Guide to the Geology of the Pere Marquette State Park Area, Jersey County

David L. Reinertsen
Janis D. Treworgy

Field Trip Guidebook 1991D, October 26, 1991
Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

Cover photo by J. D. Treworgy

Bluff of Mississippian strata along the Great River Road at Chautauqua, Jersey County, Illinois.

Geological Science Field Trips The Educational Extension Unit of the Illinois State Geological Survey conducts four free tours each year to acquaint the public with the rocks, mineral resources, and landscapes of various regions of the state and the geological processes that have led to their origin. Each field 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 preparing 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 earlier field trip guide leaflets 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) 244-2407 or 333-7372.

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Printed by the authority of the State of Illinois/1991/500

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615 E. Peabody Dr., Champaign, IL 61820

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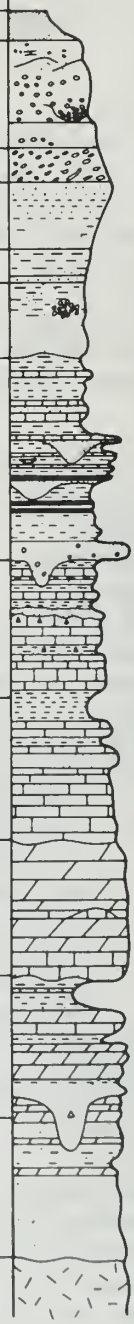
FIGURES

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



Generalized geologic column showing succession of rocks in Illinois.

PERE MARQUETTE STATE PARK AREA

Overview

This guide will acquaint you with the geology, landscape, and mineral resources in the Pere Marquette State Park area of Jersey County, Illinois. Pere Marquette State Park is about 75 miles southwest of Springfield, some 250 miles southwest of Chicago, and approximately 30 miles northwest of St. Louis. The area is characterized by gently rolling uplands that developed on deposits left by two periods of continental glaciation during the last 300,000 years. The area's surface continuity is broken where these glacial deposits are eroded by the Mississippi and Illinois Rivers and their tributaries. Stone is the only mineral resource presently produced in Jersey County.

This field trip will be somewhat of a departure from our normal field trip procedures. After registration in the morning, you will leave the park and drive eastward to the first three stops, where you will have the opportunity to collect fossils and perhaps a geode. In addition, you will cross the uplands away from the major river valleys. You will then return to the park for lunch. In the afternoon, you will be able to walk to several stops in the park where Survey geologists will be stationed to describe the various strata and answer your questions. The best vantage points for a superb view of the Illinois and parts of the Mississippi River Valleys entail about a 0.4-mile walk (each way).

Definitions

Bedrock is a general term for the solid rock that underlies soil or other unconsolidated, nonindurated, surface material. The strata underlying Illinois are divided into formations. A *formation* is a consistent body of rocks that has easily recognizable top and bottom boundaries, is readily traceable in the field, and is sufficiently widespread to be represented on a map. Many of the sedimentary formations have *conformable contacts*, that is, no significant interruptions in deposition took place between them. 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 essentially continuous. At other contacts, however, the lower formation was subjected to weathering, and partial erosion occurred before the overlying formation was deposited. The fossils and other evidence in the formations may indicate a significant gap in time between deposition of the lower unit and the overlying unit. This type of contact is called an *unconformity*. The unconformity is called a *disconformity* if the beds above and below the unconformity are essentially parallel and an *angular unconformity* if the lower beds have been tilted and eroded before the overlying beds were deposited. Figure 1 shows several major unconformities (marked by a wavy line). Each unconformity represents a long interval of time during which a considerable thickness of rock, present in nearby regions, was either eroded or never deposited in parts of this area. Several smaller unconformities are also present. They represent shorter time intervals and thus smaller gaps in the depositional record.

Geologic History

Precambrian basement The geology of the Pere Marquette State Park area, like the rest of Illinois, has undergone many changes over several billion years of geologic time (see rock succession column, facing page). The oldest rocks beneath us on the field trip 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 in Illinois for geologists to collect samples from Precambrian rocks. From these samples, however, we know that these rocks consist mostly of granitic igneous and possibly metamorphic, crystalline rocks about 1.5 to 1.0 billion years old. These ancient rocks, which underwent deep weathering and erosion when they were part of Earth's surface until about 0.6 billion years ago, formed a landscape that must have been quite similar to the present-day Missouri Ozarks. The long time interval separating Precambrian

CENOZOIC

System		Series	Stage	Substage	Formation	Graphic Column	Thickness (m)
Quaternary		Pleistocene	Holocene		Cahokia Alluvium		0-46
			Wisconsinan	Wood-fordian	Peoria Loess /Henry		0-23
							0-15
				Farmdalian	Robein Silt		0-3
				Altonian	Roxana Silt		0-4
			Sangamonian				
			Illinoian		Loveland Silt /Pearl		0-30
					Glasford		
			Yarmouthian				
			Kansan		Banner		0-14
Tertiary		Pliocene			Grover Gravel		0-9

PALEOZOIC

System	Megagroup	Series	Group	Subgroup	Formation	Graphic Column	Thickness (m)
Pennsylvanian		Desmoinesian	Kewanee		Carbondale		20-36
					Spoon		0-26
Mississippian	Mammoth Cave Limestone	Valmeyeran			Ste. Genevieve Ls.		0-9
					St. Louis Ls.		52-73
					Salem Ls.		16-24
					Warsaw Sh.		15-24
					Keokuk Ls.		18-21
					Burlington Ls.		43-61
					Fern Glen		0-9
					Meppen Ls.		0-6
					Chouteau Ls.		6-21
	Knobs	Kinderhookian	New Albany Sh.		Hannibal Sh.		3-21
					Horton Creek		0-8
		Upper			Louisiana Ls.		0-1
					Saverton Sh.		0-2
Devonian					Sylamore Ss.		0-0.1
	Hunton Ls.	Middle			Cedar Valley Ls. Hoing Ss. Mbr.		0-12
Silurian		Niagaran			Joliet		0-8
		Alexandrian			Kankakee		0-9
					Edgewood		3-15
Ordovician		Cincinnatian	Maquoketa Sh.				30-61
	Ottawa Ls.	Champlainian	Galena	Kimmswick			21-27
				Decorah			9
			Platteville	Plattin			30
			Ancell		Joachim Dol.		24
					St. Peter Ss.		46
	Knox Dol.	Canadian	Prairie du Chien		*Shakopee Dol.		3+

*Only upper part exposed

Figure 1 Generalized stratigraphic column for the field trip area.

crystalline rocks from Cambrian sediments, for which we have no rock record in Illinois, is almost as long as all of recorded geologic time from the Cambrian to the present. Although geologists in Illinois do not see Precambrian rocks, except as cuttings from drill holes, they can determine some of the characteristics of the basement complex through the use of various techniques.

Rifting in the early Paleozoic Era In southernmost Illinois, near what is now the Kentucky–Illinois Fluorspar Mining District, evidence from gravity and magnetic field measurements, surface mapping, and seismic exploration for oil indicates that rift valleys formed. These valleys formed during a period when plate tectonic movements (slow global deformation) were beginning to rip apart an ancient supercontinent in Early to Middle Cambrian time, about 570 to 525 million years ago. In the Midcontinent region, these buried rift valleys are referred to as the Rough Creek Graben and the Reelfoot Rift (fig. 2).

Subsidence and deposition in the Paleozoic Era During late Middle Cambrian time, some 525 million years ago, the rifting stopped and the surrounding hilly Precambrian landscape began to slowly sink (subside) on a broad, regional scale. This permitted the invasion of a shallow sea from the south and southwest. During the several hundred millions of years of the remainder of the Paleozoic Era, what is now the Illinois region continued to receive sediments that were deposited in shallow seas. As subsidence continued, these seas repeatedly covered the area until at least 15,000 feet of sedimentary strata had accumulated in southern Illinois. Subsidence decreased in magnitude northward, away from the rift, so the strata become thinner northward. At times during the Paleozoic Era, the seas withdrew and the deposits were subjected to weathering and erosion. As a result, there are some gaps in the sedimentary record in Illinois.

Mesozoic and Cenozoic Eras Following the Paleozoic Era, during the Mesozoic Era, the Pascola Arch (fig. 2) rose in southeastern Missouri and western Tennessee. It closed off the southern end of the Illinois embayment and thus formed the Illinois Basin, separating it from

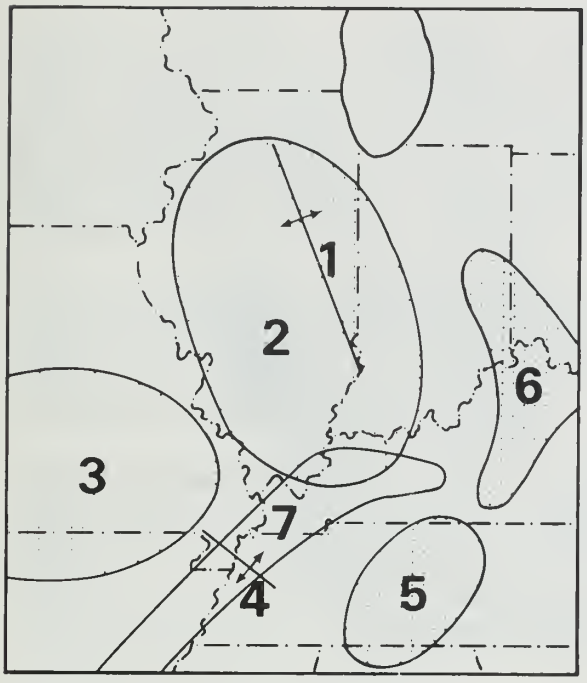


Figure 2 Locations of some of the major structures in the Illinois region: (1) La Salle Anticlinal Belt, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Reelfoot Rift, southwest to northeast, and Rough Creek Graben, west to east.

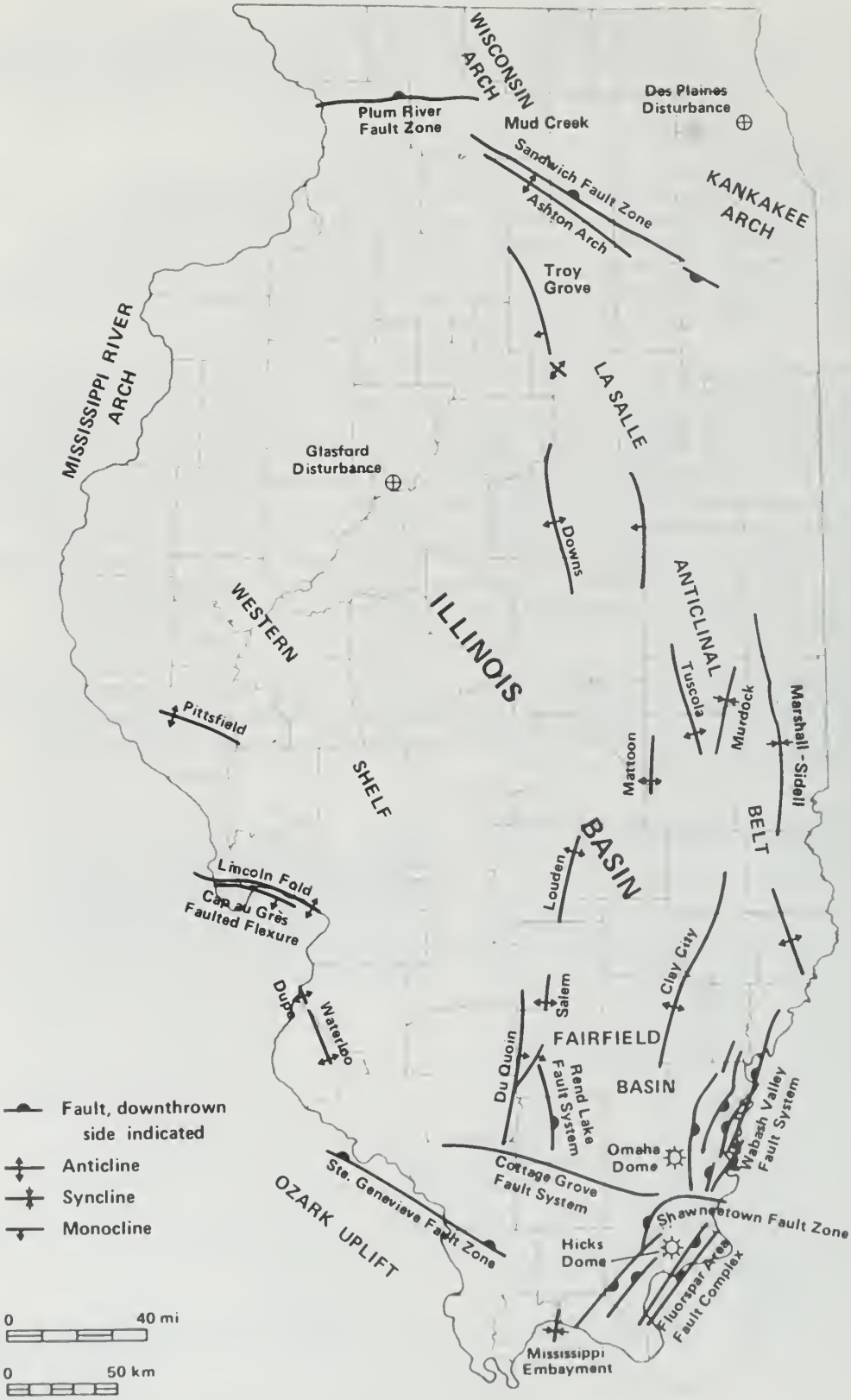


Figure 3 Structural features of Illinois (Treworgy 1981).

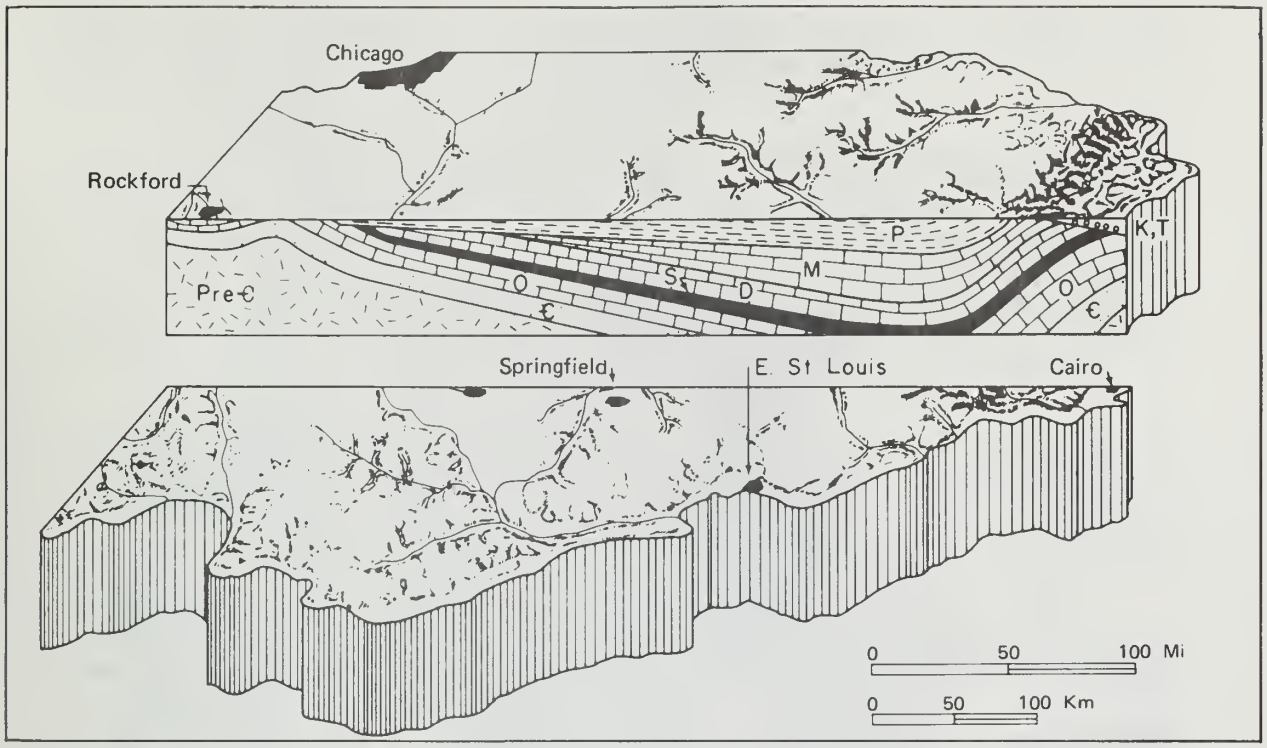


Figure 4 Stylized north-south cross section shows the structure of the Illinois Basin. The thickness of the sedimentary rocks has been greatly exaggerated to show detail, and the younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-C) granites. They form a depression filled with layers of sedimentary rocks of various ages: Cambrian (C), Ordovician (O), Silurian (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). Scale is approximate.

other basins to the south. The Illinois Basin is a broad downwarp covering much of Illinois, southern Indiana, and western Kentucky (figs. 2, 3, and 4). The development of the Pascola Arch in conjunction with the earlier subsidence of deeper parts of the region that would become the Illinois Basin, gave the basin its present asymmetrical, spoon shape. The geologic map in figure 5 shows the distribution of the rock systems of the various geologic time periods as they occur at the bedrock surface; that is, as if all glacial, windblown, and surface materials were removed.

The Pere Marquette State Park field trip area is located on the western flanks of the Illinois Basin. Bedrock strata here are tilted slightly to the east and south toward the deeper part of the basin located in Hamilton and White Counties about 140 miles away. Because tilting of the bedrock layers occurred several times during the Paleozoic Era, dips of successive strata are not always parallel to one another.

During the Mesozoic Era and part of the Cenozoic Era, before the start of glaciation 1 to 2 millions years ago, the ancient Illinois land surface was exposed to long, intense weathering and erosion, which carved a series of deep valley systems into the gently tilted bedrock formations. Later, the topography was flattened and filled in by the repeated advance and melting of the glaciers, which scoured and scraped the old erosion surface, affecting all bedrock except the Precambrian rocks. The glaciers finally melted away, leaving nonindurated deposits into which the Modern Soil developed.

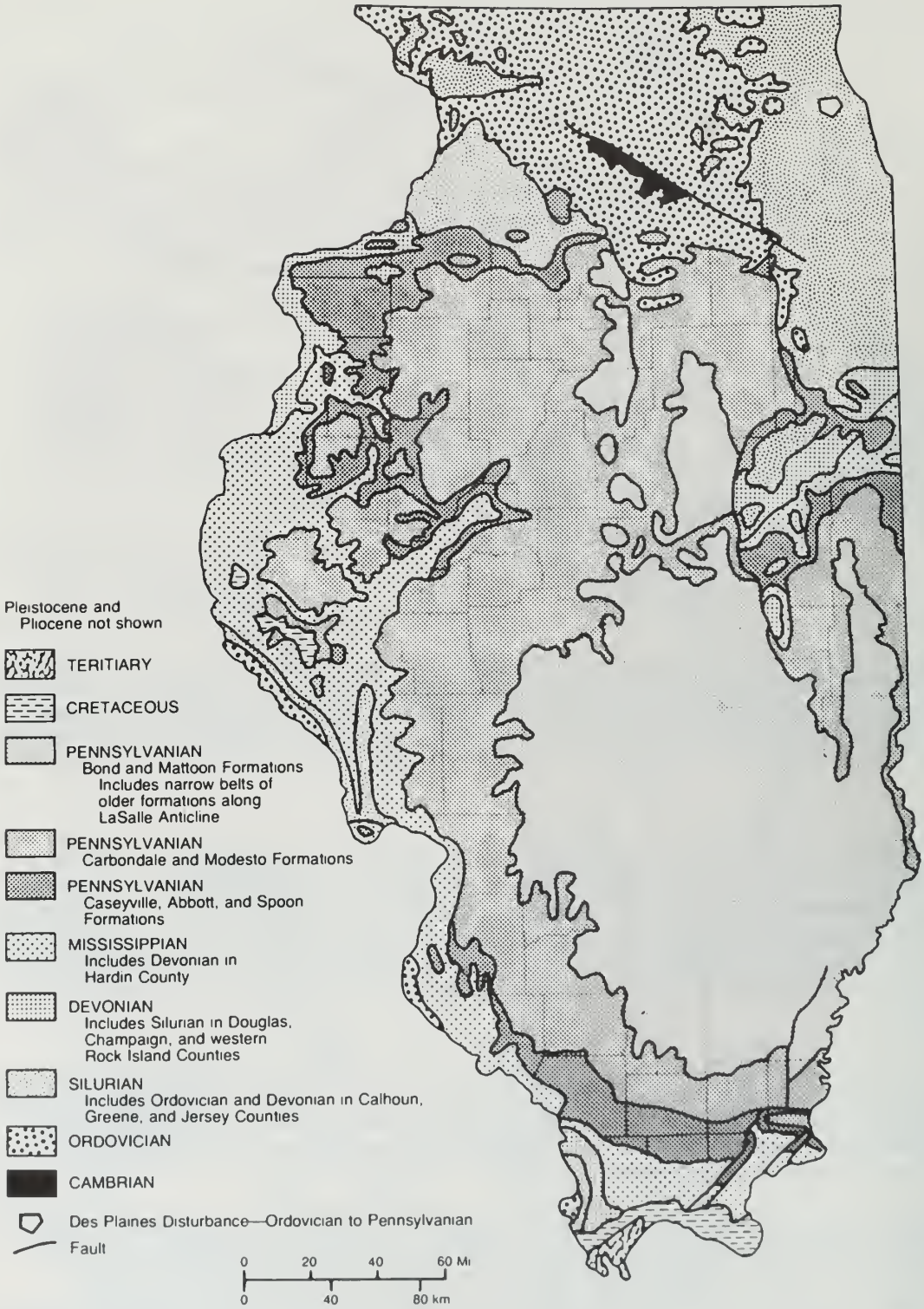


Figure 5 Geologic map of Illinois showing lateral distribution of rock systems at the bedrock surface.

Glacial history A brief general history of glaciation in North America and a description of the deposits commonly left by glaciers is found in *Pleistocene Glaciations in Illinois*, a section at the back of this guide.

Beginning about 1.6 million years ago, during the Pleistocene Epoch, massive ice sheets called continental glaciers, flowed slowly southward from centers of snow and ice accumulation in Canada. The last of these glaciers melted from northeastern Illinois about 13,500 years before the present (B.P.). Although ice sheets covered parts of Illinois several times during the Pleistocene Epoch, pre-Illinoian drift deposits are known only from the deeper parts of the largest bedrock valleys. During the Illinoian glaciation, around 270,000 years B.P., North American continental glaciers reached their southernmost extent, advancing as far south as the northern part of Johnson County, about 130 miles southeast of Pere Marquette State Park (fig. 6).

Until recently, glaciologists had assumed that ice thicknesses of 1 mile or more were reasonable for these glaciers. However, the ice may have been only about 2,000 feet thick in the Lake Michigan Basin and perhaps only 700 feet thick across much of the land surface (Clark et al. 1988). These conclusions are the result of studying (1) the degree of consolidation and compaction of rock and soil materials that must have been under the ice, (2) comparisons between the inferred geometry and configuration of the ancient ice masses and those of present-day glaciers and ice caps, (3) comparisons between the mechanics of ice-flow observed in modern-day glaciers and ice caps and those inferred from detailed studies of the ancient glacial deposits, and (4) the amount of rebound of the Lake Michigan Basin, which had been depressed by the tremendous weight of the ice.

Although Illinoian glaciers probably formed morainic ridges similar to those of the later Wisconsinan glaciers, Illinoian moraines are not nearly so prominent or apparently so numerous. In addition, Illinoian moraines have been exposed to weathering and erosion for thousands of years longer than their younger Wisconsinan counterparts. Scattered high hills in this part of Illinois have been attributed to morainal remnants.

As mentioned previously, erosion had carved an extensive network of bedrock valleys deeply into the irregular bedrock surface by the time glaciation began about 1.6 million years ago. As glaciation began, however, the streams began to fill up with sediments because the flow or volume of water was insufficient to carry increasing loads of materials. During times of deglaciation, vast quantities of meltwater and sediments were released from the waning ice front. No evidence, however, indicates that any pre-Illinoian fills in the preglacial valleys were ever completely flushed out of their channels by succeeding deglaciation meltwater torrents.

The topography of the bedrock surface through much of Illinois is largely hidden from view by glacial deposits except along the major streams and in areas mantled by thin drift near the glacial margins. This field trip is in an area where glacial drift is generally less than 25 feet thick and does not completely mask the underlying bedrock surface configuration. Because of erosion and the irregular bedrock surface, glacial drift is unevenly distributed across Jersey County; it generally increases to the north and northwest along Otter Creek.

A cover of Woodfordian windblown silt, or loess (pronounced "luss"), covers the bedrock and glacial drift in Jersey and neighboring counties. These fine-grained dust deposits are mainly of Wisconsinan age and are more than 25 feet thick near the park, but they thin to less than 8 feet in eastern Jersey County. The fertile soils in the field trip area have developed in the loess and the alluvial fill of the stream valleys.

Stratigraphy

The geologic column in figure 1 shows the succession of sedimentary rock strata, about 3,400 to 4,000 feet thick, that a drill bit might encounter in the field trip area. Here, these bedrock strata range in age from about 490 million years old, the Ordovician Period, to about 300 million

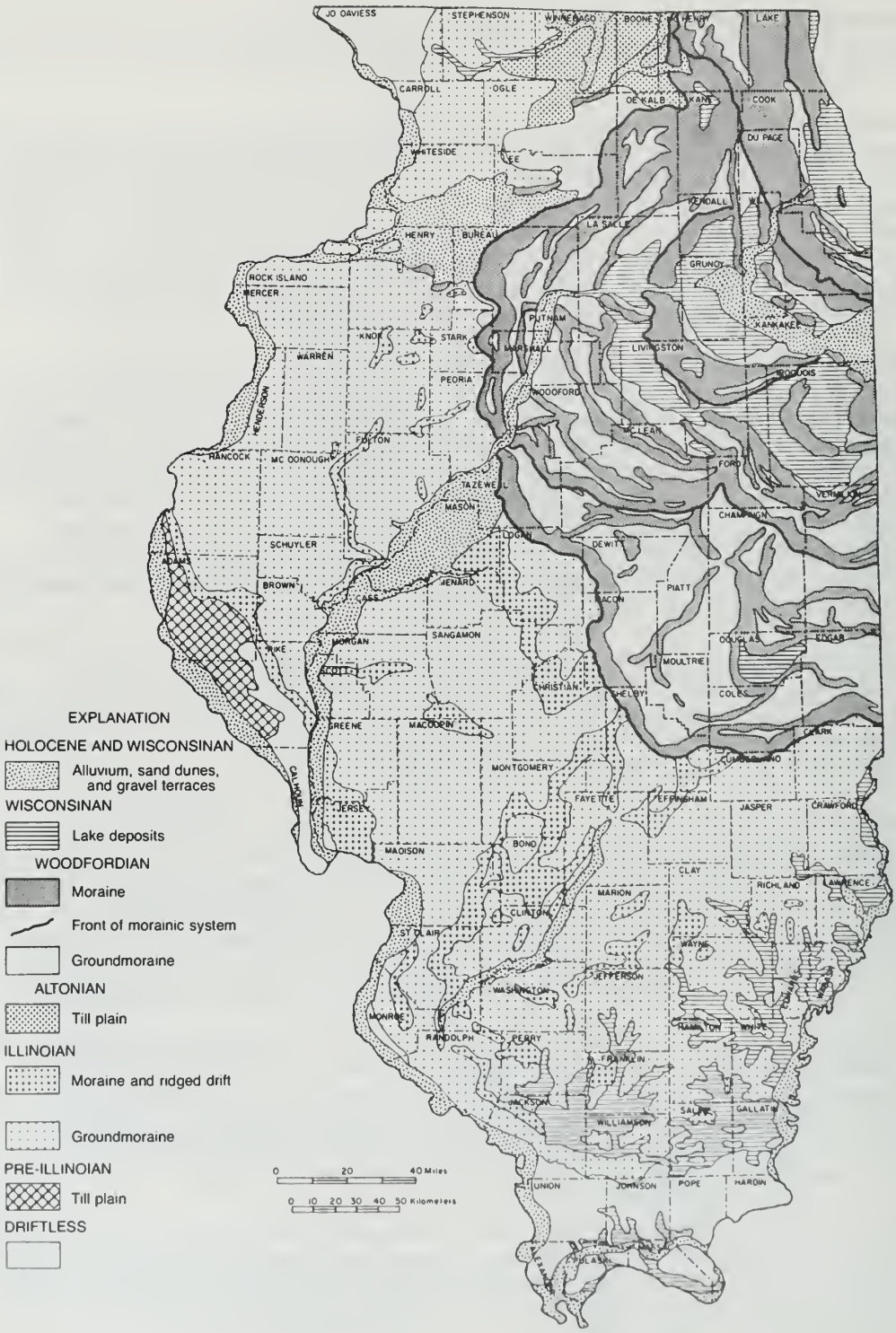


Figure 6 Generalized map of glacial deposits in Illinois (modified from Willman and Frye 1970).

years old, the Pennsylvanian Period. The oldest rocks that you might see at the surface on this field trip are Ordovician in age. Younger strata of Silurian, Devonian, Mississippian, and Pennsylvanian ages (fig. 1) underlie all or parts of Jersey County and also occur at the surface in places.

Pennsylvanian bedrock strata occur only in the northeastern part of the field trip area. These rocks consist of sandstone, siltstone, shale, limestone, coal, and underclay that were deposited as sediments in shallow seas and swamps about 330 to 300 million years ago. They are not exposed at the surface. However, in the eastern part of Jersey County about 10 miles east of Stop 1, Pennsylvanian strata are nearly 200 feet thick. A description of these rocks and their occurrence may be found in *Depositional History of the Pennsylvanian Rocks* (at the back of the guidebook).

STRUCTURAL FEATURES

Pere Marquette State Park is located in the central Mississippi Valley area where strata dip gently away from the Ozark Dome in southern Missouri to the east and northeast into the Illinois Basin (figs. 2 and 3). The Ozark Dome was a low-lying landmass during late Cambrian time and subsequently subsided and re-emerged at various times during the Paleozoic Era. It has remained a prominent landform from Pennsylvanian time.

To the north of the Ozark Dome, two other major positive structures, the Lincoln Anticline and the Mississippi River Arch, separate the Forest City Basin in northwestern Missouri and southwestern Iowa from the Illinois Basin on the east. The Mississippi River Arch is very broad and flat; it trends northward and extends generally along the Mississippi River between Illinois and Iowa. The Lincoln Anticline generally trends northwestward, roughly parallel to the Mississippi River in northeastern Missouri from the Missouri–Iowa boundary to Madison County, Illinois.

The southeastern end of the Lincoln Anticline curves sharply eastward into Calhoun County, Illinois, just to the west of the park; it has several smaller structures superimposed upon its gently sloped northern flank. The southern flank of the fold in Illinois forms the steeply inclined, faulted monocline known as the Cap au Grès Faulted Flexure (fig. 3).

The Cap au Grès Faulted Flexure derived its name from Cap au Grès bluff (French for sandstone headland) in western Calhoun County. It is a narrow zone of strata that dips up to 90° southward and is penetrated by discontinuous, vertical faults. According to Rubey (1952), the zone containing dips greater than 5° is about 1,000 to 1,475 feet wide. Strata ranging in age from Ordovician to Mississippian are exposed at the surface within this narrow, deformed zone. The structure extends east-southeastward for about 60 miles through Lincoln County in Missouri, and southern Calhoun, Jersey, and northwestern Madison Counties in Illinois. It dies out between Grafton and Alton beneath the broad alluvium-filled valley of the Mississippi River.

This flexure was recognized before 1870 and was originally thought to be a fault with a vertical displacement of 650 to 800 feet or more. Some later workers thought that most of the structure was a monocline. On the basis of his extensive field work in the area, Rubey ascribed the greater part of the structural relief to folding and indicated that faults are less important than previously thought. The extent and continuity of recognized faults are difficult to determine because of limited exposures and the scarcity of subsurface data. From calculations on the dips of strata, the distance between outcrops, and the thickness of a missing stratigraphic interval, Rubey determined whether the presence of a fault was necessary to explain apparent anomalies or whether folding would sufficiently explain the anomalies. He felt that faults account for no more than one-third of the total structural relief at any locality. However, where faults do occur, displacements of 5 to 450 feet have been observed. Although several theories have been proposed to explain the nature and origin of the structure, Rubey concluded that the Cap au Grès Faulted Flexure was caused by horizontal compressive forces acting within Earth's crust. The best exposures of the Cap au Grès Faulted Flexure are in a series of outcrops in Pere Marquette State Park along State Route (SR) 100; they will be discussed at Stop 5.

The Cap au Grès Faulted Flexure has undergone recurrent deformation throughout the Paleozoic Era and in later times. Major movement along the Cap au Grès structure occurred in middle or late Mississippian to early Pennsylvanian time. This movement is evidenced by an angular unconformity where the Pennsylvanian Spoon Formation (Desmoinesian Series) overlies steeply folded Mississippian St. Louis Limestone (Valmeyeran Series) and older strata (Rubey 1952). If younger Mississippian strata (the Ste. Genevieve Limestone and Chesterian-aged rocks) had been deposited across the area and been involved in the deformation, they were removed by erosion before the Pennsylvanian strata were deposited. This movement of the Cap au Grès Faulted Flexure is contemporaneous with other major tectonic events in the Eastern Interior Region and coincides with the Alleghenian and Ouachita orogenies along the eastern edge of the North American continent.

Later movements along the faulted flexure tilted Pennsylvanian strata. This left nearly 150 feet of the Pennsylvanian Spoon and Carbondale Formations preserved on the south side of the flexure and only patchy remnants of the two formations on the structurally high north side (Rubey 1952). Still more recent movement along the Cap au Grès Faulted Flexure occurred in the late Tertiary, coincident with or immediately following deposition of the Pliocene Grover Gravel onto the flat, post-Pennsylvanian erosional surface (Willman et al. 1975). The gravel is preserved on both the south and north sides of the flexure and has been displaced about 150 feet (Rubey 1952). This late Tertiary movement is reflected in the upland topography to the west in Calhoun County.

There is no evidence for movement along the flexure since the Tertiary. Saint Louis University, which has seismograph records from the downtown area since 1909, established a seismic network in 1962. On the basis of these monitoring capabilities, university seismologists have determined that the Cap au Grès Faulted Flexure is an area of "infrequent earthquakes" (R. Heinrich, personal communication, 1979).

GEOMORPHOLOGY

Several interesting geomorphological features in the field trip area are attributable to the Cap au Grès Faulted Flexure.

(1) The most dramatic feature is the abrupt change in direction of the courses of the Mississippi and Illinois Rivers. The two rivers flow generally south-southeast, forming the west and east boundaries of Calhoun County. Shortly after they cross the area of the flexure, they loop back counterclockwise and flow east-southeast as one river, the Mississippi. Here, they are parallel to and superimposed upon the Cap au Grès Faulted Flexure. About 5 miles (8 km) beyond Alton at Wood River, the Mississippi again curves southward. Because water follows the path of least resistance, it is reasonable to postulate that the courses of the Illinois and Mississippi Rivers followed the relatively weak zone of deformation along the Cap au Grès Faulted Flexure.

(2) The reflection of the Cap au Grès Faulted Flexure in the upland topography in Calhoun County has already been mentioned. You will be able to observe it from the shelter house at McAdams Peak, Pere Marquette State Park, at Stop 5G.

(3) A third feature is the cuspate nature of the bluffs on the north side of the Mississippi River about 2.5 to 6 miles east of Grafton, between Chautauqua and Lockhaven, where the Mississippian Burlington and Keokuk Limestones occur. The steep bluffs have been eroded in such a way that turret-like segments remain as protrusions, or cusps, whereas adjacent areas have been weathered back in a crescent shape. The areas that have receded are concave outward and have occasional zones that have been carved back so deeply that they form shallow caves. Travertine deposits have been found at one locality in the bluffs near Elsah. These features may have developed as subsurface solution cavities or caverns that were formed by groundwater moving through the jointed zone of the Cap au Grès Faulted Flexure before the Mississippi River eroded its valley and exposed them.

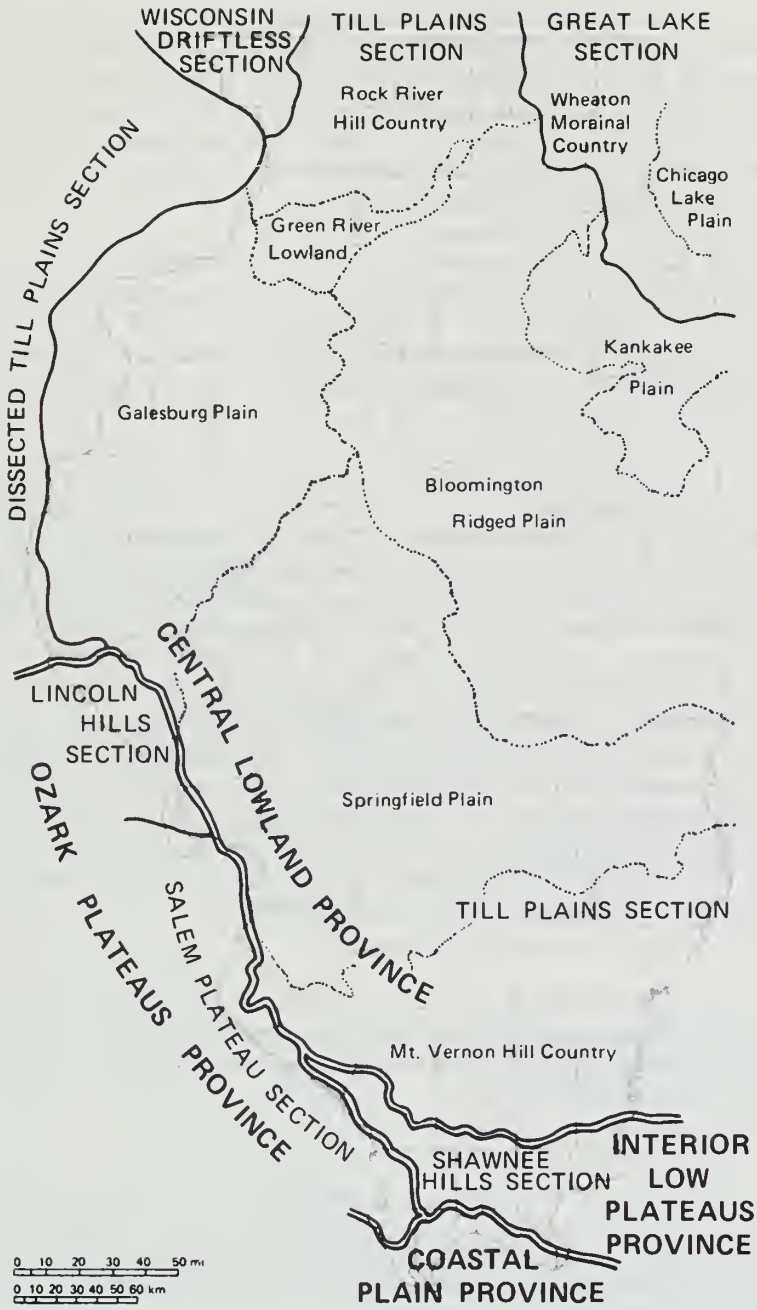


Figure 7 Physiographic divisions of Illinois (Leighton et al. 1948).

Physiographic Provinces

A physiographic province is a region in which the relief and landforms differ markedly from those in adjacent regions. The Pere Marquette field trip area is situated on the southwestern boundary of the Till Plains Section of the Central Lowlands Province with the Lincoln Hills and Salem Plateau Sections of the Ozark Plateaus Province (fig. 7). The present gross features of the Till Plains Section and the Ozark Plateaus are determined largely by their preglacial topography.

The Till Plains Section has seven divisions in Illinois and we encounter one of them on this field trip—the Springfield Plain. The Springfield Plain on the east and northeast part of the field trip area includes the outer portion of the level area of the Illinoian glacial drift. Although the plain generally is flat in this part of the state, in some areas its surface is gently undulating with modern shallowly entrenched drainage. Even though glacial deposits are somewhat thinner than in the area covered by younger glaciers, the surface topography is essentially the result of glacial deposition and subsequent erosion by streams.

The western edge of the field trip area is beyond the Illinoian drift border on the discontinuous older Ozark Plateaus upland, which represents the eastern edge of an extensive upland in southern Missouri and northern Arkansas. It includes the driftless and thinly drift-veneered cuestas (pronounced "kwestas"—asymmetric ridges with a steep slope on one side and a gentle slope on the other) on pre-Pennsylvanian rocks that are structurally and topographically a part of the Ozark Dome.

The Lincoln Hills Section includes the partially drift-covered dissected plateau above the junction of the Mississippi and Illinois Rivers. The principal physiographic feature in Illinois is a maturely dissected central ridge, which forms the watershed between the two major rivers throughout the length of the section. As noted previously, the eastern boundary follows the Illinoian drift border. The southern boundary with the Salem Plateau is drawn along the Cap au Grès flexure in southern Calhoun County. In Illinois, the upland central ridge is largely underlain by Mississippian Valmeyeran limestones, of which the Burlington Limestone is most important physiographically; its boundaries coincide quite closely with the Mississippian–Pennsylvanian contact. The southern part is known as the Calhoun County Driftless Area, except for loess deposits and a single high-channel filling of pre-Illinoian outwash gravel. Patchy remnants of pre-Illinoian drift are found in the northern part of the section. The plateau surface is rugged and broken by closely spaced valleys and ridges. Remnants of flat to gently rolling upland representing the Calhoun Peneplain are present along the ridge crest. The Mississippi and Illinois valleys are broad, deeply alluviated, terraced, and have precipitous walls. Most of the minor valleys are narrow, V-shaped, and have steep gradients.

Drainage

The field trip area is drained on the west and south by the Illinois and Mississippi Rivers and their tributaries. Only the lower portion of some of the largest tributaries have been somewhat widened by alluvial deposits. Most of the small tributaries, as noted previously, have narrow, V-shaped valleys with steep gradients.

Relief

The highest land surface on the field trip route is at Tucker Knob along the ridge road in Pere Marquette State Park east of the Visitors Center, where the crest of a loess hill (and Indian Mound?) is 892 feet mean sea level (msl) in elevation. The lowest elevation is approximately 419 feet msl in the pool above the Melvin Price Locks and Dam No. 26 across the Mississippi River at Alton. The surface relief of the field trip route, calculated as the difference between the highest and lowest elevations, is thus about 473 feet. Local relief near the bluffs can be as much as 400 feet within less than 1,000 feet horizontally and range from about 200 to 300 feet at the bluffs near Alton.

MINERAL RESOURCES

Mineral Production

Among the 102 counties of Illinois, Jersey County ranked 95th in 1989 for the total value of minerals extracted, with stone being the commodity extracted. However, the total production of stone is grouped with 14 other counties in District 4, where 28 companies have 33 operations. The total production of stone for this district was 11,953,000 tons valued at $43,851,000 (Samson and Bhagwat, in preparation).

Ninety-eight counties in Illinois reported mineral production during 1989, the most recent year for which complete records are now being published. The total value of all minerals extracted, processed, and manufactured in Illinois during 1989 was $2,842,900,000, an increase of some $35.3 million (1.2 percent) from 1988.

During 1989, the value of minerals extracted in Illinois was $2,550,900,000, an increase of 2.4 percent from 1988. Mineral fuels (coal, crude oil, and natural gas) made up 81.5 percent of the total. Illinois ranked 17th among the 50 states in total production of nonfuel minerals, but continued to lead all other states in production of fluorspar, industrial sand, and tripoli.

Water Supply

Surface water The Illinois and Mississippi Rivers are the principal sources of surface water in Jersey County. Despite the vast quantities of water available from these rivers, there has been relatively little withdrawn for use by cities, farms, and industries in western Illinois. Most of the direct and indirect use of water by people in the area comes from the large reservoir of water stored in the ground.

Groundwater Most of us generally do not think of groundwater as a mineral resource in assessing the natural resource potential of an area. Yet, the availability of groundwater is essential for orderly economic and community development. More than 48 percent of the state's 11 million citizens depend on groundwater for their water supply.

The source of groundwater in Illinois is precipitation that infiltrates the soil and percolates downward into the groundwater system, which lies below the water table in the zone of saturation. Groundwater is stored in and transmitted through saturated earth materials called *aquifers*. An aquifer is a body of saturated earth materials of variable thickness that will yield sufficient water to serve as a water supply for some use. The pores and other empty spaces in the earth materials must be permeable, that is, they must be large enough and interconnected so that water can overcome confining friction and move readily toward a point of discharge, such as a well, spring, or seep. Generally, the water-yielding capacity of an aquifer can be evaluated by constructing wells into it. The wells are then pumped to determine the quantity and quality of groundwater available for use.

Because geologic conditions differ from place to place, groundwater is readily available in some areas and extremely difficult to obtain in others. The variability of groundwater conditions in this area is shown in figure 8. Bergstrom and Zeizel (1957) reported that water-yielding sand and gravel deposits suitable for drilled wells are found mainly in the Illinois River valley and locally in Otter and Macoupin Creeks. Sand is commonly encountered below 30 feet in the Illinois Valley, and coarse sand usually below 50 feet.

Many farm wells in the eastern half of Jersey County obtain small supplies of groundwater from fractures in Pennsylvanian shales within a depth of 180 feet (fig. 8). In wells drilled into underlying Mississippian limestones, the Pennsylvanian rocks are commonly cased off to prevent caving of the shales.

The Keokuk–Burlington Limestone is the source of private groundwater supplies in much of the county, with wells ranging in depth from less than 50 feet in some of the hollows east of the confluence of the Illinois and Mississippi Rivers to more than 350 feet on the upland east of Jerseyville. At shallower depths in the eastern two-thirds of the county, the St. Louis–Salem Limestone is sufficiently thick and creviced locally to yield water for farm wells.

Devonian–Silurian rocks, which are extensively exposed along the Illinois River bluffs above the confluence with the Mississippi in the southwestern part of the county, locally yield water. The Kimmswick–Joachim rocks, which occur about 150 feet below the base of the Silurian rocks in the same area, commonly contain water unsuitable for domestic use.

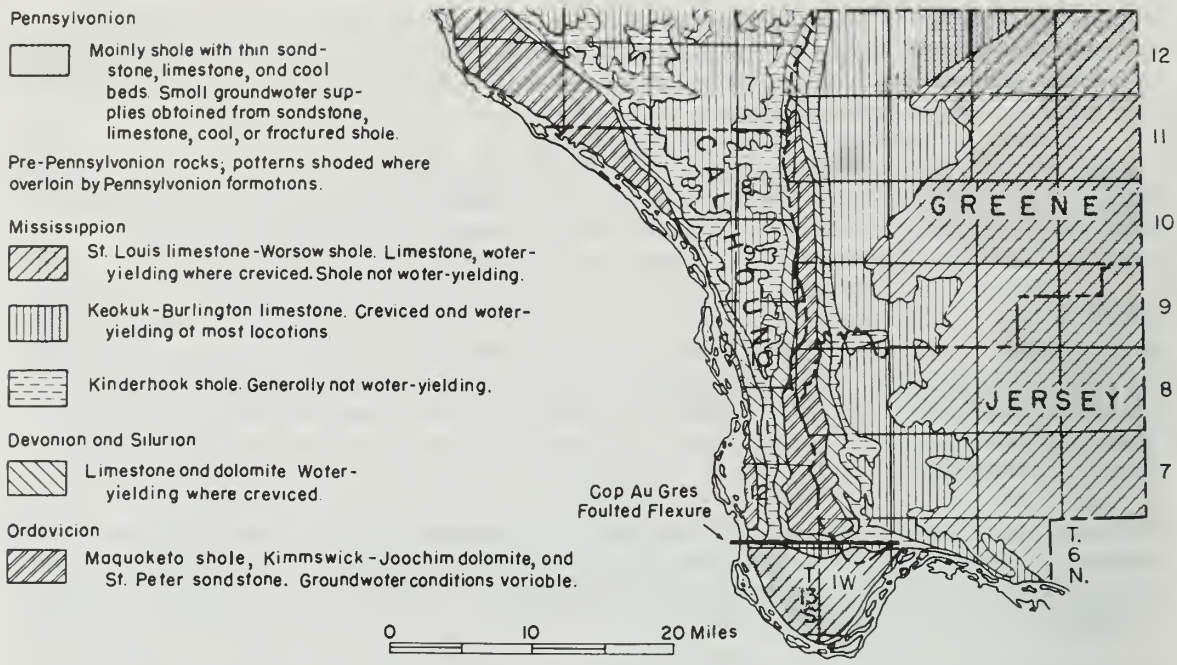
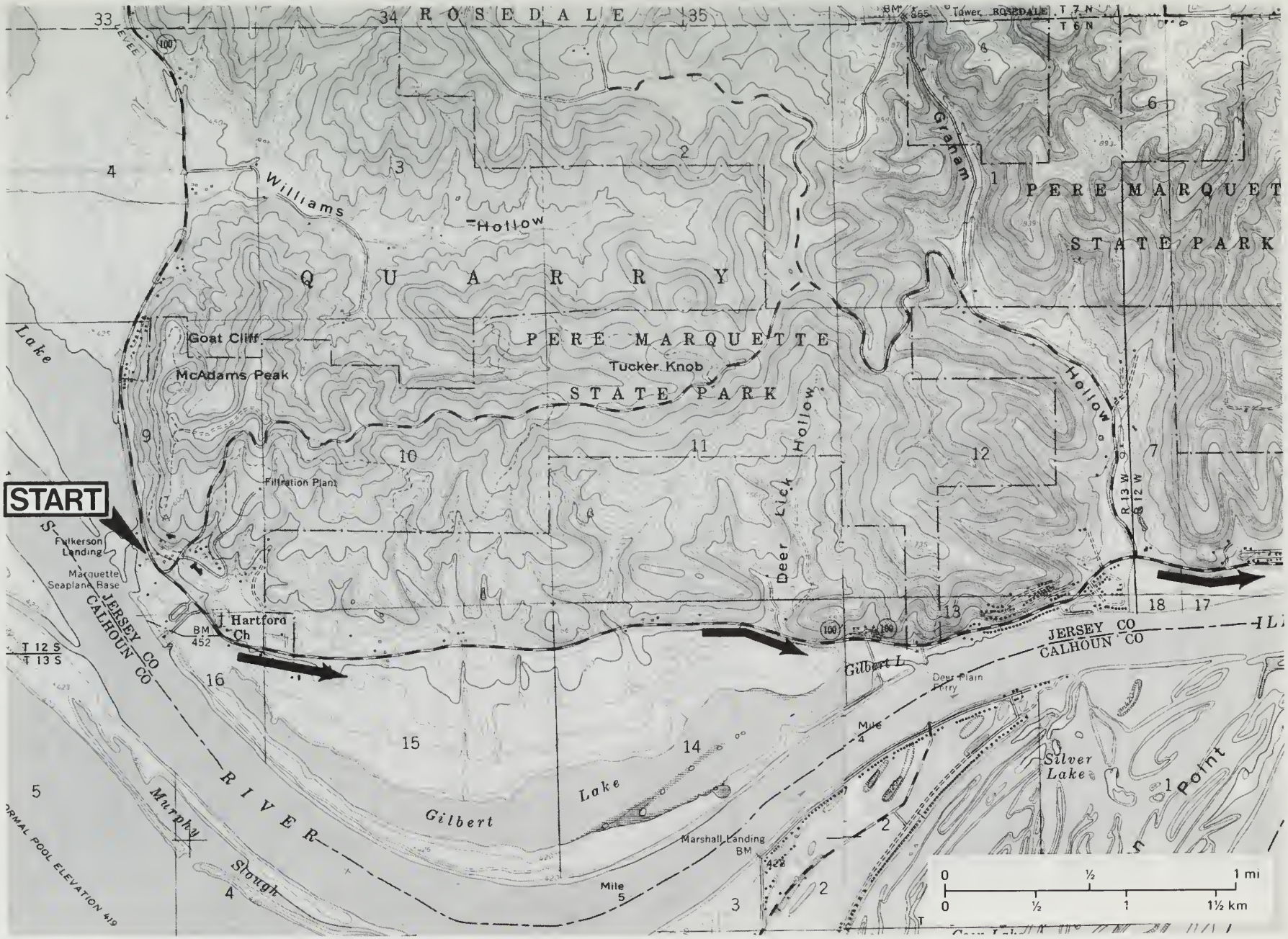


Figure 8 Areal distribution, type, and water-yielding character of upper bedrock formations (modified from Willman et al. 1967).

Groundwater from bedrock frequently is considerably more mineralized (salty) and is not considered as important a source as is the supply from unconsolidated deposits. Although it is not generally used, some of the moderately mineralized water from bedrock aquifers can be given to livestock when more desirable quality water is in short supply.

Information on the distribution of earth materials and the contained groundwater is constantly upgraded as new data are collected and compiled from drillers logs, test borings, and geophysical studies conducted by the Illinois State Geological Survey.


START
ROSEDALE
Tower
T 7 N
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PERE MARQUETTE
STATE PARK
Graham
Hollow
Williams
Hollow
QUARRY
PERE MARQUETTE
STATE PARK
Goat Cliff
McAdams Peak
Tucker Knob
Deer Lick
Hollow
Hollow
Filtration Plant
Fulkerson Landing
Marquette Seaplane Base
Hartford Ch
BM 452
JERSEY CO
CALHOUN CO
T 12 S
T 13 S
R 13 W
R 12 W
Gilbert L
Deer Plain Ferry
Mile 4
Silver Lake
Point
Lake
Gilbert
Murphy Slough
RIVER
Marshall Landing
BM 429
Mile 5
NORMAL POOL ELEVATION 419
0 ½ 1 mi
0 ½ 1 1½ km

GUIDE TO THE ROUTE

Assemble in the parking lot of the Visitors Center, the first entrance north of the main entrance to the lodge on SR 100, Pere Marquette State Park (NE NW SW SE Sec. 9, T6N, R13W, 3rd P.M., Jersey County, Brussels 7.5-Minute Quadrangle [38090H5]*).

You must travel in the caravan. Please drive with your headlights on while in the caravan. Drive safely but stay close to the car in front of you. Please obey all traffic signs unless the road crossing is protected by an emergency vehicle with flashing lights and flags. When we stop, park close to the car in front and turn off your lights.

Some stops on the field trip are on private property. The owners have graciously given us permission to visit their lands 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, 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 plan to use this booklet for a field trip with your students, youth group, or family, because of trespass laws and liability constraints, you *must* get permission from property owners or their agents before entering private property.

Miles to next point	Miles from start	
0.0	0.0	STOP: 1-way at exit from Visitors Center parking lot and SR 100. CAUTION: fast traffic. The highway curve limits your visibility from both directions. TURN LEFT (southeast). NOTE: you will pass some very interesting bedrock exposures between the park and Stop 1. Because of highway widening, most parking along the roadway has become almost nonexistent. So we will be unable to stop at these exposures as a group. Later, you may wish to retrace part of the route, find parking for your own vehicle, and hike to the exposures for a closer look at the rocks.
0.05+	0.05+	To the left is the entrance to Pere Marquette State Park and the Lodge.
0.05	0.1+	To the left, the Lodge sits on the Pleistocene Brussels Terrace at an elevation of about 470 feet mean sea level (msl). SR 100 crosses the lower, younger Deer Plain Terrace at an elevation of about 435 feet msl.
0.45+	0.6	Entrance to Pere Marquette State Park Campground and Ranger's Office lies to the left. CONTINUE AHEAD (east).
0.2+	0.8+	The house about 450 feet to the left (north) of SR 100 is on the Brussels Terrace.
0.6+	1.45	Flat-lying Pennsylvanian Carbondale Formation shale and siltstone are exposed in the roadcut on the left. We are on the south side of the Cap au Grès Faulted Flexure here.

* The number in brackets [38090H5] after the topographic map name is the code assigned to that map as part of the National Mapping Program. The state is divided into 1° blocks of latitude and longitude. The first two numbers refer to the latitude of the southeast corner of the block; the next three numbers designate the longitude. The blocks are divided into sixty-four 7.5-minute quadrangles; the letter refers to the east-west row from the bottom, and the last digit refers to the north-south column from the right.

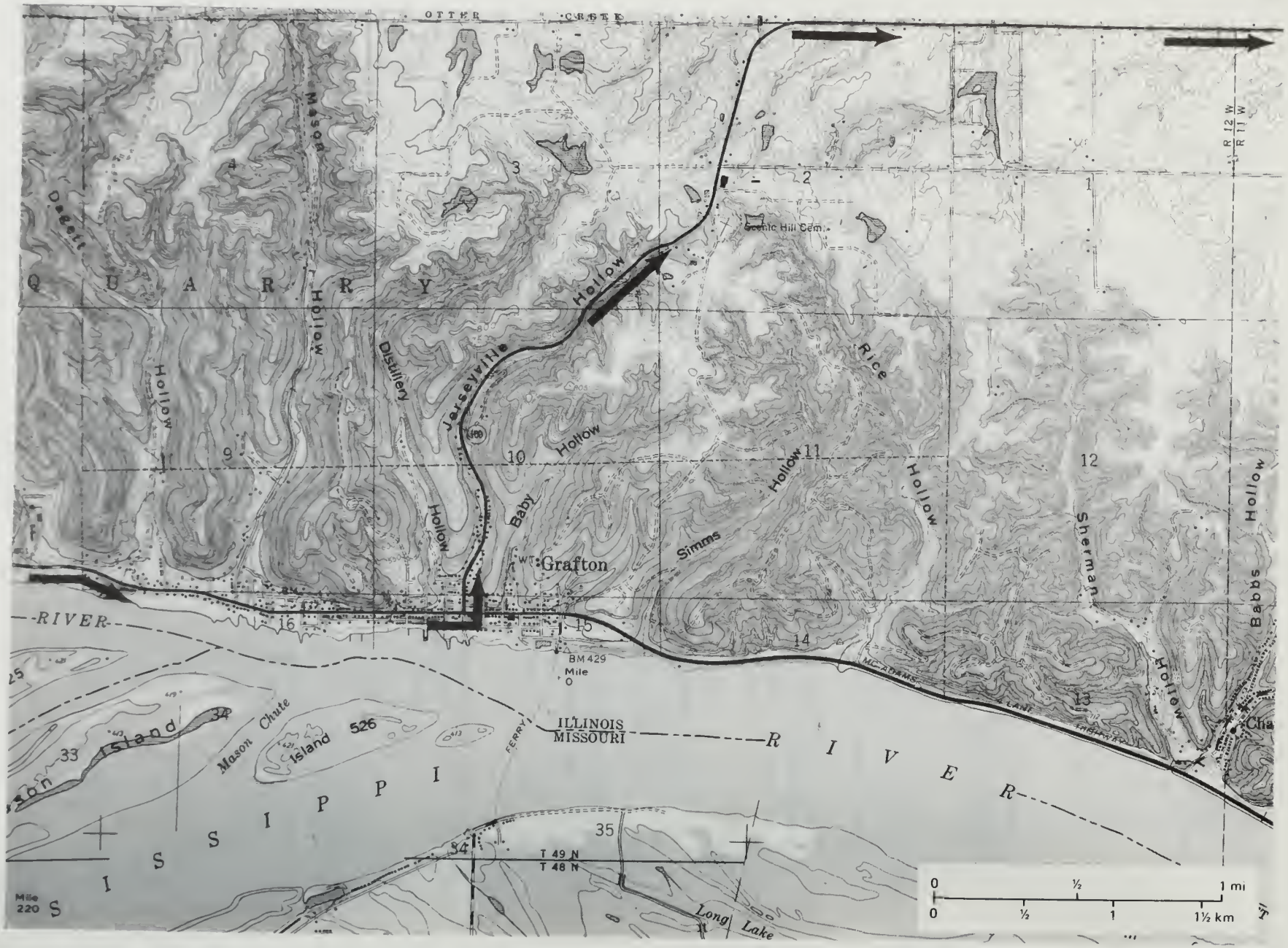
0.2	1.65	The Brussels Terrace (elevation ±460 feet msl) is well developed along SR 100 for about the next mile.
0.15	1.8	The old barn and the house ahead on the left are constructed of Silurian dolomite quarried in this area. Because the stone contains a small amount of iron carbonate, it weathers to a soft tan.
0.5	2.3	Cross Deer Lick Hollow. The rock strata rise nearly 900 feet stratigraphically in the next 0.75 mile from our position on the flank of the Cap au Grès structure. Rubey (1952) reports that a group of small transverse faults has broken directly across the Cap au Grès structure. Rocks on the west side of the valley are offset so that they crop out about 200 feet farther north and somewhat higher than those on the east side. The large strike fault that cuts the flexure is offset about 300 feet horizontally, and the rocks immediately south of it and west of the transverse fault group are overturned so that they dip about 60°NNE.
0.05+	2.35+	To the left is the oolitic Mississippian Ste. Genevieve Limestone that is dipping southward at 40° to 45°. We are now slightly south of the crest of the Cap au Grès Faulted Flexure. The strike (direction a bed takes as it intersects the horizontal) of Mississippian strata, which crop out along the left side of SR 100 for the next 0.7 mile, ranges from N70°W to N85°W with dips ranging from 22°S to 75°S.
0.25+	2.65	To the left, the cut for the bike path some 40 feet above SR 100 has exposed Mississippian Burlington Limestone. These are the easternmost exposures of the steeply dipping beds of the Cap au Grès Faulted Flexure. Strata strike N78°W and dip 68°S. According to Collinson (1957), the Burlington is about 100 feet lower topographically than the base of the flat-lying Silurian about 500 farther north, but it is 300 feet higher stratigraphically.
0.1	2.75	CAUTION: you are entering the congested area of the Brussels Ferry.
0.2	2.95	CAUTION: entrance to the free Brussels Ferry to Calhoun County lies to the right. CONTINUE AHEAD (east).
0.45+	3.4+	The entrance to the former River Science Center, operated by the Illinois State Natural History Survey, is to the right.
0.15+	3.6+	T-road from the left is from Graham Hollow. The ridge road in Pere Marquette State Park ends a short distance to the north.
0.25	3.85+	To the left, the road swings around a large slump block of Silurian dolomite several hundred feet long and 60 to 80 feet thick. The block has pulled away from the joint-faced cliff behind it (lubricated by the underlying Maquoketa shale) and rotated so that it dips back 40°N to 55°N. Silurian Edgewood Dolomite is exposed in the slump block beneath the fence, Kankakee Dolomite in the lower third above the fence, Joliet Formation in the upper two-thirds, and 1 or 2 feet of Devonian Cedar Valley Limestone at the top.
0.3	4.15+	The Maquoketa shale underlies the slope in front of the Silurian bluffs 800 feet to the left (north). The crest of the Lincoln Anticline plunges to the east.

0.25	4.4+	The large stone cross to the left commemorates the first recorded entrance of white men, Louis Joliet and Father Jacques Marquette, into present-day Illinois. They had explored the Mississippi from Wisconsin southward looking for a passage to the Pacific Ocean. They turned back at the Arkansas River. On their return upstream in September of 1673, they camped near here after having entered the Illinois River Valley. Father Marquette noted these facts in his journal of the trip.
0.15	4.6+	To the left is the entrance to the Illinois Youth Center Corrections Division, Grafton facility.
0.1+	4.75	Silurian dolomite occurs in the lower cliff to the left (north). The upper cliff is mainly Mississippian Chouteau Limestone with the Meppen Limestone in the reentrant near the top and nearly 30 feet of Burlington Limestone at the top.
0.05	4.8	CAUTION: enter Grafton, known by local Indian tribes as "the gathering of the waters." In Grafton, you will notice that many of the buildings and chimneys are constructed of the Silurian dolomite, which weathers tan.
0.4+	5.2+	The Mississippian rocks exposed at mileage 4.75 are exposed again in the cliff about 250 feet to the left, but the Burlington Limestone appears to be fairly thin.
0.1	5.3+	The mouth of Mason Hollow lies to the left.
0.15+	5.5+	The lower cliff, nearly 400 feet to the left behind the stone church, is Silurian dolomite separated from the upper cliff of Chouteau Limestone by a slope developed on the lower Mississippian Hannibal Shale.
0.3	5.8	The 30 foot high cliff of Silurian dolomite, with the Kankakee Dolomite at road level, dips very slightly to the south because this exposure is about 300 feet south of the crest of the Lincoln Anticline.
0.05+	5.9	The Grafton Grade School is to the left.
0.1+	6.0+	The house on the left has a garden wall and rock garden made of geodes from the Mississippian Warsaw Shale.
0.1	6.1+	STOP: 4-way at SR 3 Junction. TURN LEFT (north) on SR 3.
0.1+	6.25+	The road curves right (northeast) and begins its ascent of Jerseyville Hollow, one of the longest and finest geologic sections in this part of the state. Exposures are essentially continuous so that a complete section from lower Silurian Edgewood dolomite up through Mississippian middle Burlington Limestone can be studied. Some of the Silurian section is repeated in the lower part of the hollow because of faulting. The following section is exposed (from the top downward):

	feet
Mississippian System	
Valmeyeran Series	
Burlington Limestone	45
Fern Glen Limestone	20
Meppen Limestone	7

Kinderhookian Series	
Chouteau Limestone	50
Hannibal Shale	25
"Glen Park" Formation	1
Devonian System	
Upper Devonian Series	
Sylamore Sandstone	1/3
Middle Devonian Series	
Cedar Valley Limestone	5
Silurian System	
Niagaran Series	
Joliet Dolomite	57
Alexandrian Series	
Kankakee Dolomite	28
Edgewood Dolomite	20
Ordovician System	
Cincinnatian Series	
Maquoketa Formation (from shallow dug well)	
Total	258 1/3

0.3+	6.55+	Small abandoned roadside quarry in Silurian Edgewood Dolomite lies on the right.
0.75+	7.3+	Small cave in Hannibal Shale beneath 30 feet of exposed Chouteau Limestone can be observed across the stream to the right.
0.1+	7.45	Chouteau Limestone is well exposed in the roadcut on the right.
0.2	7.65	Cherty Burlington Limestone (tan) overlies Chouteau (gray). Burlington occurs on both sides of the road for the next 0.2 mile.
0.95	8.6	Curve right (east): Otterville T-road intersects to the left on the curve. CONTINUE AHEAD.
2.4+	11.0	Elsah T-road intersects from the right. CONTINUE AHEAD (east). Note the gently rolling upland here. Bedrock is mantled with a thin veneer of Illinoian glacial drift beneath Wisconsinan loess.
1.6+	12.65	Salem Limestone is exposed in both sides of the roadcut.
0.05	12.7+	Cross Mill Creek. Warsaw Shale is exposed near the creek bottom.
0.05+	12.8+	Crossroad, called Newbern to the left and Cemetery Road to the right. CONTINUE AHEAD (east).
1.3+	14.1+	STOP: 1-way at T-junction with SR 109. TURN LEFT (north) on SR 109.
0.9	15.0+	Prepare to turn left. Note the large hills ahead to the right and left.
0.1	15.1+	TURN LEFT (west) at Dow crossroad (600N/1600E).
0.3	15.4+	Begin ascent of glacial hill.


OTTER CREEK
Q U A R R Y
Mason Hollow
Desert Hollow
Distillery Hollow
Jerseyville
Hollow
Baby Hollow
Rice Hollow
Simms Hollow
Sherman Hollow
Babbs Hollow
Scenic Hill Cem.
Grafton
RIVER
BM 429
Mile 0
ILLINOIS
MISSOURI
R I V E R
Mason Island
Mason Chute Island 526
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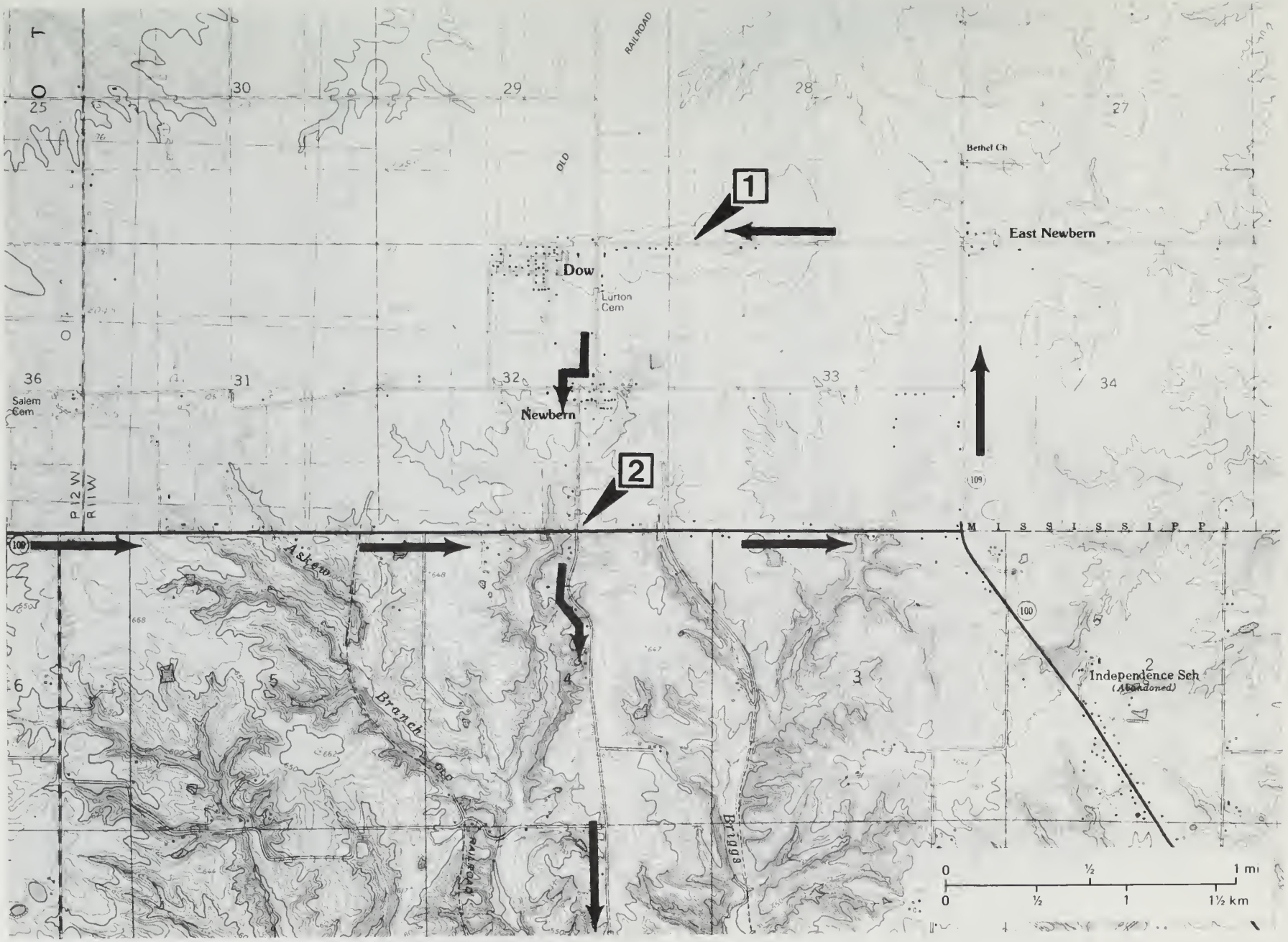
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0.45	15.85+	Telephone transmission tower stands to the right near the crest of the hill. To the left is the large water tank of the Jersey County Rural Water Company.
0.15	16.05	PARK along the roadway. Please do not block the road as visibility is somewhat restricted from the east.

STOP 1 We'll discuss the glacial features of the field trip area (S edge of SE SW SW SW Sec. 28, T7N, R11W, 3rd P.M., Jersey County, Jerseyville South 7.5-Minute Quadrangle [39090A3]).

This hill, nearly 100 feet above the surrounding area, provides an excellent view of the countryside and the opportunity to see similar hills to the north. All may be part of an old Illinoian end moraine. The combined thickness of drift and loess in this hill is nearly 100 feet. Near the river bluffs to the south and southwest, till has not been identified; but as noted earlier, the loess is thick. The Illinoian glacial margin appears to have been about 8 or 9 miles to the west and perhaps 6 miles to the south.

The hill and the immediate vicinity are underlain by the Pennsylvanian Colchester Coal Member. Pennsylvanian strata extend north and east from here. These rocks were eroded away between here and where the strata are exposed along SR 100 near the state park. The erosion probably occurred long before glaciers advanced across the area. Overlying coals have been mined north and east of this location in the past.

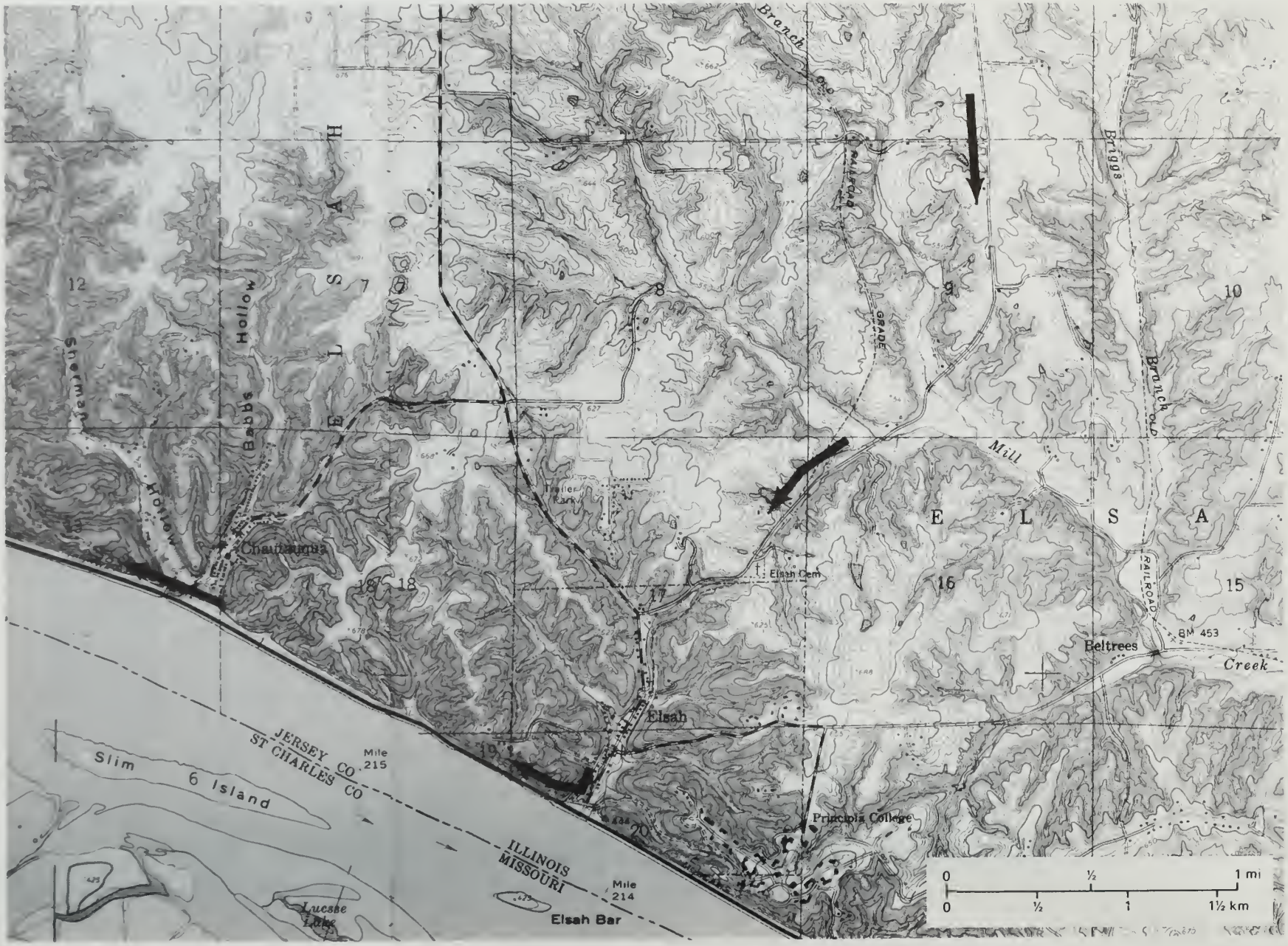
0.0	16.05	Leave Stop 1 and CONTINUE AHEAD (west).
0.35	16.4	TURN LEFT (south) at the crossroad (600N/1470E) west of the church. This is the east side of the community of Dow.
0.5	16.9	STOP: 4-way at Joe Knight Road (550N/1470E) in Newburn. TURN RIGHT (west).
0.05+	16.95+	TURN LEFT (south) at T-intersection (550N/1465E).
0.45+	17.45	PARK along the road before reaching SR 3. Please do NOT block the driveway. CAUTION: walk south to SR 3 and then to the right (west) along the shoulder of the road to Mill Creek.

STOP 2 We'll examine and discuss the Mississippian Salem Limestone and Warsaw Shale in the roadcut and creek bank (SE SW SW SE Sec. 32, T7N, R11W; and NE NE NE NW Sec. 4, T6N, R11W, 3rd P.M., Jersey County, Elsah 7.5-Minute Quadrangle [38090H3]).

The Mississippian Salem Limestone exposed on both sides of the SR 3 roadcut on the west side of Mill Creek is the same stone quarried in western Indiana and used for building construction throughout the Midwest. The stone here is quite pure and 15 to 18 feet thick. This is probably the best Salem exposure in the Grafton area. Locally, cavities are filled with calcite.

Below the Salem, the Warsaw shale is exposed down to stream level. In western Illinois, this formation locally contains abundant geodes. Here the Warsaw contains geodes filled with a variety of minerals. Minerals reported from this locality include quartz, chalcedony, calcite, chalcopyrite, malachite, kaolinite, dolomite, and ankerite. Not enough specimens are available, though, for you to collect representatives of each mineral. The origin of these geodes is uncertain, but at least some geodes formed by mineral deposition in cavities left by fossils.

0.0	17.45	Leave Stop 2 and CONTINUE AHEAD (south).
0.05-	17.45+	STOP: 2-way at SR 3 (500N/1465E). CAUTION: FAST TRAFFIC. CONTINUE AHEAD (south) on Cemetery Road.
0.7	18.15+	Shallow sinkhole occurs to the right.
0.3	18.45+	T-road intersects from right. CONTINUE AHEAD (south).
0.5+	19.0+	Curve right (southwest) and descend hill.
0.35+	19.4+	Cross Mill Creek.
0.25	19.65+	Cross small stream.
0.2	19.85+	Cross the same small stream.
0.8	20.7+	STOP: 1-way at T-intersection with Elsah Road. TURN LEFT (south) and enter village of Elsah. This historic town began as a river town in the 1850s. Its 19th century charm has been well preserved. This is the first entire community to be listed on the National Register of Historic Places.
0.25+	20.95+	CAUTION: narrow bridge.
0.2+	21.2	Access road to the left leads to Principia College, a Christian Science liberal arts school with a beautiful campus overlooking the Missisippi River.
0.2+	21.4+	Bear right (southwest).
0.05+	21.45+	STOP: 1-way at intersection with SR 100, the McAdams Highway. TURN RIGHT (northwest). For 3 miles east and west of Elsah, the bluffs are predominatly Burlington Limestone. As discussed in the introduction, unusual erosion of the bluffs has produced projecting buttes or cusps and alternating hollows. Excellent exposures of Mississippian strata occur in the 1.5 miles of river bluff that separate Elsah and Chautauqua.
1.45+	22.95+	Entrance to the right leads to Chautauqua, a private community.
0.25	23.2	Chautauqua West geologic section (fig. 9). This location is special because a distinct angular unconformity occurs between the Kinderhookian Chouteau Limestone and overlying Valmeyeran Meppen Limestone. The Meppen attains its maximum thickness (20 feet) in Illinois here.
0.75	23.95	Rock slide area: the lower slope developed on the Hannibal Shale. The shale formed the slide plane down which a large segment of the overlying bluff slid after heavy rains in the spring of 1975. The bluff above the shale includes the Chouteau, Meppen, Fern Glen, and Burlington Formations. Large slabs of the Chouteau, which were involved in the collapse, are quite fossiliferous.
0.75+	24.7+	Abandoned quarry in Silurian dolomite on the right.


Branch
Briggs
Branch
Mill
Creek
RAILROAD
GRADE
RAILROAD
H A S T E E L S A
Hollow
Babbs
Sherman
Hollow
Chautauqua
Trailer Park
Elsah Cem
Elsah
Beltrees
BM 453
Principia College
JERSEY CO
ST CHARLES CO
Mile 215
Slim
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ILLINOIS
MISSOURI
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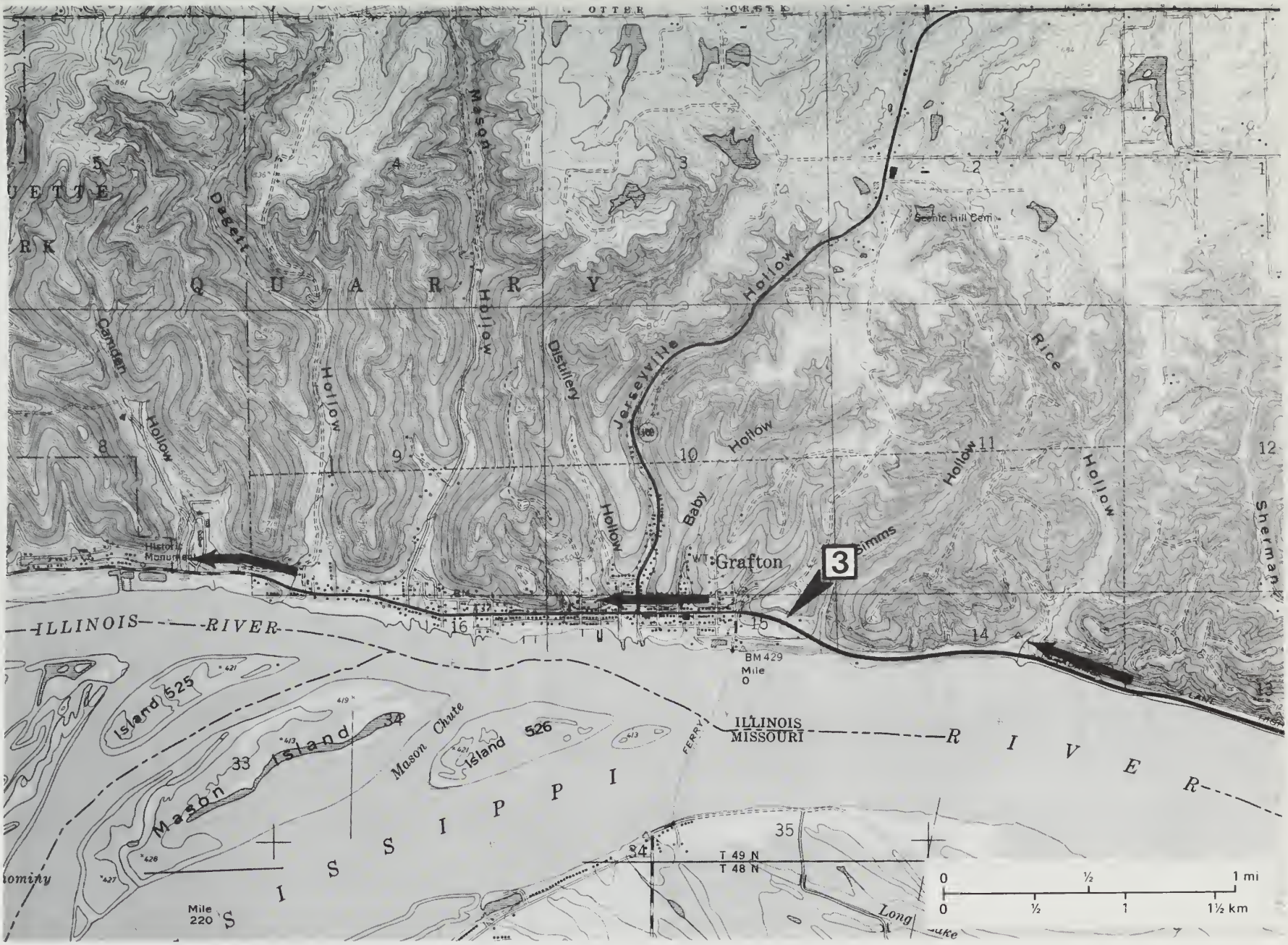
OTTER CREEK
Q U A R R Y
Mason
Degen Hollow
Camden Hollow
Hollow
Distillery
Jerseyville Hollow
Baby Hollow
Rice Hollow
Sherman
Scenic Hill Cem
Historic Monument
Grafton
Simms
3
ILLINOIS RIVER
BM 429
Mile 0
ILLINOIS
MISSOURI
R I V E R
Island 525
Island 34
Island 526
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Long Lake
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0 ½ 1 1½ km

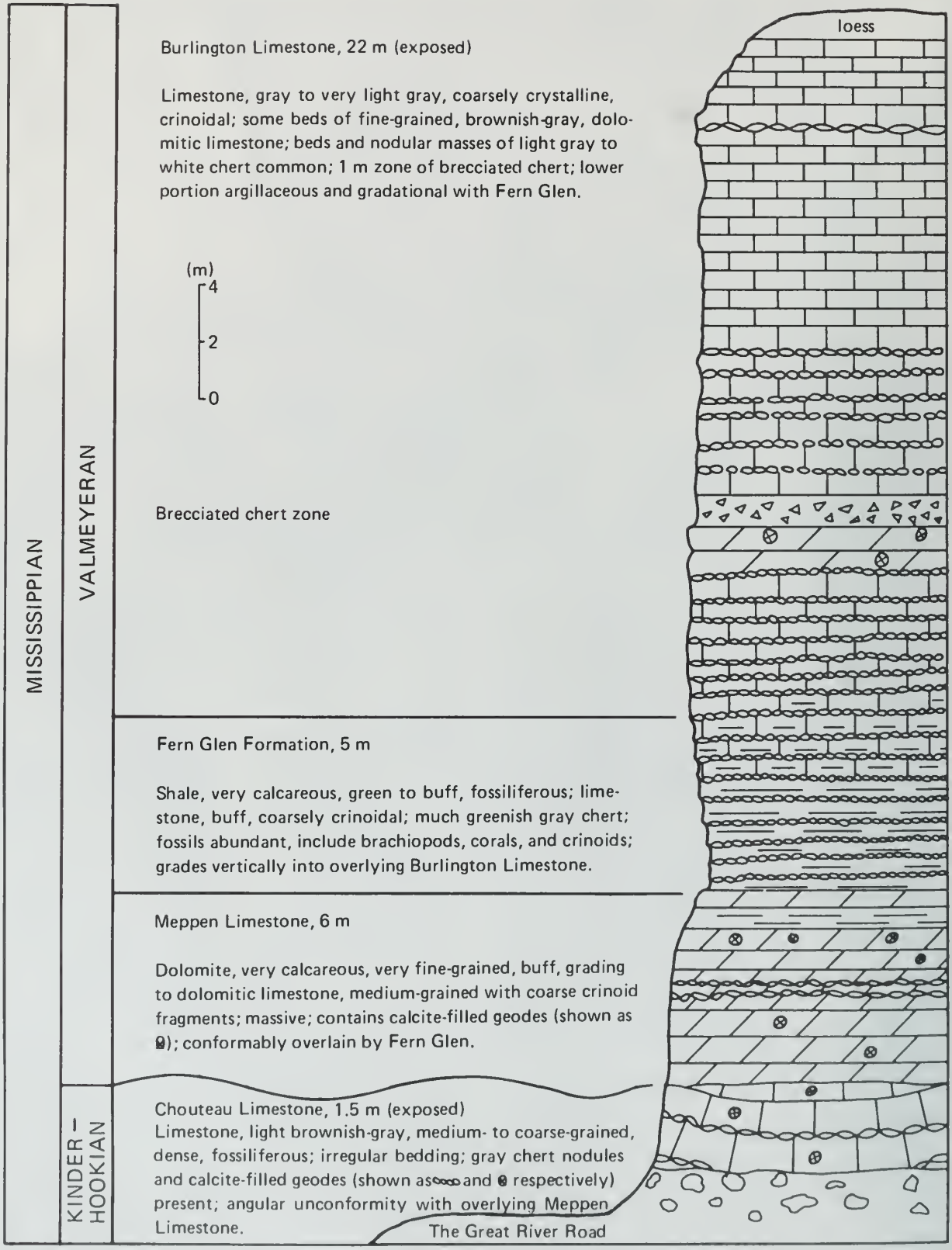


Figure 9 Chautauqua West, near mileage 23. NW¼ NE¼ SE¼ Sec. 13, T6N, R12W, Jersey County, Illinois (modified from Collinson et al. 1954).

0.15+	24.9	Simms Hollow lies to the right. Prepare to turn right.
0.05+	24.95+	CAUTION: TURN RIGHT and enter the abandoned quarry. PARK away from the face. Wear your hard hat and safety goggles, if you have them. ***Do not climb on the face.*** If you hammer on or near the face, ***check the rocks directly above you—they might be loose!***
		You must be careful here! Take charge of your youngsters.

STOP 3 We'll examine Silurian dolomite exposed in the quarry (entrance: SE NW NE NE Sec. 15, T6N, R12W, 3rd P.M., Jersey County, Grafton 7.5-Minute Quadrangle [38090H4]).

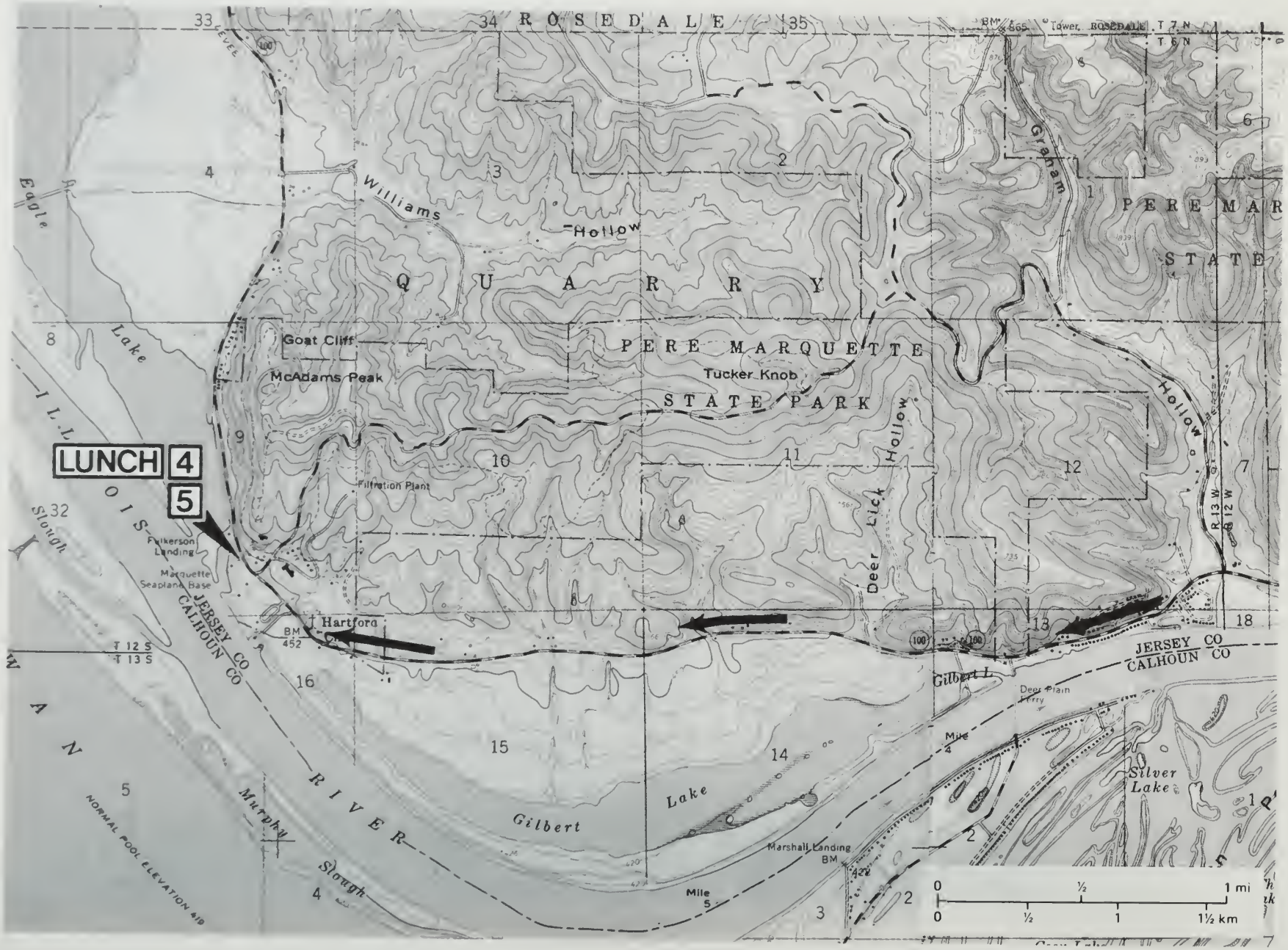
The Silurian dolomite, about 100 feet thick here, is an excellent building stone that was used in the construction of many local buildings. The stone is gray on fresh surfaces but weathers to a light tan. In this vicinity, the Silurian yields complete, well-preserved trilobites, mostly *Calymene*. In some places, the Devonian is present up to 5 to 10 feet at the top of the exposure, but it is inaccessible. (If you wish to see the Devonian, see the Jerseyville Hollow section at mileage 6.25+.)

Elsewhere in the Illinois Basin, reefs that formed in Silurian rocks have been studied by ISGS scientists (Whitaker 1988). Some reefs have been significant oil reservoirs and producers. Conditions for the formation of reefs were better about 40 miles east of the field trip area.

0.1	25.05+	Leave Stop 3. STOP: 1-way at SR 100. USE EXTREME CAUTION entering SR 100. The McAdams Highway narrows down to a 2-lane road here.
0.1+	25.2	CAUTION: enter Grafton.
0.35	25.55	STOP: 4-way at SR 3 Junction. CONTINUE AHEAD (west) on SR 100.
1.3+	26.85+	Leave Grafton.
1.15+	28.0+	T-road intersects from the right on the curve. This leads to the back entrance to Pere Marquette State Park. CONTINUE AHEAD.
0.65+	28.7+	To the left is the entrance to the Brussels Ferry. CONTINUE AHEAD.
2.85	31.55+	To the right is the main entrance to Pere Marquette State Park. CONTINUE AHEAD and prepare to TURN RIGHT.
0.1	31.65+	Entrance to the parking lot of the Visitors Center.

STOP 4 LUNCH at the tables outside the Visitors Center or at one of the other picnic areas close to SR 100. Please return to the parking lot in 1 hour.

Pere Marquette State Park is named for Father Jacques Marquette. The site, acquired in 1932, is now Illinois' largest state park with nearly 7,996 acres. In addition to the Visitors Center and Museum, there are many miles of hiking trails, bridle paths, campgrounds, and picnic areas. About 18 prehistoric Indian village sites and a few burial mounds lie within the park.


LUNCH 4
5
ROSEDALE
PERE MARQUETTE
STATE PARK
QUARRY
Goat Cliff
McAdams Peak
Tucker Knob
Williams Hollow
Graham Hollow
Deer Lick Hollow
Filtration Plant
Eagle Lake
Fulkerson Landing
Marquette Seaplane Base
Hartford
BM 452
JERSEY CO
CALHOUN CO
Gilbert Lake
Silver Lake
Marshall Landing
Mile 4
Mile 5
Murphy Slough
ILLINOIS RIVER
NORMAL POOL ELEVATION 419
0 ½ 1 mi
0 ½ 1 1½ km

STOP 5 In Pere Marquette State Park, you'll be free during the afternoon to take a walking tour at your own pace. Survey geologists will be available at special sites to discuss various features, such as the Ordovician, Silurian, Devonian, and Mississippian strata, Cap au Grès Faulted Flexure, and the landscape. Figure 10 shows how Stop 5 has been organized into a series of substops, 5A - 5I, and where the geologists are leading the discussions.

■ **5A: Trailside Museum** You may tour through the park museum, which houses collections of fossils, artifacts, plants, and animals from the park and surrounding area.

■ **5B - 5D: Pleistocene deposits and landforms** From the museum, you can look across to the lodge. Take note of stops 5B, 5C, and 5D (fig. 10).

The lodge sits on the Brussels terrace (Stop 5B), which slopes down in front of the lodge to the surface of the Deer Plain terrace (Stop 5C), crossed by the main highway. Just beyond, the terrain drops about 10 feet to the floodplain level (Stop 5D), which is largely inundated by backwater from the Melvin Price Locks and Dam at Alton.

Studies of the sedimentology and bathymetry (measuring water depth and charting bottom topography) of the Illinois and Mississippi Rivers were conducted in Pool 26 above the locks and dam at Alton by the Illinois State Water Survey, the Illinois State Geological Survey, and the Illinois State Natural History Survey in the early 1980s. The Surveys were examining the effects of boat traffic on habitats of the riverine ecosystem (Schnepper et al. 1981, Goodwin and Masters 1983).

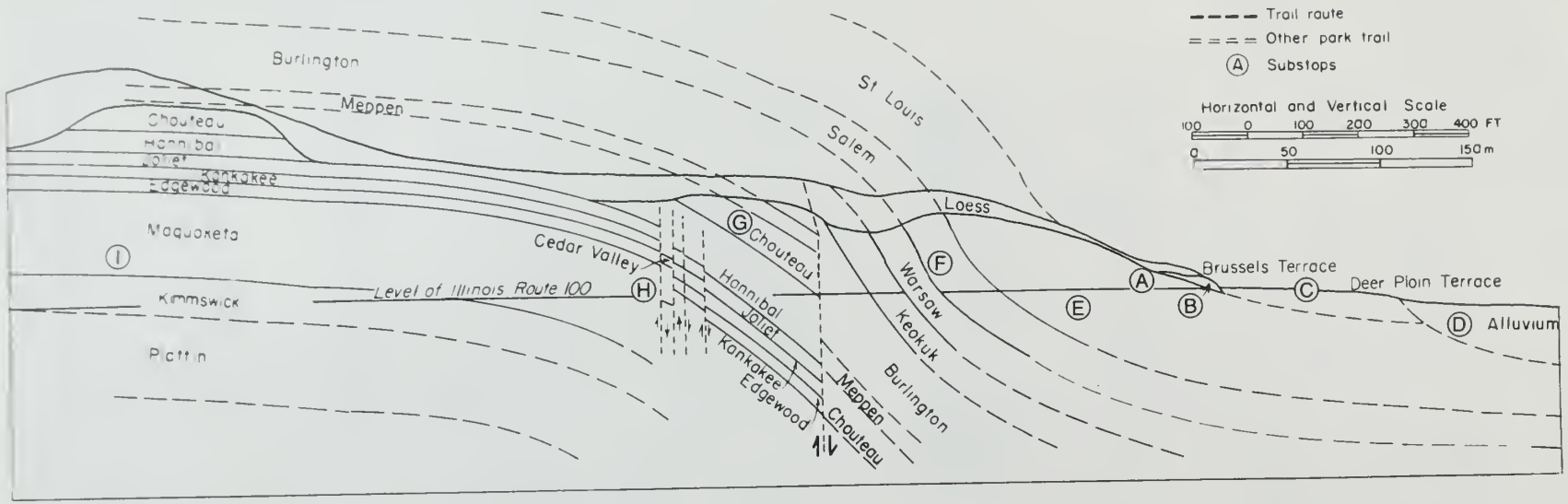
They found that, with few exceptions, bottom materials in the deeper parts of the channel, where it has been dredged for navigation, are mainly sand. In shallower parts of the channel bottom, silt is the major constituent of the sediments. Navigation traffic may contribute greatly to the relative lack of clay and silt in the deeper parts of the channels. Bottom-dwelling organisms such as clams, mussels, and worms (food source for fish, ducks, and early man) have difficulty living in a sandy habitat. Creating wetlands along the valley bottoms, as some government agencies are now doing, should improve bottom habitats outside the navigation channels. This in turn will provide a better environment for fish and waterfowl.

■ **5E: St. Louis Limestone breccia, upper St. Louis, and possible Ste. Genevieve strata** The trail ascends a series of steps past a nearly complete section of the main St. Louis breccia. The breccia, dipping 26°S, is composed mainly of angular fragments of fine-grained limestone that is slightly argillaceous and silty. Some fragments are partly rounded, so the deposit is called a conglomerate in some reports. The breccia is widely distributed from southeastern Iowa through western Illinois and northeastern Missouri.

Overlying the breccia, about 70 feet of limestone are exposed along the trail. Apparently, the beds above the breccia exhibit some type of cyclical deposition. The top 10 feet of the section consists of very sandy coarsely oolitic limestone that may be Ste. Genevieve or it may represent a St. Louis-Ste. Genevieve transition zone.

In a zone about 10 feet above the breccia, *Lithostrotion proliferum* and *Lithostrotionella castelnaui* are common, along with bryozoans and brachiopods. *Spirifer littoni* and *Dictyoclostus tenuicostus* have been identified from beds immediately above the breccia, and *Linoproductus ovatus* is common in the uppermost oolitic beds.

■ **5F: Salem Limestone and lower St. Louis** The Salem Limestone is represented in the section along this trail by a single long, narrow, rather steeply dipping outcrop of limestone on the promontory just south of the Warsaw re-entrant. The outcrop, which consists of rounded, broken fossil fragments and whole small fossils in a calcium carbonate matrix, extends to the



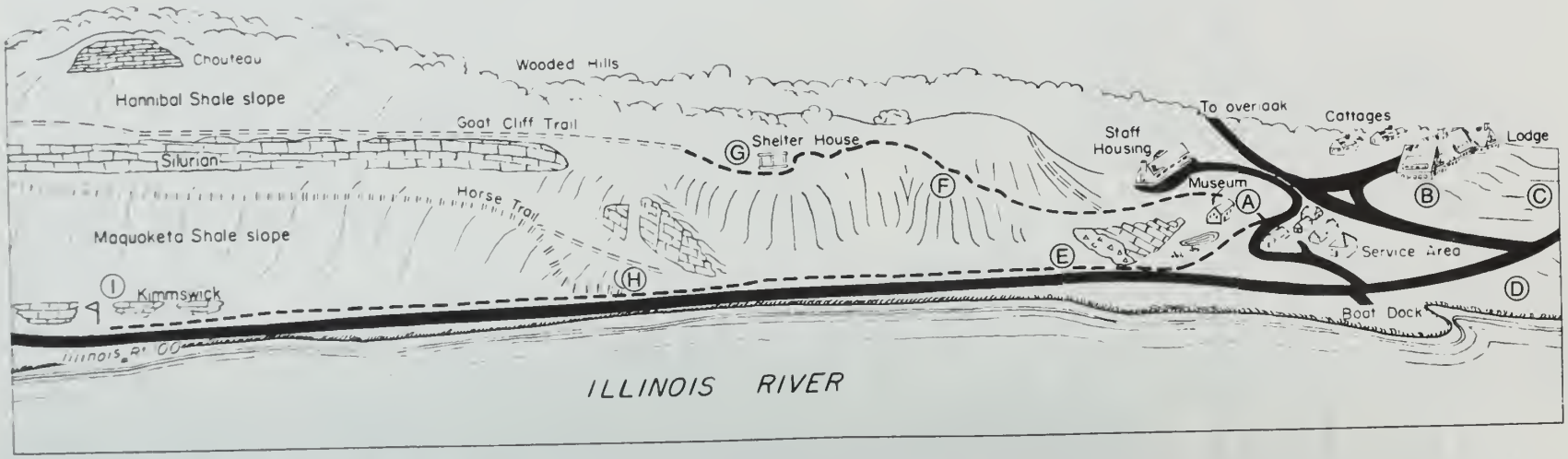


Figure 10 Stop 5, Pere Marquette State Park. Cross section (above) through Twin Springs showing Cap au Grès Faulted Flexure. Trail guide (below) to substops (modified from Rubey 1952, and Collinson et al. 1954).

base of the bluff, where it includes some oolitic limestone. Beyond the Salem ridge is a more prominent spur exposing the lower St. Louis limestone.

■ **5G: Shelter House at McAdams Peak—landforms** From this point, you can look directly west across the valley of the Illinois River toward peninsular Calhoun County, the crest of which rises about 400 feet above the river. On the far side of the river, the Deer Plain terrace of late Wisconsin age makes a low apron, about 1 mile wide, that slopes gently (15 to 20 feet per mile) away from the base of the bluffs. Above it lies the Brussels terrace of Illinoian age; it can be seen clearly behind the white barn in the middle of the large valley almost directly opposite us. The valley, Greenbay Hollow, developed in the crest of the Lincoln Anticline.

About 1 mile north of Greenbay Hollow, nestled at the base of the first bold cliffs your eyes encounter, is the village of Meppen for which the Mississippian Meppen Limestone is named.

The upland surface on both sides of the Illinois River in this region truncates the Lincoln Anticline and is interpreted as a peneplain (a low, nearly featureless, almost plane land surface formed through long, continued erosion) named the Calhoun peneplain by Rubey (1952, p. 102-104).

The steeply dipping beds of the Cap au Grès flexure, on which we're standing, cross the valley and transect the opposite bluffs in the small conical hill on the left (south) side of Greenbay Hollow. As we can see from this point, the upland surface of Calhoun County north of the structure is about 175 feet higher than on the south side.

■ **5H: Twin Springs, Silurian, Devonian, and Mississippian formations** The Silurian reaches road level at Twin Springs, striking approximately east-west and dipping about 28 degrees south. The Twin Springs outcrop is cut by at least five faults. The best-exposed fault planes also strike east-west, but dip north at about 65°, nearly perpendicular to the beds. The main face is slightly oblique to both bedding and faults. The minor faults are exposed and the throw of a couple of faults can be estimated visually from the obvious offsets. Drag on one of the faults can be seen best behind and above the balance boulder, as approached from the left along the ledge nearly halfway up the face. The planes of the two larger faults are not exposed. Determining their throw depends upon identifying the stratigraphy of the rocks on either side.

■ **5I: Kimmswick and Maquoketa (slumped)** The oldest rocks exposed in Pere Marquette Park belong to the middle Ordovician Kimmswick Formation, which crops out in three small exposures along Highway 100 at the base of the bluff. At Florissant 18 miles southeast, the formation produces oil at a depth of 1,000 feet. The Waterloo and Dupo production in Illinois just southeast of St. Louis is also from the Kimmswick Limestone.

End of the trip to Pere Marquette State Park.

We look forward to seeing you at Cave in Rock in Hardin County on April 25, 1992, and at Galena in Jo Daviess County on May 16, 1992.

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MISSISSIPPIAN DEPOSITION

(The following quotation is from Report of Investigations 216: Classification of Genevievian and Chesterian...Rocks of Illinois [1965] by D. H. Swann, pp. 11-16. One figure and short sections of the text are omitted.)

During the Mississippian Period, the Illinois Basin was a slowly subsiding region with a vague north-south structural axis. It was flanked by structurally neutral regions to the east and west, corresponding to the present Cincinnati and Ozark Arches. These neighboring elements contributed insignificant amounts of sedment to the basin. Instead, the basin was filled by locally precipitated carbonate and by mud and sand eroded from highland areas far to the northeast in the eastern part of the Canadian Shield and perhaps the northeastward extension of the Appalachians. This sediment was brought to the Illinois region by a major river system, which it will be convenient to call the Michigan River (fig. 4) because it crossed the present state of Michigan from north to south or northeast to southwest....

The Michigan River delivered much sediment to the Illinois region during early Mississippian time. However, an advance of the sea midway in the Mississippian Period prevented sand and mud from reaching the area during deposition of the St. Louis Limestone. Genevievian time began with the lowering of sea level and the alternating deposition of shallow-water carbonate and clastic units in a pattern that persisted throughout the rest of the Mississippian. About a fourth of the fill of the basin during the late Mississippian was carbonate, another fourth was sand, and the remainder was mud carried down by the Michigan River.

Thickness, facies, and crossbedding...indicate the existence of a regional slope to the southwest, perpendicular to the prevailing north 65° west trend of the shorelines. The Illinois Basin, although developing structurally during this time, was not an embayment of the interior sea. Indeed, the mouth of the Michigan River generally extended out into the sea as a bird-foot delta, and the shoreline across the basin area may have been convex more often than concave.

....The shoreline was not static. Its position oscillated through a range of perhaps 600 to 1000 or more miles. At times it was so far south that land conditions existed throughout the present area of the Illinois Basin. At other times it was so far north that there is no suggestion of near-shore environment in the sediments still preserved. This migration of the shoreline and of the accompanying sedimentation belts determined the composition and position of Genevievian and Chesterian rock bodies.

Lateral shifts in the course of the Michigan River also influenced the placement of the rock bodies. At times the river brought its load of sediment to the eastern edge of the basin, at times to the center, and at times to the western edge. This lateral shifting occurred within a range of about 200 miles. The Cincinnati and Ozark areas did not themselves provide sediments, but, rather, the Michigan River tended to avoid those relatively positive areas in favor of the down-warped basin axis.

Sedimentation belts during this time were not symmetrical with respect to the mouth of the Michigan River. They were distorted by the position of the river relative to the Ozark and Cincinnati shoal areas, but of greater importance was sea current or drift to the northwest. This carried off most of the mud contributed by the river, narrowing the shale belt east of the river mouth and broadening it west

of the mouth. Facies and isopach maps of individual units show several times as much shale west of the locus of sand deposition as east of it. The facies maps of the entire Chesterian...show maximum sandstone deposition in a northeast-southwest belt that bisects the basin. The total thickness of limestone is greatest along the southern border of the basin and is relatively constant along that entire border. The proportion of limestone, however, is much higher at the eastern end than along the rest of the southern border, because little mud was carried southeastward against the prevailing sea current. Instead, the mud was carried to the northwest and the highest proportion of shale is found in the northwestern part of the basin.

Genevievian and Chesterian seas generally extended from the Illinois Basin eastward across the Cincinnati Shoal area and the Appalachian Basin. Little terrigeneous sediment reached the Cincinnati Shoal area from either the west or the east, and the section consists of thin limestone units representing all or most of the major cycles. The proportion of inorganically precipitated limestone is relatively high and the waters over the shoal area were commonly hypersaline... Erosion of the shoal area at times is indicated by the presence of conodonts eroded from the St. Louis Limestone and redeposited in the lower part of the Gasper Limestone at the southeast corner of the Illinois Basin...

The shoal area included regions somewhat east of the present Cincinnati axis and extended from Ohio, and probably southeastern Indiana, through central and east-central Kentucky and Tennessee into Alabama....

Toward the west, the seaway was commonly continuous between the Illinois Basin and central Iowa, although only the record of Genevievian and earliest Chesterian is still preserved. The seas generally extended from the Illinois and Black Warrior regions into the Arkansas Valley region, and the presence of Chesterian outliers high in the Ozarks indicates that at times the Ozark area was covered. Although the sea was continuous into the Ouachita region, detailed correlation of the Illinois sediments with the geosynclinal deposits of this area is difficult.

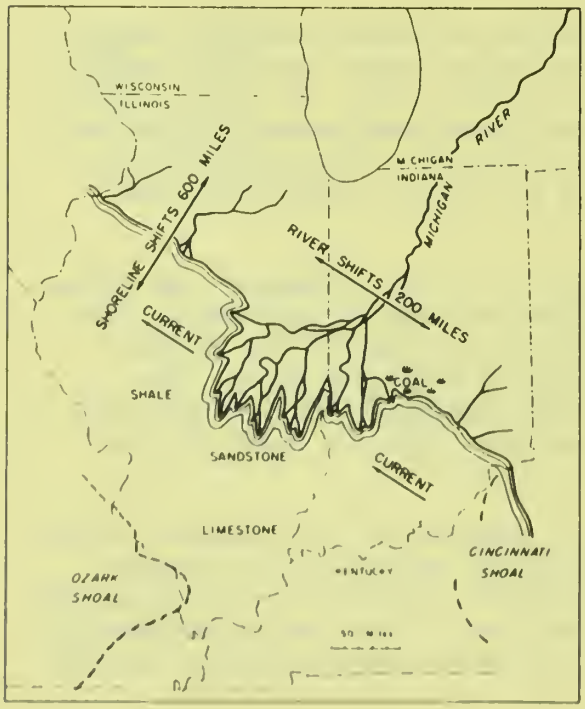
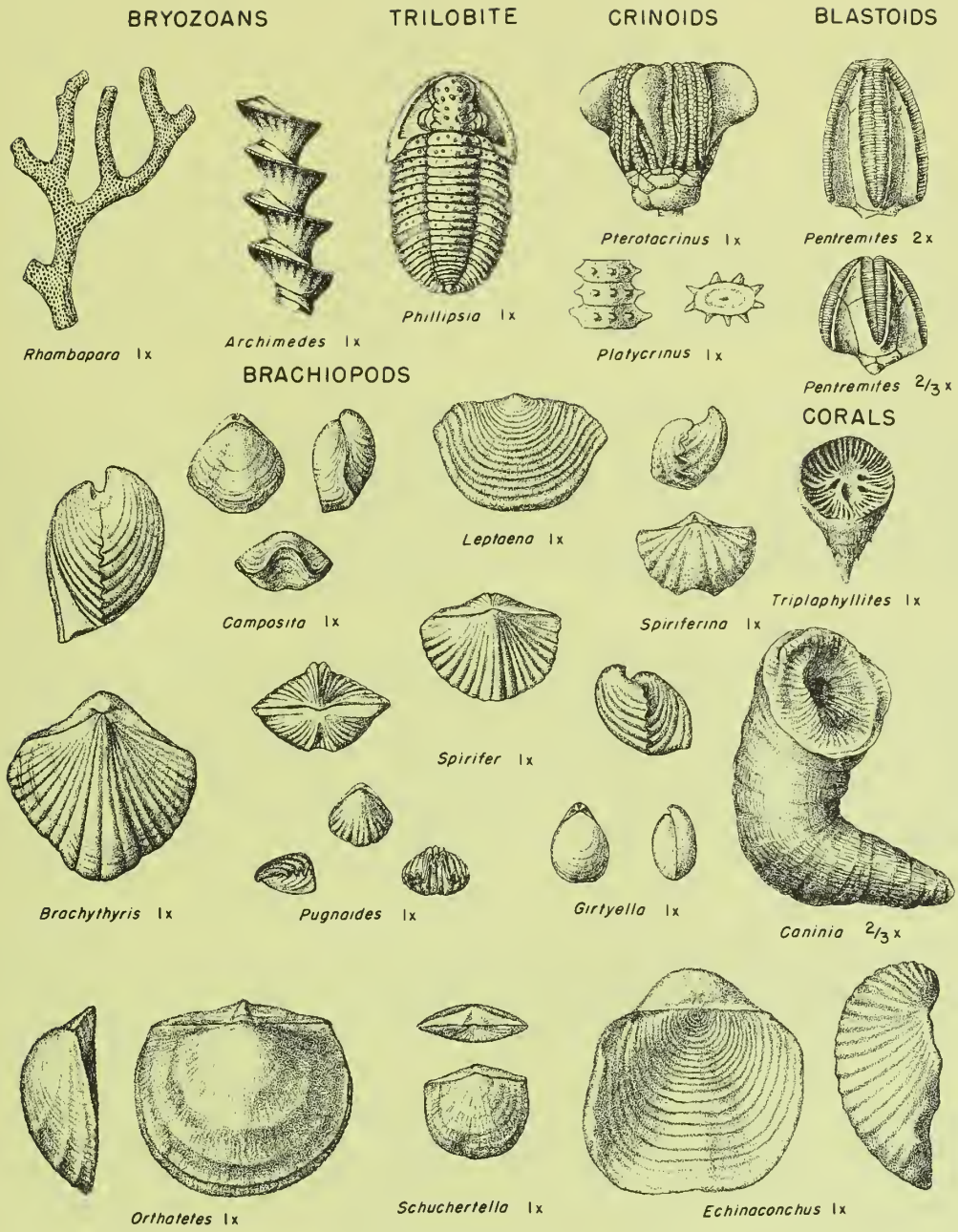


Figure 4: Paleogeography at an intermediate stage during Chesterian sedimentation.


BRYOZOANS
TRILOBITE
CRINOIDS
BLASTOIDS
Rhombopora 1x
Archimedes 1x
Phillipsia 1x
Pterotocrinus 1x
Platycrinus 1x
Pentremites 2x
Pentremites 2/3 x
BRACHIOPODS
CORALS
Leptaena 1x
Composita 1x
Spiriferina 1x
Triplophyllites 1x
Spirifer 1x
Brachythyris 1x
Pugnoides 1x
Girtyella 1x
Caninia 2/3 x
Orthotetes 1x
Schuchertella 1x
Echinoconchus 1x

DEPOSITIONAL HISTORY OF THE PENNSYLVANIAN ROCKS IN ILLINOIS

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

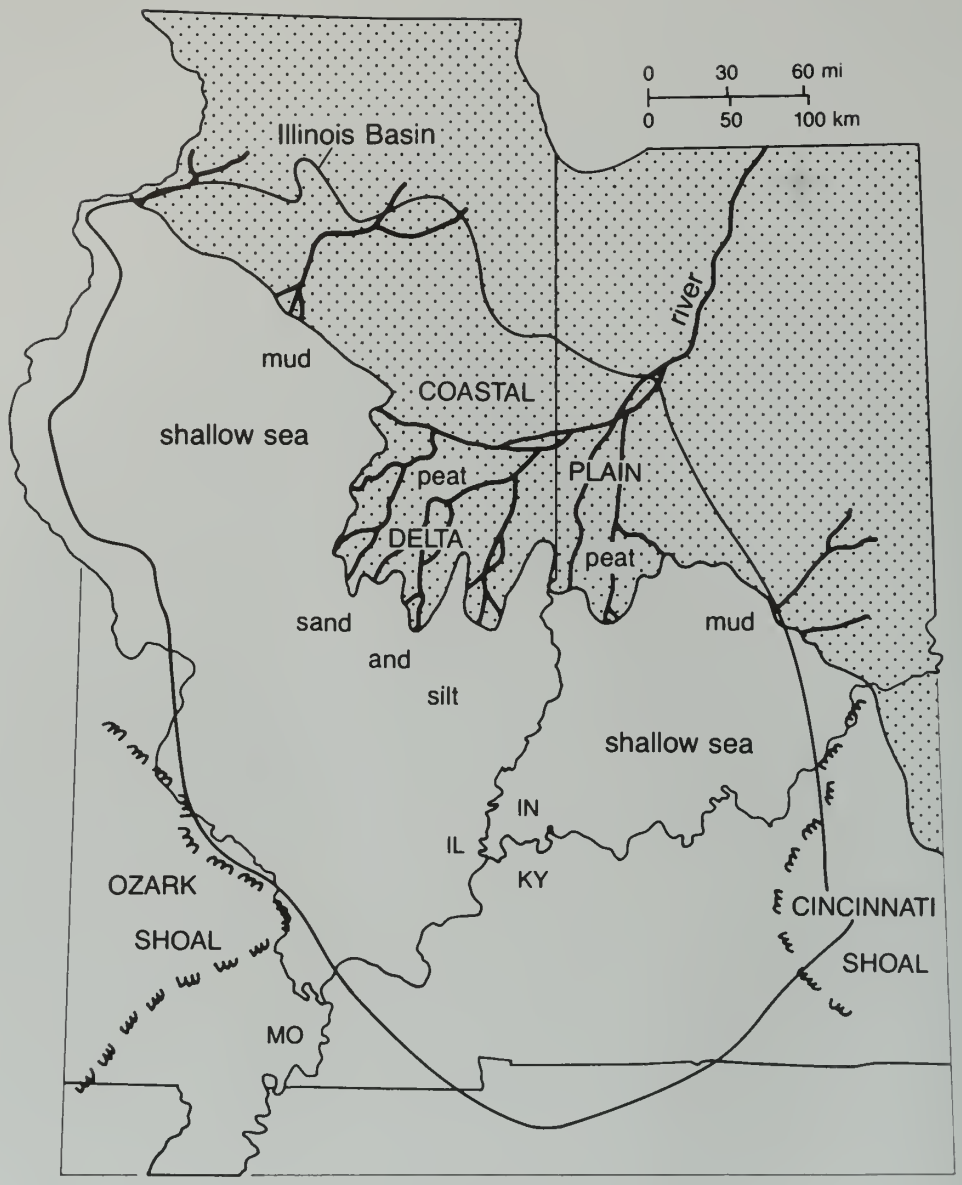
Depositional conditions in the Illinois Basin during the Pennsylvanian Period were somewhat similar to those of the preceding Chesterian (late Mississippian) time. A river system flowed southwestward across a swampy lowland, carrying mud and sand from highlands to the northeast. This river system formed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

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

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

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

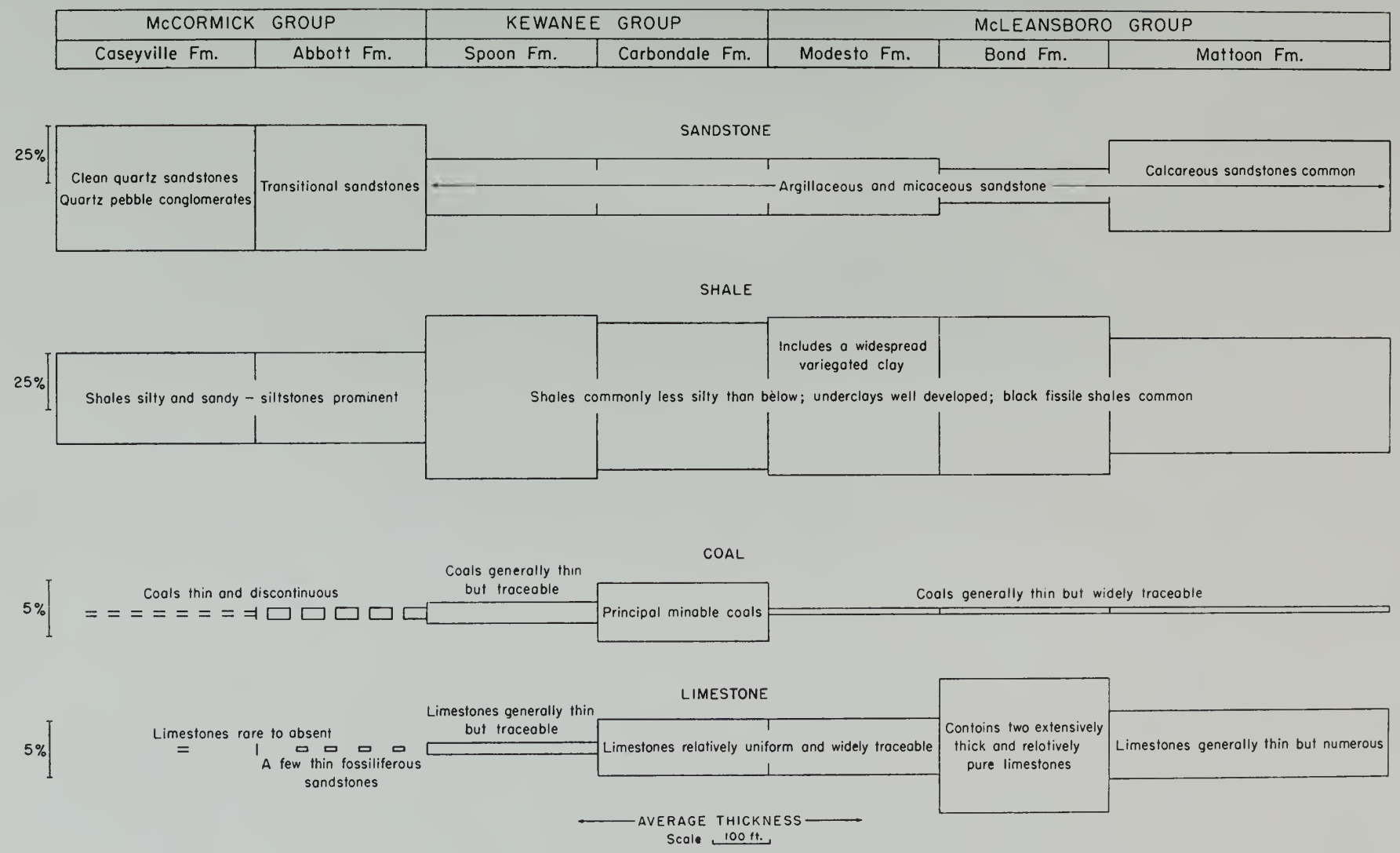
Beneath the quiet water of extensive swamps that prevailed for long intervals on the emergent coastal lowland, peat was formed by accumulation of plant material. Lush forest vegetation covered the region; it thrived in the warm, moist Pennsylvanian-age climate. Although the origin of the underclays beneath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



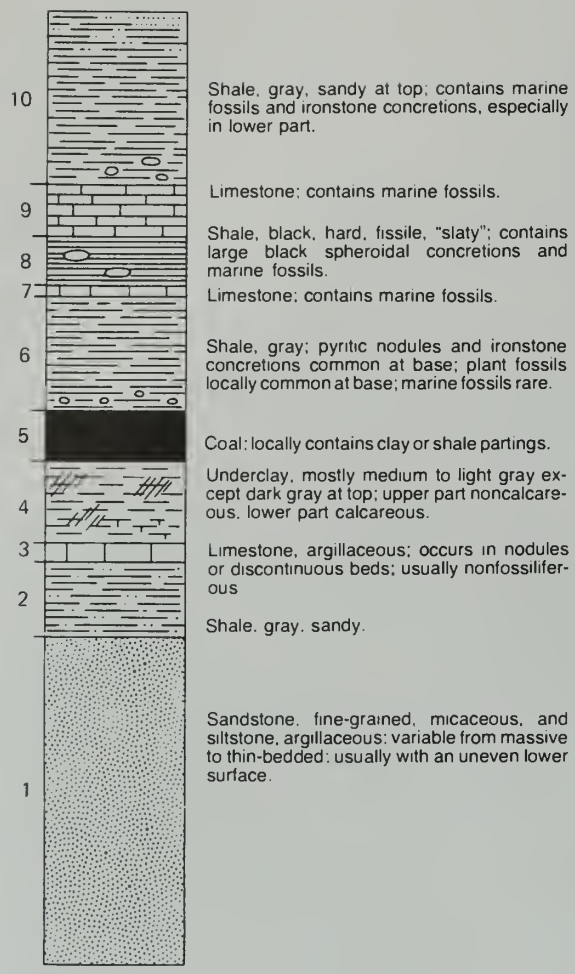
Paleogeography of Illinois-Indiana region during Pennsylvanian time. The diagram shows a Pennsylvanian river delta and the position of the shoreline and the sea at an instant of time during the Pennsylvanian Period.

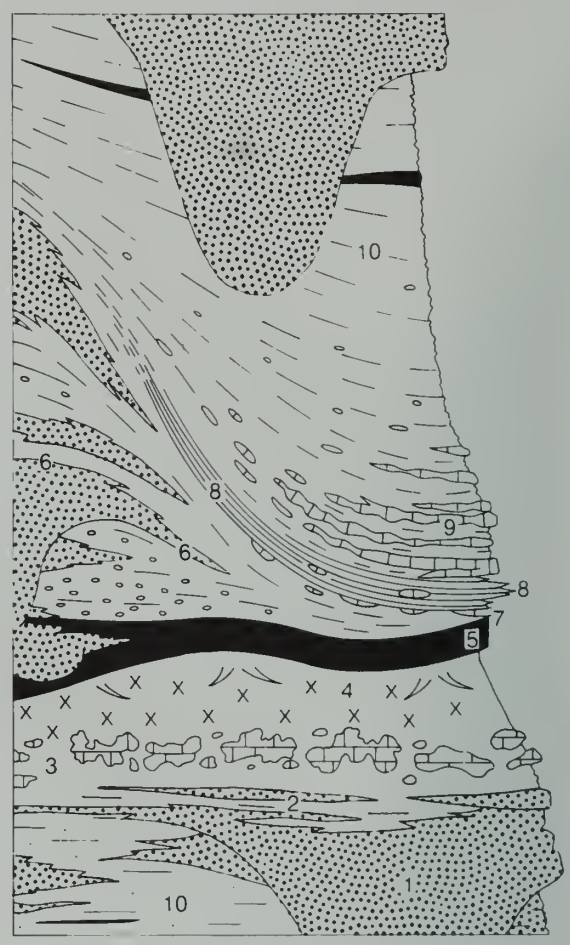
Pennsylvanian Cyclothems

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



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





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

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

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

Origin of Coal

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

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

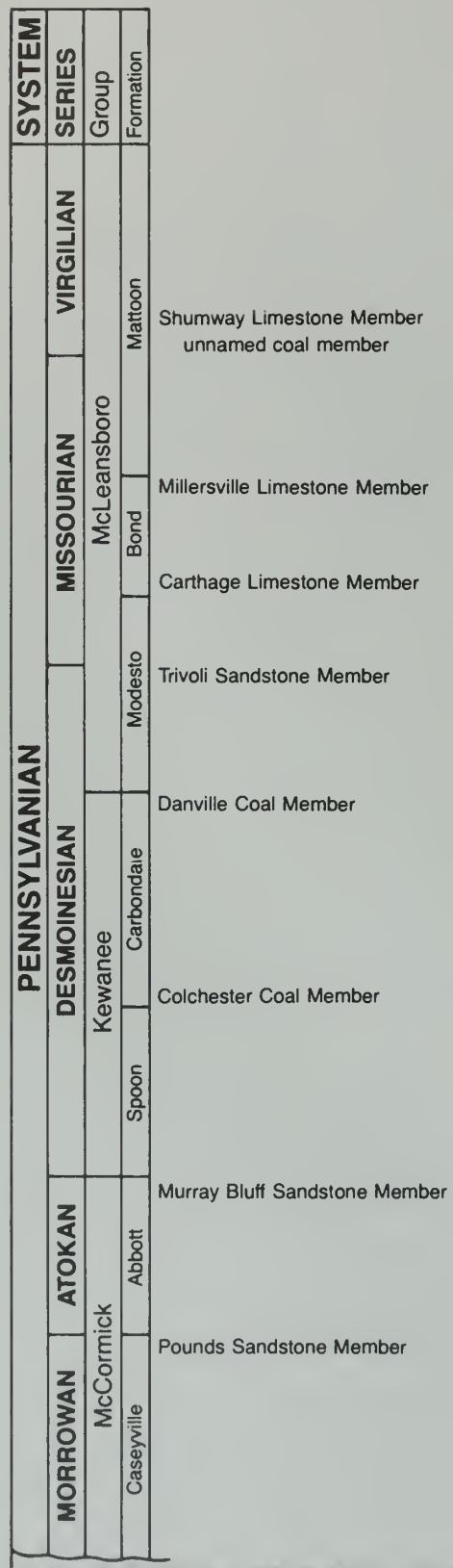
The periodic invasions of the Pennsylvanian sea across the coastal swamps killed the Pennsylvanian forests, and the peat deposits were often buried by marine sediments. After the marine transgressions, peat usually became saturated with sea water containing sulfates and other dissolved minerals. Even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

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

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

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

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



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

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

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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.

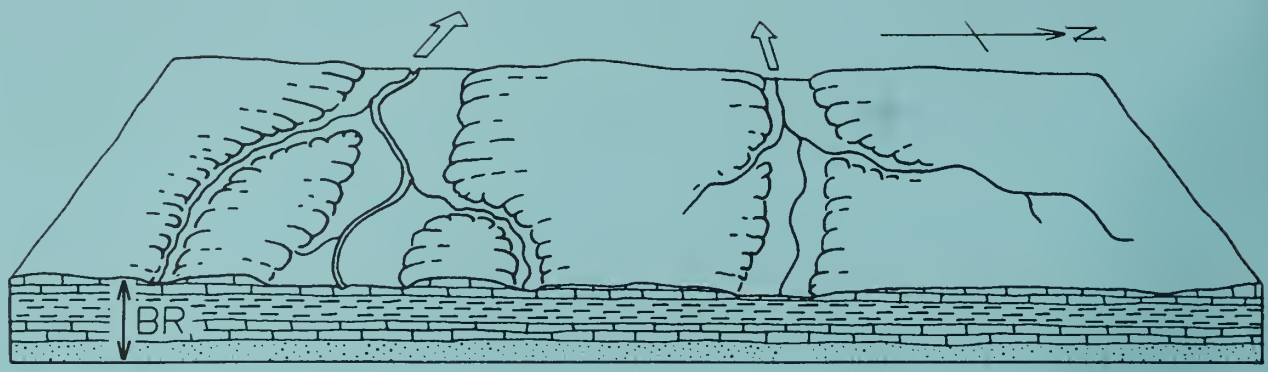
Eolian deposition occurred when certain climatic conditions were met, probably in a seasonal pattern. Deposition could have occurred in the fall, winter or spring season when low precipitation rates and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and 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.

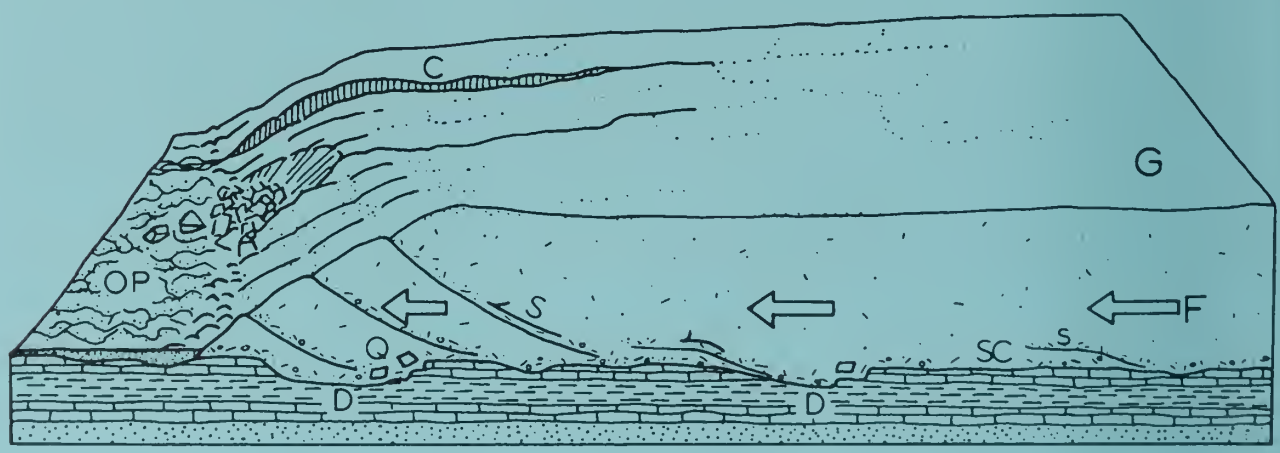
Glaciation in a Small Illinois Region

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.

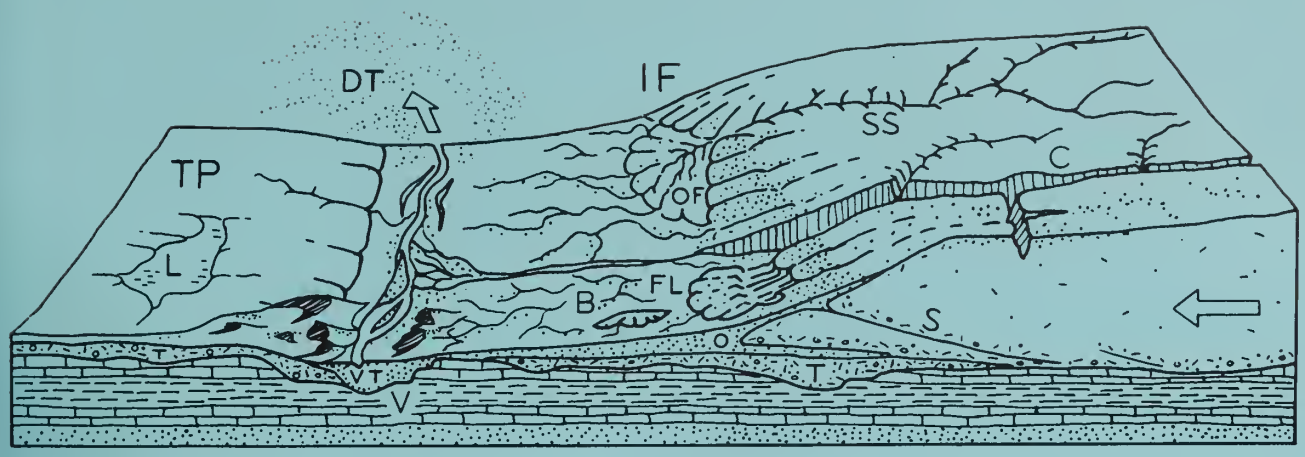
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated—layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



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.



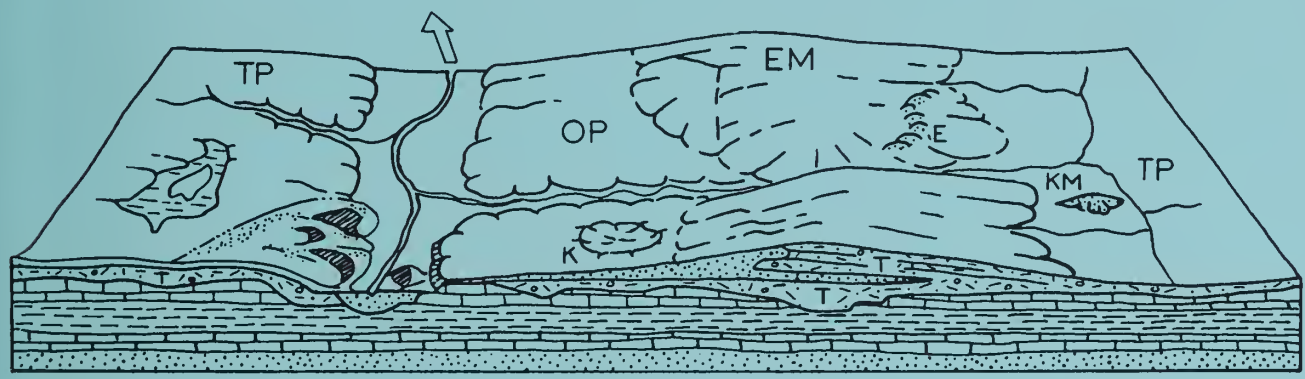
2. **The Glacier Advances Southward** — As the Glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughnesses 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.

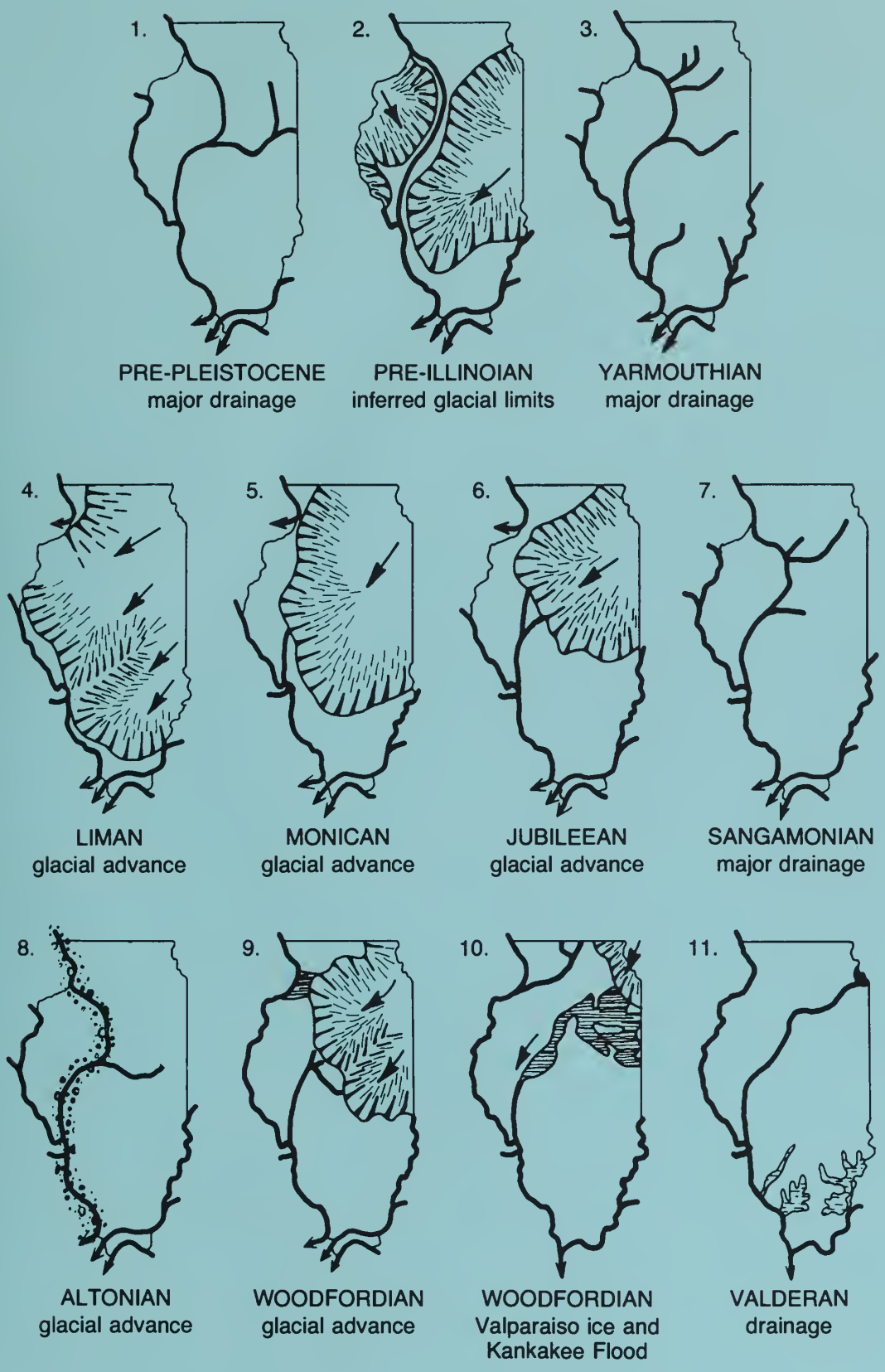
TIME TABLE OF PLEISTOCENE GLACIATION

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

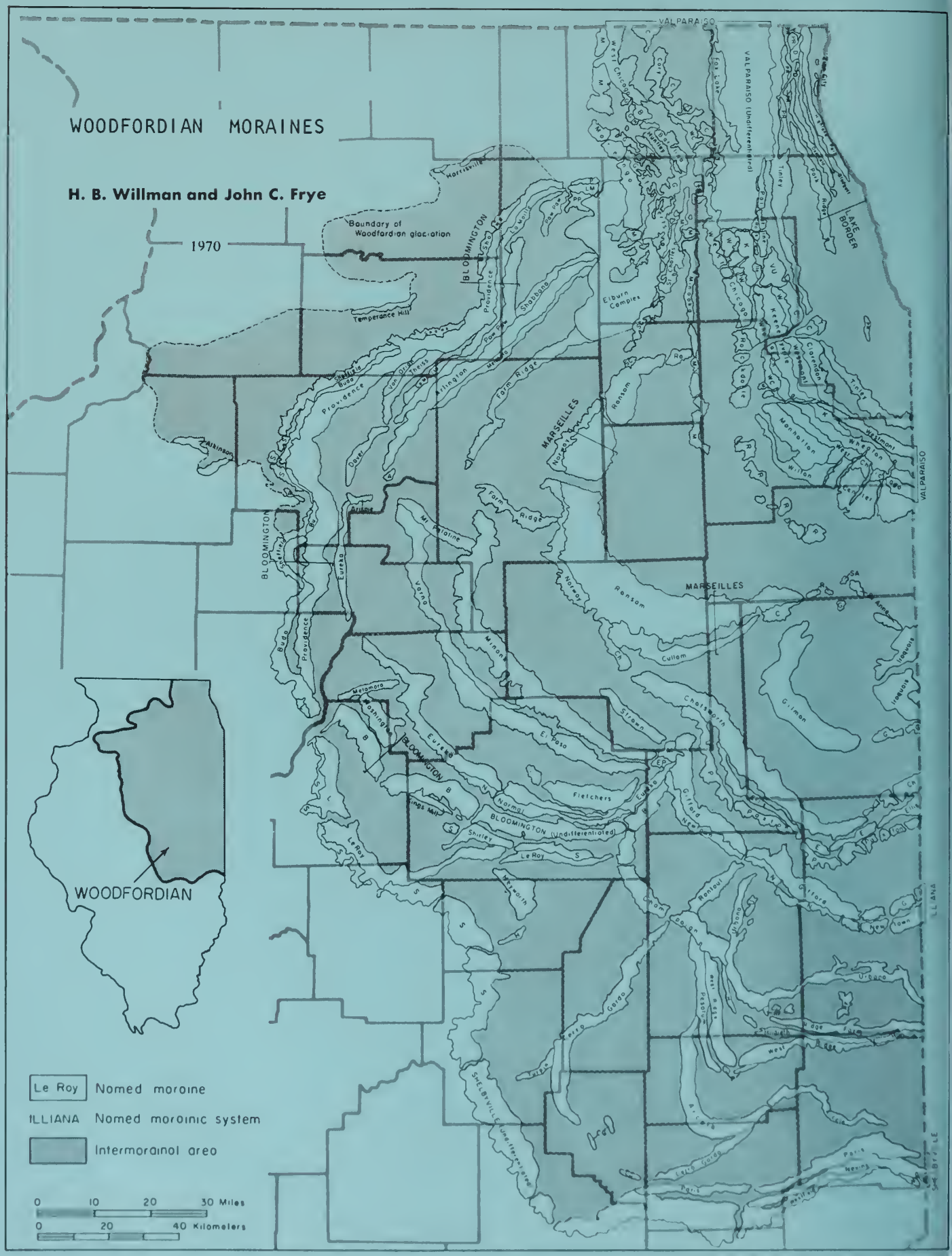
*Old oversimplified concepts, now known to represent a series of glacial cycles.

(Illinois State Geological Survey, 197

SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



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

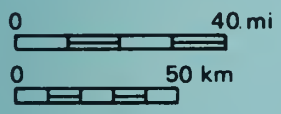

WOODFORDIAN MORAINES
H. B. Willman and John C. Frye
1970
Boundary of Woodfordian glaciation
Temperance Hill
Harrisville
BLOOMINGTON
MARSEILLES
VALPARAISO
VALPARAISO (Undifferentiated)
LAKE BORDER
Elburn Complex
Ransom
Norway
Fox Ridge
Providence
Shaubena
Dover
Atkinson
Mt. Palatine
Minonk
Cullom
Chatsworth
Stream
Fletchers
Shirley
Le Roy
Rantoul
Urbana
Gifford
Gilman
Paris
Sheldon
Shelbyville
WOODFORDIAN
Le Roy Named moraine
ILLIANA Named morainic system
Intermorainal area
0 10 20 30 Miles
0 20 40 Kilometers

QUATERNARY DEPOSITS OF ILLINOIS

Jerry A. Lineback

1981

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



AGE	UNIT
Holocene and Wisconsinan	Cahokia Alluvium, Parkland Sand, and Henry Formation combined; alluvium, windblown sand, and sand and gravel outwash.
Wisconsinan	Peoria Loess and Roxana Silt combined; windblown silt more than 6 meters (20 ft) thick.
	Equality Formation; silt, clay, and sand in glacial and slack-water lakes.
	Moraine / Ground moraine — Wedron and Trafalgar Formations combined; glacial till with some sand, gravel, and silt.
Wisconsinan and Illinoian	Winnebago and Glasford Formations combined; glacial till with some sand, gravel, and silt; age assignments of some units is uncertain.
Illinoian	Glasford Formation; glacial till with some sand, gravel, and silt.
	Teneriffe Silt, Pearl Formation, and Hagarstown Member of the Glasford Formation combined; lake silt and clay, outwash sand, gravel, and silt.
Pre-Illinoian	Wolf Creek Formation; glacial till with gravel, sand, and silt.
	Bedrock.

ISGS 1981

ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, Illinois 61801

GEOGRAM 5
October 1975

ANCIENT DUST STORMS IN ILLINOIS

Myrna M. Killey

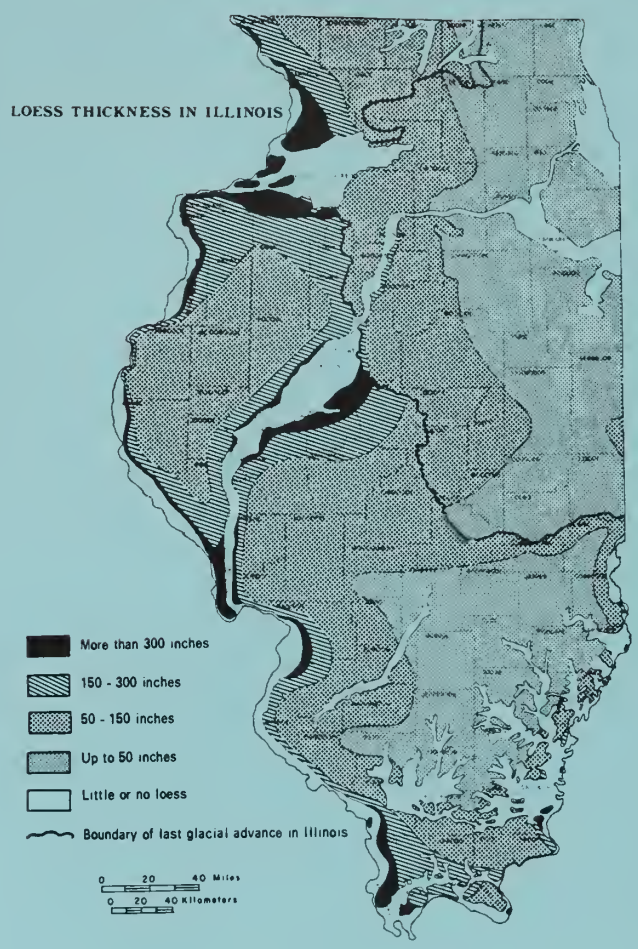
Fierce dust storms whirled across Illinois long before human beings were here to record them. Where did all the dust come from? Geologists have carefully put together clues from the earth itself to get the story. As the glaciers of the Great Ice Age scraped and scoured their way southward across the 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 meltwater stopped flowing and the silt was left along the channels the water had followed, where it dried out and became dust. Strong winds picked up the dust, swept it from the floodplains, and carried it to adjacent uplands. There the forests along the river valleys trapped the dust, which became part of the moist forest soil. With each storm more material accumulated until the high bluffs adjacent to major rivers were formed. The dust deposits are thicker along the eastern sides of the valleys than they are on the western sides, a fact from which geologists deduce that the prevailing winds of that time blew from west to east, the same direction as those of today. From such clues geologists conclude that the geologic processes of the past were much like those of today.

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

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

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

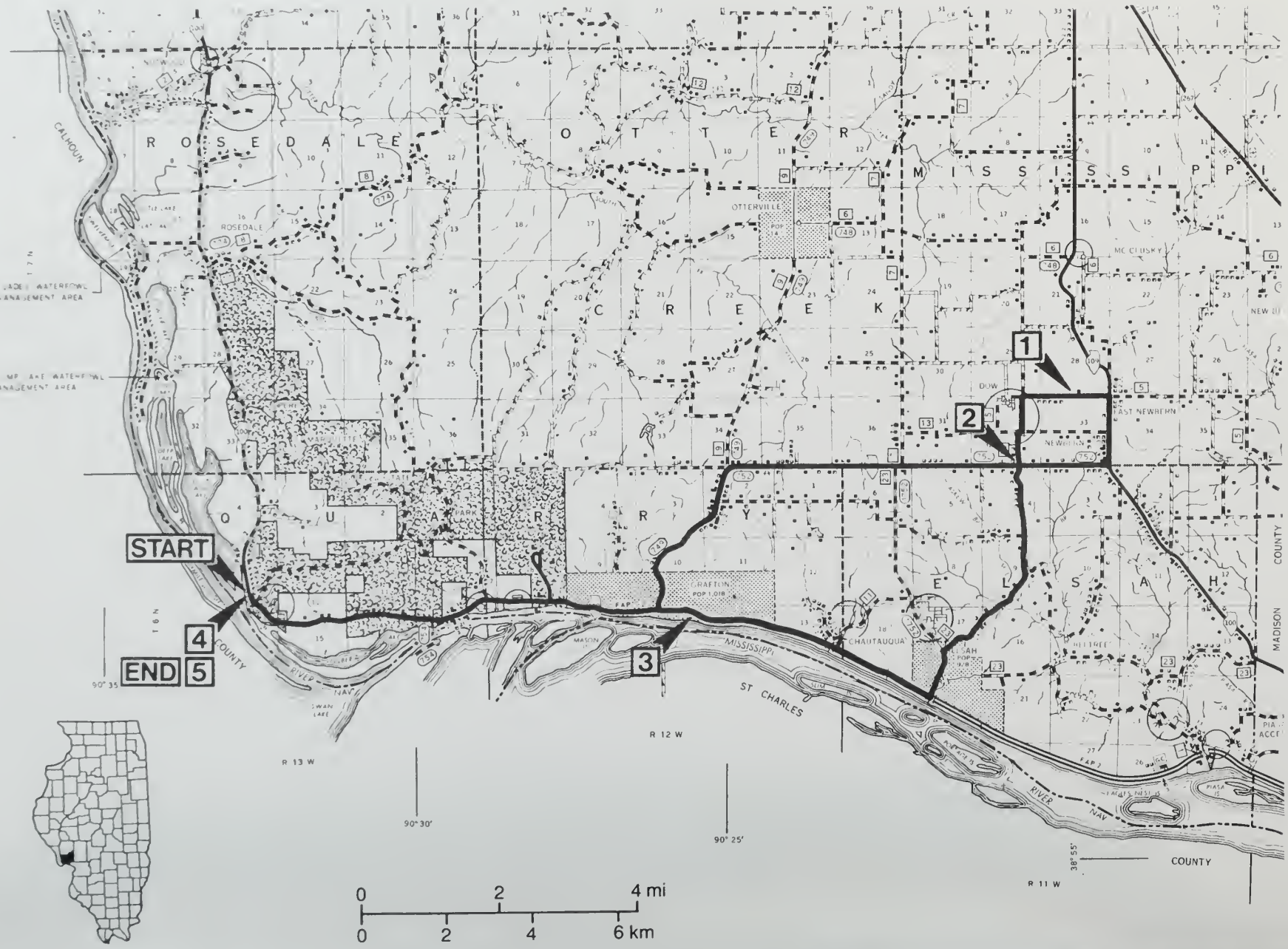


limestone grains. Some of the dissolved minerals later became solid again, gathering around a tiny nucleus or along roots to form the lumpy masses. A few such concretions are shaped roughly like small dolls and, from this resemblance, are called "loess kindchen," a German term meaning "loess children." 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.


START
END
1
2
3
4
5
ROSEDALE
OTTERVILLE
CREEK
MISSISSIPPI
QUARRY
ELSAH
CALHOUN
MADISON
COUNTY
MISSISSIPPI
RIVER
NAV
ST CHARLES
CHAUTAUQUA
GRAFTON
MASON
MC CLUSKY
EAST NEWBERN
NEWBERN
DOW
ROSEDALE
OTTERVILLE
R 13 W
R 12 W
R 11 W
90° 35'
90° 30'
90° 25'
38° 55'
0 2 4 mi
0 2 4 6 km