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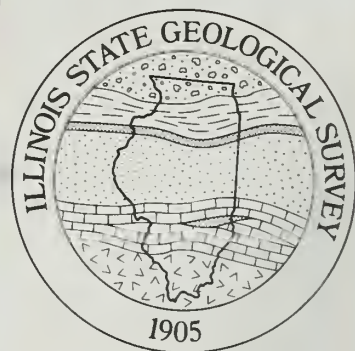
# Guide to the Geology of the Hoopeston Area, Vermilion and Iroquois Counties, Illinois

Wayne T. Frankie  
Myrna M. Killey  
Russell J. Jacobson



Field Trip Guidebook 1996B May 18, 1996

Department of Natural Resources  
ILLINOIS STATE GEOLOGICAL SURVEY



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Department of Natural Resources  
ILLINOIS STATE GEOLOGICAL SURVEY  
Natural Resources Building  
615 E. Peabody Drive  
Champaign, IL 61820

**Cover photo** North Fork of the Vermilion River south of Hoopeston (photo by Wayne T. Frankie).

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

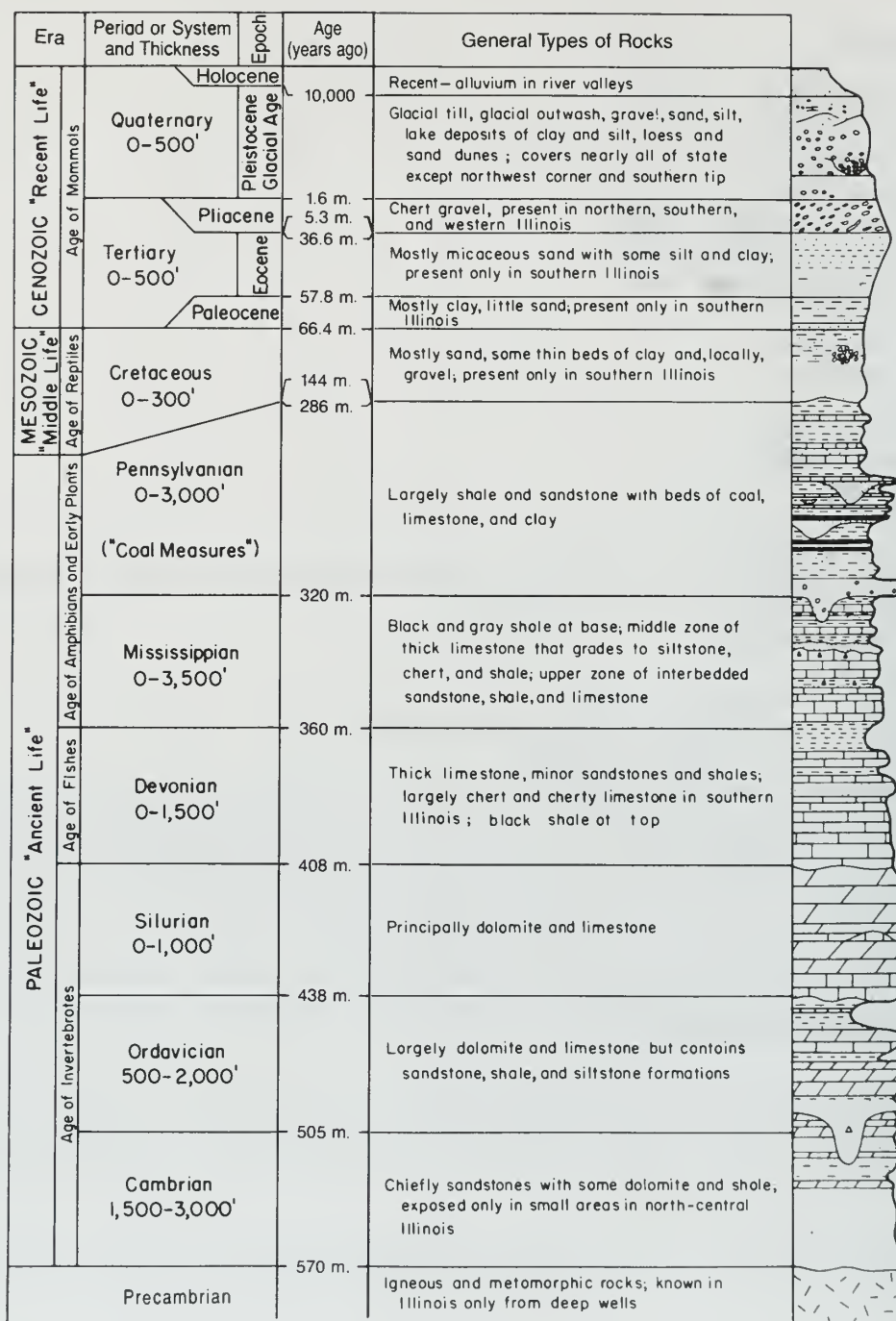
A list of guidebooks of earlier field trips for planning class tours and private outings may be obtained by contacting the Educational Extension Unit, Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820. Telephone: (217) 244-2427 or 333-4747.

Three USGS 7.5-minute topographic quadrangle maps (all available from the ISGS) provide coverage for the field trip: Ambia, Hoopeston, and Wellington.



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Generalized geologic column showing succession of rocks in Illinois.



## HOOPESTON AREA

The Hoopeston geological science field trip will acquaint you with the *geology*, landscape, and mineral resources of northern Vermilion County and the extreme southern part of Iroquois County, Illinois. The city of Hoopeston is located in east-central Illinois, approximately 95 miles south of Chicago, 260 miles northeast of Cairo, 190 miles northeast of St. Louis, and 120 miles east and slightly north of Springfield.

### GEOLOGIC FRAMEWORK

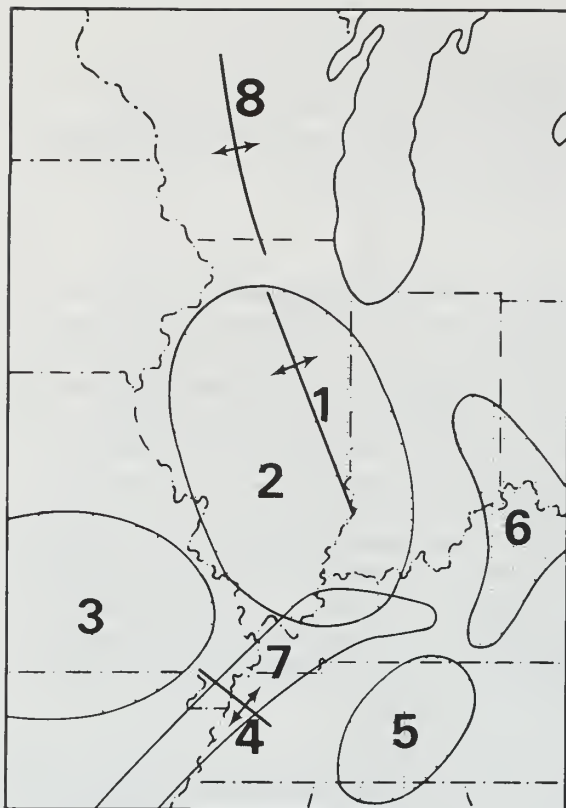
**Precambrian Era** Through the several billion years of geologic time, Vermilion and Iroquois Counties and surrounding areas have undergone many changes (see the generalized geologic column, facing page). The oldest rocks beneath the field trip area belong to the ancient Precambrian *basement complex*. 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 the 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 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 various other techniques, such as measurements of Earth's gravitational and magnetic fields and seismic exploration, to map out the regional characteristics of the basement complex. The evidence 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 movements of crustal plates (plate *tectonics*) began to rip apart the Precambrian-age North American continent. These rift valleys in the midcontinent region are referred to as the Rough Creek Graben and the Reelfoot Rift (fig. 1).

**Paleozoic Era** 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). However, there are no exposures of bedrock within the field trip area. The bedrock is overlain by a thick sequence of glacial till. 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 5,500 feet below sea level in northern Vermilion County to 6,500 feet below sea level in southern Vermilion County. This 1,000 foot difference in elevation takes place within a distance of approximately 40 miles. The top surface of the Precambrian rocks dips southward into the Illinois Basin at a rate of about 25 feet per mile. The thickness of the Paleozoic sedimentary strata ranges from about 5,850 feet in northern Vermilion County to about 7,100 feet in southern Vermilion County.



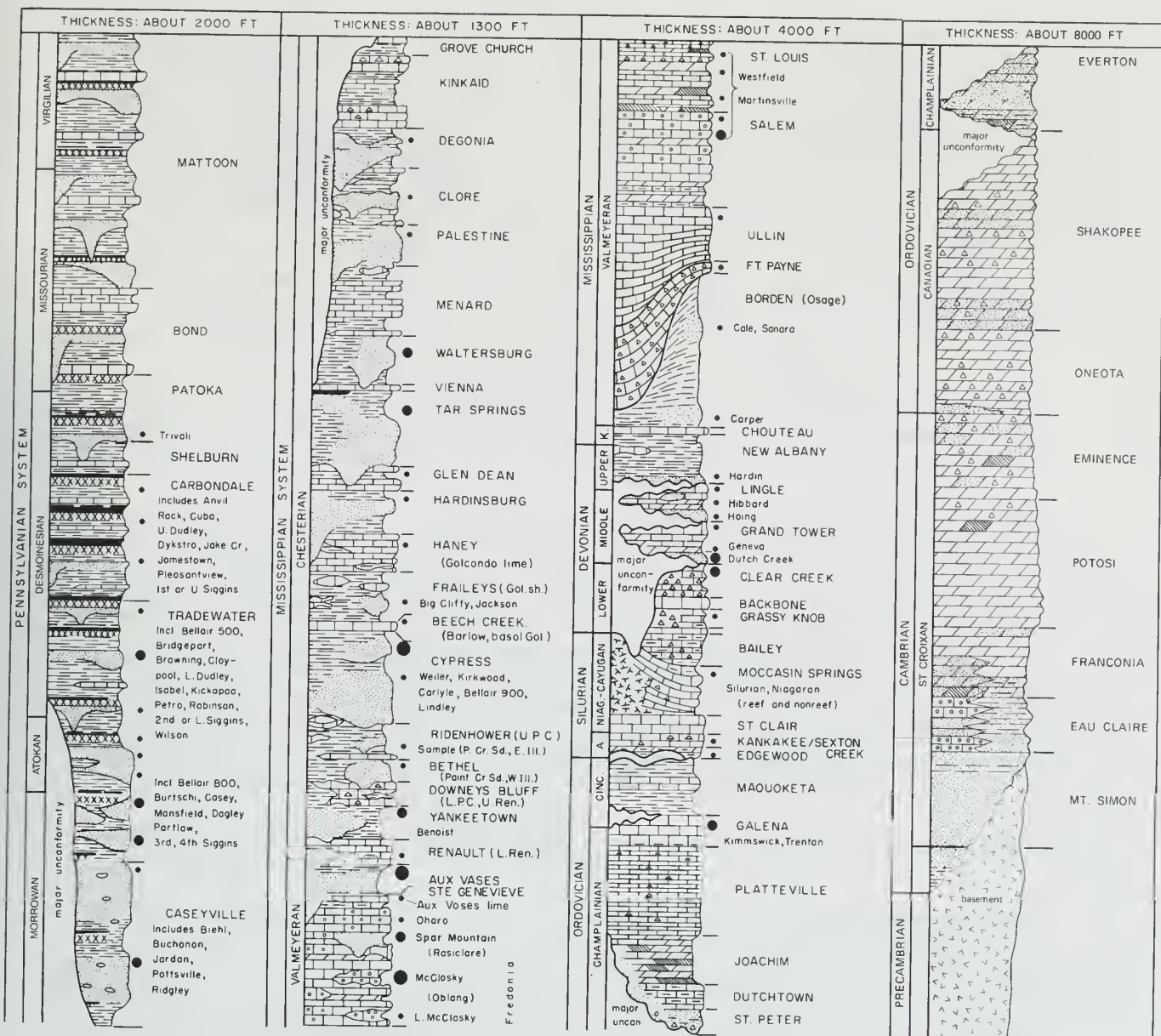
**Figure 1** Location of some of the major structures in the Illinois region. (1) La Salle Anticlinorium, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Rough Creek Graben-Reelfoot Rift, and (8) Wisconsin Arch.

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. Within the field trip area, these rocks are not exposed at the surface because they are overlain by a thick (up to 400 feet) cover of glacial deposits. The Pennsylvanian-age rocks are exposed in the southern half of Vermilion County along the stream valleys. The thickness of the glacial deposits decreases to the south and varies between 25 and 100 feet in the southern half of Vermilion County.

Pennsylvanian strata within the field trip area increase in thickness from 0 feet in the northernmost part of Vermilion County, where they have been completely removed by erosion, to approximately 500 feet in southeastern Vermilion County. An erosional unconformity between the overlying glacial deposits of the Quaternary Period and the Pennsylvanian deposits within the field trip area provides evidence that some of the Pennsylvanian rocks were removed by erosion. The thickness of Pennsylvanian strata increases to 2,500 feet in southern Illinois.

Mississippian-age bedrock strata are found immediately beneath the Pennsylvanian rocks or directly under the glacial deposits where the Pennsylvanian rocks have been eroded away in the northern part of Vermilion County. Mississippian strata do not outcrop in Vermilion County. The Mississippian rocks, which consist of limestones, dolomites, shales, and sandstones, were deposited as sediments in shallow seas between 360 and 320 million years ago. These formations are part of the thick succession of strata in the upper Mississippi River Valley in Illinois that constitute the type section for rocks of the Mississippian Period throughout the world. The thickness of Mississippian strata increases from approximately 600 feet in central Vermilion County to more than 3,200 feet in southern Illinois.



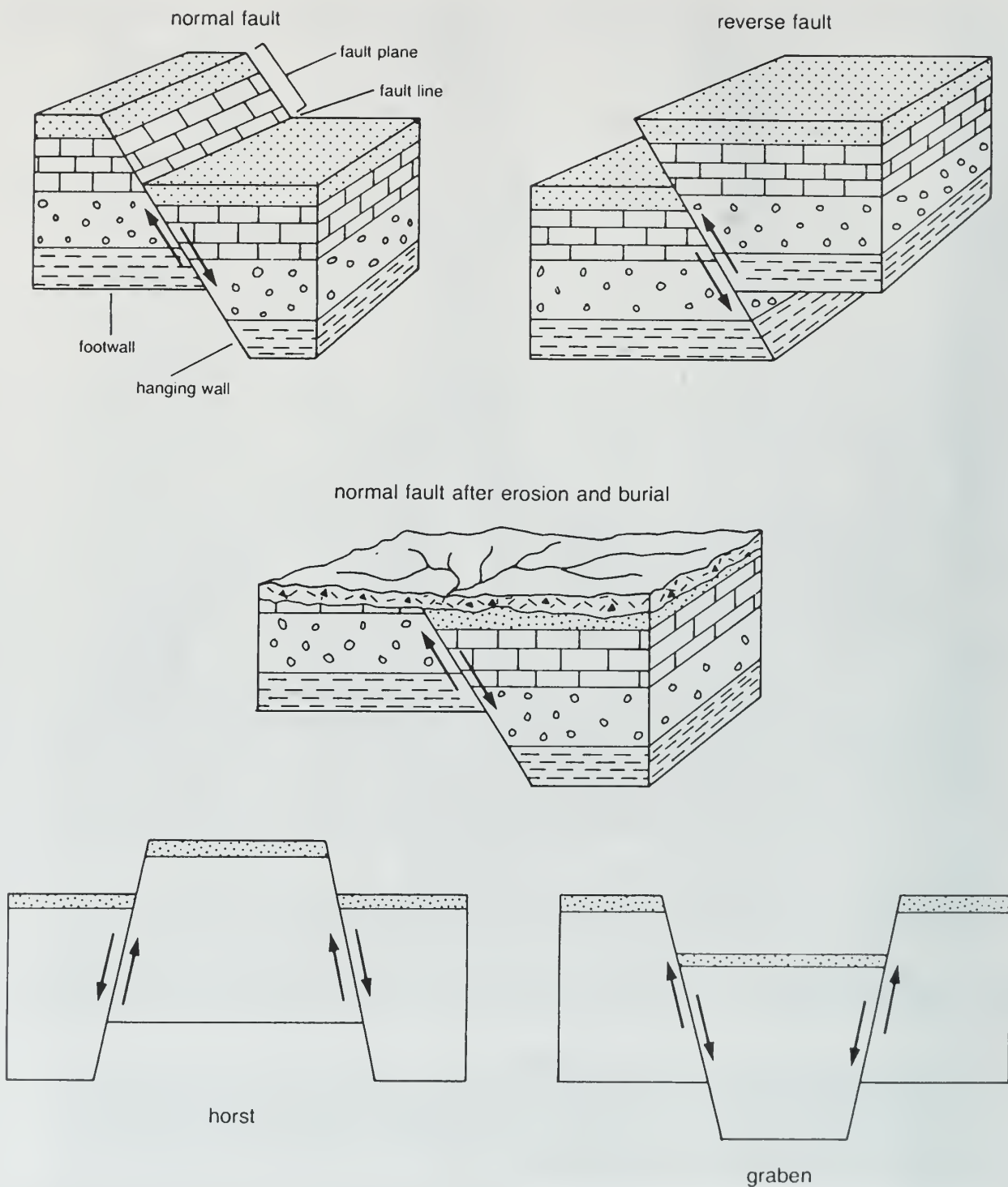


**Figure 2** Generalized stratigraphic column of the field trip area. Black dots indicate oil and gas pay zones (variable vertical scale; from Leighton et al. 1991).

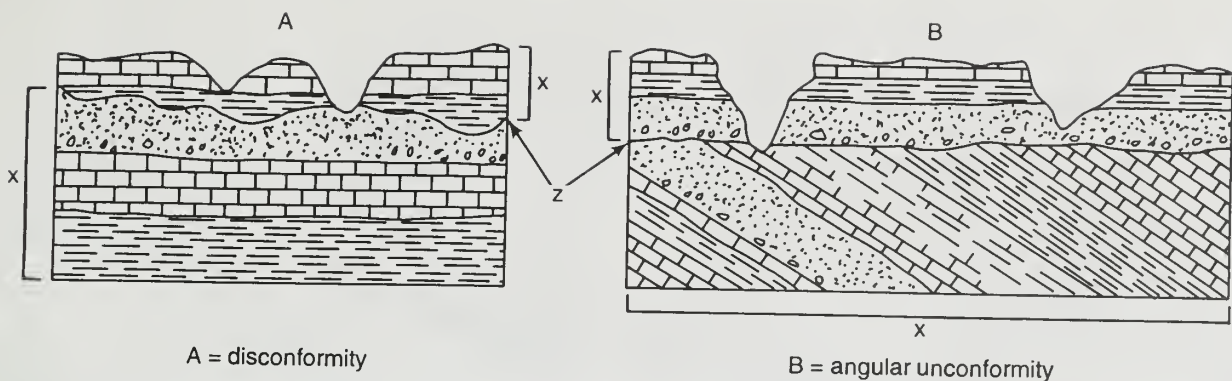
### STRUCTURAL AND DEPOSITIONAL HISTORY

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 areas to the north, allowing a greater thickness of sediment to accumulate. Earth's thin crust was periodically flexed



**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).

and warped as stresses built up in places. These movements caused repeated invasions and withdrawals of the seas across the region. The former seafloors were thus periodically exposed to erosion, which removed some sediments from the rock record.

Many of the sedimentary units, called formations, have conformable contacts—that is, no significant interruption in deposition occurred as one formation was succeeded by another (figs. 2 and 4). In some instances, even though the composition and appearance of the rocks change significantly at the contact between two formations, the fossils in the rocks and the relationships between the rocks at the contact indicate that deposition was virtually continuous. In some places, however, the top of the lower formation was at least partially eroded before deposition of the next formation began. Fossils and other evidence in the two formations indicate that there is a significant age difference between the lower unit and the overlying one. This type of contact is called an *unconformity* (fig. 4). If the beds above and below an unconformity are parallel, the unconformity is called a *disconformity*; if the lower beds have been tilted by tectonic forces and eroded before the overlying beds were deposited, the contact is called an angular unconformity.

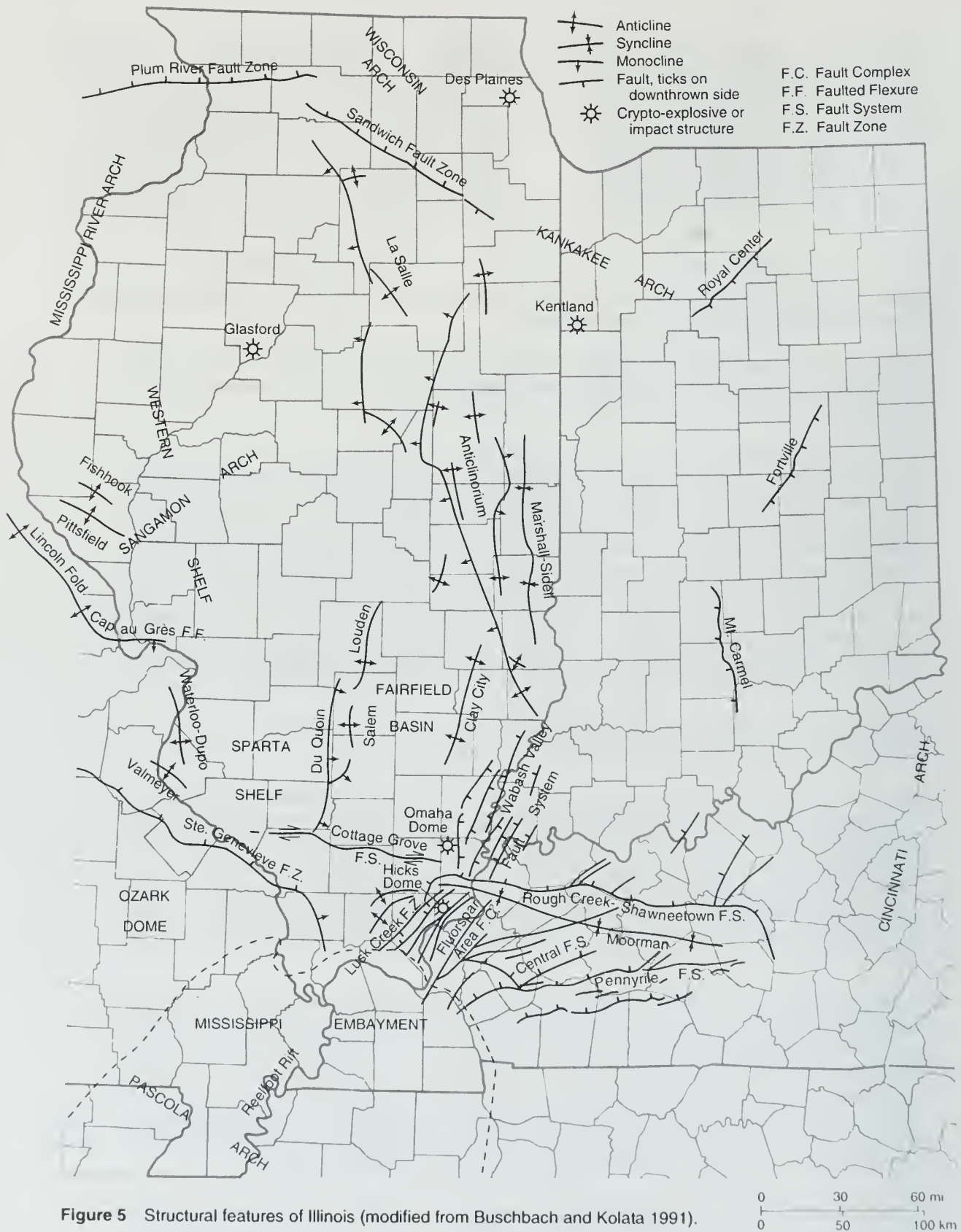
Unconformities are shown in the graphic column in figure 2 as wavy lines. Each unconformity represents an interval of time for which there is no rock record.

Near the close of the Mississippian Period, gentle arching of the rocks in eastern Illinois initiated the development of the 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.

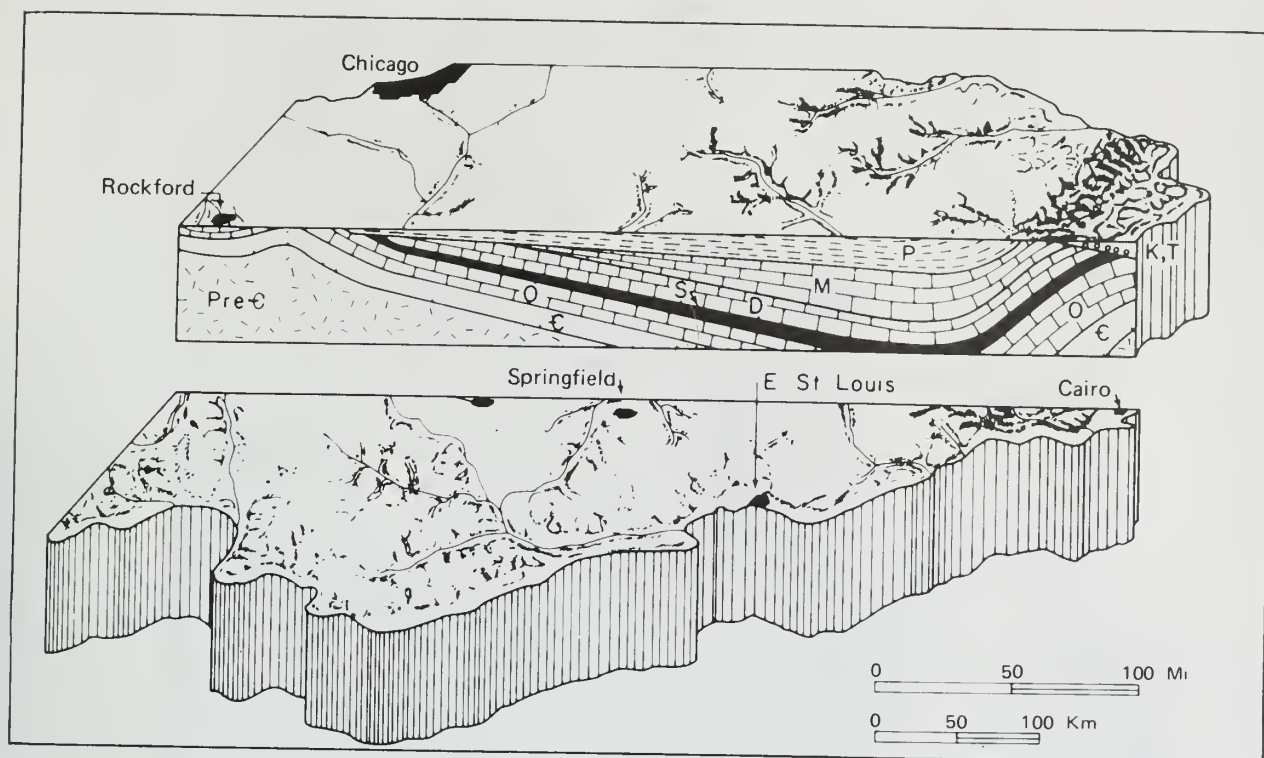
During the Mesozoic Era, which followed the Paleozoic Era, the rise of the Pascola Arch (fig. 1) in southeastern Missouri and western Tennessee formed the Illinois Basin by closing off the embayment and separating it from the open sea to the south. The Illinois Basin is a broad, subsided region covering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

The Hoopston field trip area is located in the north-central part of the Illinois Basin (fig. 5). Structural features in the vicinity of the field trip area include the north-south-trending Marshall-Sidell





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



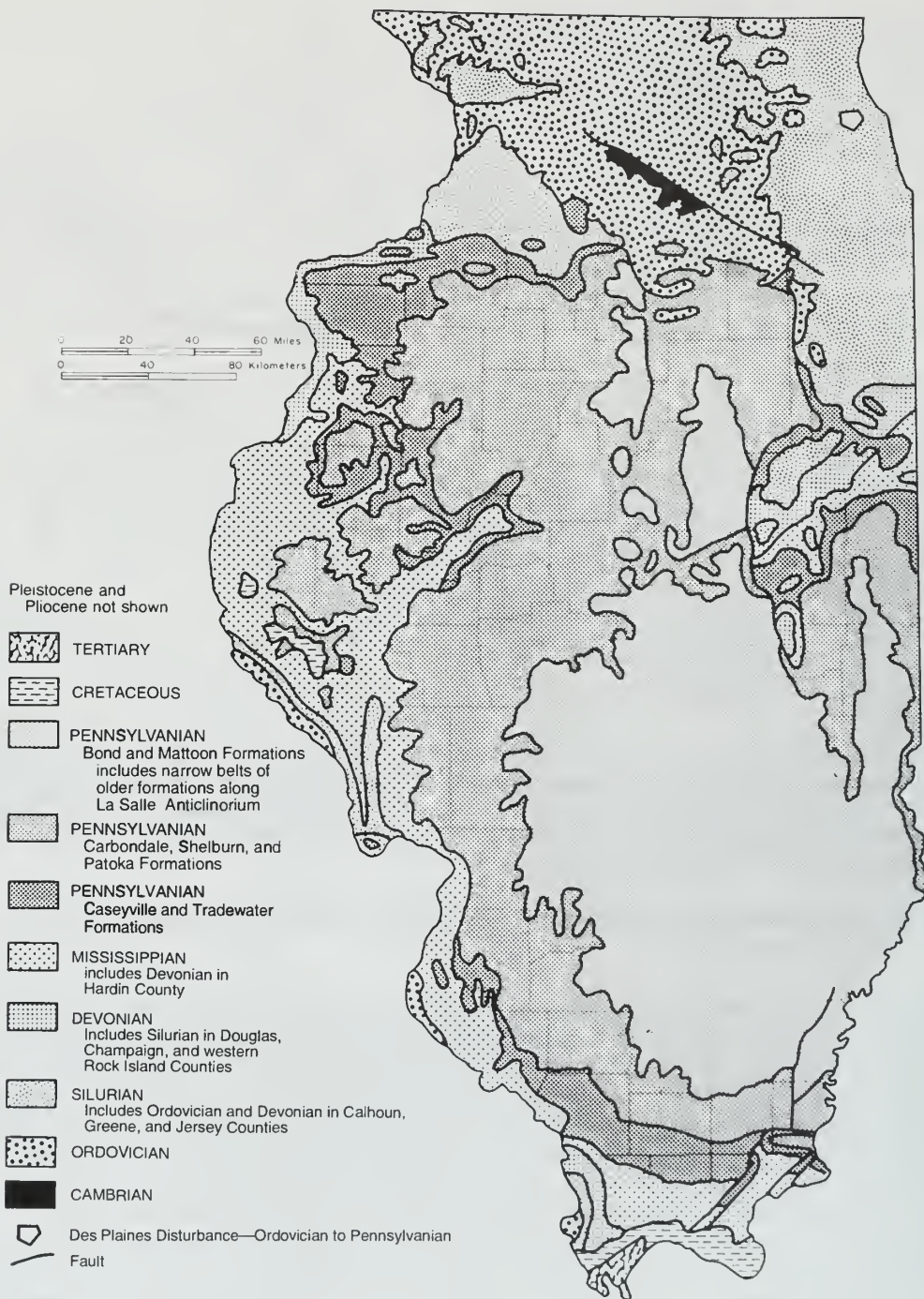
**Figure 6** Stylized north-south cross section shows the structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks has been greatly exaggerated and younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-Є) granites. They form 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.

Anticline and the Crescent City Anticline (fig. 8). Both of these structural features are part of the larger La Salle Anticlinorium.

Younger rocks of the latest Pennsylvanian and perhaps the Permian (the youngest rock system of the Paleozoic) may at one time have covered the areas of Vermilion and Iroquois Counties. It is possible that Mesozoic and Cenozoic rocks (see generalized geologic column) could also have been present here. Indirect evidence, based on the stage of development (rank) of coal deposits and the generation and maturation of petroleum from source rocks (Damberger 1971), indicates that perhaps as much as 1.5 miles of latest Pennsylvanian and younger rocks once covered southern Illinois. However, during the more than 240 million years since the end of the Paleozoic Era (and before the onset of glaciation 1 to 2 million years ago), several thousands of feet of strata may have been eroded. Nearly all traces of any post-Pennsylvanian bedrock that may have been present in Illinois were removed. During this extended period of erosion, deep valleys were carved into the gently tilted bedrock formations (fig. 9). Later, the topographic relief was reduced by repeated advances and melting back of continental glaciers that scoured and scraped the bedrock surface. This glacial erosion affected all the formations exposed at the bedrock surface in Illinois. The final melting of the glaciers left behind the nonlithified deposits in which our Modern Soil has developed.

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





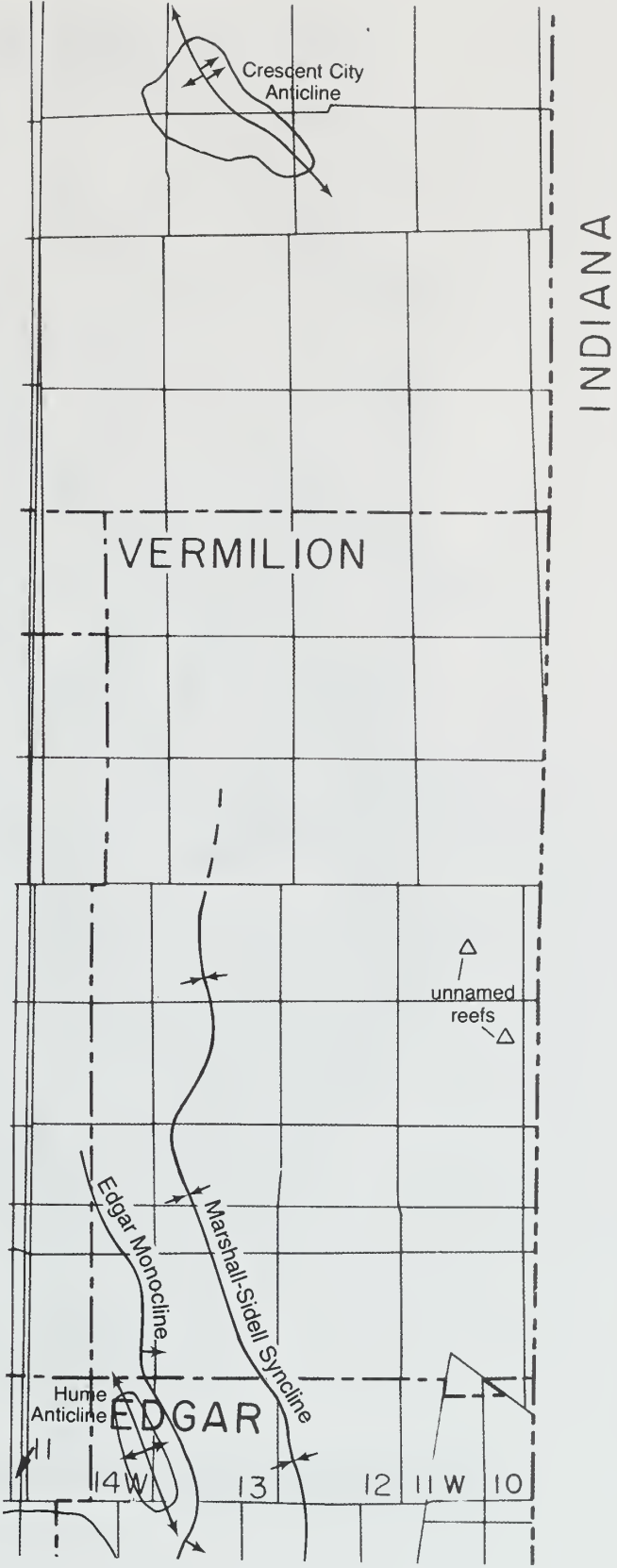
**Figure 7** Bedrock geology beneath surficial deposits in Illinois.

Prior to glaciation, Vermilion and Iroquois Counties and adjacent areas were drained by several rivers that flowed in ancient bedrock valleys, including the Mahomet, Onarga, and Danville valleys (fig. 9). After glaciation, new drainage systems were established. In the field trip area, all of the bedrock valleys are buried beneath glacial sediments. Quaternary deposits along the Mahomet bedrock valley, within the field trip area, exceed 400 feet thick.

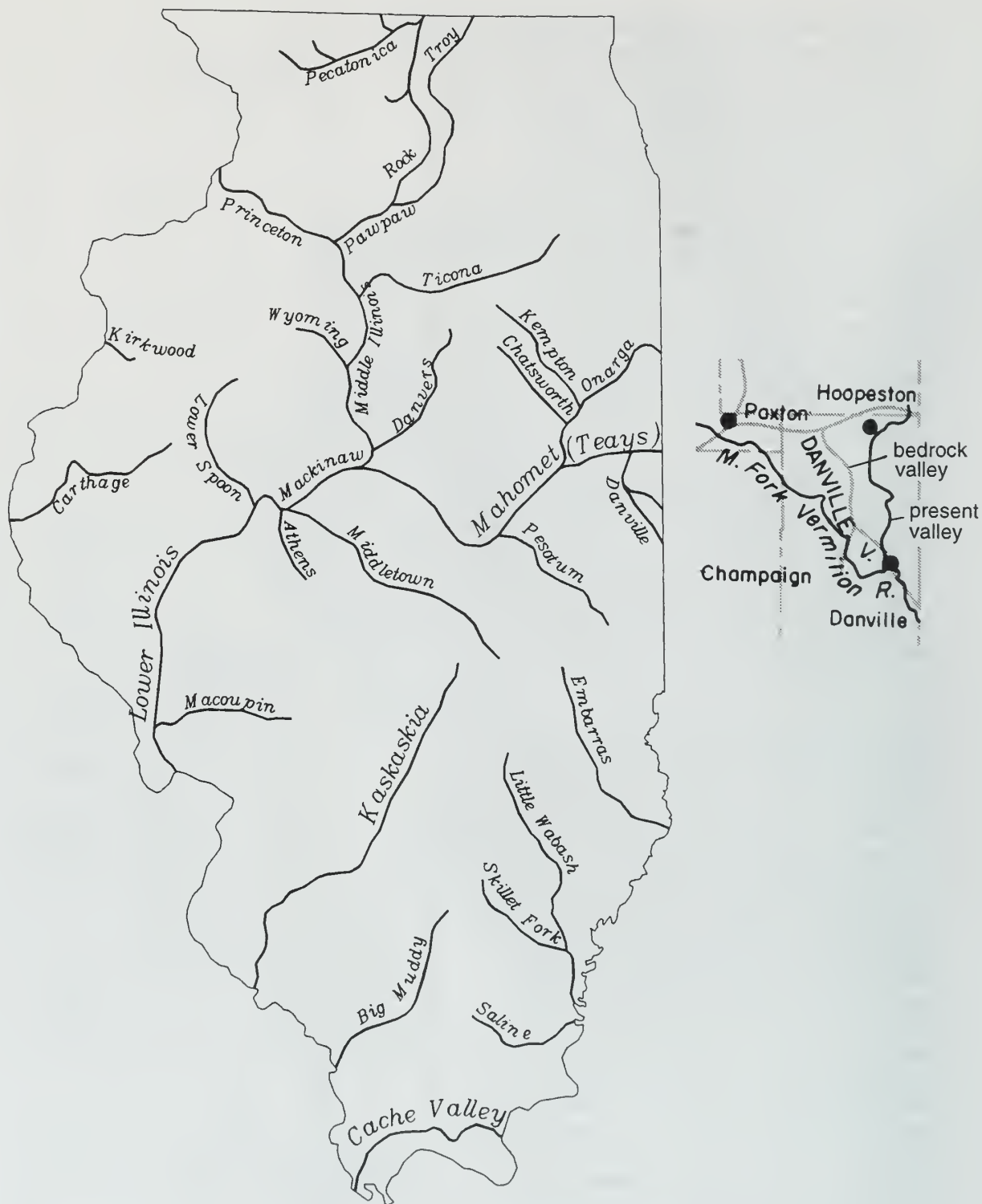
During the Pleistocene Epoch, beginning about 1.6 million years ago, massive sheets of ice (called continental glaciers), thousands of feet thick, flowed slowly southward from Canada. The last of these glaciers melted from northeastern Illinois about 13,500 years before the present (B.P.). During the Illinoian glaciation (also now called the Illinois Episode), which began around 300,000 years B.P., North American continental glaciers reached their southernmost position, approximately 210 miles south-west of Hoopston in the northern part of Johnson County (fig. 10). 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 *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. All of northern Vermilion County and southern Iroquois County is covered either by glacial moraines or by ground moraines of the Wisconsin glacial episode.

Overlying the Wisconsin Episode deposits is a thin cover of deposits called the Peoria Loess (pronounced luss). These sediments, deposited as windblown 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.) Thickness of the loess decreases from approximately 25 feet adjacent to the Illinois River valley near Peoria, Illinois, to less than 2 feet in northern Vermilion and Iroquois Counties. This fine grained dust, which covers most of Illinois, commonly reaches thicknesses exceeding 25 feet along most of the Mississippi and Illinois Rivers, and is as much as 80 feet thick on the east bluff of the Mississippi Valley in the East St. Louis area. (Loess deposits are described in *Ancient Dust Storms in Illinois - Geogram 5* at the back of the guidebook.) Soils in this area have developed in the loess and in the underlying weathered silty, clayey Wisconsin till.

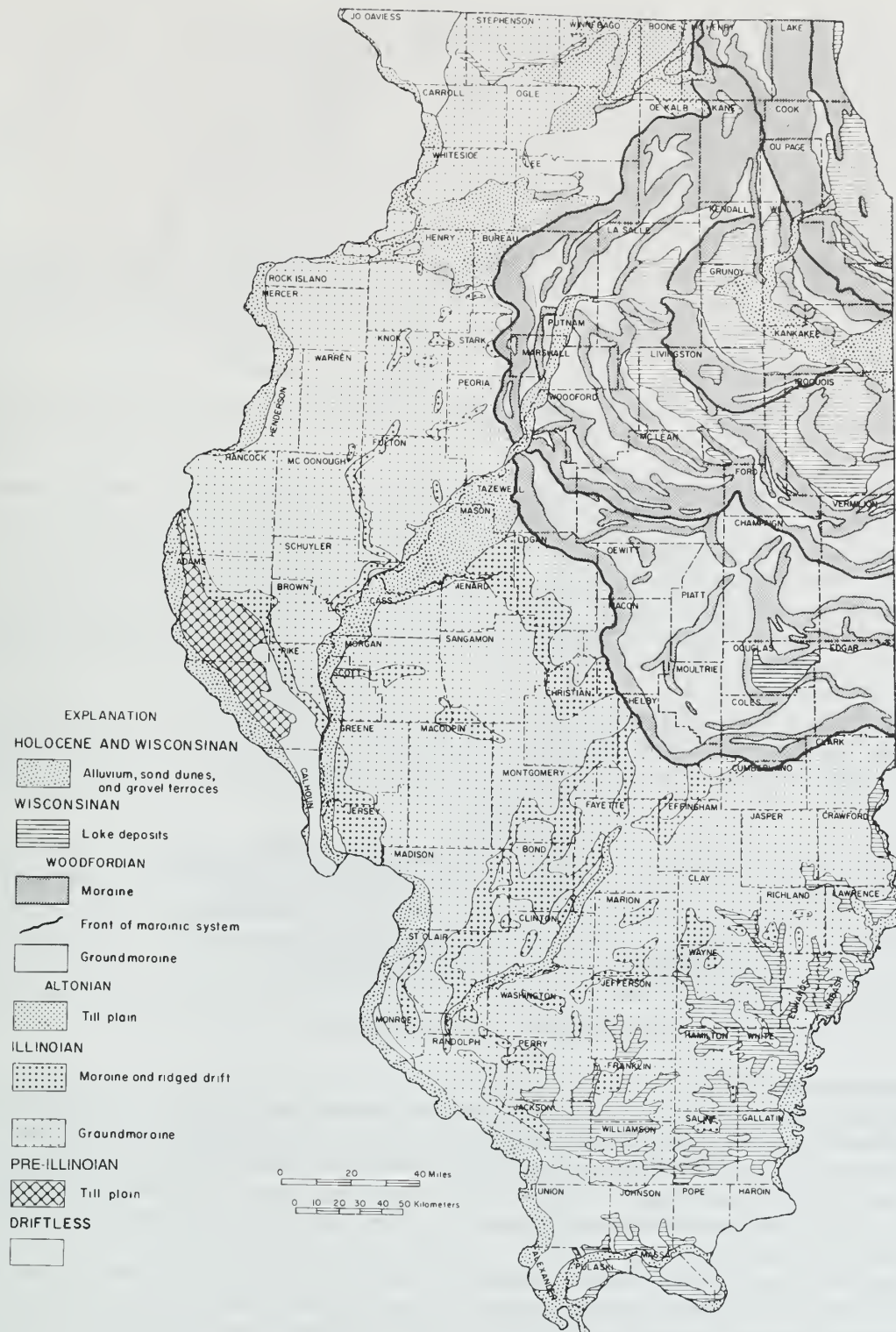


**Figure 8** Structural features within the field trip area (modified from Nelson 1995).



**Figure 9** Bedrock valleys of Illinois and inset of Vermilion County (modified from Bristol and Buschbach 1973).





**Figure 10** Generalized map of glacial deposits in Illinois (modified from Willman and Frye 1970).

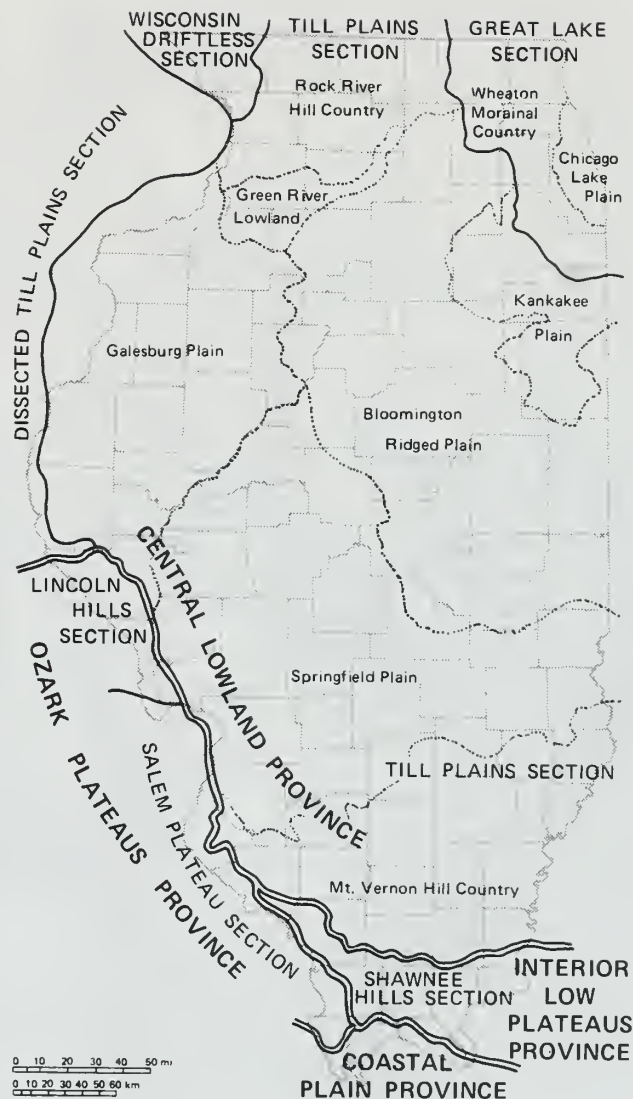


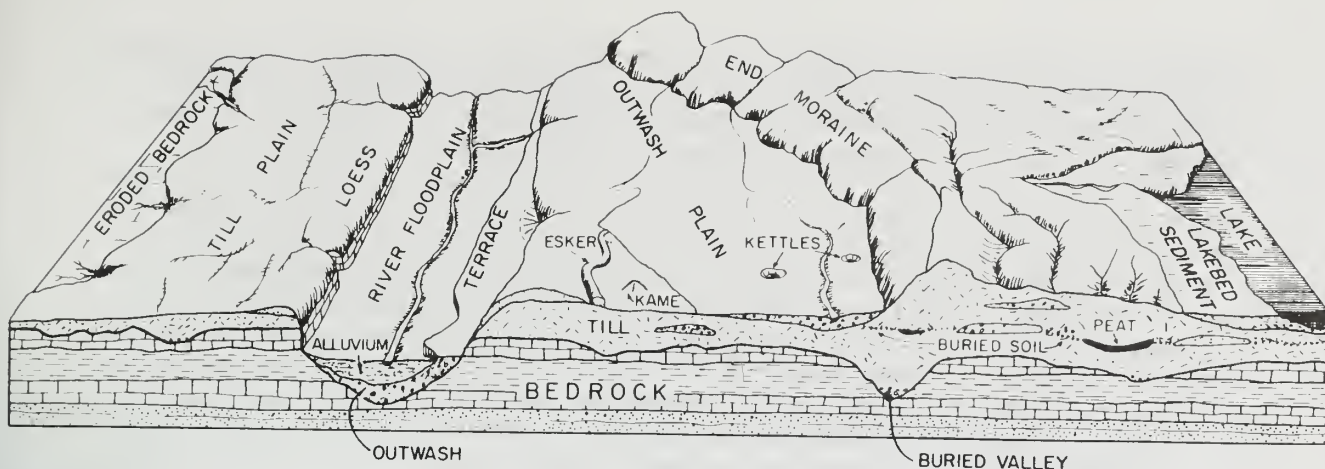
Figure 11 Physiographic divisions of Illinois.

## GEOMORPHOLOGY

**Physiography** The Hoopston field trip area includes parts of the Bloomington Ridged Plain and the Kankakee Plain; both are part of the Till Plains Section of the Central Lowland Physiographic Province (fig. 11). This area is covered with a variety of glacial landforms (fig. 12). The Till Plains Section is in an early stage of erosion and is characterized by broad till plains that are relatively uneroded, in contrast to the deeply eroded Dissected Till Plains on older drift sheets in Iowa.

According to Horberg (1950) and others (for example, Leighton et al. 1948), an extensive lowland called the central Illinois *penneplain* (a low, nearly featureless, gently undulating land surface) was eroded prior to glaciation into the relatively weak rocks of Pennsylvanian age east and south of the present Illinois River. As glaciation began, streams probably changed from erosion to aggradation; that is, their channels began to fill up with sediments because the streams did not have sufficient volumes of water to carry and move the increased amounts of sediment (a process called alluviation). To date, no evidence indicates the early fills in these preglacial valleys ever were completely flushed out of their channels by succeeding glacial meltwater torrents.





**Figure 12** Block diagram shows the relationship of glacial and alluvial deposits to landforms and bedrock surface (modified from Piskin and Bergstrom 1975).

**Kankakee Plain** The Kankakee Plain, according to Leighton et al. (1948), is a level to gently undulatory plain, with low morainic islands, glacial terraces, torrent bars, and dunes. The landscape was formed in part by the depositional and erosional processes of streams and lakes. The glacial lakes which periodically covered it were temporary expansions due to the glacial meltwater floods and did not extensively alter its surface either by deposition or by erosion, except along the courses of strong outlet currents. The Kankakee Plain could be considered a modified basin that formed between major moraines, floored largely with ground moraine, and bedrock.

Most of the region is poorly drained by shallow low-gradient streams which follow constructional depressions. The two major streams—the Kankakee and the Des Plaines—occupy glacial sluiceways. The drift in the Kankakee region is less than 25 feet thick and scarcely conceals the bedrock surface.

**Bloomington Ridged Plain** The Bloomington Ridged Plain, according to Leighton et al. (1948), includes most of the Wisconsin moraines and is characterized by low, broad morainic ridges with intervening wide stretches of relatively flat or gently undulatory ground moraine. In many places, the major moraines rise with gentle slopes, and, although they are conspicuous from a distance, they become less so near at hand, whereas the minor moraines are prominent locally. It was in this district more than in any other that the grass-covered stretches of rolling prairie and extensive swamps, described by early settlers, were most typically and extensively developed.

The glacial deposits are relatively thick throughout the district and completely conceal the bedrock topography, except locally. Illinoian and older drift are present below the Wisconsin in most places, so that the level aspect of present drift-plains is due largely to the presence of the older drift-sheets, which filled in and covered the irregularities of the bedrock surface.

Drainage is generally in the initial stages of development, and most streams follow and are eroding in constructional depressions, many of which cross morainic ridges. The valleys of principal streams are large, owing in part to the greater areal extent of this division and to its somewhat greater age, and they have floodplains bordered by valley-train terraces. The Illinois River, the master-stream of the district, has a broad, flat-bottomed valley with steep walls and is bordered by numerous narrow steep-walled valleys with steep gradients.

**Drainage** In this field trip area, drainage is controlled by the North Fork of the Vermilion River and its tributaries south of Hoopeston and by Gay Creek and its tributaries north of Hoopeston. The North Fork of the Vermilion River flows southward into Lake Vermilion near Danville, Illinois,

where the overflow enters the Vermilion River and eventually empties into the Wabash River. Gay Creek flows to the north and eventually empties into the Illinois River, via Sugar Creek, the Iroquois River, and the Kankakee River. The North Fork of the Vermilion River and Gay Creek and their tributaries have narrow valleys and low gradients (bottom slopes).

**Relief** The highest land surfaces in the field trip area occur atop the crests of the moraines. Elevations of 750 feet above mean sea level (msl) occur along the crests of several of the moraines. The highest elevation encountered along the field trip route is 760 feet at the crest of the Chatsworth Moraine, at Stop 1, just north of Hoopston. The lowest elevation is 670 feet along Gay Creek, at Stop 2, west of the village of Wellington. The surface relief of the field trip area, calculated as the difference between the highest and lowest elevations, is 90 feet. *Local relief* is most pronounced along the route where the moraines have been dissected by stream erosion or where streams flow along the front of the moraines. This local relief rarely exceeds 50 feet, even when comparing the elevations of points separated by more than a mile.

## **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, 0.5% lower than the 1991 total. Minerals extracted accounted for 90% of this total. Coal continued to be the leading commodity, accounting for 64% of the total, followed by industrial and construction materials at 21.4% and oil at 14.2%. The remaining 0.4% included metals, peat, and gemstones. Illinois ranked 13th among the 31 oil-producing states in 1992 and 16th among the 50 states in total production of nonfuel minerals, but it continued to lead all other states in the production of fluorspar, industrial sand, and tripoli.

Vermilion and Iroquois Counties ranked 49th and 72nd, respectively, among all Illinois counties in 1992 on the basis of the value of all minerals extracted, processed, and manufactured. Economic minerals mined in Vermilion County in 1992 included stone (limestone and dolomite) and sand and gravel. Iroquois County only produced stone.

No coal production was reported in Vermilion County for 1992. However, a new slope mine (called the Riola Mine) was opened by the Catlin Coal Company and began production in April 1996. The mine is located about 6 miles south of Catlin. The slope has reached the Herrin Coal at a depth of 251 feet. The coal averages 5 to 6 feet thick but locally is less than 4.6 feet thick. The overlying Danville Coal is at a depth of 186 feet. At full production, they anticipate an output of 300,000 tons per year. Vermilion County's historic cumulative coal production is 30,651,670 tons. Coal has been mined primarily from the Herrin and Danville Coal seams.

**Groundwater** Groundwater is a resource frequently overlooked in assessments of an area's natural resource potential. The availability of this resource 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 thick glacial deposits occur in this area, sand and gravel deposits are common throughout most of the area, especially along the North Fork of the Vermilion River and in the buried Mahomet bedrock valley. Within these valleys are thick zones of permeable sands and gravels which yield large amounts of water. The city of Hoopston withdraws its municipal water supply from the buried Mahomet bedrock valley, and the village of Rossville withdraws its water supply from the sand and gravel deposits along the North Fork of the Vermilion River.

## GUIDE TO THE ROUTE

Assemble at the parking lot of the Hoopeston Community School District No. 11 (NE, NE, NW, Sec. 13, T23N, R12W, 2nd P.M., Vermilion County, Hoopeston 7.5-minute Quadrangle). We'll start calculating mileage at the intersection of the northeast exit of the parking lot and Orange Street (Illinois Route 9).

***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:

- Please do not litter or climb on fences.
- Leave all gates as you found them.
- These simple rules of courtesy also apply to public property.

If you use this booklet for a field trip with your students, youth group, or family, *you must* (because of trespass laws and liability constraints) *get permission from property owners or their agents before entering private property.*

The following 7.5-Minute Quadrangle maps provide coverage for the area of the field trip: Ambia, Hoopeston, and Wellington.

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Miles to next point	Miles from start	
0.0	0.0	Exit at the northeast end of the parking lot. TURN RIGHT (east) onto Orange Street (State Route 9).
0.1	0.1	T-intersection from the right: 1500E. CONTINUE AHEAD.
0.3	0.4	View to the right of the Illinois Landfill Inc. landfill, which is 1 mile south of State Route 9.
0.85	1.25	Cross North Fork of the Vermilion River. This segment of the North Fork flows between the Chatsworth Moraine to the north and the Ellis Moraine to the south.
0.25	1.5	CAUTION: Prepare to turn left at the next crossroad.
0.1	1.6	Crossroad intersection of 4100N (State Route 1) and 1700E. TURN LEFT (north) onto 1700E.
0.25	1.85	Cross North Fork of the Vermilion River.



0.05	1.9	Small lake on the right side of the road is in an abandoned sand and gravel pit. This is now the North Fork Conservation Club.
0.25	2.15	Cross abandoned railroad grade. This was the New York-Chicago-St. Louis Railroad, which is now the Norfolk Southern. The tracks have been removed.
0.05	2.2	The bank of the small drainage creek on the left side of the road contains a number of small slumps. These slumps are the result of erosion by the creek cutting into the sides of the ditch. The slumps mark where the creek is trying to establish meanders.
0.35	2.55	STOP (2-way): Intersection of 4200N (Vermilion County Highway 24) and 1700E. CONTINUE AHEAD. CAUTION: Approaching traffic on Highway 24 does not stop.
0.15	2.7	The road begins a gentle ascent onto the Chatsworth Moraine.
0.8	3.5	Road crosses the crest of the Chatsworth Moraine, elevation 760+ feet.
0.05	3.55	Crossroad intersection of 1700E and 4300N. TURN LEFT (west) onto 4300N. This is the county line road; Iroquois County is to the north and Vermilion County is to the south. Notice the sign on the northeast corner of the intersection reads 000N and 2600E. The gently rolling landscape on the top of the Chatsworth Moraine is called swell and swale topography.
0.75	4.3	T-intersection from the left (Vermilion County): 1630E. CONTINUE AHEAD.
0.25	4.55	T-intersection from the right (Iroquois County): 2500E. CONTINUE AHEAD.
0.6	5.15	CAUTION: Road makes a sharp 90° jog to the left and then immediately back to the right.
0.15	5.3	Stop 1. Chatsworth Moraine. Pull over to the right side of the road. The low area immediately to the north of Floral Hill Cemetery is the origin of Gay Creek.

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**STOP 1** We'll view and discuss the moraines surrounding Hoopeston, the origin of ancient glacial Lake Watseka, and the development of the four outlet channels of this lake.

---

0.0	5.3	Leave Stop 1. CONTINUE AHEAD.
0.1	5.4	STOP (one-way): T-intersection of 1510E and 4300N. TURN RIGHT, then immediately TURN LEFT. Entrance to Floral Hill Cemetery is to the right.
0.15	5.55	T-intersection from the right (Iroquois County): 2400E. CONTINUE AHEAD.
0.05	5.6	CAUTION: Cross single railroad track (signal lights only, unguarded). Chicago and Eastern Illinois Railroad, now CSX Transportation.
0.2	5.8	View to the left (south). The topographically low area marks the position of one of the Lake Watseka outlet channels, which has dissected the

Chatsworth Moraine. This erosional feature was created by erosion as water flowed through the outlet channel of glacial Lake Watseka. The back and end (facing the channel) slopes of the Chatsworth Moraine also are visible.

0.65	6.45	STOP (2-way): intersection of 000N and 2300E (State Route 1). TURN RIGHT (north) onto State Route 1. Entering Iroquois County.
0.35	6.8	Notice the very flat topography of the land. This is the bottom of the pro-glacial lake called Lake Watseka. The very small and gentle hills on the landscape probably are the result of shallow-water wave action on the bottom of the lake.
0.6	7.4	Crossroad intersection of 100N: CONTINUE AHEAD.
1.0	8.4	T-intersection from the left: 200N. CONTINUE AHEAD.
0.85	9.25	CAUTION: Prepare to turn left at next side road.
0.1	9.35	T-intersection from the left: 300N. TURN LEFT (west) onto 300N. To the northeast of the intersection is the village of Wellington. CAUTION: Watch out for approaching traffic on Highway 1.
1.1	10.45	Stop 2. Gay Creek. Pull over to the right side of the road. Do not park on the bridge.

**STOP 2** We'll view and discuss the deposition of glacial meltwater sands and gravels of the Batavia Member of the Henry Formation along Gay Creek, as well as the effects of channelization, by humans, along Gay Creek.

0.0	10.45	Leave Stop 2. Cross Gay Creek and CONTINUE AHEAD.
0.9	11.35	Crossroad intersection: 2100E and 300N. TURN LEFT (south) onto 2100E.
1.0	12.35	Crossroad intersection: 200N. CONTINUE AHEAD.
0.45	12.8	The ditch on the right side of the road has been deepened and channelized to help improve drainage from the fields. Several of the field tiles that empty into the ditch are visible from the road.
0.5	13.3	STOP (2-way): Intersection of 2100E and 100N. CONTINUE AHEAD.
1.0	14.3	STOP (2-way): T-intersection of 2100E and 000N (county line road). TURN LEFT (east) onto 000N.
0.35	14.65	Stop 3. Exposure of Yorkville Till. Pull over to the right side of the road.



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**STOP 3** We'll view and discuss the origin and deposition of the ground moraine of the Yorkville Till Member of the Wedron Formation, as well as the development of soils.

---

0.0	14.65	Leave Stop 3. CONTINUE AHEAD.
0.65	15.3	T-intersection from the right (Vermilion County): 1300E. TURN RIGHT (south) onto 1300E. Located on the southeast corner of the intersection is a large pile of bulldozed debris that contains numerous glacial erratics, some of which are up to 3 feet in diameter.
0.2	15.5	The road begins a descent into a small depression. The lowest point of this depression marks the path of one of the Lake Watseka outlet channels (see route map). The low drainage area in the field to the right is usually wet after a rain.
0.3	15.8	Middle of the outlet channel; this is the lowest elevation in this depression on the landscape.
0.2	16.0	Southern edge of the outlet channel.
0.3	16.3	STOP (2-way): Intersection of 4200N and 1300E. TURN LEFT onto 4200N (east).
0.4	16.7	Cross small drainage ditch; this marks the position of an ancient outlet channel of Lake Watseka.
0.7	17.4	STOP (2-way): Intersection of 1400E (State Route 1) and 4200N. TURN RIGHT (south) onto State Route 1.
0.3	17.7	Merge into the center lane.
0.1	17.8	T-intersection from the left: West Main Street. CONTINUE AHEAD and PREPARE to turn left.
0.05	17.85	T-intersection from the left: West Penn Street: TURN LEFT onto West Penn Street.
0.1	17.95	Entrance to McFerrin Park: (TURN RIGHT). Enter the park and follow the park road to the right.
0.1	18.05	Stop 4. TURN LEFT into the parking lot in front of the Jaycees Shelter. ARE YOU HUNGRY? This is the shelter we will use for lunch. We'll reset our trip odometer after leaving the park.

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**STOP 4** Lunch and discussion of the Mahomet bedrock valley.

---

Leave Stop 4: Follow the park road and exit the park using the south entrance. TURN RIGHT at the flagpole and then TURN RIGHT onto West Elm Street.

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Miles to next point	Miles from start	
0.0	0.0	Stop (1-way): Intersection of State Route 1 and West Elm Street, which is located at the southeast corner of the park. TURN LEFT onto State Route 1. Note: Reset trip odometer to 0.0
0.15	0.15	STOP (4-way flashing red light): Intersection of State Route 1 and State Route 9. CONTINUE AHEAD (south).
0.15	0.3	Cross drainage ditch. The ditch follows the course established by the middle outlet channel of Lake Watseka (see route map).
0.85	1.15	Crossroad intersection of 4000N and State Route 1. TURN LEFT (east). After making the turn, looking to the left you can see that a part of east Hoopeston is built on the Chatsworth Moraine and is topographically higher than the section of Hoopeston near the water tower. The water tower is located near the middle of the outlet channel that we observed at Stop 1.
0.35	1.5	T-intersection from the left: 1450E. CONTINUE AHEAD.
0.2	1.7	Cross channelized drainage ditch. This creek flows south into the North Fork of the Vermilion River.
0.15	1.85	T-intersection from the left: 1500E. CONTINUE AHEAD.
0.15	2.0	CAUTION: Cross single railroad track (unguarded, no signal lights). Former Chicago and Eastern Illinois Railroad, now CSX Transportation.
0.35	2.35	Cross North Fork of the Vermilion River.
0.15	2.5	Crossroad intersection of 1550E and 4000N. CONTINUE AHEAD. 2-way stop from the right and left. From the middle of the intersection, looking south (your right) you can see that the road ascends to the top of the Ellis Moraine.
0.55	3.05	Stop 5. Illinois Landfills Inc. Hoopeston landfill. Pull over to the right side of the road.

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**STOP 5** We'll view and discuss the origin and deposition of the ground moraine of the Yorkville Till Member of the Wedron Formation, the formation of a paleosol, and the construction and operation of the landfill.

---

0.0	3.05	Leave Stop 5. CONTINUE AHEAD.
0.45	3.5	T-intersection from the right: 1650E. CONTINUE AHEAD.
0.5	4.0	T-intersection from the left: 1700E. CONTINUE AHEAD.

0.6	4.6	Crest of the Ellis Moraine, elevation 754 feet. The farmhouse located to the left has three large glacial erratics next to the driveway. The topographic high to your right, approximately 3 miles to the south, is the Paxton Moraine.
0.65	5.25	STOP (2-way): Intersection of 1830E and 4000N. CONTINUE AHEAD
0.75	6.0	STOP (2-way): Intersection of 4000N and 1900E. TURN RIGHT (south) onto 1900E.
0.15	6.15	Cross drainage ditch.
0.85	7.0	T-intersection from the left: 3900N. CONTINUE AHEAD.
0.1	7.1	Cross channelized drainage ditch. Along the drainage ditch, on the left side of the road, are several small slumps that are the result of meanders starting to develop.
0.4	7.5	Crossroad intersection: 3850N. CONTINUE AHEAD.
0.35	7.85	Look directly ahead; the road begins a slight ascent. This rise in the landscape is the Paxton Moraine.
0.5	8.35	Antioch Church on the right.
0.1	8.45	Crossroad intersection of 1900E and 3750N. TURN LEFT (east) onto 3750N. After making the turn, to your right and directly ahead the topographic highs on the landscape mark the position of the Paxton Moraine.
0.05	8.5	CAUTION: Cross single railroad track (unguarded, no signal lights). Former Chicago, Milwaukee, St. Paul, and Pacific Railroad, now Kankakee, Beaverville, and Southern.
0.4	8.9	Cross small creek. This creek cuts through and divides the Paxton Moraine.
0.55	9.45	T-intersection from the left: 2000E. CONTINUE AHEAD.
0.5	9.95	T-intersection from the right: 2040E. TURN RIGHT (south) onto 2040E. Note channelized drainage ditch on the left side of the road.
0.55	10.5	Cross Middle Branch of the North Fork of the Vermilion River. This stream flows along the southern edge of the Paxton Moraine.
0.1	10.6	Stop 6. Exposure of Snider Till Member. Pull over to the right side of the road.

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**STOP 6** We'll view and discuss the deposition and origin of the ground moraine of the Snider Till Member of the Wedron Formation, the formation of soils, and deposits associated with the Middle Branch of the North Fork of the Vermilion River.

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0.0	10.6	Leave Stop 6. CONTINUE AHEAD.
0.3	10.9	T-intersection from the right: 3650N. TURN RIGHT (west) onto 3650N.

0.6	11.5	Cross Middle Branch of the North Fork of the Vermilion River. Notice that this is a channelized creek and that the creek has reestablished some small meanders.
0.3	11.8	Cross small drainage creek.
0.5	12.3	CAUTION: Road narrows; cross single railroad track (unguarded, no signal lights). Former Chicago, Milwaukee, St. Paul, and Pacific Railroad, now Kankakee, Beaverville, and Southern.
0.05	12.35	STOP (2-way): Intersection of 3650N and 1900E. CONTINUE AHEAD. Note: At one time, the country school house called College Corners stood at the southeast corner of the intersection. A few red bricks in the field were probably a part of the school.
0.75	13.1	STOP (2-way): Intersection of 1830E and 3650N. CONTINUE AHEAD.
1.0	14.1	T-intersection from the left: 1730E. TURN LEFT (south) onto 1730E. NOTE: You are entering an area containing numerous sand dunes.
0.25	14.35	Road cuts through a small sand dune. Notice the sandy texture of the soil.
0.25	14.6	Notice the sandy texture of the soil.
0.25	14.85	Stop 7. Sand dune. Pull over to the right side of the road. PLEASE! PLEASE! NOTE: We will be walking to the sand dune immediately to the left of the road. Don't trample the newly planted crops; stay out of the fields. Walk only on the green grass-way along the south side of the fence row.

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**STOP 7** We'll view and discuss the deposition and origin of the sand dunes in this region, as well as the formation of soils.

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0.0	14.85	Leave Stop 7. CONTINUE AHEAD
0.45	15.3	STOP (1-way): T-intersection of 1730 and Attica Road. TURN RIGHT (west) onto Attica Road and cross the small creek. After crossing the bridge, notice the sand dune on the left side of the road.
0.25	15.55	T-intersection from the left: 1700E. CONTINUE AHEAD.
0.55	16.1	T-intersection to the right: 1650E. CONTINUE AHEAD.
1.0	17.1	Enter the village of Rossville.
0.25	17.35	CAUTION: Cross dual set of railroad tracks (signal lights only, no crossing gate). Former Chicago and Eastern Illinois Railroad, now CSX Transportation.
0.3	17.65	Stoplight (4-way): Intersection of Chicago Street (State Route 1) and Attica Street. TURN RIGHT (north) onto State Route 1.
0.65	18.3	Leaving the village of Rossville.

0.5	18.8	T-intersection from the right 3650N. CONTINUE AHEAD.
0.25	19.05	T-intersection from the left 3680N. TURN LEFT (west). CAUTION: Watch out for approaching traffic as you turn across the southbound lane of Route 1.
0.25	19.3	Stop 8. Entrance to sand and gravel pit: TURN LEFT.

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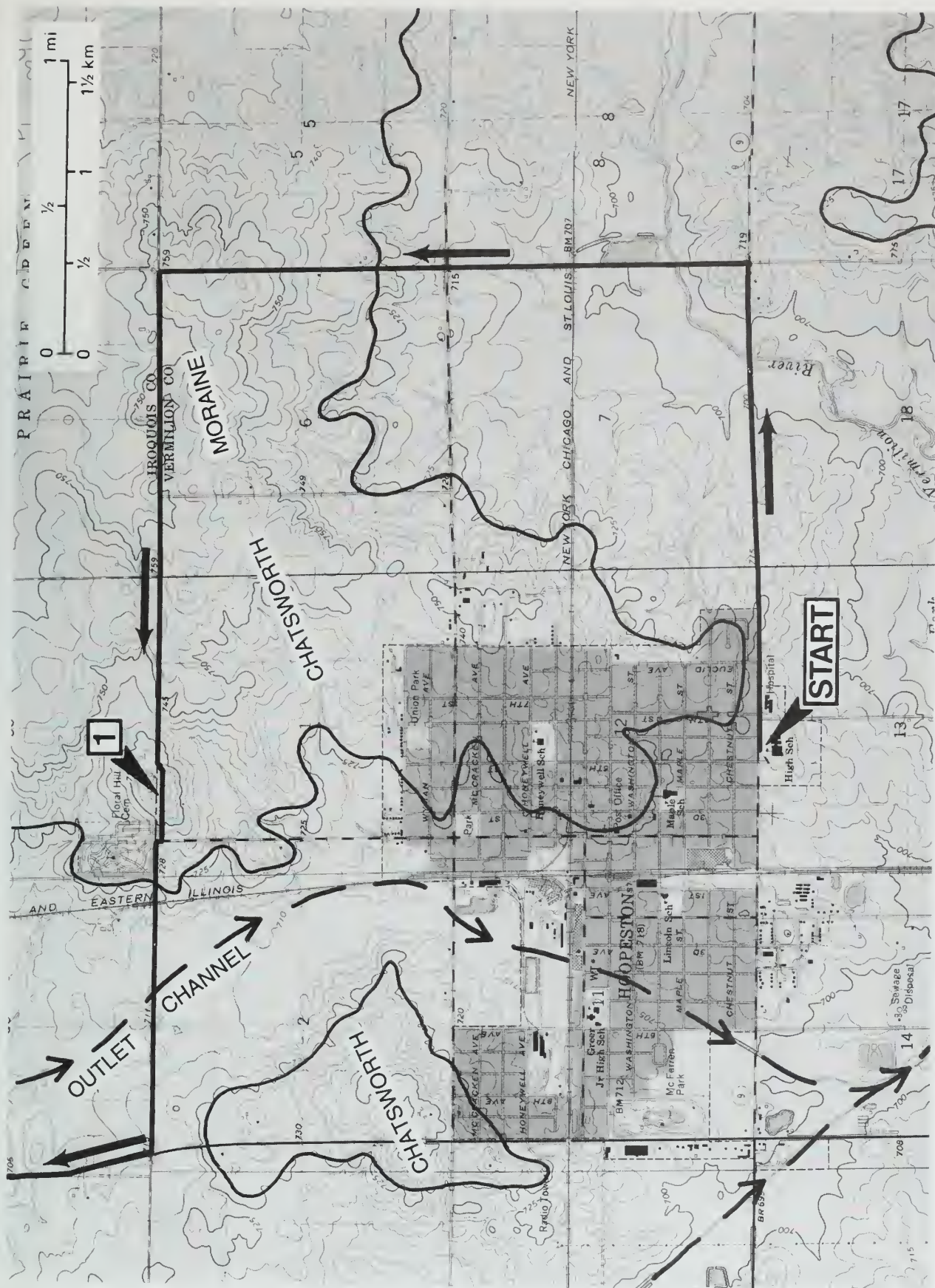
**STOP 8** We'll view and discuss the origin and deposition of the valley-train sands and gravels of the Mackinaw Member of the Henry Formation along the North Fork of the Vermilion River.

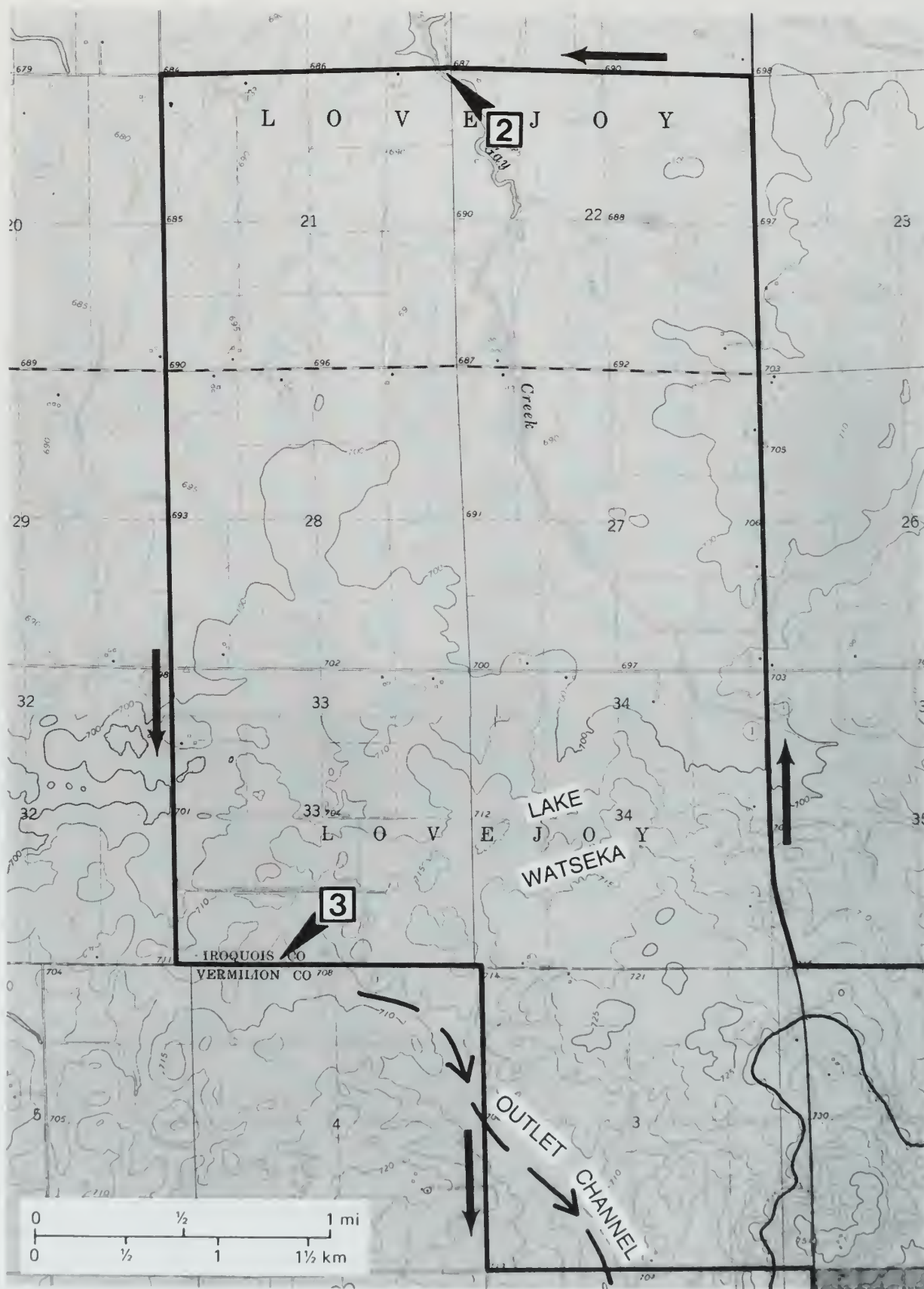
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#### END OF FIELD TRIP

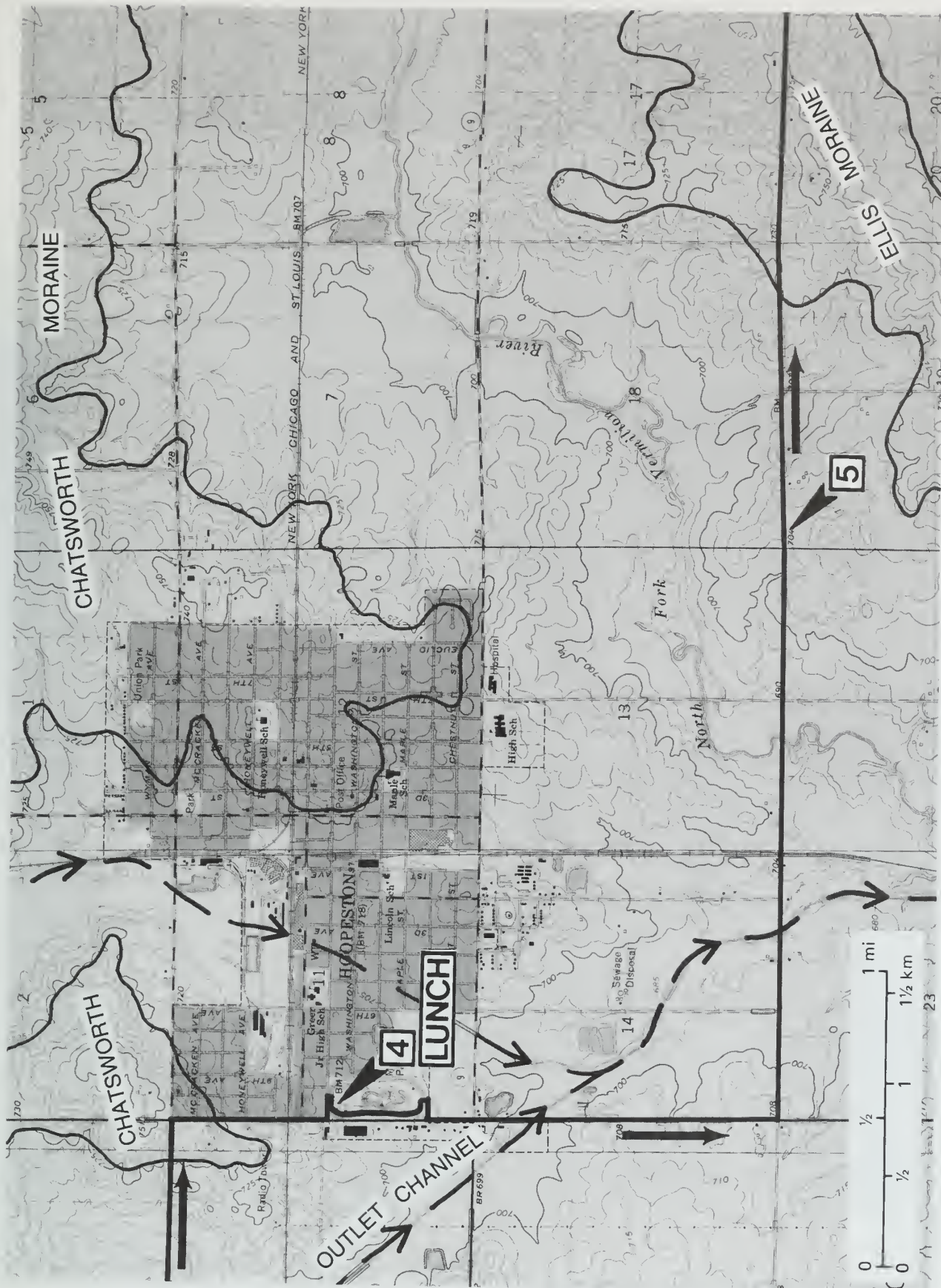
We hope you enjoyed this excursion and found the geology of the area around Hoopston to be interesting and educational. Have a safe journey home! Join us this fall for more exciting and fun-filled adventures.

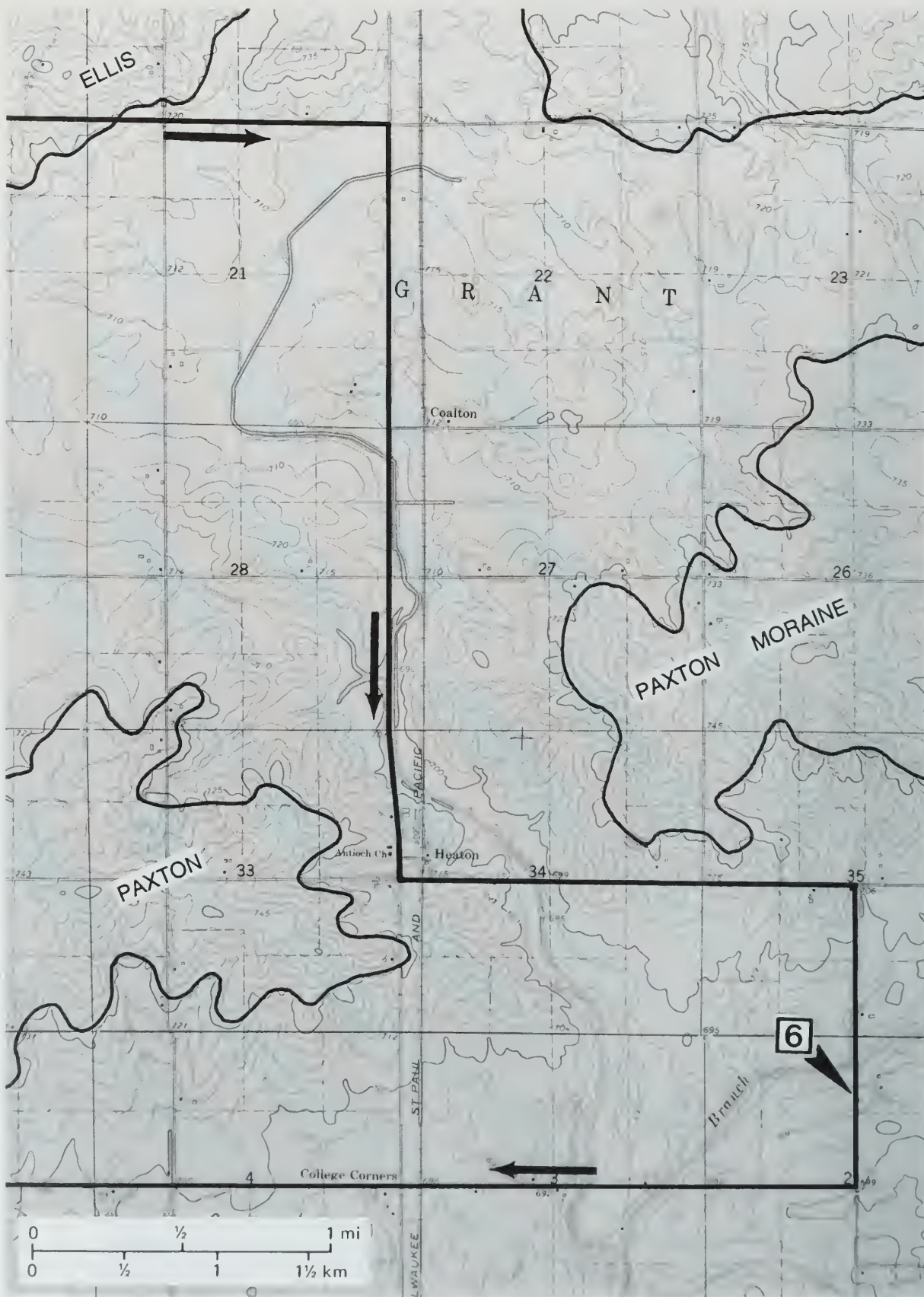












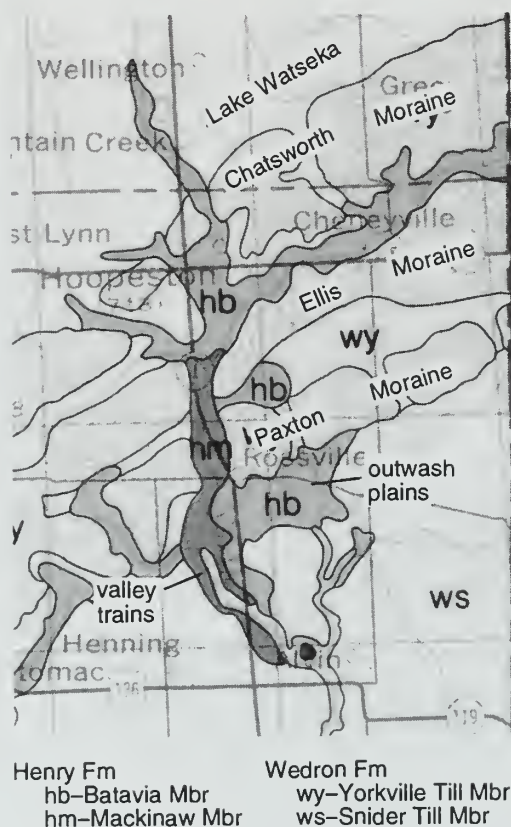




## STOP DESCRIPTIONS

**STOP 1** Chatsworth Moraine (SW, SW, SE, SW, Sec. 36, T24N, R12W, 2nd P.M., Vermilion County, Hoopeston 7.5-minute Quadrangle).

The Hoopeston area offers an excellent opportunity to observe the various types of landforms left by the glaciers of the most recent Wisconsin episodes (figs. 12 and 13). Within the field trip area, a series of three moraines, from north to south, the Chatsworth, Ellis, and Paxton, form the most conspicuous features on the landscape. This stop is on the crest of the Chatsworth Moraine (see route map).



**Figure 13** Glacial deposits within the field trip area (modified from Lineback 1979).

*outwash* material is deposited near the ice-front, and progressively finer material is deposited farther away. Where the outwash material was spread widely in front of the glacier it formed an *outwash plain*; and where it was restricted to the river valleys, it formed terraces and elongate stringers of coarser deposits that are called *valley trains* (fig. 13).

At times, especially in the winter when melting slowed or stopped, the outwash plains and valley trains were exposed as the meltwater flow subsided. The harsh, dry winter wind picked up silt and fine sand from these surfaces, blew the materials across the country, and dropped them to form the deposits known as *loess* that mantle most of Illinois. Near the larger river valleys, the loess may be as much as 60 to 80 feet thick. Far from the valleys, including the area surrounding Hoopeston, it is measured only in inches, if it can be identified at all.

The vast flat-lying area north of the Chatsworth Moraine was once occupied by an ancient glacial lake called Lake Watseka, which covered most of what is now Iroquois County. During the gradual melting back of the Wisconsin episode glacier, an ice-marginal lake formed when meltwater was dammed up between the Chatsworth Moraine and the retreating ice front.

Four outlet channels of this lake have dissected the Chatsworth, Ellis, and Paxton Moraines. To the east is one of the outlet channels of Lake Watseka located within the topographically low area that dissects the Chatsworth Moraine. The small creeks to the north, northwest, and west of Hoopeston mark the locations of the other three outlet channels of Lake Watseka. Sand and gravel deposits occur in these channels and in the outwash plains and valley trains into which they merge.

### Glacial Deposits

As a glacier melts, the soil and rocks which it had picked up as it advanced are released from the ice. Some of this material, called drift, is deposited in place as the ice melts. Such material consists of a thorough mixture of all kinds and sizes of rocks and is known as *till*. Some of the glacial drift is washed out (transported) by the meltwaters. The coarsest of this water-transported



## Moraines

The position of the ice front at various times during each major advance of the glacier is usually marked by a ridge of till, or an end *moraine*. The end moraine consists mostly of the accumulation of drift formed at the ice margin when the rates of forward flow and melting of the glacier were essentially in balance. As more and more material was carried forward to the edge of the ice, it melted out and piled up to form the end moraine. When melting exceeded the rate of advance, and the ice front retreated, the resulting drift deposits formed a *till plain*, whose surface may be almost level or slightly rolling.

The surface relief of end moraines, which is generally greater than that of the drift plains, is generally referred to as swell-and-swale or knob-and-kettle topography. At some places there are gaps in the end moraines where meltwater streams have presumably eroded away most of the drift.

## Glacial Lakes

As the glaciers receded, meltwater commonly accumulated in local ponds or lakes between the ice front and the last formed moraine, except where there were channels through the moraine through which the water could drain. Where such drainage channels were absent, the local ponds and lakes gradually merged into one large lake that persisted until either the receding glaciers uncovered some outlet or the level of the water in the lake overtopped the confining moraine and formed a channel by erosion, through which the lake could be drained.

Glacial Lake Watseka developed behind the Chatsworth Moraine in the Hoopeston area. In its earliest stages, this lake drained through four outlet channels, all essentially at an elevation of between 700 and 710 feet above mean sea level in the vicinity of Hoopeston. The four channels merged south of the Chatsworth Moraine and then flowed south following what is now the course of the North Fork of the Vermilion River (fig. 13). As the ice front receded, it uncovered, near what is now the city of Buckley in southwestern Iroquois County, a lower outlet for the lake to the Illinois-Vermilion River to the west at an elevation about 670 feet above sea level, and the outlets near Hoopeston were consequently abandoned. Still later, the retreating ice uncovered a still lower westward outlet at an elevation about 650 feet above sea level near Onarga in west-central Iroquois County. Presumably the lake was completely drained when the glacier uncovered the Kankakee River Valley to the north. However, Lake Watseka must have been raised again to the 650-foot level when the Marseilles glacier readvanced and again blocked the Kankakee Valley.

The glacial drift exposed in the Hoopeston area is all of Wisconsinan age, but drift belonging to the older Illinoian and pre-Illinoian glacial advances has been encountered in water wells.

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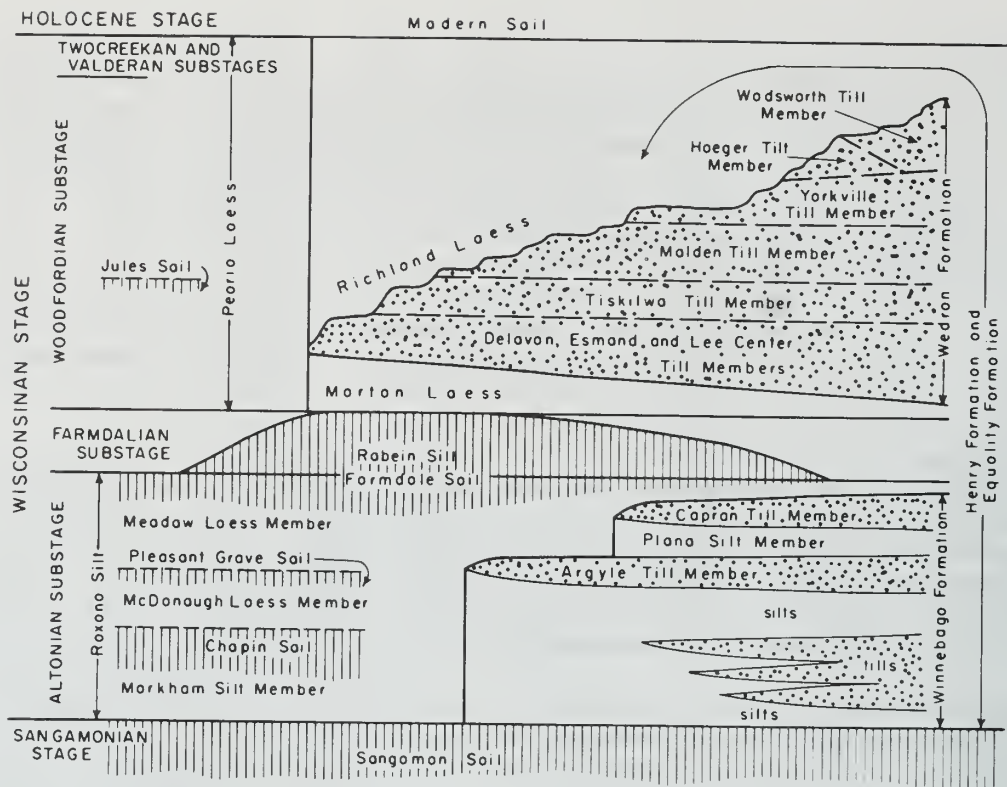
**STOP 2** Gay Creek (SE, SE, SE, Sec. 16, T24N, R12W, 2nd P.M., Iroquois County, Wellington 7.5-minute Quadrangle).

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Deposits along Gay Creek consist of sands and gravels deposited by glacial meltwater of the Batavia Member of the Henry Formation (figs. 13, 14). These well sorted sands and gravels were deposited when Lake Watseka drained to the south through the Chatsworth Moraine outlet channel.

Since they become progressively finer to the south, we know that the stream that deposited them flowed in that direction toward the North Fork of the Vermilion River. Gay Creek now flows to the north rather than the south. This reversal of direction is most likely the result of the receding glaciers uncovering the outlet to the north that had a lower elevation than the Chatsworth Moraine outlet to the south. The origin of Gay Creek is located directly north of stop 1.

A portion of Gay Creek north of the bridge has been channelized (fig. 15). Compare the course of Gay Creek on the 1963 aerial photo (fig. 16) with the course observed from the bridge. Streams



**Figure 14** Diagrammatic cross section shows the relationship of formations and members of Wisconsin Age in Illinois (from Lineback 1979).



**Figure 15** View of Gay Creek at stop 2 (photo by Wayne T. Frankie).

do not ordinarily flow in a straight line for very long. Small irregularities in the channel cause local fluctuations in velocity, which result in erosion where the water flows strongly against the sides of the channel and deposition of sediment where the current slows down. Small bends or meanders





**Figure 16** 1963 air photo of Gay Creek and area surrounding stop 2.

begin to form within the straightened channel during periods of low flow, and these gradually grow in size, gradually eroding the artificially straightened course of the channelized stream. The channelized stream course, with its steeper gradient, will transport more water during floods, moving the flood crest rapidly downstream to areas of the stream that haven't been channelized.

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**STOP 3** Yorkville Till Member of the Wedron Formation (SE, SW, SE, SW, Sec. 33, T24N, R12W, 2nd P.M., Iroquois County, Hoopeston 7.5-minute Quadrangle).

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The Yorkville Till Member of the Wedron Formation is exposed along both sides of the road in the drainage ditch (figs. 13, 14). The gently undulating surface of the landscape is typical of ground moraines. The sediments of this ground moraine were deposited as the glacier melted back from the Chatsworth Moraine (see route map). The Yorkville is a gray or greenish gray, very clayey till. Approximately 6 miles north of this stop, the Yorkville is overlain by the Carmi Member of the Equality Formation. The Carmi Member consists of well bedded silts and clays deposited in the quiet water of proglacial Lake Watseka.

### **Soil Survey**

The Soil Survey of Vermilion County (Wacker 1996) shows two dominant soils within the immediate area of this stop, the Lisbon silt loam and the Milford silty clay loam. The Lisbon silt loam is developed on the slight rises and is surrounded by the Milford silty clay loam which is developed in the broad, flat areas and in the shallow depressions and drainageways. The parent materials for both of these soils include the Peoria Loess and the Yorkville Till.

The following soil descriptions are modified from The Soil Survey of Vermilion County (Wacker 1996).

**Lisbon silt loam** The Lisbon silt loam is a somewhat poorly drained soil. Typically, the surface soil is very dark gray, friable silt loam about 11 inches thick. The subsoil is about 28 inches thick and is mottled. The upper part is dark brown and dark grayish brown, friable clay loam; and the lower part is grayish brown, friable, calcareous clay loam. The underlying material to a depth of 60 inches or more is light brownish gray, mottled, firm, calcareous loam. In some places the subsoil is thicker. In other places the upper part of the subsoil contains less silt and more sand or more clay. In some areas the underlying material is stratified loam and sandy loam.

**Milford silty clay loam** The Milford silty clay loam is a poorly drained soil which is occasionally ponded for brief periods in the winter and spring. Typically, the surface soil is black and very dark gray, friable silty clay loam about 18 inches thick. The subsoil is about 34 inches thick and is mottled. The upper part is dark grayish brown, firm silty clay loam, and the lower part is gray, friable silty loam that has strata of clay loam. The underlying material to a depth of 60 inches or more is mottled gray and light olive brown, friable, stratified silty clay loam, clay loam, and loam. In some areas the underlying material is firm, calcareous silty clay loam. In a few places the surface soil is thicker. In some places the subsoil contains less clay and more silt or sand.

### **AN INTRODUCTION TO SOIL SCIENCE**

Soil is important to everyone, but we rarely think about how it affects our lives. In this upper few feet of the land's surface we construct our buildings and roads, grow much of our food, and find some of our drinking water.

What is soil? Dirt is what you track into the house. Soil is the mixture of particles of rocks and minerals, organic matter, water, and air that covers most of the land surface. Soils are the reservoir of nutrients and water from which plants draw their food. As such, soils are essential elements of the habitats of most living things on the land.

The wide variety of soils found in Illinois is the result of varying natural conditions and substances that interact to produce a soil. The interrelationships between parent material, climate, organisms (plants and animals), topography, and time are commonly referred to as the soil-forming factors.

Soil characteristics are the result of the types of plants and animals (biota) that live on or in the soil and the physical processes of water movement, freezing and drying, and erosion and deposition.

### Soil Texture and Soil Types

A soil's texture determines its ability to absorb the air and water that are essential for root life and many other biological activities.

Mineral particles in soil can be grouped into three main categories, based on their size. The largest (coarsest) particles are *sand*, the next finer particles are *silt*, and the finest particles are *clay*. The relative amounts of sand, silt, and clay in a soil are used to describe its *texture*.

Particle	Size range	Characteristics
Gravel	larger than 2.0 mm	
Sand	0.05 to 2.0 mm	Easily seen with naked eye, feels gritty
Silt	0.002 to 0.05 mm	Scarcely seen with naked eye, feels and looks like flour
Clay	less than 0.002 mm	Too fine to be seen under an ordinary microscope,

The terms heavy, light, and sandy refer to a soil's texture. Heavy soils are predominantly clay, water moves through slowly, and aeration is poor. Light soils are a mixture of nearly equal amounts of clay, silt, and sand. They readily yield moisture to plants and are well aerated. Sandy soils are predominantly sand, have poor moisture-holding ability, but are well aerated. A soil's basic textural class is determined using the chart shown in figure 17.

Textural classes showing relative proportions of sand, silt and clay

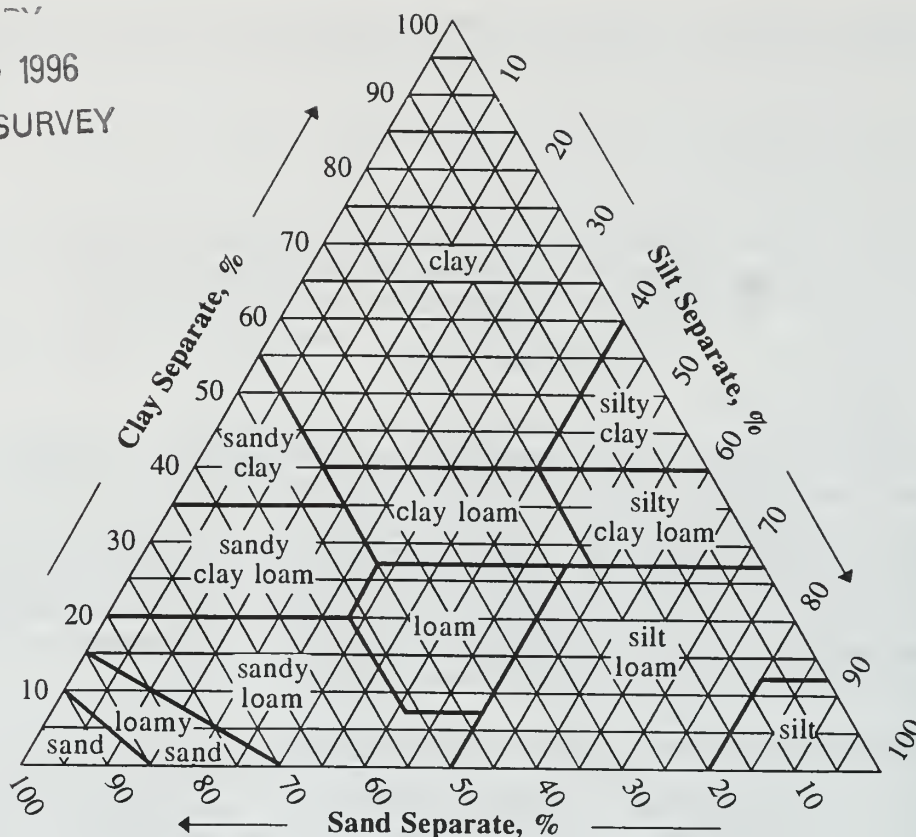
<b>Clay</b> 40-100% clay 0-40% silt 0-45% sand	<b>Sandy clay</b> 35-55% clay 0-20% silt 45-65% sand	<b>Sandy clay loam</b> 20-35% clay 0-28% silt 45-80% sand
<b>Clay loam</b> 27-40% clay 15-43% silt 20-45% sand	<b>Silty clay loam</b> 27-40% clay 40-73% silt 0-20% sand	<b>Silty clay</b> 40-60% clay 40-60% silt 0-20% sand
<b>Sand</b> 0-10% clay 0-15% silt 85-100% sand	<b>Loamy sand</b> 0-15% clay 15-30% silt 70-90% sand	<b>Sandy soam</b> 0-20% clay 15-50% silt 45-80% sand
<b>Loam</b> 7-27% clay 28-50% silt 23-52% sand	<b>Silty loam</b> 0-27% clay 50-80% silt 0-28% sand	<b>Silt</b> 0-12% clay 80-100% Silt 0-15% sand

### Classifying Soil Texture

To test for texture (the relative proportions of sand, silt, and clay particles), fill a quart jar about 2/3 full of water. Add soil until the jar is almost full. To achieve the clearest stratification, also add about 1 tablespoon of Calgon water softener per quart of water. Screw on the jar lid and shake vigorously. Then let the soil settle. In a short time the coarsest sand particles will sink to the bottom, making the sand layer visible. The next layer to form will be the silt layer, and finally the extremely small clay particles will settle on the top. The clay particles are so small that the molecular action of the water alone may keep the particles in suspension for several hours. The experiment should be ready to read in two to three hours.



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**Figure 17** Soil texture classification diagram (U.S. Department of Agriculture).

Then chart each of the proportions by marking off the layers on a piece of paper held up to the jar. Compare the proportions of the layers with the information in the chart shown in figure 17.

### Conducting a simple test for drainage

To test how fast or slow water moves through the soil. Remove both ends from a coffee can. Select an area you want to test, push the can into the soil to a depth of 4 inches. Fill the can with water and allow it to drain through. Fill the can again, and then time how long it takes for the water level to drop 1 inch. If it takes longer than two hours, you have a poorly drained soil and can probably expect to have problems with plants "drowning," especially those plants intolerant of "wet feet."

### Soil Structure

Soil structure is composed of natural features called "peds," which are described as small, large, rounded, or angular.

Soil particles are held together in clusters or shapes of various sizes, called aggregates or *peds*. The arrangement of these *peds* is called soil structure. Soil peds may be classified as granular, crumbly, platy, blocky, subangular, prismatic, and columnar. Soil peds tend to become larger with increasing depth. In mature soil profiles, some peds are covered with a thin clay layer.

### Soil Profile

As weathering of parent material proceeds, soil gradually evolves and develops characteristic zones called *soil horizons*. These horizons, from the surface downward to the unaltered parent material, constitute a soil profile.



Horizons are distinguished by differences in their humus content, mineral composition, color, and texture.

### **Soil Horizons**

#### **A Horizon** (Zone of leaching and organic matter accumulation)

Color - grayish or blackish. The A Horizon contains organic matter called humus, the decomposed residue of plant and animal tissue. Some of the original substance of parent material is lost through the downward transport of clay particles and through the chemical leaching of soluble minerals. The A Horizon of a typical fertile soil is teeming with life. Bacteria, fungi, molds, ants, earthworms, centipedes, spiders, and a host of other creatures live here. They burrow and dig and generally act as decomposers of the organic matter. This is the zone where plant roots proliferate.

#### **B Horizon** (Zone of accumulation)

Color - brownish or reddish (in uplands), gray in wetlands. The B Horizon is enriched in clay and soluble minerals, and iron oxides. Characterized by structure, it breaks into blocks or prisms (peds), each of which may be coated with clay. Although penetrated by longer roots, it contains less organic matter than the humus-rich A Horizon.

#### **C Horizon** (Zone of slightly weathered parent material)

Change in color of parent material due to oxidation. The C Horizon consists of parent material in various stages of decomposition and weathering. It sits upon unweathered parent material.

#### **D Horizon** (Unaltered glacial material)

#### **R Horizon** (Unaltered bedrock)

### **HOW DO SOILS FORM?**

Soil is formed through the complex interaction of physical and chemical weathering processes that break down parent materials, and biological activities that add organic matter to the soil profile.

- Physical weathering changes the physical form of the parent material—for example, by breaking it into smaller pieces—without changing its chemical composition. The actions of freezing and thawing, plant roots, and burrowing animals are important agents of physical weathering.
- Chemical weathering changes the parent materials' chemical composition—for example, feldspar, a common rock-forming mineral, chemically weathers to clay. Another example of chemical weathering is the rusting of a nail. When iron rusts in the presence of moisture, iron atoms combine with oxygen atoms to form rust (iron oxide).
- Plants and animals add organic matter in the form of waste products and dead organisms. The transformation (decomposition and decaying) of organic matter into humus (chemically stable, finely divided organic matter) is called humification. The decay of organic remains produces organic acids which accelerate chemical weathering. The burrowing of animals such as earthworms, insects, and rodents helps circulate air and water throughout the soil and mix together minerals and organic remains.

In general, the net result over time is the formation of horizons, a separation process driven by weathering.

### **Parent materials**

**Loess** The parent material for most of Illinois' soils is loess, a wind-deposited silt. Loess deposits are thickest near the major river valleys and become thinner with increased distance.

**Glacial Till** Soils with glacial till as the parent material are most common in northeastern Illinois. Texture ranges from gravel to clay. The diversity of parent material is partly responsible for the great variety of environments and varied biota of northeastern Illinois.

**Glacial Outwash** Soils formed on glacial outwash parent materials occur on terraces along major streams throughout Illinois. In some instances the soils develop from sand-supported plants.

**Alluvium** Soils formed on modern flood plains of streams and rivers tend to be lighter (sandier) in central and northern Illinois than in southern Illinois. They frequently support distinctive biota.

**Organic (peat and muck)** Soils formed in peat and muck commonly support unusual plant and animal communities.

**Bedrock** Soils formed on bedrock are generally restricted to areas that have not been glaciated. The soils present are commonly thin.

### **HOW OLD IS OUR SOIL?**

In general, the soil is as old as the age of the parent geologic material in which it develops. Most of the soils in Illinois formed within the last 10,000 to 12,000 years, since the last glaciers retreated from Illinois. This is "geologically" a young soil. Most of Illinois' soils are developed in relatively recent deposits of till, loess, or alluvium, which are rich in mineral nutrients because they're relatively unweathered, and closely reflect the composition of the parent materials.

Older soils tend to be more strongly developed—many of their more soluble minerals and clay particles have been leached from the surface layers, leaving only the insoluble minerals that provide few plant nutrients. A strongly developed soil may have a claypan formed by the accumulation of clay particles in the subsoil. A claypan that is thick enough to resist penetration by plant roots and the infiltration of rain may control the types of plants that can grow.

### **Soil Erosion**

Soil erosion and deposition are natural geological processes. However, the disturbance of the land by farming can increase the rate and amount of erosion. An estimated 180 million tons of soil (158 million tons of topsoil from farmlands) erodes from Illinois each year. This is equivalent to approximately 0.03 inch per year.

Soil is technically classified as a renewable resource because new soil is formed every day. Soil formation, however, is an extremely slow process. Nature may take anywhere from 500 to 1,000 years to replace every 2.5 centimeters of topsoil that has been lost. Because soil formation is such a slow process, we must regard topsoil as a nonrenewable resource.

### **Paleosols**

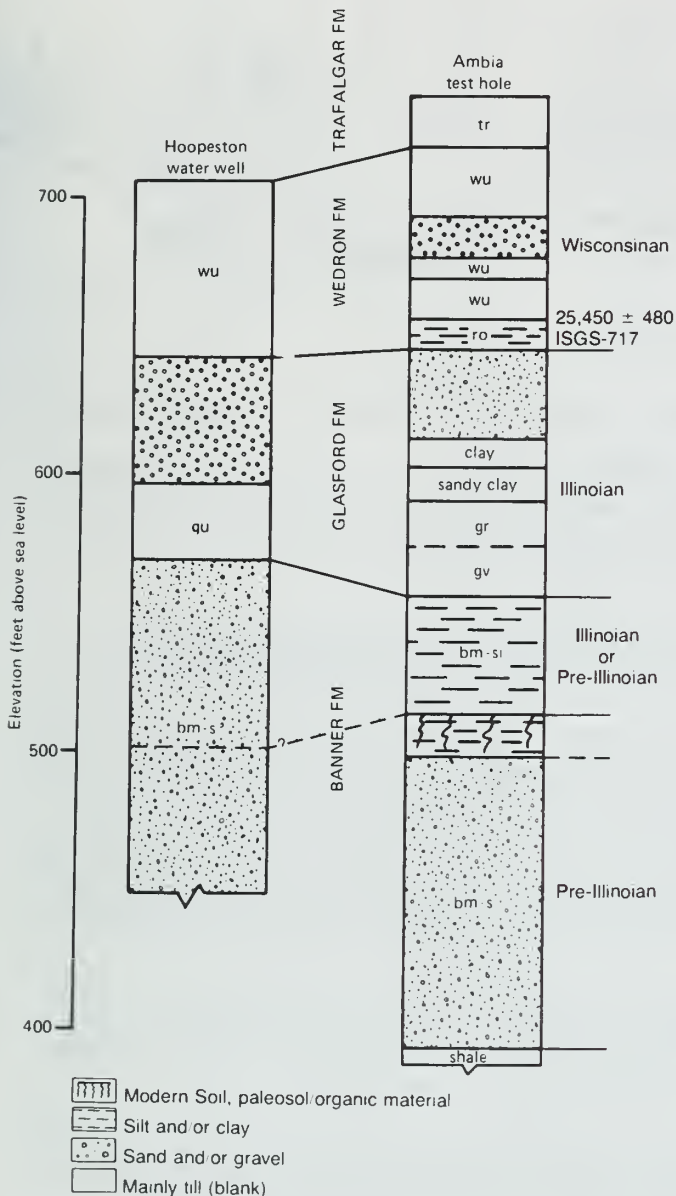
If a landscape and its soils are buried by new sediments, the buried surface becomes part of the geologic record. The buried soil is now a paleosol, defined as a soil that formed at the surface and was subsequently buried and preserved. Paleosols have been identified in rocks and sediments of many different ages, but they are especially common in the deposits of the Quaternary Period.

We will see a paleosol at Stop 5.

**STOP 4 LUNCH** at McFerrin Park and discussion of the Mahomet Bedrock Valley (NW, NW, SW, Sec. 11, T23, R12W, 2nd P.M., Vermilion County, Hoopeston 7.5-minute Quadrangle).

### Mahomet Bedrock Valley

The Mahomet Bedrock Valley is an ancient river valley carved into the bedrock surface across much of central Illinois (fig. 9). It was discovered more than 45 years ago when numerous water wells were drilled in the eastern and midwestern United States. The story of this vast ancient river system has been pieced together largely from information obtained from records made during the drilling of the wells.



The Mahomet Bedrock Valley began to develop during the Tertiary Period, according to indirect evidence from the midcontinent and Appalachian regions (personal communication from Ross Brower, ISGS hydrogeologist). By the time of the Great Ice Age, the drainage from a large area converged into the Mahomet Valley and flowed toward the Mississippi embayment. The Mahomet Valley was once thought to be part of the larger "Teays" drainage system that extended from West Virginia into Illinois. However, recent studies indicate that the Teays was not a single, coherent drainage system (Kempton et al. 1991).

During the Pleistocene, glaciers advanced and retreated across the area, filling the valley with layer upon layer of ice-laid tills and associated water-laid sand and gravel (outwash) (figs. 18 and 19). The oldest deposits include a thick outwash, called the Mahomet Sand, and some deeply buried tills and lake sediments from several pre-Illinoian glacial advances. Overlying these pre-Illinoian deposits are tills and outwash sediments of the Glasford Formation, left by Illinois Episode glaciers. The upper layer of tills named the Wedron Formation was deposited by Wisconsin Episode glaciers. In places these are overlain by sands and gravels of the Henry Formation. Together these sediments preserve a remarkable record of glaciation in the region.

**Figure 18** Stratigraphy of deposits along the Mahomet Valley in Illinois and Indiana (modified from Kempton et al. 1991).

The Mahomet Valley has been traced for about 150 miles across Illinois. It enters the state from west-central Indiana



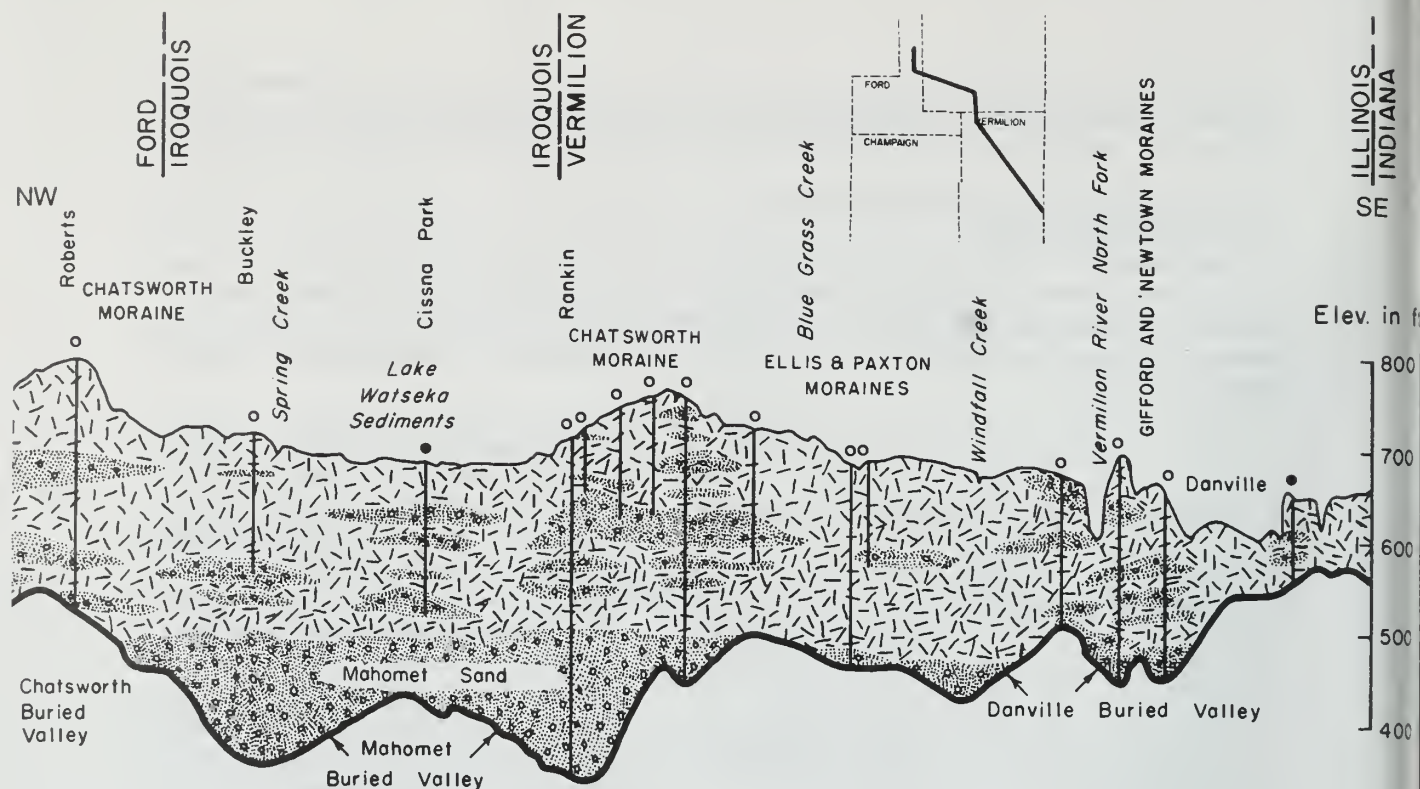


Figure 19 Stratigraphic cross section shows the deposits within the Mahomet Valley (modified from Piskin and Bergstrom 1975).

and meandered westward to join the Ancestral Mississippi Valley in the vicinity of Tazewell and Mason Counties (fig. 9). They valley lies at an average depth of more than 200 feet below land surface, and its bottom is at an average elevation of 350 feet above sea level (figs. 20 and 21). The ancient valley varies in width from 8 miles to almost 11 miles.

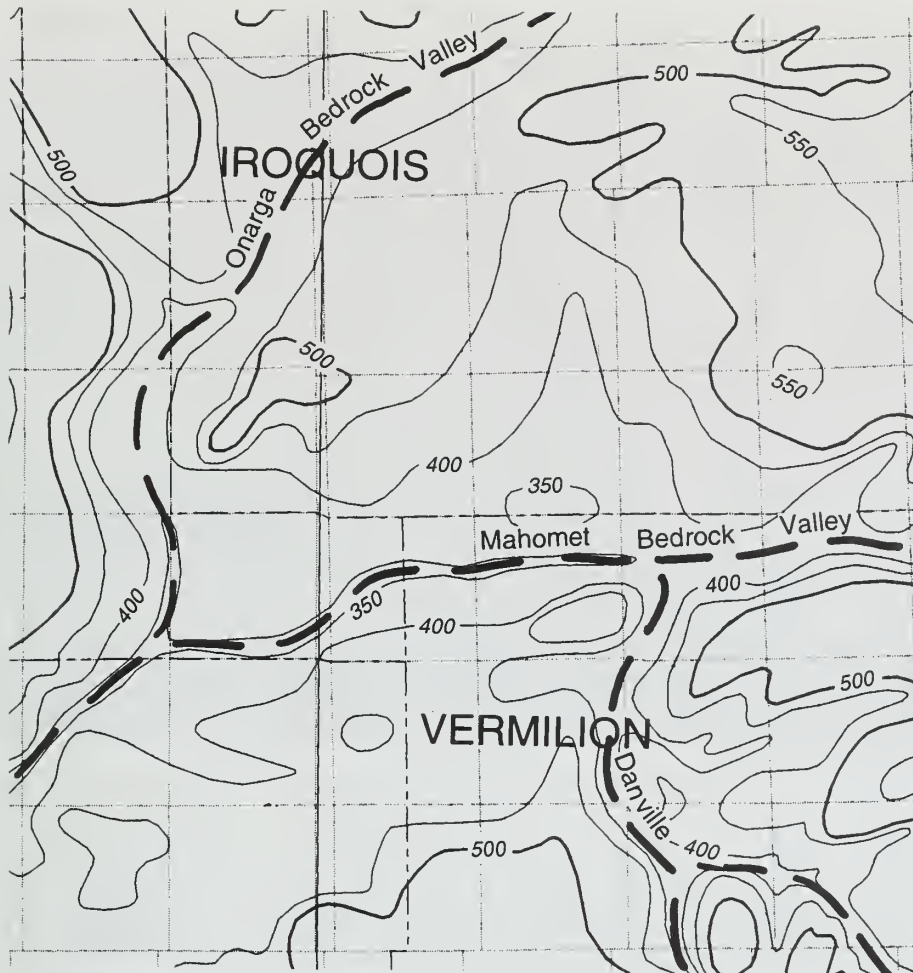
**Groundwater resources** The buried Mahomet Valley is invaluable to east-central Illinois because its porous sand and gravel deposits act as vast underground reservoirs (aquifers) for storing water. Recharge (replenishment of water) to the Mahomet Valley aquifer is a result of vertical percolation of rainwater and snowmelt through overlying glacial deposits and leakage out of the bedrock in the sides and floor of the valley. The highest hydraulic heads along the Mahomet Valley occur near the junction of the Onarga Valley. Hydraulic head is the elevation to which water rises in a well drilled into an aquifer and is a measurement of the energy in a groundwater flow system. Groundwater flows from areas with higher hydraulic head toward areas with lower hydraulic head. In this part of the Mahomet valley, groundwater flow directions are to the north into the Onarga Valley, to the east toward Indiana, and to the southwest and west through Champaign County.

Water flows relatively easily through the sand and gravel into wells drilled in the porous material. More than 30 communities including Hoopeston, Champaign-Urbana, Mahomet, Monticello, and Clinton withdraw municipal water supplies from the buried Mahomet Valley.

The oldest of the thick outwash sands and gravels, the Mahomet Sand is locally as much as 200 feet thick; its top is approximately 540 to 560 feet above mean sea level (msl) in the Hoopeston area. Where present, the Mahomet Sand is the principal aquifer in this part of the county.

Several other good aquifers exist in the Hoopeston area. Outwash at the base of the Glasford Formation is the second most significant aquifer. In the Hoopeston vicinity the Glasford aquifer may

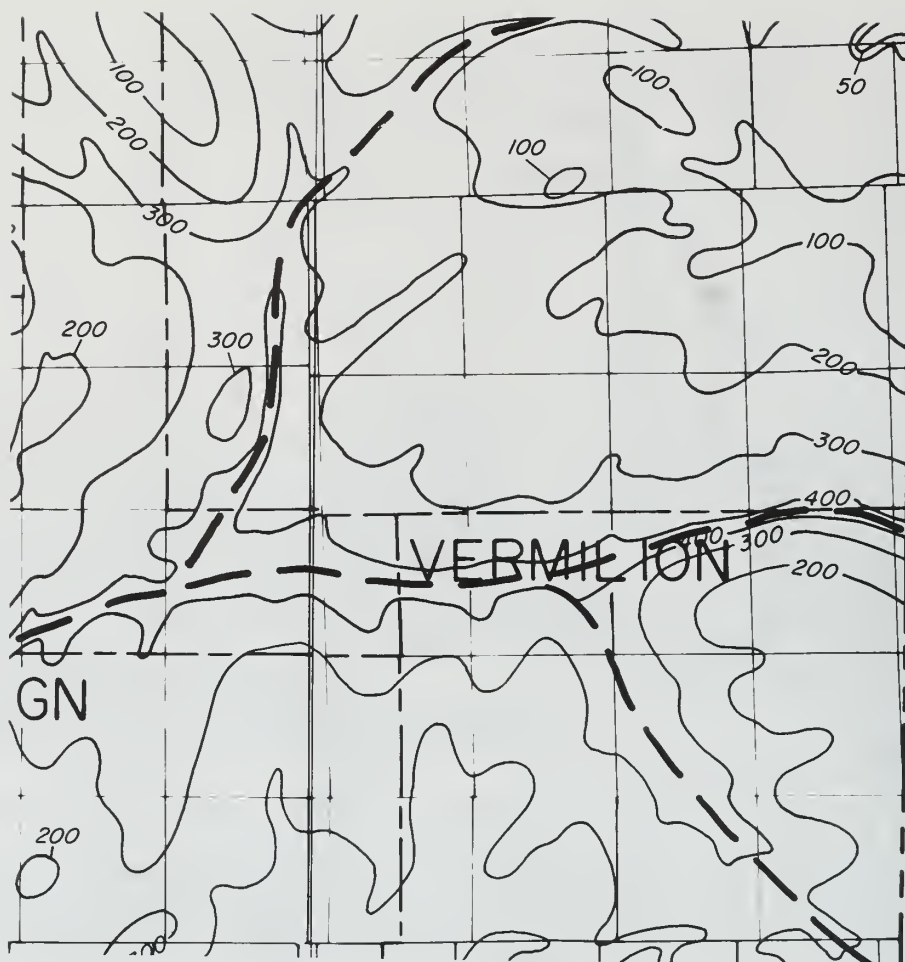




**Figure 20** Buried Bedrock surface structure map of field trip area; dashed lines indicate the main channels of the bedrock valleys (contour interval 50 feet)(modified from Herzog et al. 1994).

be 20 to 60 feet thick, and its top ranges in elevation from 640 to 660 feet above msl. Minor quantities of water are obtained from the surficial sands and gravels of the Henry Formation, which occurs in the larger stream valleys throughout the field trip area.

**Public water supply** Hoopeston is the largest municipality in the area to use groundwater for its public water supply. Although the town sits directly above the Mahomet Bedrock Valley, the local water supply comes from four wells 98 to 110 feet deep drilled into the Glasford aquifer. (It is less expensive to drill 100 feet to reach the Glasford than it is to drill from 150 to 250 feet or more to tap the Mahomet Sand, especially as adequate amounts of water are available from the Glasford aquifer.) Typically, yields of 650 to 750 gallons per minute (gpm) are available from the Glasford, and high-capacity wells in this aquifer are quite feasible. Because the sand and gravel aquifers beneath Hoopeston are thick and extensive, there should be little problem in satisfying increased demand for water in the future. In the surrounding countryside, however, finding a good water supply can be somewhat more problematic, because the outwash sands do not uniformly underlie the entire area. The Glasford aquifer, for example, may provide an adequate supply for irrigation and municipal use in one area but, a few miles away, be marginal for domestic and farm use. Nevertheless, groundwater supplies for the general region are considered to be adequate to abundant for most purposes.



**Figure 21** Drift thickness within the field trip area; dashed lines indicate the main channels of the bedrock valleys (contour interval 100 feet) (modified from Piskin and Bergstrom 1975).

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**STOP 5** Illinois Landfill Inc. Hoopeston Landfill (SW, SW, SW, Sec. 18, T23N, R11W, 2nd P.M., Vermilion County, Hoopeston 7.5-minute Quadrangle).

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This landfill is constructed in the Yorkville Till Member of the Wedron Formation. The Yorkville is a gray to greenish gray very clayey till, one of the most suitable materials in which to construct a landfill facility because of its low permeability and because it can be effectively recompacted. The current facility design is a single composite landfill liner system. The cells are floored by 3 feet of compacted till, which is covered with a 60-millimeter thick liner made of high-density polyethylene (HDPE) plastic (fig. 22).

Exposures of the gray Yorkville till can be examined in the excavated portions of the landfill. The Yorkville is generally very clayey and exhibits a blocky structure. The till tends to dry out when it is exposed after excavation, but a freshly exposed till may exhibit a fairly high moisture content. With moist till one can form a "ribbon" by squeezing the till outwards between one's thumb and forefinger, a sure sign that the material contains a great deal of clay. Even if the material has lost moisture, one can easily feel the "toughness" of this dense, clayey till as you break a piece apart with your hands.



**Figure 22** Illinois Landfill Inc. Hoopston Landfill at Stop 5 (photo by Wayne T. Frankie).

Vertical cracks, or “joints,” in the till usually form because of drying out, or “desiccation,” of the sediment. Another factor, probably relatively minor, is the slight rebound of the earth’s crust after having been depressed from the weight of the massive glacier on the land. Joints also form by expansion upon removal of overburden, like the expansion of a cork pulled from the neck of a bottle.

An east-facing exposure in the northwest portion of the landfill (fig. 23) provides a good opportunity for us to use the scientific method to figure out what these units are: observations that identify a particular problem, formulation of hypotheses to account for the observations, testing of the hypotheses, and arrival at a solution that best fits and explains the observations.

**The problem:** What stratigraphic units are exposed here?

**Formulation of hypotheses:** *Hypothesis 1:* The buried soil is an interglacial soil, most likely the Sangamon Geosol (the major soil that developed during the Sangamonian interglacial episode, between the Illinoian and Wisconsinan glacial advances (fig. 14). The overlying gray till would then be the Yorkville.

*Hypothesis 2:* The buried soil is an interstadial soil, that is, it formed during a minor retreat of Wisconsinan ice between the advance that formed the Ellis Moraine and the advance that formed the Chatsworth Moraine.

*Hypothesis 3:* The buried soil is the modern soil, and it has been buried by gray Yorkville diamicton excavated from elsewhere in the pit during landfill operations.

**Facts about the soil that have to be explained by any hypothesis:** Leon R. Follmer, ISGS geologist and soil scientist, observed that this soil is moderately well developed; it has distinct horization, very similar to what one sees in the modern soil in this region. Note that this





Starting at the top:

2 feet – gray clayey till, sharp contact below

5 inches – dark brown to black organic A Horizon, gradational contact below

16 inches – oxidized reddish brown B Horizon, gradational contact below

27 inches – greenish gray C Horizon, gradational contact below

22 feet – greenish gray clayey unaltered till

**Figure 23** East-facing exposure in the northwest portion of the land-fill shows the Yorkville Till Member of the Wedron Formation at Stop 5 (photo by Wayne T. Frankie).

observation does not prove that it is the modern soil; it simply makes a statement about the stage of development of the soil. From this we can make a comparison of the amount of time necessary for its development. We know that this part of Illinois has been free of glacial ice for approximately 17,000 years, and that periglacial conditions (at and near the margins of glaciers, influenced by the cold temperature of the ice) may have persisted for another 3,000 years or so, with gradual warming over the next 2,000 years to conditions more like those of today. In addition, we know that silt from the major meltwater valleys blew across the Illinois landscape as the glaciers melted back; this windblown silt (loess) is generally less than 2 feet thick in northern Vermilion County. The modern soil must have developed to its present stage in the last 12,000 years or so, and must have incorporated the silt as it settled onto the landscape. Therefore, we can conclude that the soil exposed here also took approximately 12,000 years to form, given approximately equal conditions such as climate, topography, and parent material.

**Testing hypothesis 1:** If this is the Sangamon Soil, how does it compare to the Sangamon Soil exposed in outcrops and drill hole samples elsewhere? Drawing upon his years of hands-on experience with both modern and buried soils in Illinois, Leon Follmer reports that the Sangamon Soil is generally thicker and better developed than the modern soil, an observation supported by our

latest information on the extent of the Sangamonian interglacial stage, which is believed to have lasted at least 50,000 years (approximately from 125,000 to 75,000 years ago).

Although this location is fairly high on the landscape (about 710 feet above mean sea level), samples from borings throughout the region show that the top of Glasford sediments is at an elevation of approximately 600 to 675 feet in this area. Elevation differences (relief) on the modern landscape exhibit as much or more range than the maximum elevation difference of 110 feet between the Glasford top and the present land surface (600 to 710 feet), so an elevation this high does not rule out the possibility that this paleosol was formed as part of the old Sangamon landscape. On the other hand, these borings from the ground surface down to bedrock generally penetrate a complete and identifiable succession of glacial sediments for each of the major glacial advances into the region. This means that all three of the Wisconsin tills normally present in this area (the Tiskilwa, Batestown, and Yorkville) commonly overlie the Sangamon Geosol; therefore, the Sangamon Geosol is unlikely to exist so close to the present-day ground surface, especially considering that this exposure is high on the landscape rather than in an erosional channel low on the landscape, where the Wisconsin tills might be absent. We can, therefore, tentatively reject hypothesis 1 on the basis that the soil does not show the degree of development expected from the Sangamon Geosol, and that borings in the area indicate that a full sequence of Wisconsin sediments should overlie the Sangamon Geosol in this area.

**Testing hypothesis 2:** If this is an interstadial soil that formed during a minor retreat of the ice between the advances that formed the Ellis and Chatsworth Moraines, it means that the hiatus between the advances had to be of sufficient duration—approximately 12,000 years—for a soil similar to the modern soil to develop. Did such a hiatus exist within the overall Wisconsin episode of glaciation? No. Radiocarbon age dates of wood and other organic debris within the sequence of Wisconsin sediments at various areas indicates that ice of the last glaciation entered Illinois around 25,000 years ago and withdrew for the last time about 13,500 years ago. Therefore the entire amount of time the northeastern quadrant of the state was covered by Wisconsin Episode ice was 11,500 years, less than the 17,000-year period during which climate conditions changed to the point that the modern soil could develop. We also know, from the many moraines that have been mapped across the northeast quadrant of the state, that the ice pulsed back and forth many times. Because the Chatsworth and Ellis Moraines are so close together, the ice could not have left the landscape exposed long enough for a soil such as this to have developed between the construction of the Ellis and Chatsworth Moraines. Therefore, we can eliminate hypothesis 2.

**Testing hypothesis 3:** If this is the modern soil, why does the Yorkville till overlying it look as if it is in place and undisturbed? It seems reasonable to expect, on the contrary, some evidence that the till has been severely disturbed, if it was actually excavated from elsewhere in the pit and dumped here on top of the modern soil. However, considering the very clayey nature of the Yorkville, and the fact that heavy equipment has been criss-crossing the area for some time, in Leon Follmer's experience compaction restores it to its original character and erases evidence of excavation. The elevation of this soil is certainly consistent with that of the modern soil. We can tentatively conclude, therefore, that this is the modern soil buried by reworked material.

It is important to note that we have not "proven" beyond a doubt that this is the modern soil with excavated Yorkville till compacted on top of it. In order to be sure of this conclusion, we would need to find some "fossil" evidence that the top of the soil was once a part of the modern landscape—a soda can, a bicycle tire, or some other unequivocal evidence. Mineralogical analyses of the sediments both above and below the soil would also help to identify them and thus to decide which hypothesis represents the true situation. Although the reasoning we have presented is not conclusive, it provides an example of how the scientific method helps scientists arrive at their conclusions.



**Suggested activity:** Some field trip participants may want to investigate whether the A and B Horizons of the soil profile here are developed in loess or in till. How would you tell which material it is developed in? What would that tell you about the possible age of the soil? Lastly, a soil scientist would note other features, such as color and soil type, that we have not discussed in detail here and that would also aid in interpreting the age of the soil.

**A final note:** Future generations of geologists are likely to encounter many situations such as this one in which an exposure that appears to be straightforward can in fact be easily misinterpreted. With humans' proclivity for moving earth around while constructing landfills, subdivisions, factories, highways, dams, and other facilities, more and more exposures such as this one will present a real challenge to future geologists to correctly interpret earth materials.

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**STOP 6** Exposure of Snider Till Member of the Wedron Formation (SW, NW, NE, Sec. 2, T22N, R11W, 2nd P.M., Vermilion County, Ambia 7.5-minute Quadrangle).

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The Snider Till Member of the Wedron Formation is exposed along both sides of the road in the drainage ditch (fig. 14). The sediments of this ground moraine were deposited in front of the Paxton Moraine (see route map). The Snider is a gray silty clayey till that generally has a blocky structure.

### Soil Survey

The Soil Survey of Vermilion County (Wacker 1996) indicates four soils within the immediate area of this stop. Starting with the soil developed adjacent to the Middle Branch of the North Fork of the Vermilion River, and proceeding to the south which is topographically higher, the soils include: the Selma silt loam, the Andres loam, the Symerton loam, and the Elliott silt loam. The parent materials for these soils include the Peoria Loess, the Snider Till, and reworked drift (technically, alluvium) found along the Middle Branch.

The following soil descriptions are modified from The Soil Survey of Vermilion County (Wacker 1996).

**Selma silt loam** The Selma silt loam is a poorly drained soil developed in broad, flat areas and in shallow depressions and drainageways on outwash plains. It is occasionally ponded for brief periods in the winter and spring. Typically, the surface soil is black, friable silt loam and loam about 22 inches thick. The subsoil, about 21 inches thick, is friable. The upper part is dark gray loam; the next part is olive gray, mottled loam, and the lower part is light gray, mottled clay loam and loam. The underlying material to a depth of 60 inches or more is light gray, mottled sandy loam. In some areas the surface soil and the subsoil contain less sand and more silt. In a few areas the underlying material is calcareous silty clay loam or loamy till.

**Andres loam** The Andres loam is a somewhat poorly drained soil developed on slight rises in the uplands. Typically, the surface soil is very dark gray, friable loam about 12 inches thick. The subsoil is about 38 inches thick. The upper part is dark brown, friable clay loam; the next part is dark yellowish brown and yellowish brown, mottled, friable clay loam; and the lower part is olive brown, mottled, firm, calcareous silty clay loam. The underlying material to a depth of 60 inches or more is olive brown, mottled, very firm, calcareous silty clay loam. In places the subsoil contains less sand and more silt or clay. In some areas the underlying material is stratified loam and sandy loam. In a few places the upper part of the subsoil is not mottled. In the area east of Hoopston, the underlying material is firm, calcareous loam. Included with this soil in mapping are moderately well drained Symerton soils.

**Symerton loam** The Symerton loam is a moderately well drained soil developed on the side slopes and ridgetops in the uplands. Typically, the surface soil is very dark gray, friable loam



about 13 inches thick. The subsoil is about 26 inches thick. The upper part is dark yellowish brown, friable loam and clay loam; the next part is dark yellowish brown, friable clay loam that has strata of sandy clay loam; and the lower part is light olive brown, mottled, firm, calcareous silty clay loam. The underlying material to a depth of 60 inches or more is light olive brown, mottled, firm, calcareous silty clay loam. In some places the surface layer is thinner or lighter in color. In other places the surface soil and the subsoil contain less sand and more silt or clay. In a few areas the underlying material is stratified loam and sandy loam. In the area east of Hoopeston, the underlying material is firm, calcareous loam.

**Elliott silt loam** The Elliott silt loam is a somewhat poorly drained soil developed on slight rises on till plains and moraines. Typically, the surface soil is very dark gray, friable silt loam about 12 inches thick. The subsoil is about 28 inches thick and is mottled. The upper part is olive brown, friable silty clay loam and silty clay; the next part is light olive brown, friable silty clay loam; and the lower part is light olive brown, mottled, firm, calcareous silty clay loam. The underlying material to a depth of 60 inches or more is light olive brown, mottled, firm calcareous silty clay loam. In some places the subsoil and underlying material contain less clay and more silt. In other places the subsoil is stratified loam and clay loam. In some areas the soil formed in lacustrine sediments.

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**STOP 7** Sand dune (SW, SW, NE, NW, Sec. 8, T22N, R11W, 2nd P.M., Vermilion County, Ambia 7.5-minute Quadrangle).

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Within a small area, approximately 2 miles wide east–west and 3 miles long north–south, located in front of the Paxton Moraine, the sand in the outwash plain has been reworked by the wind, and some of it has been blown into dunes. One of these dunes (fig. 24) is located directly east of the road, and others are visible to the north, west, and south. The well-sorted, medium-grained wind-blown sand deposits associated with sand dunes are classified by geologists as the Parkland Sand. Locally within this area the Parkland Sand is from reworked (windblown) deposits of the Batavia Member of the Henry Formation. The sands and gravels of the Batavia Member in this area form an outwash plain along the front of the Paxton Moraine.



**Figure 24** Sand dune of Parkland Sand at Stop 7 (photo by Wayne T. Frankie).

Because of the limited areal extent of the sand dunes within this area, the the dune sand was probably derived locally from the outwash deposits associated with the small stream valley located directly west of this stop. This stream valley, which cuts through the Paxton Moraine to the

north, has undergone two cycles of erosion. The first resulted in the formation of a broad flat valley bottom, and the second cycle incised the present stream into the valley. The broad valley bottom was created when the stream was at a temporary base level, so that it could no longer deepen the valley, and therefore its erosive energy was used in forming meanders which widened the valley. The temporary base level that determined this action was most likely caused by the filling of the valley of the North Fork of the Vermilion River with outwash from the Chatsworth glacier or with valley train deposits from the draining of Lake Watseka.

Measurements conducted during the preparation of this field trip indicated that approximately 5.5 to 6 feet of the original dune has been eroded away from the south and north ends. This partial erosion of the dune occurs within the cultivated fields and is the result of the combined effect of field tillage and wind erosion. The ridge formed along the fence line gives the appearance of an east–west orientation. However, the original dune orientation is northwest–southeast. The vegetation along the fence line has helped to control erosion.

### **Soil Survey**

The Soil Survey of Vermilion County (Wacker 1996) shows three dominant soils within the immediate area of this stop, the Selma silt loam, the La Hogue loam, and the Sparta loamy fine sand. The Sparta loamy fine sand is developed on the sand dunes and is surrounded by the La Hogue loam, which has developed on slight rises below the Sparta soil. The Selma silt loam is developed in the broad, flat areas and in the shallow depressions and drainageways below the Sparta soil. The parent materials for these soils include the Parkland Sand, the sands and gravels of the Batavia Member of the Henry Formation, and the Peoria Loess.

The following soil descriptions are modified from The Soil Survey of Vermilion County (Wacker 1996).

**Sparta loamy fine sand** The Sparta loamy fine sand is an excessively drained soil which is developed on side slopes and ridgetops in the uplands. Typically, the surface soil is very dark grayish brown, very friable loamy fine sand about 11 inches thick. The subsoil is about 26 inches thick and is very friable. The upper part is brown loamy fine sand, and the lower part is dark yellowish brown and yellowish brown fine sand. The underlying material to a depth of 60 inches or more is yellowish, loose fine sand. In some areas the surface layer is thinner or lighter in color. In a few areas the subsoil contains less sand and more clay or silt.

**La Hogue loam** The La Hogue loam is a somewhat poorly drained soil developed on slight rises on outwash plains and stream terraces. Typically, the surface soil is very dark gray, friable loam about 12 inches thick. The subsoil is about 31 inches thick and mottled. The upper part is brown, friable loam; the next part is dark yellowish brown, friable clay loam; and the lower part is brown, friable clay loam and stratified loamy coarse sand to clay loam. The underlying material to a depth of 60 inches or more is brown, mottled, friable, stratified loamy coarse sand to clay loam. In places the underlying material is firm, calcareous loam. In some areas the subsoil is gravelly sand and loamy sand. In other areas the upper part of the subsoil contains more clay and less sand. In a few areas the subsoil is thinner.

**Selma silt loam** The Selma silt loam is a poorly drained soil developed in the broad, flat areas and in shallow depressions and drainageways on outwash plains. It is occasionally ponded for brief periods in the winter and spring. Typically, the surface soil is black, friable silt loam and loam about 22 inches thick. The subsoil is about 21 inches thick and friable. The upper part is dark gray loam; the next part is olive gray, mottled loam; and the lower part is light gray, mottled clay loam and loam. The underlying material to a depth of 60 inches or more is light gray, mottled sandy loam. In some areas the surface soil and the subsoil contain less sand and more silt. In a few areas the underlying material is calcareous silty clay loam or loamy till.

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**STOP 8** Sand and gravel pit (NW, NE, SW, NW, Sec. 11, T22N, R12W, 2nd P.M., Vermilion County, Hoopeston 7.5-minute Quadrangle).

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The deposits along the North Fork of the Vermilion River consist of valley train sands and gravels of the Mackinaw Member of the Henry Formation. These sediments were deposited by meltwater from the Chatsworth Glacier and by the raging flood torrents which flowed through the outlet channels of Lake Watseka.

While the Chatsworth glacier stood at its most advanced position and was forming the Chatsworth Moraine, the meltwater from the portion of the glacier east of what is now Hoopeston flowed westward on the drift plain behind the Ellis Moraine and then escaped southward through a meltwater channel across the Ellis Moraine. The meltwater then flowed through what is now the valley of the North Fork of the Vermilion River. This meltwater carried considerable outwash which was deposited not only as a valley train along the principal valley but also in the numerous tributary streams leading from the glacier. The courses of these tributaries now appear as small creeks along the front or across the moraine.

Water flowing through the four outlet channels of Lake Watseka transported sediments from the Chatsworth Moraine to the south. The channels converged north of the Ellis Moraine where the North Fork of the Vermilion River cuts through the Ellis Moraine. From this point southward the valley train deposits flowed through what is now the valley of the North Fork of the Vermilion River.

The texture, variation of size, and degree of sorting of the deposits exposed in the pit at this stop are characteristic of valley train outwash. The thickness of the deposits along the river is variable. This stop will afford us the opportunity to collect a variety of glacial erratics, some marked by glacial striations, and sedimentary, igneous, and metamorphic rocks. In addition, a number of geodes have been found at this locality.



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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 ( $\text{CaCO}_3$ ); limy.

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

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



- Clastic** Fragmental rock composed of detritus, including broken organic hard parts as well as rock substances of any sort.
- Closure** The difference in altitude between the crest of a dome or anticline and the lowest contour that completely surrounds it.
- Columnar section** A graphic representation in a vertical column of the sequence and stratigraphic relations of the rock units in a region.
- Conformable** Layers of strata deposited one upon another without interruption in accumulation of sediment; beds parallel.
- Delta** A low, nearly flat, alluvial land deposited at or near the mouth of a river where it enters a body of standing water; commonly a triangular or fan-shaped plain sometimes extending beyond the general trend of the coastline.
- Detritus** Material produced by mechanical disintegration.
- Disconformity** An unconformity marked by a distinct erosion-produced irregular, uneven surface of appreciable relief between parallel strata below and above the break; sometimes represents a considerable interval of nondeposition.
- Dolomite** A mineral, calcium-magnesium carbonate ( $\text{Ca,Mg}[\text{CO}_3]_2$ ); applied to those sedimentary rocks that are composed largely of the mineral dolomite; it also is precipitated directly from seawater. It is white, colorless, or tinged yellow, brown, pink, or gray; has perfect rhombohedral cleavage; appears pearly to vitreous; effervesces feebly in cold dilute hydrochloric acid.
- Drift** All rock material transported by a glacier and deposited either directly by the ice or reworked and deposited by meltwater streams and/or the wind.
- Driftless Area** A 10,000 square mile area in northeastern Iowa, southwestern Wisconsin, and northwestern Illinois where the absence of glacial drift suggests that the area may not have been glaciated.
- End moraine** A ridge-like or series of ridge-like accumulations of drift built along the margin of an actively flowing glacier at any given time; a moraine that has been deposited at the lower or outer end of a glacier.
- Epoch** An interval of geologic time; a division of a period.
- Era** A unit of geologic time 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.
- 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).
- Geology** The study of the planet Earth. It is concerned with the origin of the planet, the material and morphology of the Earth, and its history and the processes that acted (and act) upon it to affect its historic and present forms.
- Geophysics** Study of the Earth by quantitative physical methods.
- Glaciation** A collective term for the geologic processes of glacial activity, including erosion and deposition, and the resulting effects of such action on the Earth's surface.

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

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

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

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

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

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

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

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

**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.

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

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

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

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

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

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



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

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

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

**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 structure and the history of geologic changes.

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

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

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

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

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

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

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

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

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

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

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

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



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

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

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

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

**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 heterogeneous mixture of different sizes and kinds of rock fragments.

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

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

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

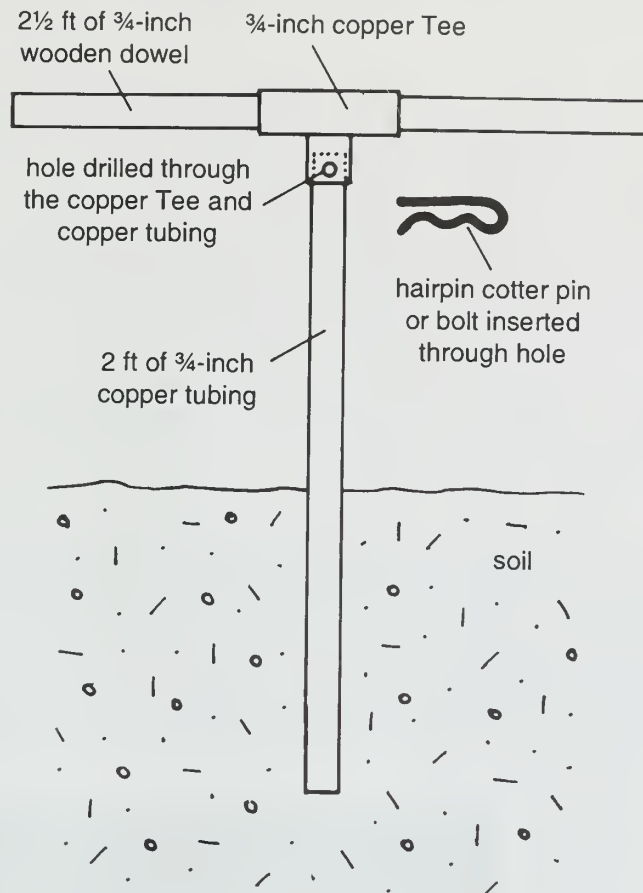
**Unconformity** A surface of erosion or nondeposition that separates younger strata from older strata; most unconformities indicate intervals of time when former areas of the sea bottom were temporarily raised above sea level.

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

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

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

## HOW TO MAKE AN INEXPENSIVE SOIL PROBE



- 1 Push assembled soil probe into soil
- 2 Remove probe
- 3 Pull pin and remove copper Tee
- 4 Use wooden dowel to push the soil core out of the copper tubing. You may need to use a hammer.





ERRATICS ARE ERRATIC

*Myrna M. Killey*

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

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

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



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

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

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

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

ANCIENT DUST STORMS IN ILLINOIS

*Myrna M. Killey*

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

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

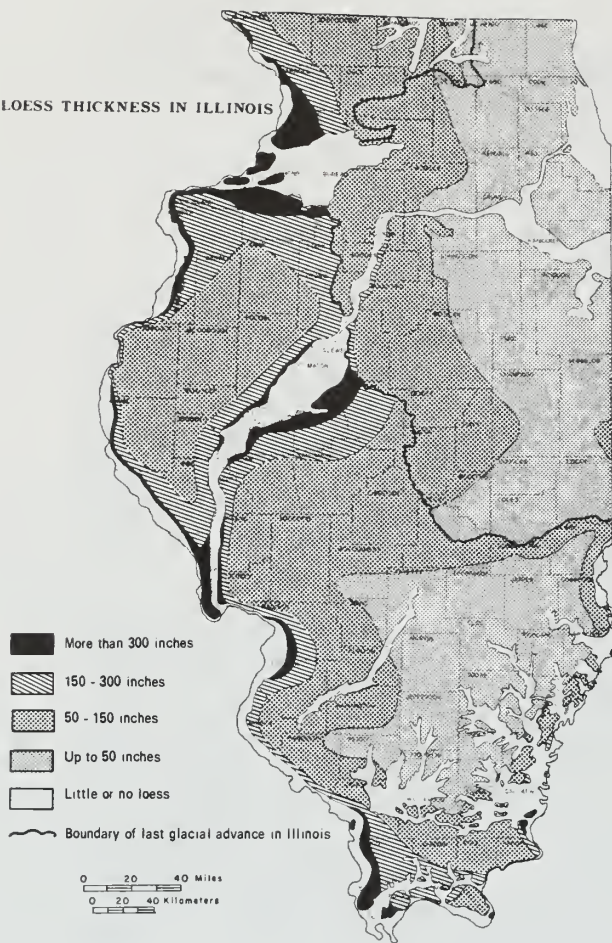
The deposits of windblown silt are called loess (rhymes with "bus"). Loess is found not only in the areas once covered by the glaciers but has been blown into the nonglaciaded areas. The glaciers, therefore, influenced the present land surface well beyond the line of their farthest advance.

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

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



LOESS THICKNESS IN ILLINOIS



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

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

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

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

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

DO YOU LIVE ABOVE AN UNDERGROUND RIVER?

*Myrna M. Killey*

Do you think of an underground river as a hidden stream rushing through a tunnel in solid rock? Such subterranean rivers do exist in some states—in Alabama and Missouri, for example. In Illinois, however, except in a few areas where water flows through cracks and channels it has created by dissolving the limestone bedrock, underground "rivers" are not really rivers at all. The Mahomet "river" that underlies part of east-central Illinois is a good example. So is the eastern part of this "river," which is called the Teays (rhymes with "days"). Such rivers are vital to many towns, for they are a reliable source of water.

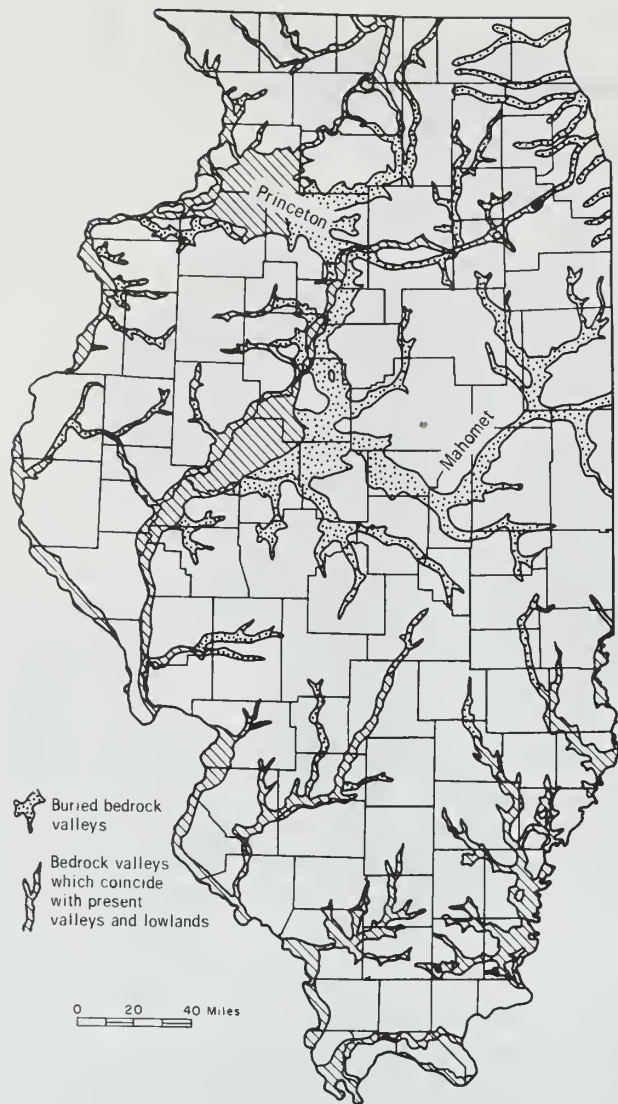
The Mahomet-Teays river system was discovered more than 25 years ago when numerous water wells were drilled in the eastern and midwestern United States. The story of this vast river system has been pieced together largely from information obtained from records made during the drilling of the wells.

More than a million years ago, before the glaciers of the Great Ice Age crept down over the Midwest, a river as large as the present Mississippi flowed generally westward from its probable source in the mountains of West Virginia, crossed Ohio and Indiana, and traversed east-central Illinois from Hoopeston to Havana. At Havana it joined another ancient river system that occupied what is now the Illinois River Valley (see map). All along its course it cut a deep valley in the bedrock.

When the successive glaciers invaded Illinois from Canada, the fringes of the ice melted during the warmer periods, and the water (meltwater) carried with it great quantities of sand and gravel that had been embedded in the ice. This material, called *outwash*, was deposited in thick layers in the Mahomet Valley. As the later glaciers advanced southward, both the valley and its outwash were buried by ice. When the ice finally melted, tremendous amounts of unsorted rock debris (pebbly, sandy clay called *till*) that had been held in the ice blanketed the land surface, including the former river valley, to depths of 50 to more than 100 feet. (The outwash and till deposits are collectively called *drift*.) The great Mahomet River Valley was obliterated from the landscape and the river no longer existed. Instead, on the new land surface the river patterns we know today developed.

The buried Mahomet Valley is invaluable to east-central Illinois because its porous sand and gravel deposits act as vast underground sponges, storing the rainwater that seeps downward from the land surface. Water flows easily through the sand and gravel into wells drilled in the porous materials. In contrast, glacial till is too fine-grained to allow the water it holds to flow easily and, therefore, cannot supply large amounts of water to wells. Towns such as Hoopeston, Champaign-Urbana, Mahomet, Monticello, and Clinton that are situated above the buried Mahomet Valley have large ground-water supplies available to them, but towns away from the valley have more difficulty obtaining their water. Perhaps the term "underground river" is still applied to the Mahomet Valley because it is easier to imagine great volumes of well water coming from a river than from beds of sand and gravel in a buried valley.





The Mahomet Valley has been traced for about 150 miles across Illinois, it lies at an average depth of more than 200 feet below land surface, and its bottom is at an average elevation of 350 feet above sea level. In some places the ancient valley varies in width from 5 miles at the Indiana line to almost 10 miles near Clinton in De Witt County.

Another major "underground river" is the Princeton Bedrock Valley in the north-central part of Illinois. Many smaller bedrock valleys in the state contain sand and gravel deposited by glacial meltwater. The Mississippi, Illinois, Kaskaskia, and Wabash Rivers also contain beds of outwash deposited by glacial meltwaters, but their courses were not obliterated by the glaciers, and their valleys have remained open as drainageways.

The water supplies in these deposits in the ancient river valleys of Illinois are one of many resources contributing to the state's natural wealth. Of the 3.3 billion gallons of water a day used by Illinois, about 450 million gallons are pumped from sand and gravel deposits, mainly of glacial origin. The value of ground water from these deposits is over \$115 million per year.

Do you live above an underground "river"? Look at the map and see. Locate the source of the water you use in your town. If you should see a well being drilled, stop and ask if you can look at the earth materials brought up from the well. These are the kinds of material used to interpret the geologic history of Illinois.



# PLEISTOCENE GLACIATIONS IN ILLINOIS

## Origin of the Glaciers

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



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

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

## Effects of Glaciation

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

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

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

## Glacial Deposits

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

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

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

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

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

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

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

## Loess, Eolian Sand and Soils

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

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

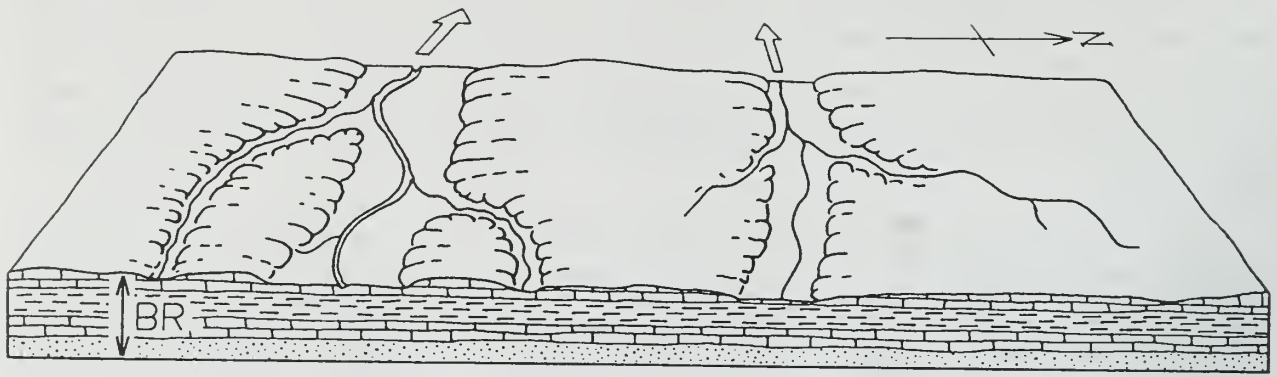
Each Pleistocene glaciation was followed by an interglacial stage that began when the climate warmed enough to melt the glaciers and their snowfields. During these warmer intervals, when the climate was similar to that of today, drift and loess surfaces were exposed to weather and the activities of living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

## Glaciation in a Small Illinois Region

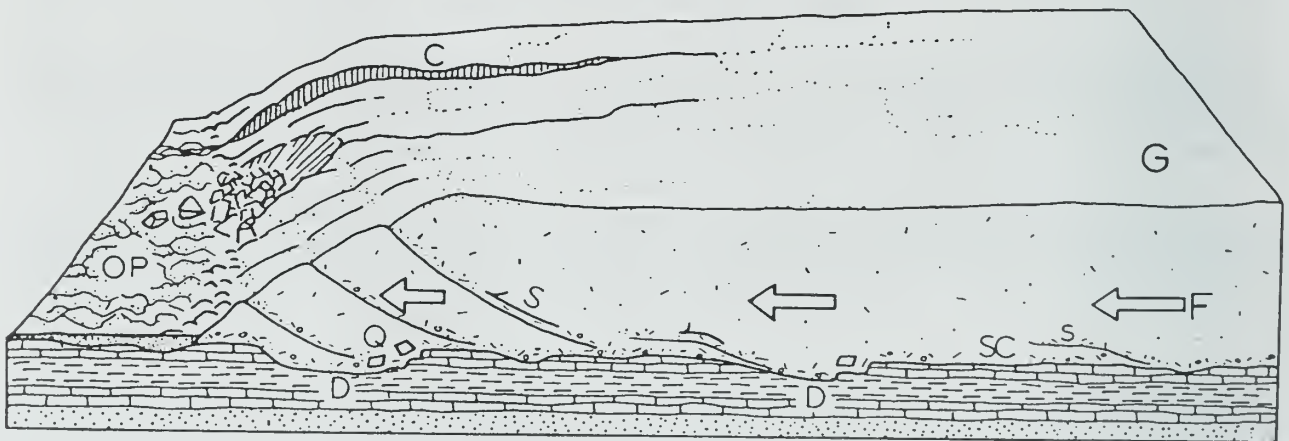
The following diagrams show how a continental ice sheet might have looked at various stages as it moved across a small region in Illinois. They illustrate how it could change the old terrain and create a landscape like the one we live on. To visualize how these glaciers looked, geologists study the landforms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

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

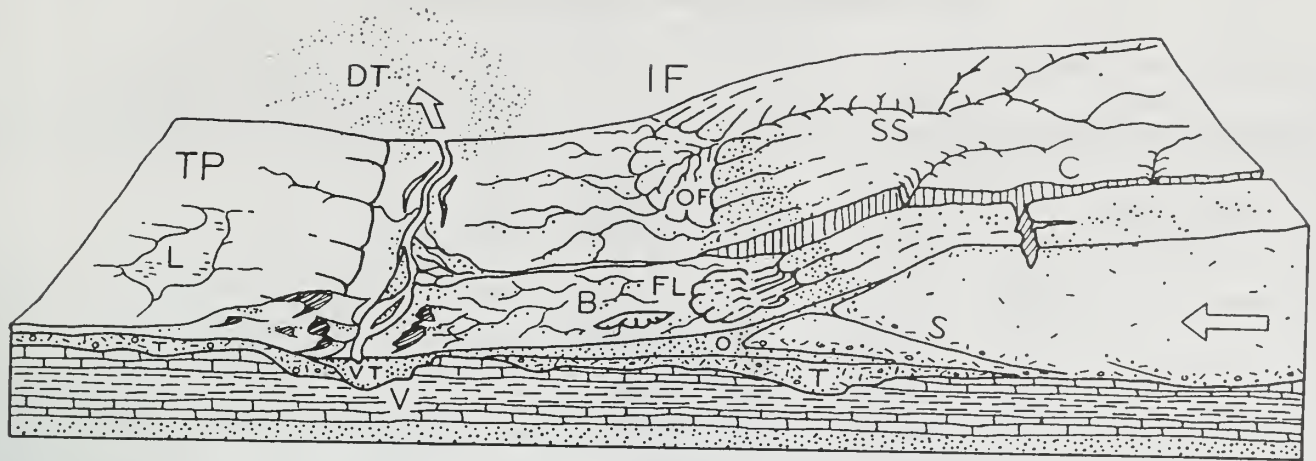




1. **The Region Before Glaciation** — Like most of Illinois, the region illustrated is underlain by almost flat-lying beds of sedimentary rocks—layers of sandstone (.....), limestone (— — —), and shale (≡≡≡). Millions of years of erosion have planed down the bedrock (BR), creating a terrain of low uplands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



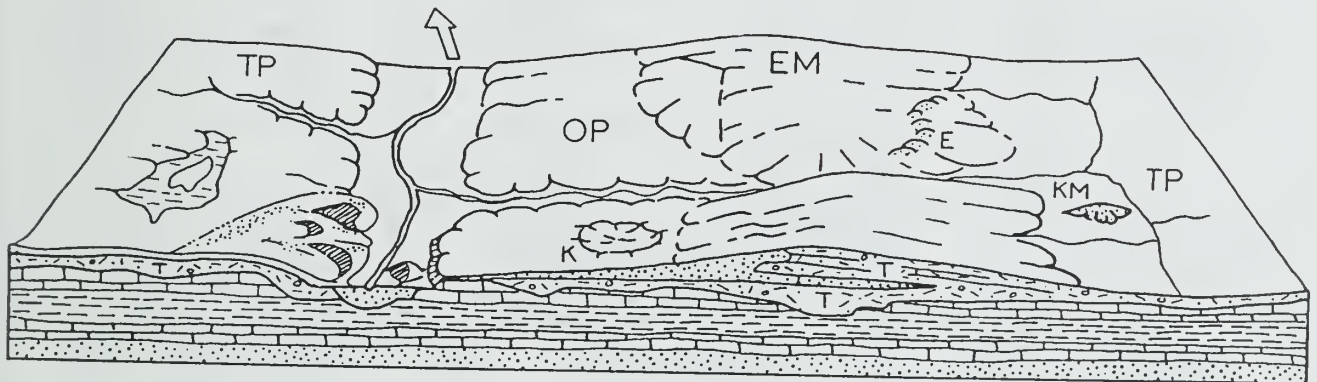
2. **The Glacier Advances Southward** — As the Glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughnesses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



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

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

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



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

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

TIME TABLE OF PLEISTOCENE GLACIATION

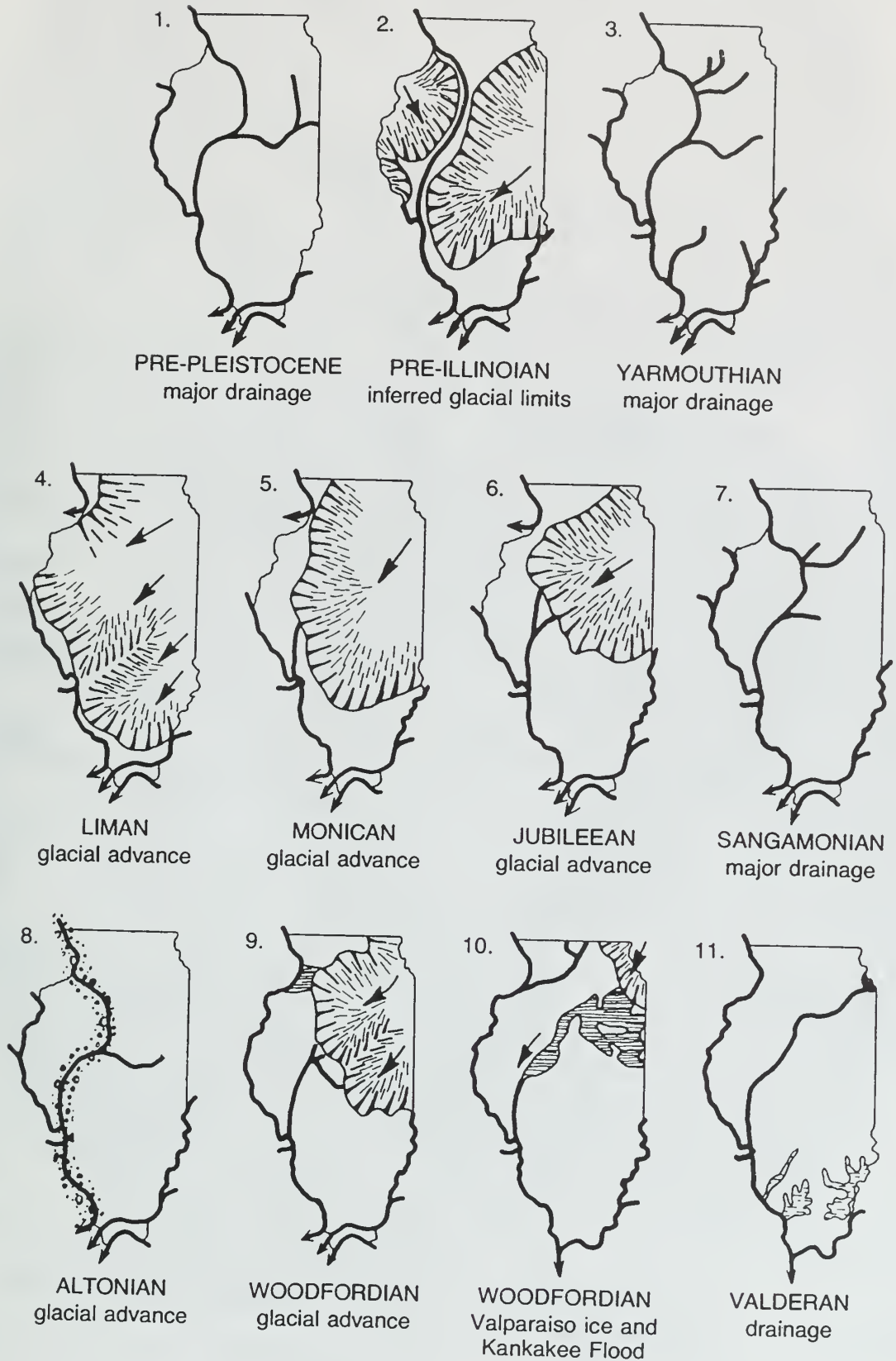
		STAGE	SUBSTAGE	NATURE OF DEPOSITS	SPECIAL FEATURES
QUATERNARY	Pleistocene	HOLOCENE (interglacial)	Years Before Present	Soil, youthful profile of weathering, lake and river deposits, dunes, peat	
		WISCONSINAN (glacial)	10,000	Outwash, lake deposits	Outwash along Mississippi Valley
			Valderan		
			11,000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

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

(Illinois State Geological Survey, 1973)



# SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



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

# GLACIAL MAP OF ILLINOIS


H.B. WILLMAN and JOHN C. FRYE

1970

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

## EXPLANATION

### HOLOCENE AND WISCONSINAN

 Alluvium, sand dunes,  
and gravel terraces

### WISCONSINAN

 Lake deposits

### WOODFORDIAN

 Moraine

 Front of morainic system

 Ground moraine

### ALTONIAN

 Till plain

### ILLINOIAN

 Moraine and ridged drift

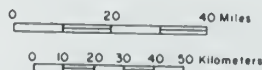
 Ground moraine

### KANSAN

 Till plain

### DRIFTLESS



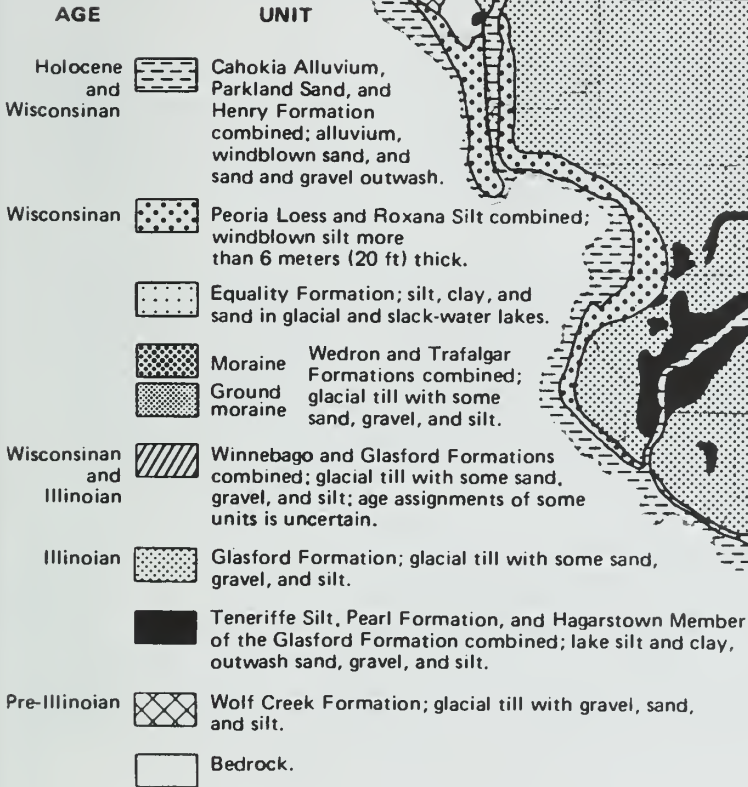
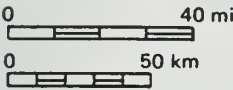




QUATERNARY DEPOSITS OF ILLINOIS

Jerry A. Lineback  
1981

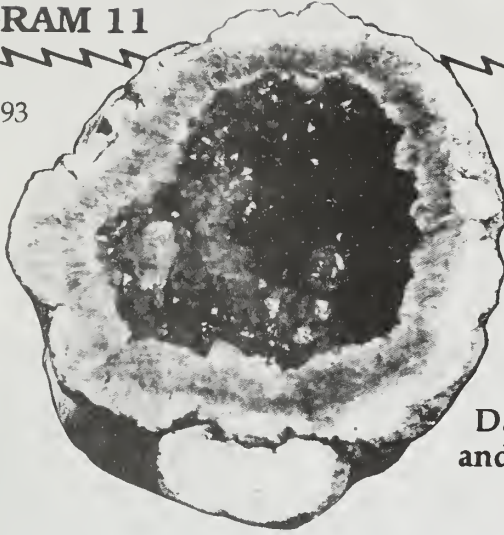
Modified from Quaternary Deposits  
of Illinois (1979) by Jerry A. Lineback







March 1993



## GEODES

### Small Treasure Vaults in Illinois

David L. Reinertsen, D. Scott Beaty,  
and Jonathan H. Goodwin

Geodes, a term derived from a Greek word meaning earth-shaped, are irregular, roughly spherical bodies. They can be oblong or shaped like invertebrate fossils (e.g. crinoid calyx). Some are hollow and lined with beautiful layers and clusters of various mineral crystals, but others are completely filled by inward-growing crystals. Hollow geodes, relatively lightweight compared with those completely filled, are more desirable because they generally contain a greater variety of minerals that have had an opportunity to grow well formed crystals. Some of Illinois' best mineral specimens were collected from the crystal linings of geodes.

Geodes found in Illinois range from less than 1 inch to more than 2 feet in diameter, but 3 to 5 inches is the average. They generally occur in limestone, a calcium carbonate ( $\text{CaCO}_3$ ), or in dolomite, a calcium-magnesium carbonate ( $\text{CaMg}(\text{CO}_3)_2$ ). Although geodes can be found in carbonate-rich rocks throughout the state, one of the most famous geode collecting areas in the country is the region of western Illinois and adjacent parts of Iowa and Missouri. The region encompasses about a 70-mile radius from the towns of Warsaw, Hamilton, and Nauvoo.



A typical geode from western Illinois has an outer shell made of chalcedony, a cryptocrystalline quartz composed of silicon dioxide ( $\text{SiO}_2$ ). Once the outer shell forms, mineral-rich water may still be inside the shell, causing more quartz to be deposited and other minerals to form toward the center. Chalcedony, much harder than the host rock of limestone, helps to preserve the specimen during weathering. As the weaker host rock is eroded, the geodes "weather out" and remain behind. They generally are easy to see because of their shape and the texture of their outer shell.

The micro-environment inside the shell is an excellent place for crystal growth. Temperature and pressure changes, as well as evaporation, cause the mineral matter to precipitate. More solutions rich in minerals may seep into the geode later, adding to the quartz crystals or forming other minerals. In addition to the chalcedony of the outer shell, the inside of some geodes is lined with a pronounced bumpy, mammillary form of blue-gray chalcedony. Some specimens also have excellent clear quartz crystals. Ankerite, aragonite, calcite, dolomite, goethite/limonite, gypsum, and marcasite/pyrite are the other minerals most commonly found. Occasionally, dark bronze, fine, hair-like masses are found inside; these may be millerite ( $\text{NiS}$ ) or a filamentous form of pyrite.

Perhaps the most fascinating geodes are those that contain petroleum, which may be under enough pressure to squirt out when the geode is broken. The enclosing rock north of Nauvoo, where these unusual geodes are found, no longer contains any significant oil. So what is the source of oil in these geodes? What is the origin of the other minerals? We don't know for sure. Perhaps trace amounts of some of the elements that make up the rarer minerals were present in shale layers associated with the carbonate strata. As a matter of fact, the most prolific zone for collecting geodes in western Illinois is in the lower part of the Warsaw Shale of the Valmeyeran Series (middle series of the Mississippian System). These sedimentary strata were deposited in shallow seas that covered what is now the midcontinent about 350 million years ago.

Geologists have proposed several theories to explain the conditions and processes that form geodes, but none seems to be entirely adequate to explain all geode features. In discussing the origin of the western Illinois geodes, Hayes (1964) noted that any theory proffered must explain why the geodes are

- (1) essentially confined to a specific stratigraphic interval, the lower part of the Warsaw Shale;
- (2) generally associated with particular lithologies (clayey, shaley dolomite, and dolomitic mudstone);
- (3) located in specific zones or beds rather than scattered randomly;
- (4) fairly uniform in size in a particular zone and round, at least initially;
- (5) enveloped by laminations in the bedrock that exhibit some thinning of layers above and below the specimen.

As limey sediments accumulated in shallow midcontinental seas, rounded cavities that are characteristic of geodes could not have formed at the interface or contact of water and sediments. Nor could they have formed during the earliest stages of sediment compaction and cementation. Therefore, some feature of a different texture than the host limestone had to be present. This feature either caused geodes to form or was transformed into a geode. Hayes hypothesized that the only features in the rocks that shared enough characteristics with geodes to serve as precursors were calcite concretions (small zones in the original sediment strongly cemented by calcite). The size and shape of these concretions, their position in the limestone, and their relation to the surrounding rocks are strikingly similar to those of geodes. In several exposures in the region, specimens may be found that display all stages of the transition from concretion to geode. Hayes suggested that calcite concretions formed where organic materials (remains of the living tissues of plants or animals) accumulated with carbonate-rich sediments under quiet-water conditions. The organic matter decomposed, causing an oxygen-poor (anaerobic), alkaline environment ( $\text{pH} > 7$ ) to develop in the sediments. These conditions encouraged calcite to precipitate from the solutions in the sediments.

The formation of many features seen in geodes may involve a step by step replacement of these concretions by quartz and other minerals. Changes in the chemical composition and acidity ( $\text{pH}$ ) of water in the sediments caused chalcedony to replace the calcite at the outer margins of the concretions. This process caused the formation of a calcite-concretion core surrounded by a hard, but slightly permeable, shell of chalcedony. Further changes in the chemistry and  $\text{pH}$  of the water percolating slowly through the sediment caused the core concretion inside the geode eventually to dissolve, leaving a hard, hollow cavity in which more chalcedony, quartz, or other minerals could precipitate.



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