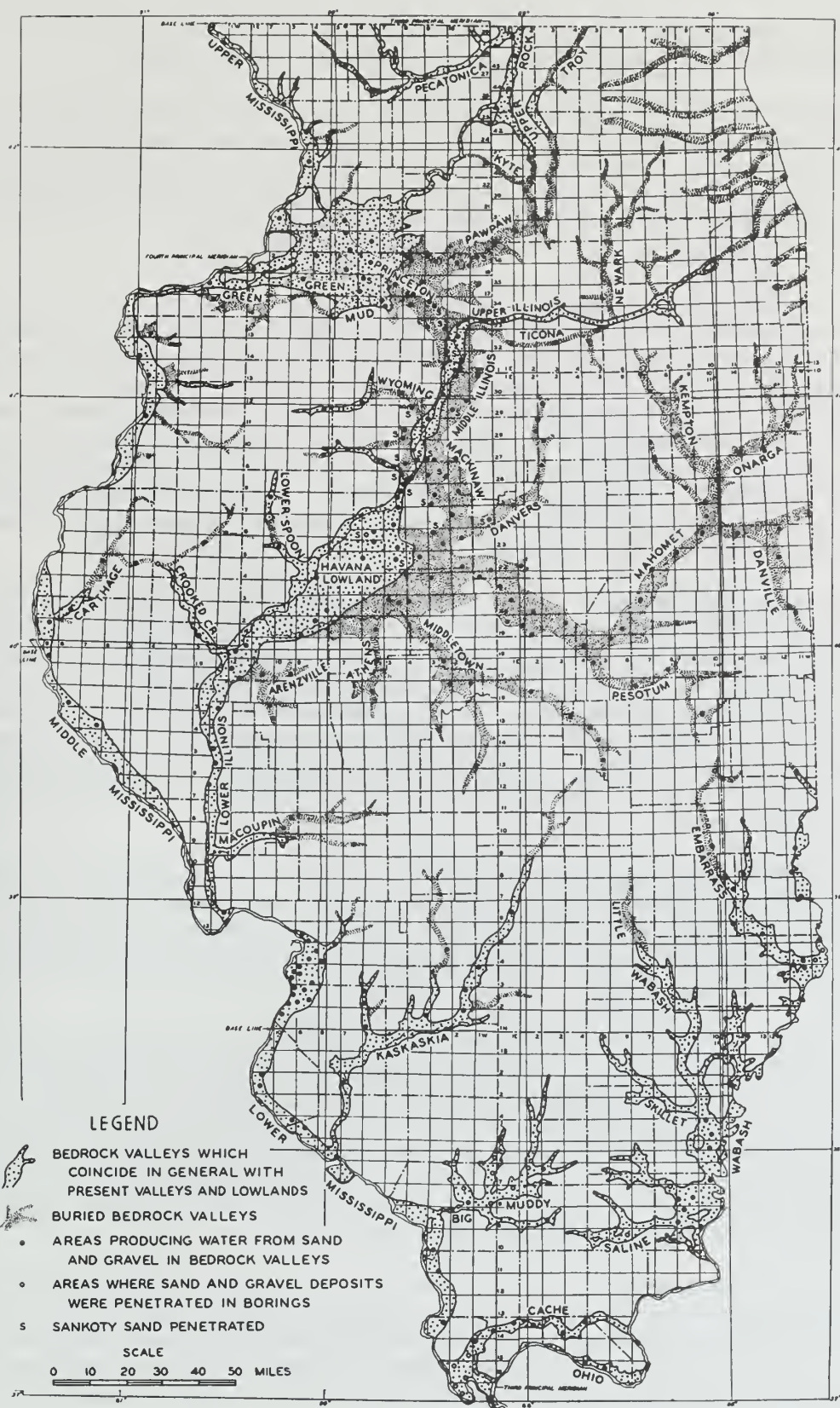


Figure 8 Bedrock valleys of Illinois (modified from Horberg 1950).



This new drainage system is called the Big Muddy River. Because of the irregular bedrock surface and erosion, glacial *drift* is unevenly distributed across Jackson County.

During the Pleistocene *Epoch*, beginning about 1.6 million years ago, massive sheets of ice (called continental glaciers), thousands of feet thick, flowed slowly southward from Canada. The last of these glaciers melted from northeastern Illinois about 13,500 years before the present (B.P.). During the Illinoian glaciation (now also called the Illinois Episode), which began around 300,000 years B.P., North American continental glaciers reached their southernmost position approximately 20 miles southeast of Carbondale in the northern part of Johnson County (fig. 9).

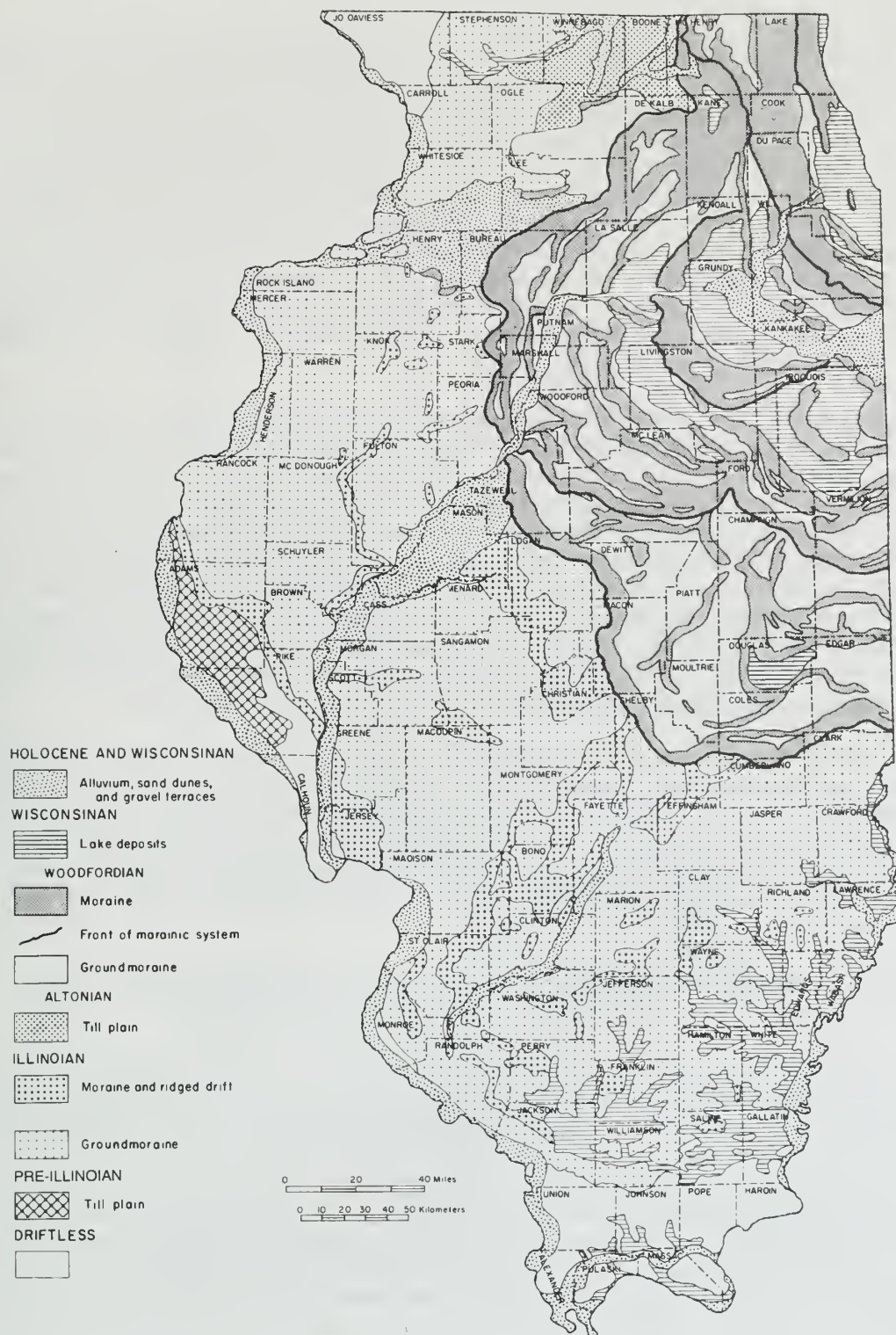
Until recently, glaciologists assumed that these glaciers may have been 1 mile or more thick. However, the maximum thickness of the ice may have been only about 2,000 feet in the Lake Michigan Basin and about 700 feet across most of the Illinois land surface (Clark et al. 1988). That conclusion was made using several lines of research evidence: (1) the degree of consolidation and compaction of rock and soil materials that must have been under the ice, (2) comparisons between the inferred geometry and configuration of the ancient ice masses and those of present glaciers and ice caps, (3) comparisons between the mechanics of ice-flow in present glaciers and ice caps and those inferred from detailed studies of the ancient glacial deposits, and (4) the amount of rebound of the Lake Michigan Basin as the heavy mass of glacial ice, which had depressed the land beneath it, melted and released the pressure.

The *topography* of the bedrock surface throughout much of Illinois is largely hidden from view by glacial deposits except along the major streams. In many areas, the glacial drift is thick enough to completely mask the underlying bedrock surface. However, the glacial deposits within the northern portion of the field trip area are thin and only slightly modify the underlying bedrock surface. Most of Jackson County is covered by either glacial moraine and ridged drift, or ground moraine of the Illinois Episode glaciation. In the northeastern part of the county the Illinois Episode deposits are overlain by Wisconsin Episode lake deposits. These lake sediments were deposited during the Woodfordian *Subage*, which began about 22,000 B.P. (See *Pleistocene Glaciations in Illinois* at the back of the guidebook).

Although the Illinois Episode glaciers probably built morainic ridges similar to those of the later Wisconsin Episode glaciers, the Illinois Episode moraines apparently were not so numerous and have been exposed to weathering and erosion for thousands of years longer than their younger counterparts of the Wisconsin Episode. For these reasons, features formed during the Illinois Episode generally are not as conspicuous as those formed during the Wisconsin Episode.

A thin cover of windblown silt called Peoria *Loess* (pronounced "luss") mantles the glacial drift in Jackson County. Thickness of the loess decreases from approximately 25 feet adjacent to the Mississippi River in southwestern Jackson County to less than 5 feet in extreme northeastern Jackson County. This fine-grained dust, which covers most of Illinois, reaches thicknesses exceeding 25 feet along the Mississippi and Illinois Rivers, and is as much as 80 feet thick on the east bluff of the Mississippi Valley in the East St. Louis area. (Loess deposits are described in *Ancient Dust Storms in Illinois*, ISGS Geogram 5, at the back of the guidebook.) Soils in this area have developed in the loess and the underlying weathered silty, clayey Illinoian *till*.

Within 1 to 3 miles of the outer edge of the area glaciated during the Illinois Episode, the drift is rarely more than 10 feet thick and has a patchy distribution (Willman and Frye, 1980). This patchy distribution is mostly related to postglacial erosion and subsequent dissection of the Illinoian till plain. North of this thinned area, the drift averages about 35 feet in thickness, absent only where locally eroded along stream valleys, and has the relatively flat topography expected for the Illinoian till plain (Willman and Frye 1980).



**Figure 9** Generalized map of glacial deposits in Illinois (modified from Willman and Frye 1970).



## GEOMORPHOLOGY

**Physiography** The Carbondale area is located in two distinct physiographic provinces in Illinois (Leighton et al. 1948): the Mt. Vernon Hill Country of the Till Plains Section of the Central Lowland Physiographic Province, and the Shawnee Hills Section of the Interior Low Plateaus Province (fig. 10). The northern part of the area, the Mount Vernon Hill Country, comprises the southern portion of the Illinoian drift sheet. 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. The southern part of the area, 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; a cuesta (ridge with a gentle slope on one side and a steep slope on the other) of lower Pennsylvanian rocks generally forms its northern margin and its southern part is composed of a dissected plateau underlain largely by Mississippian rocks.

According to Leighton et al. (1948), an extensive lowland called the central Illinois *peneplain* (a low, nearly featureless, gently undulating land surface) had been eroded into the Pennsylvanian rocks prior to glaciation. In the Mt. Vernon Hill Country, remnants of an older erosion surface are preserved on the uplands of this peneplain. A system of deep bedrock valleys, many of which are occupied by present streams, were entrenched below the level of the peneplain uplands. This preglacial topography is largely responsible for determining many of the local features of the Mt. Vernon Hill Country area. In the Shawnee Hills Section, remnants of a preglacial land surface called the Ozark Plateaus are extensive along the Pennsylvanian escarpment (a long, more or less continuous cliff or steep slope facing in one general direction, generally marking the outcrop of a resistant layer of rocks). Locally higher summits and some lower surfaces on Mississippian rocks indicate a complex erosional history that continued during the glacial period.

**Drainage** In the area of the field trip, drainage is controlled by the location of the Pennsylvanian escarpment, which forms a natural drainage divide. North of the escarpment the Big Muddy River is the major tributary; it empties into the Mississippi River in extreme southwestern Jackson County south of Grand Tower. Drainage south of the Pennsylvanian escarpment, within the area of the field trip, is towards the Cache River, which empties into the Ohio River south of Mound City. The Cache River forms part of the boundary between Alexander and Pulaski Counties near its intersection with the Ohio River.

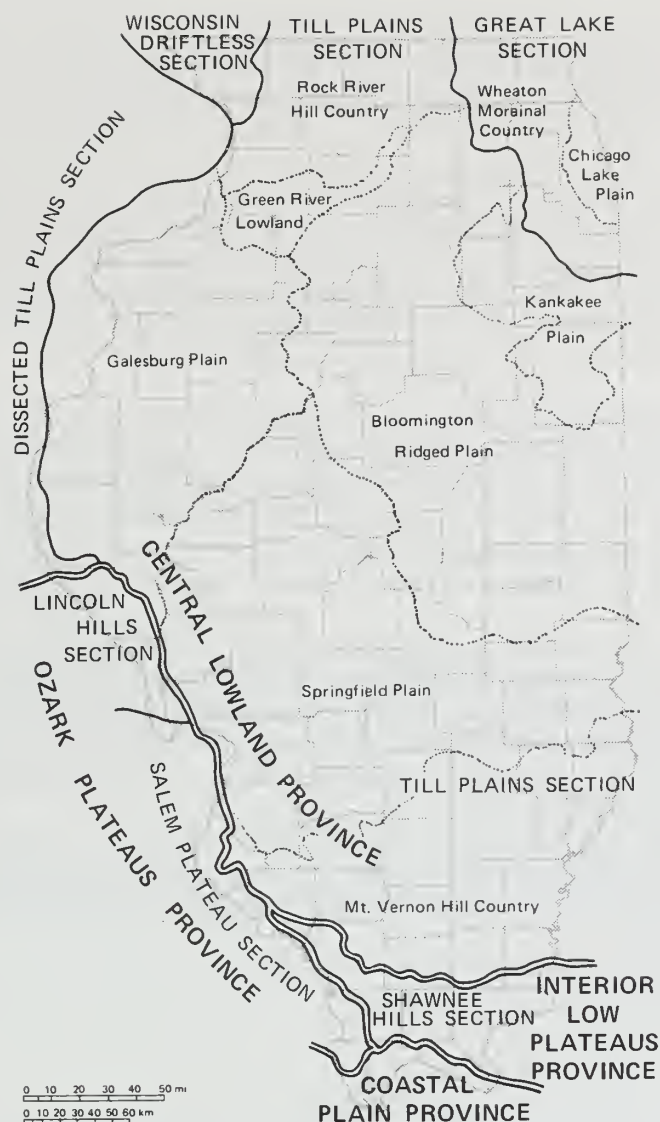
The Big Muddy River and its tributaries have incised a relatively thin cover of Illinoian till and Pennsylvanian sedimentary rocks along the northern edge of the escarpment.

**Relief** The highest land surface in the field trip area is Bald Knob, where the elevation is 1,020 feet above mean sea level (msl). Bald Knob, the third highest point in Illinois, is located southwest of stop 3 and can be viewed from the scenic overlook along county highway 2, southeast of Alto Pass. West of stop 4 is another high point of interest, Tiptop Knob, with an elevation of 888 feet above msl. The lowest elevation is about 400 feet above msl along Cave Creek south of stop 2 at the Pomona Natural Bridge. The surface relief of the field trip area, calculated as the difference between the highest and lowest surfaces, is about 620 feet. *Local relief* is most pronounced along the route between Alto Pass and Cobden where the road follows along the crest of the Pennsylvanian escarpment. Along the escarpment, local relief can exceed 300 feet within a distance of 1/2 mile or less.

## MINERAL RESOURCES

**Mineral production** Of the 102 counties in Illinois, 98 reported *mineral* production during 1992, the last year for which complete records are available. "Complete" is somewhat inaccurate because data on stone production have been reported only for the odd-numbered years and sand and





**Figure 10** Physiographic divisions of Illinois.

gravel production, only for the even-numbered years. Furthermore, not all companies have reported their production figures and values to the U.S. Bureau of Mines.

Estimates for the total stone production for 1992 (actually 1991 production) are included in the total value given for mineral production. The total value of all minerals extracted, processed, and manufactured in Illinois during 1992 was \$2,894,300,000, 0.5% less than the 1991 total. Minerals extracted accounted for 90% of this total. Coal continued to be the leading commodity, accounting for 64% of the total, followed by industrial and construction materials at 21.4% and oil at 14.2%. The remaining 0.4% included metals, peat, and gemstones. Illinois ranked 13th among the 31 oil-producing states in 1992 and 16th among the 50 states in total production of nonfuel minerals, but it continues to lead all other states in the production of fluorspar, industrial sand, and tripoli.

Jackson County ranked 59th among all Illinois counties in 1992 on the basis of the value of all minerals extracted, processed, and manufactured. Economic minerals currently mined in Jackson County include coal, stone, sand and gravel, and crude oil.

Of the 18 counties reporting coal production in 1992, Jackson County ranked 18th with 9,242 tons. All production was from the Central Mining Company's Burning Star No. 1 mine, a strip mine producing from the Herrin coal. Coal has been mined primarily from the Herrin, Springfield, Murphysboro, and Seahorne Coals. Cumulative production for the county equals 128,239,232 tons.

**Groundwater** Groundwater is a mineral resource frequently overlooked in assessments of an area's natural resource potential. The availability of an ample supply of clean water is essential for economic and community development. More than 48% of the state's 11 million citizens and 97% of those who live in rural areas depend on groundwater for their water supply. Groundwater is derived from underground formations called *aquifers*. The water-yielding capacity of an aquifer can only be evaluated by constructing wells into it. After construction, the wells are pumped to determine the quality and quantity of groundwater available for use.

Because glacial deposits occur in this area, sand and gravel deposits are common through most of the county. Most of these deposits are thin, however, and do not yield large amounts of water. The exception is in southwestern Jackson County where thick permeable deposits of sand and gravel occur in the bottomlands of the Mississippi River (figs. 8 and 9). Some thin, scattered deposits of sand and gravel adequate for farmstead or domestic supplies are present in the partially buried bedrock valley of the Big Muddy Drainage Basin in the northeastern part of the county (Pryor 1956).

Groundwater from bedrock aquifers is easily obtained through most of Jackson County. In the northeast, the bedrock aquifers occur in the Pennsylvanian sandstone. In the southwest, the aquifers are in the creviced Mississippian Valmeyeran limestones. In the southeast, the aquifers are in the Mississippian Kinkaid Limestone and Degonia Sandstone, and in the extreme southwestern part of the county aquifers occur in the Devonian limestones (Pryor, 1956). The depth to these bedrock aquifers varies throughout the county.

In addition to the groundwater aquifers, a number of communities obtain their water supplies from manmade lakes. The city of Carbondale withdraws its municipal water supply from the Carbondale Reservoir.

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## GUIDE TO THE ROUTE

Assemble at Southern Illinois University's parking lot 10B, off Lincoln Drive, north of the football stadium and east of Parkinson Hall (NW NW NE, Sec. 28, T9S, R1W, 3rd P.M., Jackson County, Carbondale 7.5-Minute Quadrangle [37089F2]\*). We'll start calculating mileage at the intersection of Lincoln Drive and US 51.

**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. At road crossings protected by an Illinois State Geological Survey vehicle with flashing lights, please obey the signals of the ISGS staff member directing traffic. When we stop, park as close as possible to the car in front of you and turn off your lights.

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

- Do not litter the area.
- Do not climb on fences.
- Leave all gates as you found them.
- Treat *public* property as if you were the owner—which you are!

When using this booklet for another field trip with 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.

Seven USGS 7.5-minute topographic quadrangle maps (all available from the ISGS) provide coverage for the area of the field trip: Carbondale, Cobden, Crab Orchard Lake, Lick Creek, Makanda, and Pomona.

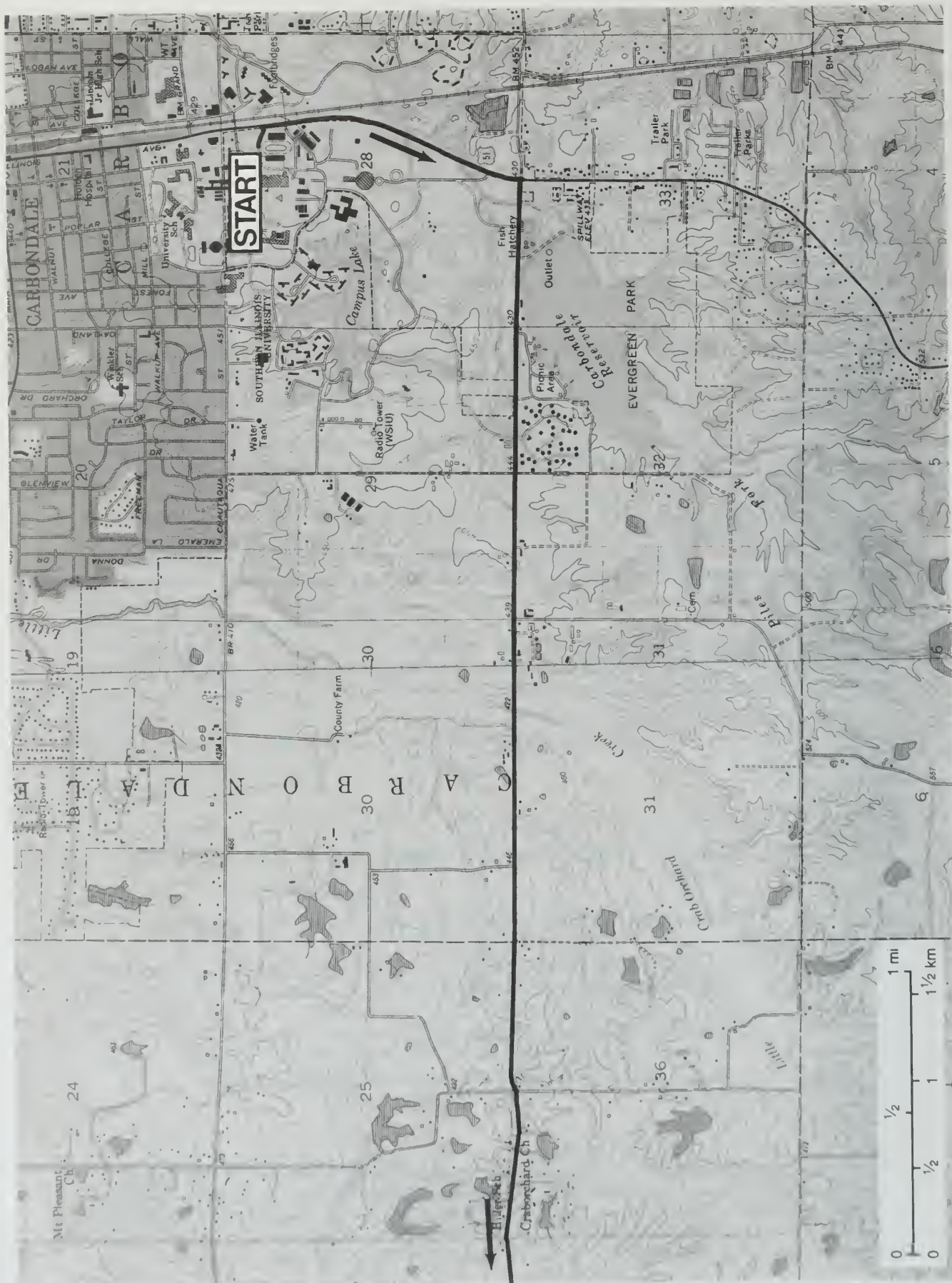
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Miles to next point	Miles from start	
0.0	0.0	CAUTION: stoplight. Intersection of Lincoln Drive and US 51. TURN RIGHT (south).
0.45	0.45	View the arena at Southern Illinois University (SIU) on the right.
0.25	0.7	CAUTION: stoplight. TURN RIGHT (west) onto Pleasant Hill Road. Note the Carbondale Reservoir spillway to the left.
1.3	2.0	CAUTION: intersection (McLafferty Road). CONTINUE AHEAD.
0.5	2.5	T-intersection from the left: Union Hill Road. CONTINUE AHEAD.

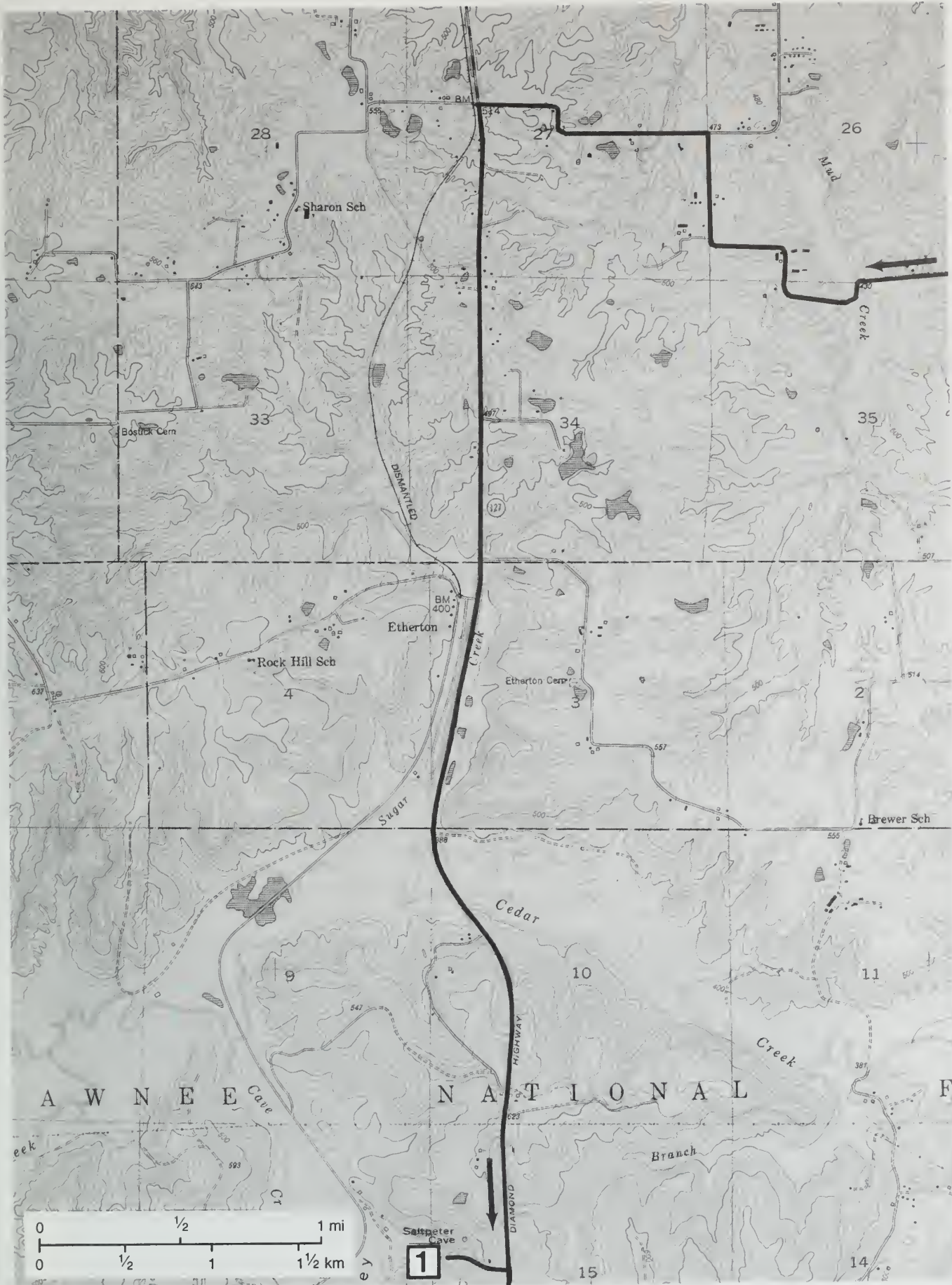
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\* The number in brackets [37089F2] after the topographic map name is the code assigned to that map as part of the National Mapping Program. The state is divided into 1° blocks of latitude and longitude. The first two numbers refer to the latitude of the southeast corner of the block; the next three numbers designate the longitude. The blocks are divided into 64 individual 7.5-minute quadrangles; the letter refers to the east-west row from the bottom and the last digit refers to the north-south column from the right.











0.35	2.85	Cross Crab Orchard Creek. For the next 3 miles, the road is a roller coaster, going up and down, crossing the drainage system that dissects the Illinoian till plain. Drainage is to the north, where it joins the Big Muddy River.
0.55	3.4	T-intersection from the right: Rouden Road. CONTINUE AHEAD.
0.3	3.7	T-intersection from the left: Clark Road. CONTINUE AHEAD.
0.5	4.2	CAUTION: 4-way stop at the intersection of Country Club Road and Pleasant Hill Road. CONTINUE AHEAD.
0.2	4.4	Crab Orchard cemetery is on the right.
0.75	5.15	CAUTION: road curves to the left.
0.05	5.2	Cross Mud Creek, then the road curves to the right.
0.1	5.3	Hog farm lies to the right. Note the erosion of the unvegetated Illinoian till plain. Several glacial erratics are scattered about the field. A thin deposit of loess is present in the upper portion of the hill. The ditch on the right side of the road has recently been rechanneled because it had filled with reworked glacial deposits.
0.15	5.45	CAUTION: road curves to the right. CONTINUE AHEAD.
0.2	5.65	Cross a small creek. Pennsylvanian-age sandstone of the Tradewater Formation is exposed in the creek.
0.25	5.9	CAUTION: road curves 90° to the right.
0.35	6.25	STOP (1-way): T-intersection of Chautauqua Road and Pleasant Hill Road. TURN LEFT onto Chautauqua Road. CAUTION: cross traffic does not stop.
0.15	6.4	Cross a branch of Mud Creek.
0.35	6.75	CAUTION: road curves 90° to the right.
0.1	6.85	CAUTION: road curves 90° to the left.
0.25	7.1	STOP (2-way): intersection of Chautauqua Road and Illinois highway 127, which is Black Diamond Highway. TURN LEFT (south). Note that Chautauqua Road is east and Orchard Hill Road is west of IL 127 at this intersection. CAUTION: because of the hill to the right, traffic visibility is very limited.
1.15	8.25	T-intersection from the left: Caraway Road. CONTINUE AHEAD.
0.45	8.7	T-intersection from the left: Grammar Road. CONTINUE AHEAD.
0.2	8.9	T-intersection from the right: Atherton Road. CONTINUE AHEAD.
1.0	9.9	Bridge crosses Cedar Creek. Note that Cedar Creek marks the southern boundary of Illinoian glaciation. This is the boundary between the Mt. Vernon

Hill County to the north and the Shawnee Hills Section to the south. As you head south, notice the change in topography.



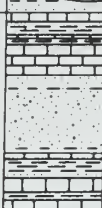
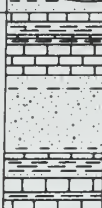
- 0.3      10.2      On the right is an outcrop of medium to thick bedded, Pennsylvanian-age sandstone interbedded with gray shale. The sandstone is from the Upper Caseyville Formation, Pounds Sandstone Member.
- 0.5      10.7      T-intersection from the right: Tomcat Hill Lane. CONTINUE AHEAD.
- 0.6      11.3      CAUTION: T-intersection from the right is the entrance to Saltpeter Cave. TURN RIGHT.

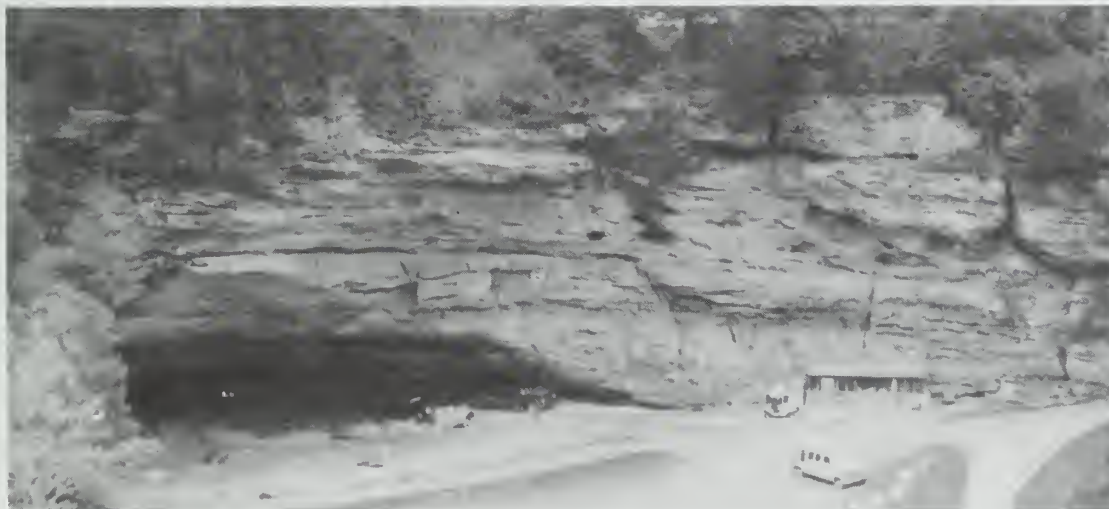
**STOP 1** We'll view and discuss the origin of Saltpeter Cave, the largest bluff shelter in Illinois (SW SW NW, Sec. 15, T10S, R2W, 3rd P.M., Jackson County, Pomona 7.5-Minute Quadrangle [37089F3]).

Saltpeter Cave is a large alcove, also called a bluff shelter, in a 90-foot-high bluff of the Battery Rock Sandstone Member of the Pennsylvanian Caseyville Formation (figs. 11, 12). The alcove was formed by an erosional process called groundwater sapping (described below). The entrance to the shelter is 215 feet wide. The large protected enclosure created by the overhang has a history—it was a natural hide-out for outlaws during the Civil War. The formation is also a natural amphitheater, so take the time to test its acoustics.

**Figure 11** (right) Generalized stratigraphy of exposed Pennsylvanian and Mississippian rocks in the field trip area (after Desborough 1961).

**Figure 12** Saltpeter Cave in bluff of Battery Rock Sandstone, Caseyville Formation.

SYSTEM	GROUP	FM.	COLUMN	
PENNSYLVANIAN	Kewanee	Tradewater		Vergennes Sandstone Member
				Murphysboro Cool Member
	McCormick	Caseyville		Pounds Sandstone Member
				Drury Shale Member
				Battery Rock Sandstone Member
				Wayside Sandstone Member
MISSISSIPPIAN	Chesterian Series			Kinkaid Limestone
				Degonio Sandstone
				Clore Formation



The Battery Rock Sandstone Member is the first persistent bluff-forming sandstone layer above the Mississippian—Pennsylvanian unconformity. As Desborough (1961) describes it:

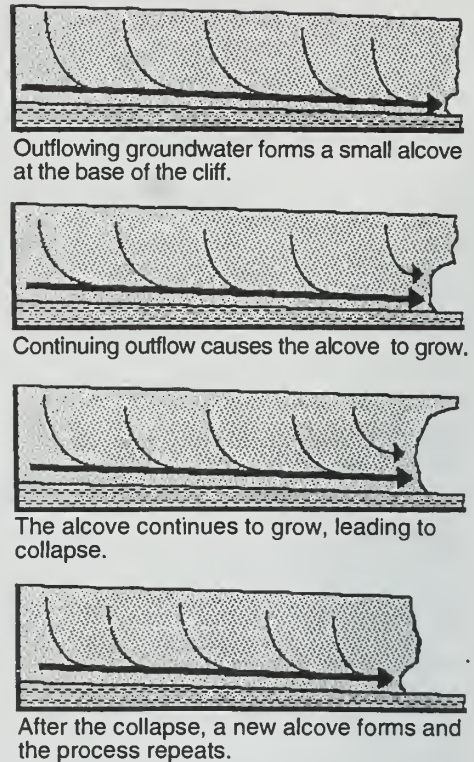
The Battery Rock is a massive sandstone generally medium to coarse in grain size and commonly containing quartz and chert pebbles. Quartz pebbles as much as 1 inch in diameter and chert pebbles 1.5 inches in diameter have been observed, but small pebbles and large granules are more common. Cross-bedding and ripple marks are prominent features of the Battery Rock Sandstone.

To the west, along the valley leading away from the entrance to Saltpeter Cave, large blocks of sandstone have moved downslope, away from the high bluffs that outline this valley. The blocks have moved because groundwater flowing down vertical *joints* lubricated the underlying shale and created a slide plane. This feature is common along the Pennsylvanian escarpment in southern Illinois. We will see the same phenomenon at our lunch stop in Giant City Park.

**Groundwater sapping** In many stream valleys, seepage or flow of groundwater from the bedrock into the stream enhances the breakdown and erosion of the rock in the valley bottom. The exposure of a vertical cliff face allows this process to occur in the open. When groundwater seeps out of a cliff face or hillside, it can undermine the cliff or slope in a process called groundwater sapping. Erosion at the seepage face creates an alcove and, as the back of the alcove retreats, the overhanging rock is undermined and eventually collapses. As time passes, the entire cliff face retreats (fig. 13). Surface water removes the debris created by sapping.

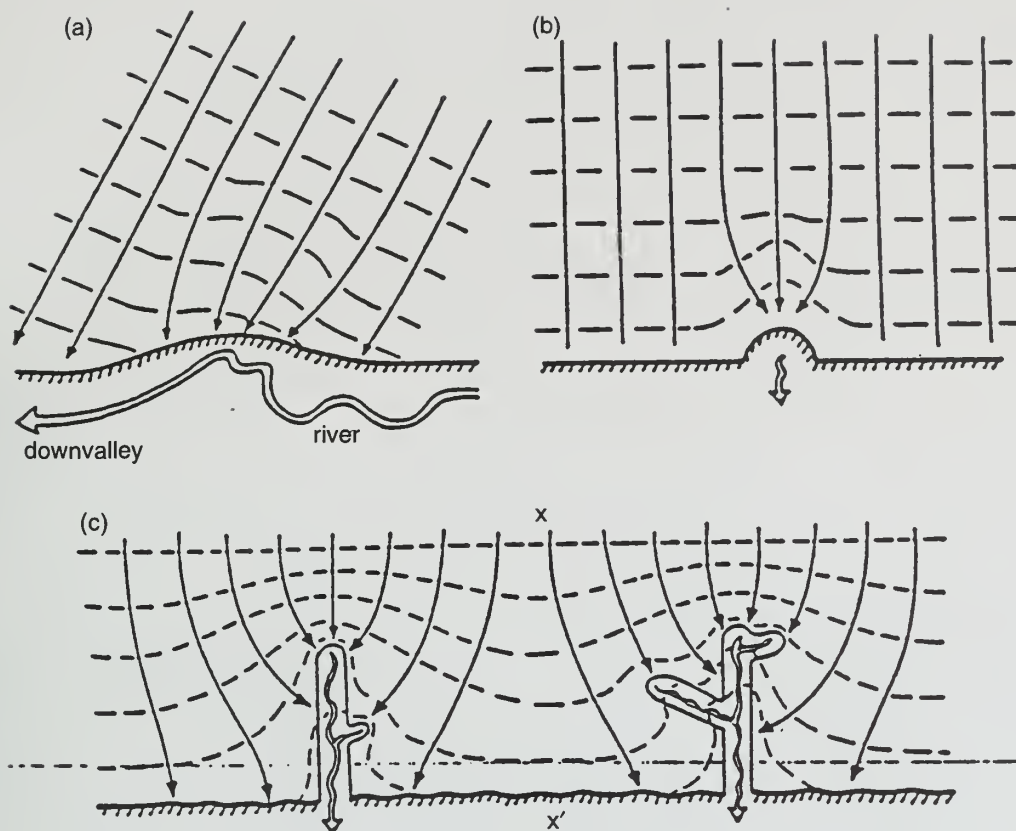
The process is complicated because variations within the rock affect the flow of groundwater. Changes in the permeability of the rock enhance the groundwater flow in certain areas. This enhanced flow speeds up the processes of weathering and erosion. Sapping alcoves commonly occur above rock layers with low permeability. Other geologic variations, such as fractures or undermining by a stream, can focus groundwater flow on a small area of the cliff face. As a result, that section of the cliff face erodes and retreats at a more rapid rate, resulting in the formation of a canyon (fig. 14).

Several distinctive features are common in areas where groundwater sapping is a dominant erosional process. Seepage zones occur above layers of low permeability and are often covered with algae or moss; they are usually most active in the spring and may dry up completely in the fall. The alcoves may be very small (inches) to very large (feet or tens of feet), and they often have slightly arched roofs. The alcoves always have seepage zones in the back. Sapping canyons have vertical sides and an amphitheater-shaped head. The walls of the sapping canyon often contain many seepage zones and alcoves, and a very large alcove is usually located at the head of the canyon. A smaller alcove will be seen at stop 6. Ferne Clyffe State Park is another good place to observe groundwater sapping features.



**Figure 13** Cliff retreat due to groundwater sapping.

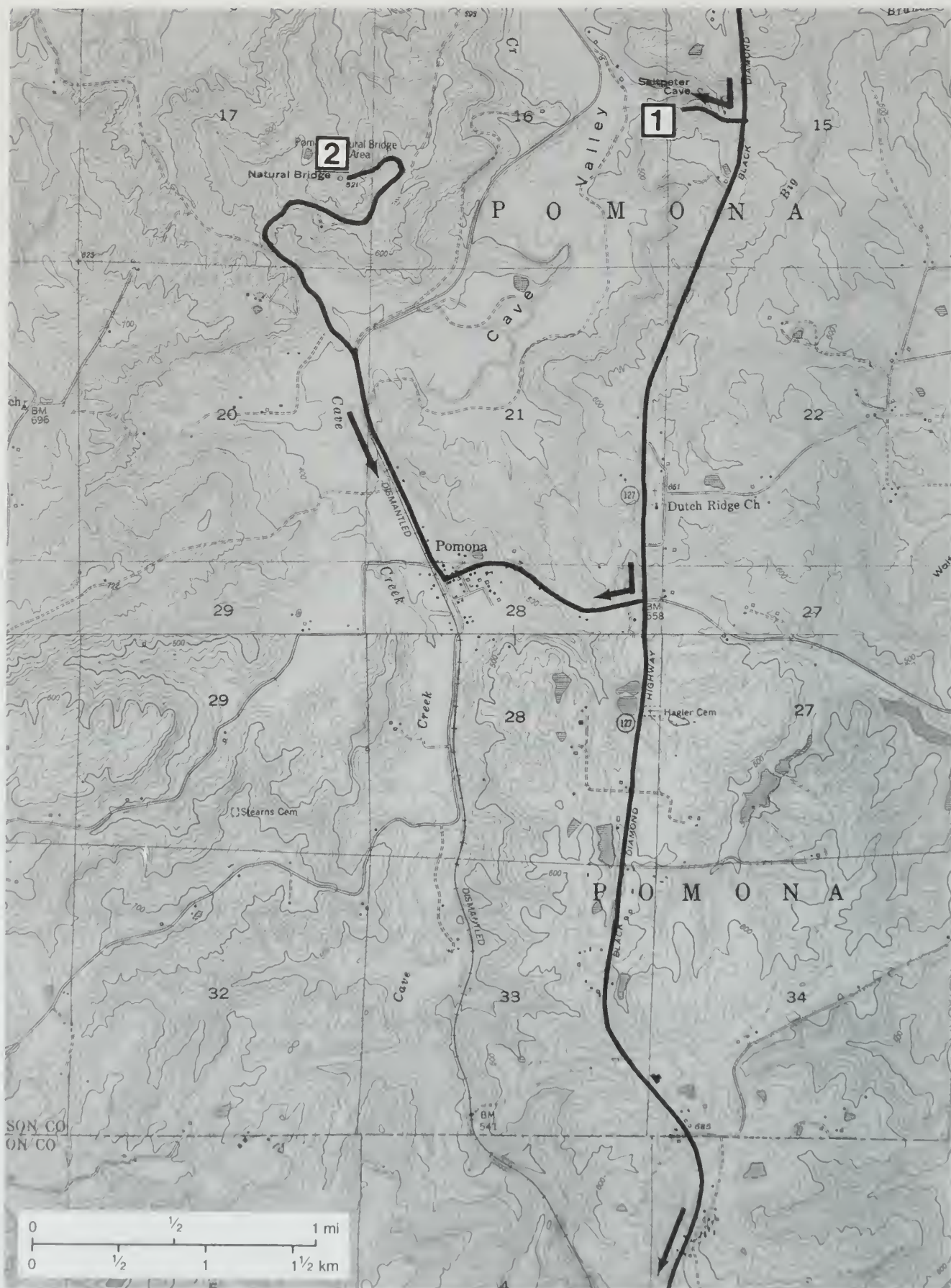




**Figure 14** initiation of a groundwater sapping valley and the subsequent concentration of groundwater flow. (a) An eroding stream initiates concentrated groundwater outflow by cutting into a cliff face. (b) The groundwater flow system is disturbed and flow is concentrated at the head of the developing canyon. (c) The concentrated flow causes a canyon to develop. After Dunne 1988.

In Arizona, some very large alcoves contain cliff dwellings shaded from the sun and cooled by the evaporating seep water. Some small alcoves have been sealed off by the Navajo to collect the seep water for drinking. In Hawaii, groundwater sapping has created large canyons on the sides of several islands. Groundwater sapping has also been proposed as a process responsible for some canyons observed on the planet Mars.

0.0	11.3	Leave Stop 1. Retrace route to the entrance and resume mileage count from there. STOP (1-way): entrance road. TURN RIGHT (south) onto IL 127.
1.2	12.5	T-intersection from the left: Dutch Ridge Road. CONTINUE AHEAD.
0.5	13.0	TURN RIGHT (west) onto Pomona Road. Note the crossroad intersection: Pomona Road to the right, and Boat Dock Road to the left.
0.7	13.7	Enter Pomona.
0.1	13.8	STOP (3-way): intersection of Sadler Road and Pomona Road. TURN RIGHT (north) onto Sadler Road.
0.1	13.9	CAUTION: Y-intersection of Jerusalem Hill Road and Natural Bridge Road. BEAR RIGHT onto Natural Bridge Road.





0.2	14.1	In the bluffs to the right are outcrops of sandstone of the Pennsylvanian Caseyville. We are following along Cave Valley.
0.5	14.6	Cross Cave Creek.
0.2	14.8	T-intersection from the left: Godwin Road. CONTINUE AHEAD.
1.25	16.05	Pomona Natural Bridge picnic area.

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**STOP 2** We'll see one of the most interesting natural features in Illinois, the Pomona Natural Bridge (SW SW NW, Sec.15, T10S, R2W, 3rd P.M., Jackson County, Pomona 7.5-Minute Quad-range [37089F3]).

The Pomona Natural Bridge is in the Pounds Sandstone Member of the Caseyville Formation (Pennsylvanian) (figs. 11, 15). It was formed by water erosion. Groundwater percolating through the joints in the sandstone eroded a less resistant zone in the underlying rock and left this solid rock bridge that now spans a small stream. The Pomona Natural Bridge has an unsupported span of 90 feet and an overall length of 125 feet. The width of the bridge ranges from 9 to 12 feet and is approximately 9 feet thick. The small stream 25 feet below the bridge is slowly and continually eroding the underlying sandstone.

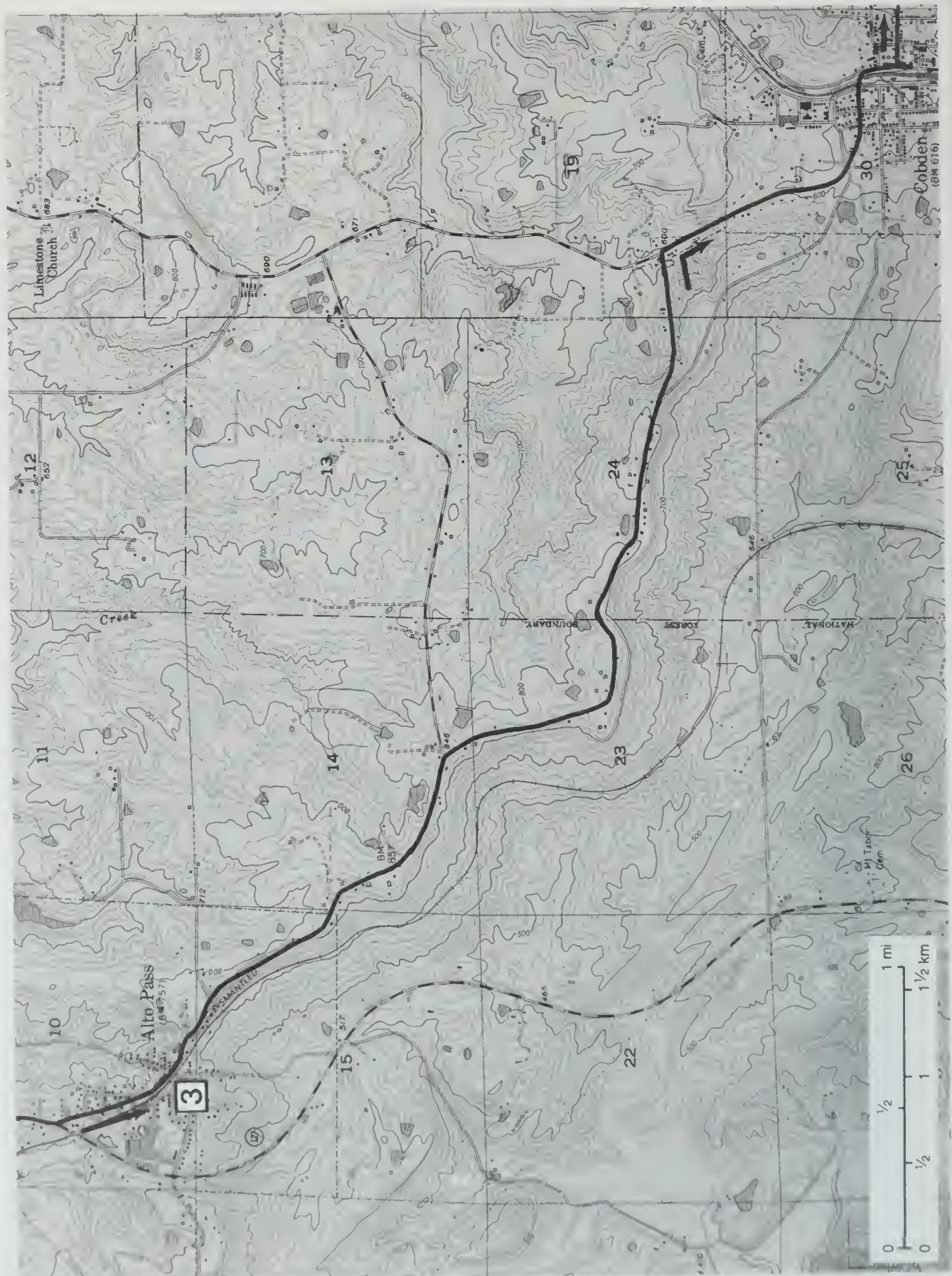
The Pounds is a medium- to coarse-grained, cross-bedded, slightly micaceous sandstone that contains quartz pebbles and a minor amount of chert pebbles (Desborough 1961). The thickness varies between 80 and 140 feet.

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0.0	16.05	Leave Stop 2. We will retrace our route back to the intersection of Pomona Road and IL 127.
1.35	17.4	T-Intersection from the right: Godwin Road. CONTINUE AHEAD.



**Figure 15** Pomona Natural Bridge, Pounds Sandstone, Caseyville Formation.





0.15	17.55	Cross Cave Creek.
0.70	18.25	Y-intersection of Jerusalem Hill Road and Natural Bridge Road. CONTINUE AHEAD. At the intersection, Natural Bridge Road changes to Sadler Road.
0.05	18.3	STOP (3-way), T-intersection from the left: Pomona Road and Sadler Road. TURN LEFT onto Pomona Road.
0.75	19.05	STOP (2-way): intersection of Pomona Road and IL 127. TURN RIGHT (south) onto IL 127. NOTE: Boat Dock Road (across IL 127) leads to Cedar Lake 2 miles ahead.
0.45	19.5	T-intersection from the left: Timberline Trail. CONTINUE AHEAD.
0.25	19.75	Crossroad intersection of Beehawk Road to the left and Bud Road to the right. CONTINUE AHEAD.
1.15	20.9	Heartline Orchards lies on the left.
0.1	21.0	T-intersection from the left: Landreth Road. This is the county line; we're entering Union County.
0.4	21.4	Rendleman Orchards lies to the left.
0.7	22.1	Enter the city limits of Alto Pass, population 350.
0.6	22.7	CAUTION: T-intersection from the left: Alto Pass Road. TURN LEFT (south-east) onto Alto Pass Road.
0.5	23.2	TURN RIGHT at Elm Street and park in the lot located in front of the two sandstone walls that mark the location of the old railroad tracks. This is the start of Quetil Trail along the old railroad bed at the south end of the Alto Pass city park.

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**STOP 3** We'll view sandstone of the Pennsylvanian Caseyville Formation along the southern crest of the Pennsylvanian escarpment (SE SE SW, Sec. 10, T11S, R2W, 3rd P.M., Union County, Cobden 7.5-Minute Quadrangle [37089E3]).

Follow Quetil Trail southeast of the parking lot. This sandstone in the lower part of the Pennsylvanian Caseyville Formation (fig. 11) forms the massive bluff along the trail (fig. 16). The sandstone is highly jointed and large blocks have crept down slope. Short natural bridges connect two such blocks with the parent upland surface of the bluff.

The massive sandstone of the Caseyville is underlain by upper Mississippian-age sandstone and shale of the Degonia Sandstone Formation. Approximately 10 feet of the Degonia is exposed west of the massive sandstone blocks near the beginning of the trail. The Degonia consists of thin, lenticular-bedded (lens shaped) sandstones with shale partings. The light gray sandstone weathers to a yellowish gray. It is very fine-grained; quartz is the main mineral, but fine mica flakes are present. Cross lamination is faintly visible. The overlying 30 feet or more of exposed Caseyville is dominantly a fine-grained sandstone with scattered medium- to coarse-grained beds, mostly massive and cross-bedded. It weathers brown, is heavily iron-stained, and contains iron-oxide bands.





**Figure 16** Bluff of Caseyville Formation sandstone at stop 3. Arrow indicates direction of block movement.

Evidence of a period of tilting and erosion between the deposition of the Mississippian and Pennsylvanian rocks can be found along this part of the escarpment. Here the Pennsylvanian Caseyville is underlain by the Mississippian Degonia Sandstone; whereas 1 mile to the east, the Mississippian Kinkaid Limestone lies between the two. West of Alto Pass the Degonia disappears and the Pennsylvanian Caseyville rests on the Mississippian Clore Formation and the underlying Palestine Sandstone (figs. 2 and 11).

Stairs, built along a joint between two large sandstone blocks, lead up to Cliff View Park. From the top of the bluff is a scenic view of the Pennsylvanian escarpment and a beautiful view of the 111-foot cross on top of Bald Knob.

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0.0	23.2	Leave Stop 3. TURN RIGHT onto Alto Pass Road.
0.2	23.4	Cliff View Park (scenic view on right side of the road) was constructed from 1937 to 1939 by the National Youth Administration, sponsored by the Alto Pass Garden Club. Take a good look at Bald Knob and the Pennsylvanian escarpment.
1.4	24.8	T-intersection from the left. CONTINUE AHEAD.
1.7	26.5	Mississippian Degonia Sandstone outcrops on the right.
0.5	27.0	CAUTION: STOP (1-WAY) at the T-intersection: Oak Street. TURN RIGHT.
0.1	27.1	Enter Cobden, population 1,100.

1.0	28.1	Intersection with Appleknocker Street is just before the bridge. Palestine Sandstone outcrops along the railroad cut below the bridge. CONTINUE AHEAD.
0.1	28.2	Intersection from the left: Poplar Street. CONTINUE AHEAD.
0.1	28.3	TURN LEFT at Ash Street.
0.05	28.35	STOP (3-way): intersection of Jefferson and Ash. CONTINUE AHEAD on Ash Street, which becomes County highway 8.
0.25	28.6	CAUTION: road makes a 90° turn to the right. St. Joseph cemetery is on the right.
0.3	28.9	CAUTION: road makes a 90° turn to the left.
1.1	30.0	STOP (2-way): intersection of county highway 8 and US 51. TURN LEFT (north) onto US 51.
0.5	30.5	Road cuts through Degonia Sandstone. CONTINUE AHEAD.

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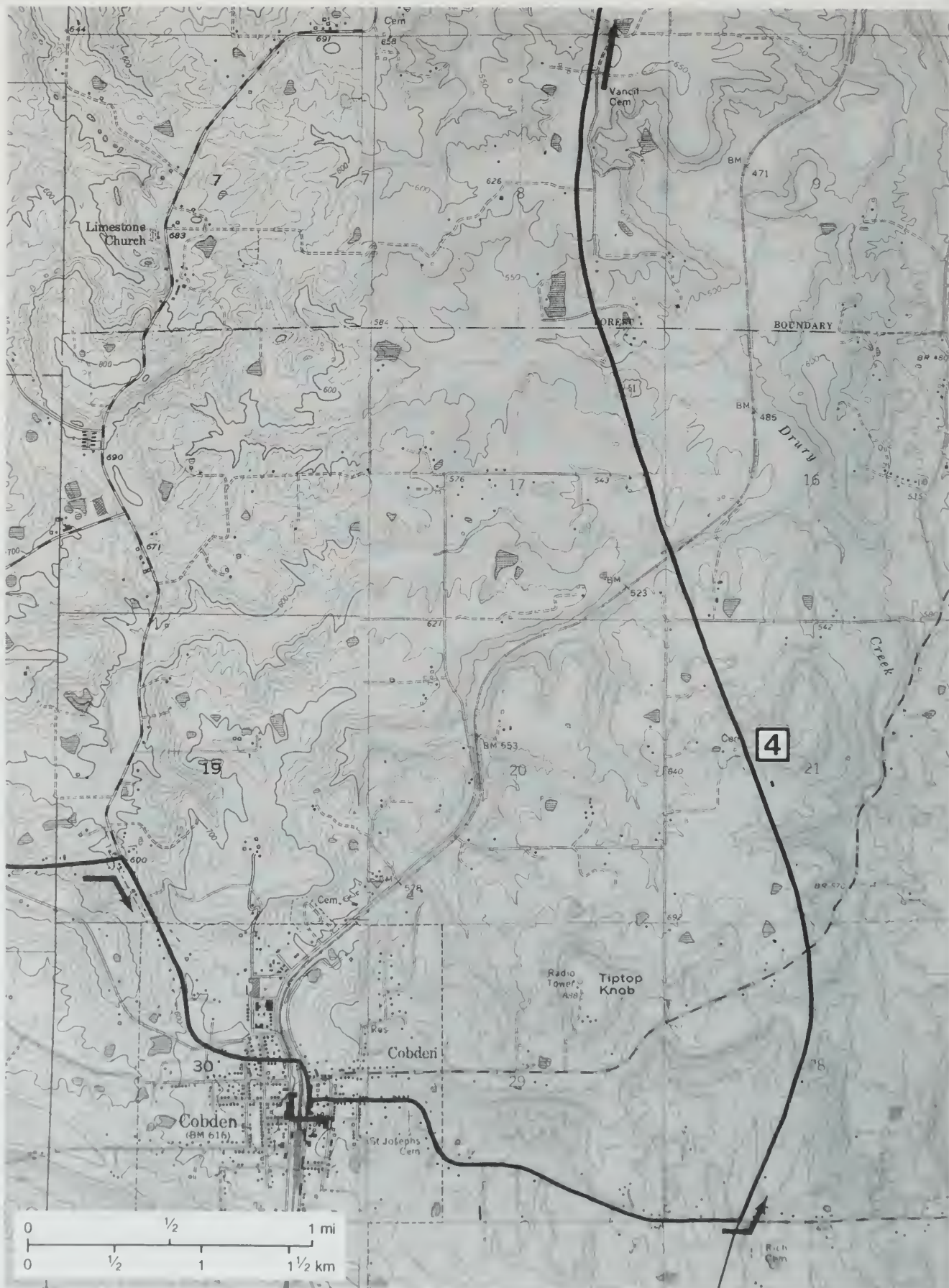
**ALTERNATE STOP** This exposure provides an excellent opportunity to study the Mississippian Degonia Sandstone (SE NW and SW NE, Sec. 28, T11S, R1W, 3rd P.M., Union County, Makanda 7.5-Minute Quadrangle [37089E2]).

The Degonia crops out over a larger region than any other Chesterian formation because of its thickness (60–124 feet), and its resistance to erosion (figs. 11, 17). Approximately 22 feet of the



**Figure 17** Degonia Sandstone with Wayne Frankie pointing out the upper Clore Formation shales beneath (both upper Mississippian) at the alternate stop.







Degonia have been exposed in this roadcut. The sandstone is light gray to brownish gray, except for the basal 1 foot, which is dark yellowish brown with a reddish brown crust up to 1 inch thick at the base. The sandstone is cross-bedded and appears massive on the fresh surface, but close examination shows that it may weather in thin to medium beds separated by very thin, silty shale partings. Scattered iron manganese nodules up to 4 inches in diameter occur in the lower 8 feet, and an incipient *liesegang* ring structure (nested bands) is present. The Degonia Sandstone resembles nonconglomeratic portions of the younger sandstones in the Caseyville (Pennsylvanian). As a result, identification is difficult wherever the two are in contact, without the Kinkaid Limestone that usually separates them.

Beneath the Degonia Sandstone is an exposure of the upper portion of the Clore Formation. The upper 12 feet of the Clore consists of olive, greenish gray, olive gray, and dark gray shales with discontinuous lenses of limestone up to 4.5 feet thick and 6 feet in diameter in the lower part. The limestones lenses are light brownish gray, dense, sparingly fossiliferous, and massively bedded. The shale is underlain by 10 inches of yellowish and reddish brown, silty, plastic clay. Beneath the clay lies 4 feet of yellowish brown, fine- to medium-grained siltstone, which in turn overlies more than 5.5 feet of medium gray and tan, fissile, silty shale.

To the east and northeast in Saline, Gallatin, White, Edwards, and Wabash Counties, the Degonia and Clore Formations are important gas- and oil-producing horizons.

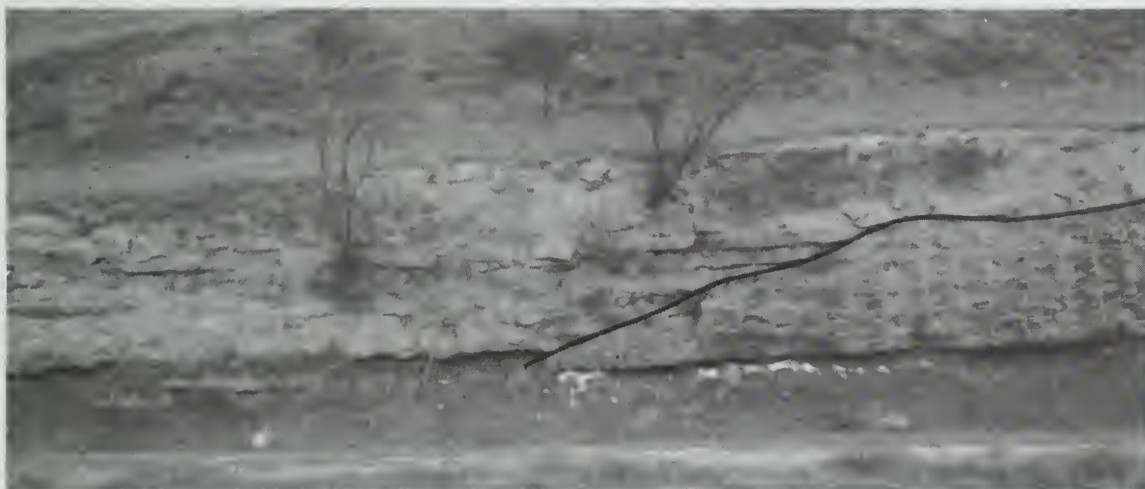
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0.5	31.0	Crossroad intersection of county highway 1: Cobden Road. Degonia Sandstone outcrops north of the intersection on the east and west side of US 51. The west side is more exposed. CONTINUE AHEAD.
0.7	31.7	Pull over and park vehicles on the far right edge of the road.

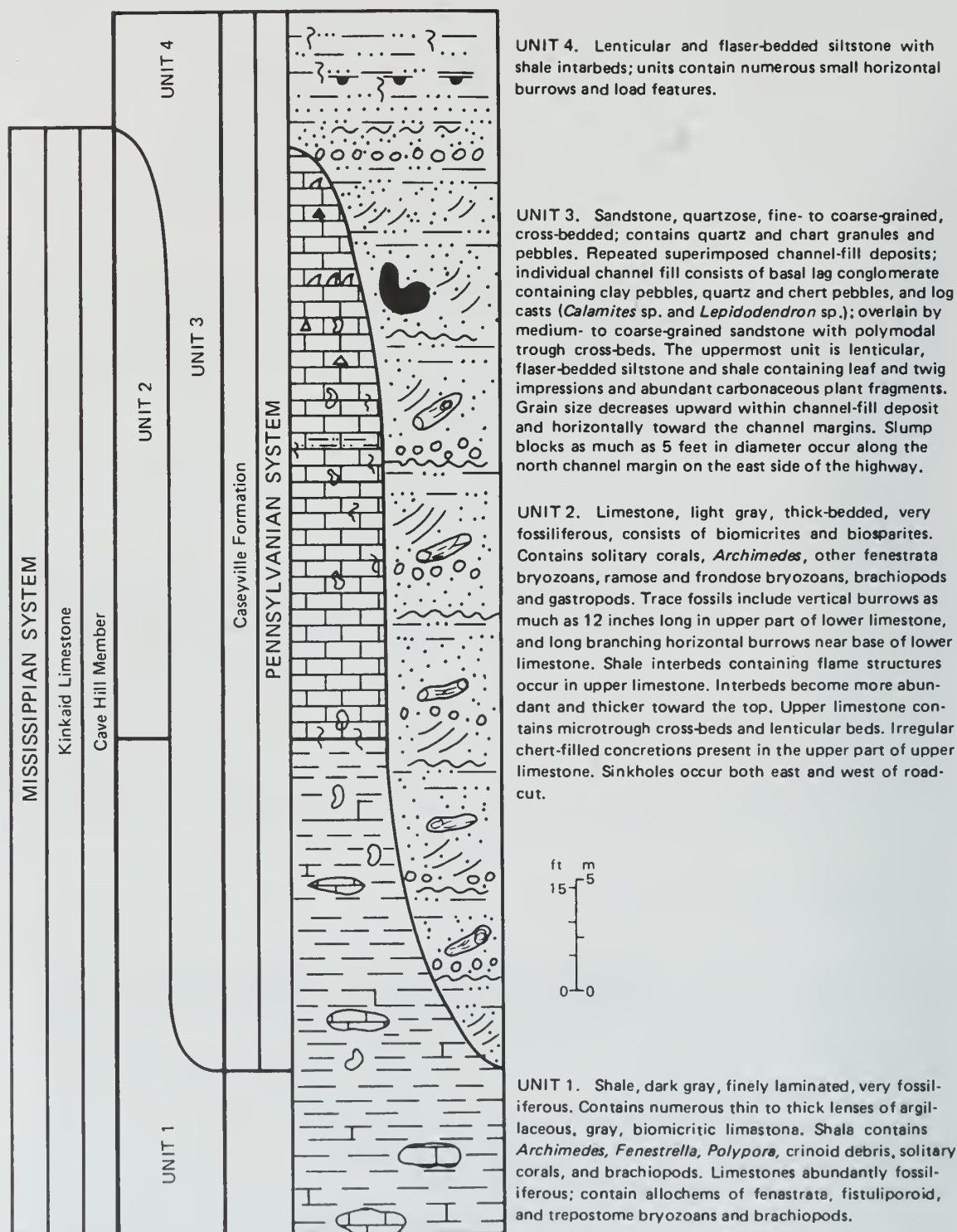
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**STOP 4** We'll discuss a classic "textbook" example of an erosional unconformity and the development of *karst* features (SW SE NW, Sec. 21, T11S, R1W, 3rd P.M., Union County, Makanda 7.5-Minute Quadrangle [37089E2]).

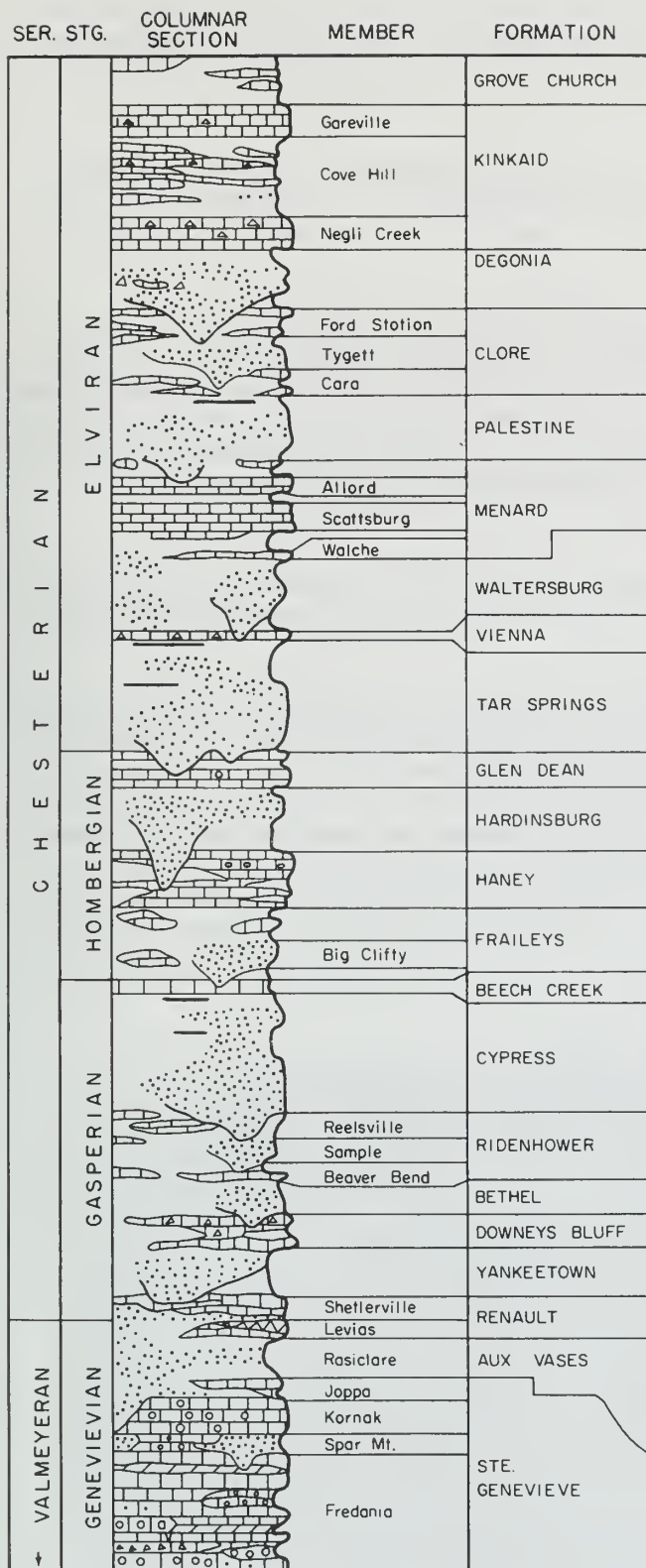
**Mississippian–Pennsylvanian unconformity** This exposure shows the contact between the Mississippian and Pennsylvanian systems of strata (fig. 18). Typical sandstone of the Pennsylvanian



**Figure 18** Unconformity filled with Pennsylvanian sandstone (lower Caseyville Formation) along US 51 south of Carbondale.



**Figure 19** Columnar section and description of rock units, Mississippian-Pennsylvanian unconformity (after Rousch and Ethridge 1973).



**Figure 20** Columnar section of the Chesterian Series (Mississippian). Unpatterned areas in the column represent shale (after Willman et al. 1975).

nian Caseyville Formation in this area rests conspicuously and unconformably on Mississippian-age upper Chesterian shales and limestones of the Cave Hill Member of the Kinkaid Formation (fig. 19). The thickness of the Kinkaid is difficult to measure in this region because of its highly eroded upper surface; it ranges from 30 to 110 feet thick. Part of the Cave Hill, the Goreville Limestone, and the Grove Church Shale (fig. 20) are missing because of erosion; 100 feet or more of strata may have been eroded here. A description of the rock units appears with figure 19.

The following depositional interpretations are based on Roush and Ethridge (1973).

*Unit 1* The gray fossiliferous calcareous shale was apparently deposited on a shallow marine subtidal shelf where sediment transport was primarily by suspension, and the sedimentation rate was low. Fossil fragments are winnowed by currents into small lenses in an otherwise quiet-water environment. Most shells show little evidence of transport.

*Unit 2* The overlying light gray, very fossiliferous limestone was apparently deposited in a shallow marine subtidal environment where currents were sufficiently strong to transport coarse bedload sediment. Abundant vertical burrows in the upper part of the lower limestone suggest a period of little or no sedimentation, permitting establishment of an abundant infauna on the carbonate shelf.

*Unit 3* The quartzose, fine- to coarse-grained sandstone is the first unit of Pennsylvanian age in this area and fills an erosional channel cut in the underlying Mississippian limestone. The channel cuts completely through the limestone and into the underlying shale. Typical features of fluvial channel deposits that can be



observed are channel lag conglomerates with various kinds of pebbles; logs of trees up to 0.3 meter (1 ft) in diameter; scour and fill structures; slump blocks up to 1.5 meter (5 ft) in diameter; superimposed channel fills; cross bedding; interbedded shales with plant impressions, and abundant carbonaceous fragments.

*Unit 4* The youngest exposed unit, a gray, flaser-bedded siltstone with shale interbeds, has a transitional contact with the underlying unit. The migrating terrestrial (nonmarine) fluvial channel environment of unit 3 changed to an estuarine environment (unit 4) as the sea transgressed onto the land.

Some typical *sinkholes* (also called dolines) have developed in the Kinkaid Limestone on the upland on both sides of the road, beyond the south end of the roadcut (fig. 21). Sinkhole development in the area of the field trip is restricted to places where thick Chesterian limestones form the bedrock surface. At this stop, the sinkholes are developed in the Kinkaid Limestone and only a relatively small area appears to be affected. Other comparatively small areas displaying sinkhole development in the Kinkaid Limestone are scattered throughout the region where this formation outcrops.

Terrain characterized by sinking or disappearing streams and subsurface drainage, caves, sinkholes, and related solutional features is called karst topography, named for the Karst region in the Dinaric Alps of the former Yugoslavia, near Trieste.

Sinkholes form in two ways: (1) roof collapse of caves near the surface, and (2) solutional enlargement of fissures from the surface downward. In the first case, sinkhole formation takes place during the second stage of karst development after uplift and entrenchment of major drainage, and an initial period of cavern formation by vadose water (rain and ground water percolating above the permanent water table). Collapse sinks, known as ponors, are usually deep and steep-walled. In the second case, large subterranean cavities may not even exist. These sinkholes, called dolines, may form at any time in the karst cycle. Dolines are usually shallow, saucer-shaped depressions; their depth is controlled by the depth of the water table at the time of formation. Both types of sinks are usually present in a sinkhole area. Some larger sinkholes in this vicinity are probably collapse sinks, but most are dolines.

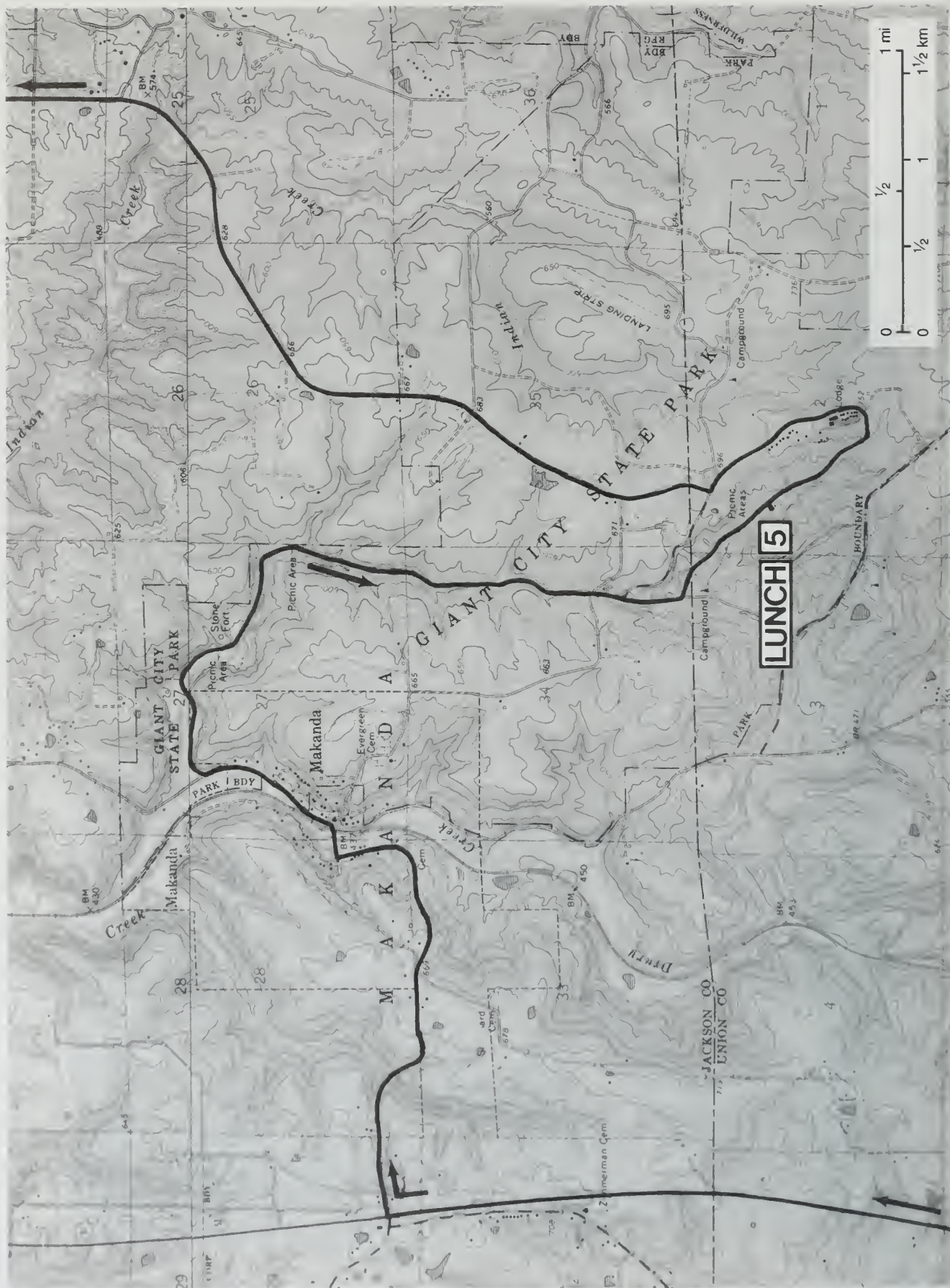


**Figure 21** Solution cavities in Kinkaid Limestone along US 51.

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0.0	31.7	Leave Stop 4. CONTINUE AHEAD (north).
0.5	32.2	Crossroads.
0.3	32.5	Bridge crosses over the Illinois Central Railroad.
0.25	32.75	T-intersection from the left.
0.1	32.85	The Kinkaid Limestone outcrops on both sides of the road—a pretty good place for fossil-collecting. You can also find some fossils on the top bench in a shale that is mostly grassed over now.
0.75	33.6	We're going up onto the top of the Pennsylvanian escarpment. Bedrock is all Pennsylvanian at this point. The roadcut has massive- to thick-bedded and some thin-bedded sandstones; shale is exposed at one end. On the left side of the outcrop is a sandstone-filled channel.
0.85	34.45	Roadcut shows sandstone-filled channel cutting down through other sandstones, which are underlain by a shale.
0.35	34.8	Sandstone outcrops on the left side of the road. Note the thick underclay or claystone below the sandstone. Thin coal may be present below the base of the sandstone. Sandstone also fills a channel on the north side of the cut.
0.3	35.1	Union–Jackson County Line.
1.2	36.3	CAUTION: crossroad intersection with Makanda Road. TURN RIGHT (east) onto Makanda Road.
0.2	36.5	CAUTION: road descends and has sharp curves. Pennsylvanian sandstones outcrop on both sides of the road as you head toward Makanda.
0.8	37.3	Cross the intersection with Shepard Lane. Use CAUTION on the sharp curves as you drive down the hill. CONTINUE AHEAD.
0.55	37.85	Enter the village of Makanda, home of U.S. Senator Paul Simon.
0.25	38.1	Cross Illinois Central railroad tracks in Makanda.
0.5	38.6	Enter Giant City State Park. T-intersection is to the left. CONTINUE AHEAD; road curves to the right.
0.5	39.1	Stone Fort Trail parking lot shelter 1: CONTINUE AHEAD.
		Stone Fort sits atop the 80-foot-high bluff of Pounds Sandstone. Prehistoric man erected seven known rock structures in southern Illinois, and this is one of the better examples. At first these structures were thought to be defensive fortifications, but research indicates that they were probably buffalo traps. Animals may have been driven into the impoundments, then stampeded over the cliff to the ground below where they could be killed more easily.
1.65	40.75	Cross under the bridge.







0.15	40.9	Y-intersection: BEAR RIGHT toward shelters 2 and 3.
0.6	41.5	TURN RIGHT into the parking lot for shelter 3 and Giant City Trail.

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**STOP 5** Are you hungry? After lunching in the park, we'll take a scenic hike along Giant City Trail (SE SW NW, Sec. 2, T11S, R1W, 3rd P.M., Union County, Makanda 7.5-Minute Quadrangle [37089E2]).

**"Giant City"** Land for the park was acquired by the State in 1927. From the initial 1,162 acres, the park has grown to 3,694 acres, which makes it one of the largest of the State's parks.

The park was named after a group of huge, detached sandstone blocks that resemble city blocks and streets—a "giant city" located in the southern part of the park (fig. 22). The northwestern part of the sandstone "city" is only about 1/4 mile northwest of the parking area for shelter 3. The trail through it is about 1 mile long and a fairly strenuous hike.

The huge blocks of rock that make up the "giant city" are masses (80 to 120 feet thick) of the Pounds Sandstone Member of the Caseyville Formation (fig. 11). In late Pennsylvanian to Permian times, not long after deposition, the rocks underwent numerous episodes of upward and downward movements that affected the orientation and/or deformation of the bedding. Past (and possibly present) earthquakes in southern Illinois, as well as slumping and compacting of the softer underlying sediments, have also contributed to jointing and fracturing of these rocks. As a result, these Pennsylvanian rocks are jointed in many directions.

When a stream cuts through hard rock such as limestone or massive sandstone into softer rock such as shale, the softer rock is removed faster than the harder rock, which is gradually undercut. Eventually, masses of the harder



**Figure 22** Blocks of Pennsylvanian sandstone (Caseyville Formation) at Giant City State Park.

rock break off, usually along a joint. The Pounds Sandstone at Giant City Park is jointed along two general directions. The resulting blocks settle down readily whenever the support of the underlying Drury Shale Member is reduced.

Because the shale is soft and "greasy" when wet, the blocks gradually slide down the shale slope and move away from the parent ledge. This sliding is assisted by the presence of considerable groundwater that moves down through the permeable Pounds Sandstone until it encounters the impermeable Drury Shale. It then flows laterally, issuing forth as seeps and springs wherever the contact between the two formations is exposed. The numerous springs in the park owe their origin to this movement of groundwater.

The Pounds Sandstone exhibits some interesting features, especially variegated colors and oddly roughened surfaces that result from weathering. A small amount of iron oxide (iron combined with oxygen) is contained in the sandstone and distributed by groundwater that seeps through the rock. When the iron oxides, sometimes mixed with water to form hydroxides, are deposited or dried, they become minerals ranging in color from tan through brown and red to black. Sandstone that has been exposed to weathering for some time may be stained various shades of red, brown, or yellow. It may also be slightly hardened by the addition of minerals left by evaporating water. The unweathered sandstone is soft and white or light tan. Sometimes the minerals collect in pellets or concretions in the rock. These concretions weather out more rapidly on exposed surfaces than does the rock and a peculiar pitted surface results. Sometimes the concretions form around sandstone grains. These sandstone-grained concretions stand up as knobs on exposed surfaces. The minerals also settle along cracks or whatever courses the groundwater follows and thus serve as a cement, binding the sandstone grains firmly together. Sandstone cemented in this way is more resistant to weathering than is the less cemented sandstone. On exposed surfaces (especially on perpendicular cliff faces), simple to intricately convoluted ridges (liesegang structures) of iron-cemented sandstone stand out in relief against the less resistant rock and form weird and fanciful designs.

**Stream changes: downstream and through time** The streams that we observe along the field trip route show evidence of change—an idea that is very important in the study of geomorphic processes, or how the shape and structure ("morph") of the earth ("geo") changes.

The sediment (silt, sand, and gravel) in a stream originates in a "source" area; for example, the steep valley slopes of Giant City. In this source area, we commonly find sediment of all sizes and shapes that has recently been weathered from adjacent cliffs. The beds of tributary streams that flow from the side valleys to the main stream are steep and filled with large, angular gravel. Small gravel and sand particles are not abundant here because even a little water in the stream will flow fast enough to carry small materials down the steep *gradient*. The streams are straight and narrow and the valley has a V-shape because the stream's energy acts mainly to cut downward (or incise). These streams are also referred to as ephemeral because they only have water when rainfall is abundant.

Stonefort Creek in Giant City State Park is a main stream channel, where we find smaller, more rounded gravel and sand particles. The lower gradient and greater abundance of sediment favors deposition. The main stream channel meanders because its lower gradient no longer gives it enough energy to cut downward. Most erosion is from side to side. Old gravel bars buried in the floodplain and now exposed in the banks of the stream provide evidence of former channel locations. The channel is wider and deeper, so the stream moves its water and sediment load more efficiently. The main stream is called a perennial stream because it contains water all year round. Drury Creek near Makanda is a main stream of a higher order than Stonefort Creek in the drainage network; its valley is wider, its sediment particles are smaller and even more rounded, and it carries more water and more sediment.

Together these streams illustrate several important geomorphic principles. As you move away from the sediment source area, the particles get smaller and less angular (rounder). As you move downstream to higher order stream channels, stream slope (gradient) decreases and stream channels get wider and deeper. Finally, as stream valleys develop through time, they get wider and develop floodplains.

There is also evidence that the character of streams changes through time. Miller (1989) discussed the recent history of several streams in the Drury Creek watershed, including Stonefort Creek, by using data from tree rings, *stratigraphy*, and historical research. A gray clayey silt layer found in the watershed represents a floodplain that was exposed until the mid-1800s. Extensive logging occurred in the area from the mid-1800s until the early 1900s. The removal of trees increased the rate at which sediment moved from the slopes to the stream, and the floodplain was covered by up to 20 inches of silt loam. Reforestation began in the 1940s, and the rate of slope erosion has slowed. The ensuing reduction of sediment load has enabled the streams to cut down through the built-up floodplain.

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0.0	41.5	Leave stop 5. CONTINUE AHEAD.
0.7	42.2	We'll drive by Giant City Lodge. CONTINUE AHEAD.

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**ALTERNATE STOP** If you have the opportunity to climb to the 50-foot-high observation deck on the water tower, you'll be rewarded with a panoramic view of the countryside (NW NE SW, Sec. 2, T11S, R1W, 3rd P.M., Union County, Makanda 7.5-Minute Quadrangle [37089E2]).

The view to the west and southwest shows several interesting features. Bald Knob, 9.5 miles to the southwest, has a summit elevation slightly greater than 1,020 feet msl. A huge concrete cross has been constructed on the top of the knob.

Bald Knob is composed of resistant lower Devonian Clear Creek Chert and marks a structural high. The Rattlesnake Ferry Fault, a northwest- to southeast-trending structure, occurs along the north side of Bald Knob. Stratigraphic displacement of nearly 2,000 feet on this fault has brought lower Devonian strata to the surface south of the fault and put them against Valmeyeran (middle Mississippian) limestone north of the fault. Both the Rattlesnake Ferry Fault and Bald Knob are located in the Salem Plateau Section of the Ozark Plateau Province (fig. 10).

In the middle distance are several high hills with summit elevations ranging from about 800 to 888 feet. They are erosional remnants (monadnocks) of the initial, relatively level surface (peneplain). These high hills are capped by resistant Pennsylvanian Caseyville sandstone. The highest is Tiptop Knob (elevation 888 ft), 4.75 miles southwest of here (standing to the left and topped with the tall radio antenna).

The Caseyville escarpment (Battery Rock Sandstone Member) lies 2 to 2.5 miles to the southwest. The topography in-between is maturely dissected by numerous streams. Little of the original upland surface remains; most of the area is rugged slopes. Beyond the Caseyville escarpment, the rolling upland is developed on the eroded remnants of the Chesterian Kinkaid Limestone, and the more resistant Degonia Sandstone beneath the relatively thin Kinkaid.

Alto Pass (elevation 757 ft msl) is 7.5 miles to the west-southwest. Cobden (elevation 616 feet msl) lies 5.75 miles to the southwest, slightly to the right of and beyond the radio tower on Tiptop Knob.



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0.45	42.65	T-intersection from the right: Indian Creek Trail and Youth Group Camping. CONTINUE AHEAD.
0.05	42.7	T-intersection from the right. TURN RIGHT, head toward Little Grassy Lake and Devil's Kitchen Lake.
0.3	43.0	T-intersection from left: Church Road. CONTINUE AHEAD.
0.7	43.7	T-intersection from right: campground. CONTINUE AHEAD.
1.5	45.2	Cross Indian Creek.
0.3	45.5	T-intersection from right: Aquaculture Road, the entrance to Touch of Nature. CONTINUE AHEAD.
0.8	46.3	Methodist Camp drive is to the right.
1.3	47.6	T-intersection from the left: Hatchery Road. CONTINUE AHEAD AROUND THE CURVE.
0.3	47.9	View Little Grassy Lake from the levee.

Little Grassy Lake was constructed by the U.S. Soil Conservation Service with assistance from the Works Project Administration and the Civilian Conservation Corps. The WPA did most of the actual construction in 1940, but it was 1952 before riprapping was complete. The site is used for group camping (youth groups, church gatherings) and as an alternate water supply for Crab Orchard Lake, which is about 4.3 miles to the north.

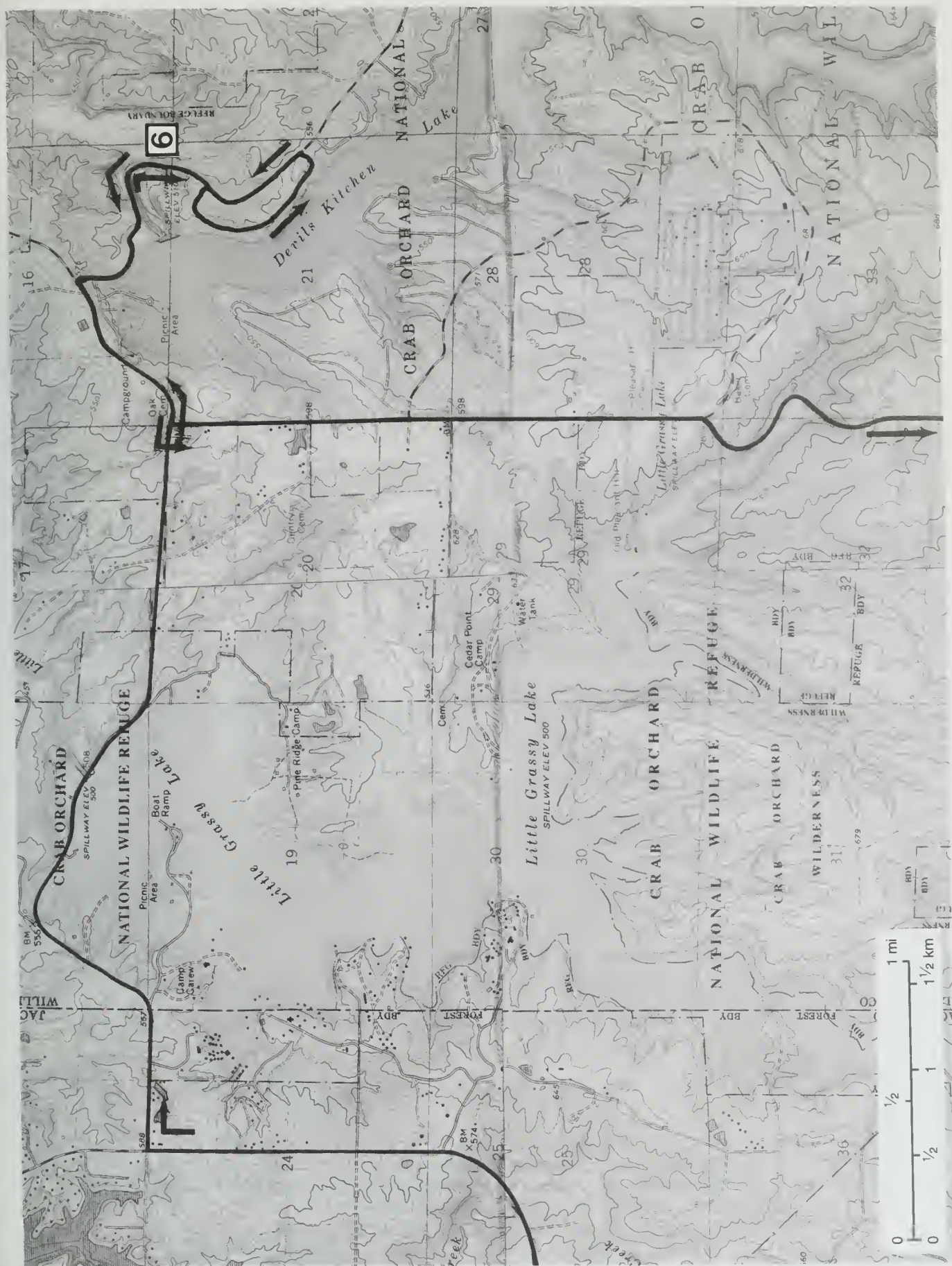
The lake's statistics are

maximum length	4 miles
maximum width	1 mile
shoreline length	about 28 miles
spillway elevation	500 feet msl
area of water	1,000 acres
greatest depth	77 feet
average depth	27 feet

0.3	48.2	Crossing spillway of Little Grassy Lake.
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The spillway empties into Little Grassy Creek. Marine sandstone in the Pennsylvanian Tradewater Formation of the Atokan Series outcrops in and along the banks of the creek. This exposure is a good example of a Lower Pennsylvanian marine zone that contains diagnostic sedimentological features, marine body fossils (actual shells, bones, or teeth or molds and casts of these), and an abundance of marine ichnofossils (tracks, trails, burrows, and other evidence of the presence of animals or plants). Devera and Fraunfelter (1989) describe the exposure along Little Grassy Creek:

The exposure is about 3.5 m (12 ft) thick and composed of gray to reddish brown, hematitic-stained quartz sandstone. The sandstone is fine- to medium-grained, well-sorted, and cemented with silica. Clay



pebbles are common, mica is present in the matrix and, in some places, the quartz sand is cemented by hematite. Common primary sedimentary structures include linguoid ripples, abundant, asymmetric, spoon-shape oscillatory ripples, small-scale trough crossbeds, and planar crossbeds. In places interbedded siltstones and claystones are found filling troughs of the rippled sandstones. Ichnofossils are characteristically abundant and diverse in this unit. Body fossils of brachiopods, gastropods, corals, and pelmatozoan fragments can occasionally be observed. Lycopod driftwood is seen throughout this marine zone.

0.35	48.55	T-intersection from the right: Ridgeline Road, the entrance to Boy Scout Camp. CONTINUE AHEAD.
0.55	49.1	Crossroad intersection: Gentry Road. CONTINUE AHEAD.
0.5	49.6	T-intersection from the right: Rocky Comfort Road. CONTINUE AHEAD.
0.6	50.2	CAUTION: T-intersection from the right is the entrance to Devil's Kitchen Lake. TURN RIGHT.
0.05	50.25	T-intersection from right: entrance to Concession Fee Area. CONTINUE AHEAD.
0.1	50.35	Devils Kitchen Lake lies to the right. The U.S. Soil Conservation Service, with assistance from the Works Project Administration and the Civilian Conservation Corps, began construction of this lake in 1940. Construction had not progressed very far by 1957, when the U.S. Army Corps of Engineers took it over. The Corps worked through the Bureau of Fisheries and Wildlife and completed the lake in 1959. The site was originally planned for cottages. The cost of installing water mains and sewer lines through bedrock was prohibitive, however, and it was finally left as a natural recreation area. The lake is also an alternate water supply for Crab Orchard Lake, about 2.7 miles to the north.
		The lake's statistics are
		maximum length      approximately 4 miles
		maximum width      1/2 mile
		shoreline length      24 miles
		spillway elevation    510 feet msl
		area of water          810 acres
		greatest depth      90 feet
		average depth        36 feet.
0.45	50.8	Cross bridge over Grassy Creek, the outlet for Devil's Kitchen Lake. The spillway is to the right.
0.15	50.95	Rocky Bluff Trail. Pull over to the right side of the road and park.

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**STOP 6** We'll view and discuss the formation of the large alcove located south of Grassy Creek and east of the spillway at Devil's Kitchen Lake (SE SE SE, Sec. 16, T10S, R1E, 3rd P.M., Williamson County, Crab Orchard Lake 7.5-Minute Quadrangle [37089F1]).



A small sapping canyon with a large alcove and a collapsed alcove at its head can be observed a short distance from the road (fig. 23). (For a description of groundwater sapping, see stop 1.) In the spring, surface water flows over a waterfall at the head and helps remove debris produced by the sapping. Just past the canyon, a cliff face with many small alcoves and seepage zones can be observed. Liesegang iron banding, another effect of groundwater flow through the sandstone, can also be observed here.

The sandstone, siltstone and shales exposed along the base of Grassy Creek to the top of the bluff are part of the Pennsylvanian Tradewater Formation (fig. 11).



**Figure 23** Natural alcove in Tradewater Formation.

0.0	50.95	Leave stop 6. CONTINUE AHEAD.
0.1	51.05	T-intersection from the right. TURN RIGHT.
0.7	51.75	STOP (1-way). TURN LEFT.
0.45	52.2	T-intersection from the left. CONTINUE AHEAD.
0.15	52.35	Rocky Bluff Trail lies on the right.
0.05	52.4	Center of bridge over Grassy Creek.
0.6	53.0	T-intersection from the right: Concession Area. CONTINUE AHEAD.
0.05	53.05	STOP (1-way): T-intersection with Grassy Road. TURN LEFT.
0.55	53.6	CAUTION: prepare to TURN LEFT.
0.1	53.7	T-intersection from the left: Rocky Comfort Road (200E) and Grassy Road (300N). TURN LEFT (south).
0.5	54.2	T-intersection from right: Gentry Road. CONTINUE AHEAD.
0.35	54.55	Crossroad intersection: 215N. CONTINUE AHEAD.
1.05	55.6	T-intersection from right: Cedar Point Lane (200E). CONTINUE AHEAD.
0.7	56.3	Pleasant Hill Cemetery is on the left side of the road.
0.2	56.5	Y-intersection: 200E and 100N. BEAR RIGHT onto 200E.

0.5	57.0	Road makes a 90° turn to the right. CAUTION: ford stream of small creek. The road is rough! Sandstone of the Pennsylvanian Tradewater Formation outcrops in the creek. Note the bedload in the creek is locally derived sandstone; it contains no glacial erratics. This creek flows into Little Grassy Lake.
1.6	58.6	Leaving Crab Orchard National Wildlife Conservation Refuge. Road jogs slightly to the right. This marks the boundary between Williamson and Union Counties.
0.2	58.8	Cross a small creek. Pennsylvanian sandstone is exposed on the right in the creek.
0.25	59.05	Cross creek, pull over, and park on the north side of the bridge and on the right edge of the road.

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**STOP 7** We'll view and discuss the deposition of the Caseyville Formation sandstones and shales (NW SW NW, Sec. 9, T11S, R1E, 3rd P.M., Union County, Lick Creek 7.5-Minute Quadrangle [37089E1]).

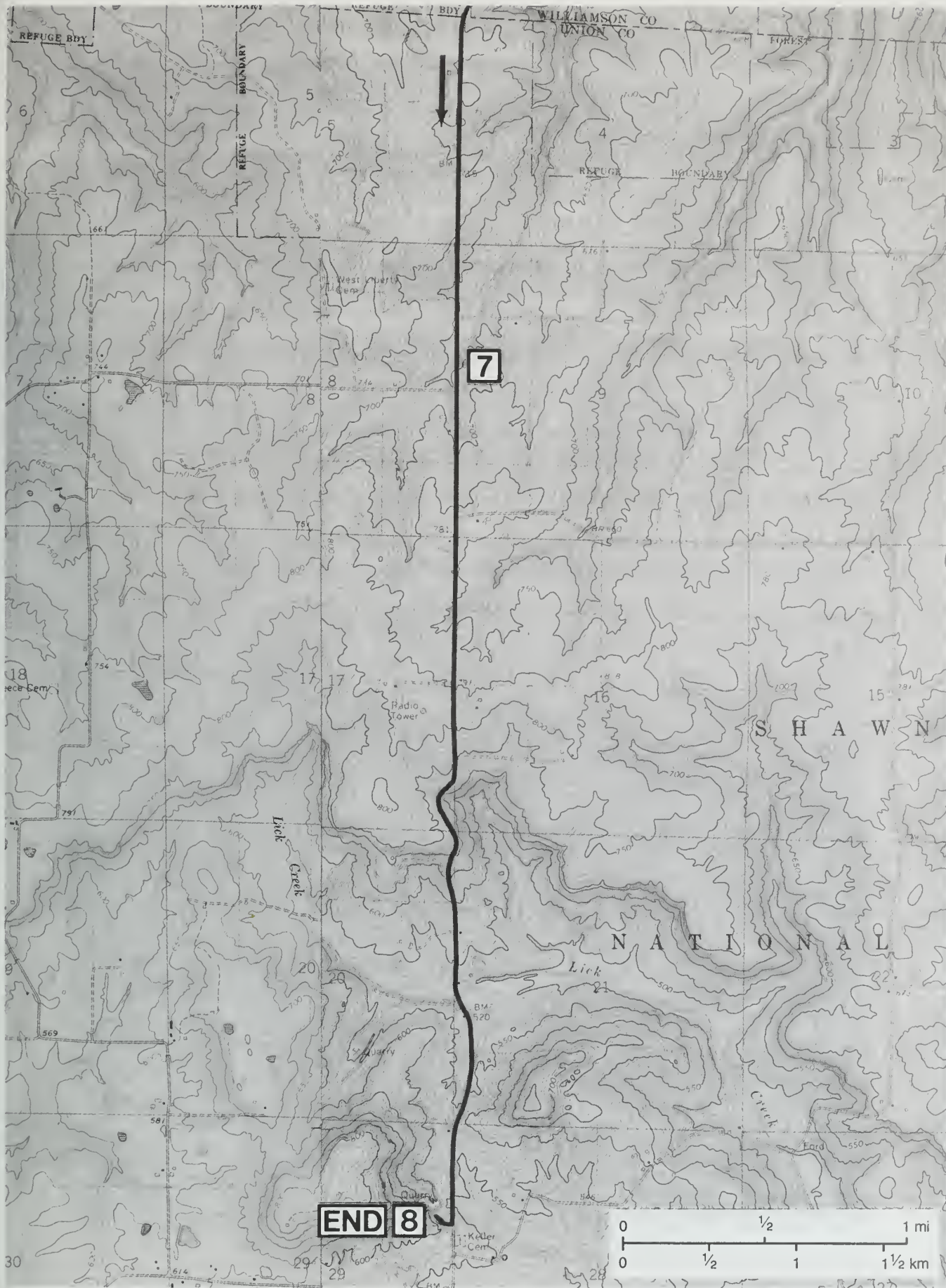
At this stop, you'll be able to observe an exposure of the Lower Pennsylvanian, upper Caseyville Formation along the banks of the creek; the upper unit consists of thin interbedded siltstones, sandstones, and shales. The siltstones and sandstones are bioturbated (churned and reworked by burrowing animals) and contain ripple marks. The upper unit is underlain by a thick gray shale that contains some microfossils. Some of the sandstones contain fossil plant impressions.

The headward erosion of this small creek has cut down through the surrounding rocks of the Tradewater Formation to expose a small "window" through which we can view rocks of the Caseyville Formation. All the creeks north of the Pennsylvanian escarpment in this area illustrate the same headward erosion. Given enough time, all of the Tradewater Formation will be removed by erosion, and the creeks will have cut down through the Caseyville Formation to open windows into the underlying Mississippian Kinkaid Limestone.

The small creeks on the south side of the escarpment also illustrate this natural progression. The creeks have removed all the Tradewater, and the Kinkaid Limestone is exposed close to the escarpment and surrounded by rocks of the Caseyville Formation. *The Geologic Map of the Lick Creek Quadrangle* (Weibel and Nelson 1993) illustrates these erosional processes.

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0.0	59.05	Leave stop 7. CONTINUE AHEAD.
0.1	59.15	T-intersection from right. CONTINUE AHEAD (south).
0.45	59.6	T-intersection from the left. CONTINUE AHEAD.
0.35	59.95	T-intersection from the left. CONTINUE AHEAD.
0.35	60.3	Scenic view to the south is from the top of the Pennsylvanian escarpment. Drainage south of this location is towards the Cache River.
0.15	60.45	T-intersection from the left. CONTINUE AHEAD.





0.05	60.5	Road makes a 90° degree turn to the right, then an immediate 90° degree curve to the left.
0.25	60.75	Pennsylvanian sandstone outcrops on the right. We are traversing down the Pennsylvanian escarpment.
0.55	61.3	CAUTION: narrow one-lane bridge crosses Lick Creek. Kinkaid Limestone outcrops in the creek.
0.1	61.4	CAUTION: cross another one-lane bridge. Kinkaid Limestone is exposed in the creek.
0.75	62.15	Pull over and park on the right edge of the road.

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**STOP 8** At this stop, the abandoned Lick Creek Quarry, you'll be able to observe exposures of the Goreville and Cave Hill Members of the Kinkaid Limestone (figs. 15, 24) (NE SE NE, Sec. 29, T11S, R1E, 3rd P.M., Union County, Lick Creek 7.5-Minute Quadrangle [37089E1]).

We'll have an excellent opportunity to collect fossils at this stop, but one word of caution.

**DANGEROUS EXPOSURE! Please be careful.** The southern portion of the highwall has been shot with explosives and is highly fractured. *Stay away from this part of the quarry.*



**Figure 24** Limestones of the Kinkaid Formation at Lick Creek Quarry.

Because of its proximity to the Pennsylvanian escarpment in this vicinity, the Kinkaid Limestone exposed here has not been as severely eroded as elsewhere in the field trip area. The outcrop belt of the Kinkaid in this vicinity is up to 2 miles wide. As noted earlier, the thickness of the Kinkaid Limestone is extremely variable because of the large amount of erosion it was subjected to from deposition until burial by early Pennsylvanian sediments. Although both the top and bottom contacts are concealed at this stop, the measurable part of the limestone exposed is approximately 110 feet thick.

Below the main bench of the quarry, the limestone is extremely argillaceous (clayey) in some zones. About 5 feet above the bench, the limestone contains irregular black chert masses. Based on examination of these cherts and the host rocks, it seems likely that the chert was formed in place. Upward in the quarry face, the Kinkaid is oolitic in some zones and quite siliceous in others.

According to Lamar (1925), the fauna of the Kinkaid contain no forms that are found only in this limestone. The most common fossils are *Orthotetes*, *Composita*, *Ovatia*, *Cleiothyridina*, *Bellerophon* sp. (very common), *Pinna*, *Edmondia*, and *Archimedes* sp. Small *Pentremites*, trilobites (*Phillipsia*), and *Myalina* are less common. Mississippian fossils are illustrated in the plate at the back of the guidebook.

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#### END OF FIELD TRIP

We hope you enjoyed this excursion and found the geology of the area around Carbondale to be interesting and educational. Have a safe journey home!

Join us in the Beardstown area in Cass, Schuyler, and Brown Counties on April 13, 1996, for another exciting and fun-filled adventure.

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## GLOSSARY

The following definitions are from several sources in total or in part, but the main reference is: Bates, R.L., and J.A. Jackson, eds., 1987, *Glossary of Geology*: American Geological Institute, Alexandria, VA, 3rd Ed., 788 p.

**Ablation** Separation and removal of rock material and formation of deposits, especially by wind action or the washing away of loose and soluble materials.

**Age** An interval of geologic time; a division of an epoch.

**Aggrading stream** One that is actively building up its channel or floodplain by being supplied with more load than it can transport.

**Alluviated valley** One that has been at least partially filled with sand, silt, and mud by flowing water.

**Alluvium** A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material deposited during comparatively recent time by a stream or other body of running water as a sorted or semisorted sediment in the bed of a stream or on its floodplain or delta, etc.

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

**Aquifer** A geologic formation that is water-bearing and which transmits water from one point to another

**Argillaceous** Largely composed of clay-sized particles or clay minerals.

**Base level** Lowest limit of subaerial erosion by running water, controlled locally and temporarily by water level at stream mouths into lakes or more generally and semipermanently into the ocean (mean sea level).

**Basement complex** Largely crystalline igneous and/or metamorphic rocks of complex structure and distribution that underlie a sedimentary sequence.

**Basin** A topographic or structural low area that generally receives thicker deposits of sediments than adjacent areas; the low areas tend to sink more readily, partly because of the weight of the thicker sediments; this also denotes an area of deeper water than found in adjacent shelf areas.

**Bed** A naturally occurring layer of Earth material of relatively greater horizontal than vertical extent that is characterized by a change in physical properties from those overlying and underlying materials. It also is the ground upon which any body of water rests or has rested, or the land covered by the waters of a stream, lake, or ocean; the bottom of a watercourse or of a stream channel.

**Bedrock** The solid rock underlying the unconsolidated (non-indurated) surface materials, such as, soil, sand, gravel, glacial till, etc.

**Bedrock valley** A drainage way eroded into the solid bedrock beneath the surface materials. It may be completely filled with unconsolidated (non-indurated) materials and hidden from view.

**Braided stream** A low gradient, low volume stream flowing through an intricate network of interlacing shallow channels that repeatedly merge and divide, and are separated from each other by branch islands or channel bars. Such a stream may be incapable of carrying all of its load.

**Calcarene** Limestone composed of sand-sized grains consisting of more or less worn shell fragments or pieces of older limestone; a clastic limestone.

**Calcareous** Containing calcium carbonate ( $\text{CaCO}_3$ ); limy.

**Calcite** A common rock-forming mineral consisting of  $\text{CaCO}_3$ ; it may be white, colorless, or pale shades of gray, yellow, and blue; it has perfect rhombohedral cleavage, appears vitreous, and has a hardness of 3 on the Mohs' scale; it effervesces (fizzes) readily in cold dilute hydrochloric acid. It is the principal constituent of limestone.

**Chert** Silicon dioxide ( $\text{SiO}_2$ ); a compact, massive rock composed of minute particles of quartz and/or chalcedony; it is similar to flint but lighter in color.

**Clastic** Fragmental rock composed of detritus, including broken organic hard parts as well as rock substances of any sort.

**Closure** The difference in altitude between the crest of a dome or anticline and the lowest contour that completely surrounds it.

**Columnar section** A graphic representation in a vertical column of the sequence and stratigraphic relations of the rock units in a region.

**Conformable** Layers of strata deposited one upon another without interruption in accumulation of sediment; beds parallel.

**Delta** A low, nearly flat, alluvial land deposited at or near the mouth of a river where it enters a body of standing water; commonly a triangular or fan-shaped plain sometimes extending beyond the general trend of the coastline.

**Detritus** Material produced by mechanical disintegration.

**Disconformity** An unconformity marked by a distinct erosion-produced irregular, uneven surface of appreciable relief between parallel strata below and above the break; sometimes represents a considerable interval of nondeposition.

**Dolomite** A mineral, calcium-magnesium carbonate ( $\text{Ca,Mg}[\text{CO}_3]_2$ ); applied to those sedimentary rocks that are composed largely of the mineral dolomite; it also is precipitated directly from seawater. It is white, colorless, or tinged yellow, brown, pink, or gray; has perfect rhombohedral cleavage; appears pearly to vitreous; effervesces feebly in cold dilute hydrochloric acid.

**Drift** All rock material transported by a glacier and deposited either directly by the ice or reworked and deposited by meltwater streams and/or the wind.

**Driftless Area** A 10,000 square mile area in northeastern Iowa, southwestern Wisconsin, and northwestern Illinois where the absence of glacial drift suggests that the area may not have been glaciated.

**End moraine** A ridge-like or series of ridge-like accumulations of drift built along the margin of an actively flowing glacier at any given time; a moraine that has been deposited at the lower or outer end of a glacier.

**Epoch** An interval of geologic time; a division of a period.

**Era** A unit of geologic time next in magnitude beneath an eon; consists of two or more periods.

**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.

**Fault** A fracture surface or zone in Earth materials along which there has been vertical and/or horizontal displacement or movement of the strata on both sides relative to one another.

**Flood plain** The surface or strip of relatively smooth land adjacent to a stream channel that has been produced by the stream's erosion and deposition actions; the area covered with water when the stream overflows its banks at times of high water; it is built of alluvium carried by the stream during floods and deposited in the sluggish water beyond the influence of the swiftest current.

**Fluvial** Of or pertaining to a river or rivers.

**Formation** The basic rock unit distinctive enough to be readily recognizable in the field and widespread and thick enough to be plotted on a map. It describes the strata, such as limestone, sandstone, shale, or combinations of these and other rock types; formations have formal names, such as Joliet Formation or St. Louis Limestone (Formation), usually derived from geographic localities.

**Fossil** Any remains or traces of an once living plant or animal specimens that are preserved in rocks (arbitrarily excludes Recent remains).

**Geology** The study of the planet Earth. It is concerned with the origin of the planet, the material and morphology of the Earth, and its history and the processes that acted (and act) upon it to affect its historic and present forms.

**Geophysics** Study of the Earth by quantitative physical methods.

**Glaciation** A collective term for the geologic processes of glacial activity, including erosion and deposition, and the resulting effects of such action on the Earth's surface.

**Glacier** A large, slow-moving mass of ice at least in part on land.



**Gradient** A part of a surface feature of the Earth that slopes upward or downward; a slope, as of a stream channel or of a land surface.

**Igneous** Said of a rock or mineral that solidified from molten or partly molten material, i.e., from magma.

**Indurated** A compact rock or soil hardened by the action of pressure, cementation, and especially heat. Joint - A fracture or crack in rocks along which there has been no movement of the opposing sides.

**Karst** Area underlain by limestone having many sinkholes separated by steep ridges or irregular hills. Tunnels and caves resulting from solution by groundwater honeycomb the subsurface.

**Lacustrine** Produced by or belonging to a lake.

**Laurasia** A combination of Laurentia, a paleogeographic term for the Canadian Shield and its surroundings, and Eurasia. It is the protocontinent of the Northern Hemisphere, corresponding to Gondwana in the Southern Hemisphere, from which the present continents of the Northern Hemisphere have been derived by separation and continental displacement. The hypothetical supercontinent from which both were derived is Pangea. The protocontinent included most of North America, Greenland, and most of Eurasia, excluding India. The main zone of separation was in the North Atlantic, with a branch in Hudson Bay, and geologic features on opposite sides of these zones are very similar.

**Liesegang banding/rings** Secondary, nested rings or bands caused by rhythmic precipitation within a fluid-saturated rock.

**Limestone** A sedimentary rock consisting primarily of calcium carbonate (the mineral, calcite).

**Lithify** To change to stone, or to petrify; esp. to consolidate from a loose sediment to a solid rock.

**Lithology** The description of rocks on the basis of color, structures, mineral composition, and grain size; the physical character of a rock.

**Local relief** The vertical difference in elevation between the highest and lowest points of a land surface within a specified horizontal distance or in a limited area.

**Loess** A homogeneous, unstratified deposit of silt deposited by the wind.

**Magma** Naturally occurring mobile rock material or fluid, generated within Earth and capable of intrusion and extrusion, from which igneous rocks are thought to have been derived through solidification and related processes.

**Meander** One of a series of somewhat regular, sharp, sinuous curves, bends, loops, or turns produced by a stream, particularly in its lower course where it swings from side to side across its valley bottom.

**Meander scars** Crescent-shaped, concave marks along a river's floodplain that are abandoned meanders, frequently filled in with sediments and vegetation.

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

**Mineral** A naturally formed chemical element or compound having a definite chemical composition and, usually, a characteristic crystal form.

**Moraine** A mound, ridge, or other distinct accumulation of...glacial drift, predominantly till, deposited...in a variety of topographic landforms that are independent of control by the surface on which the drift lies.

**Morphology** The scientific study of form, and of the structures and development that influence form; term used in most sciences.

**Natural gamma log** These logs are run in cased, uncased, air, or water-filled boreholes. Natural gamma radiation increases from the left to the right side of the log. In marine sediments, low radiation levels indicate non-argillaceous limestone, dolomite, and sandstone.

**Nonconformity** An unconformity resulting from deposition of sedimentary strata on massive crystalline rock.

**Outwash** Stratified drift (clay, silt, sand, gravel) that was deposited by meltwater streams in channels, deltas, outwash plains, on floodplains, and in glacial lakes.

**Outwash plain** The surface of a broad body of outwash formed in front of a glacier.

**Oxbow lake** A crescent-shaped lake in an abandoned bend of a river channel.

**Pangea** A hypothetical supercontinent; supposed by many geologists to have existed at an early time in the geologic past, and to have combined all the continental crust of the Earth, from which the present continents were derived by fragmentation and movement away from each other by means of some form of continental displacement. During an intermediate stage of the fragmentation, between the existence of Pangea and that of the present widely separated continents, Pangea was supposed to have split into two large fragments, Laurasia on the north and Gondwana on the south. The proto-ocean around Pangea has been termed Panthalassa. Other geologists, while believing in the former existence of Laurasia and Gondwana, are reluctant to concede the existence of an original Pangea; in fact, the early (Paleozoic or older) history of continental displacement remains largely undeciphered.

**Ped** A naturally formed unit of soil structure, e.g. granule, block, crumb, or aggregate.

**Penepplain** A land surface of regional proportions worn down by erosion to a nearly flat or broadly undulating plain.

**Period** An interval of geologic time; a division of an era.

**Physiography** The study and classification of the surface features of Earth on the basis of similarities in geologic structure and the history of geologic changes.

**Physiographic province (or division)** (1) A region, all parts of which are similar in geologic structure and climate and which has consequently had a unified geologic history; (2) a region whose pattern of relief features or landforms differs significantly from that of adjacent regions.

**Radioactivity logs** Logs of bore holes obtained through the use of gamma logging, neutron logging, or combinations of the several radioactivity logging methods.

**Relief** (a) A term used loosely for the actual physical shape, configuration, or general unevenness of a part of Earth's surface, considered with reference to variations of height and slope or to irregularities of the land surface; the elevations or differences in elevation, considered collectively, of a land surface (frequently confused with topography). (b) The vertical difference in elevation between the hilltops or mountain summits and the lowlands or valleys of a given region; "high relief" has great variation; "low relief" has little variation.

**Sediment** Solid fragmental material, either inorganic or organic, that originates from weathering of rocks and is transported by, suspended in, or deposited by air, water, or ice, or that is accumulated by other natural agents, such as chemical precipitation from solution or secretion from organisms, and that forms in layers on Earth's surface at ordinary temperatures in a loose, unconsolidated form; e.g. sand, gravel, silt, mud, till, loess, alluvium.

**Sedimentary rock** A rock resulting from the consolidation of loose sediment that has accumulated in layers (e.g., sandstone, siltstone, limestone).

**Sinkholes** Small circular depressions that have formed by solution in areas underlain by soluble rocks, most commonly limestone and dolomite.

**Stage, substage** Geologic time-rock units; the strata formed during an age or subage, respectively.

**Stratigraphy** The study, definition, and description of major and minor natural divisions of rocks, especially the study of the form, arrangement, geographic distribution, chronologic succession, classification, correlation, and mutual relationships of rock strata.

**Stratigraphic unit** A stratum or body of strata recognized as a unit in the classification of the rocks of Earth's crust with respect to any specific rock character, property, or attribute or for any purpose such as description, mapping, and correlation.

**Stratum** A tabular or sheet-like mass, or a single and distinct layer, of homogeneous or gradational sedimentary material of any thickness, visually separable from other layers above and below by a discrete change in character of the material deposited or by a sharp physical break in deposition, or by both; a sedimentary bed.

**Subage** An interval of geologic time; a division of an age.

**Syncline** A downfold of strata which dip inward from the sides toward the axis; youngest rocks along the axis; the opposite of anticline.

**System** The largest and fundamental geologic time-rock unit; the strata of a system were deposited during a period of geologic time.

**Tectonic** Pertaining to the global forces involved in, or the resulting structures or features of Earth's movements.

**Tectonics** The branch of geology dealing with the broad architecture of the upper (outer) part of Earth's crust; a regional assembling of structural or deformational features, their origins, historical evolution, and mutual relations.

**Temperature-resistance log** This log, run only in water, portrays the earth's temperature and the quality of groundwater in the well.

**Till** Unconsolidated, nonsorted, unstratified drift deposited by and underneath a glacier and consisting of a heterogeneous mixture of different sizes and kinds of rock fragments.

**Till plain** The undulating surface of low relief in the area underlain by ground moraine.

**Topography** The natural or physical surface features of a region, considered collectively as to form; the features revealed by the contour lines of a map.

**Unconformable** Having the relation of an unconformity to underlying rocks and separated from them by an interruption in sedimentation, with or without any accompanying erosion of older rocks.

**Unconformity** A surface of erosion or nondeposition that separates younger strata from older strata; most unconformities indicate intervals of time when former areas of the sea bottom were temporarily raised above sea level.

**Valley trains** The accumulations of outwash deposited by rivers in their valleys downstream from a glacier.

**Water table** The upper surface of a zone of saturation.

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



ERRATICS ARE ERRATIC

*Myrna M. Killey*

You may have seen them scattered here and there in Illinois—boulders, some large, some small, lying alone or with a few companions in the corner of a field, at the edge of a road, in someone's yard, or perhaps on a courthouse lawn or schoolyard. Many of them seem out of place, like rough, alien monuments in the stoneless, grassy knolls and prairies of our state. Some—the colorful and glittering granites, banded gneisses, and other intricately veined and streaked igneous and metamorphic rocks—are indeed foreign rocks, for they came from Canada and the states north of us. Others—gray and tan sedimentary rocks—are native rocks and may be no more than a few miles from their place of origin. All of these rocks are glacial boulders that were moved to their present sites by massive ice sheets that flowed across our state. If these boulders are unlike the rocks in the quarries and outcrops in the region where they are found, they are called erratics.

The continental glaciers of the Great Ice Age scoured and scraped the land surface as they advanced, pushing up chunks of bedrock and grinding them against each other or along the ground surface as the rock-laden ice sheets pushed southward. Hundreds of miles of such grinding, even on such hard rocks as granite, eventually rounded off the sharp edges of these passengers in the ice until they became the rounded, irregular boulders we see today. Although we do not know the precise manner in which erratics reached their present isolated sites, many were

probably dropped directly from the melting front of a glacier. Others may have been rafted to their present resting places by icebergs on ancient lakes or on the floodwaters of some long-vanished stream as it poured from a glacier. Still others, buried in the glacial deposits, could have worked their way up to the land surface as the surrounding loose soil repeatedly froze and thawed. When the freezing ground expands, pieces of rock tend to be pushed upward, where they are more easily reached by the farmer's plow and also more likely to be exposed by erosion.



An eight-foot boulder of pink granite left by a glacier in the bed of a creek about 5 miles southwest of Alexis, Warren County, Illinois. (From ISGS Bulletin 57, 1929.)

Generally speaking, erratics found northeast of a line drawn from Freeport in Stephenson County, southward through Peoria, and then southeastward through Shelbyville to Marshall at the east edge of the state were brought in by the last glacier to enter Illinois. This glaciation, called the Wisconsinan, spread southwestward into Illinois from a center in eastern Canada, reaching our state about 75,000 years ago and (after repeated advances and retreats of the ice margin) melting from the state about 12,500 years ago. Erratics to the west or south of the great arc outlined above were brought in by a much older glacier, the Illinoian, which spread over most of the state about 300,000 to 175,000 years ago. Some erratics were brought in by even older glaciers that came from the northwest.

You may be able to locate some erratics in your neighborhood. Sometimes it is possible to tell where the rock originally came from by determining the kind of rock it is. A large boulder of granite, gneiss, or other igneous or metamorphic rock may have come from the Canadian Shield, a vast area in central and eastern Canada where rocks of Precambrian age (more than 600 million years old) are exposed at the surface. Some erratics containing flecks of copper were probably transported here from the "Copper Range" of the upper peninsula of Michigan. Large pieces of copper have been found in glacial deposits of central and northern Illinois. Light gray to white quartzite boulders with beautiful, rounded pebbles of red jasper came from a very small outcrop area near Bruce Mines, Ontario, Canada. Purplish pieces of quartzite, some of them banded, probably originated in the Baraboo Range of central Wisconsin. Most interesting of all are the few large boulders of Canadian tillite. Tillite is lithified (hardened into rock) glacial till deposited by a Precambrian glacier many millions of years older than the ones that invaded our state a mere few thousand years ago. Glacial till is an unsorted and unlayered mixture of clay, sand, gravel, and boulders that vary widely in size and shape. Tillite is a gray to greenish gray rock containing a mixture of grains of different sizes and scattered pebbles of various types and sizes.

Many erratics are of notable size and beauty, and in parts of Illinois they are commonly used in landscaping. Some are used as monuments in courthouse squares, in parks, or along highways. Many are marked with metal plaques to indicate an interesting historical spot or event. Keep an eye out for erratics. There may be some of these glacial strangers in your neighborhood that would be interesting to know.

ANCIENT DUST STORMS IN ILLINOIS

*Myrna M. Killey*

Fierce dust storms whirled across Illinois long before human beings were here to record them. Where did all the dust come from? Geologists have carefully put together clues from the earth itself to get the story. As the glaciers of the Great Ice Age scraped and scoured their way southward across the landscape from Canada, they moved colossal amounts of rock and earth. Much of the rock ground from the surface was kneaded into the ice and carried along, often for hundreds of miles. The glaciers acted as giant grist mills, grinding much of the rock and earth to "flour"—very fine dust-sized particles.

During the warm seasons, water from the melting ice poured from the glacier front, laden with this rock flour, called silt. In the cold months the melt-water stopped flowing and the silt was left along the channels the water had followed, where it dried out and became dust. Strong winds picked up the dust, swept it from the floodplains, and carried it to adjacent uplands. There the forests along the river valleys trapped the dust, which became part of the moist forest soil. With each storm more material accumulated until the high bluffs adjacent to major rivers were formed. The dust deposits are thicker along the eastern sides of the valleys than they are on the western sides, a fact from which geologists deduce that the prevailing winds of that time blew from west to east, the same direction as those of today. From such clues geologists conclude that the geologic processes of the past were much like those of today.

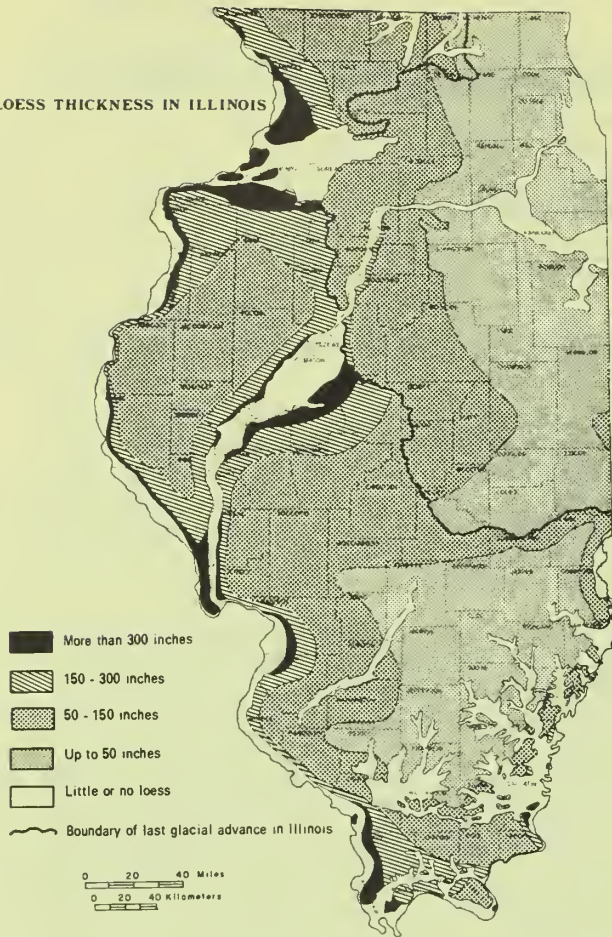
The deposits of windblown silt are called loess (rhymes with "bus"). Loess is found not only in the areas once covered by the glaciers but has been blown into the nonglaciated areas. The glaciers, therefore, influenced the present land surface well beyond the line of their farthest advance.

Loess has several interesting characteristics. Its texture is so fine and uniform that it can easily be identified in roadcuts—and because it blankets such a vast area many roads are cut through it. Even more noticeable is its tendency to stand in vertical walls. These steep walls develop as the loess drains and becomes tough, compact, and massive, much like a rock. Sometimes cracks develop in the loess, just as they do in massive limestones and sandstones. Loess makes good highway banks if it is cut vertically. A vertical cut permits maximum drainage because little surface is exposed to rain, and rainwater tends to drain straight down through it to the rock underneath. If the bank is cut at an angle more water soaks in, which causes the loess to slump down. Along Illinois roads the difference between a loess roadcut and one in ordinary glacial till is obvious. The loess has a very uniform texture, while the till is composed of a random mixture of rock debris, from clay and silt through cobbles and boulders.

Many loess deposits are worth a close look. Through a 10-power hand lens separate grains can be seen, among them many clear, glassy, quartz grains. Some loess deposits contain numerous rounded, lumpy stones called concretions. Their formation began when water percolating through the loess dissolved tiny



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limestone grains. Some of the dissolved minerals later became solid again, gathering around a tiny nucleus or along roots to form the lumpy masses. A few such concretions are shaped roughly like small dolls and, from this resemblance, are called "loess kindchen," a German term meaning "loess children." They may be partly hollow and contain smaller lumps that make them rattle when shaken.

Fossil snails can be found in some loess deposits. The snails lived on the river bluffs while the loess was being deposited and were buried by the dust. When they are abundant, they are used to determine how old the loess is. The age is found by measuring the amount of radioactive carbon in the calcium carbonate of their shells.

Some of the early loess deposits were covered by new layers of loess following later glacial invasions. Many thousands of years passed between the major glacial periods, during which time the climate was as warm as that of today. During the warm intervals, the surface of the loess and other glacial deposits was exposed to weather. Soils developed on most of the terrain, altering the composition, color, and texture

of the glacial material. During later advances of the ice, some of these soils were destroyed, but in many places they are preserved under the younger sediments. Such ancient buried soils can be used to determine when the materials above and below them were laid down by the ice and what changes in climate took place.

The blanket of loess deposited by the ancient dust storms forms the parent material of the rich, deep soils that today are basic to the state's agriculture. A soil made of loess crumbles easily and has great moisture-holding capacity. It also is free from rocks that might complicate cultivation. Those great dust storms that swirled over the land many thousands of years ago thus endowed Illinois with one of its greatest resources, its highly productive soil.

# PLEISTOCENE GLACIATIONS IN ILLINOIS

## Origin of the Glaciers

During the past million years or so, an interval of time called the Pleistocene Epoch, most of the northern hemisphere above the 50th parallel has been repeatedly covered by glacial ice. The cooling of the earth's surface, a prerequisite for glaciation, began at least 2 million years ago. On the basis of evidence found in subpolar oceans of the world (temperature-dependent fossils and oxygen-isotope ratios), a recent proposal has been made to recognize the beginning of the Pleistocene at 1.6 million years ago. Ice sheets formed in sub-arctic regions many times and spread outward until they covered the northern parts of Europe and North America. In North America, early studies of the glacial deposits led to the model that four glaciations could explain the observed distribution of glacial deposits. The deposits of a glaciation were separated from each other by the evidence of intervals of time during which soils formed on the land surface. In order of occurrence from the oldest to the youngest, they were given the names Nebraskan, Kansan, Illinoian, and Wisconsinan Stages of the Pleistocene Epoch. Work in the last 30 years has shown that there were more than four glaciations but the actual number and correlations at this time are not known. Estimates that are gaining credibility suggest that there may have been about 14 glaciations in the last one million years. In Illinois, estimates range from 4 to 8 based on buried soils and glacial deposits. For practical purposes, the previous four glacial stage model is functional, but we now know that the older stages are complex and probably contain more than one glaciation. Until we know more, all of the older glacial deposits, including the Nebraskan and Kansan will be classified as pre-Illinoian. The limits and times of the ice movement in Illinois are illustrated in the following pages by several figures.



The North American ice sheets developed when the mean annual temperature was perhaps 4° to 7°C (7° to 13°F) cooler than it is now and winter snows did not completely melt during the summers. Because the time of cooler conditions lasted tens of thousands of years, thick masses of snow and ice accumulated to form glaciers. As the ice thickened, the great weight of the ice and snow caused them to flow outward at their margins, often for hundreds of miles. As the ice sheets expanded, the areas in which snow accumulated probably also increased in extent.

Tongues of ice, called lobes, flowed southward from the Canadian centers near Hudson Bay and converged in the central lowland between the Appalachian and Rocky Mountains. There the glaciers made their farthest advances to the south. The sketch below shows several centers of flow, the general directions of flow from the centers, and the southern extent of glaciation. Because Illinois lies entirely in the central lowland, it has been invaded by glaciers from every center.

## Effects of Glaciation

Pleistocene glaciers and the waters melting from them changed the landscapes they covered. The glaciers scraped and smeared the landforms they overrode, leveling and filling many of the minor valleys and even some of the larger ones. Moving ice carried colossal amounts of rock and earth, for much of what the glaciers wore off the ground was kneaded into the moving ice and carried along, often for hundreds of miles.

The continual floods released by melting ice entrenched new drainageways, deepened old ones, and then partly refilled both with sediments as great quantities of rock and earth were carried beyond the glacier fronts. According to some estimates, the amount of water drawn from the sea and changed into ice during a glaciation was enough to lower the sea level from 300 to 400 feet below present level. Consequently, the melting of a continental ice sheet provided a tremendous volume of water that eroded and transported sediments.



In most of Illinois, then, glacial and meltwater deposits buried the old rock-ribbed, low, hill-and-valley terrain and created the flatter landforms of our prairies. The mantle of soil material and the buried deposits of gravel, sand, and clay left by the glaciers over about 90 percent of the state have been of incalculable value to Illinois residents.

## Glacial Deposits

The deposits of earth and rock materials moved by a glacier and deposited in the area once covered by the glacier are collectively called **drift**. Drift that is ice-laid is called **till**. Water-laid drift is called **outwash**.

Till is deposited when a glacier melts and the rock material it carries is dropped. Because this sediment is not moved much by water, a till is unsorted, containing particles of different sizes and compositions. It is also stratified (unlayered). A till may contain materials ranging in size from microscopic clay particles to large boulders. Most tills in Illinois are pebbly clays with only a few boulders. For descriptive purposes, a mixture of clay, silt, sand and boulders is called **diamicton**. This is a term used to describe a deposit that could be interpreted as till or a mass wasting product.

Tills may be deposited as **end moraines**, the arc-shaped ridges that pile up along the glacier edges where the flowing ice is melting as fast as it moves forward. Till also may be deposited as **ground moraines**, or **till plains**, which are gently undulating sheets deposited when the ice front melts back, or retreats. Deposits of till identify areas once covered by glaciers. Northeastern Illinois has many alternating ridges and plains, which are the succession of end moraines and till plains deposited by the Wisconsinan glacier.

Sorted and stratified sediment deposited by water melting from the glacier is called **outwash**. Outwash is bedded, or layered, because the flow of water that deposited it varied in gradient, volume, velocity, and direction. As a meltwater stream washes the rock materials along, it sorts them by size—the fine sands, silts, and clays are carried farther downstream than the coarser gravels and cobbles. Typical Pleistocene outwash in Illinois is in multilayered beds of clays, silts, sands, and gravels that look much like modern stream deposits in some places. In general, outwash tends to be coarser and less weathered, and alluvium is most often finer than medium sand and contains variable amounts of weathered material.

Outwash deposits are found not only in the area covered by the ice field but sometimes far beyond it. Meltwater streams ran off the top of the glacier, in crevices in the ice, and under the ice. In some places, the cobble-gravel-sand filling of the bed of a stream that flowed in the ice is preserved as a sinuous ridge called an **esker**. Some eskers in Illinois are made up of sandy to silty deposits and contain mass wasted diamicton material. Cone-shaped mounds of coarse outwash, called **kames**, were formed where meltwater plunged through crevasses in the ice or into ponds on the glacier.

The finest outwash sediments, the clays and silts, formed bedded deposits in the ponds and lakes that filled glacier-dammed stream valleys, the sags of the till plains, and some low, moraine-diked till plains. Meltwater streams that entered a lake rapidly lost speed and also quickly dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sand and silts were commonly redistributed on the lake bottom by wind-generated currents, and the clays, which stayed in suspension longest, slowly settled out and accumulated with them.

Along the ice front, meltwater ran off in innumerable shifting and short-lived streams that laid down a broad, flat blanket of outwash that formed an **outwash plain**. Outwash was also carried away from the glacier in valleys cut by floods of meltwater. The Mississippi, Illinois, and Ohio Rivers occupy valleys that were major channels for meltwaters and were greatly widened and deepened during times of the greatest meltwater floods. When the floods waned, these valleys were partly filled with outwash far beyond the ice margins. Such outwash deposits, largely sand and gravel, are known as **valley trains**. Valley train deposits may be both extensive and thick. For instance, the long valley train of the Mississippi Valley is locally as much as 200 feet thick.



## Loess, Eolian Sand and Soils

One of the most widespread sediments resulting from glaciation was carried not by ice or water but by wind. **Loess** is the name given to windblown deposits dominated by silt. Most of the silt was derived from wind erosion of the valley trains. Wind action also sorted out **eolian sand** which commonly formed **sand dunes** on the valley trains or on the adjacent uplands. In places, sand dunes have migrated up to 10 miles away from the principle source of sand. Flat areas between dunes are generally underlain by eolian **sheet sand** that is commonly reworked by water action. On uplands along the major valley trains, loess and eolian sand are commonly interbedded. With increasing distance from the valleys, the eolian sand pinches out, often within one mile.

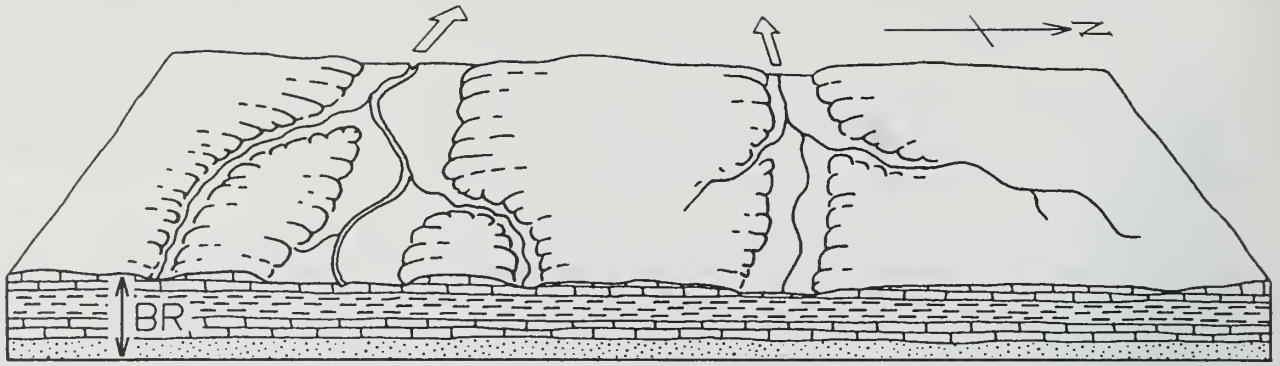
Eolian deposition occurred when certain climatic conditions were met, probably in a seasonal pattern. Deposition could have occurred in the fall, winter or spring season when low precipitation rates and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and permitting them to dry out. During Pleistocene time, as now, west winds prevailed, and the loess deposits are thickest on the east sides of the source valleys. The loess thins rapidly away from the valleys but extends over almost all the state.

Each Pleistocene glaciation was followed by an interglacial stage that began when the climate warmed enough to melt the glaciers and their snowfields. During these warmer intervals, when the climate was similar to that of today, drift and loess surfaces were exposed to weather and the activities of living things. Consequently, over most of the glaciated terrain, soils developed on the Pleistocene deposits and altered their composition, color, and texture. Such soils were generally destroyed by later glacial advances, but some were buried. Those that survive serve as "key beds," or stratigraphic markers, and are evidence of the passage of a long interval of time.

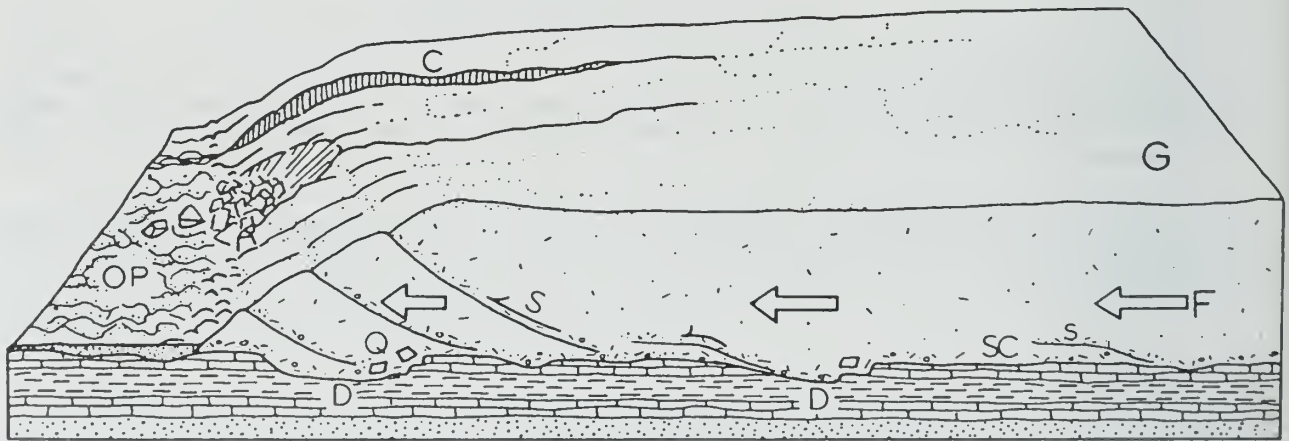
## Glaciation in a Small Illinois Region

The following diagrams show how a continental ice sheet might have looked at various stages as it moved across a small region in Illinois. They illustrate how it could change the old terrain and create a landscape like the one we live on. To visualize how these glaciers looked, geologists study the landforms and materials left in the glaciated regions and also the present-day mountain glaciers and polar ice caps.

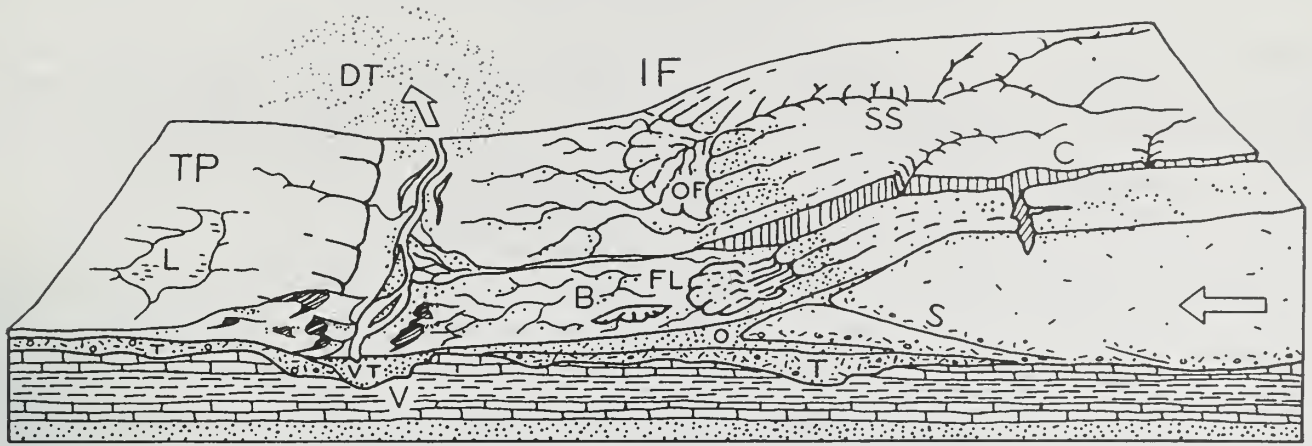
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated—layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



1. **The Region Before Glaciation** — Like most of Illinois, the region illustrated is underlain by almost flat-lying beds of sedimentary rocks—layers of sandstone (▨), limestone (▧), and shale (▩). Millions of years of erosion have planed down the bedrock (BR), creating a terrain of low uplands and shallow valleys. A residual soil weathered from local rock debris covers the area but is too thin to be shown in the drawing. The streams illustrated here flow westward and the one on the right flows into the other at a point beyond the diagram.



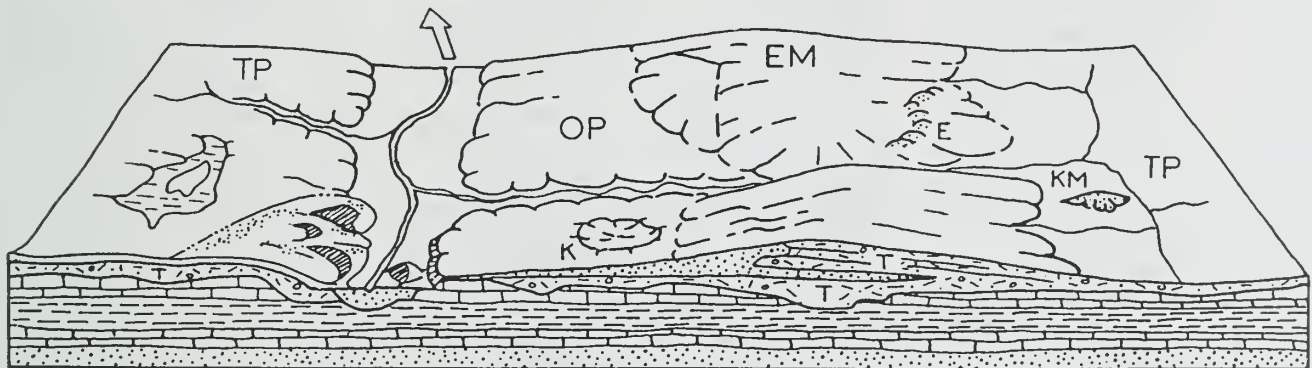
2. **The Glacier Advances Southward** — As the Glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughnesses in the terrain slow or stop flow (F), the ice "current" slides up over the blocked ice on innumerable shear planes (S). Shearing mixes the load very thoroughly. As the glacier spreads, long cracks called "crevasses" (C) open parallel to the direction of ice flow. The glacier melts as it flows forward, and its meltwater erodes the terrain in front of the ice, deepening (D) some old valleys before ice covers them. Meltwater washes away some of the load freed by melting and deposits it on the outwash plain (OP). The advancing glacier overrides its outwash and in places scours much of it up again. The glacier may be 5000 or so feet thick, and tapers to the margin, which was probably in the range of several hundred feet above the old terrain. The ice front advances perhaps as much as a third of a mile per year.



**3. The Glacier Deposits an End Moraine** — After the glacier advances across the area, the climate warms and the ice begins to melt as fast as it advances. The ice front (IF) is now stationary, or fluctuating in a narrow area, and the glacier is depositing an end moraine.

As the top of the glacier melts, some of the sediment that is mixed in the ice accumulates on top of the glacier. Some is carried by meltwater onto the sloping ice front (IF) and out onto the plain beyond. Some of the debris slips down the ice front in a mudflow (FL). Meltwater runs through the ice in a crevasse (C). A supraglacial stream (SS) drains the top of the ice, forming an outwash fan (OF). Moving ice has overridden an immobile part of the front on a shear plane (S). All but the top of a block of ice (B) is buried by outwash (O).

Sediment from the melted ice of the previous advance (figure 2) remains as a till layer (T), part of which forms the till plain (TP). A shallow, marshy lake (L) fills a low place in the plain. Although largely filled with drift, the valley (V) remains a low spot in the terrain. As soon as the ice cover melts, meltwater drains down the valley, cutting it deeper. Later, outwash partly refills the valley: the outwash deposit is called a valley train (VT). Wind blows dust (DT) off the dry floodplain. The dust will form a loess deposit when it settles. Sand dunes (D) form on the south and east sides of streams.



**4. The Region after Glaciation** — As the climate warms further, the whole ice sheet melts, and glaciation ends. The end moraine (EM) is a low, broad ridge between the outwash plain (OP) and till plains (TP). Run-off from rains cuts stream valleys into its slopes. A stream goes through the end moraine along the channel cut by the meltwater that ran out of the crevasse in the glacier.

Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left by the ice block's melting has made a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel into a crevasse or other depression in the glacier or at its edge is a kame (KM). A few feet of loess covers the entire area but cannot be shown at this scale.



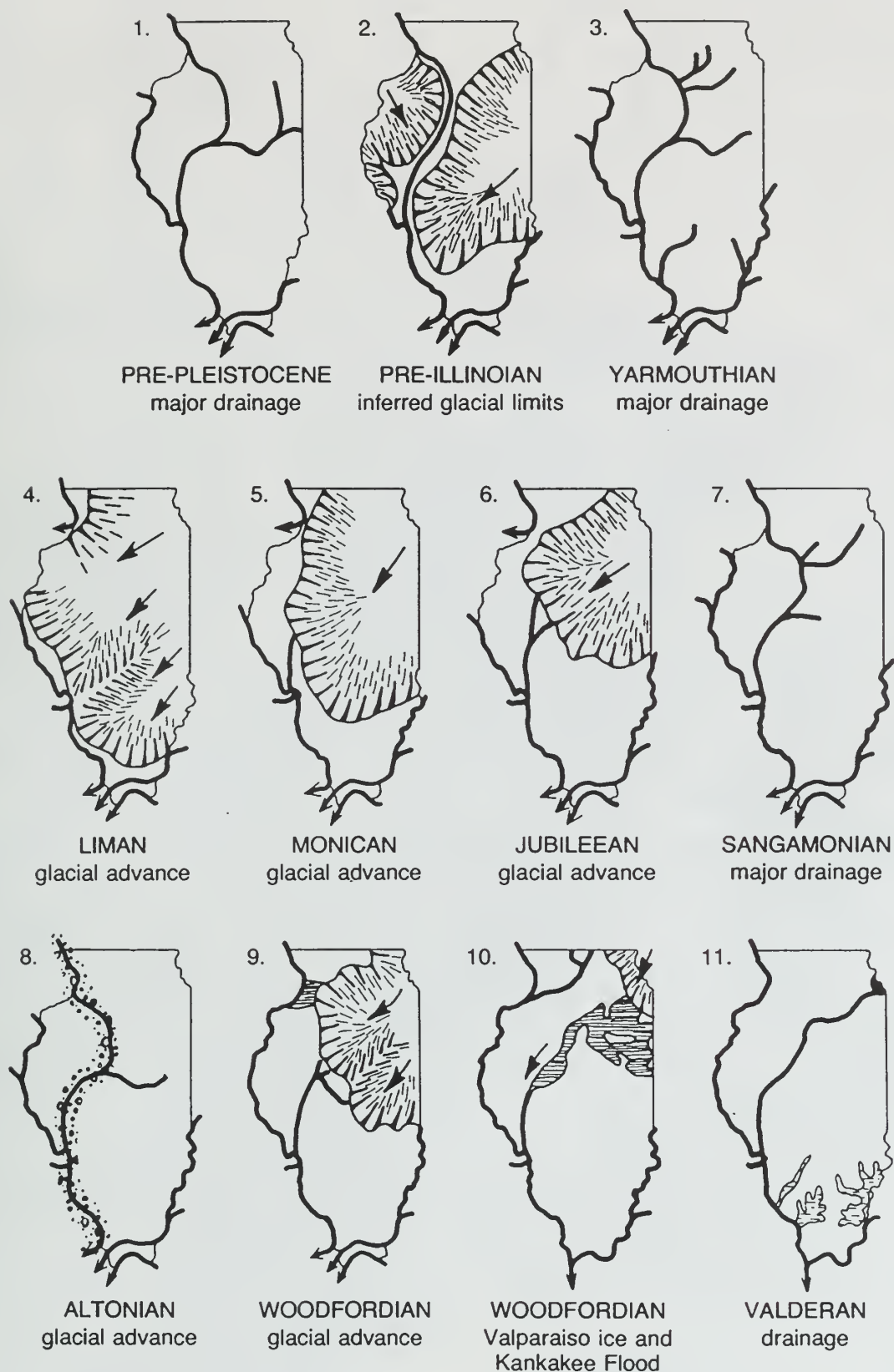
TIME TABLE OF PLEISTOCENE GLACIATION

		STAGE	SUBSTAGE	NATURE OF DEPOSITS	SPECIAL FEATURES	
QUATERNARY	Pleistocene	HOLOCENE (interglacial)	Years Before Present	Soil, youthful profile of weathering, lake and river deposits, dunes, peat		
		WISCONSINAN (glacial)	late	10,000		
				Valderan	Outwash, lake deposits	Outwash along Mississippi Valley
				11,000		
				Twocreekan	Peat and alluvium	Ice withdrawal, erosion
				12,500		
				Woodfordian	Drift, loess, dunes, lake deposits	Glaciation; building of many moraines as far south as Shelbyville; extensive valley trains, outwash plains, and lakes
				25,000		
			mid	Farmdalian	Soil, silt, and peat	Ice withdrawal, weathering, and erosion
				28,000		
		early	Altonian	Drift, loess	Glaciation in Great Lakes area, valley trains along major rivers	
			75,000			
		SANGAMONIAN (interglacial)		Soil, mature profile of weathering	Important stratigraphic marker	
		ILLINOIAN (glacial)		125,000		
				Jubileean	Drift, loess, outwash	Glaciers from northeast at maximum reached Mississippi River and nearly to southern tip of Illinois
				Monican	Drift, loess, outwash	
			Liman	Drift, loess, outwash		
YARMOUTHIAN (interglacial)		300,000?				
			Soil, mature profile of weathering	Important stratigraphic marker		
Pre-Illinoian		KANSAN* (glacial)	500,000?	Drift, loess	Glaciers from northeast and northwest covered much of state	
		AFTONIAN* (interglacial)	700,000?	Soil, mature profile of weathering	(hypothetical)	
		NEBRASKAN* (glacial)	900,000?			
				Drift (little known)	Glaciers from northwest invaded western Illinois	
			1,600,000 or more			

\*Old oversimplified concepts, now known to represent a series of glacial cycles.

(Illinois State Geological Survey, 1973)

# SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



# WOODFORDIAN MORAINES

H. B. Willman and John C. Frye

1970

Boundary of Woodfordian glaciation

Temperance Hill

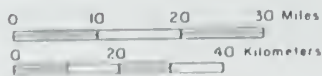
BLOOMINGTON

MARSEILLES

MARSEILLES

WOODFORDIAN

- Le Roy Named moraine
- ILLIANA Named morainic system
- Intermarinal area















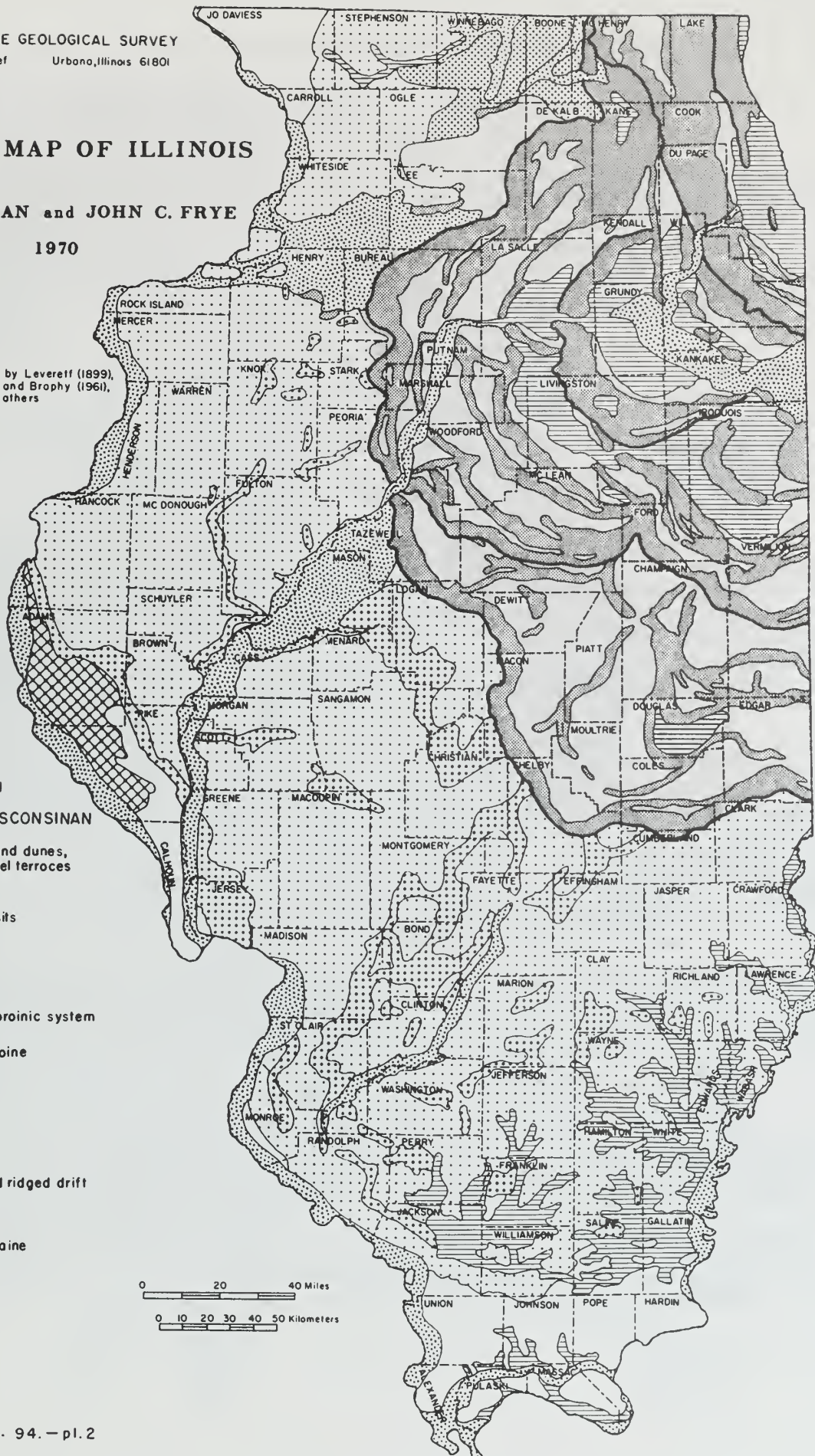
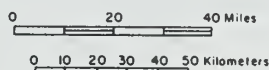
# GLACIAL MAP OF ILLINOIS

H.B. WILLMAN and JOHN C. FRYE

1970

Modified from maps by Leverett (1899),  
Ekblaw (1959), Leighton and Brophy (1961),  
Willman et al. (1967), and others

- EXPLANATION**
- HOLOCENE AND WISCONSINAN**
-  Alluvium, sand dunes,  
and gravel terraces
- WISCONSINAN**
-  Lake deposits
- WOODFORDIAN**
-  Moraine
-  Front of morainic system
-  Ground moraine
- ALTONIAN**
-  Till plain
- ILLINOIAN**
-  Moraine and ridged drift
-  Groundmoraine
- KANSAN**
-  Till plain
- DRIFTLESS**
- 

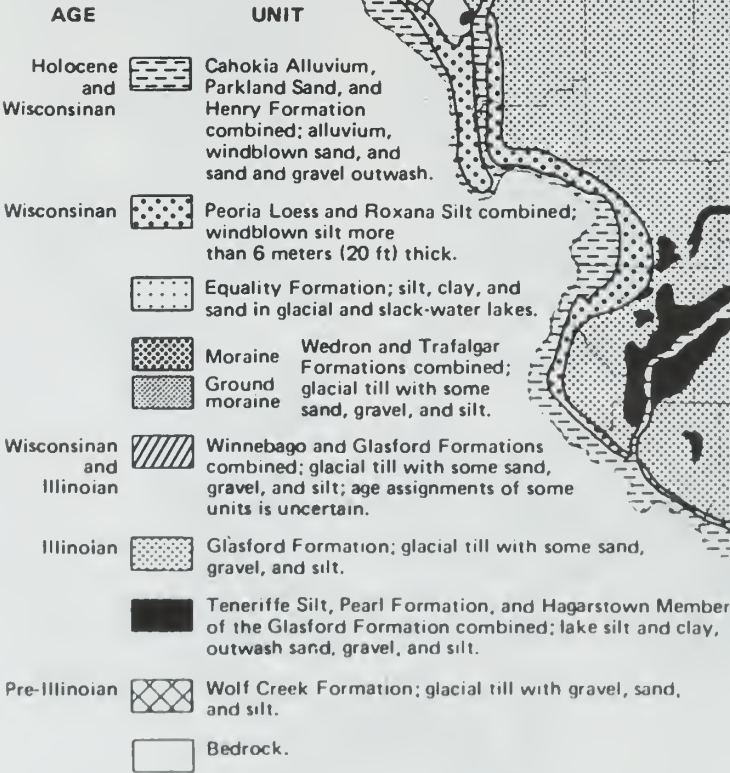
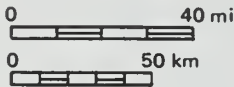




QUATERNARY DEPOSITS OF ILLINOIS

Jerry A. Lineback  
1981

Modified from Quaternary Deposits  
of Illinois (1979) by Jerry A. Lineback



## DEPOSITIONAL HISTORY OF THE PENNSYLVANIAN ROCKS IN ILLINOIS

At the close of the Mississippian Period, about 310 million years ago, the sea withdrew from the Midcontinent region. A long interval of erosion that took place early in Pennsylvanian time removed hundreds of feet of the pre-Pennsylvanian strata, completely stripping them away and cutting into older rocks over large areas of the Midwest. Ancient river systems cut deep channels into the bedrock surface. Later, but still during early Pennsylvanian (Morrowan) time, the sea level started to rise; the corresponding rise in the base level of deposition interrupted the erosion and led to filling the valleys in the erosion surface with fluvial, brackish, and marine sands and muds.

Depositional conditions in the Illinois Basin during the Pennsylvanian Period were somewhat similar to those of the preceding Chesterian (late Mississippian) time. A river system flowed southwestward across a swampy lowland, carrying mud and sand from highlands to the northeast. This river system formed thin but widespread deltas that coalesced into a vast coastal plain or lowland that prograded (built out) into the shallow sea that covered much of present-day Illinois (see paleogeographic map, next page). As the lowland stood only a few feet above sea level, slight changes in relative sea level caused great shifts in the position of the shoreline.

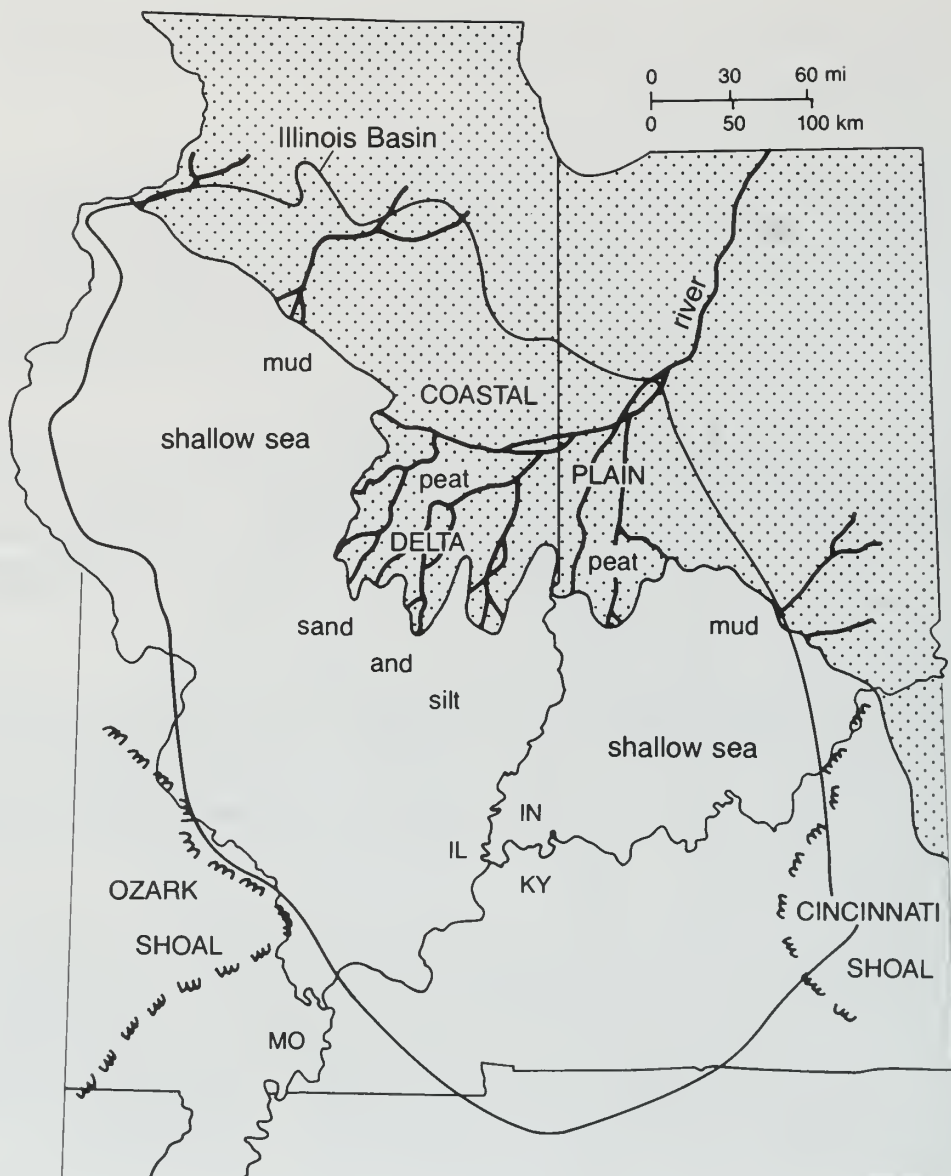
During most of Pennsylvanian time, the Illinois Basin gradually subsided; a maximum of about 3000 feet of Pennsylvanian sediments are preserved in the basin. The locations of the delta systems and the shoreline of the resulting coastal plain shifted, probably because of worldwide sea level changes, coupled with variation in the amounts of sediments provided by the river system and local changes in basin subsidence rates. These frequent shifts in the coastline position caused the depositional conditions at any one locality in the basin to alternate frequently between marine and nonmarine, producing a variety of lithologies in the Pennsylvanian rocks (see lithology distribution chart).

Conditions at various places on the shallow sea floor favored the deposition of sand, lime mud, or mud. Sand was deposited near the mouths of distributary channels, where it was reworked by waves and spread out as thin sheets near the shore. Mud was deposited in quiet-water areas — in delta bays between distributaries, in lagoons behind barrier bars, and in deeper water beyond the nearshore zone of sand deposition. Limestone was formed from the accumulation of limy parts of plants and animals laid down in areas where only minor amounts of sand and mud were being deposited. The areas of sand, mud, and limy mud deposition continually changed as the position of the shoreline changed and as the delta distributaries extended seaward or shifted their positions laterally along the shore.

Nonmarine sand, mud, and lime mud were deposited on the coastal plain bordering the sea. The nonmarine sand was deposited in delta distributary channels, in river channels, and on the broad floodplains of the rivers. Some sand bodies 100 or more feet thick were deposited in channels that cut through the underlying rock units. Mud was deposited mainly on floodplains. Some mud and freshwater lime mud were deposited locally in fresh-water lakes and swamps.

Beneath the quiet water of extensive swamps that prevailed for long intervals on the emergent coastal lowland, peat was formed by accumulation of plant material. Lush forest vegetation covered the region; it thrived in the warm, moist Pennsylvanian-age climate. Although the origin of the underclays beneath the coal is not precisely known, most evidence indicates that they were deposited in the swamps as slackwater mud before the accumulation of much plant debris. The clay underwent modification to become the soil upon which the lush vegetation grew in the swamps. Underclay frequently contains plant roots and rootlets that appear to be in their original places. The vast swamps were the culmination of nonmarine deposition. Resubmergence of the borderlands by the sea interrupted nonmarine deposition, and marine sediments were laid down over the peat.

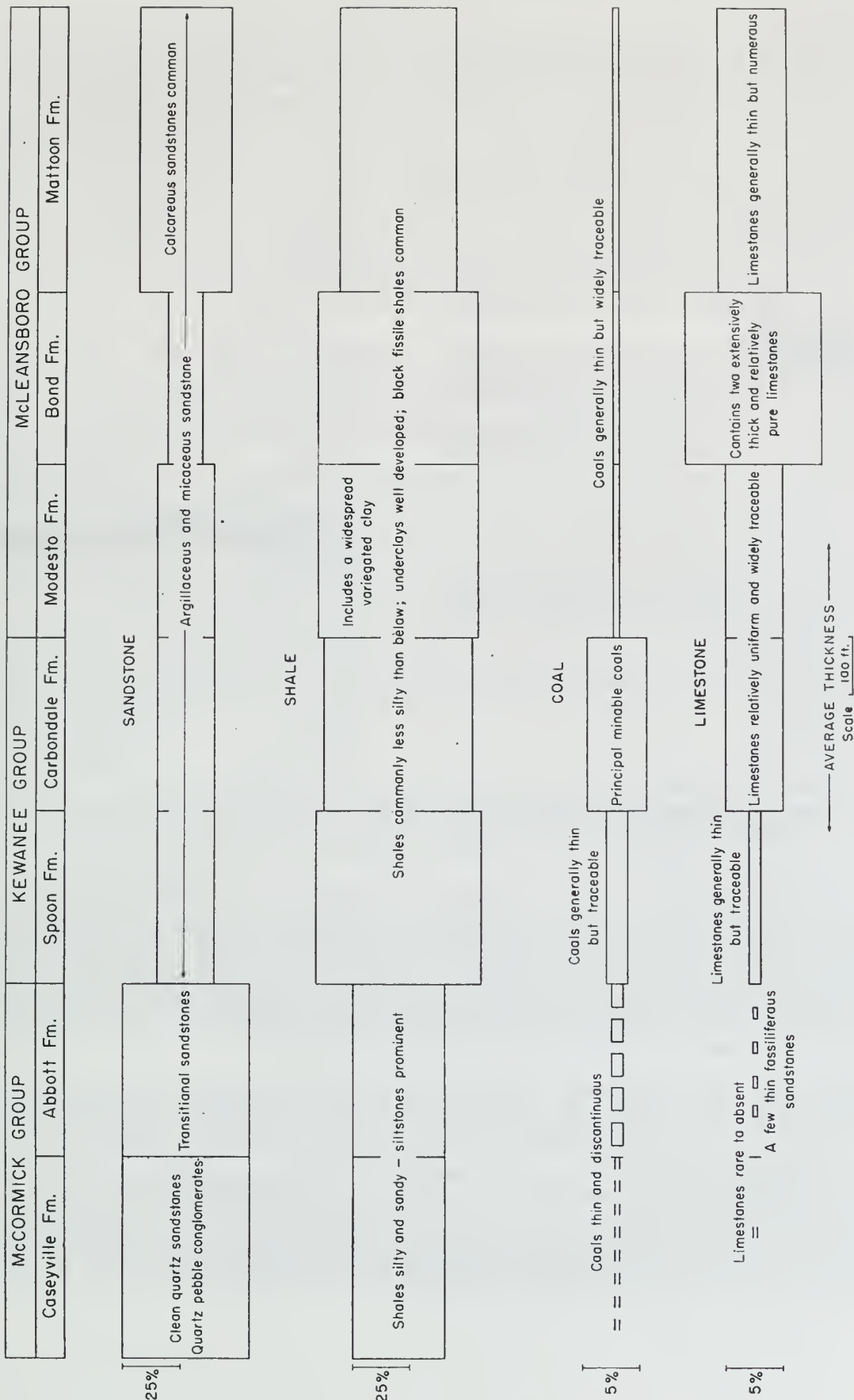




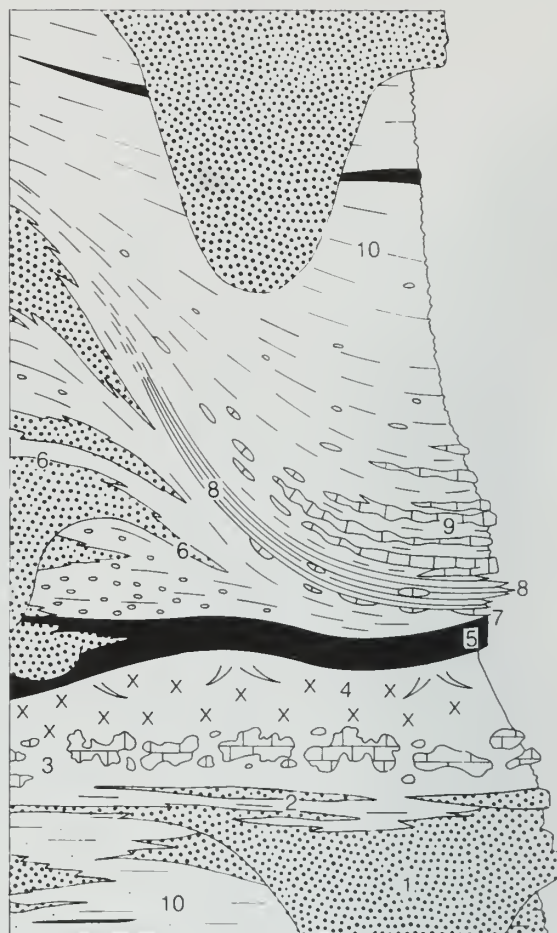
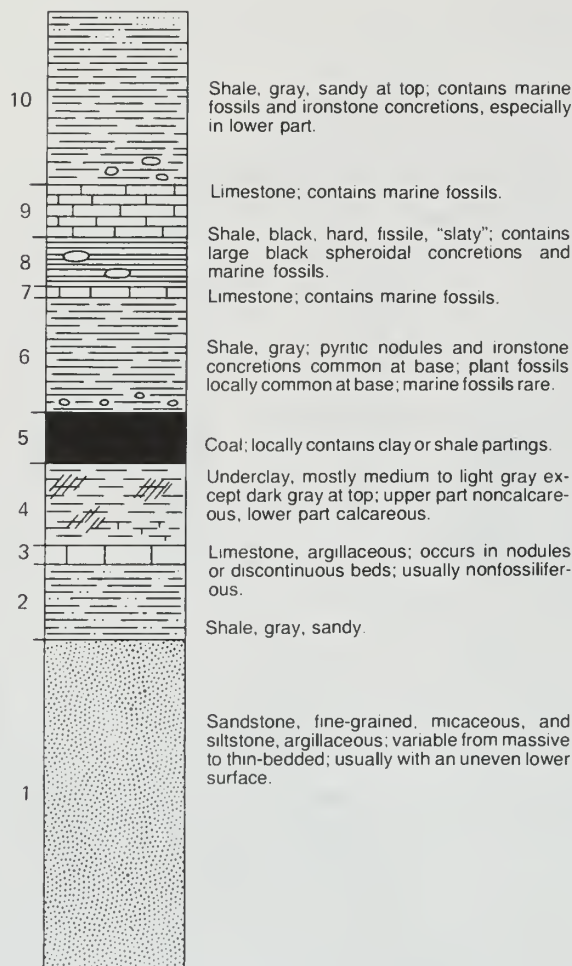
Paleogeography of Illinois-Indiana region during Pennsylvanian time. The diagram shows a Pennsylvanian river delta and the position of the shoreline and the sea at an instant of time during the Pennsylvanian Period.

### Pennsylvanian Cyclothems

The Pennsylvanian strata exhibit extraordinary variations in thickness and composition both laterally and vertically because of the extremely varied environmental conditions under which they formed. Individual sedimentary units are often only a few inches thick and rarely exceed 30 feet thick. Sandstones and shales commonly grade laterally into each other, and shales sometimes interfinger and grade into limestones and coals. The underclays, coals, black shales, and some limestones, however, display remarkable lateral continuity for such thin units. Coal seams have been traced in mines, outcrops, and subsurface drill records over areas comprising several states.



General distribution of the four principal lithologies in Pennsylvanian strata of Illinois.



The idealized cyclothem at left (after Willman and Payne, 1942) infers continuous, widespread distribution of individual cyclothem units, at right the model of a typical cyclothem (after Baird and Shabica, 1980) shows the discontinuous nature of many units in a cyclothem.

The rapid and frequent changes in depositional environments during Pennsylvanian time produced regular or cyclical alternations of sandstone, shale, limestone, and coal in response to the shifting shoreline. Each series of alternations, called a cyclothem, consists of several marine and nonmarine rock units that record a complete cycle of marine invasion and retreat. Geologists have determined, after extensive studies of the Pennsylvanian strata in the Midwest, that an "ideally" complete cyclothem consists of ten sedimentary units (see illustration above contrasting the model of an "ideal" cyclothem with a model showing the dynamic relationships between the various members of a typical cyclothem).

Approximately 50 cyclothem have been described in the Illinois Basin but only a few contain all ten units at any given location. Usually one or more are missing because conditions of deposition were more varied than indicated by the "ideal" cyclothem. However, the order of units in each cyclothem is almost always the same: a typical cyclothem includes a basal sandstone overlain by an underclay, coal, black sheeted shale, marine limestone, and gray marine shale. In general, the sandstone-underclay-coal-gray shale portion (the lower six units) of each cyclothem is nonmarine: it was deposited as part of the coastal lowlands from which the sea had withdrawn. However, some of the sandstones are entirely or partly marine. The units above the coal and gray shale are marine sediments deposited when the sea advanced over the coastal plain.



## Origin of Coal

It is generally accepted that the Pennsylvanian coals originated by the accumulation of vegetable matter, usually in place, beneath the waters of extensive, shallow, fresh-to-brackish swamps. They represent the last-formed deposits of the nonmarine portions of the cyclothem. The swamps occupied vast areas of the coastal lowland, which bordered the shallow Pennsylvanian sea. A luxuriant growth of forest plants, many quite different from the plants of today, flourished in the warm, humid Pennsylvanian climate. (Illinois at that time was near the equator.) The deciduous trees and flowering plants that are common today had not yet evolved. Instead, the jungle-like forests were dominated by giant ancestors of present-day club mosses, horsetails, ferns, conifers, and cycads. The undergrowth also was well developed, consisting of many ferns, fernlike plants, and small club mosses. Most of the plant fossils found in the coals and associated sedimentary rocks show no annual growth rings, suggesting rapid growth rates and lack of seasonal variations in the climate (tropical). Many of the Pennsylvanian plants, such as the seed ferns, eventually became extinct.

Plant debris from the rapidly growing swamp forests — leaves, twigs, branches, and logs — accumulated as thick mats of peat on the floors of the swamps. Normally, vegetable matter rapidly decays by oxidation, forming water, nitrogen, and carbon dioxide. However, the cover of swamp water, which was probably stagnant and low in oxygen, prevented oxidation, and any decay of the peat deposits was due primarily to bacterial action.

The periodic invasions of the Pennsylvanian sea across the coastal swamps killed the Pennsylvanian forests, and the peat deposits were often buried by marine sediments. After the marine transgressions, peat usually became saturated with sea water containing sulfates and other dissolved minerals. Even the marine sediments being deposited on the top of the drowned peat contained various minerals in solution, including sulfur, which further infiltrated the peat. As a result, the peat developed into a coal that is high in sulfur. However, in a number of areas, nonmarine muds, silts, and sands from the river system on the coastal plain covered the peat where flooding broke through levees or the river changed its course. Where these sediments (unit 6 of the cyclothem) are more than 20 feet thick, we find that the coal is low in sulfur, whereas coal found directly beneath marine rocks is high in sulfur. Although the seas did cover the areas where these nonmarine, fluvial sediments covered the peat, the peat was protected from sulfur infiltration by the shielding effect of these thick fluvial sediments.

Following burial, the peat deposits were gradually transformed into coal by slow physical and chemical changes in which pressure (compaction by the enormous weight of overlying sedimentary layers), heat (also due to deep burial), and time were the most important factors. Water and volatile substances (nitrogen, hydrogen, and oxygen) were slowly driven off during the coal-forming ("coalification") process, and the peat deposits were changed into coal.

Coals have been classified by ranks that are based on the degree of coalification. The commonly recognized coals, in order of increasing rank, are (1) brown coal or lignite, (2) sub-bituminous, (3) bituminous, (4) semibituminous, (5) semianthracite, and (6) anthracite. Each increase in rank is characterized by larger amounts of fixed carbon and smaller amounts of oxygen and other volatiles. Hardness of coal also increases with increasing rank. All Illinois coals are classified as bituminous.

Underclays occur beneath most of the coals in Illinois. Because underclays are generally unstratified (unlayered), are leached to a bleached appearance, and generally contain plant roots, many geologists consider that they represent the ancient soils on which the coal-forming plants grew.

The exact origin of the carbonaceous black shale that occurs above many coals is uncertain. Current thinking suggests that the black shale actually represents the deepest part of the marine transgression. Maximum transgression of the sea, coupled with upwelling of ocean water and accumulation of mud and animal remains on an anaerobic ocean floor, led to the deposition of black organic mud over vast areas stretching from Texas to Illinois. Deposition occurred in quiet-water areas where the very fine-grained iron-rich

PENNSYLVANIAN						SYSTEM		
MORROWAN	ATOKAN	DESMOINESIAN		MISSOURIAN	VIRGILIAN	SERIES		
Caseyville	McCormick	Spoon	Kewanee	Modesto	McLeansboro	Group		
	Abbott					Bond	Mattoon	Formation
	Pounds Sandstone Member							
	Murray Bluff Sandstone Member							
Colchester Coal Member				Carbondale	Danville Coal Member			
Trivoli Sandstone Member								
Carthage Limestone Member								
Millersville Limestone Member								
Shumway Limestone Member unnamed coal member								

# MISSISSIPPIAN TO ORDOVICIAN SYSTEMS

Generalized stratigraphic column of the Pennsylvanian in Illinois (1 inch = approximately 250 feet).

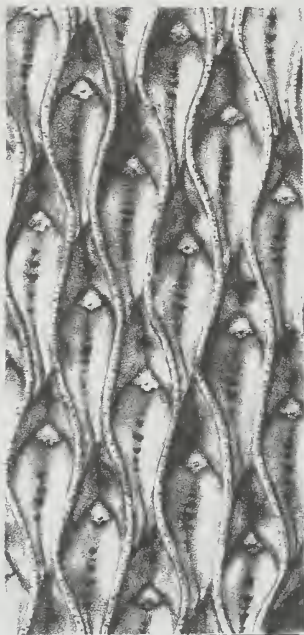
mud and finely divided plant debris were washed in from the land. Most of the fossils found in black shale represent planktonic (floating) and nektonic (swimming) forms — not benthonic (bottom-dwelling) forms. The depauperate (dwarf) fossil forms sometimes found in black shale formerly were thought to have been forms that were stunted by toxic conditions in the sulfide-rich, oxygen-deficient water of the lagoons. However, study has shown that the “depauperate” fauna consists mostly of normal-size individuals of species that never grew any larger.

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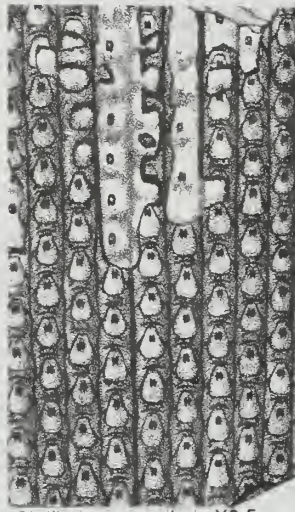
Common Pennsylvanian plants: lycopods, sphenophytes, and ferns



*Lepidodendron aculeatum* X0.8



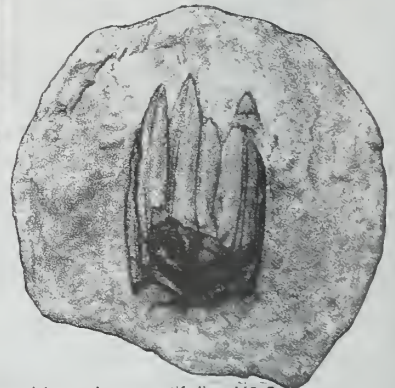
*Lepidophlois laricinus* X0.63



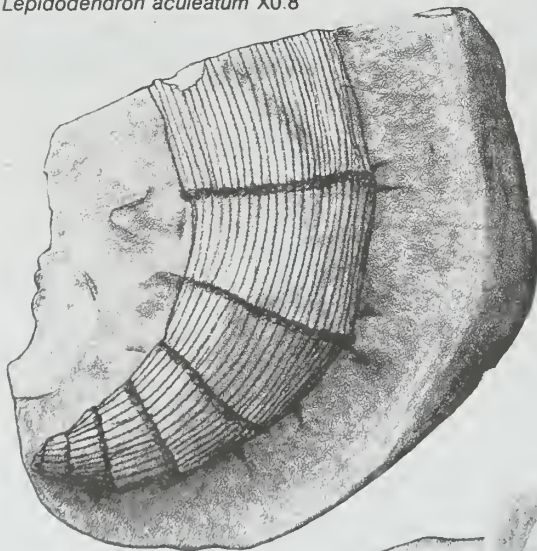
*Sigillaria mammilaris* X0.5



*Stigmaria ficoides* X0.32



*Lepidostrobus ovatifolius* X0.8



*Calamites suckowii* X0.5



*Annularia stellata* X0.63



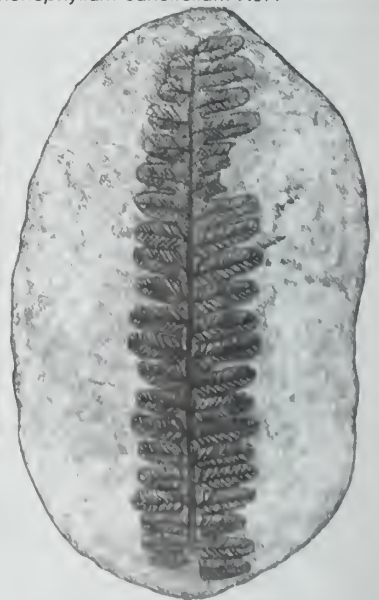
*Sphenophyllum cuneifolium* X0.4



*Pecopteris* sp. X0.32



*Pecopteris miltonii* X2.0



*Pecopteris hemitelioides* X1.0



# Common Pennsylvanian plants: seed ferns and cordaites



*Alethopteris serlii* X0.63



*Alethopteris ambigua* X0.63



*Neuropteris rarinervis* X0.5



*Neuropteris scheuchzeri* X0.63



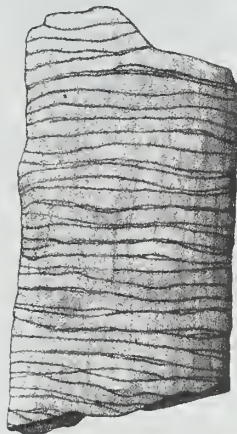
*Sphenopteris rotundiloba* X0.8



*Mariopteris nervosa* X0.8



*Cordaiacladus* sp. X1.0



*Artisia transversa* X0.63



*Trigonocarpus parkinsonii* X1.25



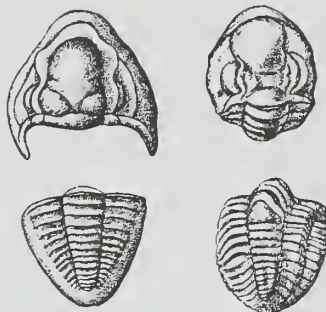
*Cordaicarpon major* X2.0



*Cordaites principalis* X0.63



### TRILOBITES



*Ameuro songomonensis*  $1\frac{1}{3}x$

*Ditomopyge parvulus*  $1\frac{1}{2}x$

### CORALS



*Laphophlidium proliferum*  $1x$

### FUSULINIDS



*Fusulino ocme*  $5x$



*Fusulina girtyi*  $5x$

### CEPHALOPODS



*Pseudorthoceras knoxense*  $1x$

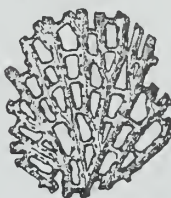


*Glaphrites welleri*  $2\frac{2}{3}x$

### BRYOZOANS



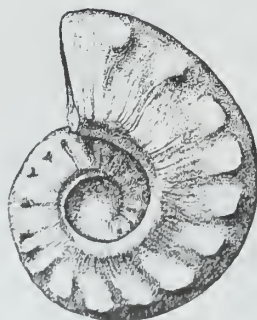
*Fenestrellino mimico*  $9x$



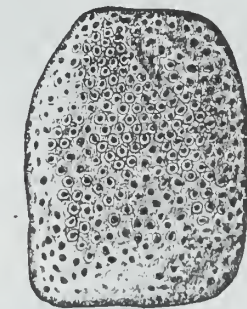
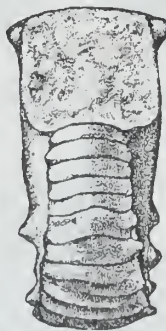
*Fenestrellino modesto*  $10x$



*Rhombopora lepidodendroides*  $6x$



*Metacoceros cornutum*  $1\frac{1}{2}x$



*Fistulipora corbonaria*  $3\frac{1}{3}x$



*Prismopora triangulata*  $12x$





*Nuculo (Nuculopsis) girtyi* 1x

## PELECYPODS



*Edmonio ovato* 2x



*Astortello concentrica* 1x



*Dunborello knighti* 1 1/2 x



*Cordiomorpha missouriensis*  
"Type A" 1x



*Cordiomorpha missouriensis*  
"Type B" 1 1/2 x

## GASTROPODS



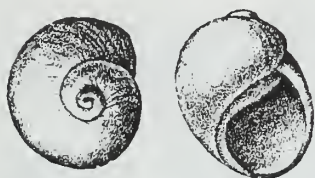
*Euphemites carbonarius* 1 1/2 x



*Trepospiro illinoisensis* 1 1/2 x



*Donaldina robusta* 8x



*Naticopsis (Jedrio) ventricosa* 1 1/2 x



*Trepaspira sphaerulata* 1x



*Knightites montfortianus* 2x



*Glabrocingulum (Glabrocingulum) grayvillense* 3x

# BRACHIOPODS



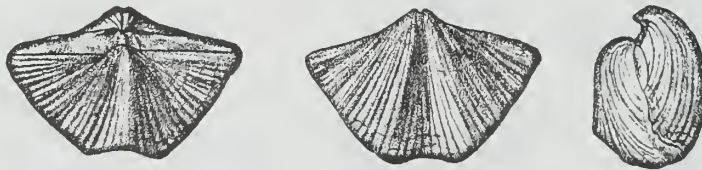
*Wellerella tetrahedra* 1 1/2 x

*Juresania nebrascensis* 2/3 x

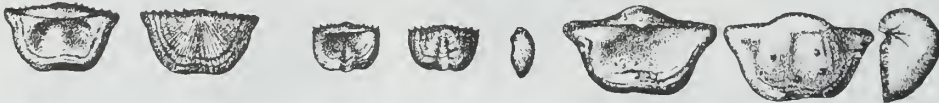


*Derbya crassa* 1x

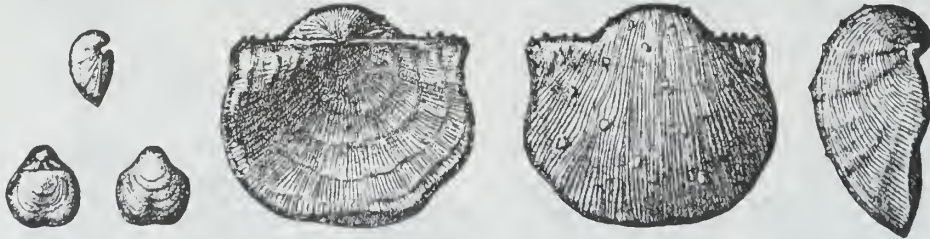
*Compasita argentia* 1x



*Neospirifer cameratus* 1x



*Chonetes granulifer* 1 1/2 x *Mesalabus mesalabus* var. *evampyus* 2x *Marginifera splendens* 1x



*Grurithyris planacavexa* 2x

*Linopraductus "cora"* 1x

## DEPOSITIONAL HISTORY OF THE MISSISSIPPIAN ROCKS

During the Mississippian Period, from 350 to 310 million years ago, the midcontinent of North America was a generally low-lying, nearly level, and stable platform. Clear, warm, shallow seas invaded the region, and the area that is now the Mississippi Valley remained almost continually submerged throughout Mississippian time. During the middle the period, the sea reached far to the north, and little sand and mud was carried into the Illinois Basin.

The relatively pure lime muds of the Valmeyeran Series, including the Burlington, Keokuk, Fort Payne, Ullin, Salem, St. Louis, and Ste. Genevieve Limestones, were deposited over enormous areas on the continental platform. The sea in which these limestones were deposited was fairly shallow, probably only a few hundred feet deep generally, and in many areas only a few tens of feet. Imagine an area much like the Bahama banks or Florida Bay, north and west of the Florida Keys. Marine animals found such shallow seas ideal for their development. Some of the limestones are almost entirely cemented fossil fragments or oolites and thus reflect the shallow, wave-swept conditions of deposition.

Throughout Mississippian time the Illinois Basin was a slowly subsiding (sinking) region, flanked on the east by the Cincinnati Arch and on the west by the Ozark Dome, both structurally high (positive) areas. These higher areas supplied little sand and mud to the Illinois Basin, and most clastic sediments were carried into the basin from land far to the north and northeast, in what is now Canada, by an ancient river system called the Michigan River.

Near the end of Valmeyeran time the sea became more restricted in extent and the shoreline shifted southward. Increased amounts of sand and mud were delivered into the Illinois Basin by the Michigan River. Thin shales and sandstones in the upper part of the Ste. Genevieve Limestone indicate the depositional changes that were taking place. The overlying Aux Vases Sandstone records a great increase in the amount of sand deposited in the nearshore areas of the Mississippian sea.

During the latter part of the Mississippian Period much greater amounts of sand and mud were carried to the sea by the Michigan River. A great delta was built out into the sea. It was very much like the present Mississippi River delta in Louisiana. As the Illinois Basin subsided periodically and as the amounts of sand and mud carried into the sea fluctuated, the position of the shoreline and the edge of the delta oscillated northward and southward for hundreds of miles.

The fluctuating shoreline, the shifting position of the delta's distributary channels, and the continually changing water depths produced the striking vertical and lateral variations in the lithology that characterize the Chesterian Series. Regular alternations of sandstone, shale, and limestone formations were formed, each alternation beginning with deposition of basal sandstone and shale followed by deposition of limestone. Sandstones and shales record times when the delta front extended far out into the basin. Limestones indicate times when the shoreline was farther away and marine conditions prevailed. In some respects the alternations of the sediments of the Chesterian Series resemble the cyclothems of the Pennsylvanian System, which overlies the Mississippian rocks in much of Illinois (see attached geologic map).

Some Chesterian limestones are very pure, but others are quite argillaceous (clayey) and sandy. Generally, the Chesterian sea was very shallow. Cross-bedding and oolitic zones are common in the limestones, as are zones that consisting of a hash of fossil remains that were broken by wave action. Sedimentary features such as pebbly zones, ripple marks, and cross-bedding are present in the sandstones, many of which are distributary and river channel sands. Thin coal seams associated with some of the sandstones indicate times when the sea withdrew temporarily and plant debris accumulated in fresh-water swamps. These late Mississippian coal swamps were forerunners of those that occurred more extensively later, during Pennsylvanian time.





# BRYOZOANS



*Rhombopora* 1x



*Archimedes* 1x

# TRILOBITE



*Phillipsia* 1x

# CRINOIDS



*Pterotocrinus* 1x



*Platycrinus* 1x



# BLASTOIDS



*Pentremites* 2x



*Pentremites* 2/3x

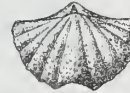
# BRACHIOPODS



*Leptæna* 1x



*Composita* 1x



*Spiriferina* 1x



*Triplophyllites* 1x



*Spirifer* 1x



*Brochthyris* 1x



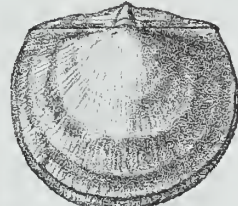
*Pugnoides* 1x



*Girtyella* 1x



*Caninia* 2/3x



*Orthotetes* 1x



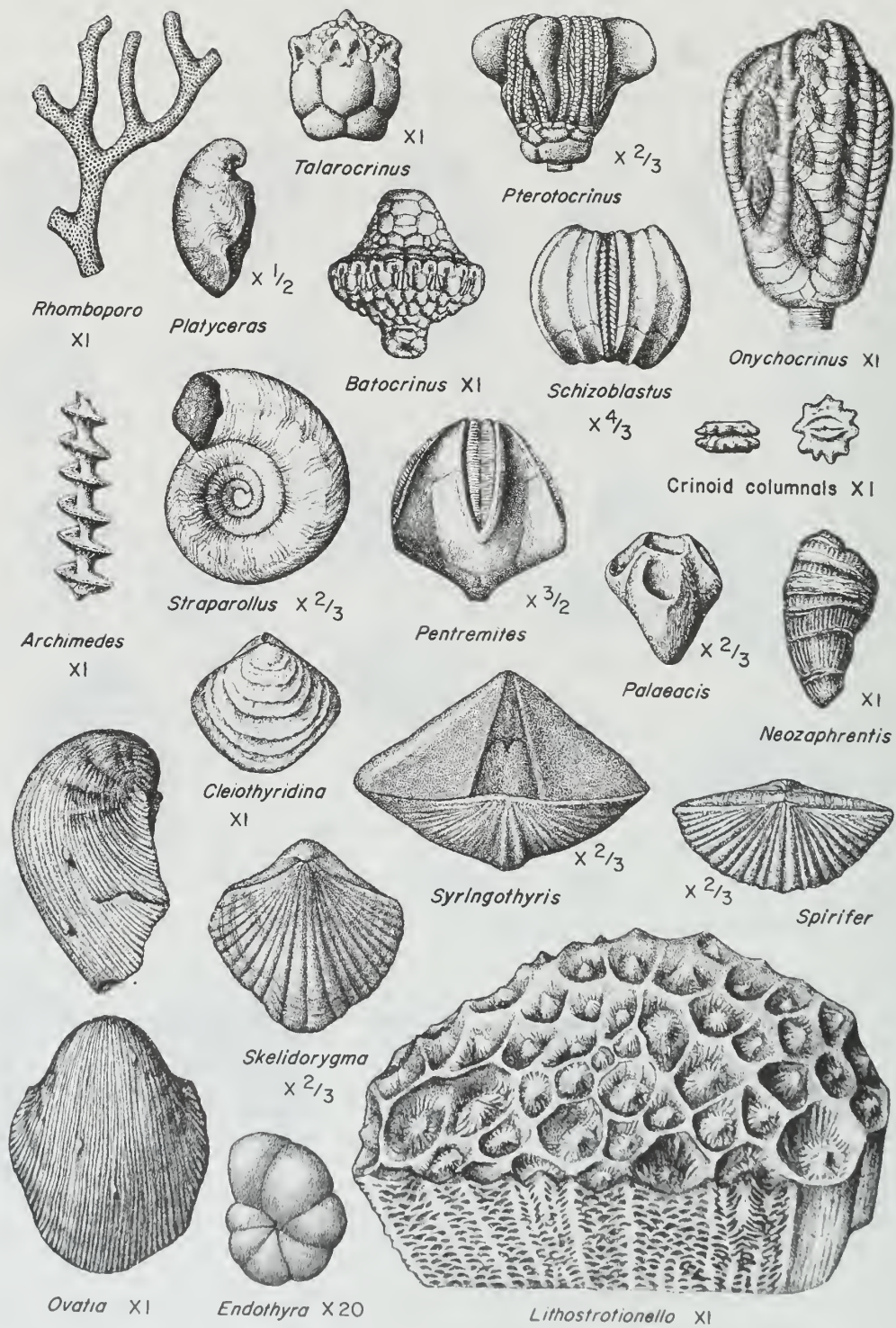
*Schuchertella* 1x



*Echinoconchus* 1x

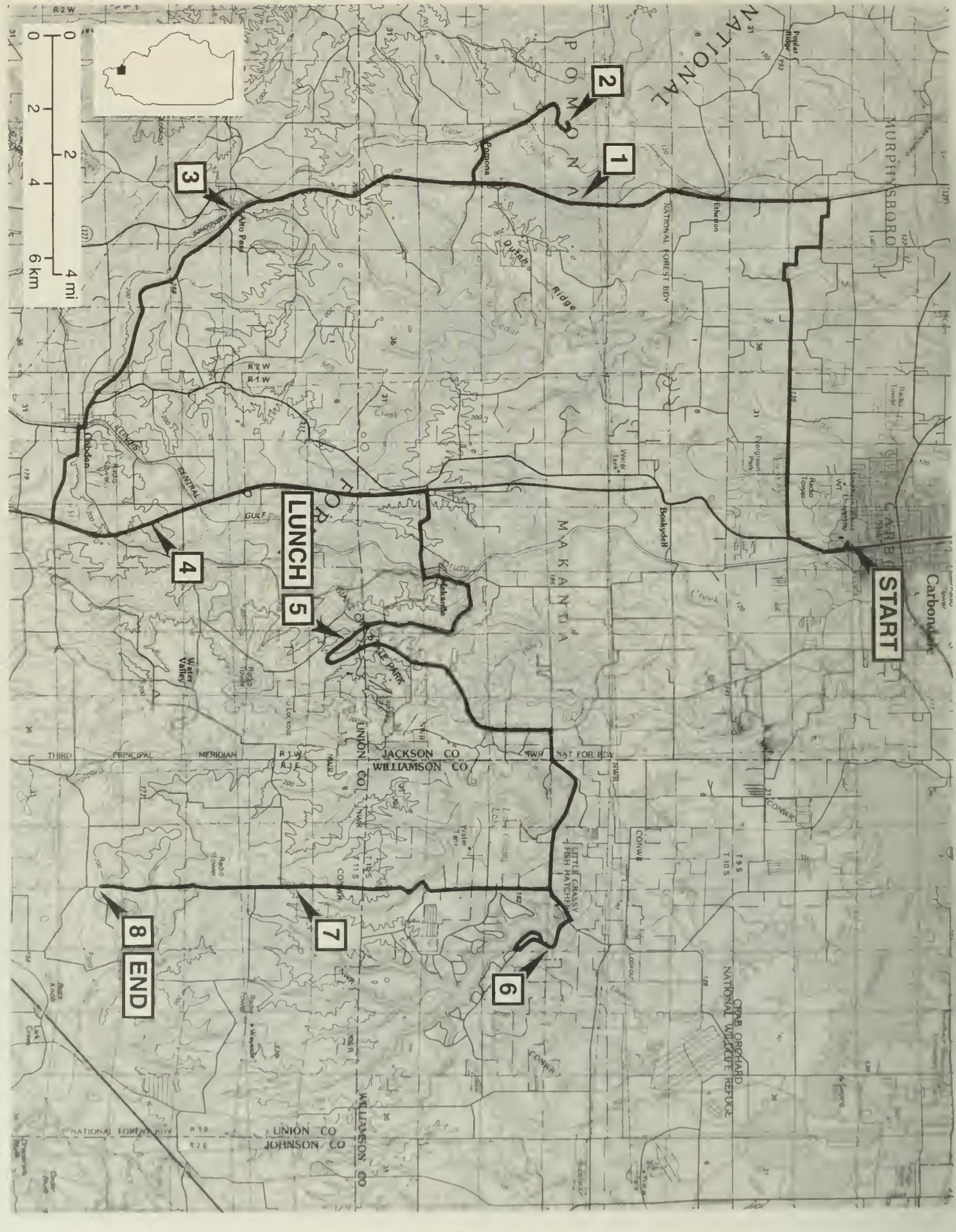


# CORALS









START

LUNCH

END

2

1

3

4

7

6

