# Guide to the Geology of the Mount Carmel Area, Wabash County, Illinois

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Illinois State Geological Survey

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Amax Coal Company

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Illinois Natural History Survey

Field Trip Guidebook 1996D
October 26, 1996

Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

## ON THE BANKS OF THE WABASH, FAR AWAY

VERSE 1

Round my Indiana homestead wave the corn fields,
In the distance loom the woodlands clear and cool.

Often times my thoughts revert to scenes of childhood,
Where I first received my lessons, nature's school.

But one thing there is missing in the picture,
Without her face it seems so incomplete.

I long to see my mother in the doorway,
As she stood there years ago, her boy to greet!

CHORUS

Oh, the moonlight's fair tonight along the Wabash,
From the fields there comes the breath of new mown hay.
Through the sycamores the candle lights are gleaming,
On the banks of the Wabash, far away.

VERSE 2

Many years have passed since I strolled by the river,
Arm in arm with sweetheart Mary by my side.

It was there I tried to tell her that I loved her,
It was there I begged of her to be my bride.

Long years have passed since I strolled through the churchyard,
She's sleeping there my angel Mary dear.

I loved her but she thought I didn't mean it,
Still I'd give my future were she only here.

REPEAT CHORUS

WORDS AND MUSIC BY PAUL DRESSER

Paul Dresser was born in Terre Haute, Indiana, on the banks of the Wabash River. He ran away from home as a boy, worked with several minstrel troupes in various humble capacities, and eventually became one of the foremost writers of popular songs of his day, and one of the most loved figures in Tin Pan Alley. Generous to a fault, always genial, with an endless store of good stories and jokes, he was a most welcome figure in all the bars of New York City.

Theodore Dreiser, his brother, writes that his songs, full of sentimentalities, "set forth with amazing accuracy the moods, the reactions, and the aspirations of the exceedingly humble, intellectually and emotionally." His most famous song, "On the Banks of the Wabash, Far Away," has a folk-like quality which places it among the best folk music of the United States. It has been chosen as the official song of the state of Indiana.

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**Cover photo** Schuh Bend on the Wabash River, a classic textbook example of a meander (photo by W.T. Frankie).

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

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

Four USGS 7.5-Minute Quadrangle Maps (East Mount Carmel, Grayville, Keensburg, and Mount Carmel) provide coverage for this field trip area.

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

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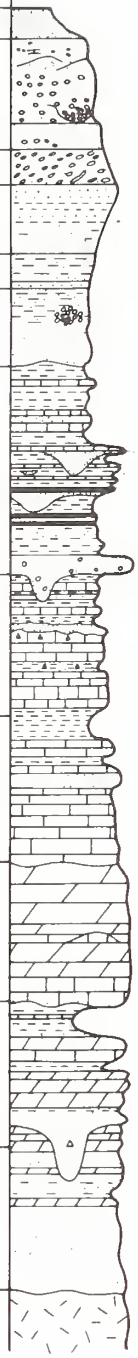
| Era | | Period or System and Thickness | Epoch | Age (years ago) | General Types of Rocks |
|---|---|---|---|---|---|
| CENOZOIC "Recent Life" | Age of Mammals | Quaternary 0-500' | Holocene | 10,000 | Recent—alluvium in river valleys |
| | | | Pleistocene Glacial Age | 1.6 m. | Glacial till, glacial 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; present 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.

## MOUNT CARMEL AREA

The Mount Carmel area geological science field trip will acquaint you with the *geology**, landscape, and mineral resources for part of Wabash County, Illinois. Mount Carmel is located in south-eastern Illinois along the west bank of the Wabash River. It is approximately 250 miles south of Chicago, 180 miles southeast of Springfield, 150 miles east of East St. Louis, and 180 miles northeast of Cairo.

### GEOLOGIC FRAMEWORK

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

Because geologists cannot see the Precambrian basement rocks in Illinois except as cuttings and cores from boreholes, they must use other various 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 indicates that in southernmost Illinois, near what is now the historic Kentucky–Illinois Fluorspar Mining District, rift valleys like those in east Africa formed as movement of crustal plates (plate *tectonics*) began to rip apart the Precambrian North American continent. These rift valleys in the midcontinent region are referred to as the Rough Creek Graben and the Reelfoot Rift (fig. 1).

**Paleozoic Era** After the beginning of the Paleozoic Era, about 520 million years ago 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 several hundred million years of the Paleozoic Era, the area that is now called the Illinois Basin continued to accumulate sediments deposited in the shallow seas that repeatedly covered it. The region continued to sink until at least 15,000 feet of sedimentary strata were deposited. At times during this era, the seas withdrew and deposits were weathered and eroded. As a result, there are some gaps in the sedimentary record in Illinois.

In the field trip area, *bedrock* strata range from more than 520 million years (the Cambrian *Period*) to less than 290 million years old (the Pennsylvanian Period). Figure 2 shows the succession of rock strata a drill bit would penetrate in this area if the rock record were complete and all the *formations* were present.

The elevation of the top of the Precambrian basement rocks within the field trip area ranges from 10,000 feet below sea level in northern Wabash County to 12,500 feet below sea level in southern Wabash County. The thickness of the Paleozoic sedimentary strata ranges from about 10,500 feet in northern Wabash County to about 12,800 feet in southern Wabash County.

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*Words in italics are defined in the glossary at the back of the guidebook. Also please note: although all present localities have only recently appeared 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.

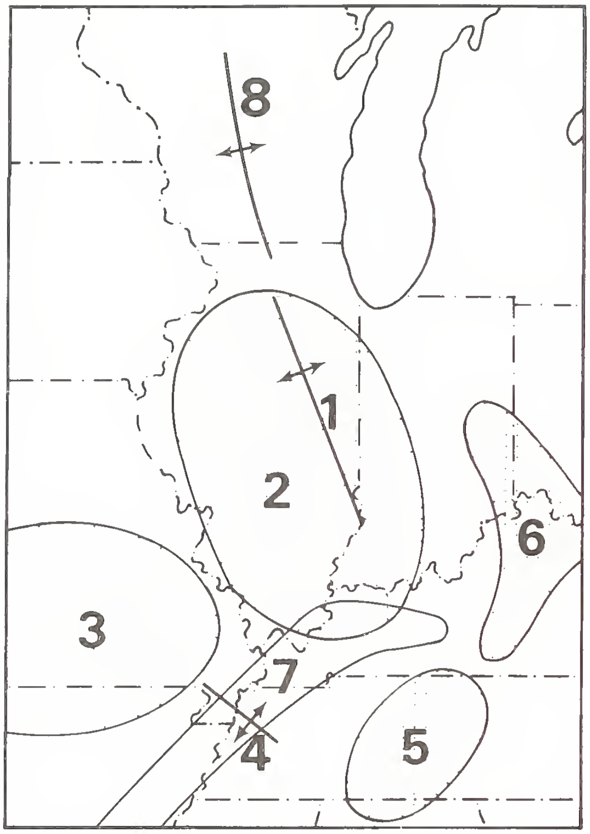


**Figure 1** Location of some of the major structures in the Illinois region. (1) La Salle Anticlinorium, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Rough Creek Graben-Reelfoot Rift, and (8) Wisconsin Arch.

Pennsylvanian-age bedrock strata consisting of shale, siltstone, sandstone, limestone, coal, and underclay were deposited as sediments in shallow seas and swamps between about 320 and 286 million years ago. These rocks are exposed in abandoned strip mines and stream cuts. Pennsylvanian strata increase in total thickness from 1,400 feet in eastern Wabash County to more than 2,000 feet in western Wabash County. (See Depositional History of the Pennsylvanian Rocks in the supplemental reading at the back of this guidebook for a more complete description of these rocks.)

## STRUCTURAL AND 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 and Mesozoic Eras** 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 like 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. Earth's thin crust was periodically flexed and warped as stresses built up in places. These movements caused repeated invasions and withdrawals of the seas across the region. 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

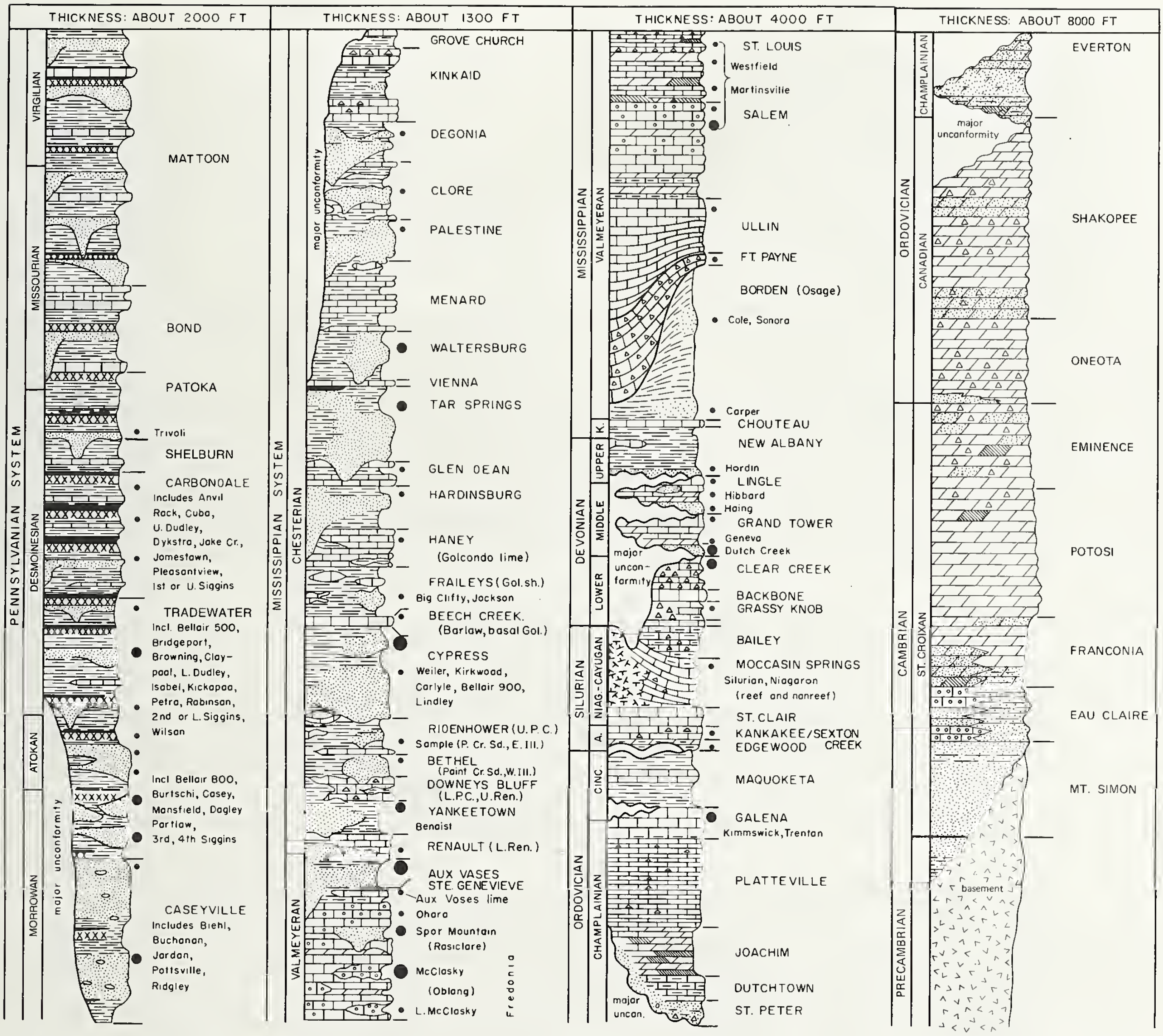


**Figure 2** Generalized stratigraphic column of the field trip area. Black dots indicate oil and gas pay zones (variable vertical scale; from Leighton et al. 1991).

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 some places, however, the top of the lower formation was at least partially eroded before deposition of the next formation began. Fossils and other evidence in the two formations indicate that there is a significant age difference between the lower unit and the overlying unit. This type of contact is called an *unconformity* (fig. 4). If the *beds* above and below an unconformity are parallel, the unconformity is called a *disconformity*; if the lower beds have been tilted and eroded before the overlying beds were deposited, the contact is called an angular unconformity.

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

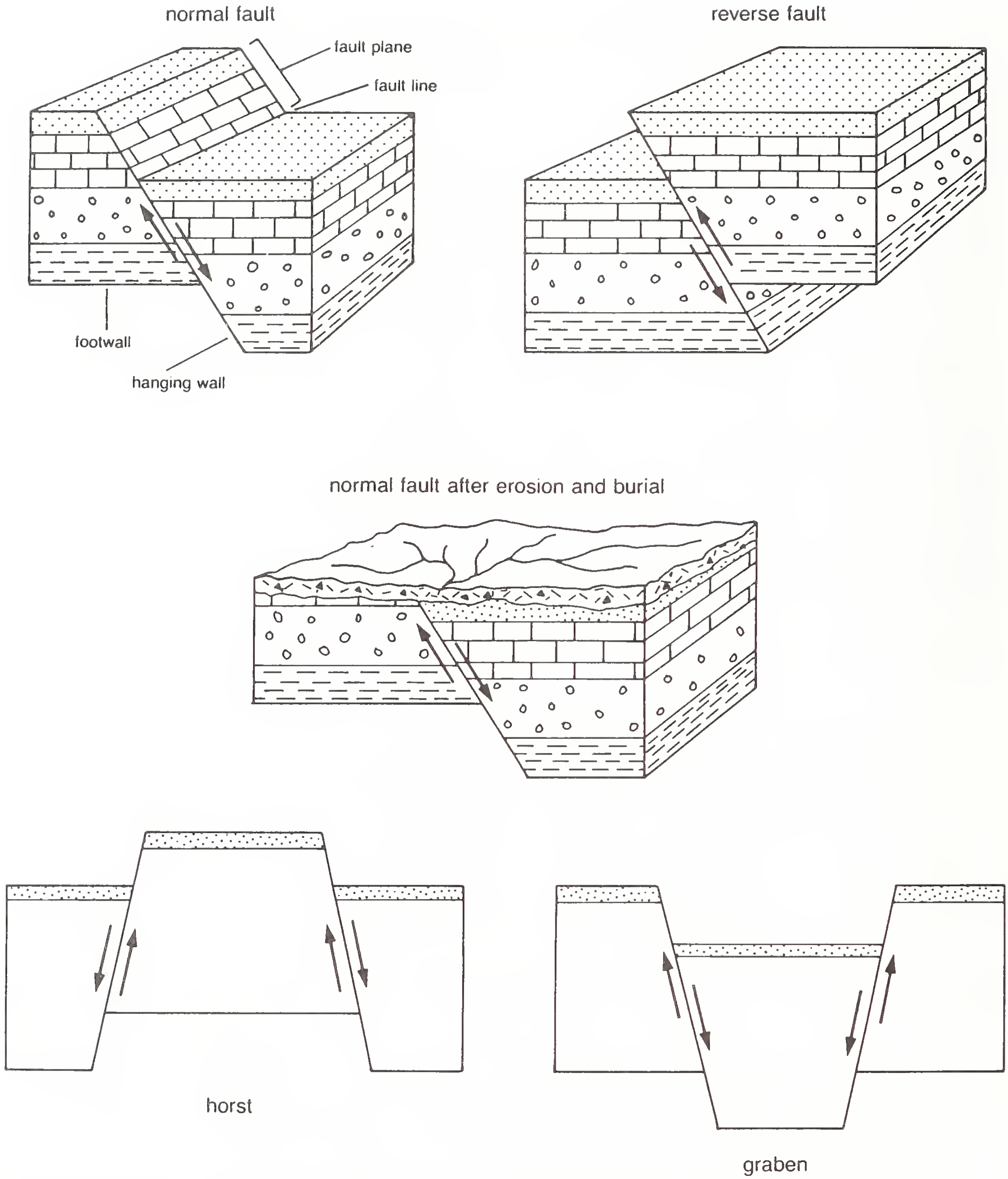


**Figure 3** Diagrammatic illustrations of fault types that may be present in the field trip area (arrows indicate relative directions of movement on each side of the fault).

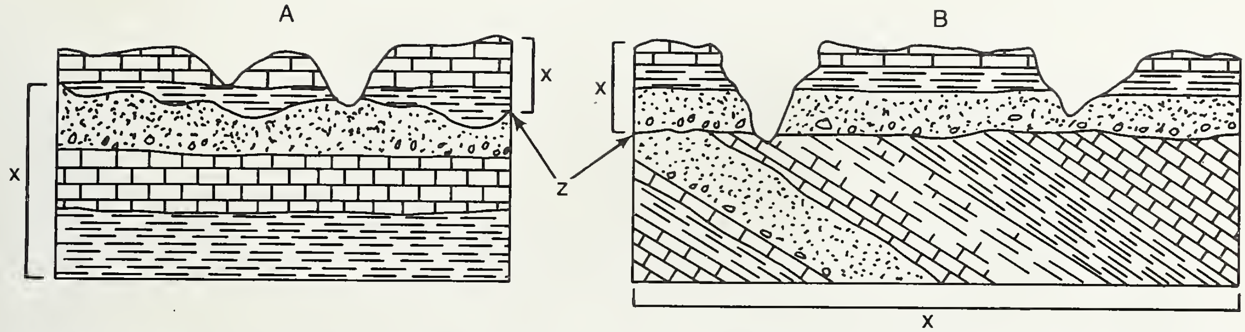


**Figure 4** Schematic drawings of (A) a disconformity and (B) an angular unconformity (x represents the conformable rock sequence and z is the plane of unconformity).

Near the close of the Mississippian Period, gentle arching of the rocks in eastern Illinois initiated the development of the La Salle Anticlinorium (figs. 1 and 5). This is a complex structure having smaller structures such as domes, *anticlines*, and *synclines* superimposed on the broad upwarp of the anticlinorium. 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.

During the Mesozoic Era, which followed the Paleozoic Era, the rise of the Pascola Arch (figs. 1 and 5) in southeastern Missouri and western Tennessee formed the Illinois *Basin* by closing off the embayment and separating it from the open sea to the south. The Illinois Basin is a broad, subsided region covering much of Illinois, southwestern Indiana, and western Kentucky (fig. 1). Development of the Pascola Arch, in conjunction with the earlier sinking of deeper parts of the area to the north, gave the basin its present asymmetrical, spoon-shaped configuration (fig. 6). The geologic map (fig. 7) shows the distribution of the rock *systems* of the various geologic time periods as they would appear if all the glacial, windblown, and surface materials were removed.

The Mount Carmel field trip area is located south of the La Salle Anticlinorium, and at the northern end of the Wabash Valley Fault System (fig. 5). The La Salle Anticlinorium is more than 200 miles long and has as much as 2,500 feet of vertical relief. The anticlinorium is a complex uplift that consists of a large number of branching, sinuous monoclines, anticlines, and related domes. The Wabash Valley Fault System is made up of a system of northeast to southwest trending faults within the lower Wabash River Valley of southeastern Illinois and southwestern Indiana. This fault system extends roughly 55 miles northeastward from the Rough Creek-Shawneetown Fault System (fig. 5). The structure of this fault system is known from records of thousands of oil test holes. Additional details of these faults are also provided by exposures in underground mines (see discussion of Amax Coal Company's Wabash Mine, Stop 3) and through seismic reflection profiles (Nelson 1995).

Pennsylvanian-age bedrock is exposed along the Wabash River and many of its smaller tributaries within eastern Wabash County. Younger rocks of the latest Pennsylvanian and perhaps the Permian (the youngest rock systems of the Paleozoic) may have at one time covered the area of Wabash County. Mesozoic and Cenozoic rocks (see the generalized geologic column) could also possibly have been present here. Indirect evidence, on the basis of 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 present in Illinois were removed. During this extended period of erosion, deep bedrock valleys were carved

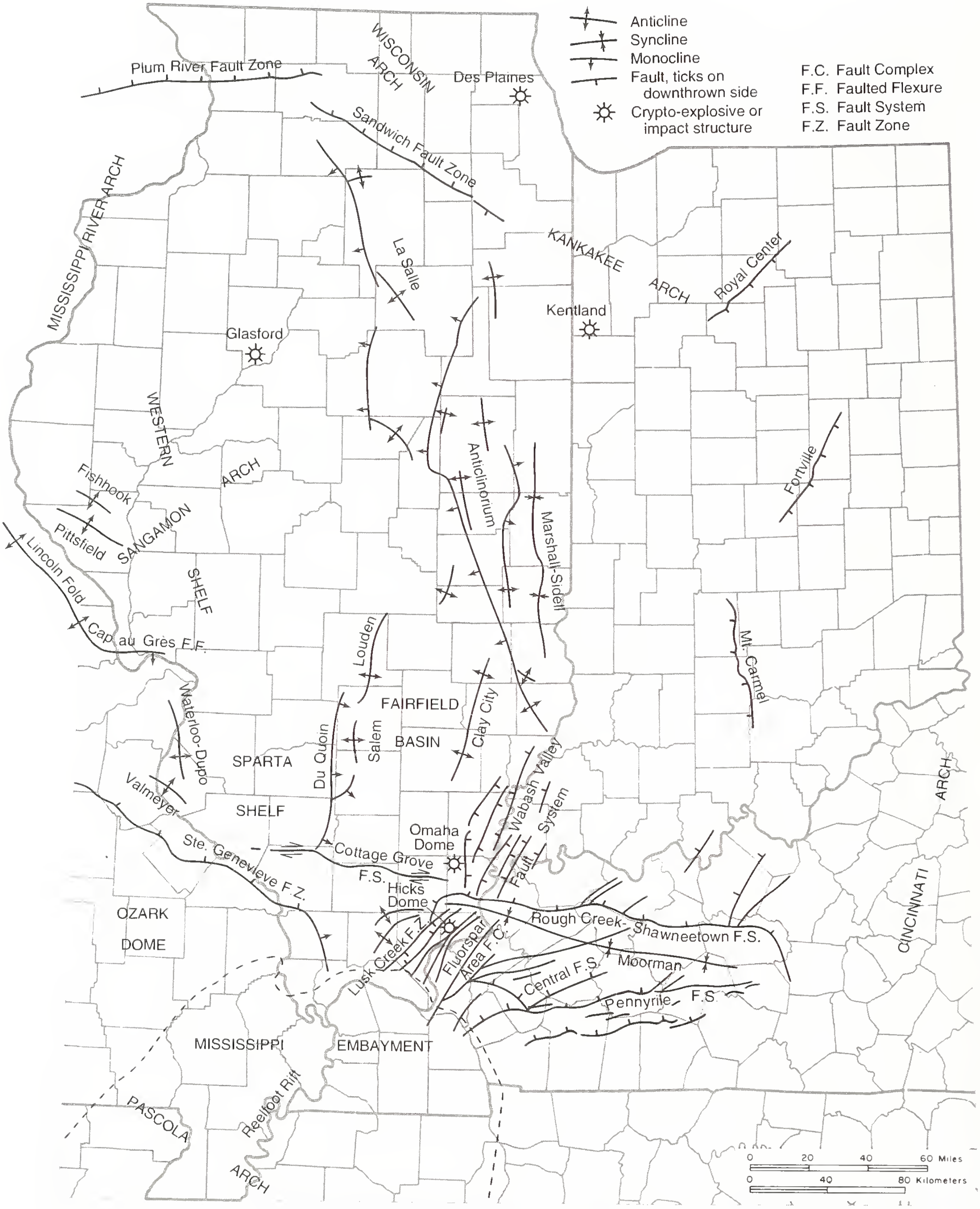


**Figure 5** Structural features of Illinois (modified from Buschbach and Kolata 1991).

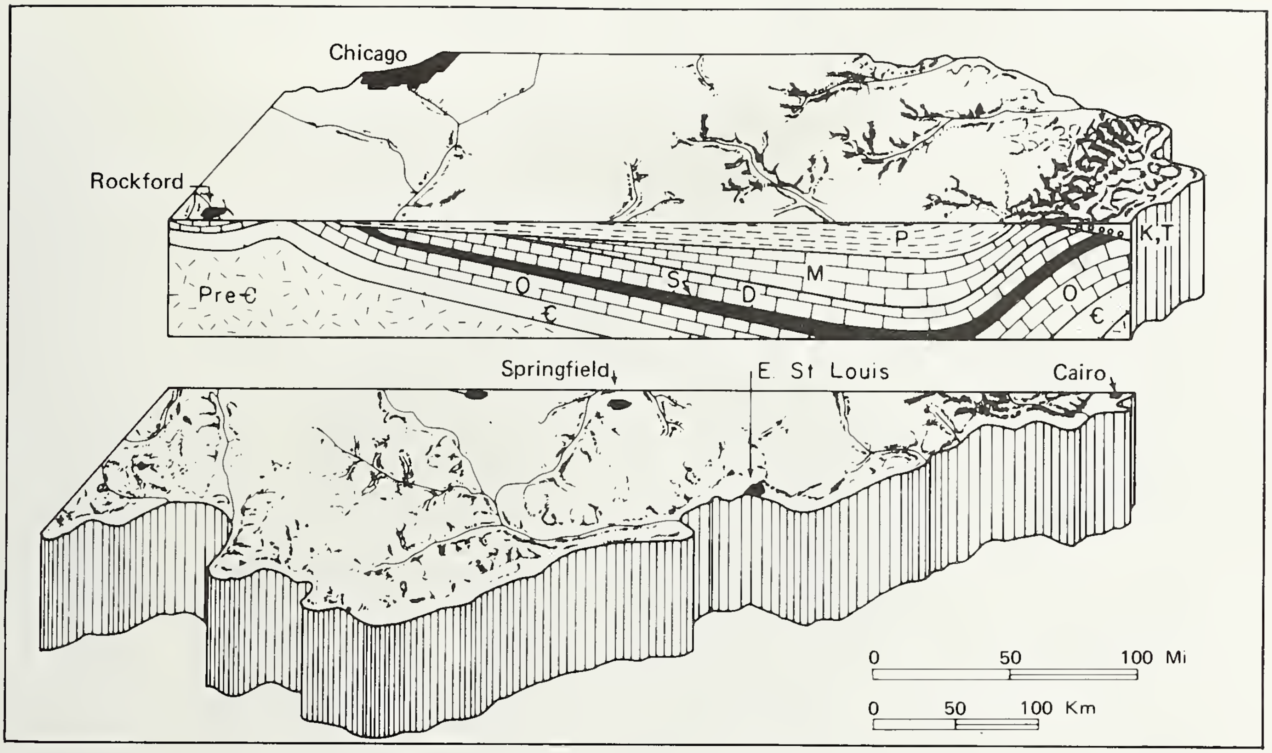


**Figure 6** Stylized north–south cross section shows the structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks has been greatly exaggerated and younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-Є) granites. They form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

into the gently tilted bedrock formations (fig. 8). Later, the topographic *relief* produced by the preglacial erosion was reduced by repeated advances and melting back of continental *glaciers* that scoured and scraped the bedrock surface. This glacial erosion affected all the formations exposed at the bedrock surface in Illinois. The final melting of the glaciers left behind the nonlithified deposits in which our Modern Soil has developed.

**Cenozoic Era: Glacial History** A brief general history of glaciation in North America and a description of the deposits commonly left by glaciers is given in *Pleistocene Glaciations in Illinois* at the back of the guidebook.

Erosion that took place long before the glaciers advanced across the state left a network of deep valleys carved into the bedrock surface (fig. 8). Prior to glaciation, a large portion of Edwards, Richland, and Wabash Counties was drained by a north–south ancient bedrock valley called the Bonpas Creek Valley. The Bonpas Creek "bedrock" Valley starts in southeastern Richland County and extends southward along the Edwards-Wabash County line to the Wabash Valley near Grayville. The Illinoian glacial drift in the Bonpas Creek Valley is about 100 feet thick at the mouth of the valley and thins northward. The modern Bonpas Creek follows the same course as the Bonpas Bedrock Valley, and there is essentially no difference between the present and preglacial drainage basins (Horberg 1950). Because of the irregular bedrock surface and erosion, glacial *drift* is unevenly distributed across Wabash County.

During the Pleistocene *Epoch*, beginning about 1.6 million years ago, massive sheets of ice (called continental glaciers), thousands of feet thick, flowed slowly southward from Canada. During the Illinoian glacial stage, which began around 300,000 years before the present (B.P.). North American

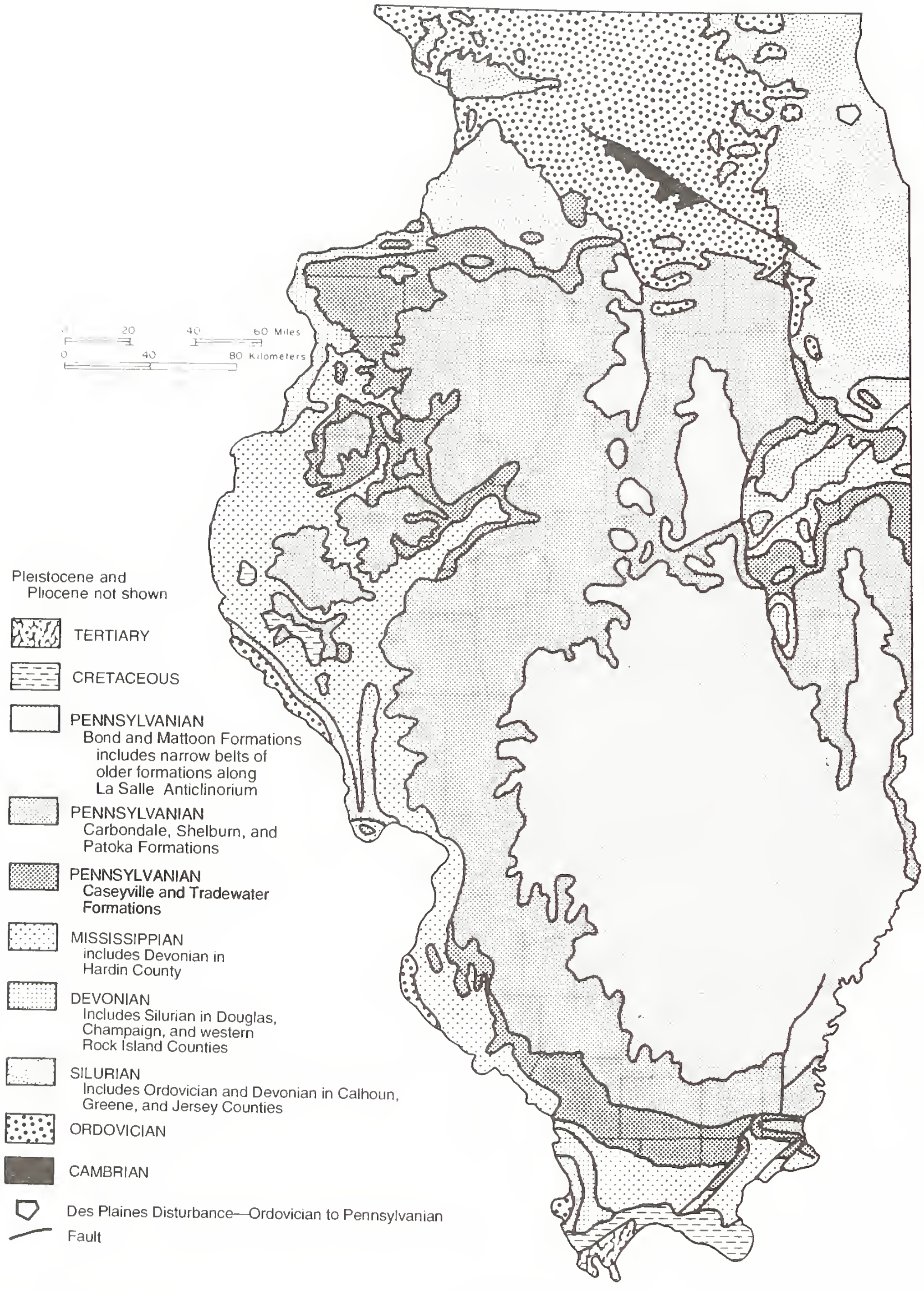


**Figure 7** Bedrock geology beneath surficial deposits in Illinois.

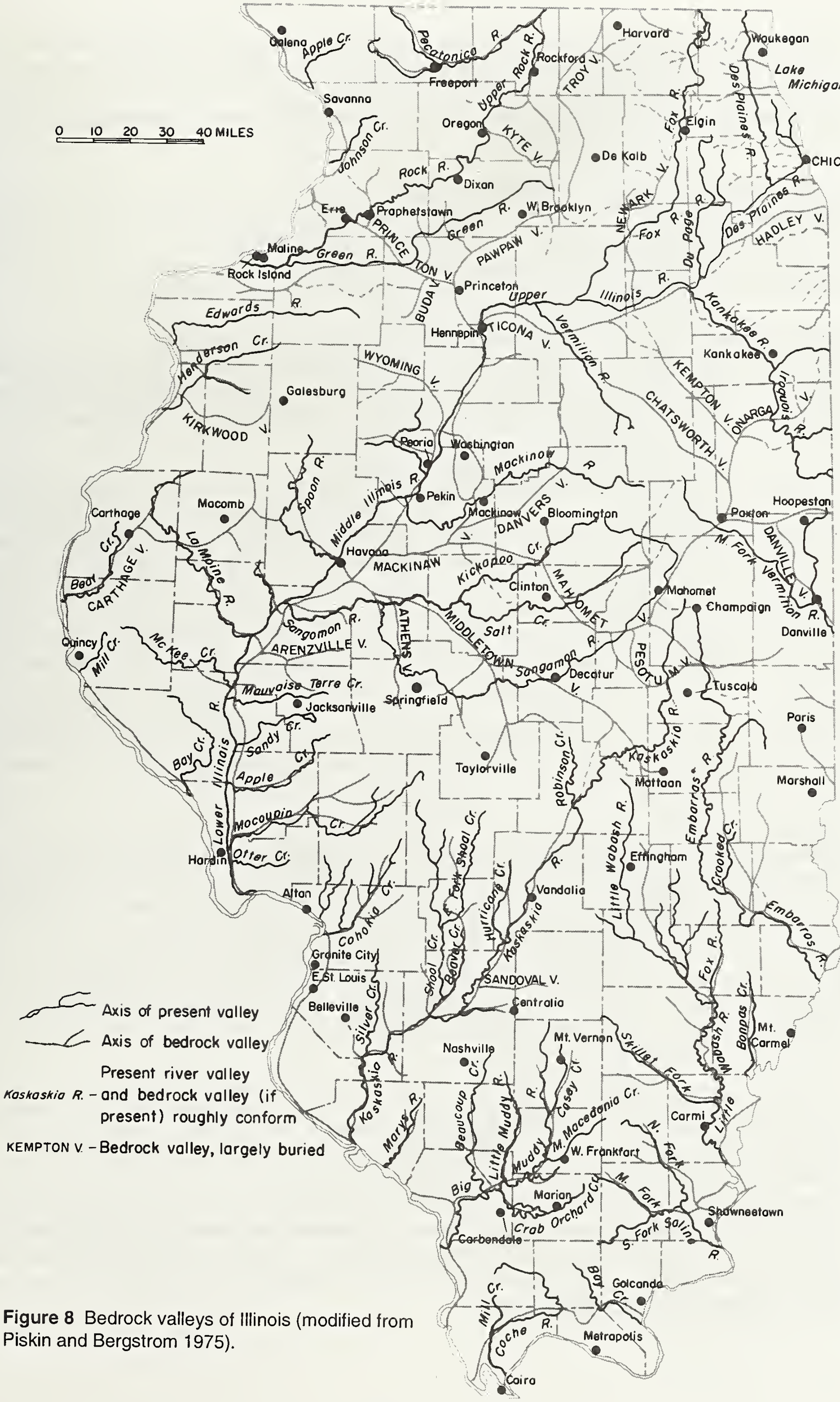


**Figure 8** Bedrock valleys of Illinois (modified from Piskin and Bergstrom 1975).

continental glaciers reached their southernmost position, approximately 85 miles southwest of here in northern Johnson County (fig. 9). The maximum thickness of the later Wisconsin Episode glacier 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 Wisconsin glacier melted from northeastern Illinois about 13,500 years B.P.

The *topography* of the bedrock surface throughout much of Illinois is largely hidden from view by glacial deposits except along the major streams. In many areas, the glacial drift is thick enough to completely mask the underlying bedrock surface. However, the buried bedrock surface within this area is primarily a surface of low relief, except along the major bedrock valleys, and is only slightly modified and subdued by a relatively thin drift cover deposited during the last 300,000 years.

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

Overlying the Illinoian Episode deposits is a thin cover of deposits called the Peoria *Loess* (pronounced "luss"). These sediments, deposited as wind-blown silts during the Woodfordian Subage, which began about 22,000 years B.P., mantle the glacial drift throughout the field trip area. (See *Pleistocene Glaciations in Illinois* at the back of the guidebook.) Within Wabash County, the loess deposits are thickest near the Wabash Valley, where they are nearly 12 feet thick, but they thin rapidly to less than 2 feet thick a few miles west of the river. This fine grained dust, which covers most of Illinois outside the area of Wisconsinan glaciation, reaches thicknesses exceeding 25 feet west of the field trip area along the Mississippi and Illinois Rivers. Soils in the Wabash area have developed in the loess, in the underlying weathered silty, clayey Illinoian *till*, and in the alluvium which fills the valleys.

Within the field trip area, glacial drift ranges in thickness from less than 25 feet, in the north and central portions of the county, to slightly more than 100 feet, in the southern portion of the county near the mouth of the Bonpas Creek.

## GEOMORPHOLOGY

**Physiography** The field trip area is located within the Mt. Vernon Hill Country of the *Till Plains* Section of the Central Lowland Physiographic Province (fig. 10). The Mt. Vernon Hill Country comprises the southern portion of the Illinoian drift sheet. The Central Lowland Province is bordered on the south and the west by uplands containing extensive remnants of an older erosional surface. Prior to glaciation, the lowland surface was incised by a drainage system consisting of many deep bedrock valleys (fig. 8). The Mt. Vernon Hill Country, according to Leighton et al. (1948), is characterized by mature topography of low relief with restricted upland prairies and broad alluviated valleys along the larger streams. For a more complete description of glacial landforms, see *Pleistocene Glaciations in Illinois* at the back of the guidebook.

According to Horberg (1950) and others (e.g., Leighton et al. 1948), an extensive lowland called the "central Illinois *peneplain*" had been eroded prior to glaciation into the relatively weak rocks of Pennsylvanian age east and south of the present-day Illinois River. Apparently, just before the beginning of glaciation, an extensive system of *bedrock valleys* was deeply entrenched below the central lowland surface level. As glaciation began, streams probably changed from erosion to aggradation, that is, their channels began to build up and fill in because the streams did not have sufficient volumes of water to carry and move the increased volumes of sediment. To date, no evidence indicates that the early fills in these preglacial valleys were ever completely flushed out of their channels by succeeding torrents of meltwater from receding glaciers.

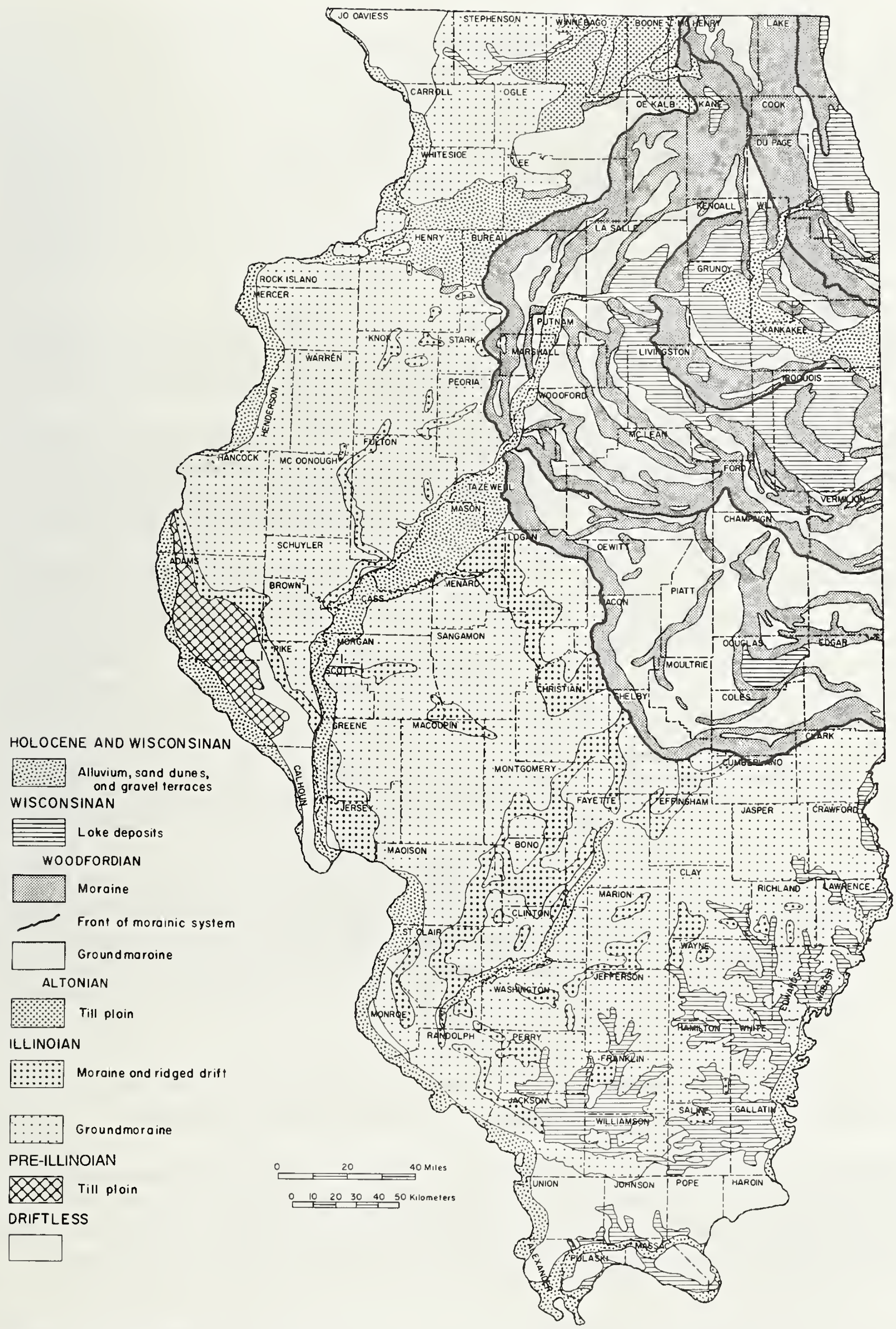


**Figure 9** Generalized map of glacial deposits in Illinois (modified from Willman and Frye 1970).

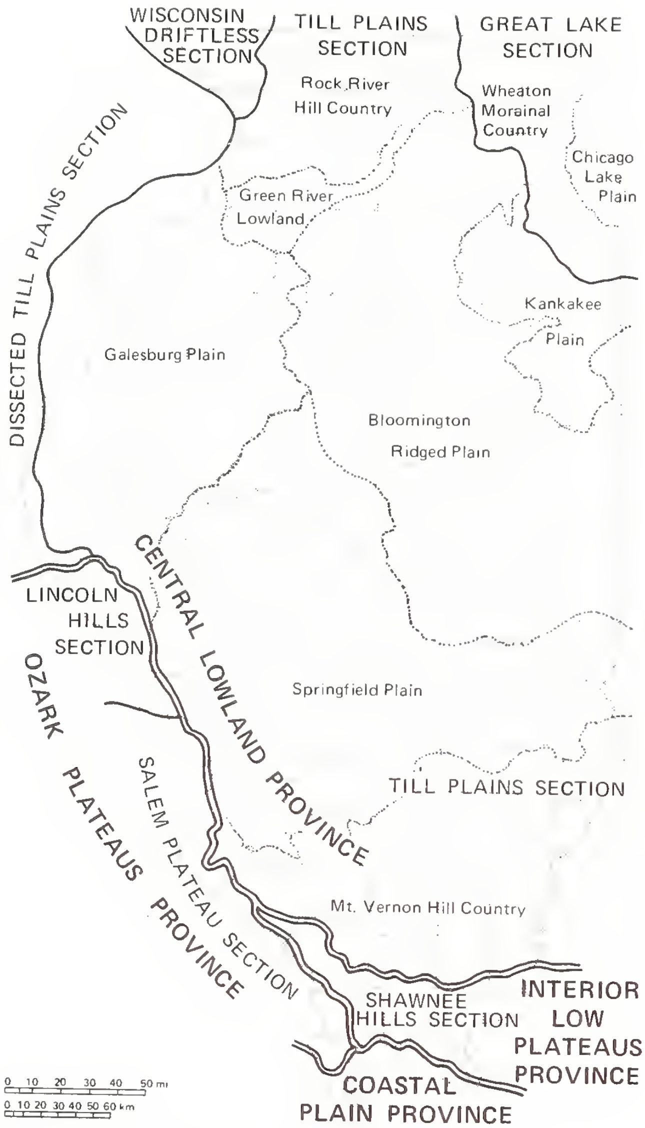


**Figure 10** Physiographic divisions of Illinois.

**Drainage** Within Wabash County, drainage is controlled by the Wabash River, which forms the east edge of the county and by the Bonpas River, which forms the west edge of the county.

The Wabash River has incised through a relatively thin cover of unconsolidated materials overlying the Pennsylvanian bedrock, and its drainage pattern is largely controlled by faults and joint patterns associated with the Wabash Valley Fault System. Sedimentary rocks of Pennsylvanian age are exposed along the Wabash Valley throughout the field trip area. The modern Bonpas Creek essentially follows the same course as an older bedrock valley named the Bonpas Creek Valley (fig. 8).

**Relief** The highest land surface on the field trip route is at the start of the field trip at the Mount Carmel High School, where the surface elevation is slightly more than 470 feet above mean sea level (msl). The lowest elevation is about 380 feet above msl at Schuh Bend along the Wabash River at Stop 7. The surface relief of the field trip area, calculated as the difference between the highest and lowest surfaces, is about 90 feet. *Local relief* is most pronounced along the Wabash River in Section 29, T2S, R13W, where the McCleary Bluffs are more than 80 feet above the river.

## NATURAL RESOURCES

**Mineral production** Of the 102 counties in Illinois, 98 reported *mineral* production during 1992, the last year for which complete records are available. The total value of all minerals extracted, processed, and manufactured in Illinois during 1992 was $2,894,300,000, which is 0.5% below the 1991 total. Minerals extracted accounted for 90% of this total. Coal continued to be the leading commodity, accounting for 64% of the total, followed by industrial and construction materials at 21.4%, and oil at 14.2%. The remaining 0.4% included metals, peat, and gemstones. Illinois ranked 13th among the 31 oil-producing states in 1992 and 16th among the 50 states in total production of nonfuel minerals, but continues to lead all other states in production of fluorspar, industrial sand, and tripoli. The last operating fluorspar mine, however, closed in December 1995.

Wabash County ranked 10th among all Illinois counties in 1992 on the basis of the value of all minerals extracted, processed, and manufactured. Economic minerals currently mined in Wabash County include coal, oil and gas, and a limited amount of sand and gravel.

Of the 18 counties reporting coal production in 1994, Wabash County ranked 6th with 3,993,838 tons. All production was from the Amax Coal Company's Wabash Mine, an underground mine producing from the Springfield coal. Coal has been mined from the Friendsville and Springfield Coals. Cumulative production for the county equals 52,455,470 tons.

Of the 45 counties reporting oil production in 1992, Wabash county ranked 9th with 863,000 barrels of oil. Cumulative production for the county equals 123,689,000 barrels.

**Groundwater** Groundwater is a mineral resource frequently overlooked in assessments of an area's natural resource potential. 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.

Because glacial deposits occur in this area, sand and gravel deposits are common throughout most of the county, and especially along the major river valleys. Most of these sand and gravel deposits yield commercial amounts of water for industrial and municipal water supplies. In addition, wells completed into the Pennsylvanian sandstones have yielded significant amounts of water. Throughout Wabash County, small municipal and farm water supplies are obtained from shallow Pennsylvanian formations.

## GUIDE TO THE ROUTE

Assemble at the northeast parking lot at the rear of the Mt. Carmel High School (NW,SE,SW, Sec. 21, T1S, R12W, 2nd P.M.), Wabash County, Mount Carmel 7.5-Minute Quadrangle.

***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!

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.

Four USGS 7.5-Minute Quadrangle Maps (East Mount Carmel, Grayville, Keensburg, and Mount Carmel) provide coverage for this field trip area.

| Miles to next point | Miles from start | |
|---|---|---|
| 0.0 | 0.0 | Begin road log at the intersection of Plum Street and Third Street. Proceed northwest on Plum Street. |
| 0.0 | 0.1 | Pass intersection of Fourth Street. |
| 0.1 | 0.2 | STOP (2-way). Intersection of Fifth Street and Plum Street. TURN RIGHT onto Fifth Street. |
| 0.2 | 0.4 | T-intersection (Fairground Road) from the right. CONTINUE AHEAD. You are driving on the flood plain; directly ahead is the levee along the Wabash River. |
| 0.25 | 0.65 | Top of levee protecting Mt. Carmel. |
| 0.15 | 0.8 | STOP (T-intersection). Sign marking old dam site to the left; boat ramp to the right. TURN RIGHT. After you make the right turn, the AMVETS building is to the right. |
| 0.1 | 0.9 | Road curves to the right, TURN LEFT into the large parking lot. |

**STOP 1 Confluence of the Wabash and White Rivers** At this stop we will discuss the geomorphology of the Wabash and White rivers. The center of the Wabash River marks the boundary between Illinois and Indiana. The White River is in Indiana. This is the site of the old Mount Carmel Ferry. The ferry crossed the Wabash River from the east bank of the Wabash, just north of the White River, to the west bank of the Wabash immediately north of the parking lot (see route map).

| | | |
|---|---|---|
| 0.0 | 0.9 | Leave Stop 1. Exit parking lot, turn right, and head north along the road parallel to the Wabash River. |
| 0.2 | 1.1 | STOP (T-intersection). CONTINUE AHEAD toward old dam site. As you drive along the Wabash River, you are driving on the flood plain. |
| 0.62 | 1.7 | To your left are some oil wells and a battery of oil tanks. The oil pumps are on elevated platforms and the oil tanks are on top of a small earthen mounds to protect them from periods of high water during floods. Along the right side of the road along the river are numerous temporary fishing campsites. |
| 0.05 | 1.75 | Crossing small drainage ditch. |
| 0.5 | 2.25 | Another series of pump jacks in the field to the left. To the right within the Wabash River, you can see a series of rapids called Grand Rapids that appear during periods of low flow. There is also a small island in the middle of the Wabash River at this point. |
| 0.15 | 2.4 | To the right, visible through the trees along the banks of the Wabash is the concrete and sandstone structure of the old Grand Rapids Dam. If you walk along the bank of the Wabash River north of this structure and look across the Wabash River toward Indiana, you can see the remnants of the dam on the Indiana side. The original Grand Rapids Dam was constructed in 1847 by the Wabash Navigation Company. This wooden dam gave way in 1879. The structures that you see today are the remains of the second Grand Rapids Dam, which was constructed by the federal government at a cost of $340,000. This second dam was 1,100 feet long and 12 feet high, and included a system of locks. An early famous resort and favorite vacation site for anglers was the Grand Rapids Dam Hotel built by Fred Zimmerman in 1921. The hotel burned in 1929, and the dam washed out in 1931 and 32, so there is nothing left but memories of the busy resort. |
| 0.05 | 2.45 | Road makes a 90° turn to the left at Grand Rapids. |
| 0.25 | 2.7 | Road makes a 90° turn to the right and starts to climb out of the flood plain. |
| 0.05 | 2.75 | Exposure of Pleistocene material of Wisconsin Age called Parkland Sand, which is well sorted, medium grained, wind-blown sand in the form of a dune. |
| 0.25 | 3.0 | Road makes a 90° turn to the left. |
| 0.10 | 3.1 | Road crosses small drainage ditch and makes a 90° turn to the right. |
| 0.65 | 3.75 | T-intersection. Road makes a 90° turn to the left. Old abandoned farmhouse directly ahead. |

| | | |
|---|---|---|
| 0.3 | 4.05 | Road takes a slight jog to the left and then back to the right. At the middle of the S-curve you will cross the abandoned railroad grade of the New York Central Railroad. |
| 0.15 | 4.2 | Road ascends hill. |
| 0.2 | 4.4 | T-intersection from the right; part of old Route 1. CONTINUE AHEAD. |
| 0.01 | 4.41 | STOP (2-way). Intersection of Route 1 and Poor Farm Road. TURN RIGHT onto Route 1 heading north. |
| 0.4 | 4.8 | Cross south branch of Crawfish Creek. Pennsylvanian outcrop on the right (south side of creek). |
| 0.45 | 5.25 | Cross Crawfish Creek. |
| 0.35 | 5.6 | Crossroad Intersection (1690N and 1180E). CONTINUE AHEAD. |
| 0.5 | 6.1 | T-intersection from the left. CONTINUE AHEAD. |
| 0.5 | 6.6 | Entering the community of Patton. |
| 0.65 | 7.25 | T-intersection from the right (1820N and 1270E). TURN RIGHT. After you make the turn, the road curves left and crosses an abandoned railroad grade. |
| 0.35 | 7.6 | T-intersection (1820N and 1300E). TURN LEFT onto 1300E. |
| 0.05 | 7.65 | T-intersection (1830N and 1300E). TURN RIGHT onto 1830N, stay on blacktop. |
| 0.25 | 7.9 | TURN RIGHT. Enter Allendale Gravel Company on the east side of the office and follow the gravel road south from the office. Notice the stockpile of sand, gravel, and limestone along the left of the road. These piles are separated by size. Each size is a specific grade designation used within the industry to determine which materials are used for various construction needs. |
| 0.2 | 8.1 | Stop 2. Entrance to abandoned sand and gravel pits along the Wabash River. NOTE: This is private property. You must ask permission before entering. |

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**STOP 2 Allendale Gravel Company, abandoned sand and gravel pits** We will view the abandoned gravel pits, discuss the importance of the sand and gravel industry in Wabash County, and observe the geomorphology of the Wabash River.

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| | | |
|---|---|---|
| 0.0 | 8.1 | Leave Stop 2 and retrace route back to the office building. |
| 0.15 | 8.25 | STOP (T-intersection, 1830N and gravel company road). TURN LEFT onto 1830N. NOTE: retrace the route back to Route 1. |
| 0.25 | 8.5 | STOP (T-intersection, 1300E and 1830N). TURN LEFT and stay on blacktop. |
| 0.05 | 8.55 | T-intersection (1300E and 1820N). TURN RIGHT. Road curves right; stay on blacktop. |

| | | |
|---|---|---|
| 0.3 | 8.85 | Crossing old abandoned railroad grade of the New York Central Railroad. |
| 0.05 | 8.9 | STOP (T-intersection, 1820N and 1207E, Route 1). TURN LEFT onto Route 1 heading southwest. |
| 0.2 | 9.1 | Entering the community of Patton. |
| 0.35 | 9.45 | Leaving the community of Patton. |
| 0.55 | 10.0 | T-intersection from the right. CONTINUE AHEAD. |
| 0.3 | 10.3 | Route 1 makes a large curve to the left. Note that the road level has been raised to help protect it during times of high water. |
| 0.6 | 10.9 | Cross Crawfish Creek. |
| 0.4 | 11.3 | Cross south branch of Crawfish Creek. Prepare to turn right. |
| 0.4 | 11.7 | Crossroad intersection (Route 1 and Poor Farm Road). TURN RIGHT onto Poor Farm Road. |
| 0.25 | 11.95 | Poor Farm Bed and Breakfast to the right. The large red brick house was part of a poor farm from 1915 to 1950. The original structure was built in 1857, and the red bricks from the original poor house were used for the interior walls of the present building. The poor house was used as a nursing home from 1950 to 1983. It stood vacant for 7 years. After 3 years of remodeling, it was opened as a bed and breakfast in 1993. |
| 0.15 | 12.1 | Lake Froman Lyons County Park on the right. Road curves left. |
| 0.1 | 12.2 | STOP (2-way). Crossroad intersection (Poor Farm Road and 1100E, Park Road). TURN LEFT onto 1100E, Park Road (heading south). |
| 0.25 | 12.45 | Old cemetery on the left. Golf course on the right. |
| 0.3 | 12.75 | Mount Carmel City Park entrance to the right. |
| 0.55 | 13.3 | STOP (3-way): intersection of Park Road and College Drive. TURN LEFT onto College Drive and prepare to make an immediate right turn. |
| 0.05 | 13.35 | T-intersection (College Drive and Oak Street). TURN RIGHT onto Oak Street. |
| 0.1 | 13.45 | To the right are the various buildings of the 120-acre Wabash Valley College. A public referendum established this college in December 1960. In February 1969, Wabash Valley College became part of the first three-campus community college district (No. 529) in downstate Illinois. The other schools in this district are Olney Central College and Lincoln Trial College, Robinson. This college district is composed of 21 high school districts covering more than 3,000 square miles in southeastern Illinois. The Brubeck Arts Center is on the immediate right. |
| 0.55 | 14.0 | Crossroad intersection of Poplar Street (1380N) and Oak Street (1090E). On the left of the road is an old geared central power unit. These pumping units |

| | | |
|---|---|---|
| | | are centrally located and provide power for pumping several wells within an oil field. Pull-rod lines connect the central power unit to the individual pumping jacks. |
| 0.6 | 14.6 | Stoplight. Intersection of Ninth Street (Route 15) and Oak Street. CONTINUE AHEAD. General Baptist Nursing Home on the right. After crossing the intersection, to the left is the Snap-On Tools Manufacturing Company. The original factory opened in 1937 and employed 300 to 400 workers. |
| 0.15 | 14.75 | CAUTION: Cross single set of railroad tracks. Guarded crossing with arms and lights. |
| 0.05 | 14.8 | T-intersection from the right (Willow Swamp Road). CONTINUE AHEAD. |
| 0.05 | 14.85 | CAUTION: Cross single set of railroad tracks. Unguarded, signal lights only, no guard gates. |
| 0.25 | 15.1 | STOP (1-way). T-intersection (Oak Street and Third Street, Route 1). TURN RIGHT onto Route 1, heading southwest. |
| 0.4 | 15.5 | T-intersection from the left (1060E). CONTINUE AHEAD. |
| 0.25 | 15.75 | Middle of overpass bridge; railroad tracks below. After crossing the bridge, Route 1 makes a large gentle curve to the left. |
| 1.55 | 17.3 | T-intersection from the left (930E). CONTINUE AHEAD. |
| 0.55 | 17.85 | T-intersection from the right. CONTINUE AHEAD. The gravel road to the right leads to a new lake that was created by damming Sugar Creek. Note: The direction of Sugar Creek is fault controlled; that is, the creek follows the same trend and directly coincides with the New Harmony Fault. |
| 0.25 | 18.1 | Crossroad intersection (1120N). CONTINUE AHEAD. The community of Schrodts Station is to the left. |
| 0.2 | 18.3 | The flat topography to the right is the former lake bottom of Glacial Lake Bonpas. |
| 0.3 | 18.6 | Crossroad intersection (820E). CONTINUE AHEAD. |
| 0.25 | 18.85 | Good view on the right of the flat topography of the bottom of the Wisconsin-age Glacial Lake Bonpas. |
| 1.3 | 20.15 | Crossroad intersection of 700E (Maud Road) and 1000N (Route 1). CONTINUE AHEAD. The community of Maud is 2 miles north of this intersection. |
| 0.05 | 20.2 | Cross Coffee Creek. |
| 0.4 | 20.6 | Prepare to turn left. |
| 0.45 | 21.05 | Entering the community of Keensburg, population 250. |
| 0.05 | 21.1 | T-intersection from the left (Coal Mine Road). TURN LEFT onto Coal Mine Road. Note brown sign marking Beall Woods. After making turn, you will cross the |

| | | |
|---|---|---|
| | | abandoned New York Central Railroad grade. Coal Mine Road becomes First Street in Keensburg. |
| 0.3 | 21.4 | Timberlake Furniture Company to the left. |
| 0.1 | 21.5 | Y-Intersection (900N and 660E). Road curves left; continue on the blacktop heading east. |
| 0.2 | 21.7 | Coffee Cemetery to the right. This small cemetery hill is a sand dune. |
| 0.6 | 22.3 | Surface operations of Amax Coal Company's Wabash Mine. |
| 0.1 | 22.4 | T-intersection from the right (750E and 900N). CONTINUE AHEAD. Prepare to TURN RIGHT into parking lot. |
| 0.05 | 22.45 | TURN RIGHT into gravel parking lot. Stop 3. |

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**STOP 3 Amax Coal Company, Wabash Mine** We will discuss the history of coal mining within Wabash County, and the current operations of the Amax Coal Company's Wabash Mine.

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|---|---|---|
| 0.0 | 22.45 | Leave Stop 3. TURN RIGHT onto 900N. |
| 0.2 | 22.65 | In the distance to the left is the large spoil pile; and close to the road are two smaller piles that are labeled topsoil. |
| 0.25 | 22.9 | Crossroad intersection (900N and 800E). CONTINUE AHEAD and prepare to make LEFT TURN into Beall Woods State Park and Natural Area. |
| 0.05 | 22.95 | TURN LEFT into park. |
| 0.15 | 23.1 | View of a manmade lake to the right; stay on the main blacktop road. |
| 0.3 | 23.4 | Y-intersection: Keep right toward the Red Barn Interpreter Center. |
| 0.3 | 23.7 | Red Barn Interpreter Center. Stop 4, LUNCH: Are you hungry? After we leave the park, we will reset our trip odometer to 0.0 at the park exit. |

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**STOP 4 Beall Woods** Following the lunch break, we will discuss the natural resources of Beall Woods, and take one of two trails within the park to view some of the geologic and natural wonders of the park. Leave Stop 4. Retrace the route to the park exit. At the park exit, reset your trip odometer to 0.0.

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| Miles to next point | Miles from start | |
|---|---|---|
| 0.0 | 0.0 | Park exit. Turn right onto 900N. |

| | | |
|---|---|---|
| 0.05 | 0.05 | Crossroad intersection (900N and 800E). CONTINUE AHEAD. |
| 0.45 | 0.5 | T-intersection from the left (750E). CONTINUE AHEAD. Entrance to Amax Coal Mine to the right. |
| 0.7 | 1.2 | Coffee Cemetery on the left. |
| 0.2 | 1.4 | CAUTION: Y-intersection (660E and 900N). Main road curves to the right. CONTINUE AHEAD and stay on 900N, the narrower road. |
| 0.2 | 1.6 | Intersection of Third and Fourth Streets. Entering Keensburg. CONTINUE AHEAD on Third Street. |
| 0.2 | 1.8 | Intersection of Market Street and Third Street. CONTINUE AHEAD. Keensburg Fire Department is to the right of the road after the intersection. |
| 0.05 | 1.85 | Intersection of Railroad and Third Streets. TURN LEFT onto Railroad Street. |
| 0.1 | 1.95 | T-intersection from the right. CONTINUE AHEAD; stay on Railroad Street. |
| 0.15 | 2.1 | Road curves left. |
| 0.35 | 2.45 | Directly ahead to the south is the beginning of part of the McCleary Bluffs, a bedrock high. |
| 0.55 | 3.0 | Road gently curves right. |
| 0.15 | 3.15 | Crossroad intersection (800N and 600E). CONTINUE AHEAD on blacktop. |
| 0.4 | 3.55 | Top of the hill. |
| 0.65 | 4.2 | T-intersection (700N and 560E). TURN RIGHT onto 700N. Note: Directly in front was an old apple orchard. To the southeast, the large hill was the site of the former Hillcrest Coal Company, a slope mine that mined the Friendsville Coal. |
| 0.15 | 4.35 | Crossroad intersection (700N and 550E). CONTINUE AHEAD. |
| 0.55 | 4.9 | Small hill in the field to the right is a sand dune, an example of the Parkland Sand. Road ascends a small hill. The texture of the soil in the ditch is very sandy at the top of the hill. |
| 0.2 | 5.1 | The hole to the right currently being drilled will produce rock dust for the Amax Coal Company mine. Powdered limestone from the surface will be delivered down into the mine. The rock dust (limestone) is used to cover the face of the coal to reduce the risk of a methane explosion. |
| 0.25 | 5.35 | T-intersection from the left (690N and 470E). CONTINUE AHEAD. |
| 0.05 | 5.4 | The small pond to the right is the site of an abandoned gravel pit. |
| 0.2 | 5.6 | To the right on top of hill is a long white barn. This hill is a sand dune (Parkland Sand). |

| | | |
|---|---|---|
| 0.2 | 5.8 | Antioch Cemetery and site of former church. Small brick building commemorating site of the church. |
| 0.1 | 5.9 | To the right is construction for the new air shaft for the Amax Coal Company. Note the tree-line to the left of the road. The road traverses McCleary Bluff. |
| 0.35 | 6.25 | T-intersection (400E and 690N). TURN RIGHT onto 400E. |
| 0.2 | 6.45 | Entrance road to Amax Coal Company air shaft. TURN RIGHT. Note: Turn off 2-way radios including CBs when entering the site. |
| 0.25 | 6.7 | Stop 5. Construction site of new mine air shaft. |

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**STOP 5 Amax Coal Company, Wabash Mine, air shaft** We will discuss the construction of the air shaft and look at some of the materials being brought to the surface.

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| | | |
|---|---|---|
| 0.0 | 6.7 | Leave Stop 5. Retrace route to the entrance road. |
| 0.25 | 6.95 | STOP (T-intersection). TURN LEFT onto 400E. |
| 0.2 | 7.15 | T-intersection (690N and 400E). TURN LEFT onto 690N. Note: Stop (1-way) from the right. |
| 0.35 | 7.5 | Passing Antioch Cemetery and site of old church on the right. |
| 0.55 | 8.05 | T-intersection from the right (690N and 470E). TURN RIGHT onto 470E. |
| 0.85 | 8.9 | Crossroad intersection (600N and 470E). CONTINUE AHEAD. Prepare to STOP. |
| 0.1 | 9.0 | Stop 6. Sand Dune. Enter through gate. Note: This is private property. You must ask permission before entering. |

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**STOP 6 Wisconsin-age sand dune (Parkland Sand)** We will view and discuss the deposition of the sand dune on the left of the road.

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| | | |
|---|---|---|
| 0.0 | 9.0 | Leave STOP 6. CONTINUE AHEAD. |
| 0.4 | 9.4 | The tree-line to your right and the second tree-line to your left mark the position of the Wabash River. We are entering a large neck of land located within a large meander. The deposits we are traversing are point bar deposits and associated flood plain deposits. |
| 0.2 | 9.6 | Road curves right 90°. |
| 0.2 | 9.8 | Road curves left 90°. The Wabash River is to the right. On the west bank of the river, a large sand bar is visible at low stage. |

| | | |
|---|---|---|
| 0.3 | 10.1 | To the left you can see the Denham Levee. |
| 0.6 | 10.7 | To the right is a large area that is lower than the surrounding flood plain. In the spring this area is filled with water and is a great site for viewing white egrets, blue herons, and other waterfowl. The slope on the right of the road contains a number of glacial erratics. |
| 0.2 | 10.9 | Directly to the right, looking west, you can see the nonvegetated portion of the levee, which was the site of a levee failure in the spring of 1996. Follow the oil field lease road that parallels the levee to left of the road. |
| 0.4 | 11.3 | Small clump of trees on the right of the road. Notice the sand that is being built up in the trees. This is the development of a young dune. The trees are acting as a sediment baffle and blocking the blowing sand from the fields, which deposits the sand near the base of the trees. |
| 0.4 | 11.7 | Stop at T-intersection of oil field lease roads directly in front of the levee. Park cars along the right side of the road. Stop 7. |

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**STOP 7 Schuh Bend on the Wabash River** At this stop we will discuss, observe, and examine oil production, a failure in the Denham Levee, and the formation of the large sand bar at Schuh Bend.

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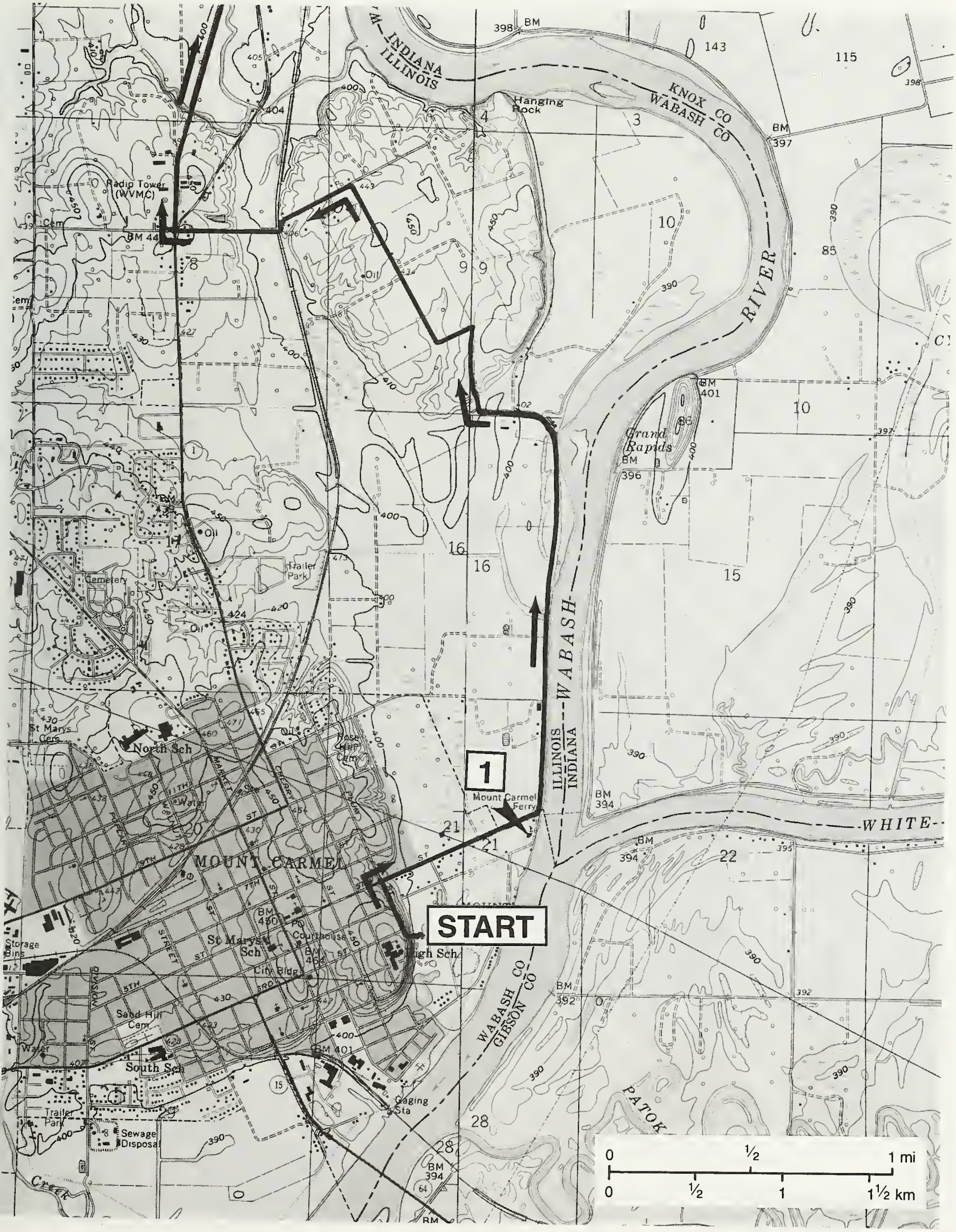
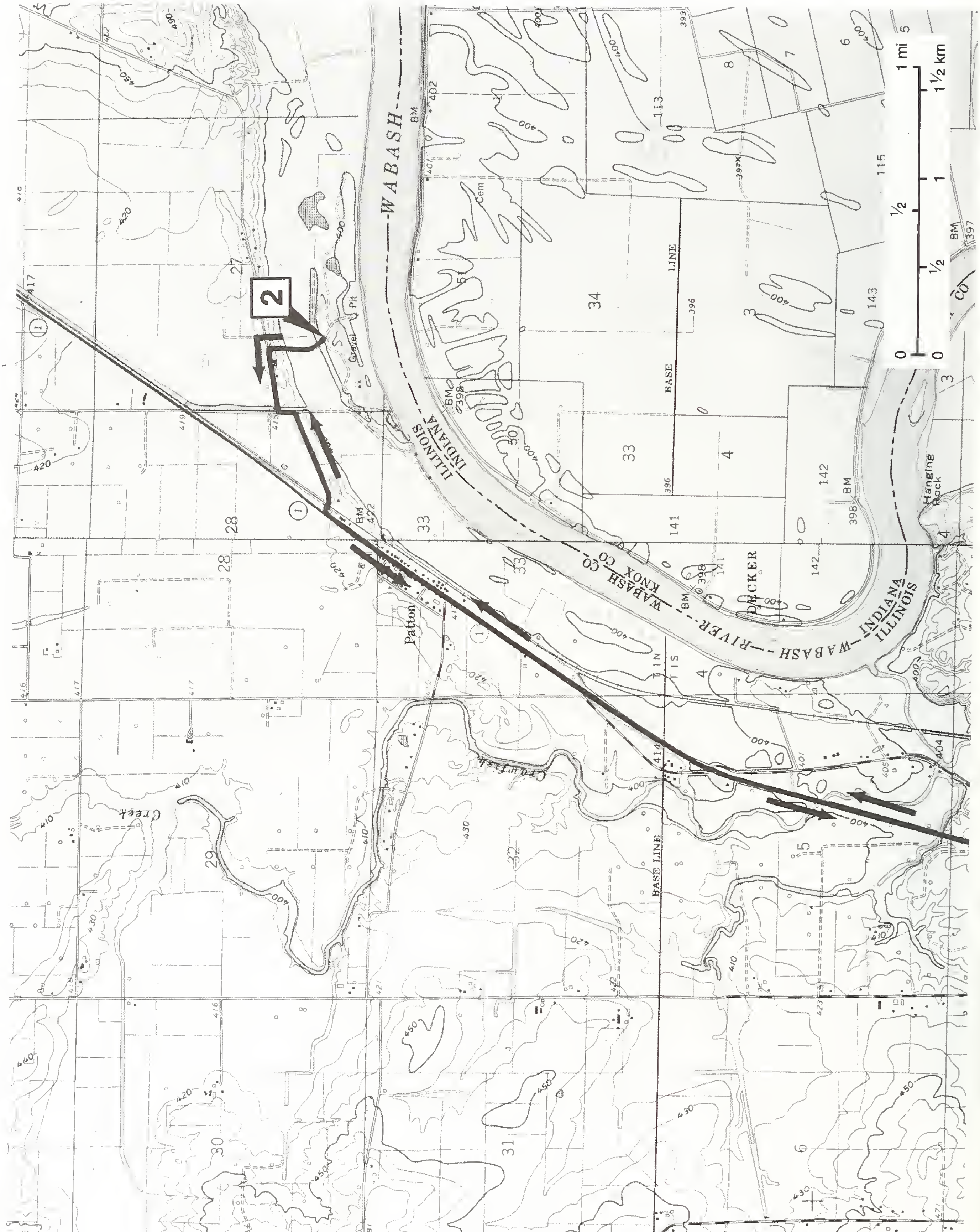
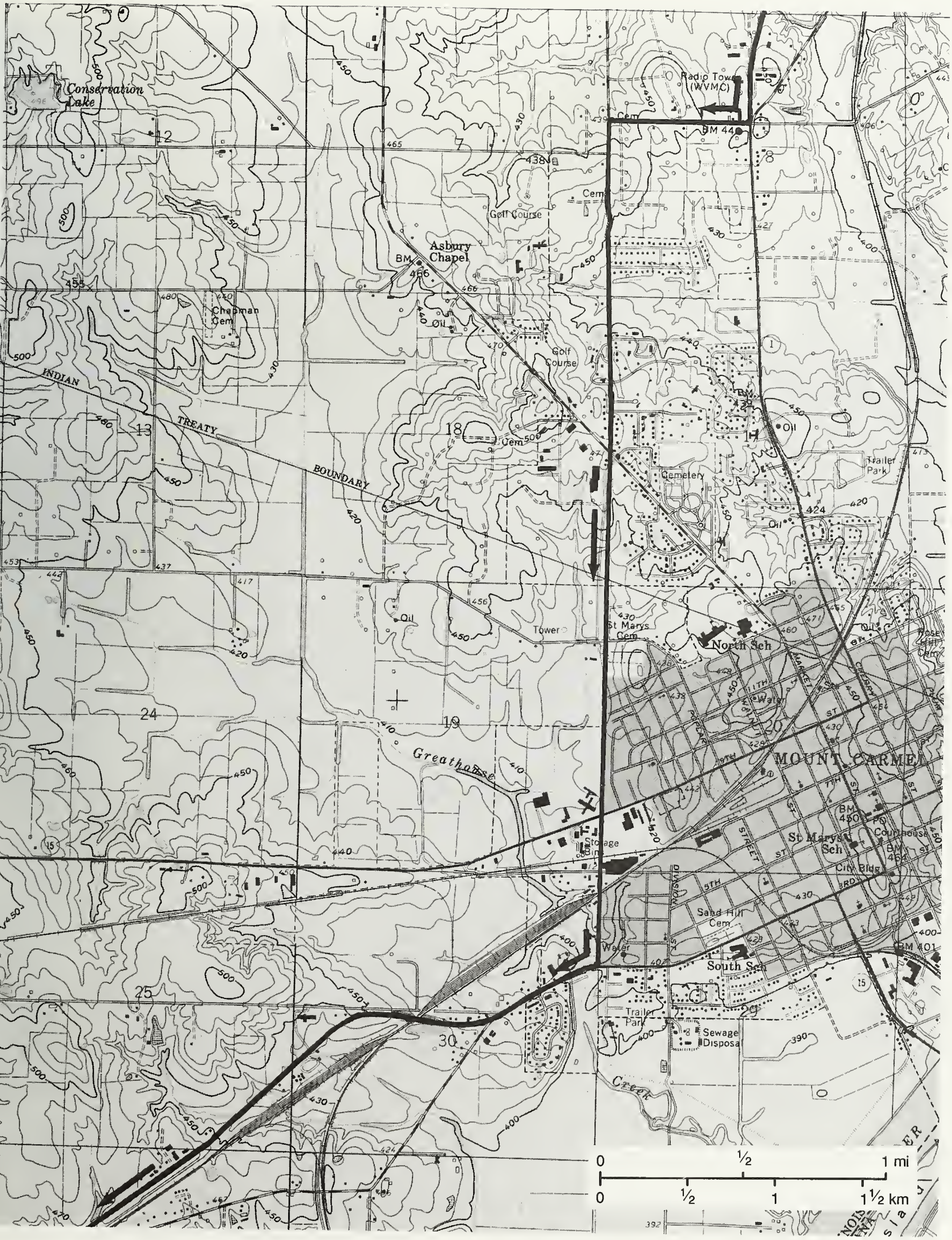
End of road log.

Leave stop 7. Retrace route north to 690N, turn left and continue to 400E and turn right. This will take you to Route 1. If you turn right onto Route 1 you will be heading toward Mt. Carmel, if you turn left you will be heading toward Grayville and Route 64. An alternate scenic route would be to follow the Wabash River.


START
1
Mount Carmel Ferry
MOUNT CARMEL
WABASH RIVER
WHITE
INDIANA
ILLINOIS
KNOX CO
WABASH CO
GIBSON CO
Hanging Rock
Grand Rapids
Radio Tower (WVMC)
North Sch
South Sch
St Marys Sch
High Sch
Courthouse
City Bldg
Sand Hill Cem
St Marys Cem
Rose Hill Cem
Cemetery
Trailer Park
Sewage Disposal
Storage Bins
Gaging Sta
PATOKA
0 ½ 1 mi
0 ½ 1 1½ km


2
WABASH
RIVER
WABASH CO
KNOX CO
INDIANA
ILLINOIS
Patton
DECKER
Hanging Rock
BASE LINE
Gravel Pit
Cem
Creek
1 mi
1½ km


Conservation Lake
(WVMC)
Cem
Golf Course
Asbury Chapel
BM 466
Chapman Cem
INDIAN
TREATY
BOUNDARY
Cemetery
Trailer Park
St Marys Cem
Tower
North Sch
Greathouse
MOUNT CARMEL
Storage Bin
St Marys Sch
Courthouse
City Bldg
Sand Hill Cem
South Sch
Water
Trailer Park
Creek
12
7
8
13
18
24
19
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29
0
½
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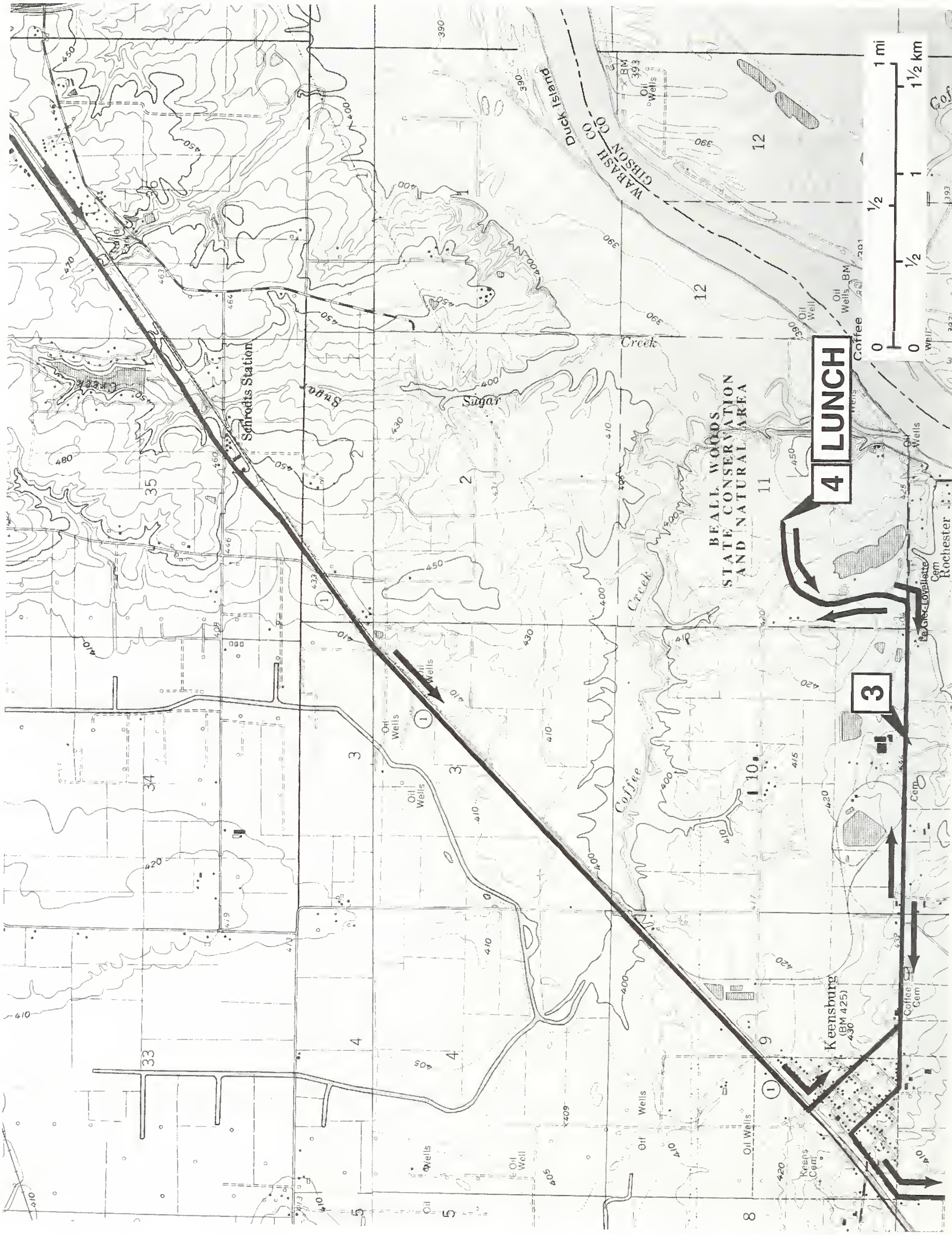
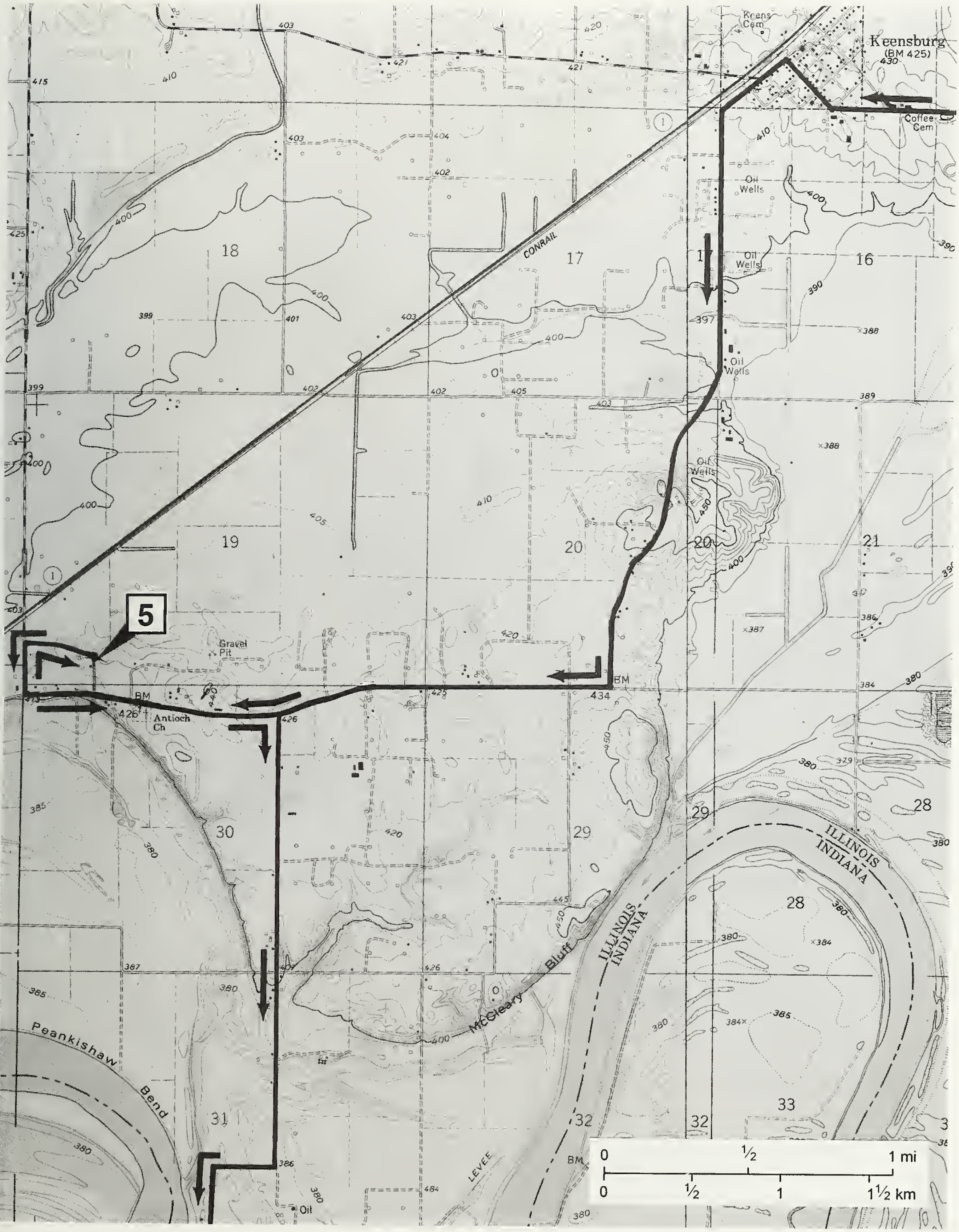
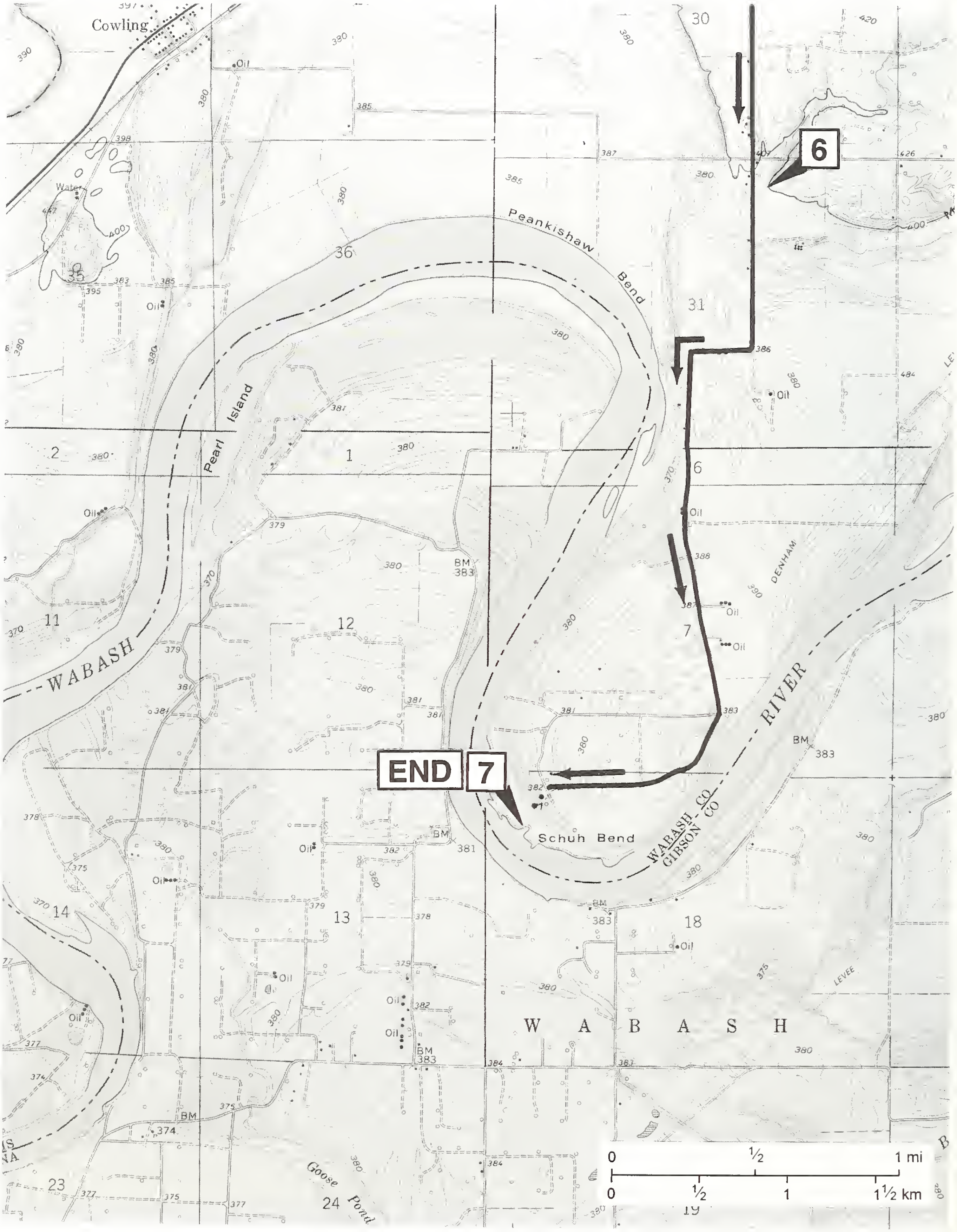
½
1
1½ km


4 LUNCH
3
BEALL WOODS STATE CONSERVATION AND NATURAL AREA
Keensburg
(BM 425)
Schrodts Station
Rochester
Duck Island
WABASH CO
GIBSON CO
Coffee Creek
Sugar Creek
La Gros-Lovellette Cem
Coffee Cem
Keens Cem
Oil Wells
0
1/2
1 mi
0
1/2
1
1 1/2 km



Keensburg
(BM 425)
Keens Cem
Coffee Cem
Oil Wells
CONRAIL
18
17
16
19
20
21
30
29
28
31
32
33
5
Gravel Pit
BM
Antioch Ch
McCleary Bluff
Peankishaw Bend
ILLINOIS
INDIANA
LEVEE
Oil
0
½
1 mi
0
½
1
1½ km


Cowling
Peankishaw Bend
Pearl Island
WABASH
RIVER
6
END
7
Schuh Bend
WABASH CO
GIBSON CO
DENHAM
LEVEE
Goose Pond
W A B A S H
0
½
1 mi
0
½
1
1½ km

## STOP DESCRIPTIONS

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**STOP 1 Confluence of Wabash and White Rivers** (NE, NW, SW, Sec. 11, T13W, R2S, 2nd P.M., Wabash County; Keensburg 7.5-Minute Quadrangle)

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At this stop we will discuss the geomorphology of the Wabash and White Rivers. An aerial view of the confluence of the White and Wabash rivers is shown in figure 11.

The name Wabash is derived from the name the Indians gave the river, "Ouabacke." In the native american language, the name means many things: "White Waters," "Moving Cloud," "Silver Water," "Swift Summer Cloud," and "Mad Bull." The early French explorers named the river St. Jerome; but the Indians and early settlers refused to accept that name, and the name Wabash remains today.

**Wabash River Basin**

The area of the Wabash River Basin is 32,910 square miles; 285 are in Ohio, 23,921 are in Indiana, and 8,704 are in Illinois (fig. 12). The Wabash River is the largest natural, free-flowing river east of the Mississippi River. The headwaters of the Wabash River start south of Grand Lake about 12 miles east of the Indiana-Ohio State line in Drake County, Ohio. The mouth flows into the Ohio River at the southern end of the Indiana-Illinois state line. The Wabash River is approximately 475 miles long, and ranks 49th among the 135 U.S. rivers that are more than 100 miles long. The river widens from 200 feet at Huntington to 400 feet at Covington, and it is 1,200 feet wide at its mouth. The river is about 30 feet deep in the lower 50 miles, but it is usually less than 5 feet deep above Huntington, Indiana. The average rate of flow at Covington, Indiana is 3 million gallons per minute (gpm); at Mount Carmel, Illinois, the rate is 12 million gpm. The Wabash ranks 15th in average discharge among the rivers of the United States. The highest recorded rate of flow, 192,086,400 gpm, occurred at Mount

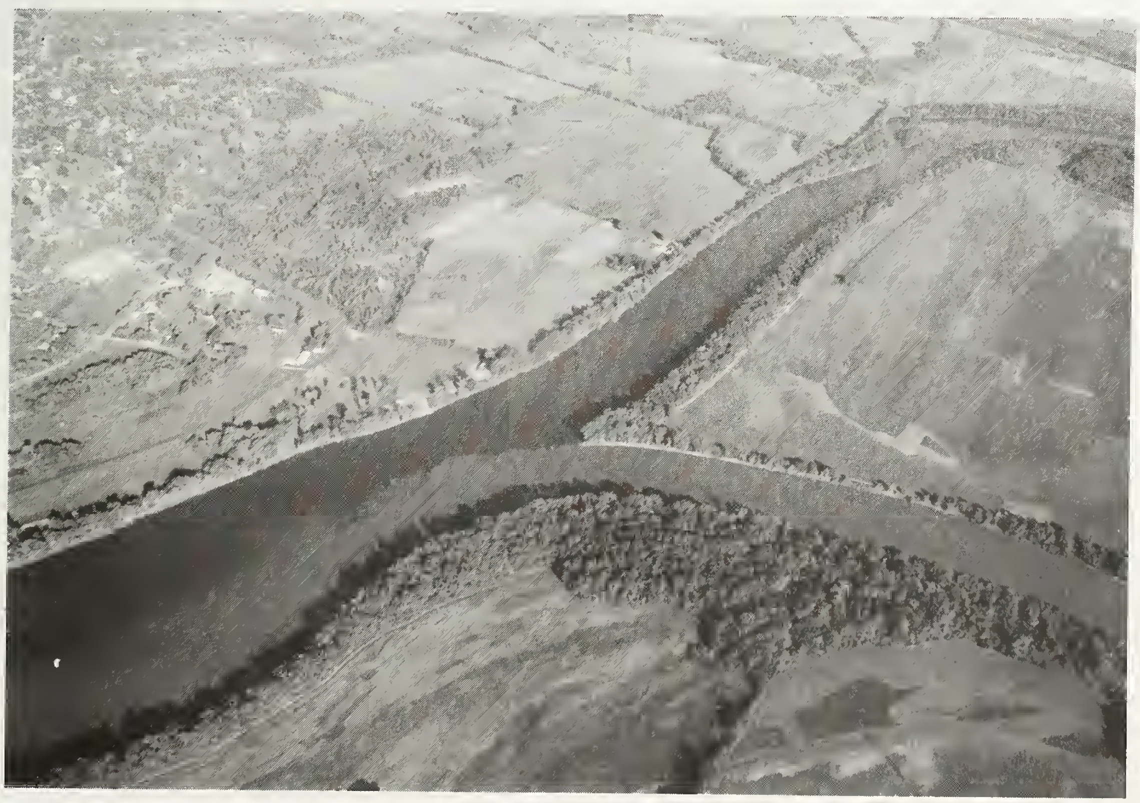

**Figure 11** Confluence of the Wabash and White Rivers (photo by W.T. Frankie).


**Figure 12** Wabash River Drainage Basin (from USGS informational flyer).

Carmel in March 1913; the lowest flow, 740,520 gpm, occurred at Mount Carmel in September 1941. About 2.5 million people within the Wabash River Basin use 500 million gallons of surface and ground water each day. About 1 million people on farms and in small towns use 170 million gallons each day, mostly groundwater.

## History of the Wabash Valley

**Ancient river drainage across the Midwest** The modern Wabash River is a recent development of a changing river system. The modern rivers—the Missouri, Mississippi, Illinois, Wabash, Ohio, to name only the larger ones—are descendants of ancient rivers, but descendants many times removed from the courses of their ancestors. In the past million or so years, the courses of the modern rivers were created and repeatedly changed by the Pleistocene glaciers. Each ice sheet flowing from Canada into Illinois and the Midwestern lowland changed the ancient drainage patterns north of central Missouri and Kentucky.

These advancing glaciers often covered river valleys, buried the valleys with drift, and diverted rivers. Each glacier shed immense quantities of meltwater that deepened some of the older valleys, eroded new ones, and filled many with outwash. When the last glaciation, the Wisconsinan, ended in Illinois about 13,500 years ago, the present drainage had been formed across the Midwest.

**Age of the Lower Wabash Valley** The approximate dating of the valley's beginning depends on a simple geologic rule: A stream valley is younger than the youngest rock or sediment deposit that it cuts through, and is older than the oldest rock or sediments that it deposited in it. The youngest deposit that is thought to pre-exist within the Lower Wabash Valley and be cut by it is the Mounds Gravel. This unit is a brown chert gravel, found in beds on the tops of a few of the higher hills near the mouth of the valley. The age of the Mounds Gravel is not precisely known. It is evidently not older than the Pliocene in Illinois but may in fact be younger, perhaps very early Pleistocene.

The oldest sediment deposits that have been found in the ancient watershed of the Wabash Valley are thought to be pre-Illinoian tills—silty, sandy, gravelly clays laid down by the earliest glaciers. But the oldest deposits found in the Wabash Valley itself were deposited by Illinoian glaciers.

From this evidence, geologists have theorized that erosion began to form the Lower Wabash Valley between, very roughly, 1 to 2 million years ago (late Pliocene) and 600,000 years ago (the estimated time of the end of the pre-Illinoian glaciation).

**Recent geologic history of the Lower Wabash Valley** Recent geologic episodes in the geologic history of the valley are the ones for which the evidence of landforms and deposits has been found.

**Early glacier-fed rivers erode the bedrock valley** Glacial deposits found in eastern Illinois and Indiana indicate that glaciers entered the region of the Lower Wabash Valley during the pre-Illinoian and the Illinoian glaciations. The glaciers flowed from Canada through the troughs now holding Lake Erie and Lake Michigan, and some of their meltwater floods drained south through the Lower Wabash Valley.

When the glaciers were distant from the valley, the meltwaters running through it were largely free of the coarser sediments and probably removed more sediment from the valley than they brought to it. At such times, the meltwaters cut the valley deeper. When glaciers were close to the valley, their meltwaters washed great quantities of mud, sand, and gravel (outwash) from the ice front into the valley, partly filling it. Between glaciations, as at present, runoff from rain and snowmelt eroded the valley and removed outwash deposits. Because the volumes of meltwater released by the Pleistocene glaciers were so very large, and because the meltwater released by each glaciation seems to have removed the drift deposits of the preceding glaciation from the valley, it is generally believed that the drainage from these earlier glaciations cut the Lower Wabash Valley deeper into bedrock and formed the Wabash Bedrock Valley. Possibly the bedrock valley was formed during the early Pleistocene by pre-Illinoian glaciation or even earlier. However, Pre Illinoian drift has not been identified in the Lower Wabash region, and the erosion of the region by the later Pleistocene glaciers and their meltwaters has apparently hidden or removed the old features and deposits that would be evidence of pre-Illinoian drainage.

**The Wisconsinan glaciation erodes and fills the valley** About 22,000 years ago, the Woodfordian advance of the Wisconsin Episode glaciation reached its southern limit and deposited the ridges of the Shelbyville Morainic System at the head of the Lower Wabash Valley, about 65 to 70 miles north of Mount Carmel. With the glacier standing at the head of the valley, meltwaters filled the valley more than half full of gravel, sand, and mud from the ice. Most of this glacial outwash remains in the valley now, forming a type of glacial deposit called a *valley train.*

In the Mount Carmel area, the surface of the valley train probably formed a floodplain and valley floor at a level perhaps 80 to 100 feet above the current floodplain of the Wabash River. Erosion in the valley since the retreat of the Woodfordian glacier has cut the valley floor down to its present level. Remnants of the Woodfordian valley-train surface can be seen on terraces along the sides of the Lower Wabash Valley north of Vincennes, Indiana. None have been found south of there. Terraces are step-like landforms produced when a stream trenches a new valley floor down into an older valley floor. The older floodplain is the upper "tread" of the step, the younger floodplain is the lower "tread," and the short slope connecting them is the "riser."

As the Woodfordian valley train filled in the Lower Wabash Valley and raised the valley floor, it blocked the mouths of the tributary creek valleys that joined the Wabash Valley at its deeper level. The tributary streams became lakes as their waters rose to the level of the water on the valley-train surface. In the Mount Carmel area, lakes filled the valleys of Crawfish and Bonpas Creeks and the Little Wabash River. The very wide, extremely level floors of these present valleys were originally lake beds. The glacial lakes trapped sediment and filled in their bottoms with silt, which was mostly washed from the hills around them.

**The Maumee Flood erodes the Woodfordian valley train** In the time between about 22,000 and 13,500 years ago, the Woodfordian glaciers melted back (retreated) from the Shelbyville Morainic System in Indiana and central Illinois to positions in the Great Lakes troughs. The glacier retreating into the Erie Basin created Glacial Lake Maumee, which was a meltwater-swollen, higher level, larger ancestor of Lake Erie. Glacial Lake Maumee extended across northern Ohio to Fort Wayne, Indiana, and was confined between the glacier along its northern margin and by the end moraine that the glacier had laid down around its southern margin.

About 13,500 years ago, the glacial lake overtopped its moraine dam at Fort Wayne, cutting a gap and spilling down the Wabash River. This torrential drainage is called the Maumee Flood. The Maumee Flood eroded the Woodfordian valley-train surface, cutting a new valley floor called the Maumee erosional surface, which is about 20 feet lower than the original deposits of the Wisconsinan valley train. Erosion in the valley since the Maumee Flood has produced the present lower floodplain and left remnants of the Maumee erosional surface as terraces down the length of the Lower Wabash Valley. In the Mount Carmel area, the Maumee erosional surface, or terrace level, is 10 to 15 feet above the present floodplain.

**The modern Wabash River excavates its floodplain** After the Maumee Flood, from the waning of the Wisconsinan glaciers to the present, the drainage from the Wabash watershed has eroded a channel in the older deposits and has filled it with alluvium to the level of the present floodplain, which is 10 to 15 feet below the level of the Maumee floodplain.

The Wabash River Channel follows a winding course through the lower Wabash Valley. The channel drops only about 6 inches for each channel mile. The landforms of the floodplain are shallow and low, streamlined grooves and ridges left by the river: oxbow lakes, channel scars, flood plain scrolls, and natural levees.

**Grand Rapids Dam** The Wabash River was once the highroad for traders and travellers through this part of Illinois and Indiana. Today, only the occasional passing of a fisherman's boat reminds us of the traffic of the past—the Indian canoes and dugouts, the French voyageurs, and the American flatboats and steamboats.

Rapids like these sometimes become sites for human settlements and enterprises. Rapids interfere with boat passage, sometimes requiring that cargo be landed and portaged. The shallow rock bottoms of rapids make good foundations for dams, which provide locks for boats and water power for mill-wheels. The Grand Rapids were apparently not a formidable barrier to shallow-draft boats. Histories of the county tell that steamboats going and coming from Terre Haute passed over the rapids about once a year from 1819 until the first dam was built in 1847.

According to T.G. Risley's *Historic of Wabash County* (1911), as early as 1837, land speculators realized the possibilities of damming the river at the rapids and attempted to create a town here. In 1847, the Wabash Navigation Company built a wooden dam and locks to aid navigation and to supply power for flour and saw mills. This wooden dam gave way in 1879. The second dam and locks were built by the federal government in the 1880s at a cost of $340,000. This second dam was 1,100 feet long and 12 feet high, and included a system of locks. An early famous resort and a favorite vacation site for anglers was the Grand Rapids Dam Hotel built by Fred Zimmerman in 1921. The hotel burned in 1929, and nothing is left but memories of the busy resort. The dam washed out in 1931 and 1932. All that remains of the dam are the sandstone and concrete structures along the banks of the Wabash.

**Shipping on the Wabash** The first steamboat to land at Mount Carmel came in 1819. It was the boat *Commerce* from Cincinnati, and it proceeded upriver to Terre Haute. By 1830, there was regular steamboat traffic to the towns of Mount Carmel and Rochester (located south of Beall Woods, Stop 4). On a spring day in 1849, just after the ice went out at Grand Rapids, one observer cited by Risley counted 40 flatboats passing Rochester and bound for New Orleans. As railroads were built in the Midwest, the river traffic diminished. In 1872, when the Southern Railroad brought its line from Albion into Mount Carmel, the town was no longer bound to the river.

**Pearl and shell fishing** For a short time in the early 1900s, this reach of the Wabash River was a pearl and shell fishery. Mussels were gathered from the river bottom and searched for pearls. The mussel shells were used to make buttons and other mother-of-pearl items.

Clams, oysters, snails, mussels, and other mollusks grow shells by secreting calcium carbonate from their mantle tissues. The lustrous, pearly inner layer of such shells is called mother-of-pearl. Pearls are the rounded, smooth concretions of shell material—separate from the shell—that sometimes grow around foreign particles that lodge in the mollusc's mantles. Although oysters supply most of the pearls that humans collect, freshwater mussels and some large marine snails also grow pearls.

According to Risley's history, pearl and shell fishing began in the Mount Carmel area in 1902 and persisted for a decade or two after that. By 1905 Mount Carmel became known as "Pearl of the Wabash." An estimated 4,000 "mussel-men" dragged the Wabash in about a 40-mile reach, which centered on Mount Carmel. These mussel-men were spurred by such legends as the Jumbo Adams pearl, said to be as big as a marble. This pale blue pearl found its way to Tiffany's of New York, and thereby to a necklace for English royalty. The real treasures, however, were the big and shiny mussel shells that were coveted by button makers the world over. By 1910 or 1911, only about 400 workers were employed, so rapidly were the shellfish depleted. Estimates that Risley obtained set the total value of the pearls taken from the river along Wabash County at about $1,300,000 and the value of the shells at as much as $700,000.

**Figure 13** Abandoned sand and gravel pits along the Wabash River (photo by W.T. Frankie).

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**STOP 2 Allendale Gravel Company, abandoned sand and gravel pits** (fig. 13) (SE and SW of SW, Sec. 27, T1N, R12W, 2nd P.M., Wabash County; East Mount Carmel 7.5-Minute Quadrangle). NOTE: This is private property. You must ask permission before entering.

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We will view the abandoned gravel pits, discuss the importance of the sand and gravel industry in Wabash County, and observe the geomorphology of the Wabash River.

Rock samples may be collected from the stockpiles, but do not scatter the rocks. These materials were mined and processed at the company pit near Lawrenceville and hauled here by truck to sell to the local market as needed.

One question which might come to mind at this stop is, How important is the mining of sand and gravel to me? In 1992 Illinois consumed 40,105,000 tons of sand and gravel at an estimated value of $180,461,000. This valuable resource is used in the construction of buildings and roads, and as fill material and industrial sand.

The Wabash River Valley may contain more than 100 feet of sand and gravel where its floor has been most deeply eroded. The sand and gravel that fills this valley is predominantly a late Wisconsinan glacial-age valley train deposit known as the Henry Formation (Willman and Frye 1970, Lineback 1979), but remnants of older valley-train deposits may be preserved in places. Downstream, the valley fill becomes more fine grained with less gravel. Gravel tends to be more abundant at depth and in the older deposits. Topographically this pit is on a very low terrace that functions as the floodplain of the Wabash River. The river is on the west side of its valley, and has eroded into an area of low-relief bedrock-cored hills and fine grained glacial-age deposits dominated by silt and clay (loess and till). In this area, bedrock may be relatively shallow under some part of the river.

About ¼ mile north of the pit is an erosional scarp where the land surface sharply rises about 20 feet. Drilling records and surficial material indicate that this higher surface is not a sand and gravel outwash terrace, but rather the eroded edge of a slack water lake deposit known as the Equality Formation (Willman and Frye 1970, Lineback 1979) that extends westward across the drainage area of Crawfish Creek. This deposit formed when the Wabash River valley was filled with outwash sand and gravel, damming up the outlets of tributary valleys and causing lakes to form. The Equality Formation is the laminated clay, silt, and sand deposited in those lakes.

Sand and gravel was mined at this location about 30 years ago by a dredge that also recovered sand and gravel from a gravel bar in the river downstream from the pit. Under favorable conditions, the deposit may have been worked to a depth of 30 feet along the banks: up to 10 feet above the water level, and 20 feet below the water level. In places, usually at depths greater than 10 feet, the deposit contained about 20% to 25% fine gravel (mostly less than 2" in diameter). The elongate shape and orientation of the pit with respect to the erosional scarp to the north and to the river (see route map) suggests that the operator may have been dredging along the trend of a subsurface gravel bar. Fine grained overburden or soil was generally only 1 or 2 feet thick, and was stockpiled for reclamation work.

At this time, small tonnages of sand are mined from this site. The sand is not processed, however, and is mainly used as trench backfill. During the early 1970s, an on-site processing plant mainly produced sand for use in asphalt-based roads.

The stockpiled gravel may be used in many construction-aggregate applications, but it probably does not meet Illinois Department of Transportation specifications for use in Portland cement highway pavement. The gravel may cause excessive D-cracking (deterioration cracking) in such highway pavement because of its relatively high content of chert with a specific gravity of less than 2.35. Sample 15 in the following table is from a pit near Russellville, Illinois. It is compared with rock-type data from sample 3, from a pit in an outwash plain in McHenry County, Illinois (data from table 18, Masters and Evans 1987, ISGS Contract Report C/G 1987-1).

| | Percentage | |
|---|---|---|
| Rock type | Sample 15 | Sample 3 |
| Dolomite | 22.2 | 64.8 |
| Limestone | 9.4 | 4.4 |
| Cherty carbonate | 6.7 | 7.4 |
| Weathered carbonate | 2.1 | 3.2 |
| Chert (low specific gravity) | 18.5+ (2.9) | 7.3+ (0.2) |
| Ironstone | 0.2 | 0.3 |
| Shale | 0.1 | 0.3 |
| Sandstone-siltstone | 8.2 | 2.7 |
| Conglomerate | 0.1 | trace |
| Mafic igneous | 4.6 | 2.8 |
| Felsic Igneous | 0.6 | 0.6 |
| Quartz & quartzite | 3.6 | 0.2 |
| Gneisses & schists | 9.0 | 3.2 |
| Metasedimentary | 8.3 | 1.4 |
| Metagraywacke | 1.3 | 1.1 |

Besides indicating the quality of the gravel product, these rock-type data also reflect differences in the kinds of rocks carried by different lobes of the Wisconsinan-age continental glacier. There is some mixing of course due to factors such as one ice lobe eroding the deposits of another. Sample 3, related to the Lake Michigan Lobe, is characterized by relatively high dolomite and low metamorphic rocks. Sample 15, mainly related to the Lake Erie Lobe, is characterized by relatively low dolomite and high metamorphic rocks.

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**STOP 3 Amax Coal Company, Wabash Mine** (figs. 14 and 15) (SW, SE, Sec. 10, T13W, R2S, 2nd P.M., Wabash County, Keensburg 7.5-Minute Quadrangle)

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Construction of the Wabash Mine began in December 1971, and coal production began in October 1973. The mine is classified as a slope mine. The mine covers approximately 36 square miles. At present, the Springfield Coal Member of the Pennsylvanian Carbondale Formation is being mined. The mine was originally designed to produce 3.6 million tons of coal annually; production in 1995 was 4.1 million tons. In 1994, eighteen continuous miners were used to mine the coal, which is then transported via underground shuttle cars to the 4-foot-wide conveyor belts that carry it to the surface preparation plant. The conveyor system is housed in a 2,670-foot-long, concrete-lined tunnel having a diameter of 17.5 feet. the tunnel slopes at an angle of 17.5°. All supplies needed underground are transported via diesel powered equipment. Miners reach the coal via an elevator in the 794-foot-deep air shaft connected to the wash-house. The Wabash Mine employs about 550 people.

The 1,500-ton-per-hour preparation plant receives the raw coal, then screens and crushes it to the size specified by the utility company. The preparation plant also removes ash, sulfur, and other undesirable materials from the coal. This plant was constructed in 1993 at a cost of $25 million. A conveyor belt carries the prepared coal up to the top of the twin 10,500-ton-capacity concrete storage silos. Each of these silos is 190 feet tall and 70 feet in diameter. Up to 5,000 tons of coal per hour can be loaded from these silos into unit trains. A unit train consisting of eighty 100-ton hopper cars can be filled from the silos in about 1.5 hours.

**Geologic characteristics of the Wabash Mine** The Galatia coal cut-out (Galatia Channel) is an ancient stream channel that existed during formation of the Springfield Coal (fig 16). The main channel body, consisting entirely of sandy shale, forms the northern limit of minable Springfield Coal reserves. The Springfield Coal thickness, quality, and, to a great extent, roof conditions are related to the Galatia Channel. Coal thickness tends to increase, and sulfur content tends to decrease near the cut-out. Mining is often inhibited near areas where the coal is split (forms two or more beds) along the channel tributaries, which locally jut out from the main channel body. Throughout the Wabash Mine, the immediate roof is a massive, silty, gray shale known as the Dykersburg Shale (fig. 17). The Dykersburg thins and becomes finer grained away from the Galatia Channel, the source area of the shale.

Regional structure dips to the northwest at approximately 20 feet per mile. Within the mine, the coal bed normally displays a gentle random structure, and the regional dip is not noticeable. Small hills and depressions, however, can create local slopes of 5% to 10% (3° to 5°).

The New Harmony Fault, trending north 20° east, separates the Wabash Mine into a west block (down-thrown), and an east block (up-thrown) (figs. 16 and 17). The mine was initially opened in the east block. Vertical displacement (throw) along the fault ranges from approximately 120 feet to 200 feet within the mine area. The fault was crossed in 1984 from the up-thrown east side, down to the west side. Coal is currently mined on both sides of the fault.

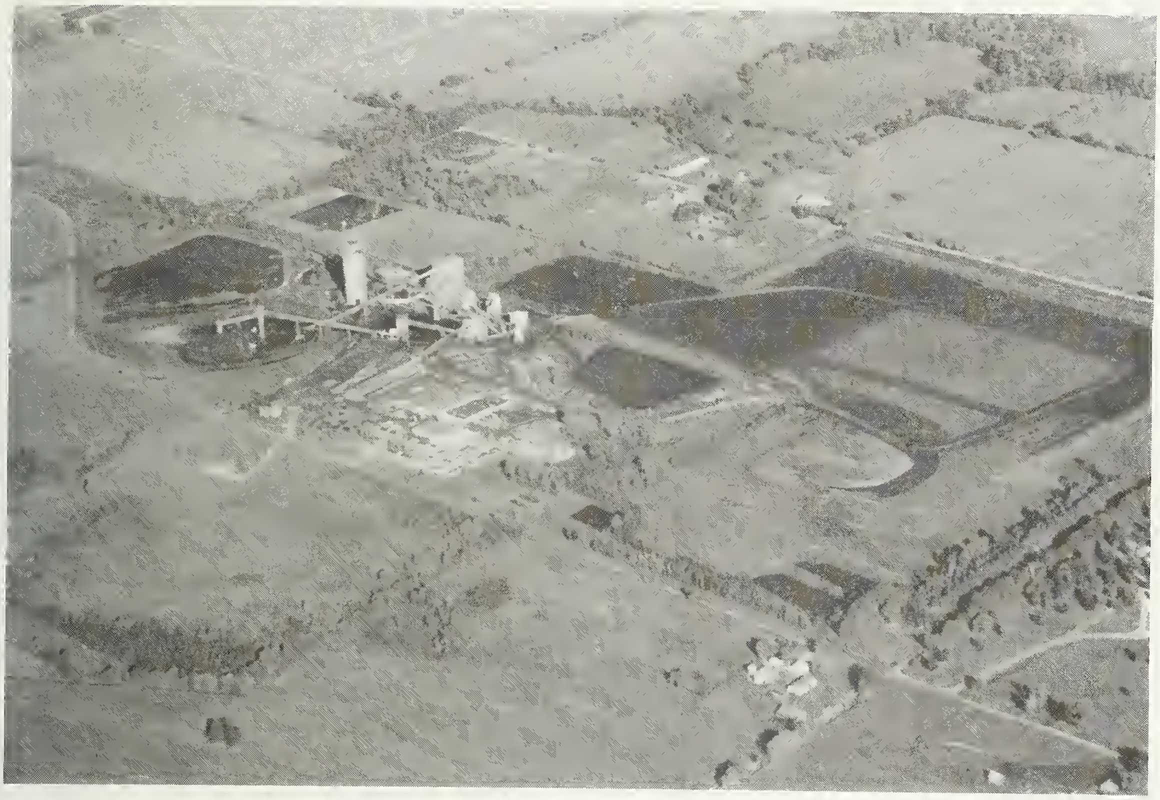


**Figure 14** Amax Coal Company, Wabash Mine (photo by W.T. Frankie).

**Figure 15** Amax Coal Company, Wabash Mine (photo by W.T. Frankie).

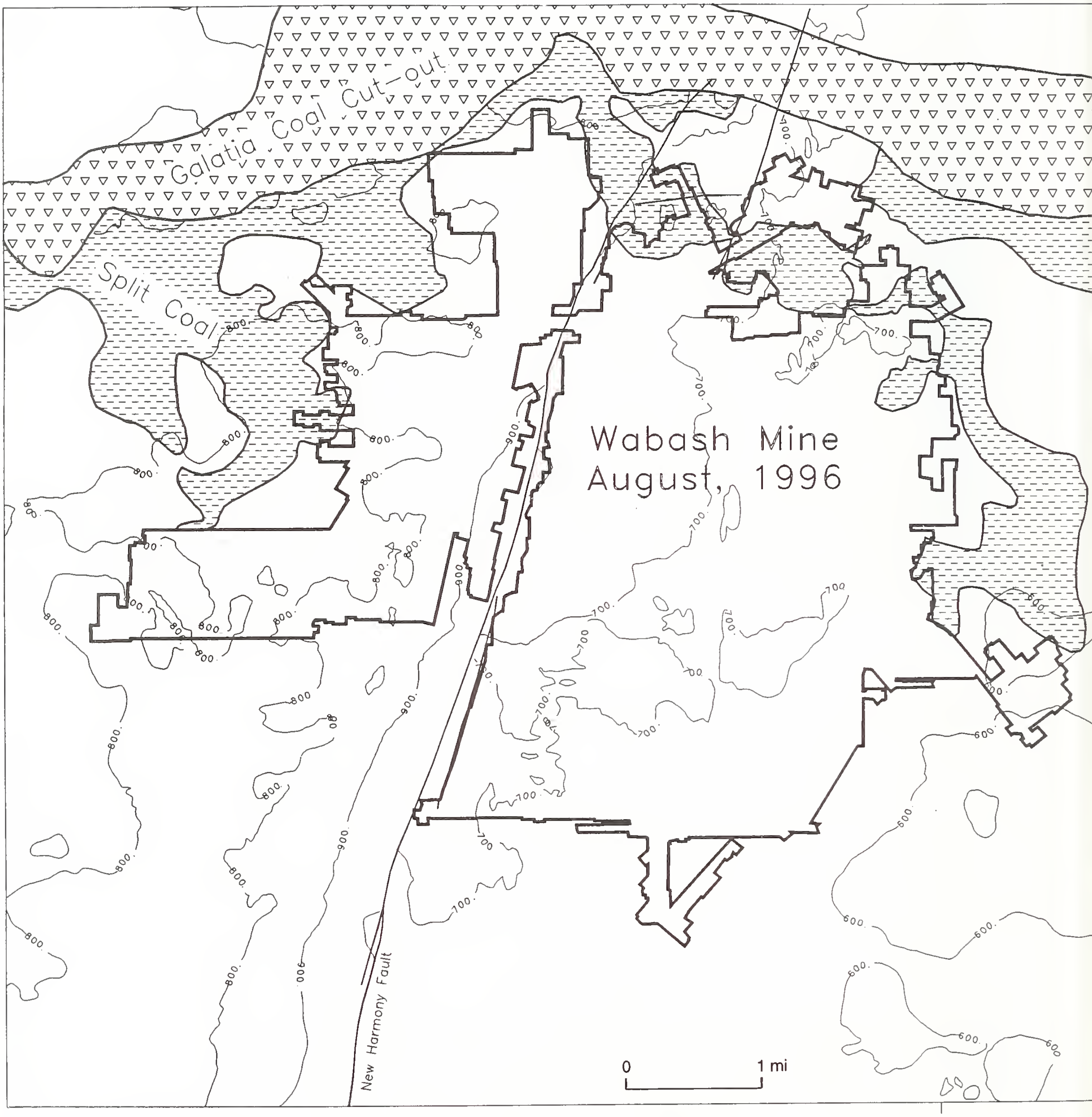
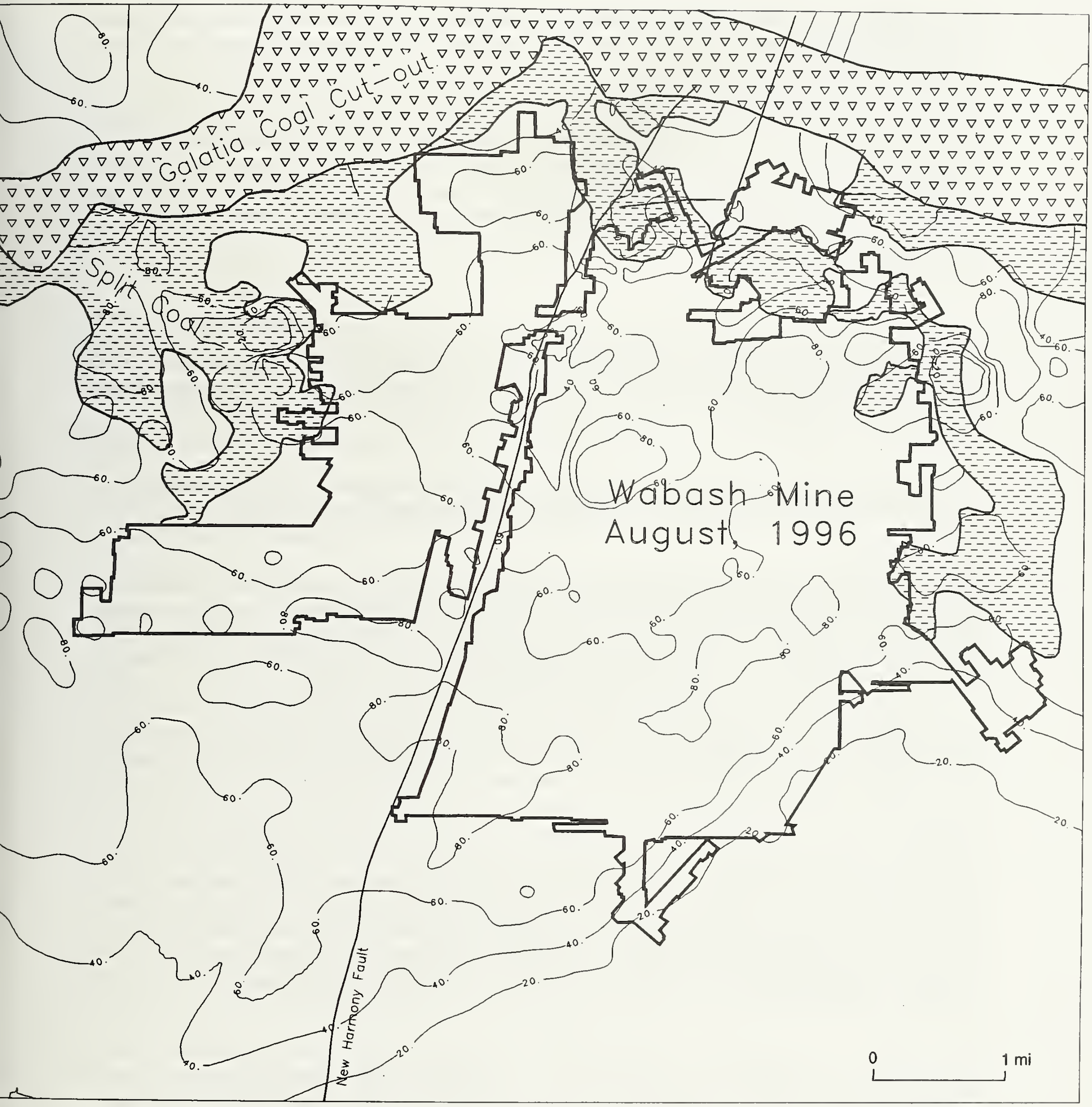



Figure 16 Mine map showing depth to the Springfield Coal (source Amax Coal Company).

**Mine depth** Surface topography above the Wabash Mine is largely flat due to the Wabash River floodplain. Variation in mine depth is due to the northwest regional dip, and the New Harmony Fault (fig. 16). Within the mined-out area, coal depth ranges from approximately 600 feet to more than 900 feet. Note the depth increase west of the New Harmony Fault. Coal depth has not been a limiting factor in mine development.




gure 17 Mine map showing thickness of the Dykersburg Shale (source Amax Coal Company).

**Dykersburg Shale thickness** The Dykersburg Shale is not entirely homogenous. Subtle variations in clay content and plant fossil debris occur throughout the mine. Note the decrease in thickness along the southeast edge of the mine outline (fig. 17). The Dykersburg becomes finer grained and thinner bedded as the total thickness decreases below approximately 50 feet. Roof control can become difficult, and sulfur in the Springfield coal bed increases, where the Dykersburg is less than approximately 20 feet thick. Therefore, relatively thin Dykersburg Shale is regarded as a limiting factor in mine development.

**Coal thickness and split coal areas** Throughout the Wabash Mine reserve area, the Springfield Coal varies in thickness from approximately 5 feet to over 9 feet. Average coal thickness is approximately 6.5 feet. The thickest coal is located near the Galatia Channel. Rock layers contained within the Springfield Coal have been encountered in the split coal areas (figs. 16 and 17). The rock layers can increase from a few inches thick to over 20 feet thick over a distance of less than 500 feet. Mining within the split coal areas is seldom productive, and prediction of split coal boundaries is a key to long-range mine planning.

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**STOP 4 Beall Woods, lunch stop** (NE, NW, SW, Sec. 11, T13W, R2S, 2nd P.M., Wabash County; Keensburg 7.5-Minute Quadrangle). Because this is a State Park, NO HAMMERS ARE ALLOWED AT THIS STOP.

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Following the lunch break, we will discuss the natural resources of Beall Woods and take one of two trails within the park to view some of the geologic and natural wonders of the park.

### Beall Woods

Beall Woods Conservation Area and Nature Preserve is located 6 miles south of Mount Carmel near Keensburg, just off Route 1. This tract previously had remained in the ownership of the Beall family for more than 102 years. After the death of Miss Laura Beall, the property's purchaser allegedly intended to clear the land of trees and farm the property. The interest and efforts of many individuals and organizations helped spur preservation of Beall Woods.

The area was purchased by the State of Illinois in 1965 by invoking the law of eminent domain against an unwilling seller to preserve the virgin woodland for posterity. The state received a grant from the Federal Land and Water Conservation Fund to help defray the cost of purchase of the 635-acre area including the timberland.

### History

Long ago, the entire eastern United States was covered with forest much like Beall Woods. This woodland helps us envision the everlasting forests that shaped our nation's ancestors and their destiny. John Audubon traveled near here a few miles to the east in Indiana. George Rogers Clark and his hardy band suffered incredible hardships while crossing similar woodlands not far to the north under terrible flooded winter conditions. As a young man, Robert Ridgeway, a great American ornithologist, roamed this area.

Of the original deciduous forests remaining in the United States, Beall Woods is one of the largest single tracts east of the Mississippi left relatively untouched by man. The stand has several distinct forest sites, ranging from well drained, rolling uplands to low areas that are subject to frequent flooding and standing water. This diversity of sites has produced a surprising number of tree species; 64 have been identified and there is reason to believe that more will be discovered. Approximately 300 trees, all with trunks greater than 30 inches at breast height, grow here.

The Illinois Department of Conservation is well aware of this natural jewel that was placed in its care. Much of the former farmland around the forest has been planted to native hardwood species to provide a natural buffer for the forest.

**National landmark** Because of its unique character, Beall Woods is registered as a National Landmark by the United States and listed in the United States Register of Natural Landmarks as the "Forest of the Wabash." The 270-acre primeval woodland bordering on the Wabash river was dedicated as an Illinois Nature Preserve to insure that this forest will remain in its natural condition for people to enjoy forever.

Sometimes acclaimed the "University of Trees," Beall Woods is more than a collection of super-sized deciduous trees. It is a living forest community—a natural ecological system containing all-native plant and animal life. Quiet hikers may be rewarded by a quick glimpse of a red fox, deer, raccoon, or pileated woodpecker. The forest floor, quite dim under summer's lush foliage, supports a variety of interesting flowers.

**Naming of Coffee Creek**

In the early days of river navigation, a keelboat loaded with coffee, on her passage up the Wabash River, took shelter overnight in the mouth of what is now known as Coffee Creek. When morning dawned, the boat was found sunken in the creek, and the cargo of coffee lost. From this incident, the creek took its name, and the township was named after the creek. Coffee Creek runs through Beall Woods, and the mouth of the creek is along the White Oak trail.

**Amphibians and Reptiles of the Lower Wabash Valley**

The following was prepared by Christopher A. Phillips, Curator of Herpetology, Illinois Natural History Survey, Center for Biodiversity.

The Lower Wabash Valley is an interesting region for amphibian and reptile distributions in Illinois. Lying at the western edge of the once-vast eastern deciduous forest, this area harbors a few eastern species, such as the eastern ribbon snake (*Thamnophis sauritus*), the two-lined salamander (*Eurycea cirrigera*), and the redback salamander (*Plethodon cinereus*). These species are restricted to the thick timber that was once common in the Wabash Valley and are usually not associated with the "broken" forest that was more typical of the wooded areas west of the Wabash Valley. Consequently, their numbers have declined as the forests of the valley have been fragmented by agriculture and development.

Another interesting aspect of the Lower Wabash Valley is its historical importance for herpetology. The communal settlement at New Harmony, Indiana, was home to several prominent scientists, including herpetologists, during the 1820s. Thomas Say, Charles LeSueur, Gerard Troost, and Prince Maximilian zu Wied-Neuwied were among those at New Harmony who studied amphibians and reptiles during this period. LeSueur named both the spiny and smooth softshell turtles (*Apalone spinifer* and *A. mutica*), and Weid described the red-eared slider (*Trachemys scripta*) from specimens they collected in the vicinity of New Harmony. In addition, J.E. Gray described the false map turtle (*Graptemys pseudogeographica*) from a specimen collected from the Wabash River at New Harmony. Probably no other place in North America can claim as many type localities for turtles as the Lower Wabash Valley.

**Mussels of the Wabash River Drainage**

The following was prepared by Kevin S. Cummings, Curator of Malacology, Illinois Natural History Survey, Center for Biodiversity.

The Wabash River, the longest free-flowing river in the eastern United States, and its floodplain contain abundant fish and wildlife. It is one of the few large rivers in the country that remains unimpounded and unchannelized throughout most of its length. From the time that Thomas Say, one of America's first naturalists, arrived in New Harmony, Indiana, in the early 1800s to the present, biologists have been interested in the diverse and abundant freshwater mussel fauna of the Wabash River. Approximately 75 species of mussels have been reported from the Wabash River; unfortunately, data collected in the past few years indicate that the number of species now present is only about 37, a 51% decrease in the number of species present historically.

Mussels are filter feeders that must continuously pass water through their gills to survive; thus, they are excellent indicators of water quality. These animals are normally long-lived and sedentary, and they are extremely susceptible to the cumulative effects of siltation and other forms of pollution.

In order to provide protection for this important part of our natural heritage, periodic stream surveys are needed to document changes in mussel populations. By comparing the number of individuals of each species found today with data from past studies, we can estimate changes that have occurred over the years. Recent surveys have indicated that many mussels that were widespread and common in the Midwest have been drastically reduced in number or are thought to be extinct.

Since 1987, the Wabash River and its major tributaries, the Embarras, Little Wabash, Vermilion, Little Vermilion, White, and Tippecanoe Rivers, have been surveyed for mussels. The objectives of the surveys were to document the distribution and abundance of mussels present with a particular emphasis on endangered species. The project is a cooperative effort between the Illinois Natural History Survey, the Indiana Department of Natural Resources Division of Nongame and Endangered Species, and the U.S. Fish and Wildlife Service.

This survey and others like it around the eastern United States indicate that we have lost or are in danger of losing many of our native mussels. The decline in mussel populations is probably due to a combination of factors, but siltation seems to be the primary cause. Stronger soil conservation measures are needed in lands bordering our streams to prevent surface run-off and to help curtail erosion. Increased controls on the commercial harvest of mussels may also be warranted if we are serious about protecting this valuable resource.

**Geology of Beall Woods**
The following are specific geologic descriptions for exposures located within Beall Woods. For the purpose of this field trip, we have selected the Sweet Gum Trail and the White Oak Trail (see fig. 18), where a number of interesting geologic features can be seen and discussed. Both trails start near the Red Barn Nature Center.

**Sweet Gum Trail**
The following geologic features are located along the Sweet Gum Trail. Follow the trail until you reach the Rocky Ford crossing of Coffee Creek.

**Bedrock geology at Rocky Ford Crossing** The purpose of this stop is to examine the geology of Pennsylvanian bedrock exposed along Coffee Creek near the Rocky Ford crossing.

**Exposure of Friendsville Coal** The Friendsville Coal Member (fig. 19) of the Mattoon Formation (Pennsylvanian) is exposed in the north side of the cutbank of Coffee Creek where the trail crosses the creek (figs. 18 and 20). This coal occurs approximately 50 feet below the Keensburg Coal, about 400 feet above the West Franklin Limestone (fig. 19), and about 250 feet above the Carthage Limestone. The position of this coal is stratigraphically related to the Millersville-Livingston-La Salle Limestone, which is not well developed in southeastern Illinois.

The Friendsville Coal has been mapped by Nance and Treworgy (1981) throughout roughly the western two-thirds of Wabash County (fig. 21). The coal is truncated along the eastern margin by the NE–SW trending faults of the Wabash Valley System. Along the west edge of Wabash County, the Friendsville Coal lies at depths over 100 feet, and it continues to become deeper to the west into Edwards County.

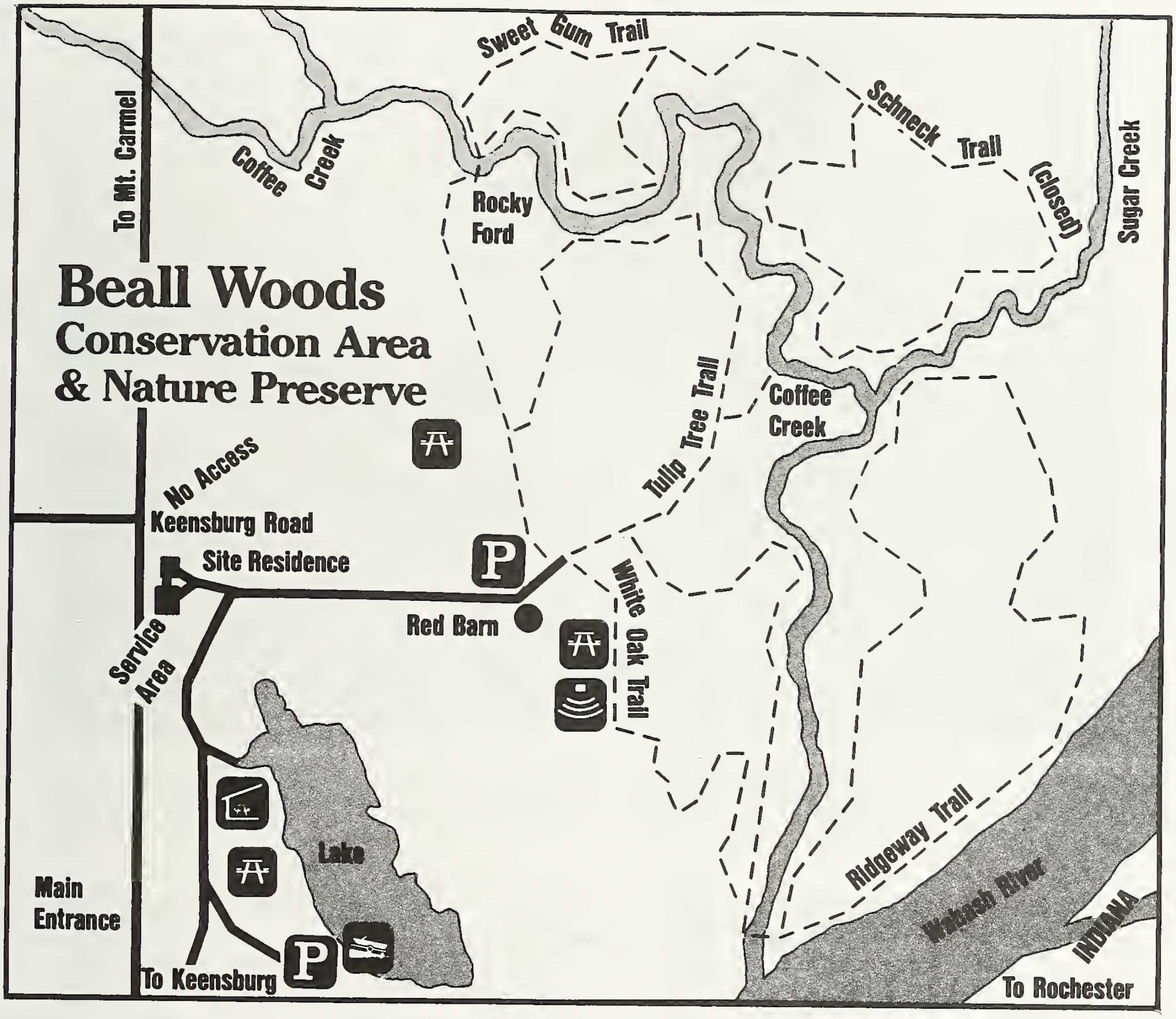


**Figure 18** Beall Woods trail map (from DNR park flyer).

To the south (near McCleary's Bluff) where the coal was up to 4 feet thick, it was mined in a series of mines up to 90 feet deep. At that location, a limestone (nodular and shaley with algal fossils) was found to overly the coal. This limestone does not seem to be present here in the vicinity of Beall Woods. In this area, the coal is slightly thinner, averaging 3 feet thick.

The Friendsville Coal in Wabash County varies from less that 1 foot thick to slightly more than 4 feet thick. It contains numerous shale and claystone partings and in some areas (such as this location) grades into a coaly shale.

**Mount Carmel Sandstone and exposure of the New Harmony Fault Zone** Looking to the east and southeast (downstream), along the meander bend of Coffee Creek you can see that the Friendsville Coal not only begins to dip but that it quickly disappears south of the Rocky Ford trail crossing. This could be attributed to erosion along the valley of Coffee Creek; however, as we work our way downstream around the beginning of the next meander, we can see that a new outcrop of Pennsylvanian rock abruptly appears along the south bank of the meander of Coffee Creek. Whereas geologists several years ago first interpreted this sandstone outcrop as a channel deposit that merely cut out the Friendsville Coal, it now appears that the story is even more exciting.

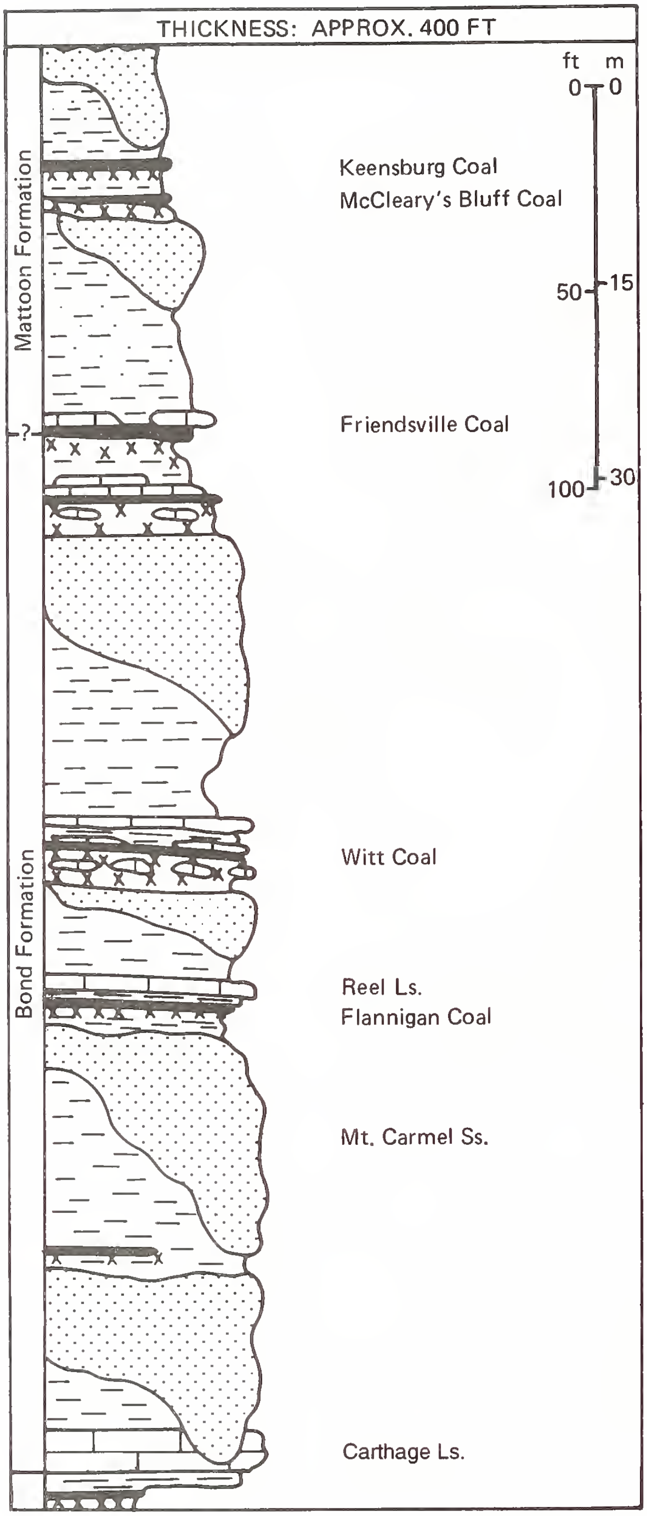


**Figure 19** Generalized stratigraphic column of upper Pennsylvanian stratigraphy within the field trip area (modified from Nance and Treworgy 1981).

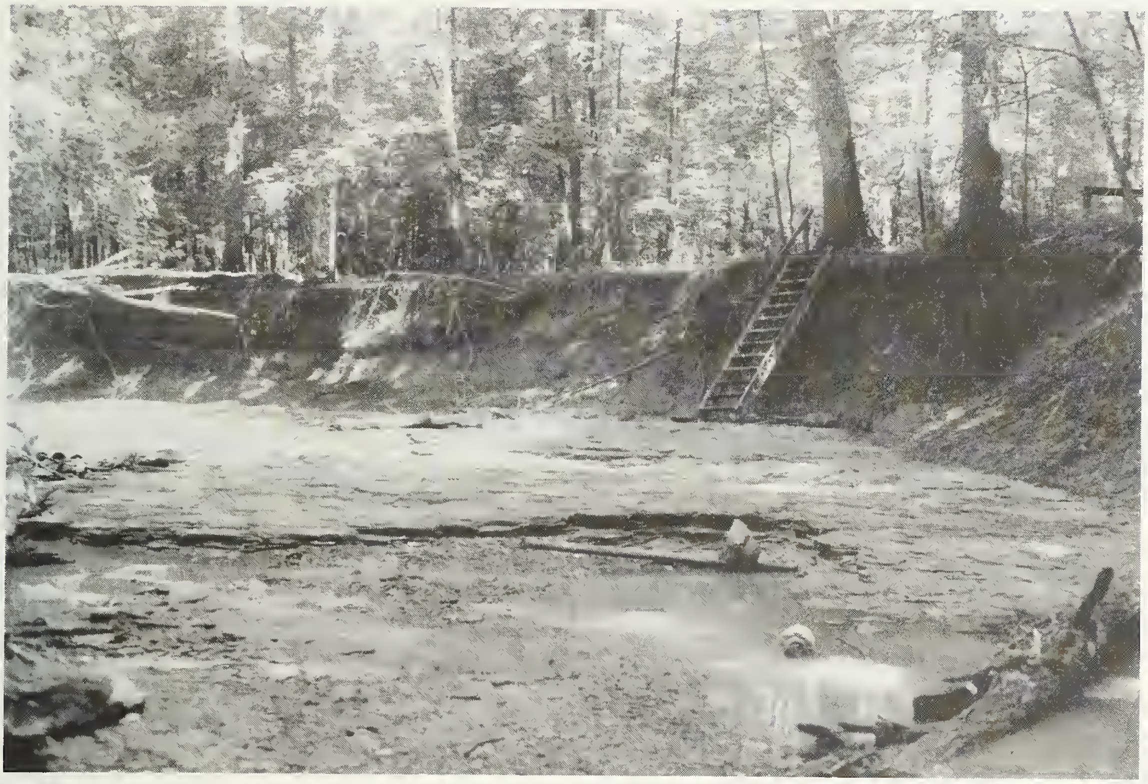

**Figure 20** Outcrop of Pennsylvanian strata, including Friendsville Coal, along Coffee Creek at Rocky Ford crossing at Sweet Gum trail, Beall Woods (photo by W.T. Frankie).

Take a look at the edge of the sandstone exposure (fig. 22) at the westernmost point of exposure. You can see that the exposure is rather abrupt and there are up to three vertical "joint" faces readily apparent. While we were visiting the site preparing this guidebook, the sunlight was highlighting these faces, and a close examination of them revealed vertical striations. These striations are what geologists call slickensides, and it turns out we are seeing the surface exposure of one of the faults in the Wabash Valley Fault System (figs. 5 and 21). One of the geologists who did some of the mapping of the Friendsville Coal (which appeared in Nance and Treworgy 1981) did apparently realize that the New Harmony Fault did fault out the Friendsville Coal at this point (fig. 21); however, we can find no indication in ISGS field notes that prior to preparation for this trip the surface exposure of the fault (the New Harmony Fault) was actually clearly exposed on the surface of this sandstone outcrop.

This interpretation also explains why the Friendsville Coal suddenly disappears along the north bank of the creek to the north and west of the exposure of the fault. The sandstone is actually the Mount Carmel Sandstone Member of the Bond Formation, which lies some 150 feet below the Friendsville Coal.

**Mount Carmel Sandstone** The Mount Carmel Sandstone is a well developed Pennsylvanian sandstone unit in eastern and southeastern Illinois. It is the first major sandstone unit above the Carthage Limestone (fig. 19) and is up to 80 feet thick locally. The Mount Carmel in this area lies roughly 10 feet below the Reel Limestone and Flannigan Coal. It represents the deposit of a river channel system and consists of fine to medium grained quartz sandstone. At this location, we can see cross-bedding in the sandstone and also see the edge of the channel deposit as we work east along the

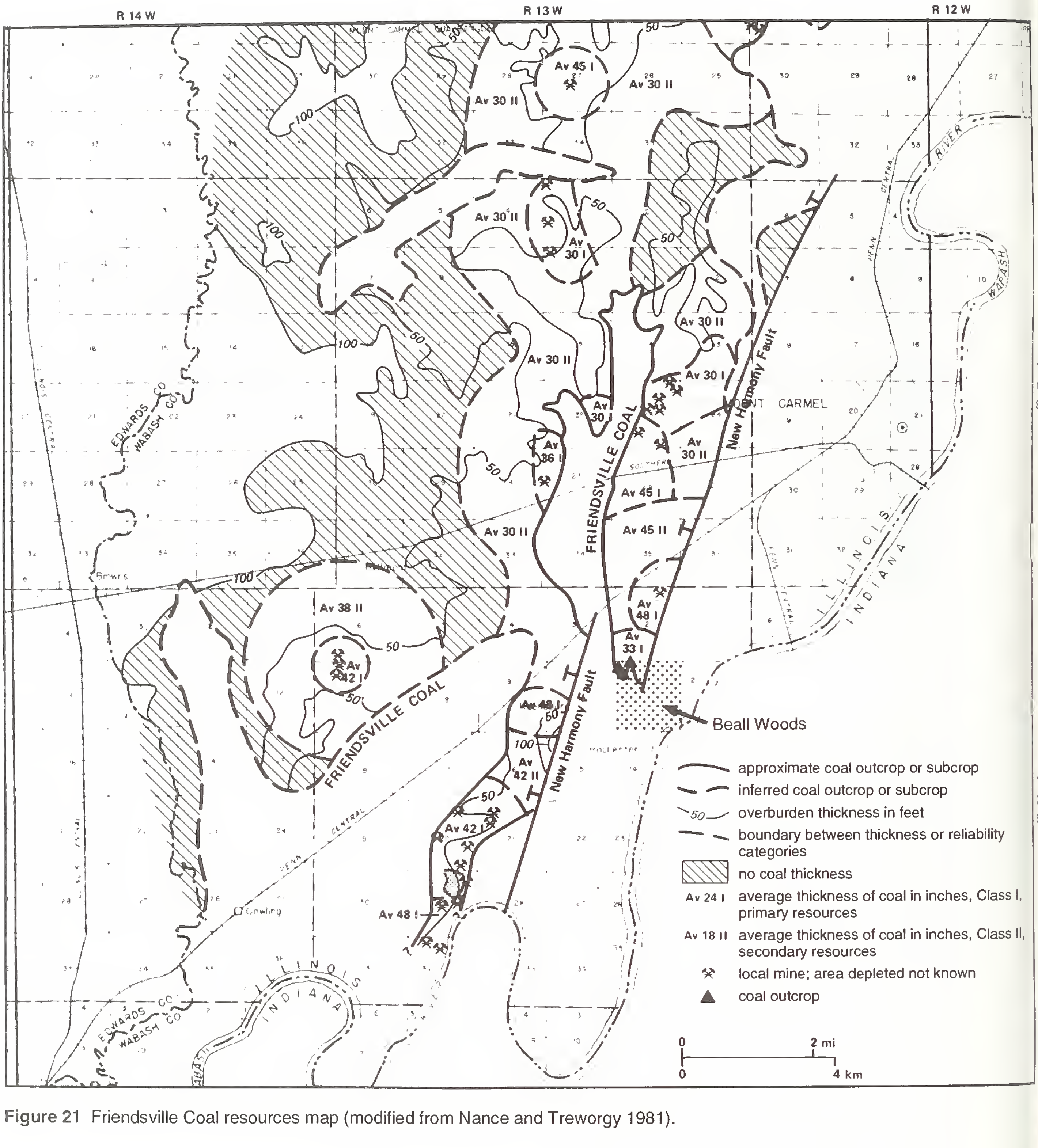


Figure 21 Friendsville Coal resources map (modified from Nance and Treworgy 1981).

**Figure 22** Mount Carmel Sandstone outcrop. The edge of the sandstone marks the surface exposure of the New Harmony Fault (photo by W.T. Frankie).

stream. Where the sandstone thins to a feather edge and grades into shale and siltstone near the east edge of the meander marks the edge of the former channel where it grades into floodplain deposits (represented by the finer grained siltstone and shale).

**New Harmony Fault Zone and the Wabash Valley Fault System** The New Harmony Fault Zone (Nelson 1995) is composed of parallel, overlapping normal faults that strike N25°E and dip 65° or steeper to the west. See figure 3 for a diagram of a normal fault. Where there are many wells, up to five distinct faults have been mapped within the zone. Overall displacement along the fault is down to the west.

The Wabash Valley Fault System is a system of northeast to southwest trending faults in the lower Wabash River Valley of southeastern Illinois and southwestern Indiana (fig. 5). The system extends roughly 55 miles northeastward from the Rough Creek-Shawneetown Fault System. The structure of this fault system is known from records of thousands of oil test holes. Exposures of these faults are also known in underground mines (see discussion of Amax Coal Company's Wabash Mine, Stop 3) and through seismic reflection profiles.

Over a dozen named faults and fault zones have been identified in the Wabash Valley Fault System. Many of these faults contain parallel faults that overlap one another end to end, such as the New Harmony Fault Zone we are seeing exposed here today. Most of the individual faults are simple normal faults with single fault surfaces. The slickensides (such as we have observed here) are primarily vertical, which indicates that movement was primarily vertical along the fault plane. This faulting occurred between late Pennsylvanian and Pleistocene time.

Geologists who have studied the fault zone believe that it is the result of horizontal extension (stresses that pull apart the rocks) due to the faults being of the normal type (hanging wall down, see fig. 3).

**White Oak Trail**

The following geologic features are located along the White Oak Trail. Follow the trail until you reach the long stretch of wooden stairs and a small wooden bridge that crosses a small ravine that flows into Coffee Creek.

**Story of the big tree** The great sycamore trees along the Wabash River have been made famous by that sweetly sentimental song "On the Banks of the Wabash." The grand monarch of them all was certainly one of the largest trees ever known to exist between the Allegheny and Rocky Mountains. It stood on the bank of Coffee Creek, a few hundred feet from where the creek empties into the Great Wabash, at Rochester, and about 6 miles below Mount Carmel, in Wabash County.

**Figure 23** Upper Pennsylvanian strata (Flannigan Coal and Reel Limestone) outcrop, at the small ravine leading into Coffee Creek along White Oak trail (photo by W.T. Frankie);

The tree was fully 28 feet in circumference and 8 feet and 11 inches in diameter, and its height was proportional. It was many hundred years old and in a fairly good state of preservation when in about 1897 the owner of the land upon which it stood cut it down in order to avoid hundreds of visitor who coming to see this great natural wonder of our forests. The tree's destruction provoked very bitter criticism and was deplored as an act of vandalism.

**Bedrock geology at a small ravine along Coffee Creek near its confluence with the Wabash River** At this location is an exposure of the Reel Limestone and Flannigan Coal Members of the Bond Formation (figs. 19 and 23). These Pennsylvanian rocks occur just above the Mount Carmel Sandstone.

The Reel Limestone is especially interesting. It is quite fossiliferous and contains many marine fossils including snails, clams, brachiopods, and crinoids. Of special note are the abundant calcareous foraminifera (small microfossils with calcareous shells, which to the naked eye appear as white, sand grain sized flakes) that can be seen in the limestone. The limestone is only 6 to 10 inches thick and overlies the Flannigan Coal. It is in turn overlain by a fissile black shale that grades upward into a medium gray shale. The black fissile shale is also a marine deposit and contains some marine fossils.

The Flannigan Coal is quite thin in the area, usually no more than 1 foot thick. It can be seen in a recess beneath the ledge formed by the limestone and overlying black shale. A bluish gray claystone (underclay) can be seen exposed beneath the coal at this location.

**Oil Production in Beall Woods**

The oil wells we see at this stop are assigned to the Rochester oil field. This field was discovered in 1948 and produces from three zones: Pennsylvanian sandstone at about 1,300 feet deep, the Waltersburg Sandstone (Mississippian) at 1,925 feet, and the Salem Limestone (Mississippian) at a

**Figure 24** Oil well located on the west side of Coffee Creek near the confluence with the Wabash River at Beall Woods, along White Oak trail (photo by W.T. Frankie).

depth of approximately 3,200 feet (fig. 2). A total of 2.7 million barrels of oil have been produced from 54 oil wells in this field.

The well located on the east side of Coffee Creek, close to the Wabash River, is the Laura Beall no. 4 (fig. 24). This well is located in the NE SW SE, Sec. 11, T2S, R13W. It was completed in 1948 to a depth of 1,944 feet. The pay zone for this well, as for others in the immediate area, is the Mississippian-age Waltersburg Sandstone (fig. 2). In this well the Waltersburg is at a depth of 1,932 feet and originally produced 41 barrels of oil per day.

When a well first penetrates a petroleum reservoir, the oil is forced towards the well bore by a gas or gas cap expansion drive, a water drive, gravity, or a combination of these drive mechanisms (fig. 25).

The gas expansion drive results from a decrease in pressure allowing gas to come out of solution and expand in the same way that carbon dioxide bubbles appear when you open a soda. If initially there is more gas than the oil can hold in solution, the free gas or "gas cap" will expand, forcing the oil out of the well. In water drive reservoirs, the pressure of water underneath the oil pushes the oil out and, as the water encroaches on the oil-saturated rock, sweeps the oil out of the pores. Only a small part of the original oil in the rock (15% to 30%) is recovered during this primary phase of production. The rest of the oil will remain in the rock due to various factors (gravity, capillary attractive forces, oil viscosity, etc.) unless another source of energy is introduced to the system. The oil wells

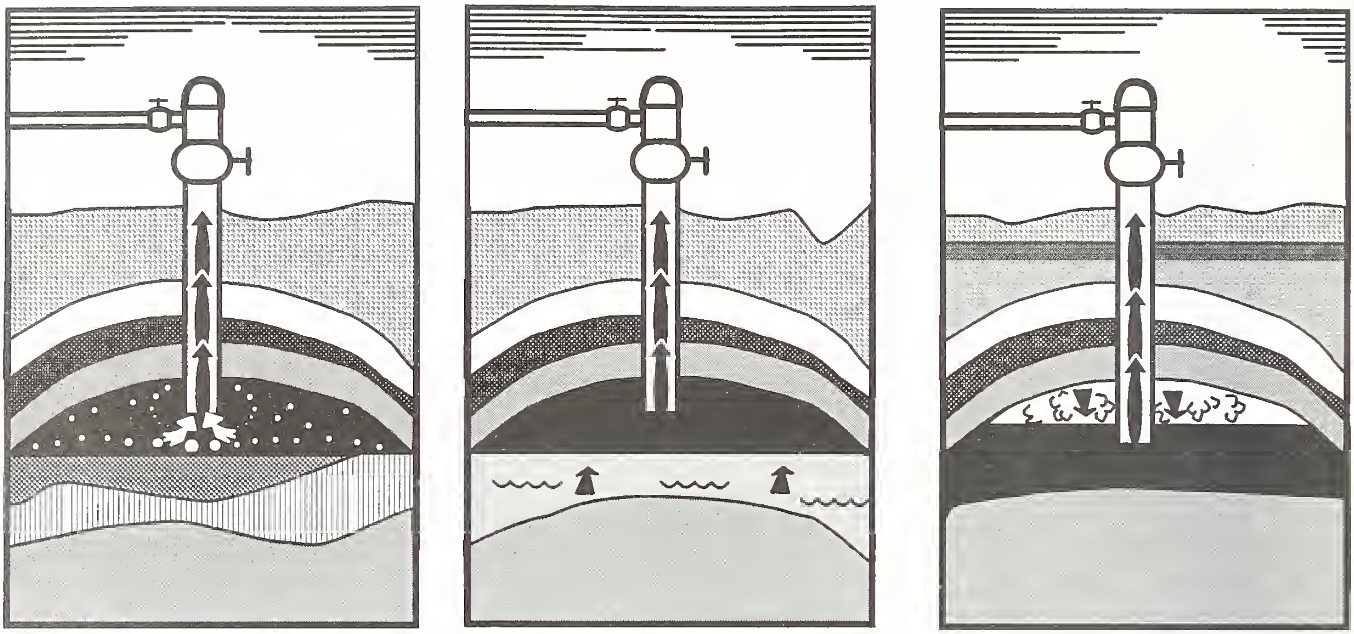


**Figure 25** Diagram of solution gas, water drive, and gas cap mechanisms forcing oil from reservoir during primary production.

you see around you are part of a secondary oil recovery project that uses a very common method, waterflooding, which can recover significant amounts of the oil left after primary production.

Early waterfloods were accidental and were usually caused by a leak developing in the casing next to water-bearing rock. This leak allowed water to free-flow into the oil zone, pushing the oil towards surrounding wells and increasing their production rates. Once the mechanics of these floods was understood, controlled waterfloods became a widespread practice in the oil fields.

In a waterflood project, water produced from oil wells and water source wells or brought in from an external source is pumped down wells and injected into the producing formation (fig. 26). The injected water restores pressure and, as the water moves through the reservoir, forms an oil bank in front of the injected water. The water pushes the oil towards the producing wells where a mixture of oil and water is pumped out. The fluid mixture is pumped into separators where the oil is segregated from the water using a special tank called a gun barrel. The gun barrel is notably taller and thinner than the storage tanks. Both types of tanks are commonly visible and make up the tank batteries in oil fields. After the fluids are separated, the oil is stored in the shorter, stouter storage tanks until a tank truck hauls the oil to a pipeline station or refinery. The water is usually treated with chemicals to prevent solids precipitating from chemicals in the water and to check the growth of bacteria. The water is then reinjected to go through the cycle again. One of the injection wells for this project is approximately 300 feet north of this production well.

**Rapids at Rochester and floodplain deposits** Continue following Coffee Creek to the south, where it empties into the Wabash River. The flat topography adjacent to the Wabash River is a forested floodplain. The fine grained sediments of the floodplain are deposited during periods of high waters. As these water-laid sediments dry out, they develop very large sets of mud cracks. Some of these surface mud cracks are deeper than 3 inches.

Looking south from the mouth of Coffee Creek during periods of low flow, the Rochester Rapids are visible within the Wabash River (fig. 27). Coffee Island, located along the east bank of the Wabash is directly east of the mouth of Coffee Creek.

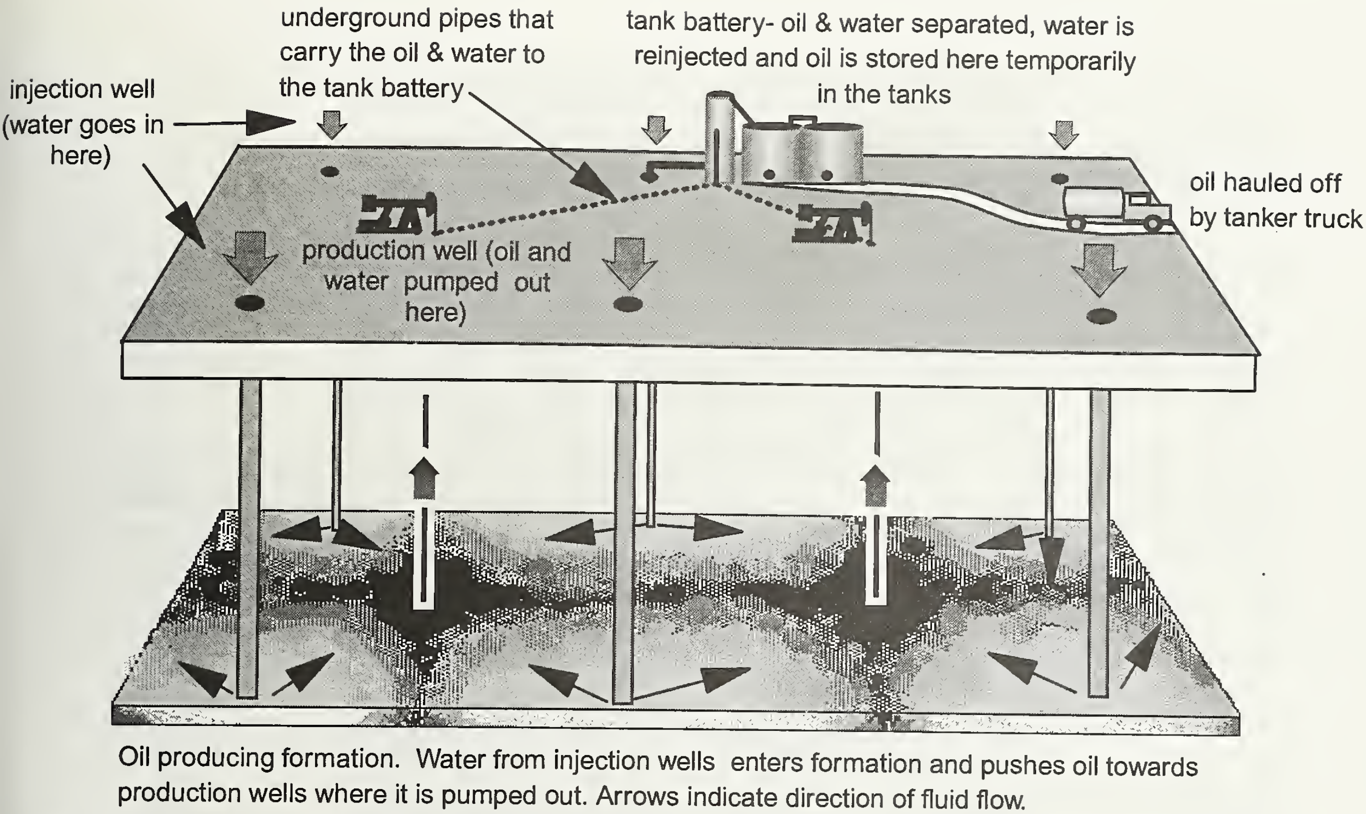


**Figure 26** Schematic showing secondary recovery by water flooding. Arrows indicate direction of fluid flow.

**Figure 27** Beall Woods, Rochester Rapids within the Wabash River, and Coffee Island, along the eastern bank of the Wabash (photo by W.T. Frankie).

**STOP 5 Amax Coal Company, Wabash Mine, air shaft** (SE, SW, SW, Sec. 19, T2S, R13W, 2nd P.M., Wabash County, Grayville 7.5-Minute Quadrangle)

This new mine air shaft is approximately 4 miles southwest from the main portal of the Wabash Mine, and about 3.5 miles west of the second portal (fig. 28). The air shaft is being constructed by the Gunther-Nash Mining Construction Company. Construction of this shaft is expected to take approximately 1 year; it employs about 35 people and will cost $3.8 million. The mining involved with the construction of this air shaft is a simple but interesting process.

Site preparation began in the winter of 1995. The first step in the construction process was to drill a series of holes surrounding the site of the air shaft. Chilled brine was injected into the ground through these holes. This procedure freezes the loose unconsolidated glacial deposits. This freezing of the ground helps prevent the sides of the shaft from collapsing into the hole during the initial mining of the shaft. The second step includes drilling and setting of explosives that break up the strata.

The loose material, called “muck,” is then scooped out of the hole using an EIMCO mucker. The mucker is a small air-driven scoop that is approximately 6 feet long. The mucker has three separate air-driven motors, one for each track and one for the scoop. The mucker is operated by one person who rides on the side of the unit. The loose material is scooped up and placed into a large bucket, which is then hoisted to the surface and dumped via a chute at the top of the construction derrick. The air shaft is excavated to a diameter of 20 feet. The final step in construction is installation of a cement liner. As mining continues downward, the previously excavated portion of the shaft is being framed in preparation for the cement liner. The cement liner is 1 foot thick and is pored at regular intervals of approximately every 21 feet. When completed, the air shaft will have an inside diameter of 18 feet and a total depth of approximately 820 feet.

The construction of this air shaft allows the mine geologist to examine a large sampling of subsurface material that ordinarily would not be available for study. Normally the mine geologist looks at subsurface strata from cored wells that are only inches in diameter. The large blocks of rock brought to the surface here are sometimes several feet in diameter, and from an area underground that is up to 21 feet in diameter.

**STOP 6 Wisconsin-age sand dune (Parkland Sand)** (NE, NW, NE, Sec. 31, T2S, R13W, 2nd P.M., Wabash County, Grayville 7.5-Minute Quadrangle)

We will discuss sand dune formation and examine the sand dune located on the left side of the road (fig. 29).

Shortly after deposition of the sand and gravel bars by the Maumee meltwater torrents, wind reworked the finer sediments from the alluvial deposits. Much of the silt and clay was blown away to become part of the loess that forms a thin blanket over the most recent glacial tills to the east. The sand drifted to form sand dunes throughout much of the field trip area. This sand is named the Parkland Sand, and the type section for this geologic unit was named for Parkland in Tazewell County, a small town about 3 miles northeast of Manito.

The sand is moderately well sorted; but coarser sand is present on the windward side of the dune, and finer sand is present on the leeward side. Because the sand and associated soils are very well drained, sand dunes commonly have flora and fauna that are unusual for Illinois. In some portions of the state,

**Figure 28** Construction site of new mine air shaft for Amax Coal Company, Wabash Mine (photo by W.T. Frankie).

**Figure 29** Sand dune (Parkland Sand) formed during the Wisconsin Glacial Episode at Stop 6 (photo by W.T. Frankie).

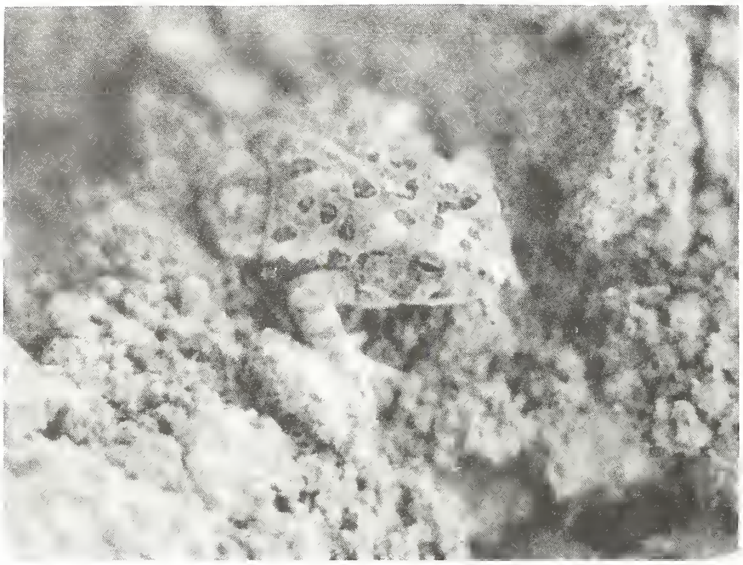

**Figure 30** Small toad living in sand dune at Stop 6, (photo by W.T. Frankie).

the prickly pear cactus is one of the most distinctive natural plants associated with sand dunes. Pine also does well in the sandy soil. During preparation of this guidebook, a small toad was encountered living in this sand dune (fig. 30), and several turtle eggs were found along the eastern side of the dune. Lizards are very common inhabitants of sand dunes, and with care you may encounter one.

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**STOP 7 Schuh Bend on the Wabash River (fig. 31)** (NW, NW, Sec. 18, T3S, R13W, 2nd P.M., Wabash County, Grayville 7.5-Minute Quadrangle)

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At this stop we will discuss, observe, and examine oil production, a failure in the Denham Levee, and the formation of the large sand bar at Schuh Bend.

**Oil Production**

Schuh Bend is located at about the middle of the New Harmony Consolidated oil field; in volume and area, it is one of the largest oil fields in the state. New Harmony Consolidated covers about 30,000 acres in Illinois and extends 10 miles to the south, where it terminates in White County. The field was discovered in 1939 and has had over 3,000 oil wells completed in 23 different producing formations. The depths of the productive zones range from 700 to 4,500 feet. The field has produced about 160 million barrels of oil since discovery.

At this stop we will visit the Mary Heil no. 9 oil well (fig. 32). This well was drilled during July 1940 by the Longhorn Oil Corporation. The well was drilled to a depth of 2,493 feet and was completed at a depth of 2,470 feet, producing 140 barrels of oil per day from the Cypress Sandstone.

Oil fields in this area are commonly associated with faults of the Wabash Valley Fault System (fig. 33).

**Failure of the Denham Levee**

During the 1996 spring flood, the water from the Wabash River crested the Denham Levee at a point southwest of the oil tank battery. When the water crested the levee, it produced a large circular scour next to the north side of the levee (fig. 34). The scour is approximately 80 to 100 feet across and 20 to 30 feet deep. The levee failure is currently being repaired, but the evidence of its existence will be noticed for some time because of the lack of vegetation.

**Figure 31** Schuh Bend, a meander of the Wabash River at Stop 7 (photo by W.T. Frankie).

**Figure 32** The Mary Heil no. 9 oil well, at Schuh Bend, Stop 7 (photo by W.T. Frankie).

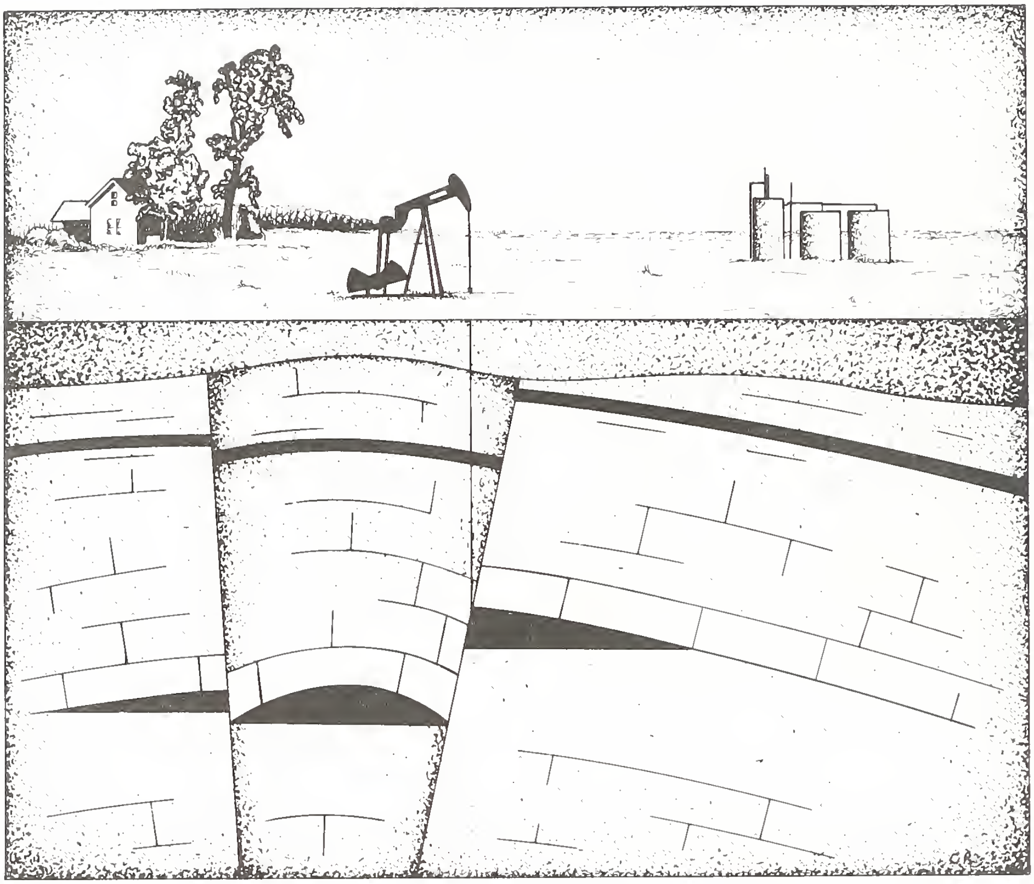

**Figure 33** Cross section illustrating faulting and folding of the Wabash Valley Fault System and their relation to oil accumulation (from Bristol and Treworgy 1979).

**Figure 34** Site failure of the Denham Levee was caused when flood waters crested the levee in the spring of 1996. This failure created a large circular scour at the base of the levee (photo by W.T. Frankie).

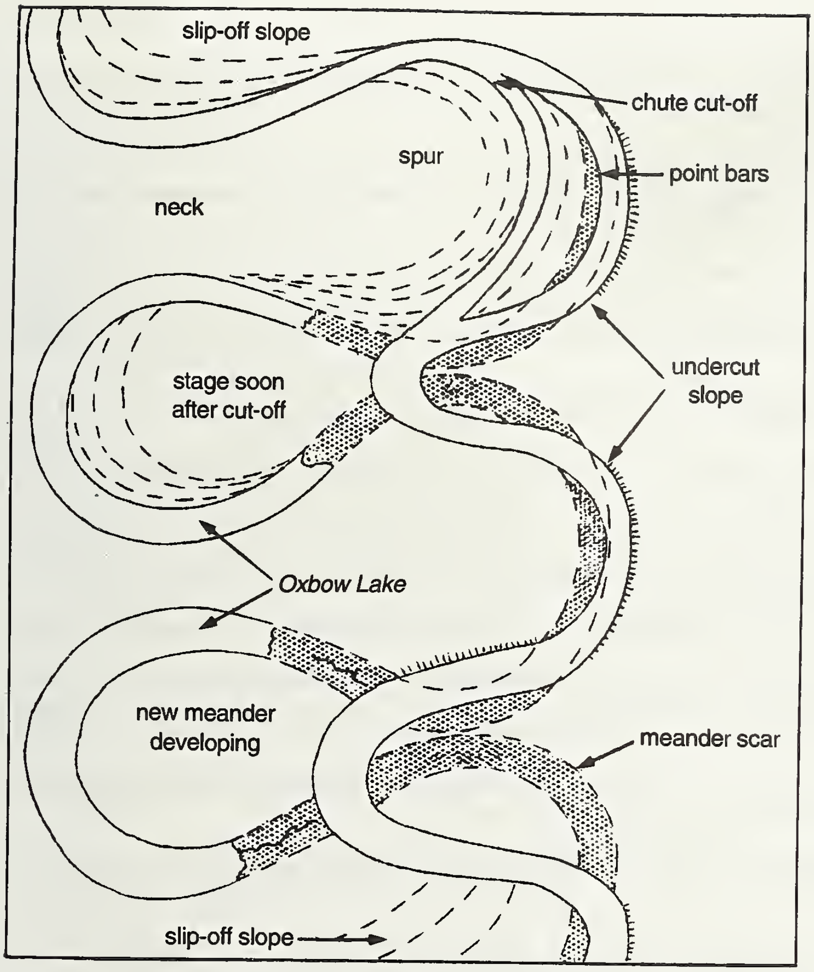


**Figure 35** Floodplain features. Water flowing through a meander curve is forced against the outside bank (called the cutbank). As the cutbank is eroded back, the channel migrates in this direction leaving a "slip-off" slope on the inside of the curve. Deposition of material may occur on the slip-off slope in crescent-shaped forms that, when incorporated into the floodplain, become flood plain scrolls. Meanders move across the valley and also downstream. Abandoned meanders generally leave evidence of their existence in the form of meander scars. The area within a meander curve is called a neck. At times of high water, the river may cut off the meander through the neck, leaving a meander core or abandoned meander. If water is left in the cut-off meander, it is called an oxbow lake. When the river cuts through channel bars or point bars which form on the slip-off slope, a chute cut-off is formed.

**Point Bar at Schuh Bend**

The large sand bar located along the Illinois side of the Wabash River has developed along the inside of a very large meander (see route map). Along the lower portion of the Wabash River, several large meanders one after another loop back and forth across the Lower Wabash Valley. As water flows along a meander, the rate of flow along the outside curve of the meander is greater than the rate of flow along the inside curve (fig. 35). The outside curve is an area of erosion and is commonly referred to as the cutbank. The inside curve is an area of deposition and is referred to as the slip-off slope. The deposit of sand and gravel along the inside of a meander is called a point bar. Compare the profiles of the outside portion of the meander and the inside of the meander. As this meander migrates to the south (as it has done in the past), the large point bars that it develops across the landscape are called floodplain scrolls.

Several different species of freshwater mussels and high spired gastropods can be collected along the point bar.

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## GLOSSARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

**Bedrock valley** A 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.

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

**Calcareous** Containing calcium carbonate ($CaCO_3$); limy.

**Calcined** The heating of limestone to its temperature of dissociation so that it loses its water of crystalization.

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

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

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

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

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

**Detritus** Material produced by mechanical disintegration.

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

**Dolomite** A mineral, calcium-magnesium carbonate ($Ca,Mg[CO_3]_2$); applied to those sedimentary rocks that are composed largely of the mineral dolomite; it also is precipitated directly from seawater. It is white, colorless, or tinged yellow, brown, pink, or gray; has perfect rhombohedral cleavage; appears pearly to vitreous; effervesces feebly in cold dilute hydrochloric acid.

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

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

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

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

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

**Escarpment** A long, more or less continuous cliff or steep slope facing in one general direction, generally marking the outcrop of a resistant layer of rocks.

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

**Flaggy** Tending 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 that has been produced by the stream's erosion and deposition actions; the area covered with water when the stream overflows its banks at times of high water; it is built of alluvium carried by the stream during floods and deposited in the sluggish water beyond the influence of the swiftest current.

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

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

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

**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 cemmented sandstone.

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

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

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

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

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

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

**Indurated** A compact rock or soil hardened by the action of pressure, cementation, and especially heat.

**Joint** A fracture or crack in rocks along which there has been no movement of the opposing sides.

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

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

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

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

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

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

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

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

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

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

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

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

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

**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 landforms that are independent of control by the surface on which the drift lies.

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

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

**Nickpoint** A place of abrupt inflection in a stream profile; A sharp angle cut by currents at base of a cliff.

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

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

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

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

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

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

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

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

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

**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.

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

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

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

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

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

**Shoaling** The effect of a near-costal sea bottom on wave height; it describes the alteration of a wave as it proceeds from deep water into shallow water. The wave height increases as the wave arrives on shore.

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

**Slip-off slope** Long, low, gentle slope on the inside of a stream meander.

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

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

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

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

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

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

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

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

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

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

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

**Till** Unconsolidated, 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 the area underlain by ground moraine.

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

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

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

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

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

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

## APPENDIX A Checklist of Birds for Beall Woods

The following information was obtained from a brochure distributed by the Illinois Department of Natural Resources.

Approximately 200 species of birds have been identified within or at the boundaries of or flying over Beall Woods State Park and Nature Preserve during the past 20 years. The information has been accumulated for all seasons of the year by many observers. This checklist was prepared by Leroy Harrison in cooperation with the Division of Natural Heritage of the Department of Conservation.

The following legend indicates the approximate relative abundance of each species during each season it would most likely occur.

a - abundant, expected every trip in large numbers in proper habitat
c - common, expected regularly in season and appropriate habitat
u - uncommon, not expected regularly even in appropriate habitat or season
o - occasional, found only infrequently
r - rare, only one to five records

The Seasons are identified as follows:

Sp = Spring, primarily March through May (although some migration may occur in February and June)
Su = Summer, primarily late May through early August
Fa = Fall, primarily August through November (although some migration begins as early as late June and continues well into December)
Wi = Winter, primarily December through February

The following symbols are keys to general habitats, if present, where the species most *likely* can be seen:

bg = bare ground (plowed fields, etc.)
cr = cropfields
an = annuals (naturally occurring)
ng = native grasses/prairies
sg = shrub/grass type old field
ts = tree/shrub type old field
ed = edge between forest and open habitat
uh = upland hardwood forest
bh = bottomland hardwood forest
co = coniferous forest/woods
bl = bluffs and road cuts
st = streams and rivers
la = lakes and ponds
ma = marsh (primarily herbaceous vegetation)
sw = swamp (primarily woody vegetation)
ur = urban areas, farmyards and man-made structures.

| | Habitat | Sp | Su | Fa | Wi |
|---|---|---|---|---|---|
| Common Loon | la | u | | u | |
| Double-crested Cormorant | la/ma | u | | u | |
| Great Blue Heron | ma/la | c | u | c | |
| Great Egret | la/ma | o | | o | |
| Green-backed Heron | ma/la | c | c | c | |
| Yellow-crowned Night Heron | ma/sw | o | o | o | |
| Snow Goose | lm/ma | o | | o | |
| Canada Goose | la/ma | c | | c | o |
| Wood Duck | st/sw | c | c | c | |
| Green-winged Teal | lm/ma | o | | o | |
| American Black Duck | la/ma | o | | o | |
| Mallard | ma/la | c | o | c | |
| Northern Pintail | la/ma | o | | o | |
| Blue-winged Teal | ma/la | c | o | c | |
| Northern Shoveler | la/ma | o | | o | |
| Gadwall | la/ma | o | | o | |
| American Wigeon | ma/la | o | | o | |
| Canvasback | la/st | o | | o | |
| Redhead | la/st | o | | o | |
| Ring-necked Duck | la | o | | o | |
| Lesser Scaup | la/st | o | | o | |
| Surf Scoter | la | r | | r | |
| Common Goldeneye | la/st | o | | o | u |
| Bufflehead | la/st | o | | o | |
| Hooded Merganser | la/sw | o | | o | |
| Common Merganser | la/st | o | | o | |
| Red-breasted Merganser | la | o | | o | |
| Ruddy Duck | la | o | | o | |
| Turkey Vulture | uh/bl | c | c | c | |
| Osprey | la/st | o | | o | |
| Bald Eagle | la/st | r | | r | r |
| Northern Harrier | ng/cr | | | | c |
| Sharp-shinned Hawk | uh/ed | o | | o | |
| Red-shouldered Hawk | bh | o | | o | o |
| Broad-winged Hawk | uh | o | | o | |
| Red-tailed Hawk | uh/ed | c | c | c | c |
| Roughlegged Hawk | cr | | | | o |
| American Kestrel | ed | c | c | c | c |
| Northern Bobwhite | ed/cr | c | c | c | c |
| American Coot | ma/la | u | | u | |
| Killdeer | bg/la | c | c | c | o |
| Greater Yellowlegs | ma/la | o | | o | |
| Lesser Yellowlegs | ma/la | o | | o | |
| Solitary Sandpiper | ma/la | o | | o | |
| Spotted Sandpiper | st/la | o | | o | |
| Least Sandpiper | ma/la | o | | o | |
| Pectoral Sandpiper | ma/la | o | | o | |
| Common Snipe | ma | o | | o | |
| American Woodcock | ed/bh | u | u | u | |
| Ring-billed Gull | la/st | o | | o | o |
| Herring Gull | la/st | o | | o | o |

| | Habitat | Sp | Su | Fa | Wi |
|---|---|---|---|---|---|
| Rock Dove | ur/cr | c | c | c | c |
| Mourning Dove | ed/ts | a | a | a | a |
| Black-billed Cuckoo | uh/ts | o | r | o | |
| Yellow-billed Cuckoo | uh/ed | c | c | c | |
| Eastern Screech-Owl | uh/bh | u | u | u | u |
| Great Horned Owl | uh/bh | u | u | u | u |
| Barred Owl | bhluh | u | u | u | |
| Short-eared Owl | ng | | | | o |
| Common Nighthawk | ur/bg | u | c | c | |
| Whip-poor-will | uh/bh | u | c | o | |
| Chimney Swift | ur | a | a | a | |
| Ruby-throated Hummingbird | ed/uh | c | c | c | |
| Belted Kingfisher | st/la | c | c | c | r |
| Red-headed Woodpecker | ed/uh | a | a | a | c |
| Red-bellied Woodpecker | uh/bh | a | a | a | a |
| Yellow-bellied Sapsucker | uh/bh | u | | u | o |
| Downy Woodpecker | uh/bh | a | a | a | a |
| Hairy Woodpecker | uh/bh | c | c | c | c |
| Northern Flicker | ed/uh | a | a | a | a |
| Pileated Woodpecker | bh/uh | c | c | c | c |
| Olive-sided Flycatcher | ed/uh | o | | o | |
| Eastern Wood-Pewee | uh/bh | c | a | c | |
| Yellow-bellied Flycatcher | uh/bh | o | | o | |
| Acadian Flycatcher | bh | c | a | c | |
| Alder Flycatcher | bh/ts | o | | o | |
| Willow Flycatcher | ts/ed | o | o | o | |
| Least Flycatcher | ed/ts | u | | u | |
| Eastern Phoebe | st/bh | u | u | u | |
| Great Crested Flycatcher | uh/bh | c | c | c | |
| Eastern Kingbird | ed/ts | c | c | c | |
| Horned Lark | bg/cr | c | c | c | c |
| Purple Martin | ur/la | o | o | o | |
| Tree Swallow | la/ma | c | r | c | |
| Northern Rough-winged Swallow | bl/at | c | o | c | |
| Bank Swallow | st | c | o | c | |
| Cliff Swallow | bl/st | o | | o | |
| Barn Swallow | ur/ma | a | a | a | |
| Blue Jay | uh/bh | a | a | a | a |
| American Crow | uh/cr | c | c | c | c |
| Black-capped Chickadee | uh/bh | | | | r |
| Carolina Chickadee | uh/bh | a | a | a | a |
| Tufted Titmouse | uh/bh | a | a | a | a |
| Red-breasted Nuthatch | co/uho | o | | o | r |
| White-breasted Nuthatch | uh/bh | c | c | c | c |
| Brown Creeper | bh/uh | | | | c |
| Carolina Wren | bh/uh | c | c | c | c |
| House Wren | ed/ur | c | c | c | r |
| Winter Wren | st/bh | u | | u | o |
| Golden-crowned Kinglet | co/bh | c | | c | u |
| Ruby-crowned Kinglet | uh/bh | c | | c | o |
| Blue-gray Gnatcatcher | uh/bh | c | c | c | |

| | Habitat | Sp | Su | Fa | Wi |
|---|---|---|---|---|---|
| Eastern Bluebird | ts/ed | c | c | c | u |
| Townsend's Solitaire | ed | | | | r |
| Veery | uh/bh | u | | u | |
| Gray-cheeked Thrush | uh/bh | u | | u | |
| Swainson's Thrush | uh/bh | c | | c | |
| Hermit Thrush | uh/bh | u | | u | o |
| Wood Thrush | uh/bh | c | c | c | |
| American Robin | ur/ed | a | a | a | c |
| Gray Catbird | ts/ed | c | c | c | |
| Northern Mockingbird | ts/ed | c | c | c | c |
| Brown Thrasher | ts/ed | c | c | c | o |
| Water Pipit | cr/bg | u | | u | |
| Cedar Waxwing | ts/ed | c | o | c | u |
| Loggerhead Shrike | ed/ts | u | u | u | u |
| European Starling | ur | a | a | a | a |
| White-eyed Vireo | ts/ed | c | c | c | |
| Bell's Vireo | ts/ed | u | u | u | |
| Solitary Vireo | uh/bh | u | | u | |
| Yellow-throated Vireo | uh/bh | c | c | c | |
| Warbling Vireo | bh/ed | c | c | c | |
| Philadelphia Vireo | uh/bh | u | | u | |
| Red-eyed Vireo | uh/bh | c | c | c | |
| Blue-winged Warbler | ts/ed | u | | u | |
| Golden-winged Warbler | ts/ed | u | | u | |
| Tennessee Warbler | uh/bh | c | | c | |
| Orange-crowned Warbler | ts/uh | u | | u | |
| Nashville Warbler | uh/bh | c | | c | |
| Northern Parula | bh/st | c | c | c | |
| Yellow Warbler | ts/bh | c | c | c | |
| Chestnut-sided Warbler | ed/ts | c | | c | |
| Magnolia Warbler | bh/uh | c | | c | |
| Cape May Warbler | uh/co | u | | u | |
| Yellow-rumped Warbler | uh/bh | c | | c | r |
| Black-throated Green Warbler | uh/bh | c | | c | |
| Blackburnian Warbler | uh/bh | c | | c | |
| Yellow-throated Warbler | bh/st | u | u | u | |
| Pine Warbler | co/uh | o | | o | |
| Prairie Warbler | ts | u | | r | |
| Palm Warbler | ts/bh | c | | c | |
| Bay-breasted Warbler | uh/bh | c | | c | |
| Blackpoll Warbler | uh/bh | c | | o | |
| Cerulean Warbler | bh/st | u | u | u | |
| Black-and-white Warbler | uh/bh | c | | c | |
| American Redstart | bh | c | o | c | |
| Prothonotary Warbler | st/sw | c | c | c | |
| Worm-eating Warbler | uh/bh | u | | r | |
| Ovenbird | uh/bh | c | | c | |
| Northern Waterthrush | st/sw | c | | c | |
| Louisiana Waterthrush | st/bh | u | u | u | |
| Kentucky Warbler | bh/uh | c | c | c | |
| Connecticut Warbler | uh/bh | o | | r | |

| | Habitat | Sp | Su | Fa | Wi |
|---|---|---|---|---|---|
| Mourning Warbler | bh/uh | o | | r | |
| Common Yellowthroat | ts/ed | c | c | c | |
| Hooded Warbler | uh/bh | o | o | o | |
| Wilson's Warbler | ts/ed | u | | u | |
| Canada Warbler | ts/bh | u | | u | |
| Yellow-breasted Chat | ts/ed | u | u | u | |
| Summer Tanager | uh/bh | c | u | c | |
| Scarlet Tanager | uh/bh | c | u | c | |
| Northern Cardinal | ed/ur | a | a | a | a |
| Rose-breasted Grosbeak | uh/bh | c | r | c | |
| Blue Grosbeak | ts/ed | o | | o | |
| Indigo Bunting | eg/ts | a | a | a | |
| Dickcissele | d/ng | c | u | c | |
| Rufous-sided Towhee | ts/ed | c | c | c | u |
| American Tree Sparrow | ts/ed | | | | c |
| Chipping Sparrow | ed/ur | c | c | c | |
| Field Sparrow | sg/ed | c | c | c | u |
| Vesper Sparrow | cr/sg | u | u | u | |
| Lark Sparrow | ed/sg | u | | u | |
| Savannah Sparrow | ng/an | c | o | c | o |
| Grasshopper Sparrow | ng/cr | u | u | u | |
| Fox Sparrow | ed/bh | u | | u | u |
| Song Sparrow | ed/ts | c | c | c | c |
| Lincoln's Sparrowed | ed/bh | u | | u | |
| Swamp Sparrow | ma/sw | c | | c | u |
| White-throated Sparrow | ed/bh | c | | c | o |
| White-crowned Sparrow | ts/ed | c | | c | u |
| Dark-eyed Junco | ed/ur | c | | c | a |
| Lapland Longspur | cr/bg | o | | o | o |
| Bobolink | ng | u | | u | |
| Red-winged Blackbird | ma/cr | a | a | a | u |
| Eastern Meadowlark | ng/cr | c | c | c | c |
| Rusty Blackbird | bh/cr | o | | o | |
| Brewer's Blackbird | cr/ur | o | | | r |
| Common Grackle | ed/ts | c | c | c | u |
| Brown-headed Cowbird | ed/uh | c | c | c | u |
| Orchard Oriole | ts/ed | c | c | u | |
| Northern Oriole | bh/ed | c | c | c | |
| Purple Finch | uh/ed | u | | u | u |
| Common Redpoll | an/ed | | | | r |
| Pine Siskin | ur | o | | o | o |
| American Goldfinch | ts/ur | c | c | c | c |
| Evening Grosbeak | ur/ed | o | | o | o |
| House Sparrow | ur | a | a | a | a |

## APPENDIX B Checklist of Trees Found in Beall Woods

These trees have been found in the woodland. The list is not complete. The number on certain trees refers to the species listed below and is included to help you identify the trees.

| Common Name | Scientific Name |
|---|---|
| 1. Cottonwood | 1. Populus deltoides |
| 2. Black Walnut | 2. Juglans nigra |
| 3. Bitternut Hickory | 3. Carya cordiformis |
| 4. Pecan | 4. Carya illinoensis |
| 5. Water Hickory | 5. Carya aquatica |
| 6. Shagbark Hickory | 6. Carya ovata |
| 7. Kingnut Hickory | 7. Carya laciniosa |
| 8. Mockernut Hickory | 8. Carya tomentosa |
| 9. Sweet Pignut | 9. Carya ovalis |
| 10. Pignut Hickory | 10. Carya glabra |
| 11. Blue Beech | 11. Carpinus caroliniana |
| 12. Hop Hornbeam | 12. Ostrya virginiana |
| 13. River Birch | 13. Betula nigra |
| 14. Beech | 14. Fagus grandifolia |
| 15. White Oak | 15. Quercus alba |
| 16. Bur Oak | 16. Quercus macrocarpa |
| 17. Swamp White Oak | 17. Quercus bicolor |
| 18. Chinquapin Oak | 18. Quercus muhlenbergii |
| 19. Northern Red Oak | 19. Quercus rubra |
| 20. Shumard Red Oak | 20. Quercus shumardii |
| 21. Black Oak | 21. Quercus velutina |
| 22. Pin Oak | 22. Quercua palustris |
| 23. Spanish Oak | 23. Qusrcus falcata |
| 24. Swamp Spanish Oak | 24. Quercus rubra (Var. Pagodaefoli) |
| 25. Shingle Oak | 25. Quercus imbricaria |
| 26. American Elm | 26. Ulmus americana |
| 27. Red Elm | 27. Ulmus rubra |
| 28. Hackberry | 28. Celtis occidentalis |
| 29. Red Mulberry | 29. Morus rubra |
| 30. Tulip Tree | 30. Liriodendron tulipfera |
| 31. Papaw | 31. Asimina triloba |
| 32. Sassafras | 32. Sassafras albidum |
| 33. Sweet Gum | 33. Liquidambar styraciflua |
| 34. Sycamore | 34. Platanus occidentalis |
| 35. Red Haw | 35. Crateagus mollis |
| 36. Black Cherry | 36. Prunus serotina |
| 37. Honey Locust | 37. Gleditsia triacanthos |
| 38. Red Bud | 38. Cercis canadensis |
| 39. Kentucky Coffee Tree | 39. Gymnodladus dioicus |
| 40. Sugar Maple | 40. Acer saccharum |
| 41. Silvar Maple | 41. Acar saccarinum |
| 42. Box Elder | 42. Acar negundo |
| 43. Basswood | 43. Tilia americana |
| 44. Flowering Dogwood | 44. Cornus florida |
| 45. Black Gum | 45. Nyssa sylvatica |
| 46. Persimmon | 46. Diospyros virginiana |

| Common Name | Scientific Name |
|---|---|
| 47. White Ash | 47. Fraxinus americana |
| 48. Green Ash | 48. Fraxinus pennsylvanica |
| 49. Rock Elm | 49. Ulmus racemosa |
| 50. Catalpa | 50. Catalpa speciosa |
| 51. Red Cedar | 51. Juniperus virginiana |
| 52. Smooth Sumac | 52. Rhus glabra |
| 53. Post Oak | 53. Quercus stellata |
| 54. Willow | 54. Salix sp. |
| 55. Sugar Berry | 55. Celtis leavigata |
| 56. Osage Orange | 56. Maclura pomifera |
| 57. Butternut | 57. Juglans cinerea |
| 58. Crab Apple | 58. Malus ioensis |
| 59. Black Maple | 59. Acer nigrum |
| 60. Red Maple | 60. Acer rubrum |
| 61. Swamp Chestnut Oak | 61. Quercus michauxii |
| 62. Overcup Oak | 62. Quercus lyrata |
| 63. American Plum | 63. Prunus americana |
| 64. Tree of Heaven | 64. Ailanthus altissima |

# PLEISTOCENE GLACIATIONS IN ILLINOIS

## Origin of the Glaciers

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

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

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

## Effects of Glaciation

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

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

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

## Glacial Deposits

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

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

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

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

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

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

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

## Loess, Eolian Sand and Soils

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

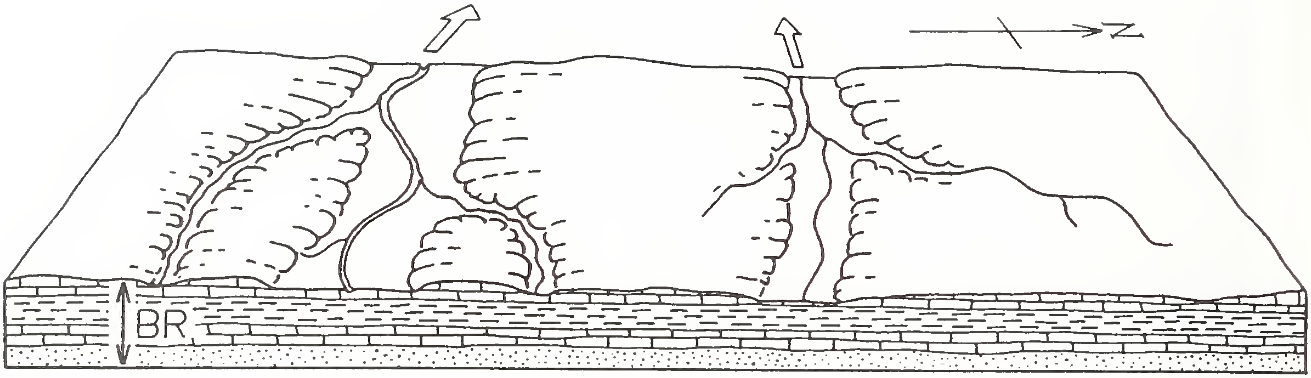
Eolian deposition occurred when certain climatic conditions were met, probably in a seasonal pattern. Deposition could have occurred in the fall, winter or spring season when low precipitation rates and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and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

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

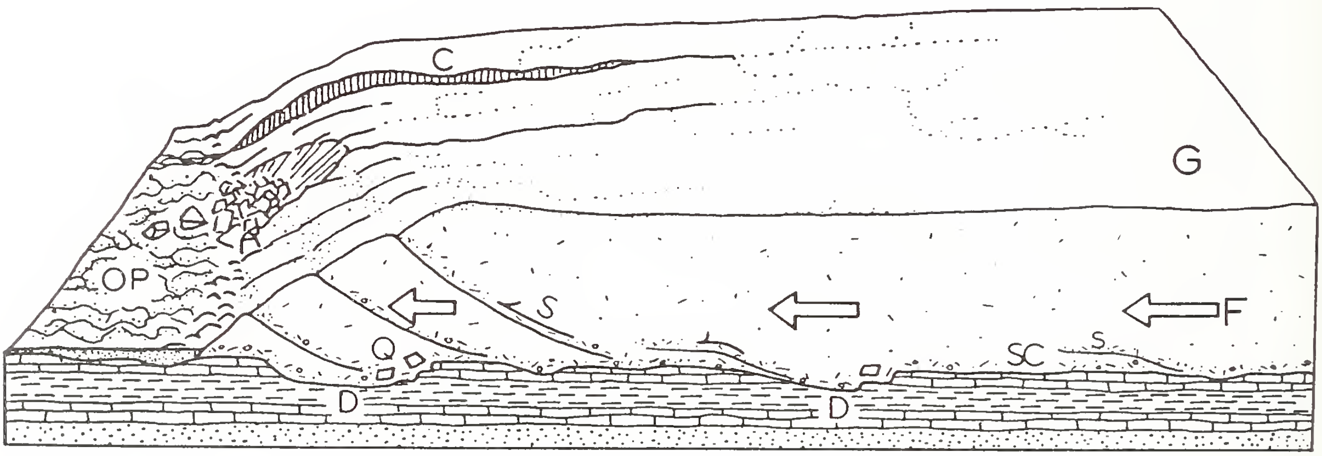
## Glaciation in a Small Illinois Region

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

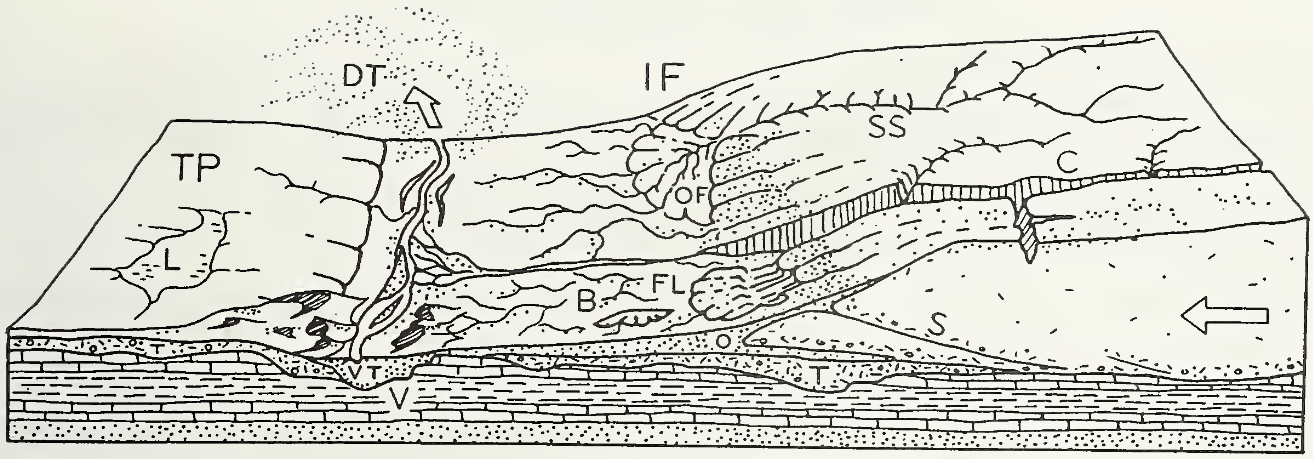
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated—layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.




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



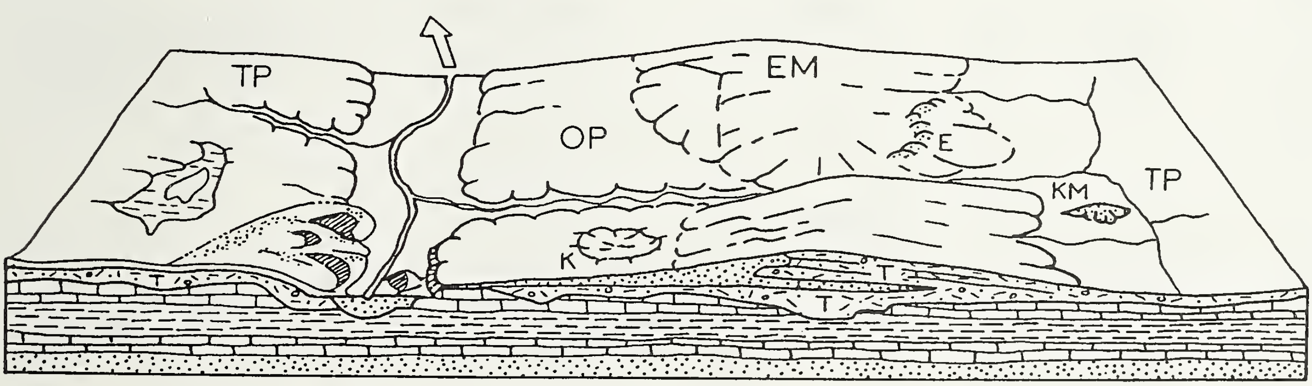

2. **The Glacier Advances Southward** — As the Glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughnesses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




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

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

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




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

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

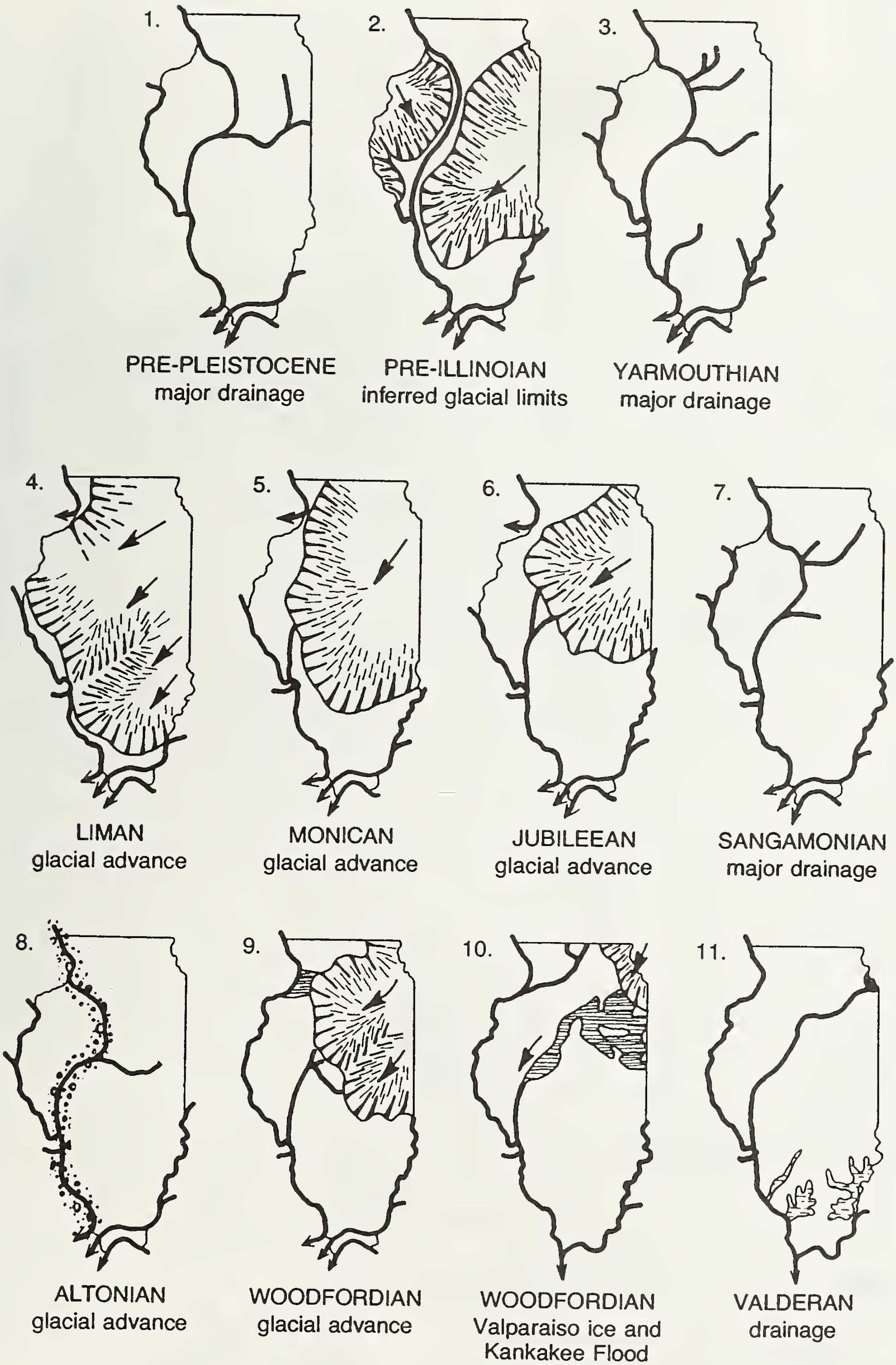
TIME TABLE OF PLEISTOCENE GLACIATION

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

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

(Illinois State Geological Survey, 1973)

## SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



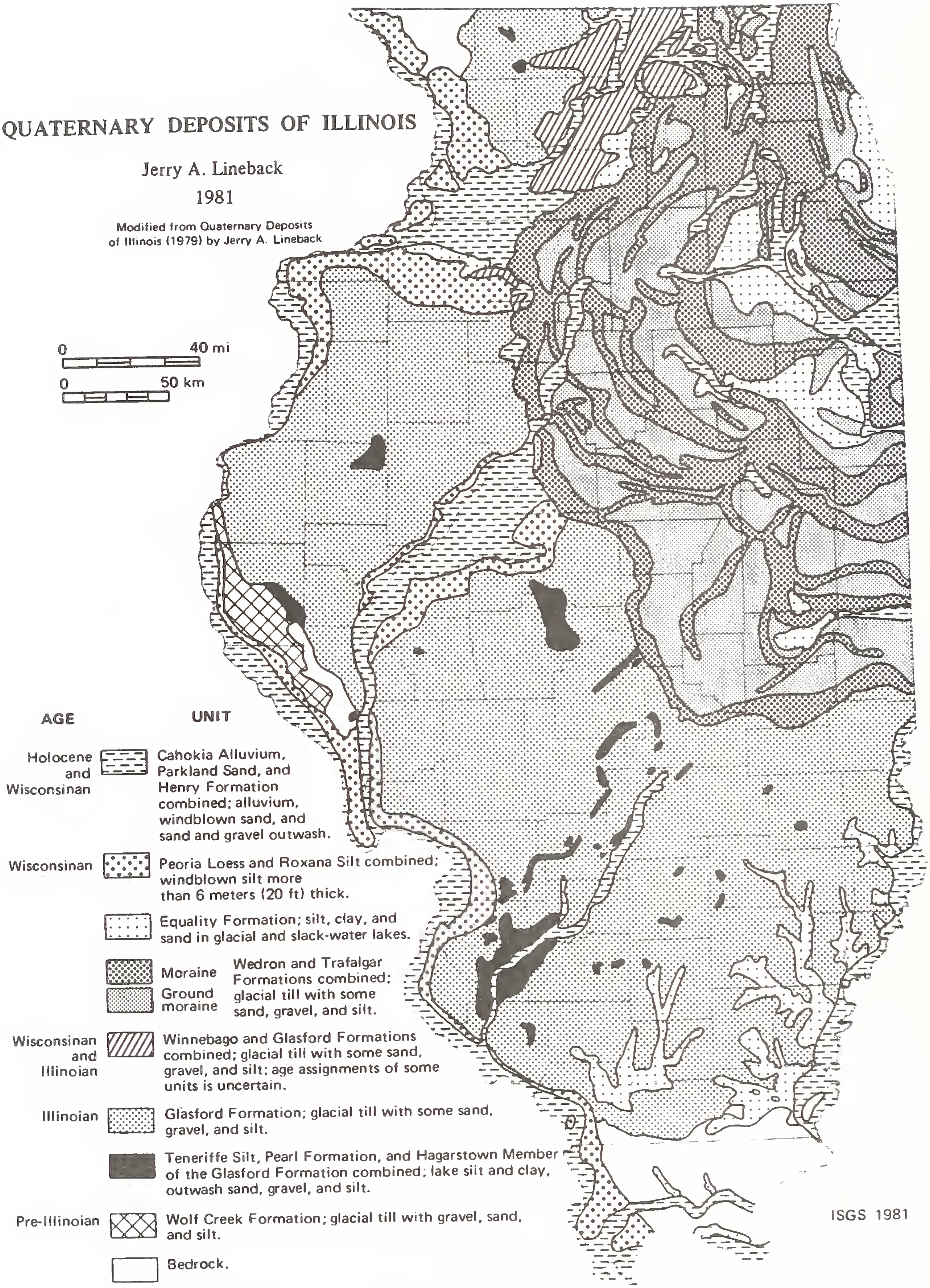

(Modified from Willlman and Frye, "Pleistocene Stratigraphy of Illinois," ISGS Bull. 94, fig. 5, 1970.)

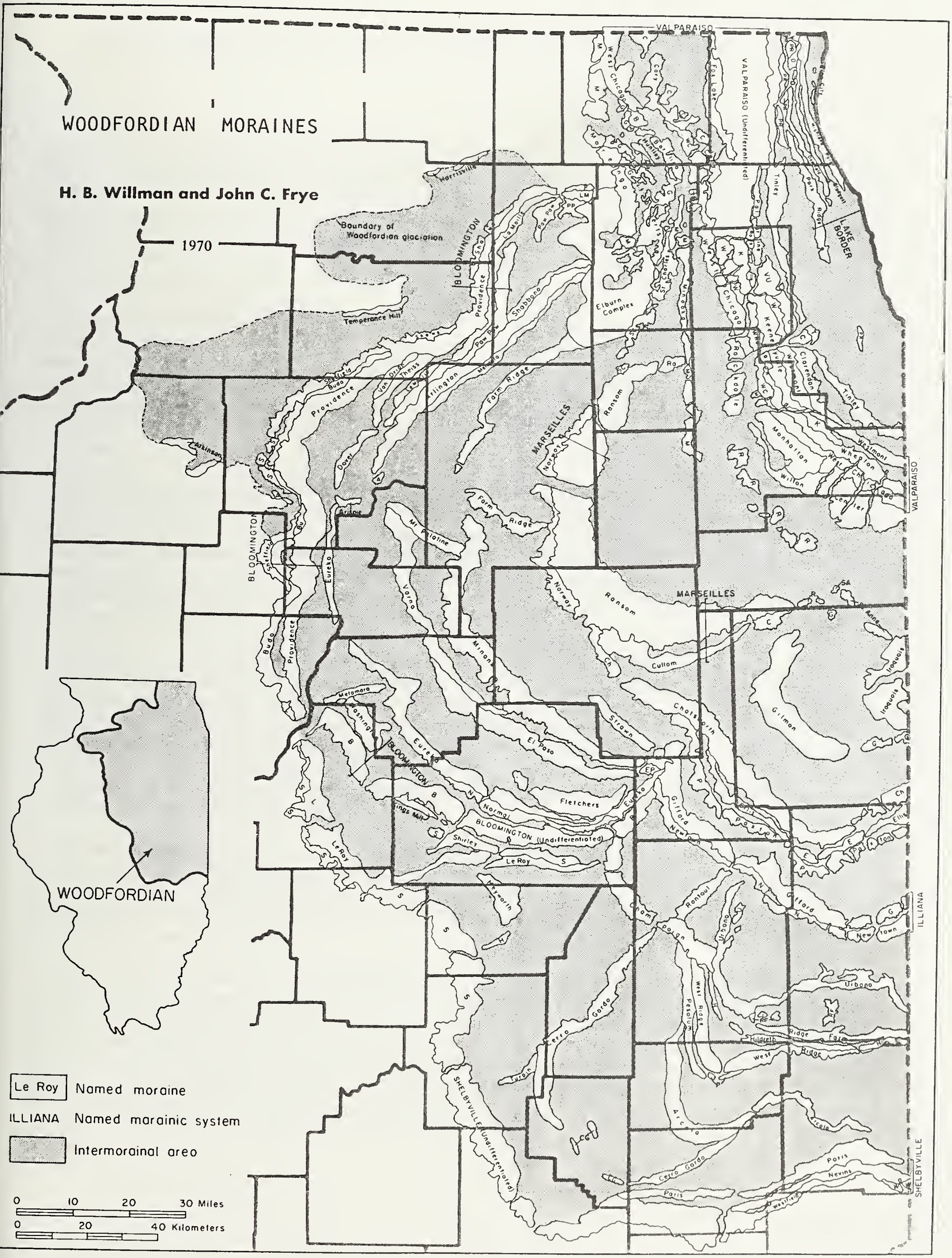
# QUATERNARY DEPOSITS OF ILLINOIS

Jerry A. Lineback

1981

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




WOODFORDIAN MORAINES
H. B. Willman and John C. Frye
1970
Boundary of Woodfordian glaciation
VALPARAISO
VALPARAISO (Undifferentiated)
LAKE BORDER
BLOOMINGTON
BLOOMINGTON (Undifferentiated)
MARSEILLES
ILLIANA
SHELBYVILLE
SHELBYVILLE (Undifferentiated)
Harrisville
Temperance Hill
Atkinson
Sheffield
Buda
Providence
Van Orin
Theiss
Lewis
Arlington
Mendota
Shabbona
Paw Paw
La Moille
Farm Ridge
Dover
Arispie
Mt Palatine
Eureka
Varna
Minonk
Norway
Ransom
Cullom
Chatsworth
Strawn
El Paso
Fletchers
Normal
Shirley
Le Roy
Metamora
Washington
Kings Mill
Heyworth
Elburn Complex
West Chicago
Cary
Fox Lake
Tinley
Park Ridge
Minooka
Rockdale
Keeneyville
Clarendon
Manhattan
Westmont
Wheaton
Wilton
Gilman
Iroquois
Gifford
Rantoul
Paxton
Newtown
Urbana
West Ridge
Pesotum
Hildreth
Cerro Gordo
Arcola
Paris
Nevins
Westfield
WOODFORDIAN
Le Roy Named moraine
ILLIANA Named morainic system
Intermorainal area
0 10 20 30 Miles
0 20 40 Kilometers

# DEPOSITIONAL HISTORY OF THE PENNSYLVANIAN ROCKS IN ILLINOIS

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

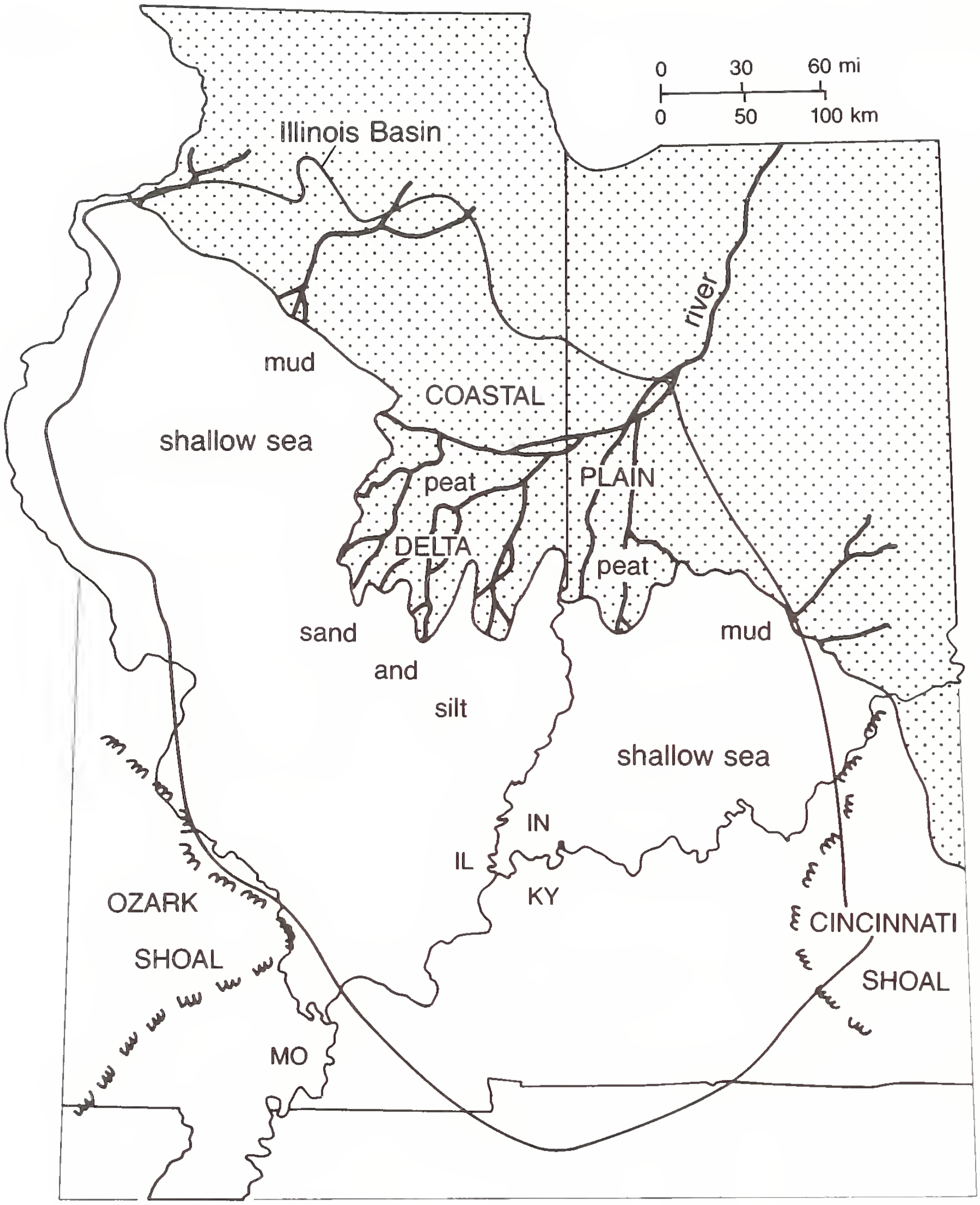
Depositional conditions in the Illinois Basin during the Pennsylvanian Period were somewhat similar to those of the preceding Chesterian (late Mississippian) time. A river system flowed southwestward across a swampy lowland, carrying mud and sand from highlands to the northeast. This river system formed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

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

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

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

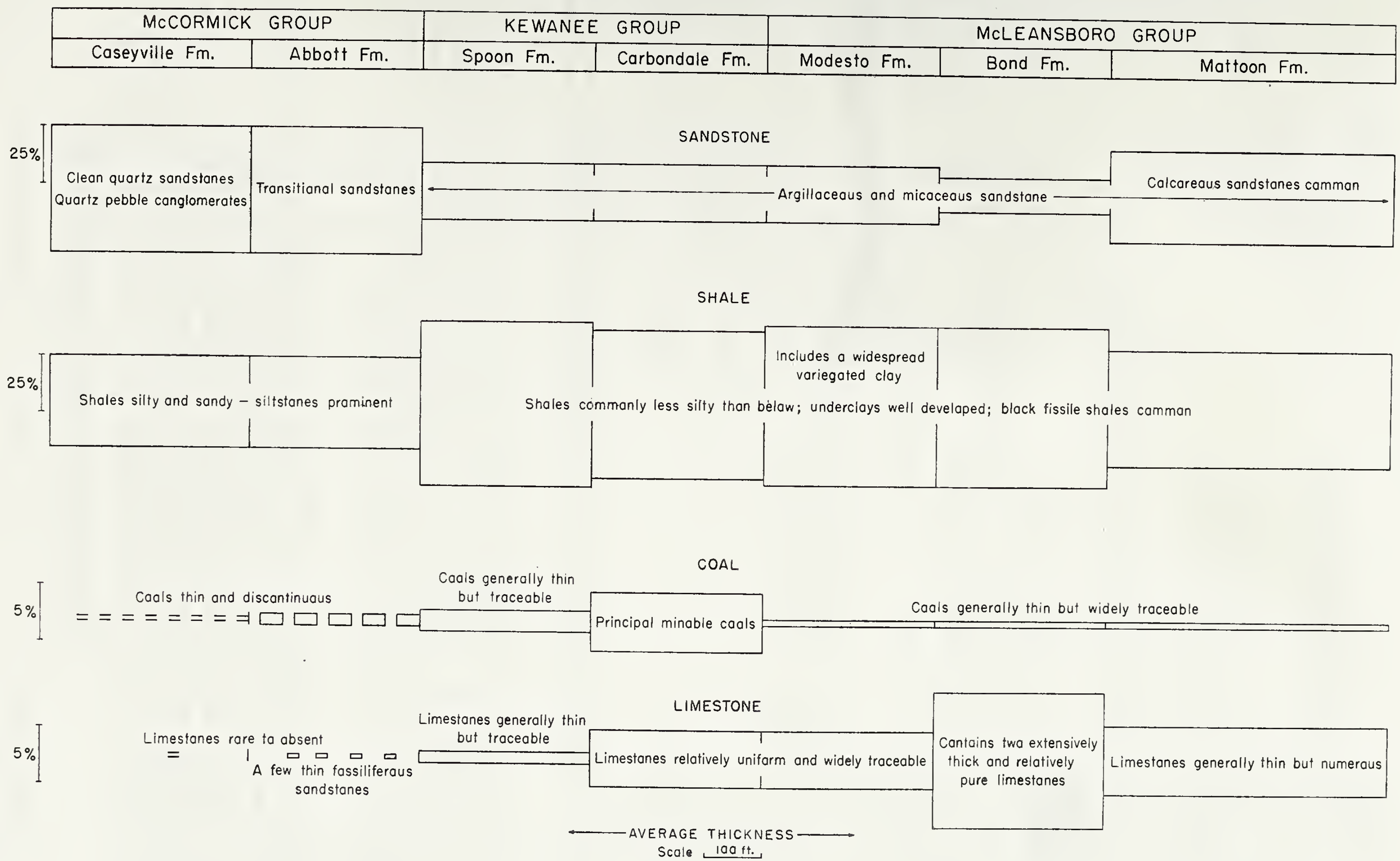
Beneath the quiet water of extensive swamps that prevailed for long intervals on the emergent coastal lowland, peat was formed by accumulation of plant material. Lush forest vegetation covered the region; it thrived in the warm, moist Pennsylvanian-age climate. Although the origin of the underclays beneath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



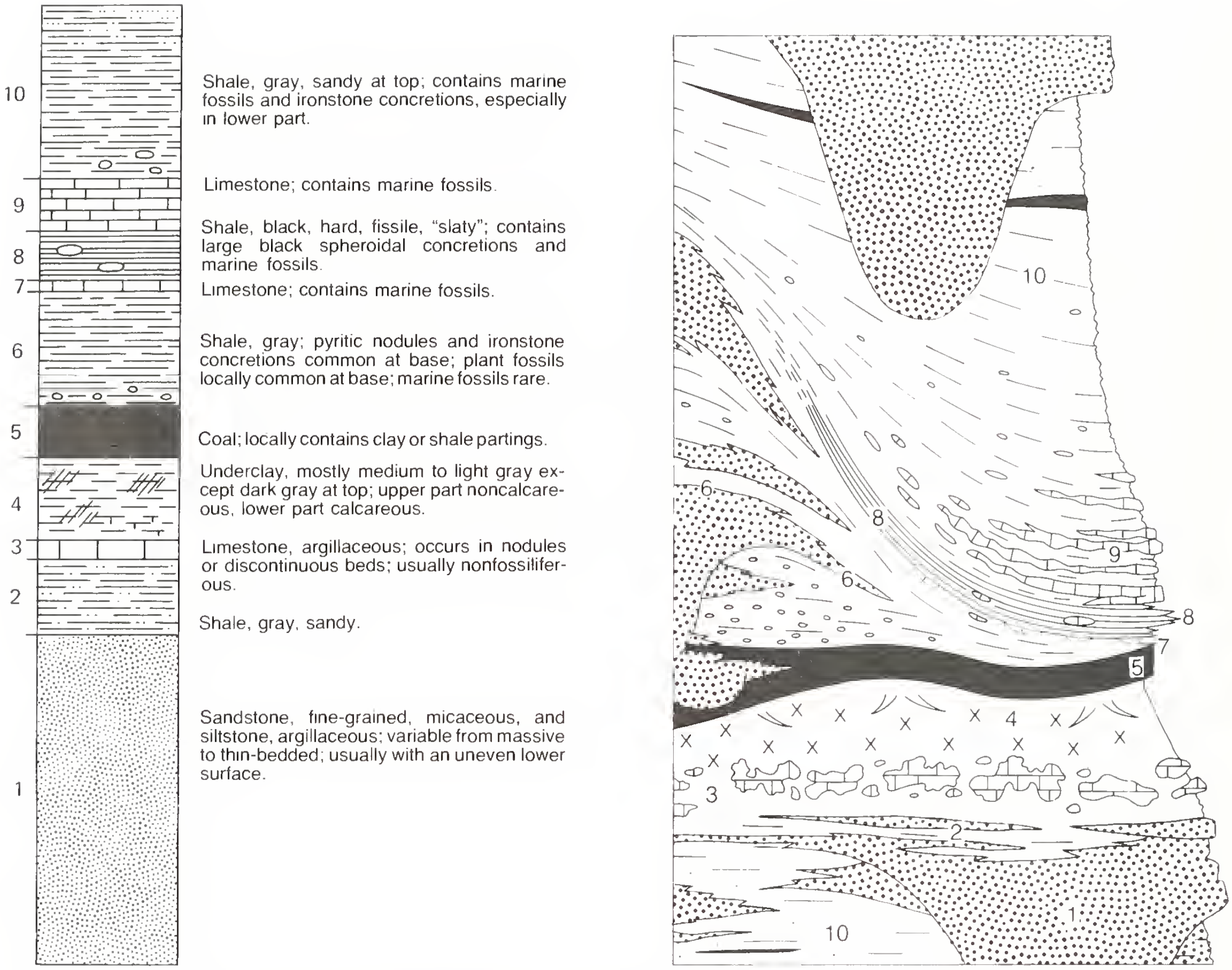

Paleogeography of Illinois-Indiana region during Pennsylvanian time. The diagram shows a Pennsylvanian river delta and the position of the shoreline and the sea at an instant of time during the Pennsylvanian Period.

## Pennsylvanian Cyclothems

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



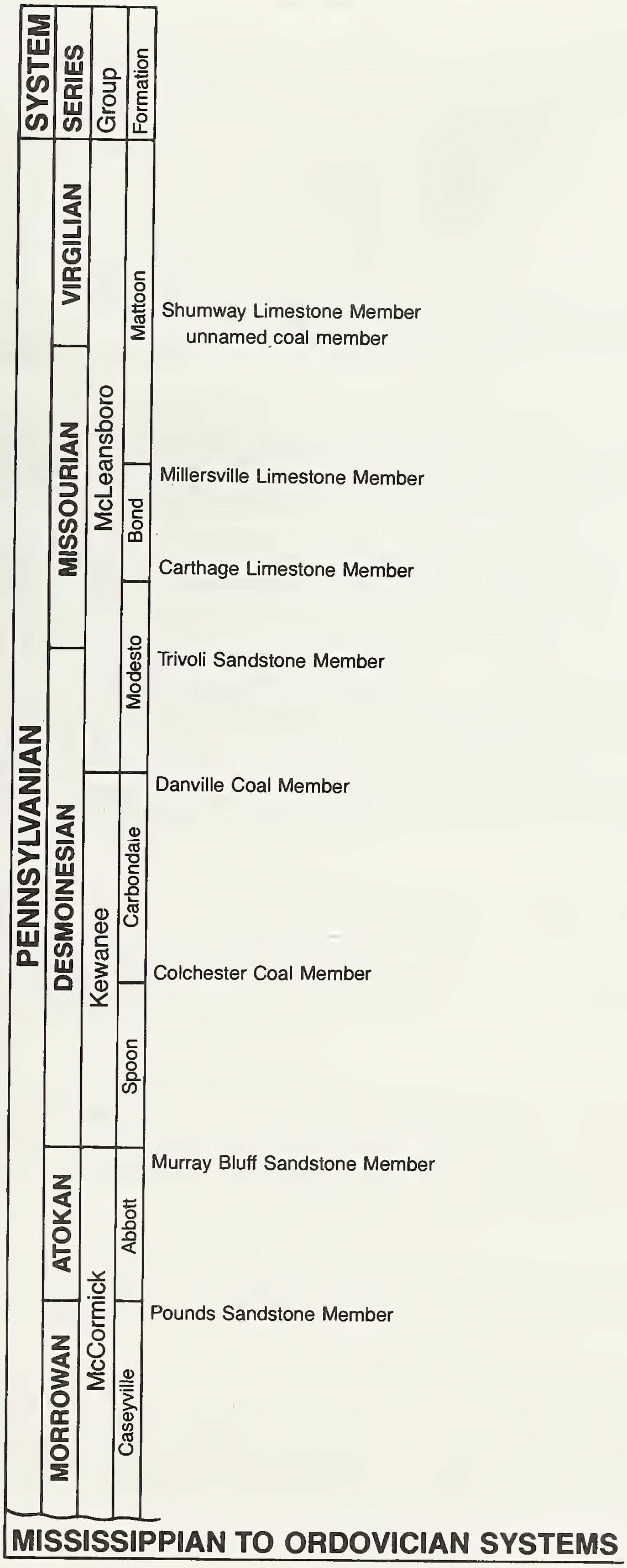

General distribution of the four principal lithologies in Pennsylvanian strata of Illinois.




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

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

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




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

## Origin of Coal

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

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

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

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

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

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

The exact origin of the carbonaceous black shale that occurs above many coals is uncertain. Current thinking suggests that the black shale actually represents the deepest part of the marine transgression. Maximum transgression of the sea, coupled with upwelling of ocean water and accumulation of mud and animal remains on an anaerobic ocean floor, led to the deposition of black organic mud over vast areas stretching from Texas to Illinois. Deposition occurred in quiet-water areas where the very fine-grained iron-rich mud and finely divided plant debris were washed in from the land. Most of the fossils found in black shale represent planktonic (floating) and nektonic (swimming) forms — not benthonic (bottom-dwelling) forms. The depauperate (dwarf) fossil forms sometimes found in black shale formerly were thought to have been forms that were stunted by toxic conditions in the sulfide-rich, oxygen-deficient water of the lagoons. However, study has shown that the "depauperate" fauna consists mostly of normal-size individuals of species that never grew any larger.

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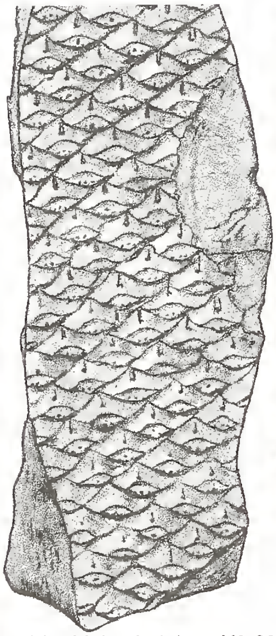
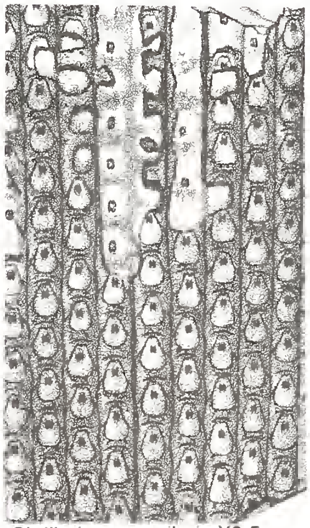
## Common Pennsylvanian plants: lycopods, sphenophytes, and ferns

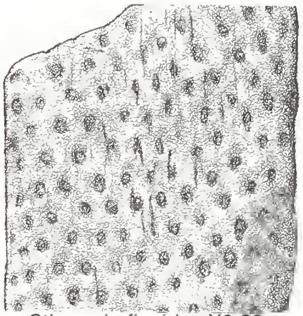
*Lepidodendron aculeatum* X0.8



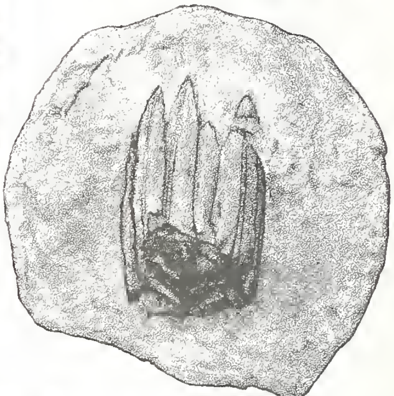
*Lepidophloios laricinus* X0.63



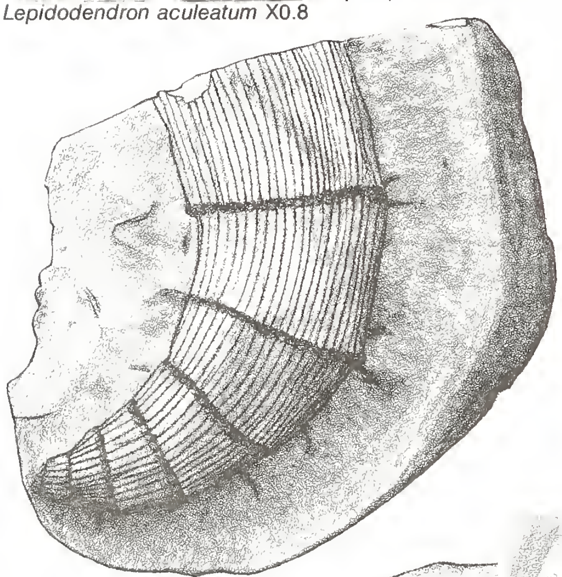
*Sigillaria mammilaris* X0.5



*Stigmaria ficoides* X0.32



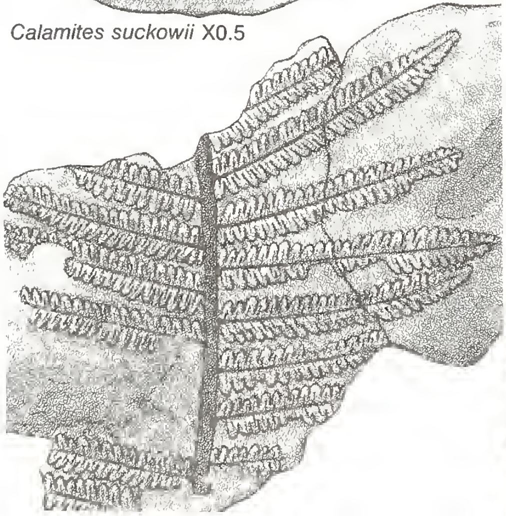
*Lepidostrobus ovatifolius* X0.8



*Calamites suckowii* X0.5

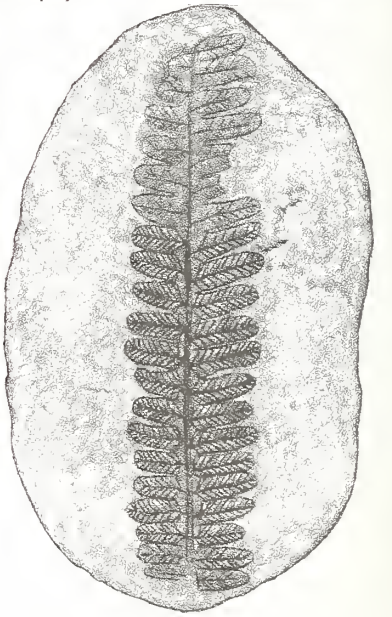
*Annularia stellata* X0.63

*Sphenophyllum cuneifolium* X0.4



*Pecopteris* sp. X0.32

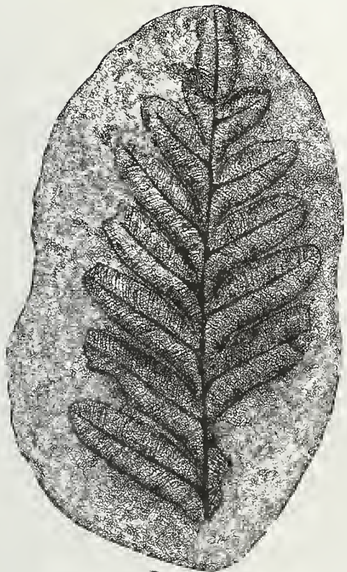
*Pecopteris miltonii* X2.0



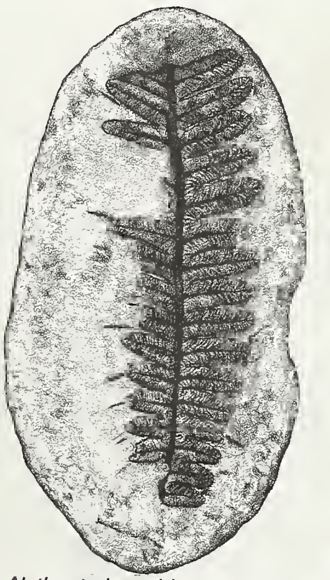
*Pecopteris hemitelioides* X1.0

J. R. Jennings, ISGS

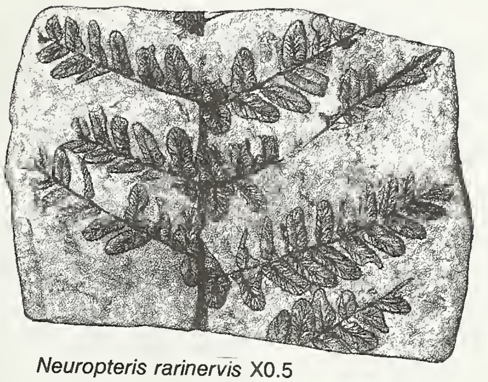
## Common Pennsylvanian plants: seed ferns and cordaiteans



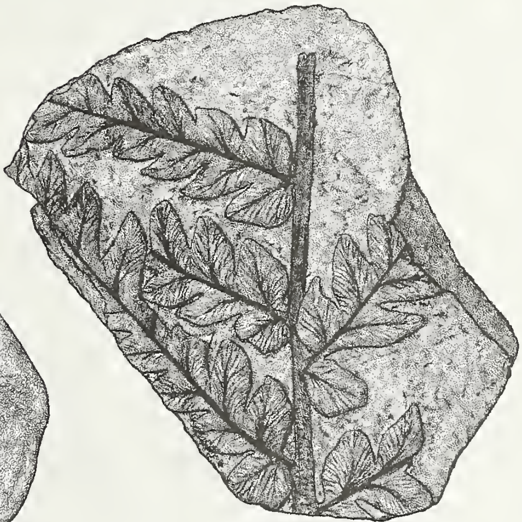
*Alethopteris serlii* X0.63



*Alethopteris ambigua* X0.63



*Neuropteris rarinervis* X0.5

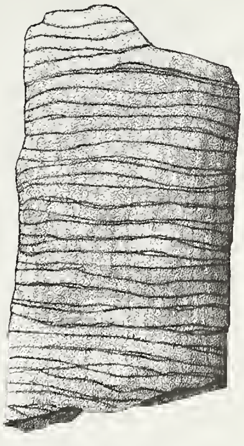


*Mariopteris nervosa* X0.8

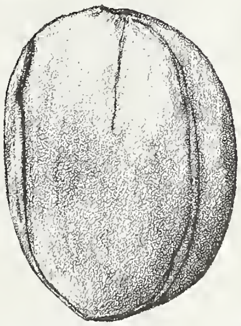
*Neuropteris scheuchzeri* X0.63

*Sphenopteris rotundiloba* X0.8

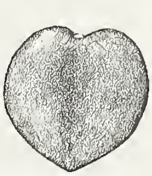
*Cordaicladus* sp. X1.0



*Artisia transversa* X0.63



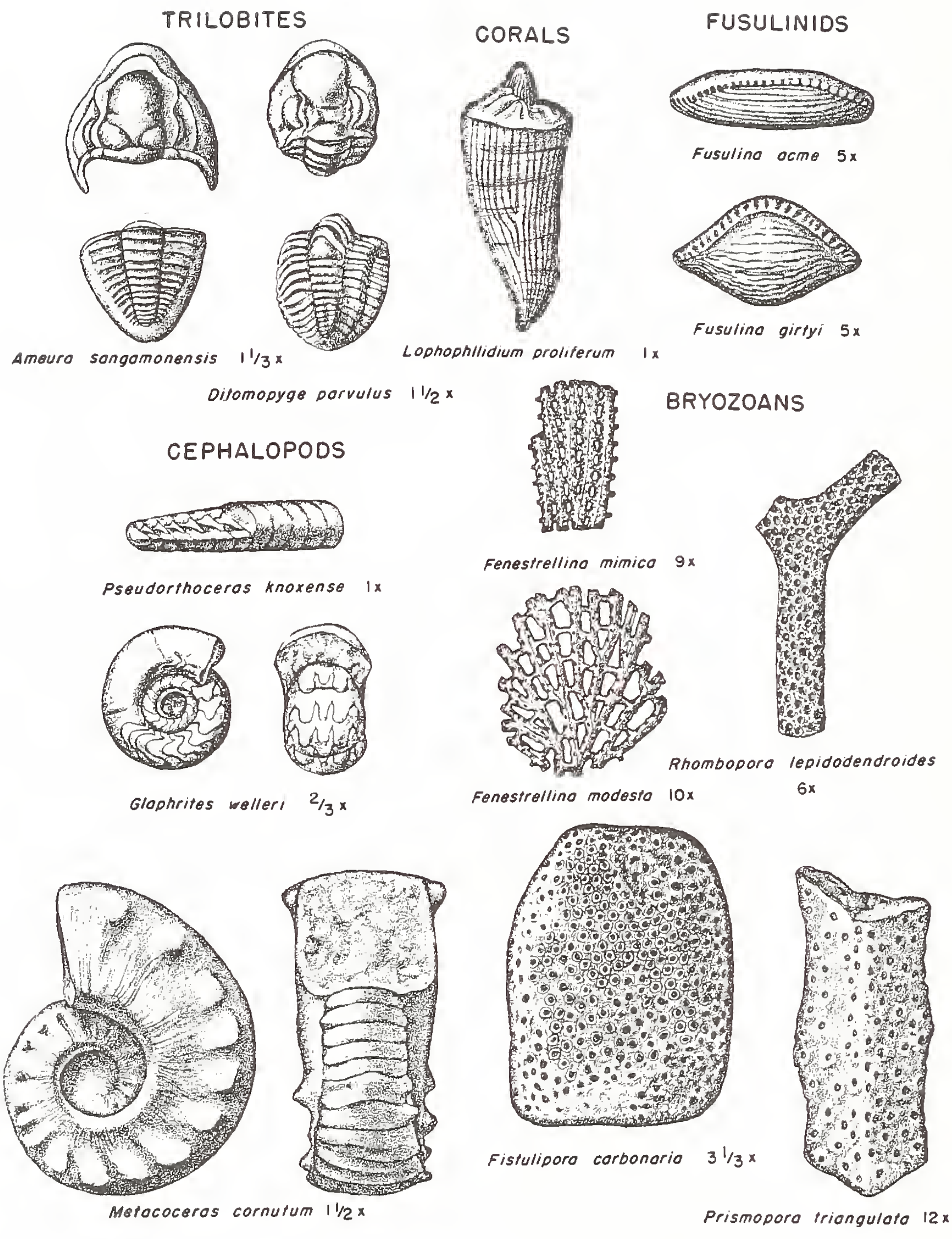
*Trigonocarpus parkinsonii* X1.25

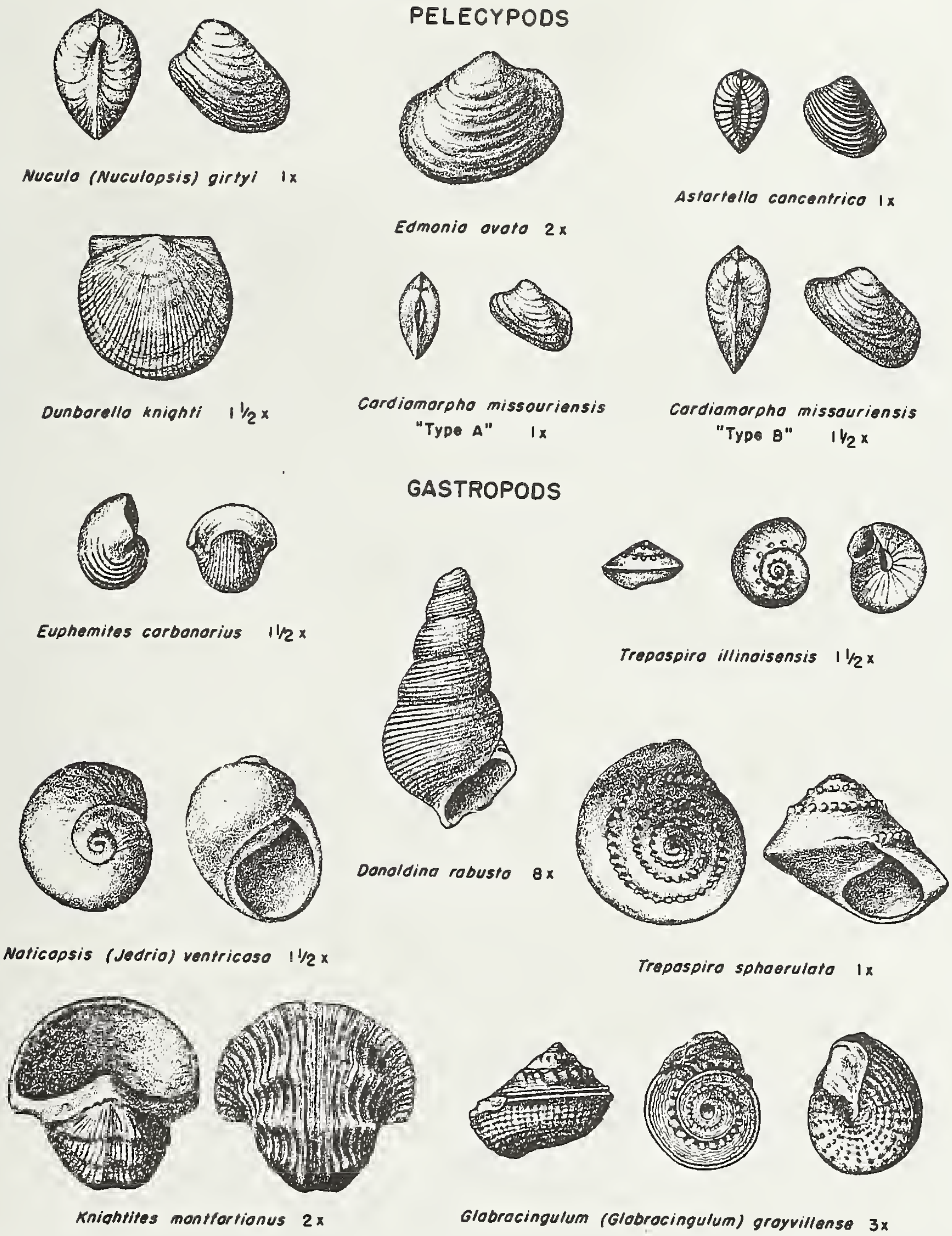


*Cordaicarpon major* X2.0

*Cordaites principalis* X0.63

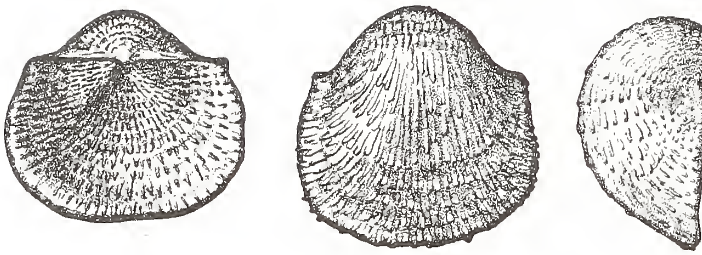
J. R. Jennings, ISGS


TRILOBITES
CORALS
FUSULINIDS
Fusulina acme 5x
Fusulina girtyi 5x
Ameura sangamonensis 1 1/3 x
Lophophilidium proliferum 1x
Ditomopyge parvulus 1 1/2 x
BRYOZOANS
CEPHALOPODS
Pseudorthoceras knoxense 1x
Fenestrellina mimica 9x
Glaphrites welleri 2/3 x
Fenestrellina modesta 10x
Rhombopora lepidodendroides 6x
Fistulipora carbonaria 3 1/3 x
Metacoceras cornutum 1 1/2 x
Prismopora triangulata 12x



PELECYPODS
Nucula (Nuculopsis) girtyi 1x
Edmonia ovata 2x
Astartella concentrica 1x
Dunbarella knighti 1 1/2 x
Cardiomorpha missouriensis "Type A" 1x
Cardiomorpha missouriensis "Type B" 1 1/2 x
GASTROPODS
Euphemites carbonarius 1 1/2 x
Trepospira illinoisensis 1 1/2 x
Donaldina robusta 8x
Naticopsis (Jedria) ventricosa 1 1/2 x
Trepospira sphaerulata 1x
Knightites montfortianus 2x
Glabrocingulum (Glabrocingulum) grayvillense 3x

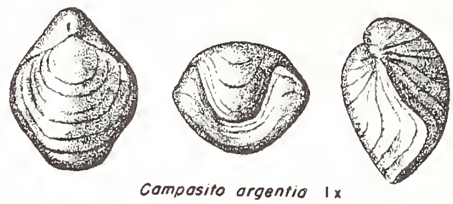
BRACHIOPODS



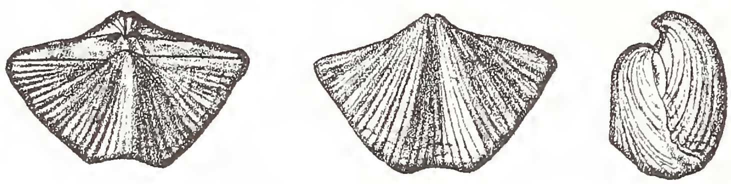
*Wellerella tetrahedra* 1½ x

*Juresonia nebroscensis* 2/3 x

*Derbya crassa* 1x



*Campasita argentia* 1x



*Neospirifer cameratus* 1x

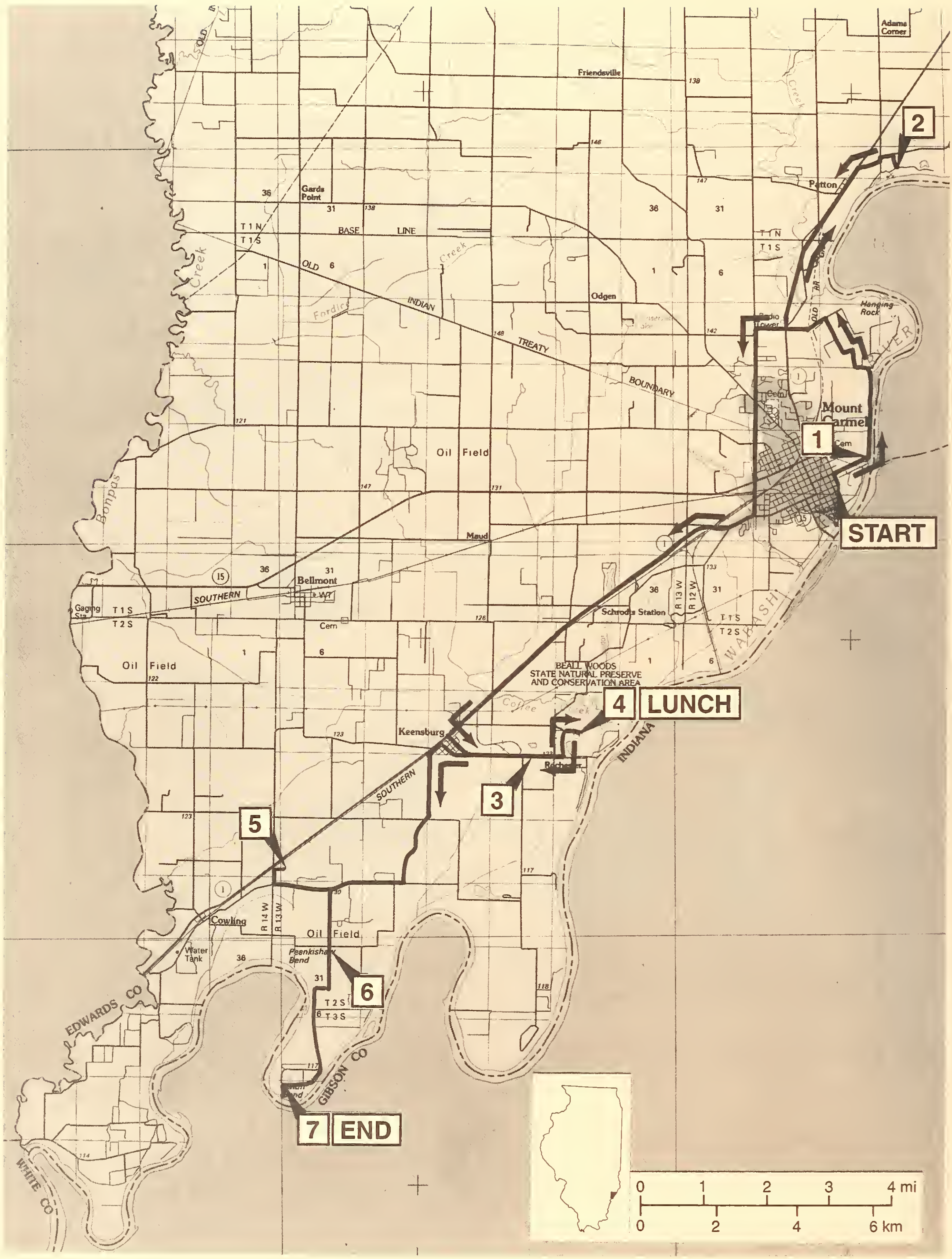
*Chonetes granulifer* 1½ x

*Mesolabus mesolabus* var. *evampygus* 2x

*Marginifera splendens* 1x

*Crurithyris planaconvexa* 2x

*Linopraductus "cora"* 1x



START
1
2
3
4 LUNCH
5
6
7 END
Mount Carmel
Patton
Adams Corner
Friendsville
Gards Point
BASE LINE
OLD INDIAN TREATY BOUNDARY
Odgen
Hanging Rock
Radio Tower
Oil Field
Maud
Bellmont
SOUTHERN
Gaging Sta
Schrodts Station
BEALL WOODS
STATE NATURAL PRESERVE
AND CONSERVATION AREA
Keensburg
Cowling
Water Tank
Peenkishaw Bend
WABASH RIVER
INDIANA
EDWARDS CO
GIBSON CO
WHITE CO
Bonpas Creek
Fordice Creek
Coffee Creek
T 1 N
T 1 S
T 2 S
T 3 S
R 14 W
R 13 W
R 12 W
0 1 2 3 4 mi
0 2 4 6 km