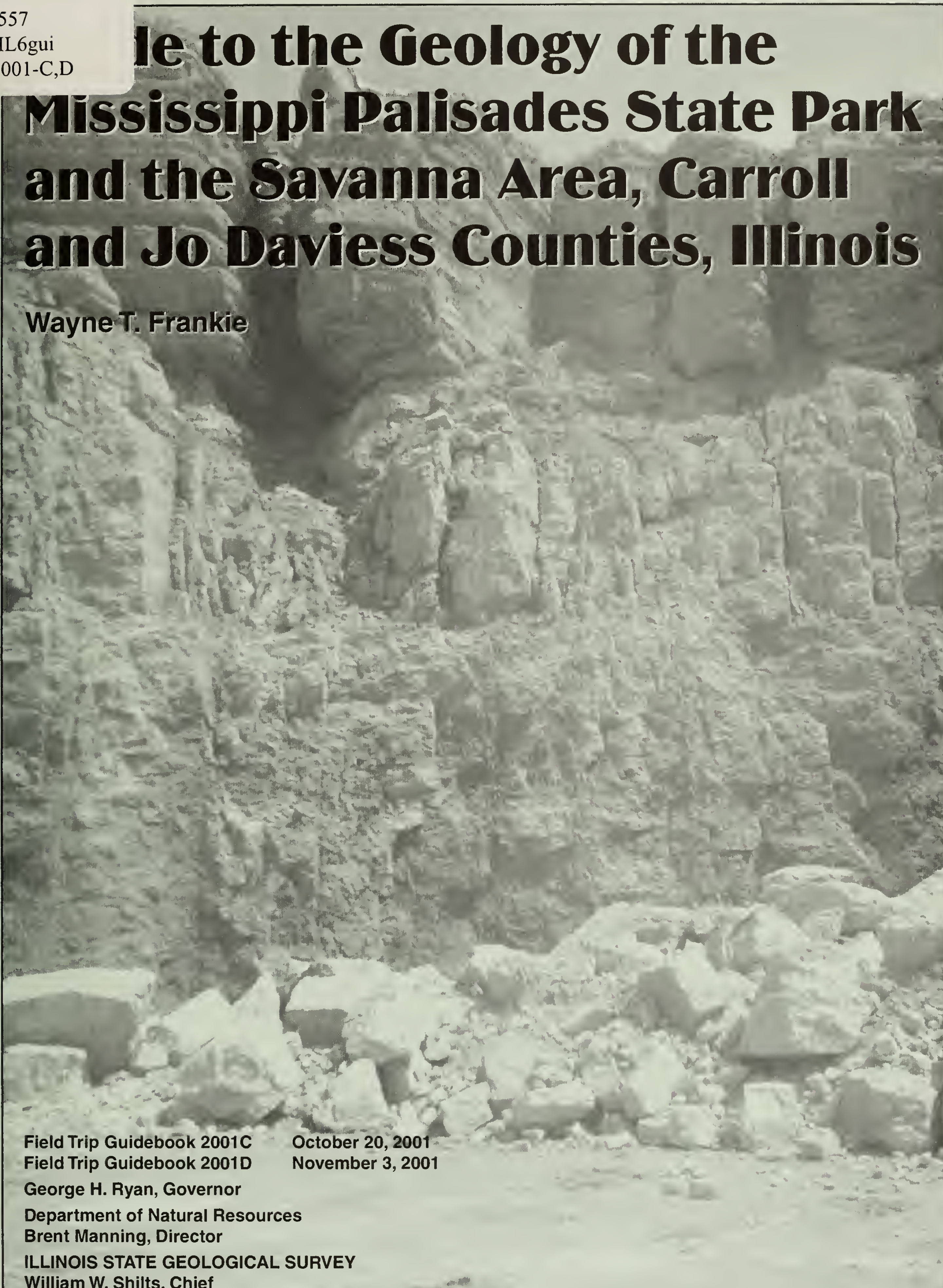

...de to the Geology of the Mississippi Palisades State Park and the Savanna Area, Carroll and Jo Daviess Counties, Illinois

Wayne T. Frankie

Field Trip Guidebook 2001C October 20, 2001
Field Trip Guidebook 2001D November 3, 2001
George H. Ryan, Governor
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Home page: http://www.isgs.uiuc.edu/

Cover photo: Highwall at Savanna Blacktop and Quarry, with karst solution features in the Ordovician dolomite near the top (photo by W. T. Frankie).

Geological Science Field Trips The Illinois State Geological Survey (ISGS) conducts four tours each year to acquaint the public with the rocks, mineral resources, and landscapes of various regions of the state and the geological processes that have led to their origin. Each trip is an all-day excursion through one or more Illinois counties. Frequent stops are made to explore interesting phenomena, explain the processes that shape our environment, discuss principles of earth science, and collect rocks and fossils. People of all ages and interests are welcome. The trips are especially helpful to teachers who prepare earth science units. We ask however, that grade school students be accompanied by at least one parent or guardian for each five students. 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 Geoscience Outreach Cordinator, Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820-6964. Telephone: (217-333-4747 or 217-244-2427). This information is on the ISGS home page: http://www.isgs.uiuc.edu.

Six USGS 7.5-Minute Quadrangle maps (Blackhawk, Clinton Northwest, Green Island, Savanna, Thomson, and Wacker) provide coverage for this field trip area.

This field guide is divided into four sections. The first section serves as an introduction to the geology of Illinois and in particular the Mississippi Palisades State Park and the Savanna area. The second section is a road log for the trip, and the third section provides detailed stop descriptions. The final section is an appendix that includes supplementary materials that are important to the field trip area.

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

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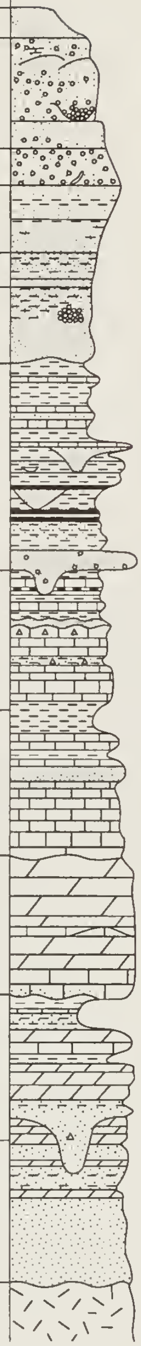
CONTENTS

Era		Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks
CENOZOIC "Recent Life"	Age of Mammals	Quaternary 0-500'	Holocene	10,000	Recent– alluvium in river valleys
			Pleistocene Glacial Age	1.6 m	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	5.3 m – 36.6 m	Chert gravel, present in northern, southern, and western Illinois
			Eocene	57.8 m	Mostly micaceous sand with some silt and clay; presently only in southern Illinois
			Paleocene	66.4 m	Mostly clay, little sand; present only in southern Illinois
MESOZOIC "Middle Life"	Age of Reptiles	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"	Age of Amphibians and Early Plants	Pennsylvanian 0-3,000' ("Coal Measures")		320 m	Largely shale and sandstone with beds of coal, limestone, and clay
		Mississippian 0-3,500'		360 m	Black and gray shale at base, middle zone of thick limestone that grades to siltstone chert, and shale; upper zone of interbedded sandstone, shale, and limestone
	Age of Fishes	Devonian 0-1,500'		408 m	Thick limestone, minor sandstones and shales; largely chert and cherty limestone in southern Illinois; black shale at top
	Age of Invertebrates	Silurian 0-1,000'		438 m	Principally dolomite and limestone
		Ordovician 500-2,000'		505 m	Largely dolomite and limestone but contains sandstone, shale, and siltstone formations
		Cambrian 1,500-3,000'		570 m	Chiefly sandstones with some dolomite and shale; exposed only in small areas in north-central Illinois
		Precambrian			Igneous and metamorphic rocks; known in Illinois only from deep wells



Generalized geologic column showing succession of rocks in Illinois.

INTRODUCTION

The Mississippi Palisades area, located in the unglaciated area of northwestern Illinois, lies along the eastern bank of the Mississippi River. "Palisades" is the word used to describe a picturesque extended rock cliff or line of bold cliffs, rising precipitously from the margin of a stream or lake. The Mississippi Palisades handsomely lives up to its name. Located in the southernmost part of the Wisconsin Driftless Division of Illinois, which is part of the highly significant North American geobiological feature, the *"Driftless Area."*[1] First described in 1823 by geologist W.H. Keating, the driftless area is world-renowned for its isolation from direct glacial impacts during the Pleistocene *Epoch.* This area contains some of the most scenic and rugged *topography* in Illinois. The towering bluffs of the Mississippi Palisades State Park offer spectacular views of the Mississippi River valley. This geological science field trip will acquaint you with the *geology*, landscape, and mineral resources for part of Carroll and Jo Daviess Counties, Illinois. Savanna, with a population of 3,819, is the largest city within the field trip area. Savanna is 40 miles south of Galena and approximately 140 miles west of Chicago, 193 miles northwest of Springfield, 274 miles north of East St. Louis, and 420 miles northwest of Cairo. Carroll County was settled by people from Maryland and was named after Charles Carroll of Carrollton, one of the signers of the Declaration of Independence. Jo Daviess County was named after Col. Joseph Hamilton Daviess, a prominent Kentucky lawyer and soldier who was slain at the battle of Tippecanoe in 1811.

Mississippi Palisades State Park

The original Palisades Park acquisition was made in 1929 with the purchase of 420 acres. Subsequent purchases through the 1970s have increased the park's acreage to about 2,500 acres. During the 1930s, the Civilian Conservation Corps built several structures in the park, including the pavilion at the south entrance and part of the present trail systems.

The Native American pathfinders along the rock palisades of the Mississippi River did as present-day hikers do—in coursing the bluffs, they took the paths of least resistance. The trails at the Mississippi Palisades, especially the park's southern routes, put you in touch with the past. Walk them and you will trace the footsteps of all those who came before you, some of whom came this way nearly a thousand years ago. The park is rich in Native American history.

Natural Features Caves are evident as are dangerous *sinkholes*—ceilingless *limestone* caves that go straight down. Erosion has carved intriguing rock *formations,* including Indian Head, with its aquiline characteristics, and Twin Sisters, a pair of humanoid figures on the bluff tops. Wooded ravines, whose brilliant hues splash the cliffs with color each autumn, dissect the unglaciated terrain. Ferns dot the deep ravines, while, in the park's northern region, leaves of the white birch ripple in the wind. Each spring and summer the valleys and slopes are dappled with the blooms of trillium, bluebell, lobelia, shooting star, and yellow lady's slipper. Animal life within the park and the river areas immediately adjoining it is varied. Waterfowl and shorebirds are numerous, as are wild turkeys. Striking pileated woodpeckers make their home in the park, and, depending on ice conditions, eagles feed at the river in January and February. Because so many birds migrate along the river, their lyrical songs can be heard at the Mississippi Palisades each spring and fall. But not all that is fascinating about Mississippi Palisades wildlife is in the skies. White-tailed deer, gray squirrel, skunk, muskrat, and weasel can be viewed in the park, as can mink, gray and red fox, woodchuck, and even occasionally badger. (Badgers, Badgers, we don't need no stinking Badgers!)

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[1] 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 within 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.

The park's biological significance has been recognized by researchers over the years. During the mid-1960s, R.P.Wunderlin studied the flora of the park and found 569 species of vascular plants. In 1973, the U.S. Department of Interior recognized the southern portion of the park, including the area of the Sentinel Nature Preserve (Stop 1), as a National Natural Landmark because of its unique geological and floristic nature. The Illinois Natural Areas Inventory identified portions of the park (also including the preserve area) as a statewide significant natural area because of the rare floristic composition, high-quality hill prairies, National Natural Landmark registry, and unique geologic features.

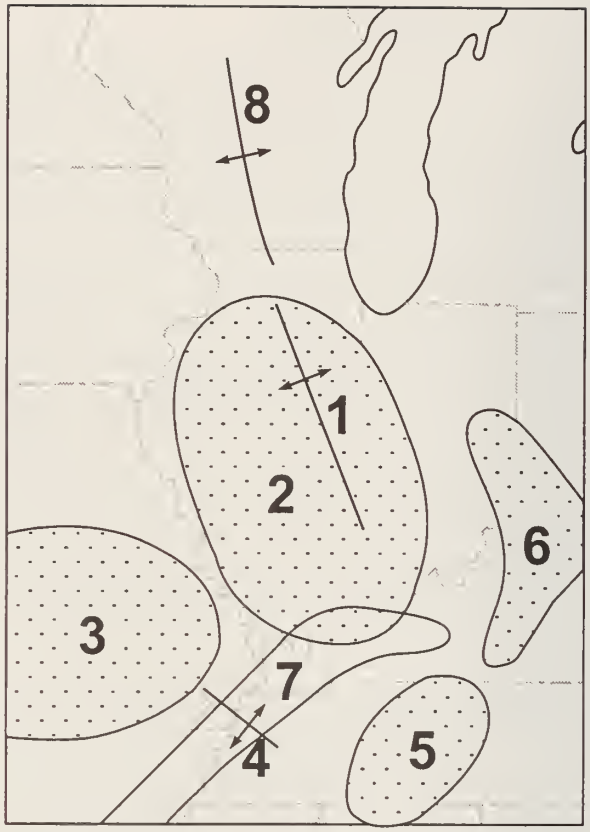


Figure 1 Location of some of the major structures in the Illinois region. (1) La Salle Anticlinorium, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Rough Creek Graben–Reelfoot Rift, and (8) Wisconsin Arch.

GEOLOGIC FRAMEWORK

Precambrian Era

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

Because geologists cannot see the Precambrian basement rocks in Illinois except as cuttings and cores from boreholes, they must use various other techniques, such as measurements of Earth's gravitational and magnetic fields and seismic exploration, to map out the regional characteristics of the basement complex. The evidence collected from these various techniques indicates that in southernmost Illinois, near what is now the historic Kentucky-Illinois Fluorspar Mining District, *rift* valleys such as those in eastern Africa formed as movement of crustal plates (plate *tectonics)* began to rip apart the Precambrian North American continent. These rift valleys in the midcontinent region are referred to as the Rough Creek Graben and the Reelfoot Rift (fig. 1).

Paleozoic Era

After the beginning of the Paleozoic *Era,* about 520 million years ago in the late Cambrian Period, the rifting stopped, and the hilly Precambrian landscape began to sink slowly on a broad regional scale, allowing the invasion of a shallow sea from the south and southwest. During the 280 million years of the Paleozoic Era, the area that is now called the Illinois *Basin* continued to accumulate sediments that were deposited in the shallow seas that repeatedly covered this subsiding basin. The region continued to sink until at least 20,000 feet of sedimentary strata were deposited in the deepest part of the basin, located in the Rough Creek Graben area of southeastern Illinois and Western Kentucky. At various times during this era, the seas withdrew, and deposits were weathered and eroded. As a result, there are some gaps in the sedimentary record in Illinois.

In the field trip area, *bedrock* strata range in age from more than 520 million years (the Cambrian Period) to less than 420 million years old (the Silurian Period). Figure 2 shows the succession of rock strata a drill bit would penetrate in this area if the rock record were complete and if all the formations were present. The oldest Paleozoic rocks exposed in the area are Ordovician in age. They formed from sediments that accumulated from about 505 to 438 million years ago.

Within the field trip area, the depth to the Precambrian basement rocks is approximately 2,800 feet. The elevation of the top of the Precambrian basement rocks ranges from 1,750 feet below sea level in northern Carroll County to greater than 2,250 feet below sea level in southern Carroll County.

DEPOSITIONAL HISTORY

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

Paleozoic Era

From the Late Cambrian to the end of the Paleozoic Era, sediments continued to accumulate in the shallow seas that repeatedly covered Illinois and adjacent states. These inland seas connected with the open ocean to the south during much of the Paleozoic, and the area that is now southern Illinois was similar to an embayment. The southern part of Illinois and adjacent parts of Indiana and Kentucky sank more rapidly than the areas to the north, allowing a greater thickness of sediment to accumulate. During the Paleozoic and Mesozoic, the Earth's thin crust was periodically flexed and warped in places as stresses built up in response to the tectonic forces associated with the collision of continental and oceanic plates and mountain building. These movements caused repeated invasions and withdrawals of the seas across the region. The former sea floors were thus periodically exposed to erosion, which removed some sediments from the rock record.

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 at the contact between two formations, the *fossils* in the rocks and the relationships between the rocks at the contact indicate that deposition was virtually continuous. In contrast, however, in some other places, the top of the lower formation was at least partially eroded before deposition of the next formation began. In these instances, fossils and/or other evidence within or at the boundary between the two formations indicate that there is a significant age difference between the lower unit and the overlying unit. This type of contact is called an *unconformity* (fig. 4).

SYSTEM	SERIES	GROUP	FORMATION Thickness, ft	LITHOLOGY	DESCRIPTION
SILURIAN	NIAGARAN		Racine 300		Dolomite, pure, gray, thin-bedded to massive; local reef structures; local areas of brownish gray, argillaceous dolomite.
SILURIAN	NIAGARAN		Marcus 35-45		Dolomite, very pure, buff, vesicular, massive; contains *Pentamerus* in great abundance in lower 5-15 ft.
SILURIAN	ALEXANDRIAN		Sweeney 45-55		Dolomite, pure, pinkish gray; in thin wavy beds with green shale partings; corals abundant; 3-5 ft cherty zone near middle contains *Microcardinalia* and *Pentamerus*.
SILURIAN	ALEXANDRIAN		Blanding 25-35		Dolomite, pure, brownish gray; contains many layers of white chert; silicified corals abundant; lower 3-5 ft slightly argillaceous.
SILURIAN	ALEXANDRIAN		Mosalem 0-100		Dolomite, gray, cherty, medium-bedded; lower part is very argillaceous dolomite grading to dolomitic shale at base.
ORDOVICIAN	CINCINNATIAN	Maquoketa	Brainard 0-50		Shale, greenish gray, dolomitic; interbedded with fine- to medium-grained, argillaceous dolomite; abundant and diverse fauna consisting largely of brachiopods and bryozoans.
ORDOVICIAN	CINCINNATIAN	Maquoketa	Fort Atkinson 0-10		Dolomite, yellowish gray, fine-grained, argillaceous, thin-bedded; interbedded with greenish gray shale.
ORDOVICIAN	CINCINNATIAN	Maquoketa	Scales 125		Shale, gray, dolomitic; conchoidal fractures; *Isotelus* common in upper part; dark brown, carbonaceous, laminated shale in lower 15 ft; one or two beds of brown argillaceous dolomite at base containing depauperate fauna, pyrite, and phosphatic pebbles.

Figure 2 Generalized stratigraphic column from the top of the Niagaran (middle Silurian) to the base of the Champlainian (middle Ordovician) in the field trip area (modified from Kolata and Buschbach 1976). Figure continues on the next page.

SYSTEM	SERIES	GROUP	FORMATION Thickness, ft	LITHOLOGY	DESCRIPTION
ORDOVICIAN	CHAMPLAINIAN	Galena	Dubuque 30-45		Dolomite, argillaceous, light gray to buff, fine- to medium-grained, thin- to medium-bedded; brown shale partings.
			Wise Lake 70-80		Dolomite, pure, light gray to buff, medium-grained, thick-bedded to massive; abundant molluscan fauna; *Receptaculites* abundant near middle.
			Dunleith 130		Dolomite, gray to buff, medium-grained, thin- to thick-bedded; white to dark gray chalky and vitreous chert, particularly in upper part; *Receptaculites* abundant. Lower part argillaceous, sandy, fossiliferous, with green shale partings.
			Guttenberg 2-15		Dolomite and limestone, argillaceous, gray to brown, fine- to medium-grained, thin-bedded; reddish brown shale partings; abundant and diverse fauna.
		Platteville	Quimbys Mill 12		Dolomite, slightly argillaceous, light gray to buff, fine-grained, thin- to medium-bedded.
			Nachusa 20		Dolomite, pure, light gray to buff, thick-bedded, medium-grained, vuggy, fucoidal; white to light gray chert.
			Grand Detour 15-45		Dolomite and limestone, light gray to buff, thin- to medium-bedded, fine-grained; reddish brown shale partings; fossiliferous.
			Mifflin 15-25		Dolomite and limestone, argillaceous, light gray to buff, thin-bedded, fine-grained; greenish gray to blue-gray shale partings; fossiliferous.
			Pecatonica 20-30		Dolomite and limestone, light gray to buff, thin- to medium-bedded, fine-grained; brownish gray shale partings; corrosion surface at top; well-rounded sand grains in lower part.
		Ancell	Glenwood 5-20		Shale, sandstone, and dolomite, greenish gray; poorly sorted, fine- to coarse-grained sand.
			St. Peter 50-200		Sandstone, white, fine-grained, well-rounded, well-sorted, friable, thick-bedded to massive.

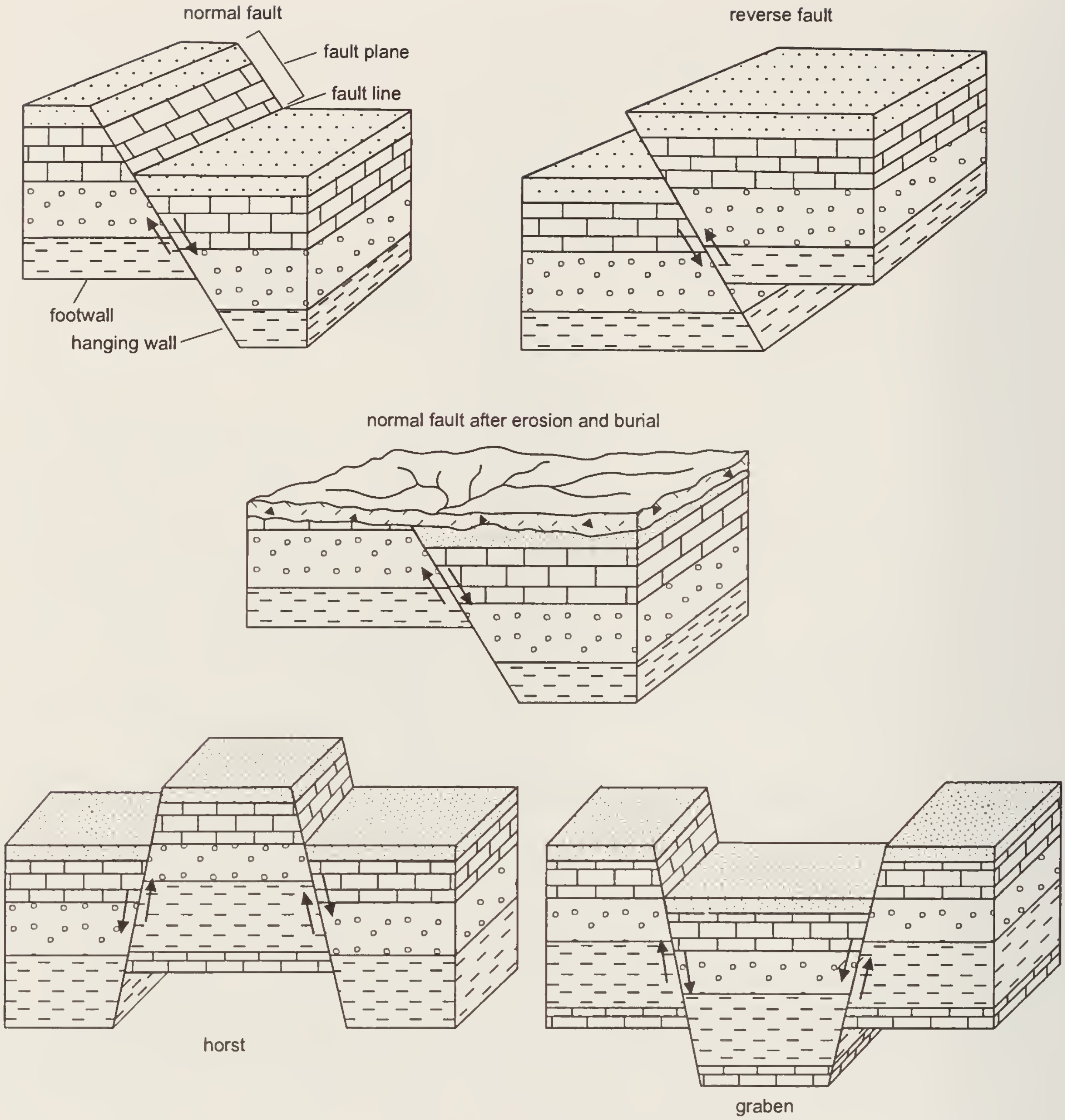


Figure 3 Diagrammatic illustrations of fault types that may be present in the field trip area. A fault is a fracture in the earth's crust along which there has been relative movement of the opposing blocks. A fault is usually an inclined plane, and when the hanging wall (the block above the plane) has moved up relative to the footwall (the block below the fracture), the fault is a reverse fault. When the hanging wall has moved down relative to the footwall, the fault is a normal fault.

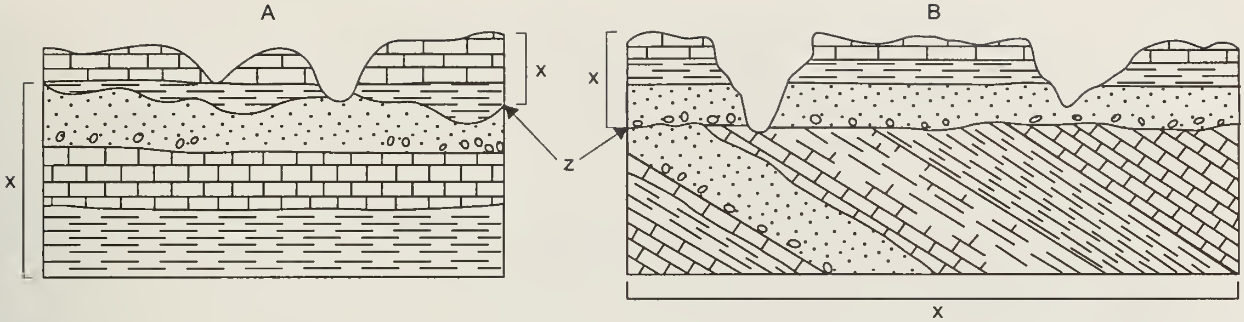


Figure 4 Schematic drawings of (A) a disconformity and (B) an angular unconformity (x represents the conformable rock sequence and z is the plane of unconformity).

If the *beds* above and below an unconformity are parallel, the unconformity is called a *disconformity.* If, however, the lower beds were tilted and eroded prior to deposition of overlying beds, the contact is called an angular unconformity.

Unconformities occur throughout the Paleozoic rock record and are shown in the generalized stratigraphic column in figure 2 as wavy lines. Each unconformity represents an extended time interval for which there is no rock record.

Near the close of the Mississippian Period, gentle arching of the rocks in eastern Illinois initiated the development of the LaSalle Anticlinorium (figs. 1 and 5), a complex structure having smaller structures such as domes, *anticlines*, and *synclines* superimposed on the broad upwarp of the anticlinorium. Further gradual arching continued through the Pennsylvanian Period. Because the youngest Pennsylvanian strata are absent from the area of the anticlinorium (either because they were not deposited or because they were eroded), we cannot determine just when folding ceased—perhaps by the end of the Pennsylvanian or during the Permian Period a little later, near the close of the Paleozoic Era.

Mesozoic Era

During the Mesozoic Era, the rise of the Pascola Arch (figs. 1 and 5) in southeastern Missouri and western Tennessee produced a structural barrier that helped form the current shape of the Illinois Basin by closing off the embayment and separating it from the open sea to the south. The Illinois Basin is a broad, subsided region covering much of Illinois, southwestern Indiana, and western Kentucky (fig. 1). Development of the Pascola Arch, in conjunction with the earlier sinking of the deeper portion of the basin north of the Pascola Arch in southern Illinois, gave the basin its present asymmetrical, spoon-shaped configuration (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.

Younger rocks of the latest Pennsylvanian and perhaps the Permian (the youngest rock systems of the Paleozoic) may have at one time covered the southern and northern portions of Illinois. It is possible that Mesozoic and Cenozoic rocks (see the generalized geologic column) could also have been present here. Indirect evidence, based on the stage of development (rank) of coal deposits and the generation and maturation of petroleum from source rocks (Damberger 1971), indicates that perhaps as much as 1.5 miles of latest Pennsylvanian and younger rocks once covered southern Illinois. During the more than 240 million years since the end of the Paleozoic Era (and before the onset of *glaciation* 1 to 2 million years ago), however, several thousands of feet of strata may have been eroded. Nearly all traces of any post-Pennsylvanian bedrock that may have been

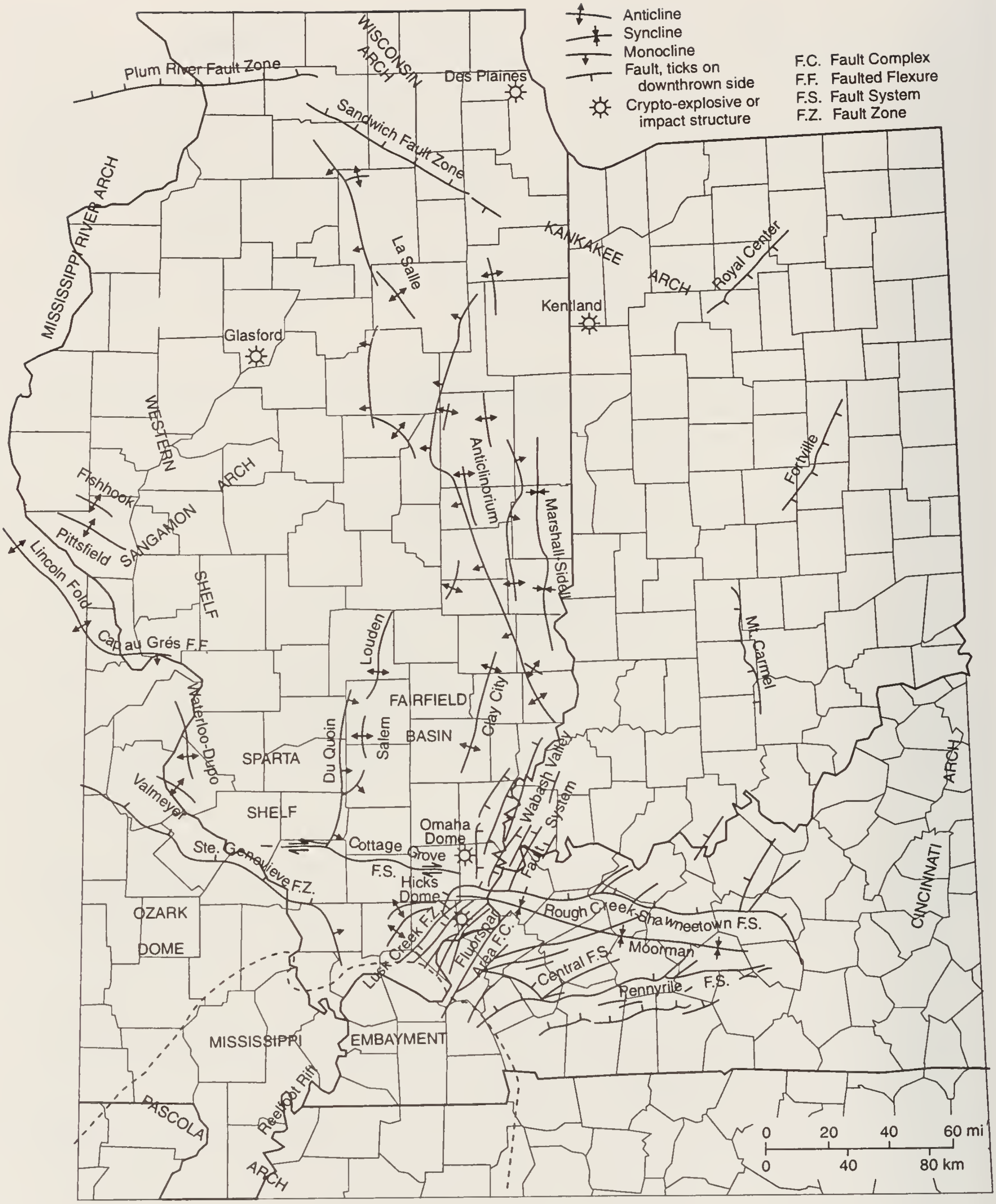


Figure 5 Structural features of Illinois (modified from Buschbach and Kolata 1991).

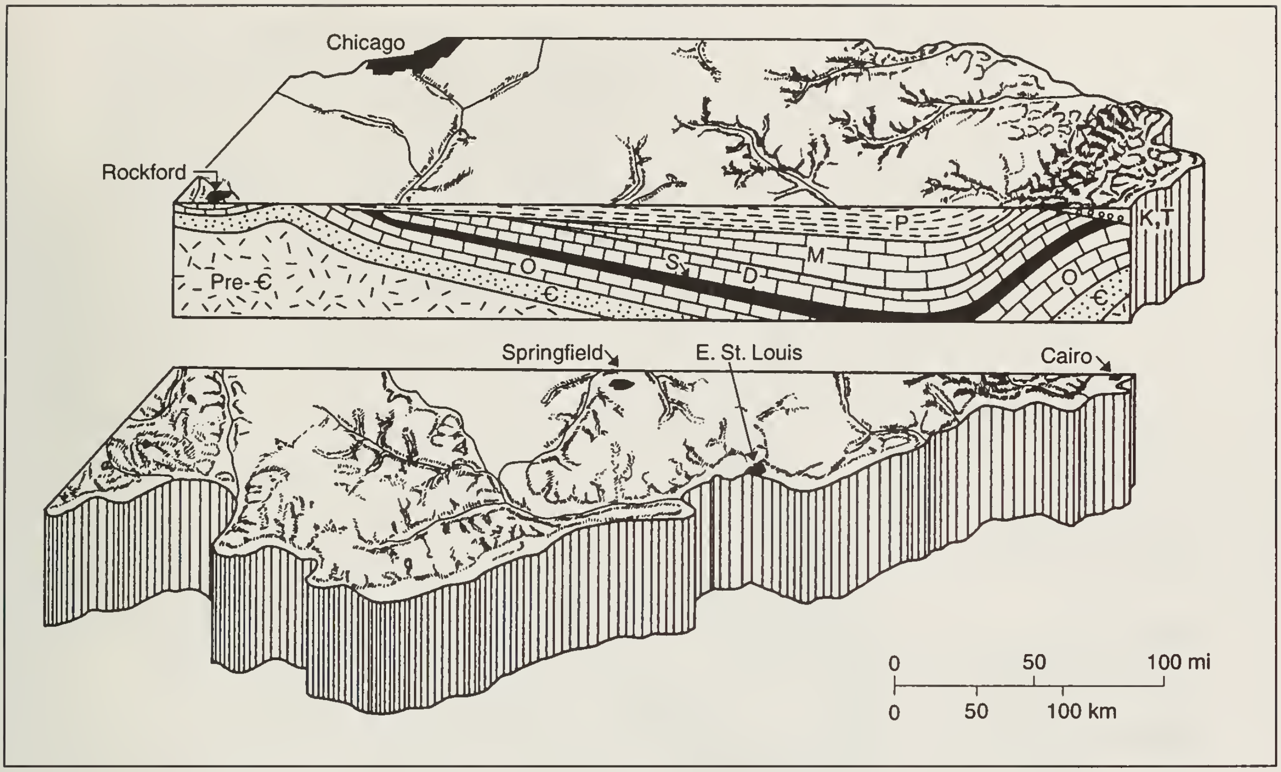


Figure 6 Stylized north-south cross section shows the structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks has been greatly exaggerated and younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre €) granites. They form a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

present in Illinois were removed. During this extended period of erosion, deep valleys were carved into the gently tilted bedrock formations (fig. 8). Later, the topographic *relief* was reduced by repeated advances and melting back of continental *glaciers* that scoured and scraped the bedrock surface. These glacial processes affected all the formations exposed at the bedrock surface in Illinois. The final melting of the glaciers left behind the non-lithified deposits in which our modern soil has developed.

STRUCTURAL SETTING

The Mississippi Palisades field trip area is located northwest of the Illinois Basin on the southwestern flank of the regional, broad, and gently sloping Wisconsin Arch (fig. 5). Paleozoic bedrock strata in the field trip area have a regional dip of 20 to 30 feet per mile to the southwest, except where the strata are affected by local structure.

Wisconsin Arch

The Wisconsin Arch is a broad, positive area that separates the Michigan Basin on the east from the Forest City Basin on the west (fig. 1). The northern end of the Wisconsin Arch—termed the Wisconsin Dome—is a region of Precambrian outcrops in northern Wisconsin. The rest of the arch is overlapped by Cambrian, Ordovician, and Silurian sedimentary rocks. The southeast end of the Wisconsin Arch connects with the Kankakee Arch, which separates the Michigan and Illinois Basins (Nelson 1995). The Illinois Basin is the major structural depression between the Ozark Dome to the west, the Cincinnati Arch to the east, and the Kankakee Arch to the north (fig. 5).

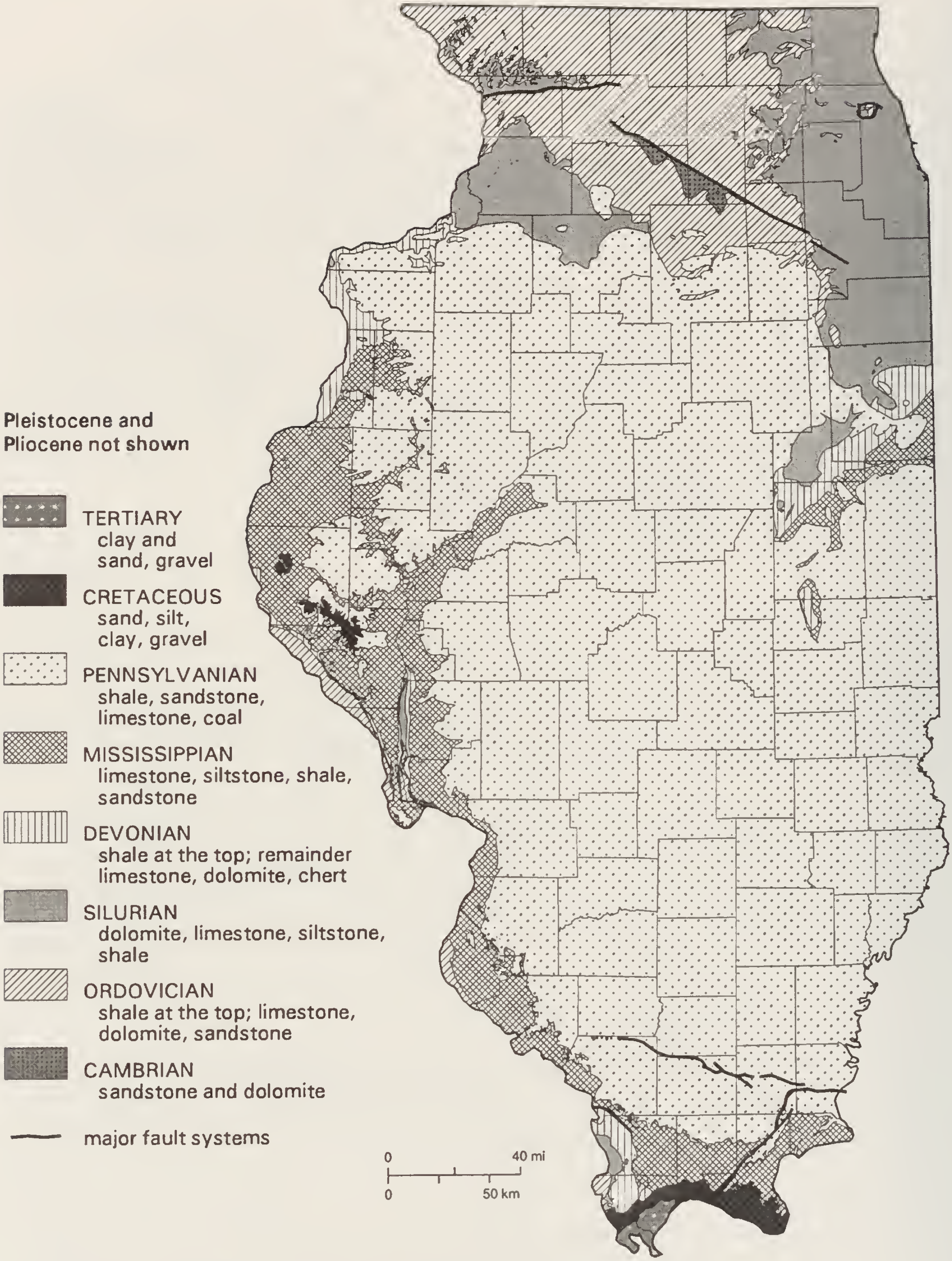


Figure 7 Bedrock geology beneath surficial deposits in Illinois.

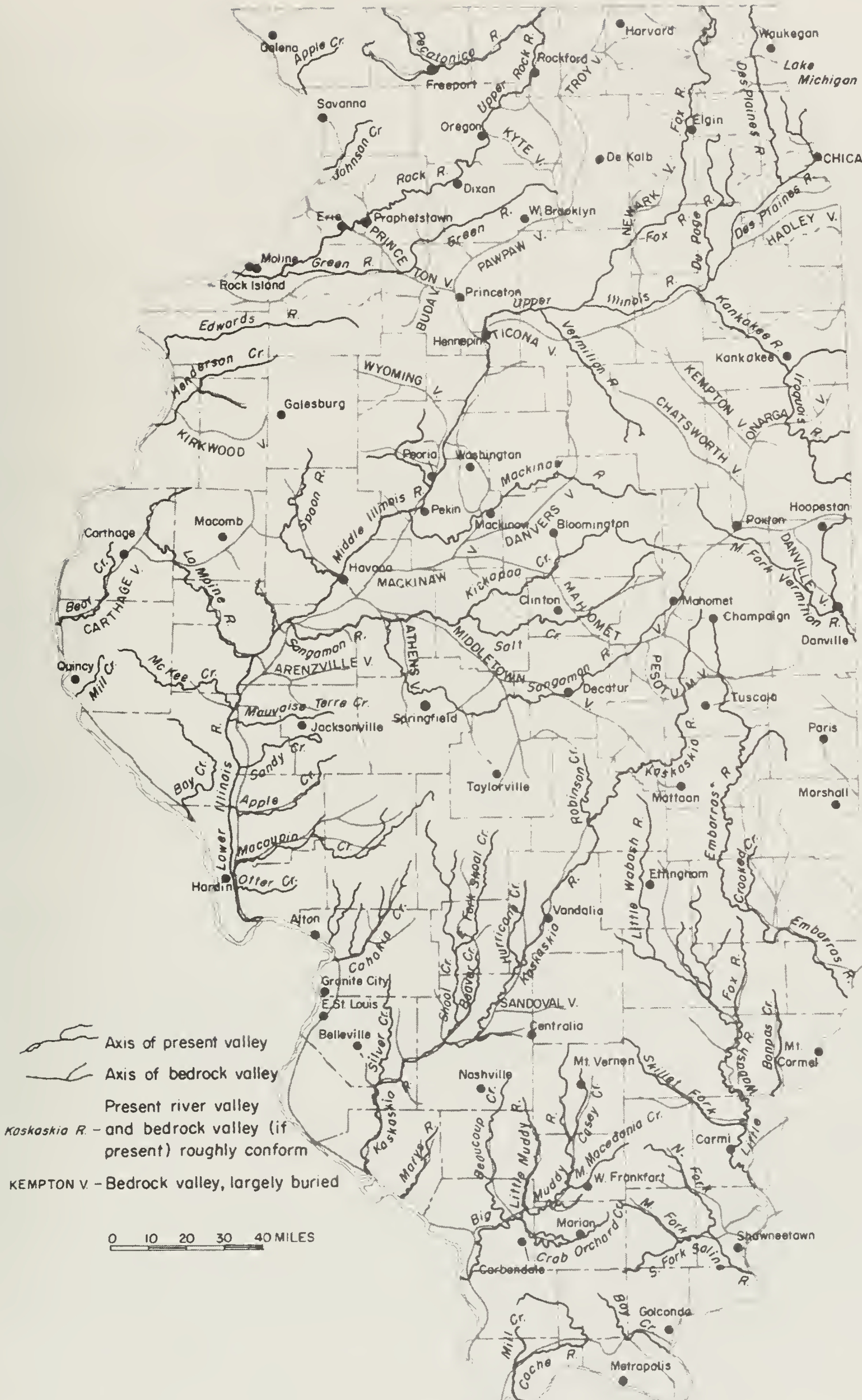


Figure 8 Major bedrock valleys of Illinois.

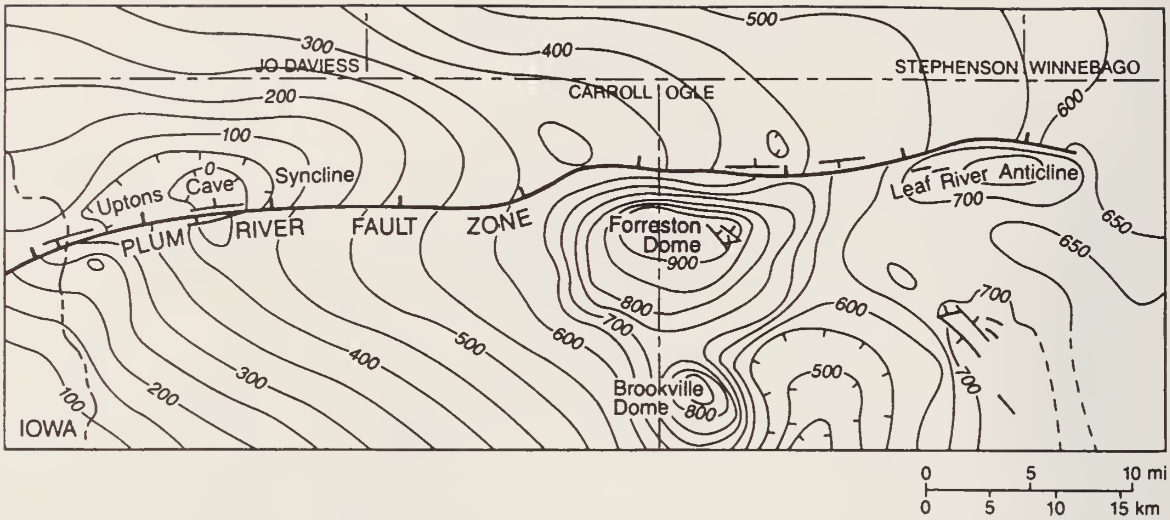


Figure 9 The Plum River Fault Zone and related structures in northwestern Illinois. Structure contours on top of the Ordovician, Glenwood Formation (Middle Ordovician). Modified from Nelson (1995) and Kolata and Buschbach (1976). Contour interval is 50 feet.

The Wisconsin Arch apparently began to emerge late in the St. Croixan Epoch (Cambrian) and was well established by the middle of the Ordovician Period. The Wisconsin Arch may have been covered by seas in the late Ordovician through middle Silurian time, but rose again in late Silurian or Devonian time (Nelson 1995).

Plum River Fault Zone

Worthen (1866) first recognized that structural deformation had occurred in this part of the state. Early investigators felt that an east-west-trending anticline and a syncline were the structural features present here. When they mapped a *fault* on the north side of Savanna, Willman et al. (1967) first recognized that the structure in this part of Illinois was partly the result of faulting.

The Plum River Fault Zone (figs. 5 and 9) extends westward for nearly 112 miles from the Leaf River in Ogle County, Illinois, through Savanna, to Cedar Rapids, Iowa (Kolata and Buschbach 1976, Nelson 1995). This zone, a narrow belt of high-angle faults in which the fault surfaces are inclined nearly 90 degrees, trends slightly north of east. Kolata and Buschbach (1976) found strong surface and subsurface evidence for the presence of faults with 100 to 400 feet of vertical displacement (fig. 10). A sharp linear boundary exists between the downthrown Silurian bedrock on the north and the upthrown Ordovician strata on the south sides of the Plum River Fault Zone. The best field evidence for faulting can be found in the bluffs and ravines in the unglaciated area from Savanna eastward to Mt. Carroll.

A vertical displacement of 100 to 150 feet can be detected in bedrock strata exposed in the vicinity of the old hospital in Savanna (SW, NW, NW, SW, Sec. 3, T24N, R3E, Savanna 7.5-minute Quadrangle). On the east side of Ridge Road across from the old hospital's parking lot, thin-bedded, *argillaceous dolomite* of the lowermost Alexandrian Series (Silurian) Mosalem Formation (fig. 2) is exposed in the roadcut. Some 600 to 700 feet west-northwest beyond the old hospital is an exposure of thick dolomite beds of the lower Niagaran Series (Silurian) Marcus Formation, which contain abundant *Pentamerus* fossils. Figures 10 and 11 show the location of the faults in this vicinity and the relationships of lower bedrock horizons. The Marcus Formation, which normally occurs stratigraphically more than 100 feet above the lower Mosalem beds, is about 40 to 50

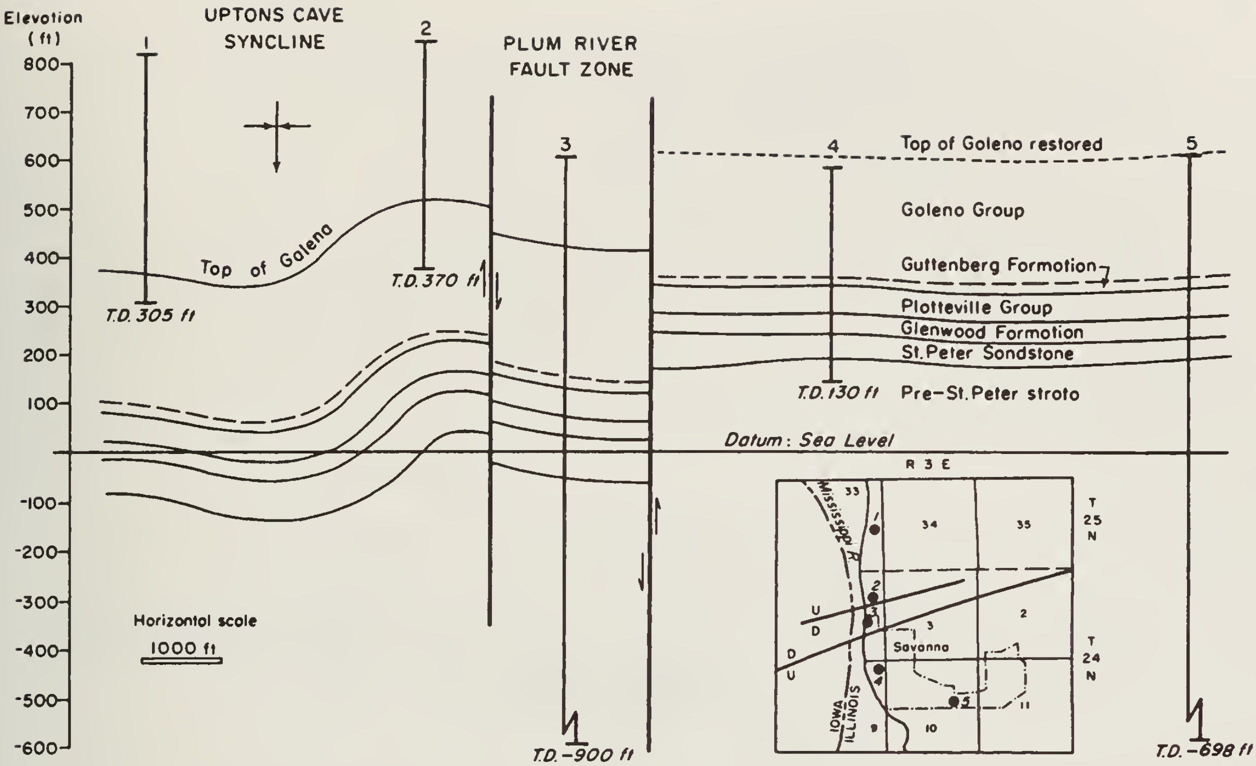


Figure 10 Structural cross section showing stratigraphic relationships of the Plum River Fault Zone near Savanna, Illinois. Interpretations are based on five wells (shown on inset map): (1) Mississippi Palisades State Park well no. 2, NE, NE, SE, 33-25N-3E; (2) Stransky farm well, SE, NE, NE, 4-24N-3E; (3) Savanna city well no. 5, NW, NE, SE, 4-24N-3E; (4) Times Theater Well, SE, NE, NE, 9-24N-3E; and (5) Savanna city well no. 4, SE, SW, NE, 10-24N-3E (modified from Kolata and Buschbach 1976).

feet lower than the Mosalem here. The Plum River Fault Zone lies beneath the blacktop parking lot. The fault zone is generally bordered by anticlines along the south and synclines along the north.

The exact timing and history of faulting has not been completely resolved. Currently the faulting is interpreted to have begun during the middle of the Silurian Period, with some additional movement occurring during the middle Devonian, the main movement being post-Devonian, followed by movement prior to the Pennsylvanian Period (Kolata and Buschbach1976, Nelson 1995).

A broad, shallow, east-west–trending syncline (downwarp) lies north of the fault zone and parallel to it. This structure, Uptons Cave Syncline (figs. 9, 10, and 11), is exposed along the east side of Illinois Route 84 in the Mississippi River bluffs north of the Savanna-Sabula Bridge. The south flank of the syncline structure can be seen from the east end of the bridge when there is no foliage to block the view. Silurian and Ordovician strata dip to the north toward the synclinal axis (the lowest point of the downwarp), which is about 500 feet north of Uptons Cave, and then rise gently northward. Subsurface data also reflect the presence of this structure.

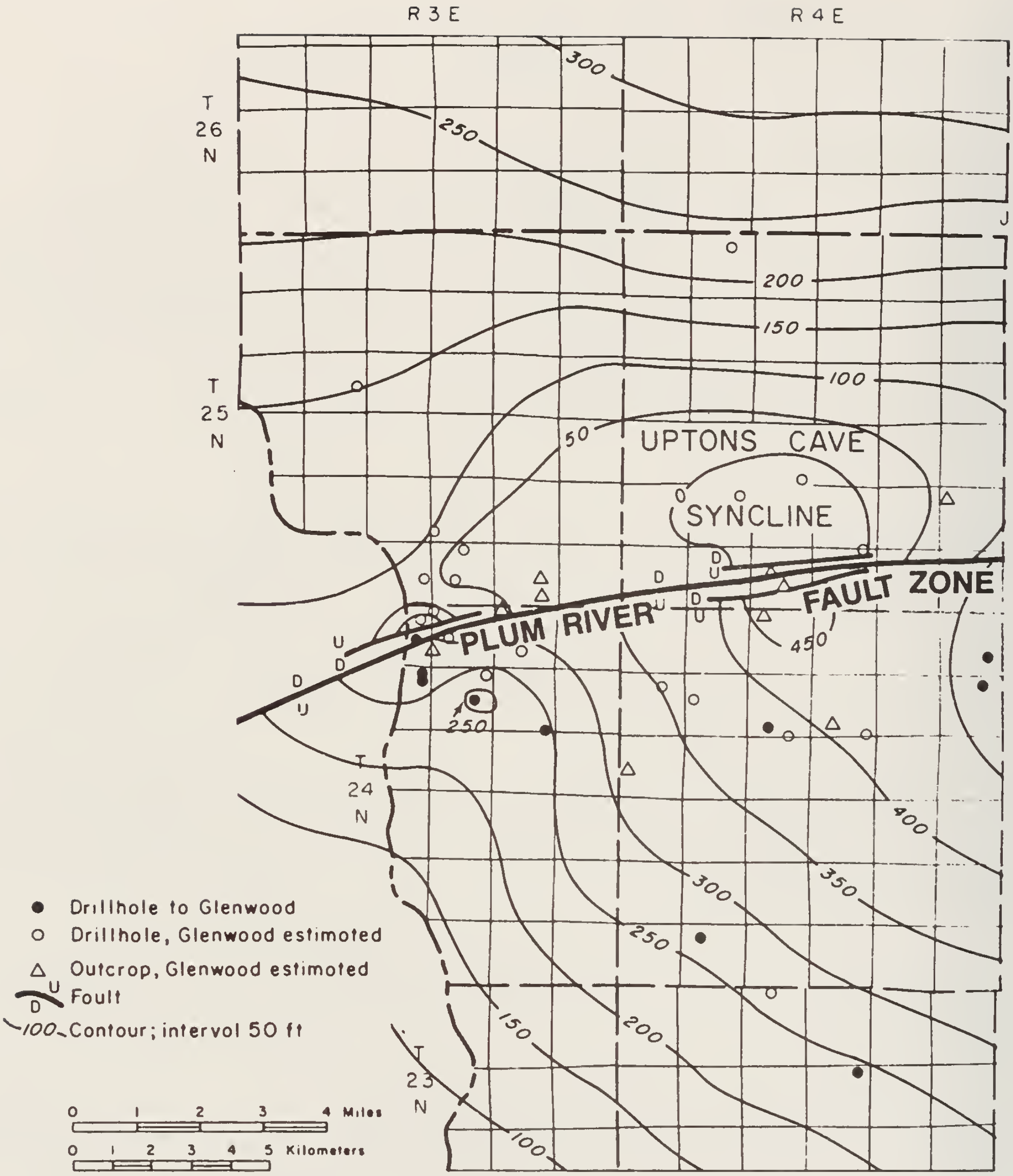


Figure 11 Structure on top of the Ordovician, Glenwood Formation (Middle Ordovician) in the vicinity of Savanna, Illinois. The top of the Glenwood was estimated from shallower horizons in some of the drill holes and outcrops (modified from Kolata and Buschbach 1976).

PREGLACIAL HISTORY OF NORTHWESTERN ILLINOIS

Since the last Paleozoic sea withdrew from the midcontinent at the end of the Pennsylvanian Period some 286 million years ago, or possibly as late as the end of the Permian Period nearly 245 million years ago, the Upper Mississippi Valley region was uplifted and has remained a land area. During this long interval of erosion, many hundreds of feet of Paleozoic strata have been stripped away. During the Pliocene Epoch between 5.3 and 1.6 million years ago, near the end of the Tertiary Period, the topography or relief of the region was reduced to a very low erosional plain, the

Dodgeville Peneplain. A *peneplain* is a land surface worn down by stream erosion and mass wasting to a low, nearly featureless plain that gradually slopes upward from the sea. Such an erosion surface would take a very long time to develop and would be characterized by sluggish streams flowing in broad valleys. Bedrock structures, such as anticlines (strata arched upward), would have no influence on the topography because they would be uniformly beveled.

In northern Jo Daviess County, the slope of the Dodgeville Peneplain and the dip of the Silurian dolomite are the same. The erosion surface corresponds to the dip slope—a fact cited by some geologists who argue that the upland surface is not a peneplain at all but a structurally controlled feature that formed when strata that were less resistant than the Silurian dolomite were stripped away. Northward in Wisconsin and Minnesota, however, the surface bevels Ordovician strata that dip more steeply. Other arguments against the peneplain idea are the absence of a thick residual soil and the apparent control of present-day streams by bedrock *joints,* factors that should not exist if the region had been peneplained.

In the unglaciated Driftless Area of Wisconsin, the Dodgeville surface is well preserved. However, in Jo Daviess County, Illinois, only remnants of the Dodgeville Peneplain are preserved as isolated, flat-topped ridges and knobs of Silurian dolomite (fig. 12). The Dodgeville Peneplain is not preserved in the Savanna area. We can imagine the tops of these Silurian flats joined by a plane surface representing the former peneplain, sloping gently southwestward from about 1,200 to 1,000 feet above mean sea level (msl).

After the Dodgeville Peneplain was formed, the region was uplifted and another partial peneplain called the Lancaster Peneplain (fig. 12) was eroded down to resistant strata about 200 feet lower. The Lancaster Peneplain is extensively preserved on the bedrock surface of northern Illinois. It is well developed in the Driftless Area. East of the Driftless Area, the Lancaster Peneplain is a gently undulating surface covered by glacial deposits. The Lancaster Peneplain closely coincides with the top of the Ordovician Galena Dolomite to the north near Galena and slopes southwestward from an elevation of about 985 to 800 feet msl. The field trip area is near the south edge of the Lancaster Peneplain.

The present topography of the Savanna area is the result of stream dissection of the Lancaster Peneplain during the Pleistocene glaciations and modification of the dissected surface by *loess* (pronounced "luss") deposits. The Driftless Area is more rugged than adjacent areas because it was never glaciated; however, its mature topography is not entirely a preglacial, erosion surface as was formerly believed. It was also eroded during the Pleistocene.

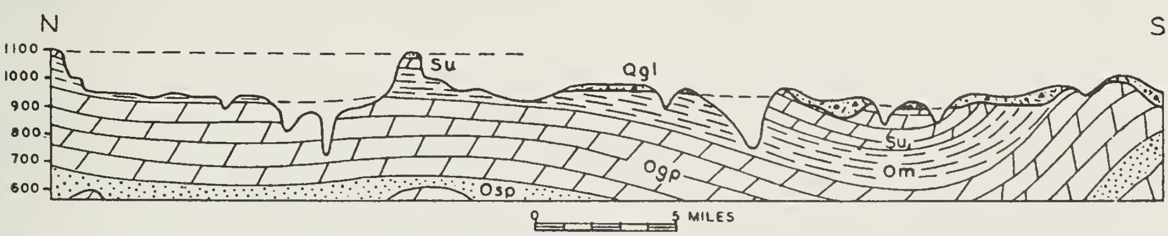


Figure 12 Projection of the Dodgeville (upper) and Lancaster (lower) Peneplain surfaces in northwestern Illinois from Apple River southeasterly to northwestern Carroll County. Qgl, glacial drift; Su, Silurian dolomite; Om, Maquoketa Shale; Ogp, Galena-Platteville dolomite; and Osp, St. Peter Sandstone (modified from Horberg 1950).

The relief of the bedrock surface is closely related to the establishment of the Mississippi Valley through the region during the earliest pre-Illinois glacial episode. Maximum relief was probably developed during the latter stages of the pre-Illinois glacial episode when the valley was eroded to its maximum depth by meltwater. After that, the valley was alternately aggraded (built up) by outwash and re-excavated during subsequent glacial and interglacial intervals. In the glaciated area to the east and south, *till* and outwash were deposited on the bedrock surface during the Illinois Glacial Episode. Loess was deposited on the uplands throughout the Upper Mississippi Valley region during the Illinois and Wisconsin Glacial Episodes. Deposition of a thick *valley train* in the Mississippi Valley during the late Wisconsin Woodfordian and Valderan Glacial Episodes aggraded the valley to a level approximately 30 feet above its present *floodplain.* This aggradation also resulted in alluviation of the tributary valleys. Since the last glacier melted away, the Mississippi River and its tributaries have been deepening their valleys in the Wisconsin Episode alluvial deposits.

GLACIAL HISTORY OF ILLINOIS

Pleistocene Epoch

A brief general history of glaciation in North America and a description of the deposits commonly left by glaciers is given in GeoNote 3, *Quaternary Glaciations in Illinois,* at the back of the guidebook.

Although the Driftless Area was never overrun by the Pleistocene glaciers of the "Ice Age" (fig. 13), nevertheless, the region has been profoundly affected by the events of the glacial period. As already stated, the 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). The present topography of Illinois is significantly different from the topography of the preglacial bedrock surface. The topography of the bedrock surface throughout much of Illinois is largely hidden from view by glacial deposits except along the major streams and in the driftless areas of northwestern and southern Illinois (figs. 13 and 14). In many areas, the glacial drift is thick enough to completely mask the underlying bedrock surface. Studies of mine shafts, water-well logs, and other drill-hole information, in addition to scattered bedrock exposures in some stream valleys and roadcuts, show that the present land surface of the glaciated areas of Illinois does not reflect the underlying bedrock surface. The topography of the preglacial bedrock surface has been significantly modified by glacial erosion and is subdued by glacial deposits.

In the past 1.6 million to 2 million years, during the Pleistocene Epoch of the Quaternary Period (also known as the "Ice Age"), much of northern North America was repeatedly covered by huge glaciers (see fig.13). These continent-size masses of ice formed in eastern and central Canada as a result of climate cooling. Their advances into the central lowland of the United States altered the landscape across much of the Midwest.

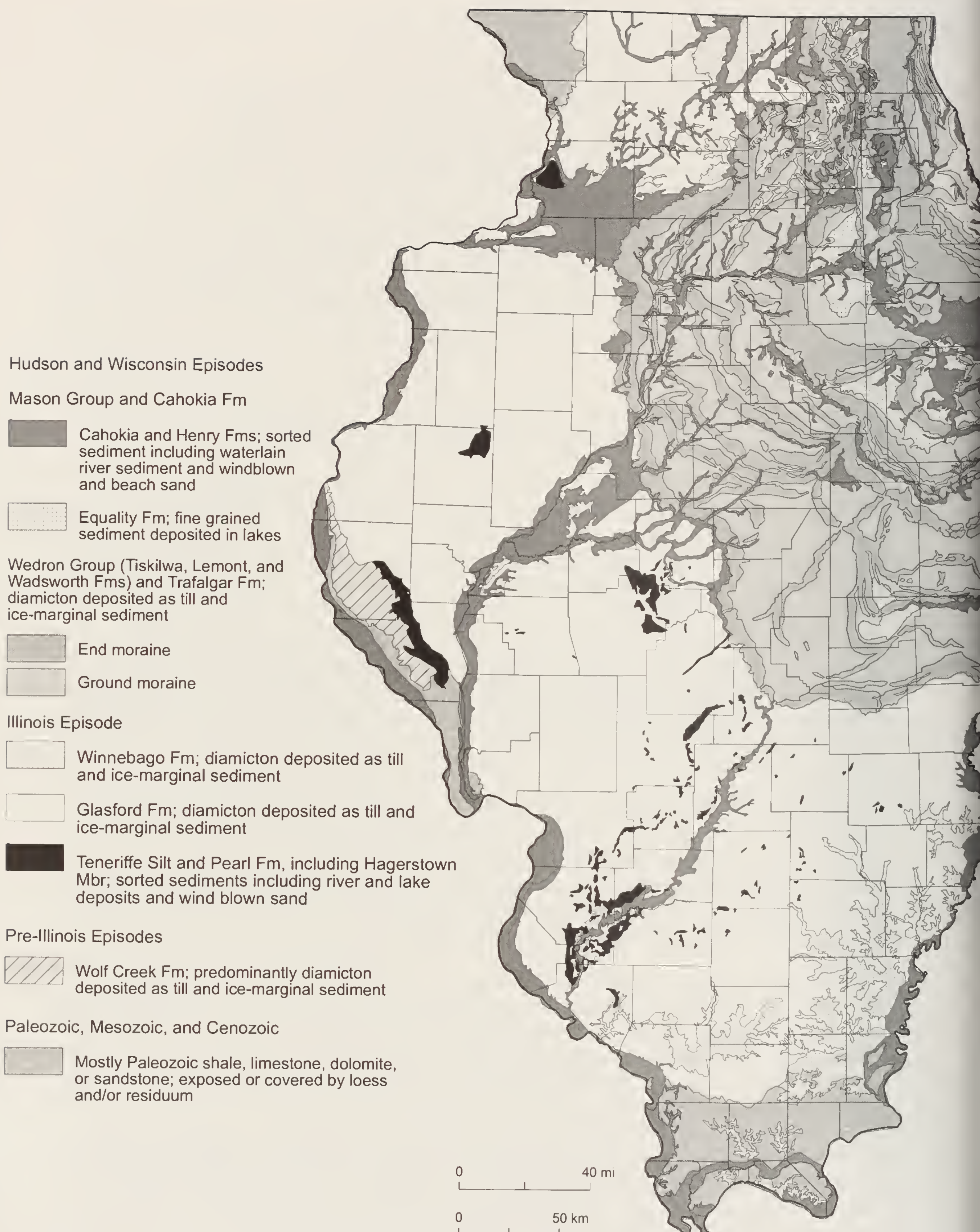
During an early part of the Pleistocene Epoch, glaciers advanced out of centers of ice accumulation both east and west of the Hudson Bay area in Canada (fig. 13b). These centers are referred to in this guidebook as northeastern and northwestern source areas because Illinois lies to the south of and between these centers of accumulation. Glaciers flowing out of these centers into Illinois carried along rock debris incorporated into the ice as they advanced; the material was dropped out as the ice melted. The number and timing of these early episodes of glaciation are uncertain at present and are therefore unnamed; but, because they precede the first named episode (the Illinois Episode; Hansel and Johnson 1996) of glaciation, they are called simply pre-Illinois glacial episodes (fig. 15). The pre-Illinois glacial episodes ended about 425,000 years ago.

Figure 13 Maximum extent of (a) early pre-Illinois glacial episode (1,000,000 ± years ago); Driftless Area shown by stippled pattern; arrow indicates direction of ice movement; (b) late pre-Illinois glacial episode (600,000 ± years ago); (c) Illinois Glacial Episode (250,000 ± years ago); and (d) late Wisconsin Glacial Episode (22,000 years ago).

A long interglacial episode, called the Yarmouth, followed the last of the pre-Illinois glacial advances (fig. 15). The Yarmouth interglacial episode is estimated to have lasted approximately 125,000 years, and deep soil formation took place during that long interval (Yarmouth Geosol). On the parts of the landscape that were generally poorly drained, fine *silts* and clays slowly accumulated (accreted) in shallow, wet depressions and formed what are called accretion gleys, which are characterized by dark gray to black, massive, and dense gleyed clays.

Approximately 300,000 years ago, the Illinois Episode of glaciation began. It lasted for about 175,000 years, and, during this interval, the ice advanced three times out of the northeastern center of accumulation (figs. 13c and 15). During the Illinois Episode, North American continental glaciers reached their southernmost position, in the northern part of Johnson County (fig. 14). Locally, the glacier stopped approximately 8 miles west of Savanna (fig. 16). During the first of these advances, ice of this episode reached westward across Illinois and into Iowa.

Another long interglacial episode, called the Sangamon (fig. 15), followed the Illinois Glacial Episode and lasted about 50,000 years. Although shorter than the Yarmouth interglacial episode, this interval's length was sufficient for another major soil, the Sangamon Geosol, to develop. The Sangamon Geosol exhibits both well-drained and poorly drained soil profiles; although accretion gleys are not as pronounced as they are in the Yarmouth Soil, their occurrence is common across


Hudson and Wisconsin Episodes
Mason Group and Cahokia Fm
Cahokia and Henry Fms; sorted sediment including waterlain river sediment and windblown and beach sand
Equality Fm; fine grained sediment deposited in lakes
Wedron Group (Tiskilwa, Lemont, and Wadsworth Fms) and Trafalgar Fm; diamicton deposited as till and ice-marginal sediment
End moraine
Ground moraine
Illinois Episode
Winnebago Fm; diamicton deposited as till and ice-marginal sediment
Glasford Fm; diamicton deposited as till and ice-marginal sediment
Teneriffe Silt and Pearl Fm, including Hagerstown Mbr; sorted sediments including river and lake deposits and wind blown sand
Pre-Illinois Episodes
Wolf Creek Fm; predominantly diamicton deposited as till and ice-marginal sediment
Paleozoic, Mesozoic, and Cenozoic
Mostly Paleozoic shale, limestone, dolomite, or sandstone; exposed or covered by loess and/or residuum
0
40 mi
0
50 km

Years before present	Time-distance diagram Interglacial and glacial episodes	Sediment record	Dominant climate conditions Dominant land forming and soil forming events
HOLOCENE	interglacial episode	River, lake, wind, and slope deposits.	Warm; stable landscape conditions. Formation of modern soil; running water, lake, wind, and slope processes.
10,000 (PLEISTOCENE EPOCH, not to scale)	WISCONSIN (late) glacial episode; glacial ice	Till and ice-marginal deposits; outwash and glacial lake deposits; loess. 6	Cold; unstable landscape conditions. Glacial deposition, erosion, and landforming processes (e.g., formation of end moraines, outwash plains, valley trains, proglacial lakes, kettles), plus running water, lake, wind, and slope processes.
25,000	WISCONSIN (early and middle) glacial margin north of Illinois	Loess; river, lake, and slope deposits. 5	Cool; stable. Weathering, soil formation (Farmdale Soil and minor soils); wind and running water processes.
75,000	SANGAMON interglacial episode	River, lake, wind, and slope deposits. 4	Warm; stable. Weathering, soil formation (Sangamon Geosol); running water, lake, wind, and slope processes.
125,000	ILLINOIS glacial episode	Till and ice-marginal deposits; outwash and glacial lake deposits; loess. 3	Cold; unstable. Glacial deposition, erosion, and landforming processes, plus proglacial running water, lake, wind, and slope processes; possible minor soil formation.
300,000	YARMOUTH interglacial episode	River, lake, wind, and slope deposits. 2	Warm; stable. Long weathering interval with deep soil formation (Yarmouth Geosol); running water, lake, wind, and slope processes.
425,000 to 1,600,000 and older	? PRE-ILLINOIS glacial and ? interglacial episodes	Till and ice-marginal deposits; outwash and glacial lake deposits; loess plus nonglacial river, lake, wind, and slope deposits. 1	Alternating stable and unstable intervals of uncertain duration. Glacial deposition, erosion, and landforming processes, plus proglacial and interglacial running water, lake, wind, and slope processes; interglacial weathering and soil formation.

Figure 15 Timetable illustrating the glacial and interglacial events, sediment record, and dominant climate conditions of the "Ice Age" in Illinois (modified from Killey 1998).

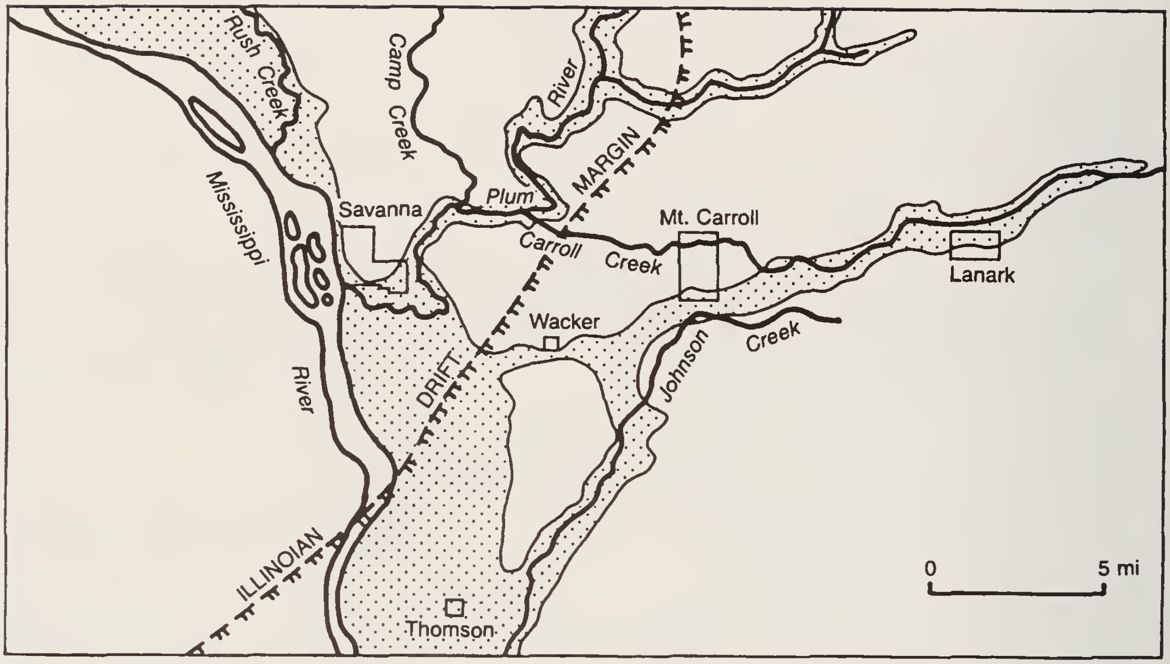


Figure 16 Pre-Illinois glacial bedrock valleys (stippled) of the Mississippi River and present major tributaries in the field trip area (modified from Horberg 1950).

the Sangamon landscape, and they are easily identified by the same characteristics as the Yarmouth accretion gleys.

About 75,000 years ago, the Wisconsin Episode of glaciation began (figs. 13d and 15). Ice from the early and middle parts of this episode did not reach into Illinois. Although late Wisconsin ice did advance across northeastern Illinois beginning about 25,000 years ago, it did not reach southern or western Illinois (figs.13d and 14). The late Wisconsin glaciation in the field trip area is represented here by backwater glacial lake sediments of the Equality Formation and the windblown silts (loess) that blanket the landscape and compose the parent materials for our modern soils. The maximum thickness of the later Wisconsin Episode glaciers was about 2,000 feet in the Lake Michigan Basin, but only about 700 feet over most of the Illinois land surface (Clark et al. 1988). The last of these glaciers melted from northeastern Illinois about 13,500 years B.P.

Wisconsin Episode moraines were deposited in Illinois from approximately 25,000 to 13,500 years ago (figs. 14 and 15). Although Illinois Episode glaciers probably built morainic ridges similar to those of the later Wisconsin Episode glaciers, the Illinois Episode moraines apparently were less numerous and had been exposed to weathering and erosion for approximately 280,000 years longer than their younger Wisconsin Episode counterparts. For these reasons, Illinois Episode glacial features generally are not as conspicuous as the younger Wisconsin Episode features.

In general, glacial deposits consist primarily of (1) till —pebbly clay, silt, and sand, deposited directly from melting glaciers; (2) outwash—mostly sand and gravel, deposited by the rapidly flowing meltwater rivers; (3) *lacustrine* deposits—silt and clay that settled out in quiet-water lakes and ponds; and (4) loess—windblown sand and silt.

Although glaciers did not advance over the field trip area or completely surround it at any one time during the major ice advances (fig.13), outwash deposits of silt, sand, and gravel were dumped along the Mississippi Valley. When these deposits dried out during the winters, strong prevailing winds from the west (the westerlies) winnowed out the finer materials, such as fine sand and silt, and carried them eastward across the unglaciated terrain.

Lacustrine deposits of the Equality Formation are found in the lower portions of the Apple River, Rush Creek, Plum River, and Johnson Creek. These quiet slack-water deposits form a flat topography, which represent long periods of flooding during the melting of the last glaciation. Most of these sediments were deposited during the melting of the Wisconsin glacier from about 20,000 to 10,000 years ago. Vast amounts of meltwater poured from the ice front and caused extensive flooding in the Mississippi, Illinois, Wabash, and Ohio Valleys. In this area, a great lake was formed as these floodwaters backed up the Apple River, Rush Creek, Plum River, and Johnson Creek.

Scattered along the Upper Mississippi River floodplain are several areas of sand dunes. These areas can usually be recognized by their characteristic topographic form, which consists of the random arrangement of small hills or mounds, elongate ridges, and enclosed depressions, and by close visual inspection, which reveals that the dunes are almost entirely made of sand. Dunes are formed by the piling up of sand by the wind and can develop in any region with a readily available source of sand and occasional strong winds. Dunes are common in this region on the valley flats along the margins of the bluffs bordering the valleys and even on the uplands back from the bluffs.

The loess that mantles the bedrock and glacial drift throughout the field trip area was laid down by the wind during all of the glacial episodes, from the earliest pre-Illinois glacial episode (approximately 1.6 million years ago) to the last glacial episode, the Wisconsin Episode (which occurred approximately 25,000 to 13,500 years ago). This yellowish brown silt occurs on the uplands and mantles the bedrock throughout the field trip area. The loess is generally between 20 to 25 feet thick, but erosion has completely removed the loess is scattered areas, especially atop the bluffs along the Mississippi River valley. In general, the thickness of the loess decreases to the east. The loess, which covers most of Illinois, is up to 15 feet thick along the Illinois River valley and is more than 50 feet thick, in some localities, along the east edge of the Mississippi River valley.

GEOMORPHOLOGY

Wisconsin Driftless Section

Physiography is a general term used for describing landforms; a physiographic province is a region in which the relief or landforms differ markedly from those is adjacent regions. The field trip area is located in the Wisconsin Driftless Section of the Central Lowland Province (fig.17). This unglaciated area covers about 10,000 square miles and extends northward into southwestern Wisconsin.

The Wisconsin Driftless Section, or "Driftless Area" as it is commonly called, has some of the most rugged topography in Illinois. The Driftless Area is a submature, deeply dissected, low plateau bounded by the outwash-filled valley of the Upper Mississippi River to the west and the margin of the Illinois Glacial Episode on the east and southeast. The high hills and sharp ridges are underlain by dolomitic strata, and the sweeping slopes and wide valleys are generally eroded into the less resistant underlying shales. Only loess, in which the modern soils developed, mantles the deeply dissected bedrock surface. Remnants of the former upland surface remain, but most of the area is in slopes that dip rather steeply toward the streams. The major streams flow in rather

Figure 17 Physiographic divisions of Illinois (modified from Leighton et al. 1948).

broad, steep-walled valleys, and relatively flat upland areas still remain. Major streams flow from a central upland westward to the Mississippi River and eastward and southward to the Rock River. Alluvium, relatively modern deposits along the streams, has been eroded, leaving terraced remnants along the valley walls. Topography in the adjacent glaciated area of the Rock River Hill Country (fig. 17) is more subdued than in the Driftless Area. Here the thin Illinois glacial deposits—which barely mask the irregularities of the major uplands and valleys formed by pre-Illinois erosion of the bedrock—have produced a rolling landscape.

NATURAL DIVISIONS AND GEOLOGY

Glacial history has played an important role in shaping Illinois topography by eroding the preglacial landscape and depositing glacial sediments. Topography influences the diversity of plants and animals (biota) of Illinois by strongly influencing the diversity of habitats. Geological processes form, shape, and create the topography on all of the Earth's surface. Specifically, geological processes not only determine the composition of the parent material of soils, but also form soils through the weathering of parent materials. Thus, the geology of a region is the foundation of its habitats.

Natural Divisions

The state has been divided into fourteen different Natural Divisions. These divisions are distinguished according to differences in significant aspects of topography, glacial history, bedrock geology, soils, aquatic habitats, and distribution of plants and animals (flora and fauna). A strong relationship exists between the Physiographic Divisions of Illinois and the Natural Divisions of Illinois because the geologic factors used to determine the Physiographic Divisions were important elements used to define the boundaries of the Natural Divisions. The field trip area is located in three Natural Divisions: the Wisconsin Driftless Division, the Upper Mississippi River and Illinois River Bottomlands Division, and the Illinois River and Mississippi River Sand Areas Division. The following descriptions of the Natural Divisions are modified from Schwegman (1973).

Wisconsin Driftless Division The Wisconsin Driftless Division is part of an area extending from northwestern Illinois into Wisconsin, Iowa, and Minnesota that escaped Pleistocene glaciation. This division is one of the most maturely developed land surfaces in Illinois and is characterized by rugged terrain and a dissected pattern of wooded ridges and includes such prominent features as canyons, ravines, bluffs, and palisades. Originally most of the area was forested. It has the coldest climate in the state. It contains several distinctive plants of northern affinity and some species that may represent relicts of the pre-"Ice Age" flora. Algific slopes are north-facing rocky slopes that retain subsurface ice through most of the year. In Illinois they occur only in the Driftless Area. The cold microclimate created on the surface of the slope supports relict northern and Pleistocene biota, including many endangered, threatened, and rare species.

- ***Bedrock*** The Wisconsin Driftless Division is a mature, dissected upland of Ordovician and Silurian limestone, dolomite, and shale. Bedrock crops out along the major watercourses. Prominent "mounds" capped with the more resistant dolomite are common. A mineralized zone containing deposits of lead and zinc is an important feature. Caves are known in the dolomite.

- ***Topography*** The topography of the Wisconsin Driftless Division is one of rolling hills and great relief, particularly along interior stream canyons. High erosional remnants (including Charles Mound, the highest point in Illinois, with an elevation of 1,257 feet) are prominent features. There are loess-capped bluffs and palisades along the Mississippi River valley and ravines and bluffs throughout the division.

• ***Soils*** The soils of this division have developed from loess or, on steeper slopes, from loess on bedrock. The loess soils are derived from thick deposits and are weakly to moderately developed. The soils on bedrock are thin to moderately thick and well drained.

Upper Mississippi River and Illinois River Bottomlands Division The Upper Mississippi River and Illinois River Bottomlands Division encompasses the rivers and floodplains of the Mississippi River above its confluence with the Missouri River and the bottomlands and associated backwater lakes of the Illinois River and its major tributaries south of La Salle. The division does not include the major sand deposits, which are in a separate division. Much of the division was originally forested, but prairie and marsh also occurred. The more sluggish nature of the Illinois River and its distinctive backwater lakes distinguish the Illinois River Section from the Upper Mississippi River Section.

• ***Bedrock*** The bedrock of the two river valleys is deeply covered by alluvial deposits.

• ***Topography*** The bottomlands of the upper Mississippi River and the Illinois River are characterized by broad floodplains and gravel terraces formed by glacial floodwaters.

• ***Soils*** The soils are from recent alluvium and glacial outwash. They are poorly drained, alka line to slightly acidic, and vary from sandy to clayey. In general, they are lighter than the alluvial soils of the Lower Mississippi River Bottomlands Division.

Illinois River and Missippippi River Sand Areas Division The Illinois River and Mississippi River Sand Areas Division encompasses the sand areas and dunes in the bottomlands of the Illinois and Mississippi Rivers and includes the "perched dunes" atop the bluffs in Carroll and Jo Daviess Counties. Scrub oak forest and dry sand prairie are the natural vegetation of this division. Several plant species found here are more typical of the short-grass prairies to the west of Illinois. Several "relict" western amphibians and reptiles are known only from these sand areas. The two sections are distinguished because of differences in flora and fauna.

• ***Topography*** The topography is generally one of level to rolling plains of sand deposited by glacial meltwaters and blown into widespread areas east of the rivers. In many areas, the sand has migrated onto the bluffs and uplands east of the river terraces. In places, dunes 20 to 40 feet high have formed, and blowouts are common in unstabilized sand.

• ***Soils*** The soils are derived from sand and sandy material. Other soils in depressions surrounded by sand are also in this division. The soils are generally droughty and subject to wind erosion. Low areas are generally wet.

Drainage

The Mississippi River is the major drainage way in northwestern Illinois. Major tributaries in the field trip area are the Apple River, Rush Creek, Plum River, and Johnson Creek; these tributaries generally flow south and west into the Mississippi River. Some of the major tributaries have incised meanders (see route maps). Most of the secondary tributaries, which flow into the Apple River, Rush Creek, Plum River, and Johnson Creek, consist of a series of smaller, relatively short, V-shaped tributaries with steep gradients. These secondary tributaries are part of a well-developed drainage network that has grown (eroded) headward into the upland remnants. Sinkholes (depressions caused by dissolution of the underlying dolomite) and other *karst* features, although present, are not conspicuous. Considerable subsurface drainage occurs through small caves and channels that have developed in the dolomitic bedrock strata. A number of springs occur within the field trip area, especially along the bluffs bordering the Mississippi River valley. A spring is located along Illinois Route 84 on the north side of the South entrance to the Mississippi Palisades State Park.

Relief

The highest point along the field trip route is Hanover Bluff, just north of Stop 3, where the highest point is 958 feet msl. The lowest point is the Mississippi River surface, which has a normal pool elevation of 583 feet msl upstream from Lock and Dam No. 13, which is located just south of Stop 5. The regional relief is therefore approximately 365 feet. Local relief is most pronounced along the Mississippi River Palisades where the bluffs rise about 225 feet above the Mississippi River valley.

NATURAL RESOURCES

Mineral Production

The total value of all minerals extracted, processed, and manufactured in Illinois during 1998 was $1,950,000,000. Minerals extracted accounted for 86.4% of this total. Coal continued to be the leading commodity, followed by construction stone (limestone and dolomite), sand and gravel, and oil. Illinois ranked 5th among coal-producing states, 13th among the 31 oil-producing states, and 16th among the 50 states in total production of nonfuel minerals. Illinois continues to lead all other states in production of industrial sand and tripoli. The mineral production in Carroll and Jo Daviess Counties is currently limited to dolomitic stone and deposits of sand and gravel.

Groundwater

Groundwater is a mineral resource frequently overlooked in assessments of an area's natural resource potential, but groundwater availability is essential for orderly economic and community development. More than 35% of the state's 11.5 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.

GUIDE TO THE ROUTE

We will start the trip at the south entrance to the Mississippi Palisades State Park. Assemble at the pavilion located just inside the south entrance (NE, SE, SE, Sec. 28, T25N, R3E, 4th P.M., Blackhawk 7.5-minute Quadrangle, Carroll County). Mileage will start at the parking lot in front of the pavilion.

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

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

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

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

Six USGS 7.5-Minute Quadrangle maps (Blackhawk, Clinton Northwest, Green Island, Savanna, Thomson, and Wacker) provide coverage for this field trip area.

Miles to next point	Miles from start	
0.0	0.0	Set your odometer to 0.0 in the parking lot in front of the pavilion. Exit the parking lot and continue into the park (heading east).
0.2	0.2	T-intersection from the right. TURN RIGHT. This is the southern extension of the main park road. CAUTION: The road contains a number of sharp turns and steep grades. As you drive along in the park, notice the deep ravines and high ridges. Some of the rock formations located in the south end of the park include Sentinel Rock, Indian Head Rock, and Twin Sisters Rock.

0.35	0.55	Parking area on the left. CONTINUE AHEAD. The trailheads (starting points) for Pine Trail and Prairie View Trail are to the left, and Sentinel Trail is to the right.
0.2	0.75	Exposure of loess deposit on the right.
0.1	0.85	Parking lot, picnic area, and playground on the left.
0.1	0.95	Parking lot on the left. A backwater slough is located on the right.
0.05	1.0	Parking lot on the right. CONTINUE AHEAD. The trailhead for Pine Trail, which leads to the Twin Sisters rock formation, is on the left. Upton's Trail, which leads to the Indian Head rock formation and Upton's Cave is on the right.
0.6	1.6	Enter loop road at the end of the park road. Pine trees are planted in the middle of the loop road.
0.2	1.8	Complete the loop and retrace your route (head north on the park road).
0.55	2.35	Pass entrances to Pine and Upton's Trails.
0.15	2.5	Pass backwater slough on the left.
0.05	2.55	Pass parking lot, picnic area, and playground on the right. On the left, built into the hillside, is an arched shelter made of native stone. It is thought that this was used as a smokehouse by some of the early settlers.
0.1	2.65	Loess deposit on the left.
0.2	2.85	Parking lot on the right. TURN RIGHT into the parking lot and park your vehicle.

STOP 1: Sentinel Trail, Mississippi Palisades State Park (NE, NW, NW, Sec. 34, T25N, R3E, 4th P.M., Savanna 7.5-minute Quadrangle, Carroll County) We will be hiking Sentinel Trail. The trail leads to the Sentinel Rock overlook and Bat Cave.

0.0	2.85	Leave Stop 1 and turn right (heading north). CAUTION: Road begins sharp descent.
0.2	3.05	Pass small pull-over to the right. A thick exposure of loess is located on the right, near the head of the small ravine.
0.15	3.2	STOP (one way). T-intersection with main park road. TURN RIGHT.
0.4	3.6	T-intersection from the left (Lookout Point). TURN LEFT.

0.25	3.85	Sunset Trail trailhead on the left.
0.15	4.0	Enter loop at the end of road leading to Lookout Point. Pull over and park your vehicles.

STOP 2: Lookout Point, Mississippi Palisades State Park (SW, NE, SE, Sec. 28, T25N, R3E, 4th P.M., Blackhawk 7.5-minute Quadrangle, Carroll County). Lookout point provides a great overview of the Mississippi River valley.

0.0	4.0	Leave Stop 2.
0.4	4.4	STOP: T-intersection with main park road. TURN LEFT.
0.5	4.9	T-intersection from the left (Oak Point lookout). CONTINUE AHEAD.
0.2	5.1	T-intersection from the left (Louis' Point lookout). CONTINUE AHEAD.
0.1	5.2	T-intersection from the left (Ozzie's Point lookout). CONTINUE AHEAD. CAUTION: Road begins long winding steep descent.
0.3	5.5	Pass prairie restoration project on the left.
0.1	5.6	Pass park office on the left and Palisades Mini-Mart on the right. CONTINUE AHEAD.
0.1	5.7	Y-intersection. BEAR LEFT (west toward the park exit).
0.1	5.8	STOP: (two-way). Crossroad intersection (park entrance and Illinois Route 84). TURN RIGHT. Note: Miller's Hollow public boat launch area is west of the main park entrance.
1.1	6.9	T-intersection from the right (Mill Hollow Road). CONTINUE AHEAD.
0.2	7.1	Cross Rush Creek.
0.75	7.85	T-intersection from the left (Marcus Road). CONTINUE AHEAD.
0.75	8.6	Good view ahead and to the right of the bluffs that form the eastern edge of the Mississippi River valley.
0.5	9.1	The landscape topography to the right was created by large sand dunes.
0.5	9.6	T-intersection from the left (Savanna Army Depot Road). CONTINUE AHEAD.
0.3	9.9	The bluffs to the right contain some steep-sloped hill prairies, which are visible from the road. These prairies are included in the Illinois Nature Preserve

		System and are appropriately named Falling Down Prairie. The name comes from the fact that the slopes are so steep that you keep falling down.
0.4	10.3	Enter Jo Daviess County.
0.45	10.75	T-intersection from the right (Four Corners Road). CONTINUE AHEAD.
0.75	11.5	T-intersection from the right (Rush Road). CONTINUE AHEAD.
0.5	12.0	T-intersection from the left (Whitton Road). TURN LEFT. You will cross the Apple River after making the left turn.
0.8	12.8	Pass Lost Mound Cemetery on the left. CONTINUE AHEAD.
0.1	12.9	View of Savanna Army Depot to the left.
1.05	13.95	T-intersection from the right (Crazy Hollow Road). CONTINUE AHEAD.
0.15	14.1	View of underground ammunition storage bunkers at the Savanna Army Depot on the left.
0.15	14.25	T-intersection from the left (dead end road). CONTINUE AHEAD and prepare to stop at the entrance to an abandoned quarry on the right.
0.05	14.3	Angled intersection from the right. TURN RIGHT. The access road to the abandoned quarry immediately ascends the hill to the right. On the day of the field trip we will open the gate and proceed uphill.

STOP 3: Lost Mound–Abandoned Shelly Quarry at Hannover Bluff (Center of the NW, SW, Sec. 28, T26N, R2E, 4th P.M., Green Island 7.5-minute Quadrangle, Jo Daviess County). NOTE: If you visit this quarry on your own at a later date, you will have to hike up the road, because the gate is normally locked.

0.0	0.0	Leave Stop 3. Retrace your route back to the quarry access road. NOTE: Reset your odometer to 0.0. TURN LEFT onto Whitton Road (heading south).
0.1	0.1	T-intersection to the right (dead end road) and an old abandoned quarry access road leading uphill to the left. An exposure of Ordovician age shale of the Maquoketa Group, possibly the Brainard Formation, is to the left near the base of the road.
0.25	0.35	T-intersection from the left (Crazy Hollow Road). TURN LEFT. Road is unmarked.
0.85	1.2	Scenic view of the Apple River valley is to your right. The bluffs directly to the east form the eastern edge of the Apple River valley. Looking to the

		south, you can see the bluffs that form the western edge of the Mississippi River valley. Notice the meandering nature of the Apple River (see route maps).
1.3	2.5	Cross the Apple River.
0.5	3.0	Stop (one-way) T-intersection (Crazy Hollow Road and Illinois Route 84). TURN RIGHT onto Route 84 (heading south). Directly across from the intersection is Whistling Wings, Inc., a Mallard duck farm. Hanover, which is 2 miles to the left, is known as the Mallard capitol of the world.
0.5	3.5	Cross small unnamed creek.
1.3	4.8	T-intersection from the right (Whitton Road). CONTINUE AHEAD. The Apple River is immediately to the right.
0.6	5.4	T-intersection from the left (Rush Road). CONTINUE AHEAD.
0.2	5.6	The large valley carved by Rush Creek is to your left. If you compare the size of the valley to the size of Rush Creek, you may wonder how a small stream such as Rush Creek could have carved such a large valley. Rush Creek can be characterized as an *underfit stream*.
0.5	6.1	T-intersection from the left (Four Corners Road). CONTINUE AHEAD.
0.5	6.6	Enter Carroll County.
0.5	7.1	T-intersection from the right (Savanna Army Depot Road). CONTINUE AHEAD.
1.9	9.0	T-intersection from the right (Marcus Road). CONTINUE AHEAD.
0.7	9.7	Cross Rush Creek.
0.2	9.9	T-intersection from the left (Mill Hollow Road). CONTINUE AHEAD.
1.2	11.1	Pass main entrance to Mississippi Palisades State Park to the left and Miller's Hollow public boat launch to the right. CONTINUE AHEAD.
1.2	12.3	Pass south entrance to Mississippi Palisades State Park to the left. A natural spring is located near the entrance on the north side of the road.
0.2	12.5	View of Sabula Bridge ahead and to the right. Savanna Bay, a backwater area of the Mississippi River, is immediately to the right. The main channel of the Mississippi River is on the opposite side of the trees.
0.5	13.0	Pass small parking lot on the left side of the road. You can follow a trail on the south side of the parking lot to Upton's Cave. View of the Mississippi River is immediately to the right. Sabula Bridge is directly ahead.

0.4	13.4	Outcrop of Silurian age dolomite on your left.
0.5	13.9	Pass entrance to the Sabula Bridge. CONTINUE AHEAD on Illinois Route 64 (east), U.S. Route 52, and Illinois Route 84 (south).
0.1	14.0	Enter the city of Savanna, nicknamed the "City of Promise" (population 3,819). NOTE: We will drive through Savanna on Main Street, following Illinois Route 84 (south).
0.6	14.6	Cross intersection of Madison Street. The historic Pulford Opera House is on the left just past the intersection.
0.2	14.8	Entrance to public boat launch and the historic Hiawatha passenger train car on your right. The Hiawatha train car is a museum and home for the Savanna Chamber of Commerce. This 1950 passenger coach is one of only 16 still in existence. At the height of the railroad days, as many as 100 freight and 30 passenger trains would depart from Savanna daily. Road curves 90 degrees to the left, and after the curve, the road is Chicago Avenue.
0.7	15.5	Pass the old Savanna High School on the left.
0.2	15.7	Pass native dolomite retaining wall on the left side of the road. MERGE TO THE RIGHT LANE. Junction of U.S. Route 52, Illinois Route 64 and Illinois Route 84 directly ahead.
0.2	15.9	Stoplight (three-way). T-intersection of U.S. Route 52 (east)/Illinois Route 64 (east) and Illinois Route 84 (south). TURN RIGHT onto Illinois Route 84 (south). A McDonald's and Amoco station are on the left. The Swiss Colony factory is on the left after you make the turn.
0.7	16.6	T-intersection from the left (Wacker Road). CONTINUE AHEAD.
0.1	16.7	Pass St. John's Cemetery on the right.
0.2	16.9	Cross Plum River. The sediments from the plum River have forced the main channel of the Mississippi River to the west. (See route maps.)
0.8	17.7	T-intersection from the right. Entrance to Upper Mississippi Refuge-Spring Lake. CONTINUE AHEAD.
0.1	17.8	Pass sand and gravel pit to the left. CONTINUE AHEAD.
0.7	18.5	CAUTION: Cross single railroad track with signal lights and guard gate. CONTINUE AHEAD.
0.25	18.75	T-intersection from the left (Airport Road). CONTINUE AHEAD.
0.25	19.0	Pass Stransky Memorial Airport on the left.

0.6	19.6	Pass sign for Upper Mississippi Refuge U.S. Fish and Wildlife Service and Refuge Office. Prepare to turn right.
0.2	19.8	T-intersection from the right (Riverview Road). TURN RIGHT.
0.05	19.85	CAUTION: Cross single railroad track with signal lights only. The boundary to the National Wildlife Refuge is to the right.
0.35	20.2	Entrance to Sloane Marsh Overlook to the right. TURN INTO THE PARKING LOT. Immediately across the road to the left is the Upper Mississippi National Wildlife and Fish Refuge–Ingersoll Wetlands Learning Center.

STOP 4: Sloan Marsh, Upper Mississippi National Wildlife and Fish Refuge (NE, SE, NE, Sec. 35, T24N, R3E, 4th P.M,, Wacker 7.5-minute Quadrangle, Carroll County).

0.0	20.2	Leave Stop 4. TURN RIGHT from the parking lot (heading south).
1.1	21.3	Pass Big Slough Recreation Area and public boat launch facility on the right. CONTINUE AHEAD.
1.0	22.3	T-intersection from the left (Three-Mile Road). CONTINUE AHEAD. A pivot point irrigation system is on the left just past the intersection.
0.4	22.7	Good view of the bluffs on the east side of the Mississippi River valley is to the left. The eastern bluffs are 2.75 miles away, and the Mississippi River valley is approximately 4.5 miles wide.
0.4	23.1	Another pivot point irrigation system on the left side of the road. You are driving across the fluvial sand and gravel deposits of the Mississippi River floodplain.
1.1	24.2	Road curves 90 degrees to the left. You are now on Ideal Road.
0.5	24.7	T-intersection. The main road curves 90 degrees to the right. TURN RIGHT onto Sandridge Road. The new Thomson Correctional Facility is on the left after the curve in the road. This facility is scheduled to open in November 2001.
0.7	25.4	Pass through a sand dune area.
0.3	25.7	Road curves 90 degrees to the left and becomes Main Street.
0.05	25.75	T-intersection from the Right (Lewis Avenue). TURN RIGHT onto Lewis Avenue. The U.S. Corps of Engineers–Thomson Causeway Recreation Area is on the right.
0.45	26.2	STOP SIGN: Entrance to Thomson Causeway Recreation Area. Just past the registration hut, the road curves to the right, and a T-intersection is on the

		right. CONTINUE AHEAD toward the Potters Marsh, Hickory Point, and Indiana Mound Day Use Area.
0.2	26.4	Cross Potters Slough. The Causeway Road is built across this old slough of the Mississippi River.
0.2	26.6	Crossroad intersection (Potters Marsh campgrounds to the right and left. Hickory Point and Indian Mound Day Use areas are straight ahead). CONTINUE STRAIGHT AHEAD.
0.1	26.7	Pass Hickory Point Campground to the right and the Hidden Slough Nature Trail to the left. A parking lot is to the right. CONTINUE AHEAD.
0.2	26.9	Enter the loop road at the Woodland Mound Day Use Area and park your vehicle. This is the lunch stop.

STOP 5: Lunch at Woodland Mound Day Use Area, Thomson Causeway Recreation Area, Upper Mississippi River Wildlife and Fish Refuge (SW, NW, SE, Sec. 26, T23N, R3E, 4th P.M., Thomson 7.5-minute Quadrangle, Carroll County). On the day of the field trip we will be using the shelter at the far west end of the area

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0.0	0.0	Leave Stop 5. Reset your odometers to 0.0 in front of the shower and restroom facilities at the Woodland Mound Day Use Area. Retrace your route back to the entrance.
0.7	0.7	STOP SIGN at registration booth. CONTINUE AHEAD.
0.4	1.1	STOP (one-way). T-intersection (Lewis Avenue and Main Street). TURN RIGHT and enter the town of Thomson, watermelon and sandburr capital of the world (population 559).
0.5	1.6	CAUTION: Cross single-track railroad (signal lights only).
0.2	1.8	STOP (two-way). Crossroad intersection (Main Street and Illinois Route 84). CAUTION: Fast-moving traffic from the right and left do not stop. TURN LEFT onto Illinois Route 84 (heading north).
0.7	2.5	Crossroad intersection (One-Mile Road). CONTINUE AHEAD.
2.25	4.75	Crossroad intersection (Three-Mile Road). CONTINUE AHEAD.
0.95	5.7	T-intersection from the left (Four-Mile Road). CONTINUE AHEAD.
0.4	6.1	T-intersection from the right (Spear Road). TURN RIGHT. Good view of the bluffs directly ahead after you make the turn.

0.3	6.4	Pivot Point Irrigation System immediately to the right. This irrigation system is approximately 1,000 feet long. There are several Pivot Point Irrigation Systems both to the right and left along Spear Road.
0.6	7.0	Cross the Savanna-York channelized ditch. This ditch provides drainage for the fields in the floodplain.
0.6	7.6	Cross a second channelized drainage ditch.
0.2	7.8	Cross another drainage ditch.
0.05	7.85	T-intersection (Spear Road and Scenic Bluff Road). TURN LEFT.
0.25	8.1	Good view of the Mississippi River floodplain to your left.
0.3	8.4	Outcrop of the Maquoketa Shale on the right where the road comes up onto a little knob.
0.5	8.9	Cross small drainage ditch.
0.7	9.6	T-intersection from the right (Airport Road and Scenic Bluff Road). CONTINUE AHEAD on Scenic Bluff Road.
0.3	9.9	Road curves 90 degrees to the left.
0.1	10.0	T-intersection from the right (Scenic Bluff Road and Airport Road). CONTINUE AHEAD on Airport Road (heading west).
0.1	10.1	Sand dunes to your right.
0.3	10.4	Cross Savanna-York channelized ditch.
0.4	10.8	Pass a wetland marsh in an abandoned slough to the right.
0.3	11.1	Ayers Sand Prairie State Nature Preserve is on the right.
0.1	11.2	Parking lot for Ayers Sand Prairie State Nature Preserve. Pull over to the right side of the road and park your vehicles.

STOP 6: Ayers Sand Prairie State Nature Preserve (SW, SW, SE, Sec. 24, T24N, R3E, 4th P.M., Wacker 7.5-minute Quadrangle, Carroll County).

0.0	11.2	Leave Stop 6. CONTINUE AHEAD.
0.3	11.5	Pass a small cemetery on the left.
0.25	11.75	STOP (one-way). T-intersection (Airport Road and Illinois Route 84). CAUTION: Fast-moving traffic from the left. TURN RIGHT onto Illinois Route 84 (heading north).

0.25	12.0	CAUTION: Cross single-track railroad (lights and guard gates).
0.5	12.5	Prepare to TURN RIGHT.
0.2	12.7	Entrance to sand and gravel pit. TURN RIGHT and follow the road to the east and enter the sand and gravel pit.

STOP 7: Voss Sand and Gravel Pit (SE, NW, NE, Sec. 23, T24N, R3E, 4th P.M., Wacker 7.5-minute Quadrangle, Carroll County). Follow the road past the scale house and bear left.

0.2	12.9	Leave Stop 7. Retrace your route back to Illinois Route 84 and TURN RIGHT (heading north).
0.2	13.1	T-intersection from the left (Entrance to Upper Mississippi Refuge Spring Lake Area). CONTINUE AHEAD.
0.8	13.9	Cross Plum River and enter the city of Savanna (population 3,800).
0.3	14.2	T-intersection from the right (Wacker Road). TURN RIGHT (heading east).
0.4	14.6	Pass the Savanna Chestnut Park School on the right.
0.15	14.75	Pass the Savanna Water Tower on the left.
0.25	15.0	Cross the overpass bridge over the railroad tracks.
0.2	15.2	The Plum River is to the left.
0.3	15.5	Cross the Plum River. T-intersection immediately from the right. TURN RIGHT onto Scenic Bluff Road.
0.4	15.9	T-intersection from the left (Wacker Road and Scenic Bluff Road). CONTINUE AHEAD on Scenic Bluff Road.
0.3	16.2	Entrance to Savanna Blacktop and Quarry on the left. TURN LEFT into the Quarry. On the day of the field trip, we drive down into the quarry.

STOP 8: Savanna Blacktop and Quarry (NW, NE, SW, Sec. 18, T24N, R4E, 4th P.M., Wacker 7.5-minute Quadrangle, Carroll County).

0.0	16.2	Leave Stop 8 and retrace your route back to Scenic Bluff Road.
0.1	16.3	At the exit of the quarry, TURN LEFT onto Scenic Bluff Road.
0.15	16.45	Cross small creek.

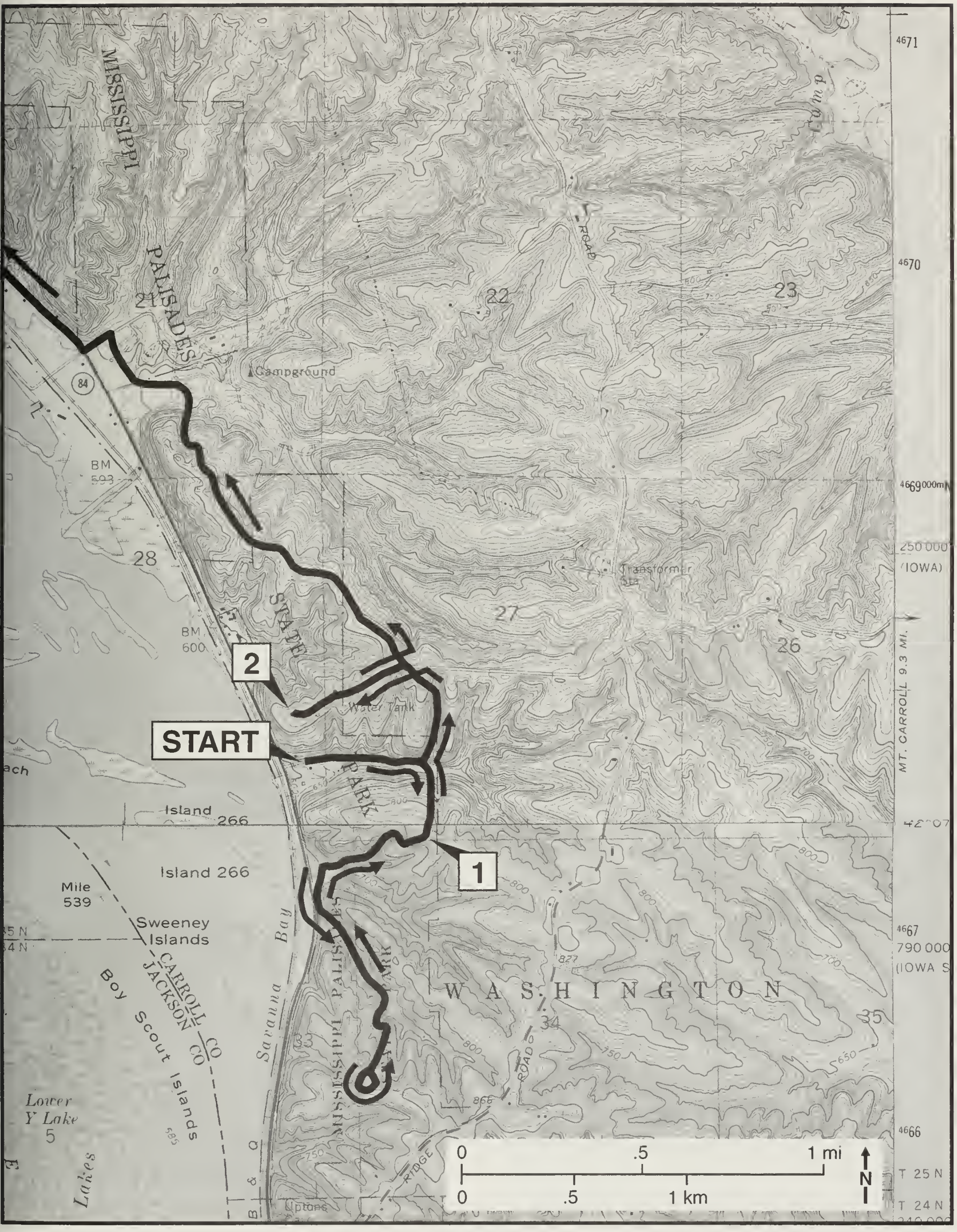
0.65	17.1	Exposure of loess to the left.
0.1	17.2	Pass under viaduct. NOTE: Clearance is 11′4″
0.7	17.9	Cross Deer Creek. Note the small waterfall in the creek to the left.
0.05	17.95	T-intersection (Scenic Bluff Road and Airport Road). TURN LEFT onto Airport Road.
0.35	18.3	T-intersection from the left (Airport Road and Scenic Bluff Road). BEAR RIGHT. Stay on Scenic Bluff Road.
0.7	19.0	Cross small creek draining the small valley to the left. Good view to the right of the bluffs on the Iowa side of the Mississippi River valley. The Mississippi River floodplain is 4.75 miles wide at this location.
1.1	20.1	T-intersection from the right (Spear Road). CONTINUE AHEAD on Scenic Bluff Road and immediately cross a small creek draining from the left.
0.1	20.2	Weathered outcrop of Ordovician Dolomite on the right side of the road overlain by up to 4 foot of loess.
0.6	20.8	Outcrop of the Ordovician age Maquoketa Shale Group on the left side of the road. Just south of the bridge with the yellow guide markers on it. This is a good fossil collecting locality. CONTINUE AHEAD
0.1	20.9	Cross unnamed creek.
0.5	21.4	Outcrop of Ordovician age Maquoketa Shale Group just before the curve in the road, and the house on the left.
0.1	21.5	T-intersection from the left (Three-Mile Road). TURN LEFT and begin ascent onto the top of the bluffs.
0.05	21.55	Loess deposits on the right and left sides of the road.
0.65	22.2	T-intersection from the left (Ashby Road). CONTINUE AHEAD on Three-Mile Road.
0.1	22.3	Road begins descent into a valley.
0.1	22.4	Guard rail on the right side of the road. Just past the guard rail on the left is an upland sand deposit overlain by loess. Estimated about 15 feet of sand overlain by about 20 feet of loess. Pull over to the far right side of the road and park your vehicle.

STOP 9: Upland Sand Dune (NW, NW, SW, Sec. 4, T23N, R4E, 4th P.M., Wacker 7.5-minute Quadrangle, Carroll County).

0.0	22.4	Leave Stop 9. CONTINUE AHEAD.
0.05	22.45	Further down the road an Ordovician age outcrop of dolomite bedrock is directly overlain by about 15 feet of loess; no sand is apparent. The sand seems to be restricted to the upper part of the valley. The bedrock is highly jumbled.
0.4	22.85	Near the bottom of the valley, a walnut tree farm is to the left.
0.1	22.95	Road begins ascent up the east slope of the valley. Loess deposit overlying bedrock on the left.
0.85	3.8	Road begins descent into a large valley cut by Johnson Creek.
0.2	24.0	Loess exposure on the right.
0.25	24.25	Cross small branch of Johnson Creek.
0.15	24.4	Yield sign. Intersection of (Three-Mile Road and Big Cut Road). TURN LEFT onto Big Cut Road. CAUTION: Traffic from the left and right do not stop.
0.45	24.85	Cross small creek.
0.6	25.45	T-intersection from the right (Vinegar Hill Road). CONTINUE AHEAD.
0.15	25.6	Good view to the right of the rolling loess cover hills of Carroll County.
0.15	25.75	Large oak trees growing on the right side of the road.
0.75	26.5	Good view to the left of the bluffs along the Mississippi River on the Iowa side. CAUTION: Approaching (four-way) intersection. No stop signs either way.
0.4	26.9	STOP: Crossroad intersection (Airport Road and Big Cut Road). CAUTION: Dangerous intersection. CONTINUE AHEAD.
0.2	27.1	Slight low area in the road provides a good view to the west of the bluffs along the Ohio River. The distance to the bluffs is 6.5 miles. You can also see the Savanna water tower, which is 4.75 miles to the northwest.
0.2	27.3	Approaching narrow bridge across railroad tracks. Pull over to the right side of the road as far as you can and park your vehicle. This is the last stop of the field trip. Follow the small path on the south side of the bridge to the east.

STOP 10: Big Cut (NW, NW, NW, Sec.27, T24N, R4E, 4th P.M., Wacker 7.5-minute Quadrangle, Carroll County). Chicago, Burlington and Quincy Railroad cut.

0.0	27.3	Leave Stop 10 CONTINUE AHEAD and cross very old, one-lane bridge. The following road log will guide you back to civilization.
0.4	27.7	CAUTION: Cross single-track railroad. DANGER: No warning lights; no gates; use EXTREME CAUTION.
0.2	27.9	STOP (stop sign missing): T-intersection (Big Cut Road and Wacker Road). TURN RIGHT onto Wacker Road. If you TURN LEFT, you will head back toward Illinois Route 84 and Savanna.
0.4	28.3	CAUTION: Approaching railroad.
0.1	28.4	CAUTION: Cross single-track railroad. Signal lights only, No guard gate.
0.2	28.6	T-intersection from the right (Airport Road). CONTINUE AHEAD.
0.1	28.7	T-intersection from the left (Preston Road). TURN LEFT.
0.5	29.2	Pass under viaduct. Clearance is 10′ 6″.
1.0	30.2	STOP (one-way). T-intersection (Preston Road/Illinois Route 64 and U.S. Route 52. TURN RIGHT. It will take you to Oregon and then eventually to Interstate 39. If you TURN LEFT, you'll head back toward Savanna.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CARROLL CO
JACKSON CO
Boy Scout Islands
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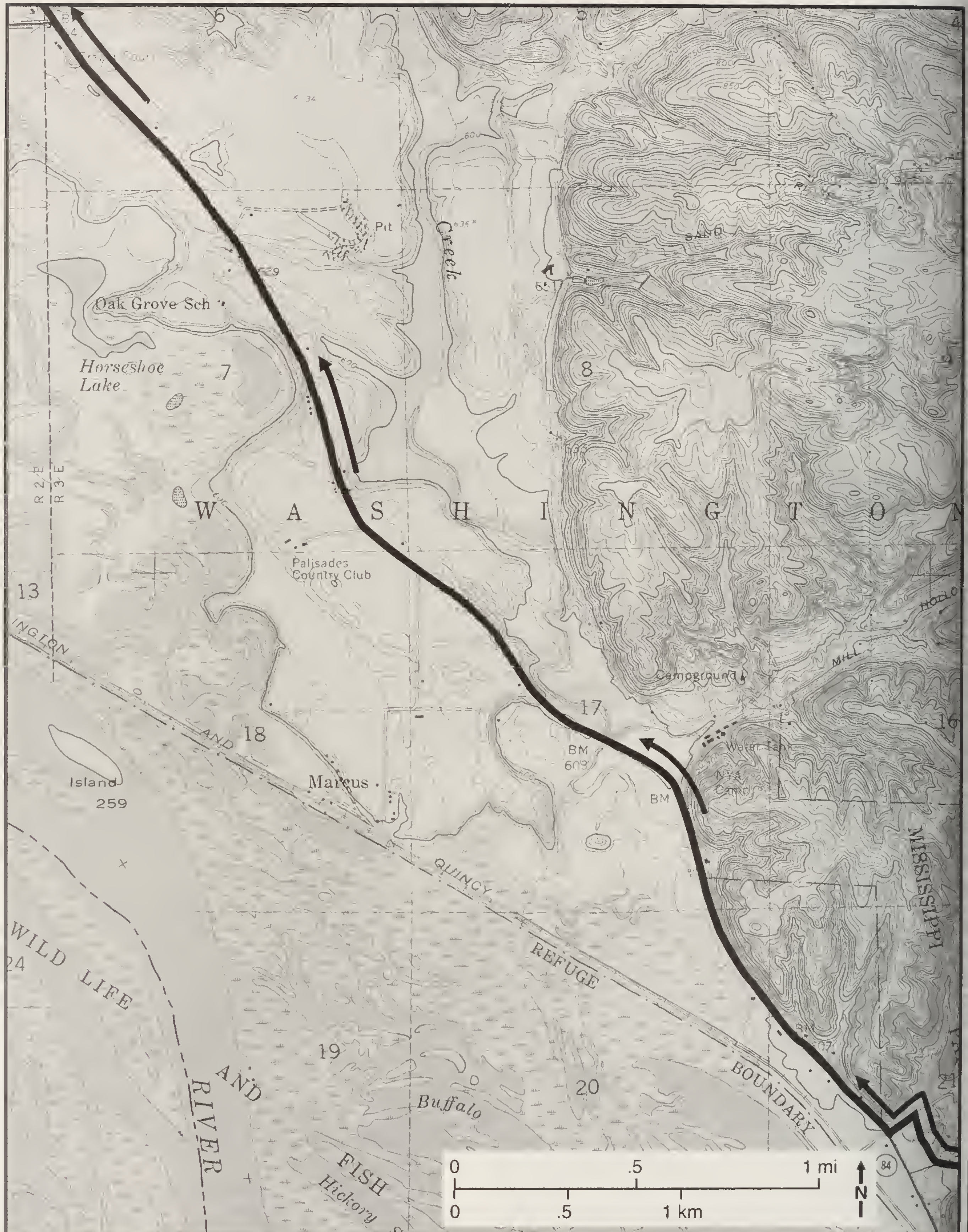

Pit
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Palisades Country Club
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BM 609
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Marcus
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Campground
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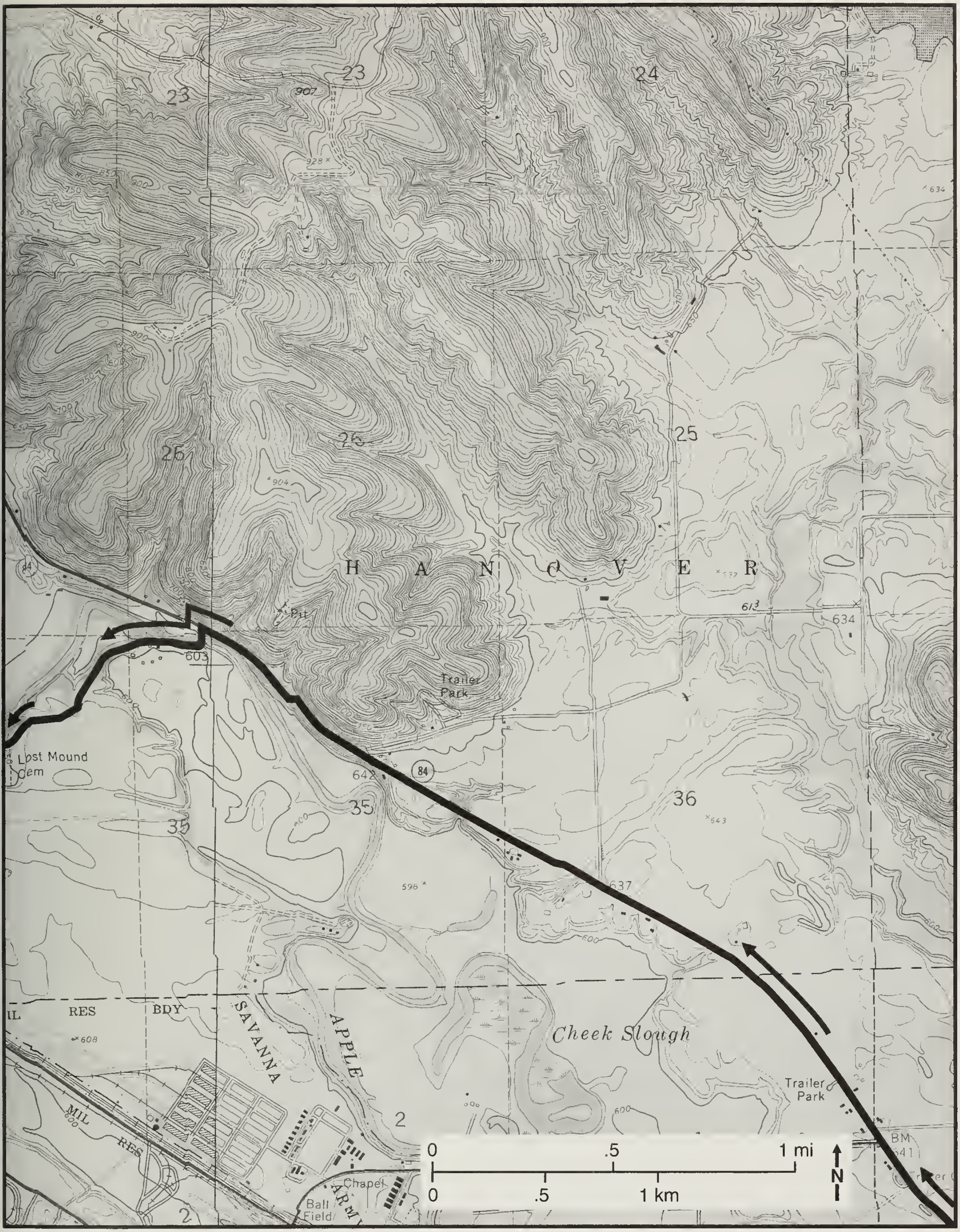

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H A N O V E R
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Pit
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Trailer Park
Lost Mound Cem
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IL RES BDY
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SAVANNA
APPLE
Cheek Slough
Trailer Park
MIL RES
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Chapel
Ball Field
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BM 641

RIVER
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Lost Mound Cem
QUINCY
JO DAVIESS CO
CARROLL CO
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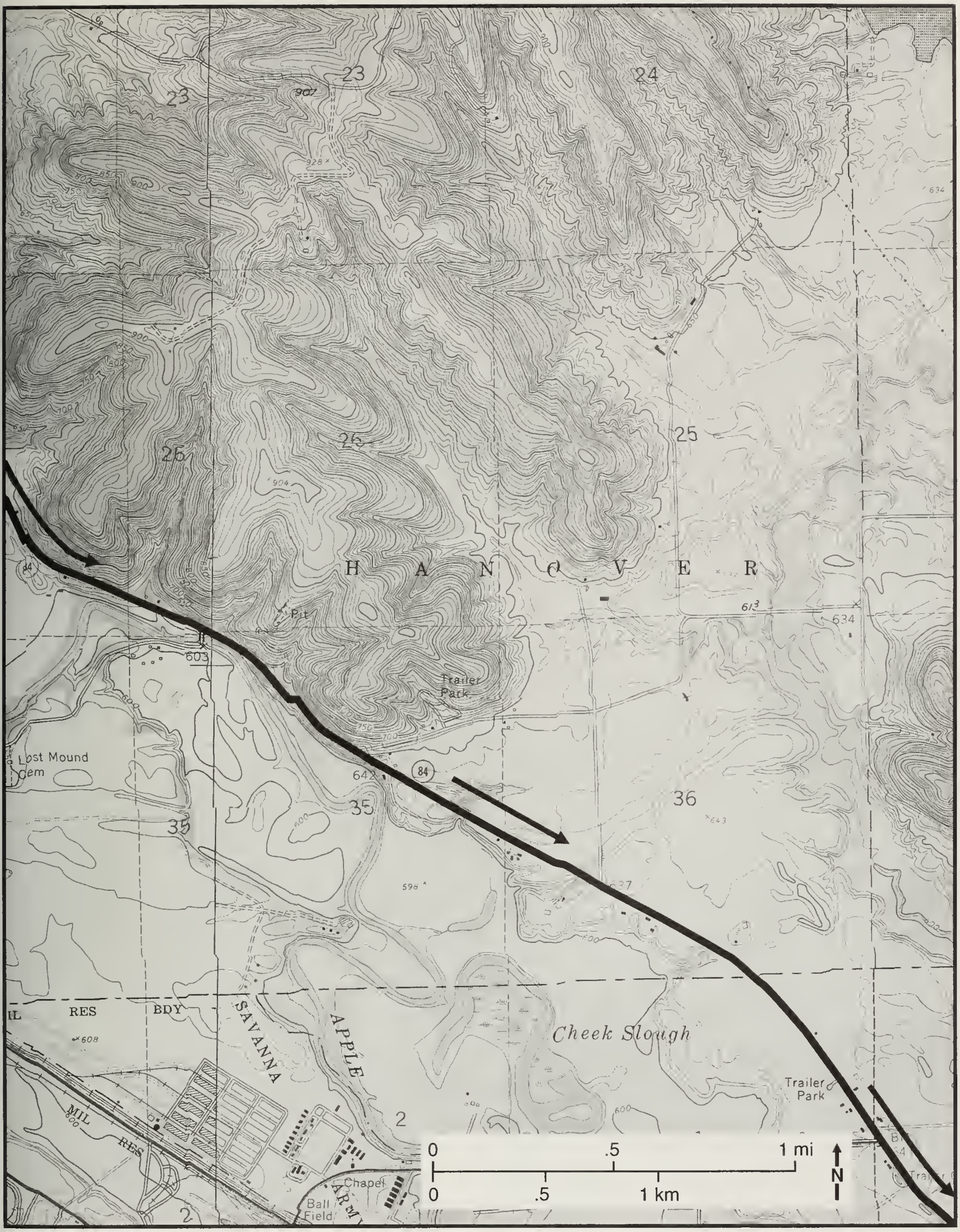
23
23
24
25
26
26
HANOVER
Pit
603
Trailer Park
Lost Mound Cem
642
84
35
35
36
Cheek Slough
SAVANNA
APPLE
RES
BDY
MIL
Chapel
Ball Field
Trailer Park
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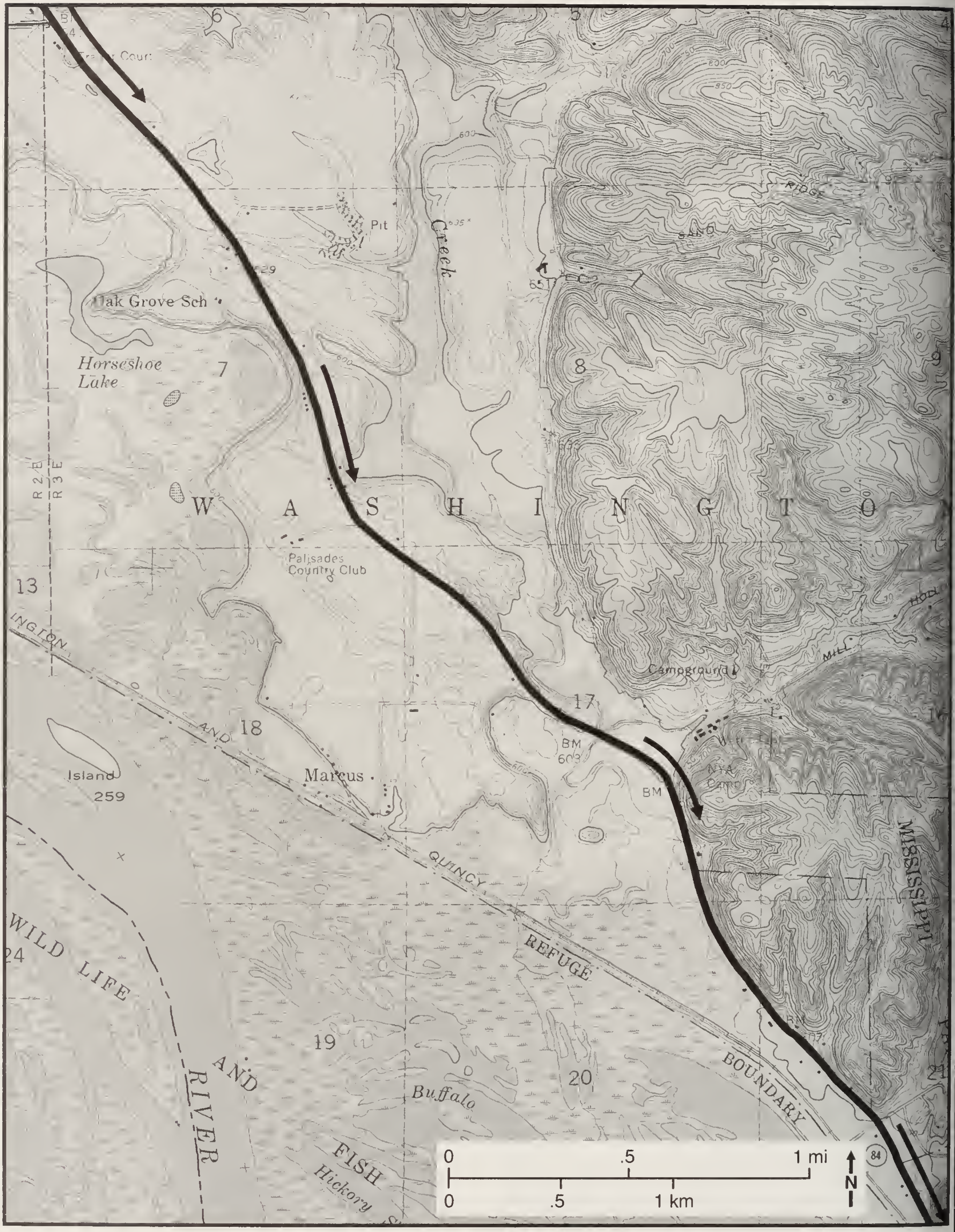
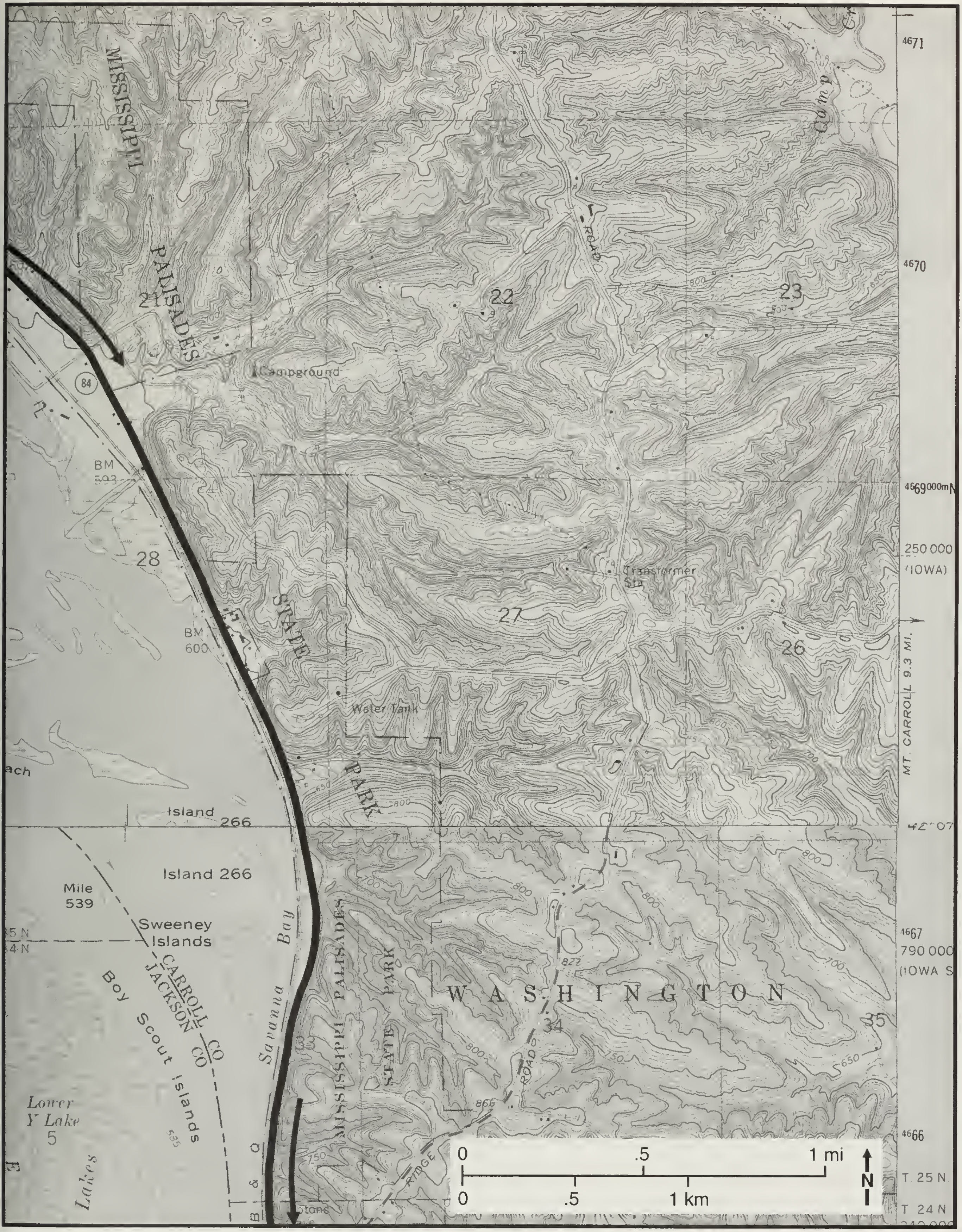

Pit
Creek
Oak Grove Sch
Horseshoe Lake
W A S H I N G T O
Palisades Country Club
Campground
MILL
RIDGE
SAND
Marcus
Island 259
QUINCY
REFUGE
BOUNDARY
WILD LIFE
AND
RIVER
FISH
Buffalo
Hickory
MISSISSIPPI
0 .5 1 mi
0 .5 1 km
N



MISSISSIPPI
PALISADES
STATE
PARK
21
22
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28
27
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33
34
35
ROAD
Campground
84
BM 593
BM 600
Transformer Sta
Water Tank
Island 266
Island 266
Mile 539
Sweeney Islands
CARROLL CO
JACKSON CO
Boy Scout Islands
Savanna Bay
Lower Y Lake
Lakes
MISSISSIPPI PALISADES
STATE PARK
WASHINGTON
RIDGE
Comp
4671
4670
4669000m N
250 000 (IOWA)
MT. CARROLL 9.3 MI.
4667
790 000
4666
T. 25 N.
T 24 N
0 .5 1 mi
0 .5 1 km
N


Island 266
Sweeney Islands
CARROLL CO
JACKSON CO
Boy Scout Islands
Savanna Bay
MISSISSIPPI PALISADES STATE PARK
WASHINGTON
RIDGE ROAD
Uptons Cave
TOLL BRIDGE
RIVER
MISSISSIPPI
Sheepshead
Bay
Marquette Park
Sewage Disp
Water Tanks
SAVANNA
High Sch
Quarry
Old Mill Park
PLUM R
Abandoned road
C B & Q
C M ST P & P
Bowens Lake
PLUM RIVER
St Johns Cem
Township Cem
Misquakee Lake
TRAILER PARK
Savanna
0 .5 1 mi
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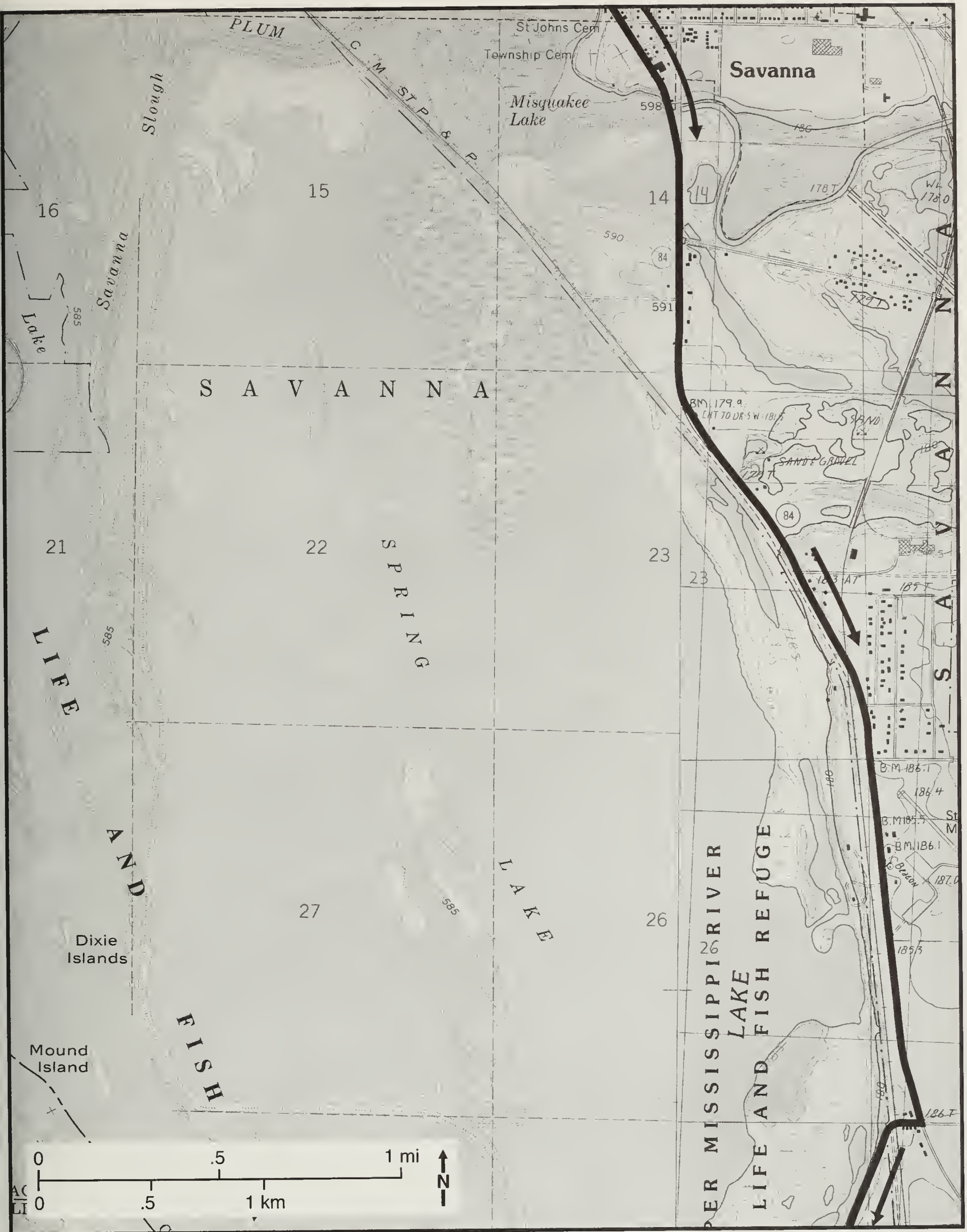
N



PLUM
Slough
St Johns Cem
Township Cem
C M ST P & P
Misquakee Lake
Savanna
598
15
14
16
590
84
591
Savanna
Lake
585
S A V A N N A
SAND
SAND & GRAVEL
84
21
22
SPRING
23
23
LIFE
585
AND
LAKE
27
26
26
Dixie Islands
FISH
Mound Island
UPPER MISSISSIPPI RIVER
LAKE
LIFE AND FISH REFUGE
SAVANNA
0
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1 mi
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.5
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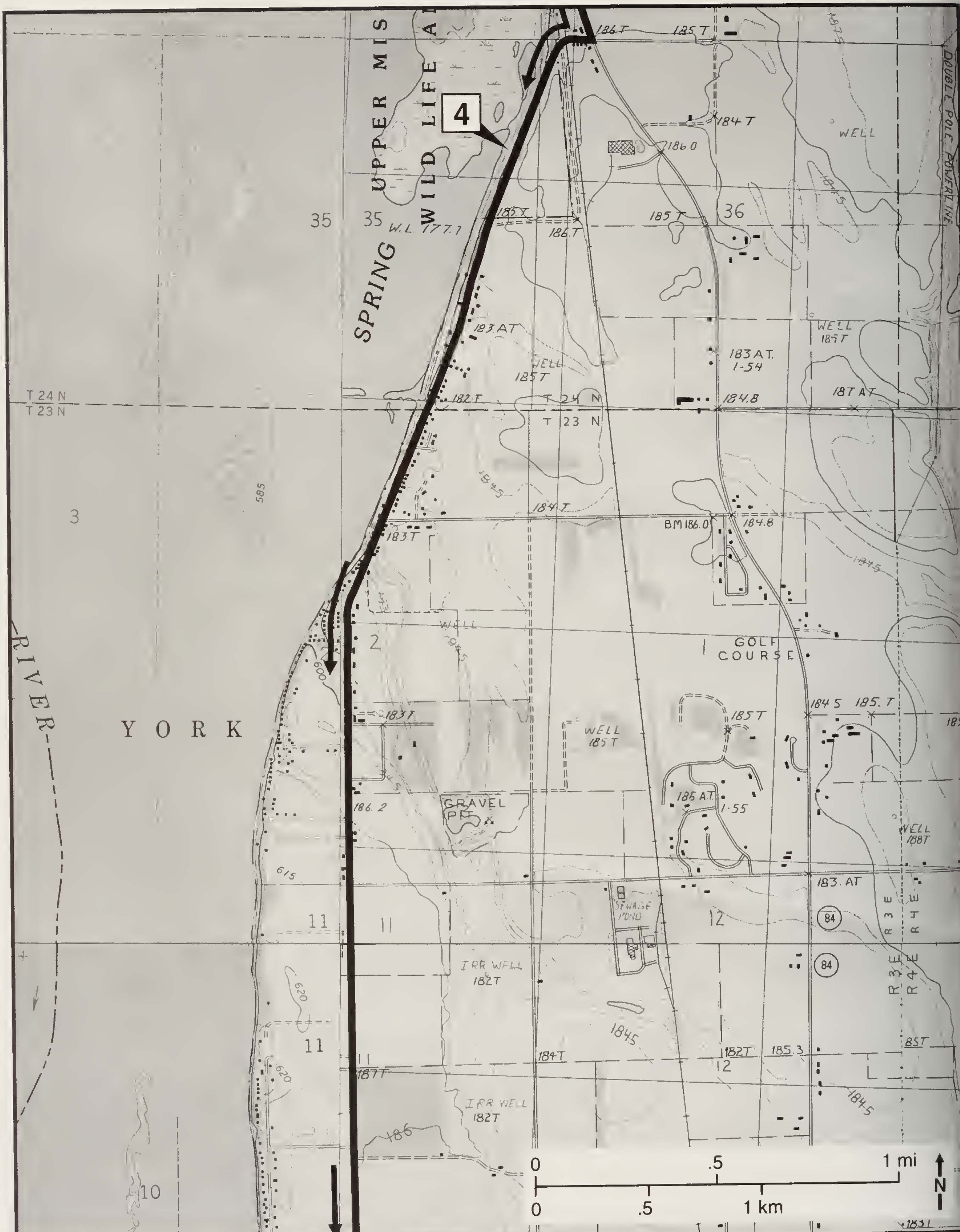
N


4
UPPER MIS
WILD LIFE A
SPRING
YORK
RIVER
GOLF COURSE
GRAVEL PIT
SEWAGE POND
DOUBLE POLE POWERLINE
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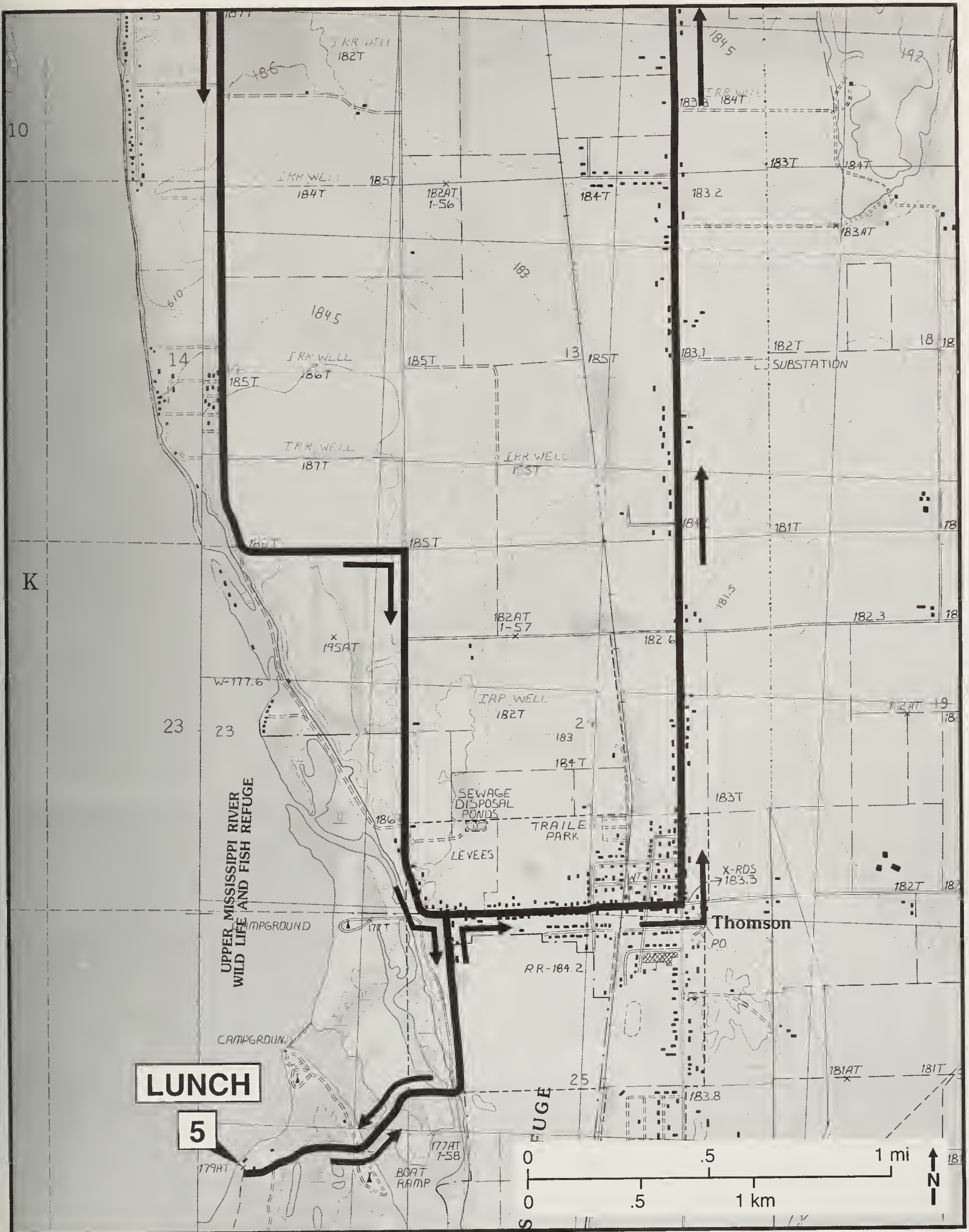
LUNCH
5
Thomson
UPPER MISSISSIPPI RIVER WILD LIFE AND FISH REFUGE
SEWAGE DISPOSAL PONDS
TRAILER PARK
LEVEES
CAMPGROUND
BOAT RAMP
SUBSTATION
X-RDS 183.3
RR-184.2
0 .5 1 mi
0 .5 1 km
N


179.AT
WELL
188T
186T
185T
184T
186.0
DOUBLE POLE POWERLINE
SAVANNA-YORK
WELL
182T
185T
36
179T
31
186T
182T
WELL
185T
183AT.
1-54
185T
T 24 N
T 23 N
184.8
18T AT
181
183T
180.T
184T
BM186.0
184.8
GOLF
COURSE
6
183T
184 S
185 T
185T
189.T
WELL
185T
185 AT
1-55
WELL
188T
188.AT
182T
183.AT
84
84
12
7
R 3 E
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184T
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185 3
85T
12
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Y
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.5
1 mi
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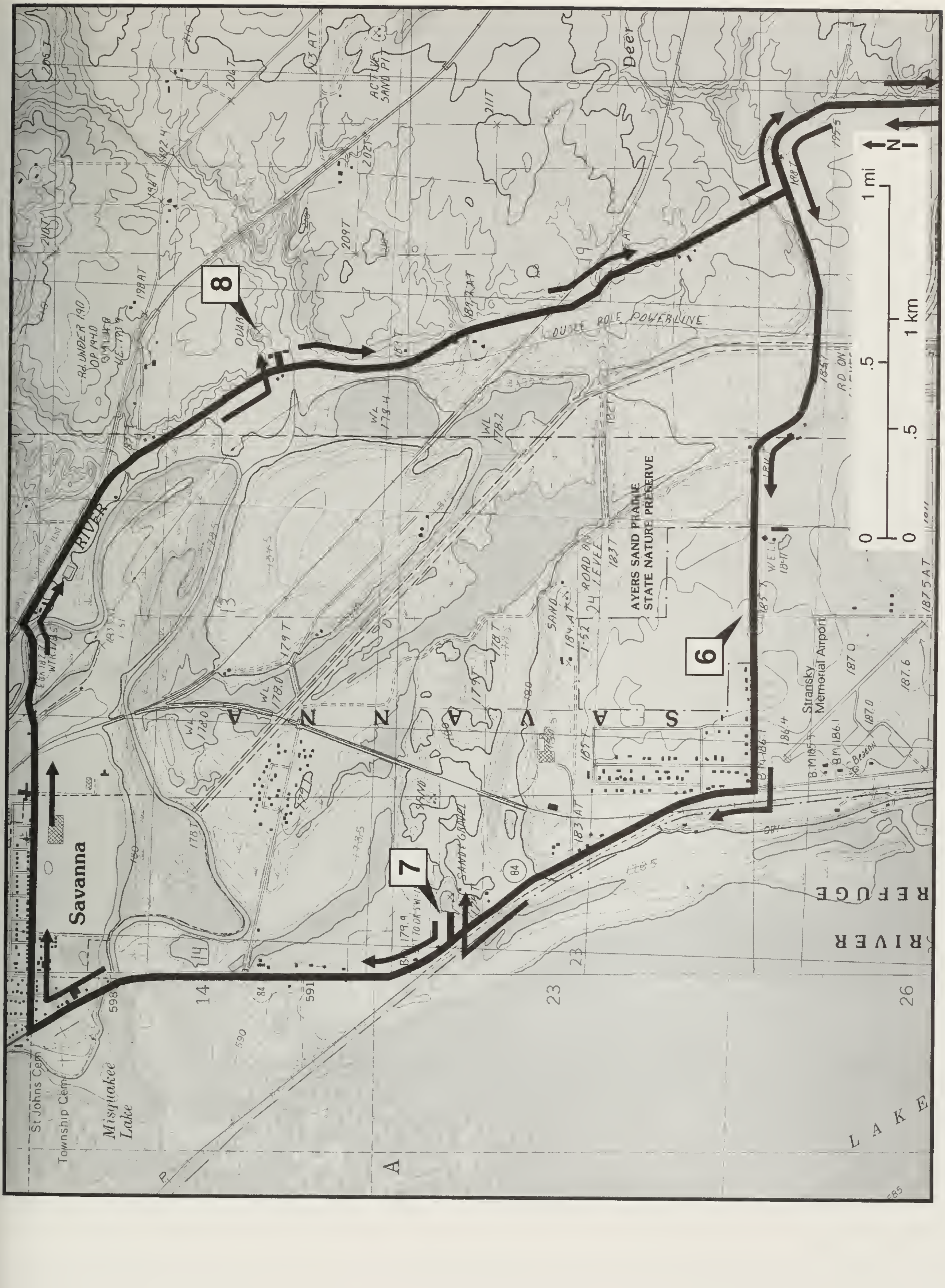
N


Savanna
Misquakee Lake
St Johns Cem
Township Cem
RIVER
AYERS SAND PRAIRIE STATE NATURE PRESERVE
Stransky Memorial Airport
DOUBLE POLE POWERLINE
Deer
SAVANNA
RIVER REFUGE
LAKE
6
7
8
0
.5
1 mi
1 km
N

To Exit
10
9
RADIO TOWER
ASHBY
OLD
0
.5
1 mi
1 km
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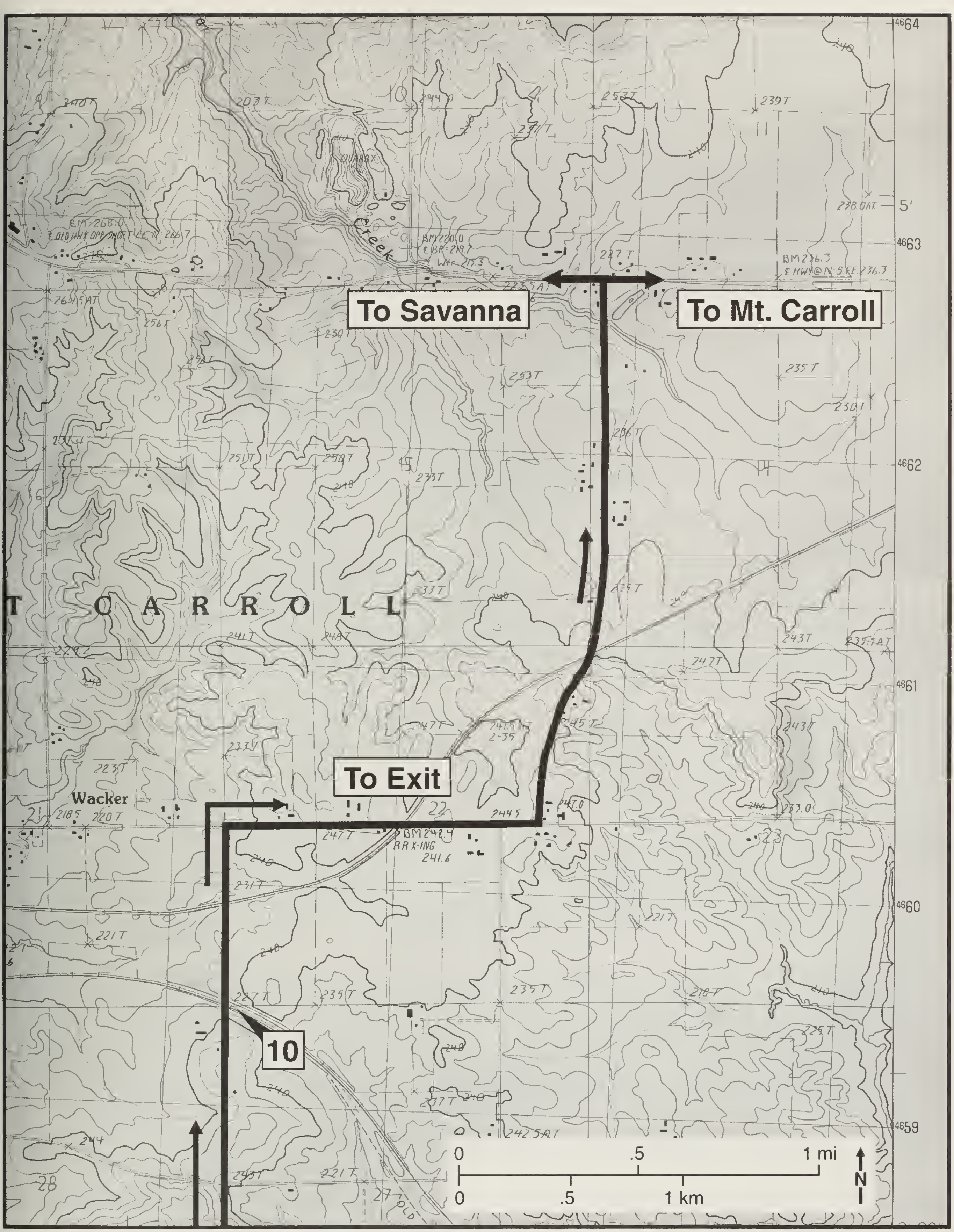
To Savanna
To Mt. Carroll
To Exit
10
Wacker
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0
.5
1 mi
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N
4664
5'
4663
4662
4661
4660
4659

STOP DESCRIPTIONS

Stop 1: Sentinel Trail, Mississippi Palisades State Park (NE, NW, NW, Sec. 34, T25N, R3E, 4th P.M., Savanna 7.5-minute Quadrangle, Carroll County) This trail is within the Sentinel Nature Preserve. We will be hiking the upper loop of the trail, which leads to the Sentinel Rock overlook and Bat Cave.

The following is from a Department of Natural Resources flyer on the Sentinel Trail and from an article by S. Post (1999):

> By early May, many of the spring wildflowers have disappeared from southern and central Illinois woodlands, yet sites in northern Illinois are just hitting their peak. The Palisades is an excellent wildflower-viewing area during May. In fact, it has been said, "Instead of giving your mother flowers for Mother's Day, take her to see the colorful explosion of wildflowers on the Sentinel Trail." Peak bloom is usually on Mother's Day.

SENTINEL NATURE PRESERVE

The Sentinel Nature Preserve was dedicated in June 1991 and is the 200th nature preserve to be dedicated in Illinois. This preserve is named for a geologic feature called the Sentinel, a free-standing dolomite column rising nearly 200 feet above the talus (rock) slopes. The 48-acre nature preserve contains a number of natural communities including mesic and dry mesic upland forests, a looms hill prairie, a cave and small sinkhole, dolomite outcrops, and towering dolomite cliffs. In addition, the preserve is home to several endangered or threatened plants and animals. Through its dedication as an Illinois Nature Preserve, the rich natural heritage found here will be protected into the future.

The Illinois Nature Preserves System An Illinois Nature Preserve is a tract of natural land that has been formally dedicated by the owner to be protected and managed to perpetuate natural conditions and/or populations of native plants and animals. Legislation enacted in 1963 established a Nature Preserves System to permanently preserve ecologically significant natural land in Illinois. The Illinois Nature Preserves Commission and the Department of Conservation share the responsibility for establishing and overseeing the system. They work closely with other governmental agencies and private groups such as The Nature Conservancy to acquire natural areas and dedicate them as part of the Nature Preserves System. The Commission and Department work with owners of nature preserves to be sure that they are being used and managed properly.

Nature preserves are maintained in their natural condition so that present and future generations can see the Illinois landscape as it appeared to the pioneers. Visitors are welcome but should please help perpetuate the area by not disturbing or removing anything. All natural features are protected by law. For further information on the Nature Preserves System or the Illinois Natural Heritage Program, contact the Illinois Department of Natural Resources, Division of Natural Heritage, 525 South Second Street, Springfield, IL 62706 (217-785-8774).

Natural Communities in Sentinel Preserve

Mesic Upland Forest occurs on the north-facing slopes and ravines of the preserve. Red oak, basswood, and sugar maples dominate the forest here. A very rich complement of spring wildflowers also occurs here, including extensive stands of Virginia bluebells. mixed with Dutchman's breeches, wild ginger, bloodroot, great white trillium, miterwort, and large-flowered bellwort. A number of ferns also are found here, including Christmas and walking fern, maidenhair, lady, bladder, and interrupted ferns. This rich forest also provides habitat for the following endangered plants: American bugbane, Canada violet, and the ill-scented red trillium, a species that resembles the great white trillium except that its flower is a deep maroon.

Dry Mesic Upland Forest predominates on the ridge, bluff tops, and southern exposures of the preserve's slopes. Mature second growth white oaks occur here. Bare rocky soil is often present with some of the more common woodland wildflowers being found here, including red trillium, spring beauties, columbine, and mayapple. Some of the upper rocky slope areas, in both the mesic and dry mesic forest, have large concentrations of the rare, jeweled shooting star. Although jeweled shooting star, with its magenta color, may resemble its cousin, the prairie shooting star, its preference is for growing on north-facing cliffs and bluffs exposed to the northwest wind. These flowers clothe the rocky slopes in a blanket of pink that can be seen from the highway far below.

Loess Hill Prairie occurs as only a small remnant located on a south-facing slope just off the bluff line. The prairie is dominated by little bluestem and side-oats grama. Common forbs found here include leadplant, Ohio spiderwort, purple prairie clover, rough blazing star, field goldenrod, and silky aster. In fall or early spring, visitors to the hill prairie may notice evidence of fires, termed prescribed burning. These fires help maintain the prairie, thus preserving this unique natural community. Fires are also used in the forest communities to help control garlic mustard, an invasive, exotic (non-native) plant species.

Geologic Features present here are the shear dolomite bluffs known as the palisades and the dolomite column known as the Sentinel. This unique geologic feature is a free-standing dolomite column, rising nearly 200 feet above the talus slopes. The Sentinel appears to be a fractured pillar from adjacent bluff lines. Small limestone outcrops also occur scattered above the sides of the slopes and provide important cliff habitat for many plant and animal species.

The bluff face provides habitat for the state-threatened cliff goldenrod. The towering bluffs also provide sanctuary for several ferns, including the bulblet fern, and provide some of the northernmost limits for the smooth cliffbrake and baby lip ferns. Along the bluff are a number of small sinkholes and at least one cave structure. Bat Cave, located on the north loop of the trail, provides an important habitat for bats.

Karst topography occurs throughout the park. Typical features include several deep solution pits or sinkholes. In addition, some small caves have formed from solution along joints and cracks in the dolomite. The sinkholes act as large funnels, collecting rainwater and channeling it into underlying joints and cracks.

Four conditions contribute to the development of karst topography. First, soluble rock, flat or nearly so, lies at or near the surface. Second—and most important—the limestone or dolomite is dense, highly jointed, and generally thin-bedded. If the stone were porous, rainwater would be absorbed and move through the whole body of the rock rather than concentrate along joints and bedding planes. Third, major valleys are entrenched below the uplands and act as outlets toward which the groundwater moves in the subsurface. Fourth, rainfall is ample. The name "karst topography" comes from the karst region of the Dinaric Alps in Yugoslavia, where such features are common.

STOP 2: Lookout Point, Mississippi Palisades State Park (SW, NE, SE, Sec. 28, T25N, R3E, 4th P.M., Blackhawk 7.5-minute Quadrangle, Carroll County). Lookout point provides a great overview of the Mississippi River valley.

Figure 18 Mississippi River valley (looking south) from Lookout Point, Mississippi Palisades State Park (photo by W. T. Frankie).

The most impressive topographic feature in the field trip area is the Mississippi River valley, especially where it has incised the resistant Silurian dolomite to form the Mississippi Palisades. High on the bluffs east of the Mississippi valley near East Dubuque, Survey geologists discovered deposits of early pre-Illinois glacial outwash—evidence that the river was probably not entrenched in its present valley in the Savanna area until after that early glaciation. These pre-Illinois outwash deposits consist of coarse gravel overlying lake sediments in small, shallow channels eroded into the surface of the dolomite bedrock 200 feet above the present Mississippi River floodplain. The position of the Mississippi River valley from the vicinity of St. Paul, Minnesota, southward along the west side of the Driftless Area closely follows the margin of the early pre-Illinois glacial deposits (fig. 13). Apparently, this early glaciation established the position of the valley, which developed from an ice-marginal stream during the maximum advance of the ice sheet.

Just south of Galena in Jo Daviess County, the Mississippi Valley cuts through a prominent north-facing escarpment of Silurian dolomite. The front of the escarpment stands about 200 feet above the level of the Lancaster Peneplain. This escarpment, or cuesta, is the erosional edge of the Silurian dolomite formations that dip gently southwestward off the Wisconsin Arch (fig. 5). From this spot, at Lookout Point, the Mississippi River valley is slightly more than 2 miles wide, whereas a short distance to the north near Hanover Bluff (Stop 3), the Mississippi River valley is a little more than 4 miles wide, and, to the south near Sloam Marsh (Stop 4), the valley is 4.5 miles wide. The widening of the Mississippi River valley to the north and south is because the Mississippi River has eroded its valley into the relatively soft Ordovician age Maquoketa shale below the resistant Silurian dolomite. The valley is as much as 6 miles wide at the Thompson Causeway (Stop 5) where the river has eroded into the softer bedrock strata.

At the beginning of the "Ice Age," the topography of Upper Mississippi Valley region of northwestern Illinois, northeastern Iowa, and southwestern Wisconsin was a plain of low relief at the level of the present uplands (Lancaster Peneplain). The Silurian escarpment was a continuous divide extending across northwestern Jo Daviess County into Iowa. Streams flowed northward and southward from the divide in broad, shallow valleys, high above the present drainage. No evidence shows that a major south-flowing stream existed in the Savanna area, but several of the major tributaries to the present Mississippi River may follow courses established at that time. Farther south, an ancestral river called the Ancient Iowa River had its headwaters in east-central Iowa and followed the present course of the Mississippi Valley below Muscatine, Iowa.

With the advance of the early pre-Illinois glacial episode, the first of the Pleistocene glaciers to invade the Upper Mississippi Valley region, northward drainage was blocked and a meltwater lake formed in front of the Silurian Escarpment north of Galena. The meltwater eventually spilled over the divide at Galena and eroded a channel through the escarpment. The water then flowed southward and eroded a valley along the margin of the early pre-Illinois glacier.

By the end of this early glaciation, the Mississippi River had established its valley along the west side of the Driftless Area southward as far as Fulton in Whiteside County. From there, it followed a southeastward course, along the Princeton Valley, to the present big bend of the Illinois River valley near Hennepin in Putnam County (fig. 8). The river then followed the present course of the Illinois Valley southward to its confluence with the Ancient Iowa River at Grafton in Calhoun County. Except for a temporary diversion by the Illinois glacier, the Ancient Mississippi River followed this course from Fulton to the big bend and southward along the Illinois River valley until the Wisconsin Glacial Episode. During the Woodfordian advance, the river was permanently diverted westward to occupy the valley of the Ancient Iowa River along the west side of what is now Illinois, a course it still follows. Its former valley from Fulton to the big bend, known as the Princeton Valley, was buried by Wisconsin glacial drift.

Willman (1973) described the following geologic section a few feet north of this observation platform. It is called the Palisades Park Main Entrance Section:

Silurian System (see also fig. 2)

Racine and Marcus Formations

- Dolomite, massive; mostly inaccessible for detailed study; *Pentamerus* abundant at base; .... 82 feet.

Sweeney Formation

- Dolomite, gray, fine-grained; massive-appearing but has weak, thin, wavy bedding with green clay partings; contains many silicified corals; .... 45 feet.

Blanding Formation

- Dolomite, light brownish gray, fine- to medium-grained, slightly argillaceous, dense to finely vesicular; in 2- to 4-inch beds; contains many 2- to 6-inch layers, lenses, and nodules of white chert; corals common; .... 28 feet.
- Dolomite, as above but more thickly bedded and contains chert only in scattered nodules in upper 2 feet and in a band 3 feet below top; .... 6 feet.

Mosalem Formation

- Strongly pitted, iron-stained corrosion surface.
- Dolomite, argillaceous, brown, mottled greenish gray; massive except for a few tight wavy bedding planes and weak laminations; upper 1 foot relatively pure and vuggy, with trace fossils; lower 3 inches is fossiliferous, vuggy, calcarenitic dolomite; strong bedding reentrant at base; .... 7 feet 3 inches.
- Dolomite, brown, fine-grained; massive ledge but strongly laminated; upper 1 foot irregularly vuggy; upper 3 inches contains many casts of fossils; 0- to 1-inch lens of white chert at base; locally thins sharply to 6 inches; .... 2 feet.
- Dolomite, argillaceous, light brown and green, laminated; thins out at margin of channel cut into underlying shale; .... 8 inches.

Ordovician System

Maquoketa Group

Brainard Shale

- Dolomite, very argillaceous, soft, light greenish gray; .... 1 foot 5 inches to 3 feet.
- Shale, dolomitic, greenish gray; .... 2 inches.
- Dolomite, very argillaceous as above; base concealed; .... 3 inches.

STOP 3: Lost Mound-Abandoned Shelly Quarry at Hannover Bluff (Center of the NW, SW, Sec. 28, T26N, R2E, 4th P.M., Green Island 7.5-minute Quadrangle, Jo Daviess County). NOTE: If you visit this quarry on your own at a later date, you will have to hike up the road, because the gate is normally locked.

Figure 19 Highwall of Silurian dolomite in abandoned quarry at Hannover Bluff Nature Preserve (photo by W. T. Frankie).

This abandoned quarry is located along the southern boundary of the Hannover Bluff Nature Preserve. This property consists of 88.4 acres and is know as the Lang Property. Contact Apple River State Park for access to the quarry (815-745-3302).

This abandoned quarry allows close examination of the Silurian age dolomite and an opportunity to collect fossils. The units exposed here are also present at the Mississippi Palisades State Park. The view from the top of the highwall in the northeast corner of the upper bench in the quarry offers a great view overlooking the Mississippi River valley and the Savanna Army Depot.

The following description of the Silurian units (see fig. 2) are general descriptions for the formations as they occur in northwestern Illinois (modified from Kolata and Buschbach 1976, Willman 1973).

Sweeney Formation

Dolomite, pure, pinkish gray; in thin wavy beds with green shale partings; corals abundant; 3 to 5 feet cherty zones near the middle contains *Microcardinalia* and *Pentamerus oblongus.*

Blanding Formation

Dolomite, pure, brownish gray; contains many layers of white chert; silicified corals abundant; lower 3 to 5 feet slightly argillaceous.

Mosalem Formation

Dolomite, upper 20 to 30 feet is argillaceous, gray, contains chert nodules in bands, medium bedded; lower part is very argillaceous dolomite grading to dolomitic shale at the base, fossils generally rare.

Detailed geologic description of units present in the quarry:

Paleozoic

Peoria Loess, 12 feet.
Parkland Sand, 5 feet.
Paleosoil, 8 inches.
Peoria Loess, 6 feet.

The following detailed description of the quarry, called the Lost Mound Section, is modified from Willman (1973).

Silurian System

Sweeney Formation

- Dolomite, gray, dense to finely vesicular, massive except for tight 1- to 3-inch wavy bedding planes with thin green clay partings; contains chert lenses and nodules in a 3-feet zone 20 feet above the base, corals common; .... 25 feet

Blanding Formation (41 feet)

- Dolomite, brownish gray, mostly dense; in 2- to 6-inch beds; contains 1- to 3- inch chart layers at about 6-inch intervals, except in the lower 2 feet 6 inches, where there is little chert; good bedding reentrant at base; .... 35 feet
- Dolomite, brownish gray, dense; in 1- to 6-inch wavy beds; greenish bedding surfaces; lenses of chert 1 foot below top; smooth sharp bedding plane at base; .... 6 feet

Mosalem Formation (30 feet 1 inch)

- Dolomite, dense, laminated; .... 2 inches
- Dolomite, gray; in 1- to 3-inch beds; contains lenses of chert locally 1 foot below top; 6 inches vuggy bed 3 feet below top; 0- to 1-inch calcarenitic porous dolomite at base; .... 5 feet 3 inches
- Dolomite, pure, red-brown, vuggy; contains horn corals; .... 6 to 8 inches

- Dolomite, argillaceous, medium to dark gray, gray weathering; 0.5- to 1-inch beds; interbedded with purer, very fine-grained, dense, brown-weathering dolomite in lenticular 1- to 2-inch beds and lenses; contains a few thin chert lenses; massive face except for strong reentrant 3 feet below top; .... 15 feet
- Dolomite, as above, but more argillaceous; makes reentrant; .... 1 feet
- Shale, dolomitic, dark brown, thinly laminated; .... 6 inches
- Dolomite, brown, massive; slightly argillaceous but has strong argillaceous streaking in middle and at base; contains fine crinoidal debris in upper 3 inches; .... 1 foot 6 inches
- Dolomite, very argillaceous, weathers shaly; smooth surface on top; .... 3 feet
- Shale, dolomitic, black specked; .... 1 foot

Two feet of the Ordovician Brainard Shale is exposed in a gully 12 feet below the quarry floor.

Hanover Bluff Nature Preserve

Hanover Bluff (361 acres) was the first dedicated nature preserve located in the Wisconsin Driftless Natural Division. Dedicated on May 1987 as the 150th Illinois Nature Preserve, the "Driftless Area" is known for its scenic topography and rare plants, several of which are considered midwestern endemics. Hanover Bluff is located on a high dolomite ridge that forms a valley wall of the Mississippi River. Here, six native plant communities survive: sand hill prairie, dry dolomite prairie, dolomite cliff, dry mesic and mesic upland forest, and seep springs. The sand hill prairie is one of the most interesting communities. Only the very steep, drier, less accessible slopes escaped grazing and still display beautiful prairie wildflowers. The highest quality slopes are dominated by little bluestem, sideoats grama, hairy grama, and over 80 other native prairie species that thrive there. The large forests and moister areas add to the diversity of this already unique area. White oak, black oak, red oak, basswood, and sugar maple are a few of the canopy species, while several rare wildflower species occur in the herbaceous layer. These communities provide habitat for many nongame wildlife species, such as the bald eagle, scarlet tanager, wood thrush, timber rattlesnake, prairie ringneck snake, and several species of frogs and toads. Management here includes cutting cedars and prescribed burning of the prairies.

STOP 4: Sloan Marsh, Upper Mississippi National Wildlife and Fish Refuge (NE, SE, NE, Sec. 35, T24N, R3E, 4th P.M., Wacker 7.5-minute Quadrangle, Carroll County).

The Upper Mississippi River National Wildlife and Fish Refuge covers more than 233,000 acres of wooded islands, forest, prairie, marsh, and water. This refuge was established in 1924 to preserve the Upper Mississippi River for fish, migratory birds, other wildlife, and people. The refuge includes acreage acquired by the U.S. Fish and Wildlife Service and land acquired during the 1930s by the U.S. Army Corps of Engineers for the construction of the 9-foot navigation channel. The refuge follows the Mississippi for more than 260 miles through four states, from Wabasha, Minnesota, to just above Rock Island, Illinois. The Savanna District protects land in Illinois, Iowa, and a small portion of Wisconsin and serves as a major migration stopover for birds. Seasonal waterfowl flights are spectacular. Bald eagles, wood ducks, warblers, vireos, thrushes, and sparrows also inhabit the refuge. Some 292 species of birds, 57 species of mammals, 45 species of amphibians and reptiles, and 118 species of fish spend all or part of their lives on the refuge.

The following two paragraphs are modified from signs at the Sloan Marsh overlook. Sloan Marsh is named in memory of Fred Sloan 1934–1999, a long-time volunteer for the Upper Mississippi River National Wildlife and Fish Refuge. Sloan Marsh is within the Spring Lake area of the refuge.

History of Spring Lake: A Glimpse of the Past

How did a tiny lake become a 3,500-acre haven for fish and wildlife? Spring Lake was once a 30-acre lake within a marshy backwater area of the Mississippi River. In the 1920s, a dike was built around the area, which was then drained for agriculture. The Spring Lake area was purchased by the U.S. Army Corps of Engineers in the 1930s, prior to construction of the lock and dam system. Once the lock and dam system was in place, the surrounding water levels rose. Water filled the dike enclosure and Spring Lake was born. This area is managed by the U.S. Fish and Wildlife Service as part of the National Wildlife Refuge. Fish and wildlife now thrive over land that once supported corn and hay. Floodwaters wrecked havoc when the Spring Lake dike was broken by flooding in 1951, 1965, and again in 1993. Silt entered through breaks and, combined with water level changes, hindered the growth of plants used by the wildlife. Ongoing rehabitation projects are improving the area for aquatic vegetation and wildlife. In the distance lies the 2,800-acre lower unit of Spring Lake. The water level there rises and falls with the river. Cattail, smartweed, and other plants provide food and shelter for a variety of wildlife. The water level in the area below the observation deck can be controlled. It is lowered in the summer to encourage the growth of moist soil plants such as smartweed, sticktites, sedges, and grasses. In the fall, the area is flooded to make food available for migrating birds such as duck, geese, and shorebirds.

STOP 5: Lunch, at Woodland Mound Day Use Area, Thomson Causeway Recreation Area, Upper Mississippi River Wildlife and Fish Refuge (SW, NW, SE, Sec. 26, T23N, R3E, 4th P.M., Thomson 7.5-minute Quadrangle, Carroll County). On the day of the field trip we will use the shelter at the far west end of the area

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The main part of the Mississippi River channel is near the Iowa shore at this location. The following is from a sign:

> Woodland Mound Day Use Area - The Mississippi River at this location is about 3 miles wide. A 9-foot channel depth is maintained for commercial traffic. Near the Iowa shore over 270 species of birds are found in this area—many protected by the Upper Mississippi River Wildlife and Fish Refuge. This public use area is designed for your enjoyment. The facilities were provided through a joint venture of the Corps of Illinois and the Illinois Department of Transportation, funded through the Great River Road Program.
>
> The Woodland Indian Mound is located on the north edge of the area just east of the pavilion. Archeological investigations made in 1980 have discovered that the remnants of this mound are associated with three early Native American cultures: the early Woodland (400 to 500 B.C.), the middle Woodland (100 B.C.), and the late Woodland (800 to 900 A.D.). The discovery also revealed that the mound was first constructed in 100 B.C. and rebuilt around 800 A.D. Evidence indicates that the three cultures involved lived around the water's edge of this area which was at that time a backwater slough. This civilization was mainly a hunter-gatherer–type culture that lived on river fish, shellfish, as well as large and small mammals from the eastward upland forest. It appears that their lifestyle was a reclusive sort with very little trading and no agriculture base.

STOP 6: Ayers Sand Prairie State Nature Preserve (SW, SW, SE, Sec. 24, T24N, R3E, 4th P.M., Wacker 7.5-minute Quadrangle, Carroll County). Discussion of sand dunes in northwestern Illinois.

Ayers Sand Prairie Nature Preserve

Ayers Sand Prairie Nature Preserve was dedicated in December 1974 as the 50th Illinois Nature Preserve. Formally dedicated as a sanctuary for native vegetation and wildlife, this area is maintained in its natural condition so that present and future generations can see the Illinois landscape as it appeared to the pioneers.

Ayers Sand Prairie is a relatively large preserve (109 acres) containing dry sand prairie, sand dune, and blowout communities typical of the Mississippi River section of the Illinois and Mississippi River Sand Areas Natural Division. An inventory of the plants revealed 39 species of grasses and sedges, 16 species of woody plants, and 96 forbs. The dominant herbaceous species are little bluestem, June grass, and hairy gramma grass. Carolina anemone, sandcress, puccoon, and sand primrose are typical sand prairie species. Black oak and cottonwood occur in the blowouts along with scattered clones of aromatic sumac. Resident mammals include deer, skunk, rabbit, mole, shrew, and western harvest mice. Summer resident birds occurring here include upland sandpiper, loggerhead shrike, western meadowlark, grasshopper sparrow, and dickcissel. A number of the characteristic reptiles found in sand prairies occur at Ayers Sand Prairie.

Geology

Glacial meltwater spilling through the narrow, resistant Silurian age Niagaran dolomite valley at Savanna easily eroded the softer shale and thin-bedded dolomite of the Maquoketa south of Savanna. Later, sediment-laden meltwater streams coursing through the narrow valley lost their ability to transport the huge volumes of sediment when they spread out across the wider valley. Valley trains formed along the main channels of the river. During the winter months, when meltwater volumes drastically declined, the upper parts and surfaces of the valley trains were exposed to the drying action of the strong winds from the west. As noted previously, finer materials were winnowed from the coarse deposits and were carried eastward by the prevailing winds. The coarser windblown material, such as sand, was deposited first, close to the streams. Increasingly finer materials were deposited farther eastward.

Here, sand lies on top of a terrace. The topography is characterized by a random arrangement of small hills or mounds, elongate ridges, and closed depressions. Wind piles up dunes wherever there is a ready source of sand and occasional strong winds. Although this dune area is not large, dune tracts similar to this one are fairly common on the valley flats adjacent to pronounced valley bluffs.

Transverse dunes are subparallel ridges that form at right angles to the effective wind direction; the downwind slopes are steeper than upwind slopes. The ridges of U-shaped dunes are convex downwind with the steepest slopes facing downwind. They form in both semi-arid and moist climates and frequently are covered with vegetation even while they are forming. The dunes here do not have well-defined shapes, but appear to be mainly of the transverse variety. They are still active dunes, even though partly vegetated. Based on the orientation of their long dimension (northwest to southeast), they appear to be migrating to the northeast, indicating that the strongest prevailing winds are from the southwest.

Figure 20 Sand dune of Parkland Sand with crossbeds at Voss Sand and Gravel Pit (photo by W. T. Frankie).

STOP 7: Voss Sand and Gravel Pit (SE, NW, NE, Sec. 23, T24N, R3E, 4th P.M., Wacker 7.5-minute Quadrangle, Carroll County). Follow the road past the scale house and bear left.

The origin of the Quaternary Pleistocene Henry Formation sand and gravel deposits and the overlying Parkland Sand will be examined and discussed. Although the glaciers did not cover the Driftless Area, the glacial outwash deposits did flow down the Mississippi River valley. These sand and gravel deposits are part of the Wisconsin Glacial Episode outwash deposits generally refereed to as valley train deposits.

During the Pleistocene glaciation, water-laid materials known as outwash, consisting of clay, silt, and sand and gravel were deposited by sediment-laden meltwaters flowing away from the ice fronts during both the advances and retreats of the glaciers. Near the glacial margins, where meltwater was not confined to definite channels, the outwash was often deposited as thin blanket-like deposits called outwash plains. River valleys, such as the Mississippi, Illinois, and Ohio Valleys, provided major channelways for the escaping meltwaters. These valleys were greatly widened and deepened in the bedrock during times of greatest flood. When the meltwater floods were waning, these valleys were partially filled with outwash far beyond the ice margins. These outwash deposits are known as valley trains. In the Mississippi Valley near Savanna, the outwash deposits are more than 300 feet thick. Many former river valleys in areas covered by the ice were completely buried by glacial deposits. The meltwaters also cut new valleys and caused numerous changes in the drainage system, some permanent and some temporary.

The material present in the stockpiles will give you an idea of what lies beneath the surface of the Mississippi River valley. The deposits consist of a variety of igneous and metamorphic rocks that are classified as erratics, being that they do not naturally occur in Illinois. In addition, an assortment of sedimentary rocks and silicified corals are also abundant. Some of these sedimentary rocks originated from the Silurian and Ordovician bluffs along the Mississippi Valley to the north.

At the east end of the sand and gravel pit is an exposed dune of Parkland Sand. The exposure consists of up to 20 plus feet of cross-bedded sand. Near the top of the dune is an organic-rich zone of sand (an old soil profile), which is overlain by 1 to 2 feet of sand. The dune is currently being excavated (mined) for the sand. This profile illustrates the mobile nature of the sand dunes, which are constantly but slowly advancing to the east.

Figure 21 Highwall at Savanna Blacktop and Quarry; karst solution features can be seen in the Ordovician dolomite near the top (photo by W. T. Frankie).

STOP 8: Savanna Blacktop and Quarry (NW, NE, SW, Sec. 18, T24N, R4E, 4th P.M., Wacker 7.5-minute Quadrangle, Carroll County). Examination of Galena Group dolomite of Ordovician age and overlying Pleistocene Parkland Sand.

Overlying the Ordovician bedrock here is an excellent exposure of Pleistocene sand that appears to be atypical in its occurrence. The lower 10 feet or so appears to have been water-laid, so it is assigned to the Wisconsin Henry Formation. The upper 20 to 25 feet is wind-laid material that is assigned to the Woodfordian Parkland Sand. Behind the equipment area, the total thickness of sand is about 30 to 35 feet. A few feet of the topmost material were removed before quarrying so that soil materials would not become mixed with the underlying sand. The large exposure shows evidence of prehistoric slumping, probably not long after the sand was deposited. Excellent cross-bedding and small-scale faults resulting from the slumping are well shown across the face.

The bedrock on the northeast part of the quarry face was described by J.H. Goodwin and D.L. Reinertsen (Reinertsen 1989) on April 17,1989:

Ordovician System
Champlainian Series
Trentonian Stage
Galena Group
Dubuque Formation

- Dolomite, yellowish tan, appears to be thinner bedded (in beds 0.5 foot or less) than underlying strata; it is more highly fractured and jointed with many iron-stained mud fillings; small sinkholes appear in the upper part; the stone becomes more sandy upwards, probably the result of weathering; it also is soft and friable in the upper part; the rock has almost a brecciated appearance in part; .... 10 feet or more.
- Dolomite, yellowish tan, sandy becoming more sandy toward top; top 0.15 foot has abundant reddish iron-staining; .... 0.9 foot.

Kimmswick Subgroup
Wise Lake Formation
Stewartville Member

- Dolomite, light brown mottled with light grayish brown; beds range from 0.8 to 2.5 feet thick; contains small vugs up to 0.5 inch in diameter; .... 8.2 feet.
- Dolomite, as above, but with reddish brown silty interbeds; .... 1.8 feet.
- Dolomite, light tan to yellowish tan with thin reddish brown interbeds; dolomitic; fine-grained; may have been a hard surface at one time as deduced from the staining; .... 0.1 to 0.2 foot.
- Dolomite, light brown mottled with light brownish gray; somewhat sandy in part; beds range from 0.8 to 2.5 feet thick; .... 9.5 feet or more.

Total thickness exposed, 31.4 feet; base under water. The south end of the pit was measured with a steel tape and a rock from above and was 47 feet to water level.

The Dubuque Formation is the shaly dolomite at the top of the Galena Group. In Illinois, the Dubuque is known only from the northwestern part of the state where it is 40 to 45 feet thick. It is truncated southward near Galesburg by overlying Maquoketa Group strata. The underlying Stewartville Member of the Wise Lake Formation is 30 to 35 feet thick in northern Illinois. This member is largely thick-bedded, pure dolomite, the lower part of which contains the Upper *Receptaculites* Zone; the upper part is thinner bedded as it grades into the overlying Dubuque Formation. The upper, thinner beds have been exposed in the quarry.

STOP 9: Upland Sand Dune (NW, NW, SW, Sec. 4, T23N, R4E, 4th P.M., Wacker 7.5-minute Quadrangle, Carroll County). Discussion of upland sand dunes and the Illinois glacial margin.

An unusual display of Pleistocene Parkland Sand, underlain by Silurian bedrock and overlain by Peoria Loess (silt), is exposed along this roadcut. Earlier we looked at sand dunes within the Mississippi River floodplain at Stops 6 and 7. The unusual feature of this dune is that it is 200 feet above the present valley floor. The exposure is just past the guardrail on the north side of the road and on the east side of the valley.

Examination of the exposure from the west end to the east reveals the following: On the west end of the exposure is an upland sand dune deposit overlain by loess. An estimated about 18 feet of sand is overlain by about 20 feet of loess. Farther down the road to the east is an outcrop of Silurian dolomite bedrock that is directly overlain by an estimated about 15 feet of loess, and no sand is present. The sand seems to be restricted to the upper part of the valley. The underlying Silurian bedrock is a jumble of broken dolomite and fragmented chert. About 10 feet of Silurian bedrock, probably the Mosalem Formation, is exposed in the lower part of the cut.

The Peoria Loess, at the west end of the exposure, maintains a vertical cutface and contains some thin, fine-grained sand zones. Mottling and a darker coloration on the face are evidence of soil development at a time when loess was accumulating. Apparently, accumulation slowed to the point that a minor soil was able to partly develop after which loess continued to accumulate. Similar minor soils also occur in the Peoria Loess farther south in Illinois. Here the loess is at least 20 feet thick with the modern soil developed in the top 18 inches. The loess appears to lap up onto the sand in the west end of the road cut. Considerable slumping of the exposure has masked some of the geometric relationships between bedrock, sand, and loess. A second exposure of loess directly overlying bedrock occurs along the north side of the road on the east side of the valley.

The presence of the overlying loess indicates that the dune was formed prior to the end of loess deposition. The dune may have migrated from the valley at a time when the floor of the valley was much shallower (at a higher elevation than it is today).

Deposits of windblown silt, called loess, which form the surface materials over extensive areas of Illinois, are the result of glaciation. The silt was blown from floodplains of the valley trains. Most loess deposition occurred during the fall and winter seasons, when colder conditions caused meltwater floods to recede, exposing the surfaces of the valley trains and permitting them to dry out. During Pleistocene time, as now, the winds prevailed westerly, and as a result, the loess deposits are thickest on the east side of the source valleys. The loess thins rapidly away from the valleys. The valley train of the Mississippi Valley was the source of loess in the Driftless Area, and along the bluffs the loess is as much as 35 feet thick.

STOP 10: Big Cut (NW, NW, NW, Sec.27, T24N, R4E, 4th P.M., Wacker 7.5-minute Quadrangle, Carroll County). Examination of the fossiliferous Brainard Shale (Maquoketa Group) on the high slopes above the Chicago, Burlington, and Quincy Railroad cut 1 mile southeast of Wacker

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The exposure of the Ordovician Brainard Shale in this railroad cut is one of the best exposures of the formation in the Upper Mississippi Valley region (fig. 22). A study of the sequence of sediments from the base upward in this exposure shows that deposition began in deep water, but conditions changed slowly and the water became shallower, or shoaled. This change brought about a change in the texture and structure of the sediments as well as a change in the faunal types from bottom to top. The formation may be 75 to 100 feet thick where it is not deeply truncated by the sub-Silurian unconformity.

The following is modified from a description by Kolata and Graese (1983), which they named the Wacker Southeast Section:

Ordovician (see also fig. 2)

Cincinnatian Series

Maquoketa Group

Brainard Shale

- Dolomite, moderate yellowish brown (10 YR 4/2), argillaceous, fine to medium grained, in 4- to 6- inch (10- to15-centimeter) even beds interbeded with shale. Very fossiliferous units contain crinoids, brachiopods, bryozoans (*Lepidocyclus* sp., giant *Prasopora* sp., *Plaeslomys* sp., *Strophomena* sp., *Platystrophia* sp. etc.); .... 5 feet.
- Shale, pale-brown (5 YR 5/2) to grayish red (10 R 4/2), soft, fossiliferous in part, (*Hypsiptycha, Strophomena* sp., bryozoans, etc.), interbeds of very argillaceous dolomite in 4- to 6-inch (10- to 15-centimeter) even beds; .... 5 feet.
- Shale, greenish gray (5 GY 6/1) to dark greenish gray (5 GY 4/1); weathers to pale yellowish brown (lOYR 5/4); soft, abundant and diverse fauna (*Strophomena* sp., *Plaeslomys* sp., *Platystrophia* spp., *Lepidocyclus* sp., *Gravicalymene?* sp., *Thaerndonta* sp.. *Hebertella* sp., *Cornulites* sp., *Isotelus* sp., *Megamyonia unicostata,* and *Prasopora* sp.); interbeds of fine-grained dolomite in even beds, lenses, and nodules up to 4 inches (10 centimeters) thick; .... 30 feet.

Figure 22 Outcrop of Ordivician Brainard Shale (Maquoketa Group) at Big Cut (stop 10) (photo by W. T. Frankie).

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Glossary

The following definitions are adapted in total or in part from several sources. The principal source is R.L. Bates and J.A Jackson, eds., 1987, *Glossary of Geology*, 3rd ed.: Alexandria, Virginia, American Geological Institute, 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 A stream that is actively depositing sediment in its channel or floodplain because it is 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 sorted or semisorted sediment deposited during comparatively recent time by a stream or other body of running water.

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

anticlinorium A complex structure having smaller structures, such as domes, anticlines, and synclines superimposed on its broad upwarp.

aquifer A geologic formation that is water-bearing and that transmits water from one point to another.

arenite A relatively clean quartz sandstone that is well sorted and contains less than 10% argillaceous material.

argillaceous Said of rock or sediment that contains, or is composed of, clay-sized particles or clay minerals.

base level Lower limit of erosion of the land's surface by running water. Controlled locally and temporarily by the water level of stream mouths emptying into lakes, or more generally and semipermanently by the level of the ocean (mean sea level).

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

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

bed A naturally occurring layer of earth material of relatively greater horizontal than vertical extent that is characterized by physical properties different from those of 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 stream channel.

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

bedrock valley A drainageway 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. Most streams that receive more sediment load than they can carry become braided.

calcarenite Describes a limestone composed of more or less worn fragments of shells or pieces of older limestone. The particles are generally sand-sized.

calcareous Said of a rock containing some calcium carbonate ($CaCO_3$), but composed mostly of something else (synonym: limey).

calcining The heating of calcite or limestone to its temperature of dissociation so that it loses its carbon dioxide; also applied to the heating of gypsum to drive off its water of crystallization to make plaster of Paris.

calcite A common rock-forming mineral consisting of $CaCO_3$; 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 (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 Said of rocks composed of particles of other rocks or minerals, including broken organic hard parts as well as rock substances of any sort, transported and deposited by wind, water, ice, or gravity.

claypan (soil) A heavy, dense subsurface soil layer that owes its hardness and relative imperviousness to higher clay content than that of the overlying material.

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

columnar section A graphic representation, in the form of one or more vertical columns, of the vertical succession and stratigraphic relations of rock units in a region.

conformable Said of strata deposited one upon another without interruption in accumulation of sediment; beds parallel.

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

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

detritus Loose rock and mineral material produced by mechanical disintegration and removed from its place of origin by wind, water, gravity, or ice; also, fine particles of organic matter, such as plant debris.

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 time interval of nondeposition.

dolomite A mineral, calcium-magnesium carbonate ($Ca,Mg[CO_3]_2$); also the name applied to sedimentary rocks composed largely of the mineral. It is white, colorless, or tinged yellow, brown, pink, or gray; has perfect rhombohedral cleavage; appears pearly to vitreous; and 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.

earthquake Ground displacement associated with the sudden release of slowly accumulated stress in the lithosphere.

end moraine A ridge or series of ridges formed by accumulations of drift built up along the outer 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 (for example, Pleistocene Epoch).

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

escarpment A long, more or less continuous cliff or steep slope facing in one general direction; it generally marks the outcrop of a resistant layer of rocks or the exposed plane of a fault that has moved recently.

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

flaggy Said of rock that tends to split into layers of suitable thickness for use as flagstone.

floodplain The surface or strip of relatively smooth land adjacent to a stream channel 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.

flux A substance used to remove impurities from steel. Flux combines with the impurities in the steel to form a compound that has a lower melting point and density than steel. This compound tends to float to the top and can be easily poured off and separated from the molten steel.

formation The basic rock unit, one distinctive enough to be readily recognizable in the field and widespread and thick enough to be plotted on a map. 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), generally derived from the geographic localities where the unit was first recognized and described.

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

fragipan A dense subsurface layer of soil whose hardness and relatively slow permeability to water are chiefly due to extreme compactness rather than to high clay content (as in claypan) or cementation (as in hardpan).

friable Said of a rock or mineral that crumbles naturally or is easily broken, pulverized, or reduced to powder, such as a soft and poorly cemented sandstone.

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

geophysics Study of the Earth with quantitative physical methods. Application of the principles of physics to the study of the earth, especially its interior.

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 formed on land by the compaction and recrystallization of snow.

graben An elongate, relatively depressed crustal unit or block that is bounded by faults on its long sides.

gradient A part of a surface feature of the Earth that slopes upward or downward; the angle of slope, as of a stream channel or of a land surface, generally expressed by a ratio of height versus distance, a percentage or an angular measure from the horizontal.

gypsum A widely distributed mineral consisting of hydrous calcium sulfate ($CaSO_4 \cdot 2H_2O$). Gypsum is soft (hardness of 2 on the Mohs scale); white or colorless when pure but commonly has tints of gray, red, yellow, blue or brown. Gypsum is used as a retarder in portland cement and in making plaster of Paris.

horst An elongate, relatively uplifted crustal unit or block that is bounded by faults on its long sides.

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

indurated Said of 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 (*see also* fault).

karst Collective term for the land forms and subterranean features found in areas with relatively thin soils underlain by limestone or other soluble rocks; characterized by many sinkholes separated by steep ridges or irregular hills. Tunnels and caves formed by dissolution of the bedrock by groundwater honeycomb the subsurface. Named for the region around Karst in the Dinaric Alps of Croatia where such features were first recognized and described.

lacustrine Produced by or belonging to a lake.

Laurasia A 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 supercontinent from which both were derived is Pangea. Laurasia 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; geologic features on opposite sides of these zones are very similar.

lava Molten, fluid rock that is extruded onto the surface of the Earth through a volcano or fissure. Also the solid rock formed when the lava has cooled.

limestone A sedimentary rock consisting primarily of calcium carbonate (the mineral, calcite). Limestone is generally formed by accumulation, mostly in place or with only short transport, of the shells of marine animals, but it may also form by direct chemical precipitation from solution in hot springs or caves and, in some instances, in the ocean.

lithify To change to stone, or to petrify; especially to consolidate from a loose sediment to a solid rock.

lithology The description of rocks on the basis of their color, structure, 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 accumulation of silt-sized material deposited by the wind.

magma Naturally occurring molten rock material generated within Earth and capable of intrusion into surrounding rocks or extrusion onto the Earth's surface. When extruded on the surface it is called lava. The material from which igneous rocks form through cooling, crystallization, 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 swales and gentle ridges along a river's flood plain that mark the positions of abandoned parts of a meandering river's channel. They are generally filled in with sediments and vegetation and are most easily seen in aerial photographs.

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

mineral A naturally formed chemical element or compound having a definite chemical composition, an ordered internal arrangement of its atoms, and characteristic crystal form and physical properties.

monolith (a) A piece of unfractured bedrock, generally more than a few meters across. (b) A large upstanding mass of rock.

moraine A mound, ridge, or other distinct accumulation of glacial drift, predominantly till, deposited in a variety of topographic land forms that are independent of control by the surface on which the drift lies (*see also* end moraine).

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

natural gamma log One of several kinds of measurements of rock characteristics taken by lowering instruments into cased or uncased, air- or water-filled boreholes. Elevated natural gamma radiation levels in a rock generally indicate the presence of clay minerals.

nickpoint A place with an abrupt inflection in a stream profile, generally formed by the presence of a rock layer resistant to erosion; also, a sharp angle cut by currents at base of a cliff.

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

nonlithified Said of unconsolidated materials.

normal fault A fault in which the hanging wall appears to have moved downward relative to the footwall.

outwash Stratified glacially derived sediment (clay, silt, sand, and gravel) deposited by meltwater streams in channels, deltas, outwash plains, glacial lakes, and on floodplains.

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. A precursor of a meander scar.

palisades A picturesque extended rock cliff or line of bold cliffs, rising precipitously from the margin of a stream or lake.

Pangea The supercontinent that existed from 300 to 200 million years ago. It combined most of the continental crust of the Earth, from which the present continents were derived by fragmentation and movement away from each other by means of plate tectonics. During an intermediate stage of the fragmentation, between the existence of Pangea and that of the present widely separated continents, Pangea was split into two large fragments, Laurasia on the north and Gondwana in the southern hemisphere.

ped Any naturally formed unit of soil structure (for example, granule, block, crumb, or aggregate).

peneplain A land surface of regional scope worn down by erosion to a nearly flat or broadly undulating plain.

Pentamarus An articulate brachiopod.

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

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

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.

point bar A low arcuate ridge of sand and gravel developed on the inside of a stream meander by accumulation of sediment as the stream channel migrates toward the outer bank.

radioactivity logs Any of several types of geophysical measurements taken in bore holes using either the natural radioactivity in the rocks, or the effects of radiation on the rocks to determine the lithology or other characteristics of the rocks in the walls of the borehole (for example, natural gamma radiation log; neutron density log).

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

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

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

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

shoaling Said of an ocean or lake bottom that becomes progressively shallower as a shoreline is approached. The shoaling of the ocean bottom causes waves to rise in height and break as they approach the shore.

silt A rock fragment or detrital particle smaller than a very fine sand grain and larger than coarse clay, having a diameter in the range of 4 to 62 microns; the upper size limit is approximately the smallest size that can be distinguished with the unaided eye.

sinkhole Any closed depression in the land surface formed as a result of the collapse of the underlying soil or bedrock into a cavity. Sinkholes are common in areas where bedrock is near the surface and susceptible to dissolution by infiltrating surface water. Sinkhole is synonymous with "doline," a term used extensively in Europe. The essential component of a hydrologically active sinkhole is a drain that allows any water that flows into the sinkhole to flow out the bottom into an underground conduit.

slip-off slope Long, low, gentle slope on the inside of a stream meander. The slope on which the sand that forms point bars is deposited.

stage, substage Geologic time-rock units; the strata formed during an age or subage, respectively. Generally applied to glacial episodes (for example, Woodfordian Substage of the Wisconsinan Stage.

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.

stratigraphy The study, definition, and description of major and minor natural divisions of rocks, particularly the study of their form, arrangement, geographic distribution, chronologic succession, naming or classification, correlation, and mutual relationships of rock strata.

stratum A tabular or sheet-like mass, or a single, distinct layer of material of any thickness, separable from other layers above and below by a discrete change in character of the material, a sharp physical break, or both. The term is generally applied to sedimentary rocks but could be applied to any tabular body of rock (*see also* bed).

subage A small interval of geologic time; a division of an age.

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

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

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

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

temperature-resistance log A borehole log, run only in water-filled boreholes, that measures the water temperature and the quality of groundwater in the well.

terrace An abandoned floodplain formed when a stream flowed at a level above the level of its present channel and floodplain.

till Nonlithified, nonsorted, unstratified drift deposited by and underneath a glacier and consisting of a heterogenous mixture of different sizes and kinds of rock fragments.

till plain The undulating surface of low relief in an 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 Said of strata that do not succeed the underlying rocks in immediate order of age or in parallel position. A general term applied to any strata deposited directly upon older rocks after an interruption in sedimentation, with or without any deformation and/or erosion of the older rocks.

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

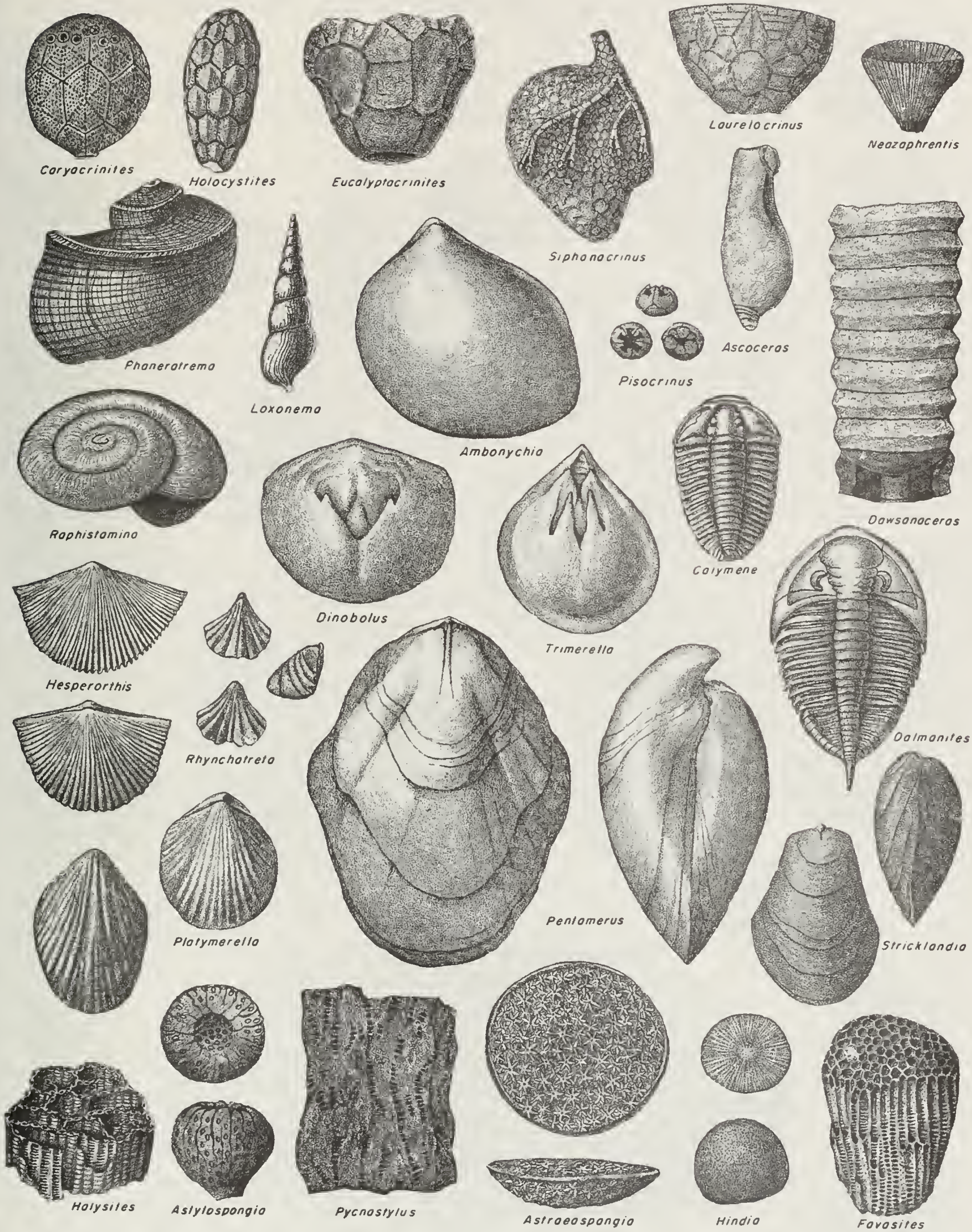
underfit stream A misfit stream that appears to be too small to have eroded the valley in which it flows. It is a common result of drainage changes effected by stream capture, by glaciers, or by climate variations.

valley train The accumulation of outwash deposited by rivers in their valleys downstream from a glacier.

water table The point in a well or opening in the Earth where groundwater begins. It generally marks the top of the zone where the pores in the surrounding rocks are fully saturated with water.

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

REPRESENTATIVE SILURIAN FOSSILS FROM NORTHWESTERN ILLINOIS



ORDOVICIAN FOSSILS

Quaternary Glaciations in Illinois

ORIGIN OF THE GLACIERS

Over the past 1.6 million years, known as the Quaternary (kwa-TURN-ah-ree) Period of geologic time, most of the northern hemisphere above the 50th parallel was repeatedly covered by glacial ice. The cooling of the earth's surface began at least 2 million years ago, and with that cooling, ice sheets eventually formed in sub-arctic regions and spread outward until they covered the northern parts of North America. With ongoing climatic change during this period, these ice sheets would form and reform many times.

Early studies of the glaciated landscape concluded that four separate glacial episodes had occurred in North America. The deposits from each episode were separated from each other by buried soils, which formed on the land during warmer intervals between glaciations. More recent studies have shown that there were more than four glaciations, but the actual number is not yet known. These studies, based on buried soils and glacial deposits, estimate 4 to 8 episodes of ice advance and melting over Illinois. We now know that the older glacial sediments are more complex than originally thought and probably represent more than one episode. Until we know more, all of the glacial deposits before the Illinois Episode (from 300,000 to 125,000 years ago) are classified as pre-Illinoian deposits.

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 this 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 the glaciers to flow outward at their margins, in several instances for hundreds of miles. As the ice sheets expanded, the areas in which snow accumulated probably also increased in extent.

Several times, huge tongues of ice, called lobes, flowed southward from two different centers, one east and one west of present-day 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 at right shows the 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 was invaded by lobes from both accumulation centers.

EFFECTS OF GLACIATION

Quaternary 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, commonly for hundreds of miles; the glaciers scoured the land surface and kneaded much of the rock debris into the moving ice.

The continual floods of glacial meltwaters entrenched new drainageways and deepened old ones, and partly refilled them with the great quantities of rock and earth carried by the glaciers. According to some estimates, the amount of water that was drawn from the sea and changed into ice during a glacial episode lowered the sea level by 300 to 400 feet below its present level. When these continental ice sheets melted, tremendous volumes of water eroded and transported sediments.

In most of Illinois, glacial and meltwater deposits buried the previous rocky, low, hill-and-valley terrain and created the flatter landforms that became our prairies. The glaciers deposited across roughly 90% of the state a mantle of ground-up rock debris, gravel, sand, and clay that at points reaches thicknesses of 400 to 500 feet. These deposits are of incalculable value to Illinois residents because they are the parent material of our rich soils, the source of drinking water for much of the state, and provide large amounts of sand and gravel for construction.

GLACIAL DEPOSITS

Drift is the term for all the deposits of earth and rock materials moved by glacial activity. ***Till*** is the type of drift deposited directly by glacial ice. Because till was not moved much by water, this sediment is unsorted, containing particles of many different sizes and compositions. It is also unstratified (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 term describes a deposit that could be interpreted as till or as a product of a different process called mass wasting, which includes such things as rockslides or other similar gravity-propelled earth movements.

End moraines are the arc-shaped ridges that formed when till piled up along a glacier's leading edge when the ice was melting at roughly the same rate as the flowing ice moved forward. Till also formed ***ground moraines***, or ***till plains***, which have gently undulating surfaces formed as the ice front melted back. Deposits of till identify areas once covered by glaciers. The many alternating ridges and plains in northeastern Illinois are the successive end moraines and till plains formed by the retreating Wisconsin Episode glaciers (about 25,000 to 13,500 years ago).

Outwash is the sorted and stratified sediments deposited by meltwater flowing away from the glacier. Outwash deposits are layered in beds because the flow of water that moved the material varied in gradient, volume, velocity, and direction. As a meltwater stream carried the rock materials along, it sorted them by size. As stream velocity decreased, heavier gravels and cobbles were deposited before fine sands, silts, and clays, which were deposited farther downstream. Typical Quaternary outwash in Illinois consists of multilayered beds of sands and gravels and some silts. These beds look much like modern stream deposits in some places. Outwash tends to be coarser and less weathered than stream sediment (alluvium), which is generally finer than medium sand and contains variable amounts of weathered rock debris.

Meltwater deposits are found not only in the area once covered by the glaciers but also in areas far beyond it. Meltwater streams ran off the top of the glacier, in crevices within the ice, and under the ice. In some places, the cobble-gravel-sand filling of the bed of a stream that flowed within or under the ice is preserved as a sinuous ridge called an ***esker***. Some eskers in Illinois are made up of sandy, silty, gravelly 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.

The finest outwash sediments, the silts and clays, formed bedded deposits in the ponds and lakes that filled glacier-dammed stream valleys, the low-lying areas on till plains, and some low till plains where meltwaters were diked behind end moraines. Meltwater streams that entered a lake rapidly lost velocity and dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sands 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, cross-cutting, and short-lived streams (called braided streams), which laid down an ***outwash plain***, a broad, flat blanket of outwash. Outwash was also carried away from the glaciers in valleys cut by floods of meltwater. The Mississippi, Illinois, and Ohio Rivers occupy valleys that were major channels for meltwaters and that were greatly widened and deepened during 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 River Valley is up to 200 feet thick in places.

LOESS, EOLIAN SAND, AND SOILS

One of the most widespread types of sediment resulting from glaciation was carried not by ice or water, but by wind. ***Loess*** (rhymes with "bus") is the name given to windblown deposits dominated by silt-sized particles. Most of the silt was derived from wind erosion of the valley trains. Wind action also sorted out 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 principal source of sand. Flat areas between dunes are generally underlain by ***eolian*** (windblown) ***sand*** that was usually 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 thins and disappears, often within one mile from the valleys.

Eolian deposition occurred when certain climatic conditions, most likely following a seasonal pattern, were met. Deposition was probably in the fall, winter, or spring when low precipitation volumes and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and permitting them to dry out. Throughout the Quaternary Period, prevailing westerly winds deposited loess more thickly on the east sides of the source valleys. Although the loess thins rapidly away from the valleys, it extends over almost all of Illinois.

Each glacial episode was followed by an interglacial episode 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 glacial deposits and altered the composition, color, and texture of the deposits. 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.

Contributed by Dwain J. Berggren
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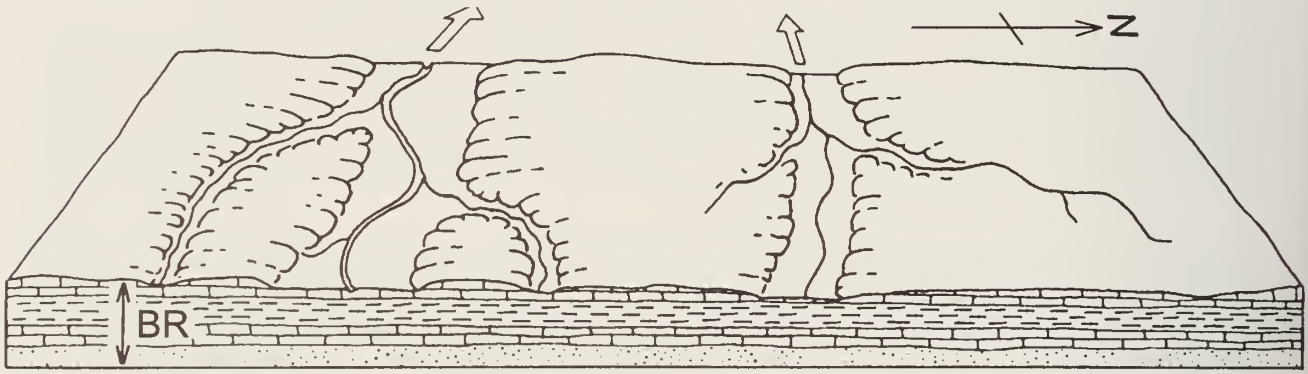
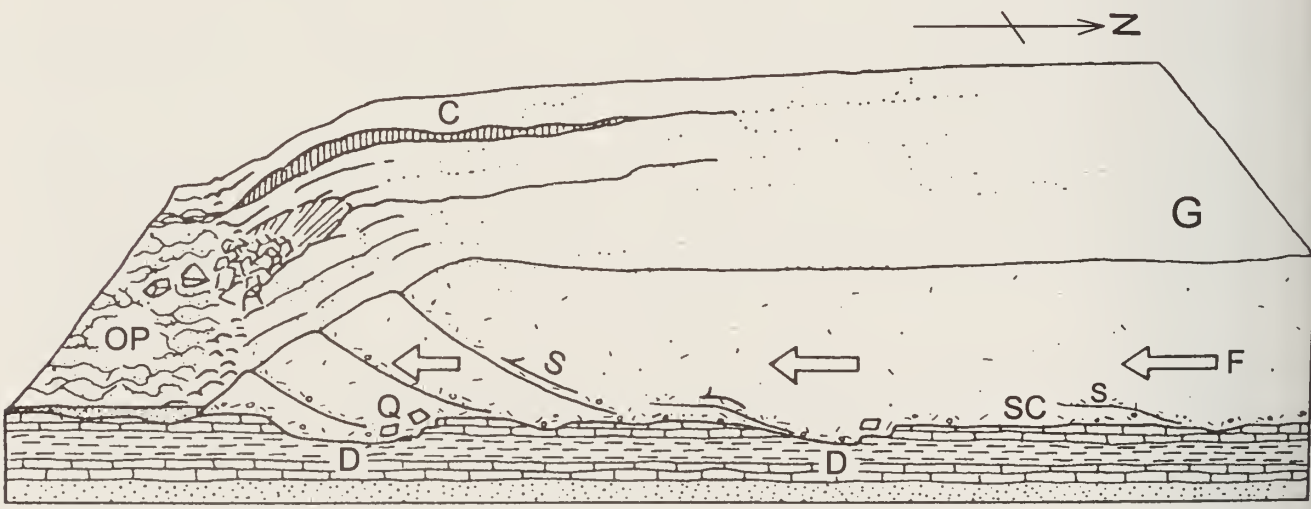
GLACIATION IN A SMALL ILLINOIS REGION

These diagrams show how a continental ice sheet might have looked at various stages as it moved across a small region in Illinois. The diagrams illustrate how the ice sheet 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, as well as present-day mountain glaciers and polar ice caps.

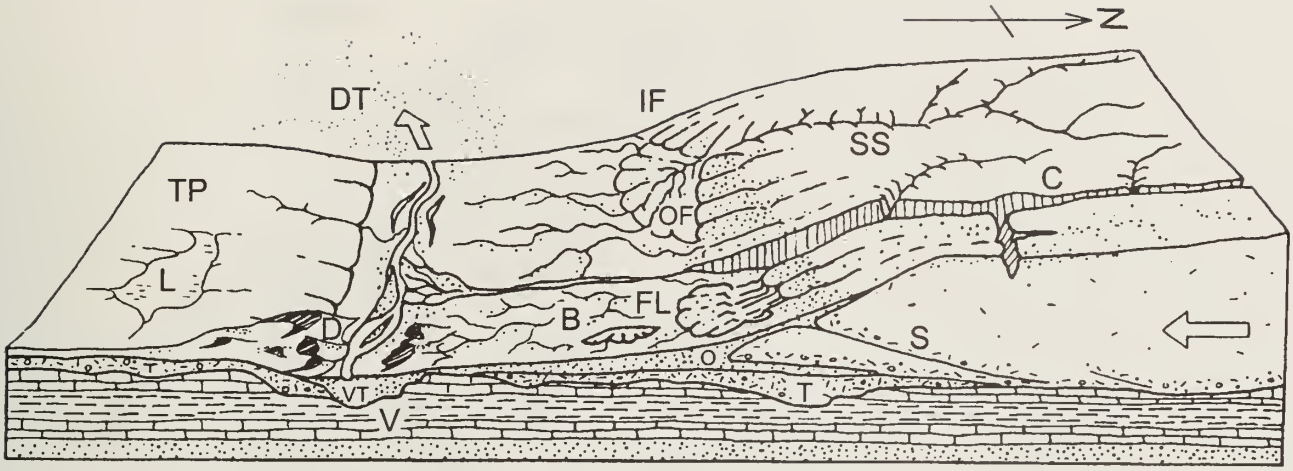
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated; layers of material and landforms are drawn proportionally thicker and higher than they actually are so that they can be easily seen.



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.



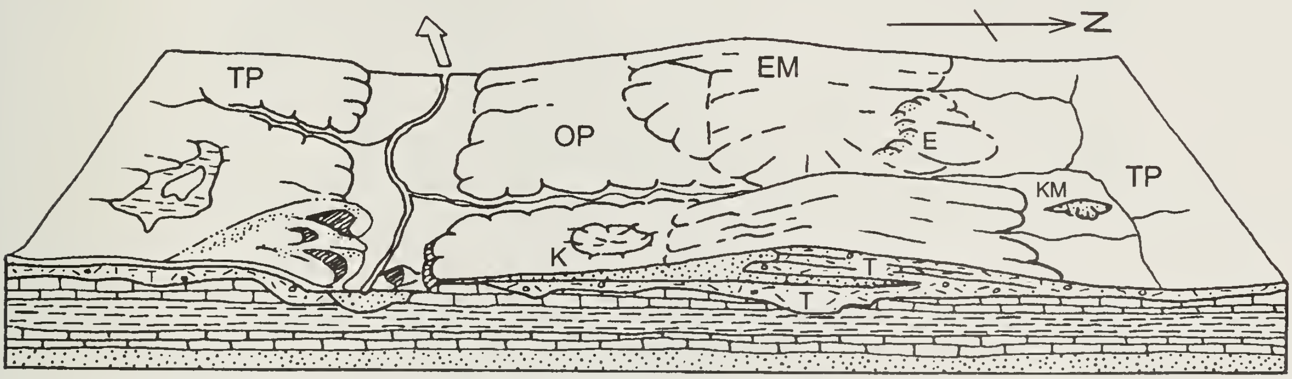
2 The Glacier Advances Southward — As the glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughness in the terrain slows or stops flow (F), the ice "current" slides up over the blocked ice on innumerable shear planes (S). Shearing thoroughly mixes the load. 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 plane (OP). The advancing glacier overrides its outwash and in places scours much of it up again. The glacier may be 5,000 or so feet thick in Canada 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 Forms an End Moraine — A warming climate halts the glacier advance across the area, 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 forming 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).

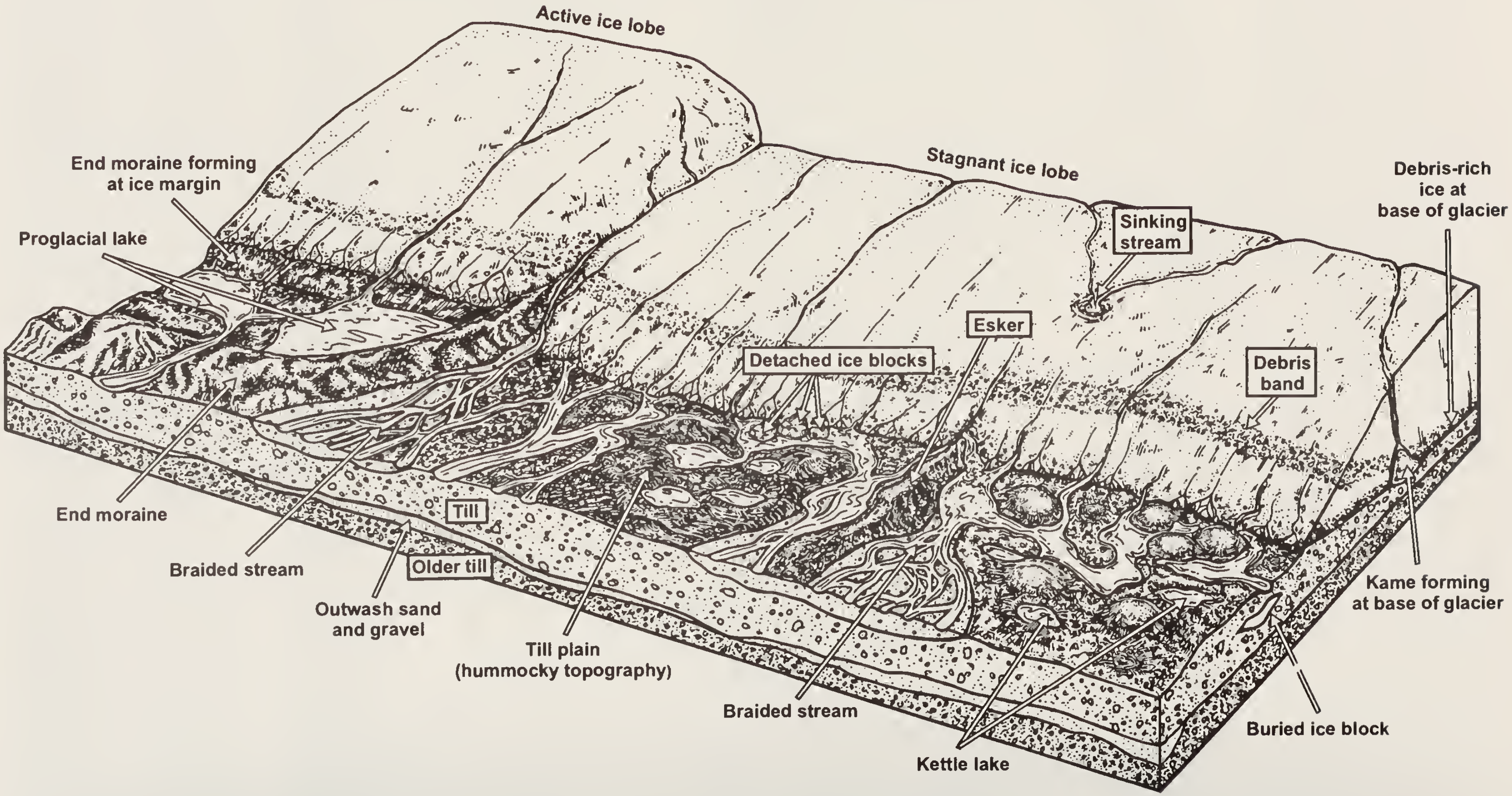
Sediment from the melted ice of the previous advance (figure 2) remains as a fill layer (T), part of which forms the till plain (TP). A shallow, marshy lake (L) fills a low place in the plain. Although largely filled with drift, the valley (V) remains a low spot in the terrain. As soon as the ice cover 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 flows 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 when the ice block melted has formed 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.

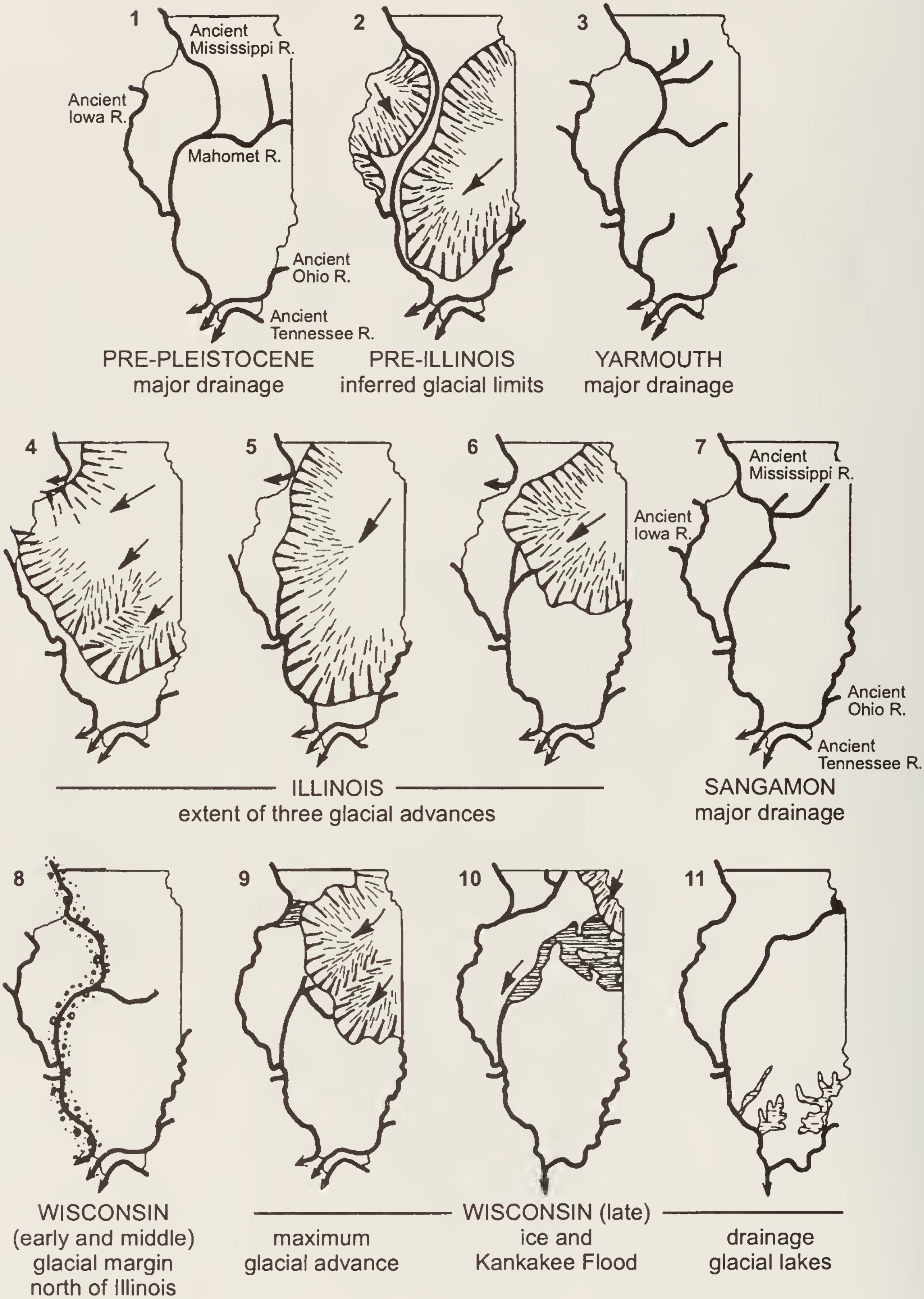
Continental Glacier



TIMETABLE OF EVENTS IN THE ICE AGE IN ILLINOIS

Epoch	Years before present	Time-distance diagram Interglacial and glacial episodes	Sediment record	Dominant climate conditions Dominant land forming and soil forming events
HOLO-CENE		interglacial episode	River, lake, wind, and slope deposits.	Warm; stable landscape conditions. Formation of modern soil; running water, lake, wind, and slope processes.
PLEISTOCENE EPOCH (not to scale)	10,000	WISCONSIN (late) glacial episode; glacial ice	Till and ice-marginal deposits; outwash and glacial lake deposits; loess.	Cold; unstable landscape conditions. Glacial deposition, erosion, and landforming processes (e.g., formation of end moraines, outwash plains, valley trains, proglacial lakes, kettles), plus running water, lake, wind, and slope processes.
	25,000	WISCONSIN (early and middle) glacial margin north of Illinois	Loess; river, lake, and slope deposits.	Cool; stable. Weathering, soil formation (Farmdale Soil and minor soils); wind and running water processes.
	75,000	SANGAMON interglacial episode	River, lake, wind, and slope deposits.	Warm; stable. Weathering, soil formation (Sangamon (Soil); running water, lake, wind, and slope processes.
	125,000	ILLINOIS glacial episode	Till and ice-marginal deposits; outwash and glacial lake deposits; loess.	Cold; unstable. Glacial deposition, erosion, and landforming processes, plus proglacial running water, lake, wind, and slope processes; possible minor soil formation.
	300,000	YARMOUTH interglacial episode	River, lake, wind, and slope deposits.	Warm; stable. Long weathering interval with deep soil formation (Yarmouth Soil); running water, lake, wind, and slope processes.
	425,000 – 1,600,000 and older	? PRE-ILLINOIS glacial and ? interglacial episodes	Till and ice-marginal deposits; outwash and glacial lake deposits; loess plus nonglacial river, lake, wind, and slope deposits.	Alternating stable and unstable intervals of uncertain duration. Glacial deposition, erosion, and landforming processes, plus proglacial and interglacial running water, lake, wind, and slope processes; interglacial weathering and soil formation.

SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



Quaternary Deposits of Illinois

Hudson and Wisconsin Episodes

Mason Group and Cahokia Fm

- Cahokia and Henry Fms; sorted sediment including waterlain river sediment and windblown and beach sand
- Equality Fm; fine grained sediment deposited in lakes

Wedron Group (Tiskilwa, Lemont, and Wadsworth Fms) and Trafalgar Fm; diamicton deposited as till and ice-marginal sediment

- End moraine
- Ground moraine

Illinois Episode

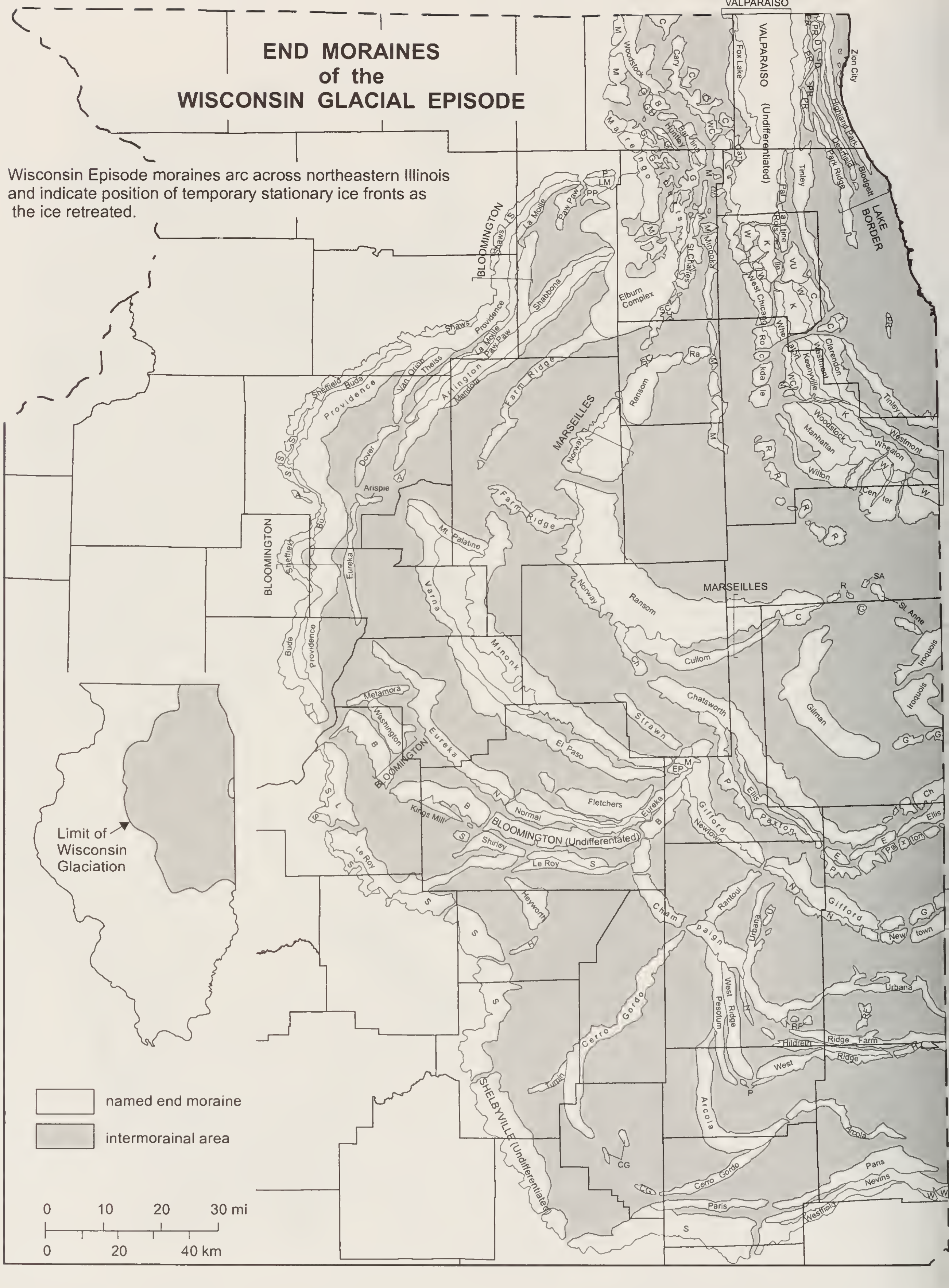
- Winnebago Fm; diamicton deposited as till and ice-marginal sediment
- Glasford Fm; diamicton deposited as till and ice-marginal sediment
- Teneriffe Silt and Pearl Fm, including Hagerstown Mbr; sorted sediments including river and lake deposits and wind blown sand

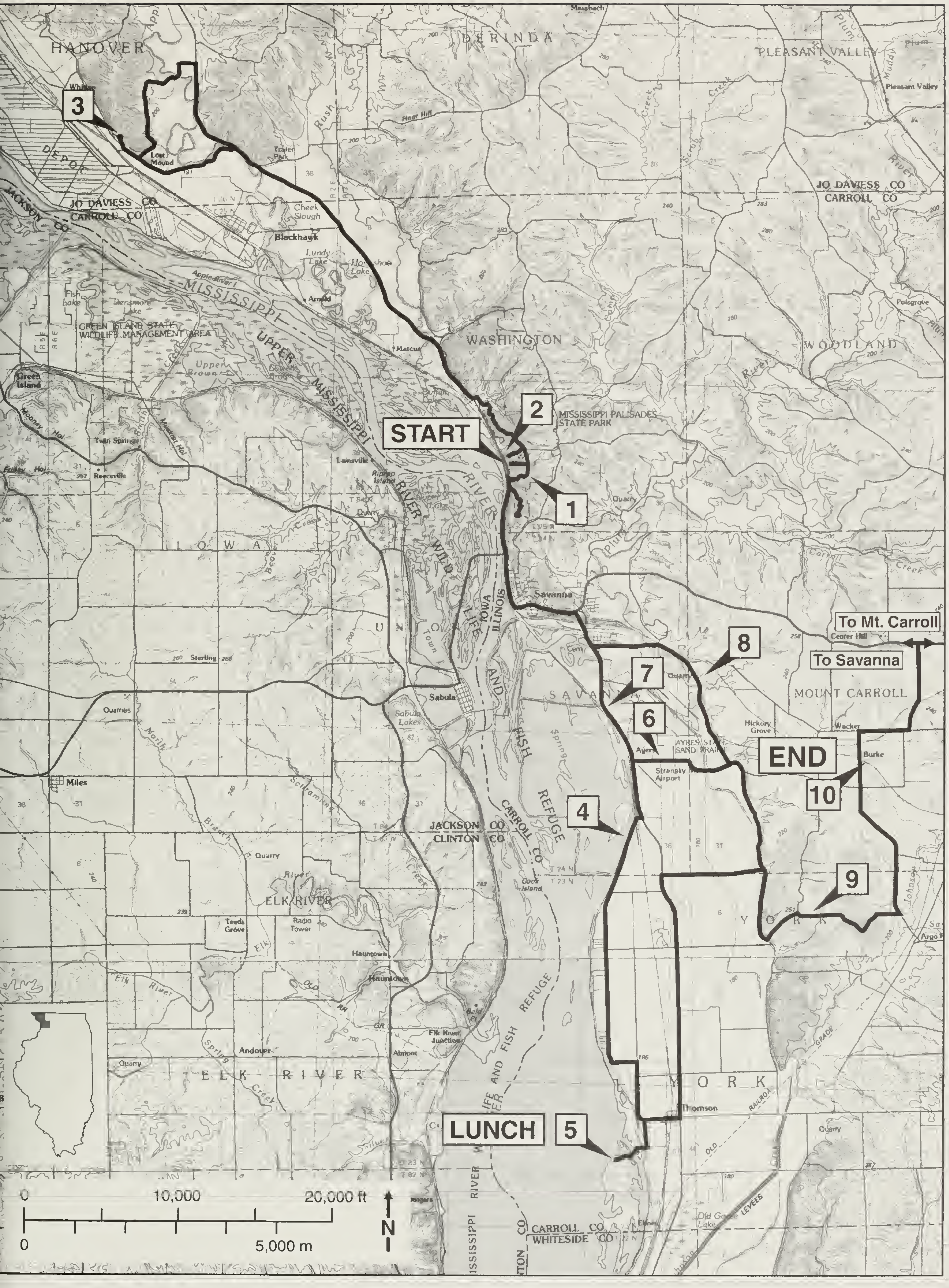
Pre-Illinois Episodes

- Wolf Creek Fm; predominantly diamicton deposited as till and ice-marginal sediment

Paleozoic, Mesozoic, and Cenozoic

- Mostly Paleozoic shale, limestone, dolomite, or sandstone; exposed or covered by loess and/or residuum


END MORAINES
of the
WISCONSIN GLACIAL EPISODE
Wisconsin Episode moraines arc across northeastern Illinois and indicate position of temporary stationary ice fronts as the ice retreated.
Limit of Wisconsin Glaciation
named end moraine
intermorainal area
0 10 20 30 mi
0 20 40 km
VALPARAISO
VALPARAISO (Undifferentiated)
LAKE BORDER
BLOOMINGTON
MARSEILLES
BLOOMINGTON (Undifferentated)
SHELBYVILLE (Undifferentiated)
Zion City
Highland Park
Deerfield
Park Ridge
Blodgett
Fox Lake
Woodstock
Cary
Huntley
Marengo
Tinley
Elburn Complex
West Chicago
Clarendon
Keeneyville
Westmont
Woodstock
Manhattan
Wheaton
Wilton
Center
Shaws
La Moille
Paw Paw
Shabbona
Providence
Sheffield
Buda
Van Orin
Theiss
Arlington
Mendota
Farm Ridge
Norway
Dover
Arispie
Mt. Palatine
Eureka
Varna
Ransom
Cullom
St Anne
Iroquois
Chatsworth
Gilman
Minonk
Metamora
Washington
El Paso
Strawn
Fletchers
Normal
Kings Mill
Shirley
Le Roy
Heyworth
Gifford
Newtown
Paxton
Ellis
Champaign
Rantoul
Urbana
West Ridge
Pesotum
Cerro Gordo
Turpin
Hildreth
Ridge Farm
West Ridge
Arcola
Paris
Nevins
Westfield


START
1
2
3
4
LUNCH
5
6
7
8
9
END
10
To Mt. Carroll
To Savanna
HANOVER
DERINDA
PLEASANT VALLEY
Pleasant Valley
WASHINGTON
WOODLAND
MOUNT CARROLL
JO DAVIESS CO
CARROLL CO
JACKSON CO
CLINTON CO
WHITESIDE CO
MISSISSIPPI PALISADES STATE PARK
UPPER MISSISSIPPI RIVER WILD LIFE AND FISH REFUGE
MISSISSIPPI RIVER
IOWA
ILLINOIS
GREEN ISLAND STATE WILDLIFE MANAGEMENT AREA
Green Island
Blackhawk
Savanna
Sabula
Miles
Thomson
AYRES SAND PRAIRIE
Hickory Grove
Wacker
Burke
Center Hill
Quarry
ELK RIVER
YORK
Hauntown
Andover
Elk River Junction
Teeds Grove
Twin Springs
Reeceville
Sterling
Lost Mound
0
10,000
20,000 ft
5,000 m
N