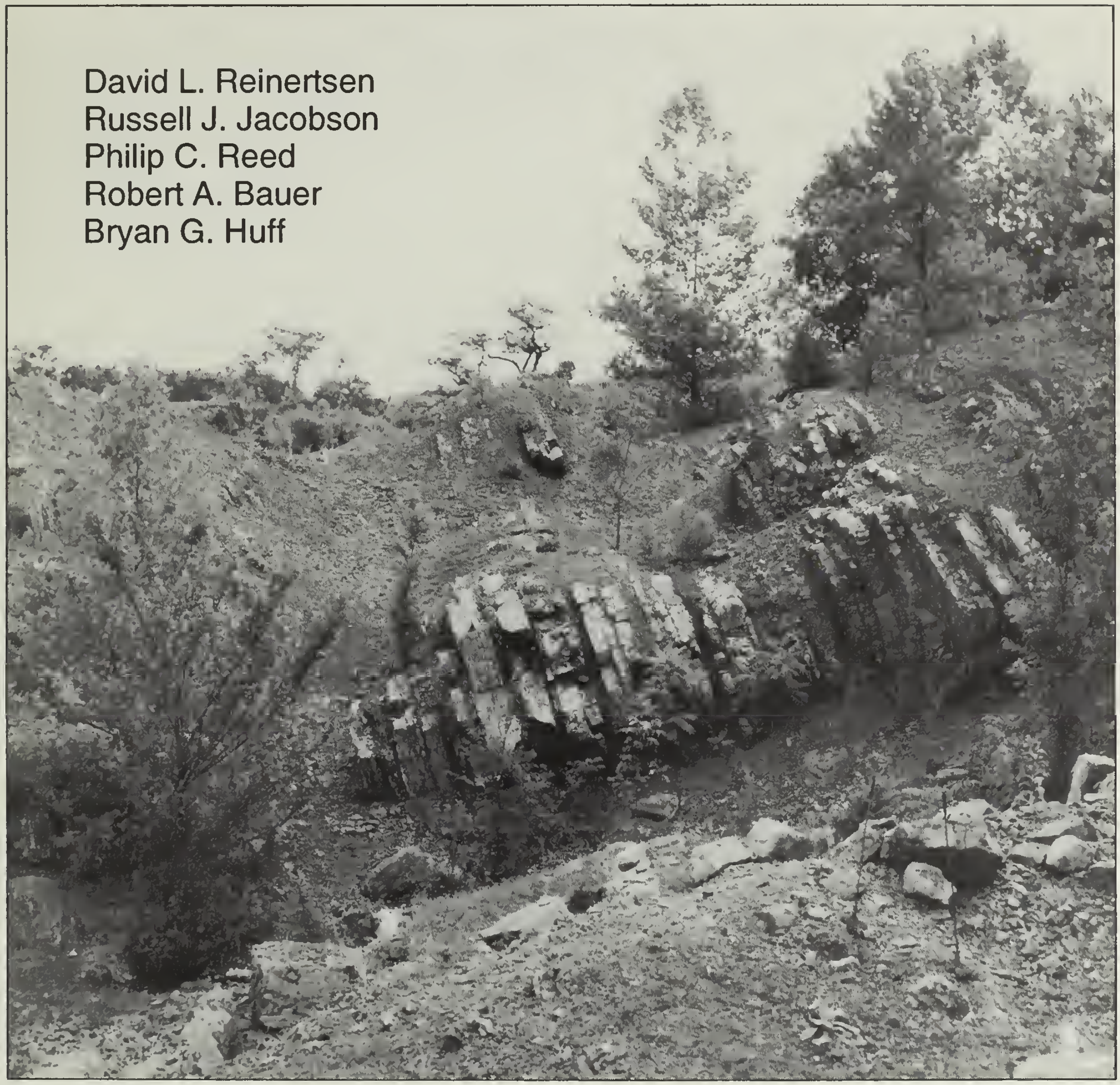
Guide to the Geology of the Harrisburg Area

Saline County, Illinois



David L. Reinertsen
Russell J. Jacobson
Philip C. Reed
Robert A. Bauer
Bryan G. Huff

Field Trip Guidebook 1993A April 17, 1993
Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

Cover photo Upturned Mississippian rocks in the abandoned Horseshoe Quarry.

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 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 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.

Field trip guide booklets are available for planning class tours and private outings. For a list, contact the Educational Extension Unit, Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820-6964. Call (217) 333-4747 or 333-7372.

printed on recycled paper

Printed by authority of the State of Illinois / 1993 / 500

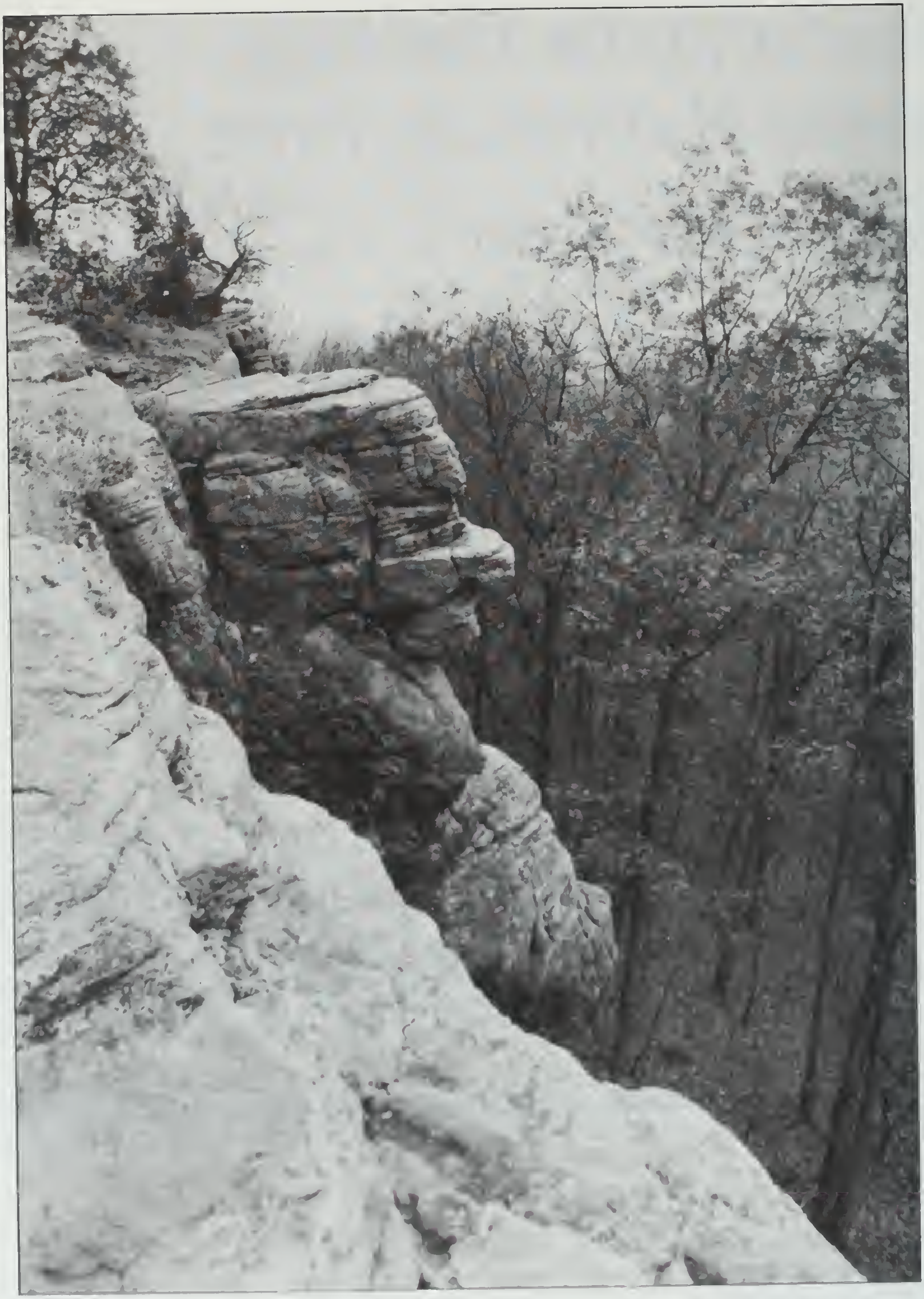
Guide to the Geology of the Harrisburg Area

Saline County, Illinois

David L. Reinertsen
Russell J. Jacobson
Philip C. Reed
Robert A. Bauer
Bryan G. Huff

Field Trip Guidebook 1993A April 17, 1993

ILLINOIS STATE GEOLOGICAL SURVEY
Morris W. Leighton, Chief
Natural Resources Building
615 East Peabody Drive
Champaign, Illinois 61820-6964

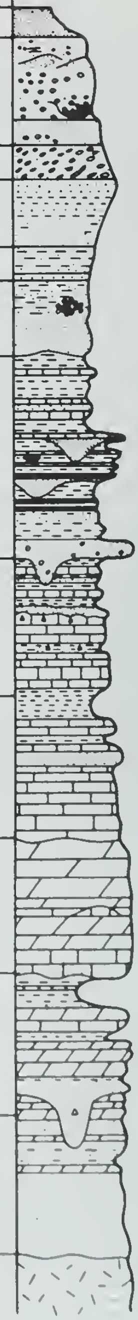


Old Stone Face.

CONTENTS

FIGURES

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



~~~~ major unconformity

Generalized geologic column showing succession of rocks in Illinois.
~~~~

HARRISBURG AREA

The route of the Harrisburg Geological Science Field Trip starts in the southernmost part of the Mount Vernon Hill Country, a relatively level to slightly rolling surface of thin, Illinoian *glacial** deposits formed perhaps 250,000 years ago, and extends to the northeastern part of the Shawnee Hills. The southeastern part of the trip crosses the scenic, upturned rim of the Eagle Valley Syncline in the Shawnee Hills, just beyond the southernmost boundary of the Illinoian glacier.

Fossilferous *limestones* of Mississippian age are exposed beneath the thin Quaternary-age *loess* (rhymes with bus) deposits covering the tilted, upturned strata along the Shawneetown–Rough Creek Faulted Complex in the southeastern part of the field trip area. Nearby mines in the Pennsylvanian-age Herrin (No. 6), Springfield (No. 5),and older, deeper coals of the Carbondale Formation have made the Harrisburg area an important coal-producing center for many years.

The Harrisburg field trip area lies approximately 330 miles south-southwest of downtown Chicago and about 185 miles southeast of Springfield. The route for the field trip will take us through about one-third of Saline County.

GEOLOGIC HISTORY

Precambrian Era

The Harrisburg area, like most of the midcontinent, has undergone many changes through the thousands of millions of years of geologic time. The oldest rocks beneath us along the route of the field trip belong to the ancient Precambrian (Archeozoic and Proterozoic) basement complex (see generalized geologic column on facing page). We know relatively little about these rocks from direct observation in Illinois because they are not exposed at Earth's surface anywhere in the state. Surface exposures of Precambrian rocks occur, however, in southeastern Missouri and central Wisconsin. About 30 drill holes in Illinois have penetrated deep enough for geologists to collect samples of Precambrian rocks. Recorded depths to the top of the basement complex range from 1,995 feet in northwestern Illinois (Stephenson County) to 12,967 feet in southeastern Illinois (Hamilton County), some 20 miles north of Harrisburg. From these samples, and from similar drill hole samples and surface exposures of Precambrian rocks in adjacent states, we know that these ancient rocks consist mostly of *igneous* and *metamorphic crystalline* rocks of granite–rhyolite composition and, rarely, some basaltic rock types. The rocks formed about 1.5 to 1.0 billion years ago when molten materials slowly solidified deep within the earth. By about 0.6 billion years ago, deep weathering and erosion had exposed the ancient rocks at the surface, probably forming a landscape rather similar to part of the present Missouri Ozarks. We have no rock record in Illinois for the long interval of weathering and erosion that lasted from the time Precambrian rocks were formed until Cambrian *sediments* were deposited across the older land surface. We know, however, that the interval was longer than the span of geologic time from the Cambrian to the present.

Because geologists have only seen the Precambrian rocks in Illinois as cuttings from drill holes, they have had to determine some characteristics of the basement complex by using various indirect techniques such as measurements of Earth's gravitational and magnetic fields, and seismic tests. This evidence indicates that rift valleys similar to those in east Africa began to form in what is now southernmost Illinois during the late Precambrian *Era*. These midcontinent *rift* structures, known as the Rough Creek *Graben* and the Reelfoot Rift (fig. 1), formed when plate *tectonic* movements (slow global scale deformation) began to rip apart an ancient Precambrian supercontinent. The slow fragmentation of this Precambrian supercontinent eventually isolated a new landmass called Laurasia, which included much of what is now the North American continent.

---

* Words in italics are defined in the glossary in the back of the guidebook.

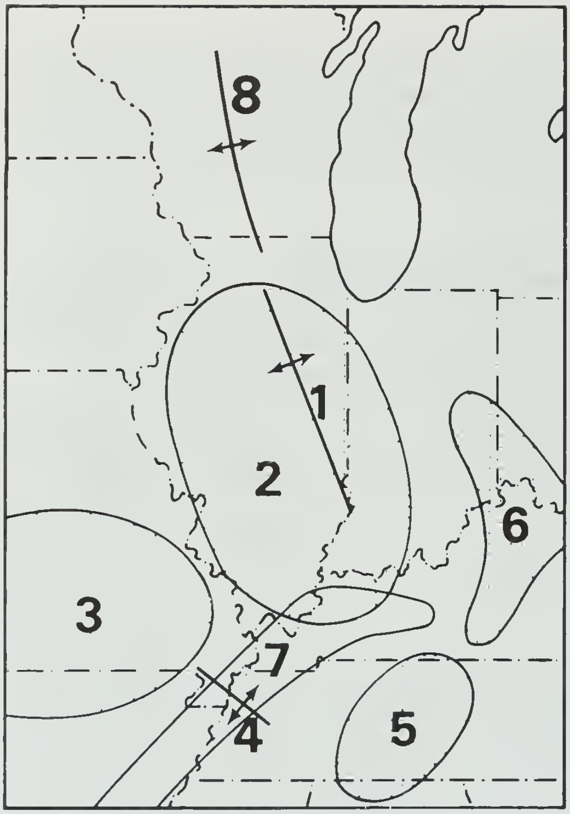


Figure 1 Location of some of the major structures in the Illinois region. (1) La Salle Anticlinal Belt, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Rough Creek Graben-Reelfoot Rift, and (8) Wisconsin Arch.

Near the end of the Precambrian Era and continuing until late Cambrian time, from about 570 million to 505 million years ago, tensional forces within the planet apparently caused block faulting (see *fault* in the glossary) and relatively rapid subsidence of the hilly Precambrian landscape on a regional scale. A broad trough formed, extending northward from the continental margin in what is now central Arkansas across what later became Illinois, Indiana, and Kentucky, into which a shallow sea encroached from the south and southwest.

Paleozoic Era

During the Paleozoic Era, which lasted from about 570 million years ago to some 245 million years ago, the land that is now southern Illinois sank slowly and layer after layer of sediment collected in shallow seas that repeatedly covered the area. Perhaps 17,000 feet of sedimentary *strata* accumulated during the 325 million years of the Paleozoic Era. These sediments, when compacted and hardened (*lithified*), together with the underlying Precambrian rocks, constitute the *bedrock* succession.

From middle Ordovician time, about 460 million years ago, until the end of the Permian Period (and the Paleozoic Era) about 245 million years ago, the midcontinent (now Illinois, Indiana, and western Kentucky) sank more slowly than it had earlier. Sediments repeatedly poured into a north-trending broad trough or embayment covering the area and overflowed onto surrounding areas as well. Shells of marine animals, and muds, silts, and sands deposited in those seas over millions of years were gradually buried and lithified into solid limestone or dolomite, and shale, siltstone, and sandstone.

Earth's thin crust has frequently been flexed and warped in various places by forces of compression and tension that developed within the earth at various times. Movements of the land surface, flexing upward then downward, recurred over millions of years and caused the seawaters to periodically drain from the region, then slowly return. When the floors of these shallow, continen-

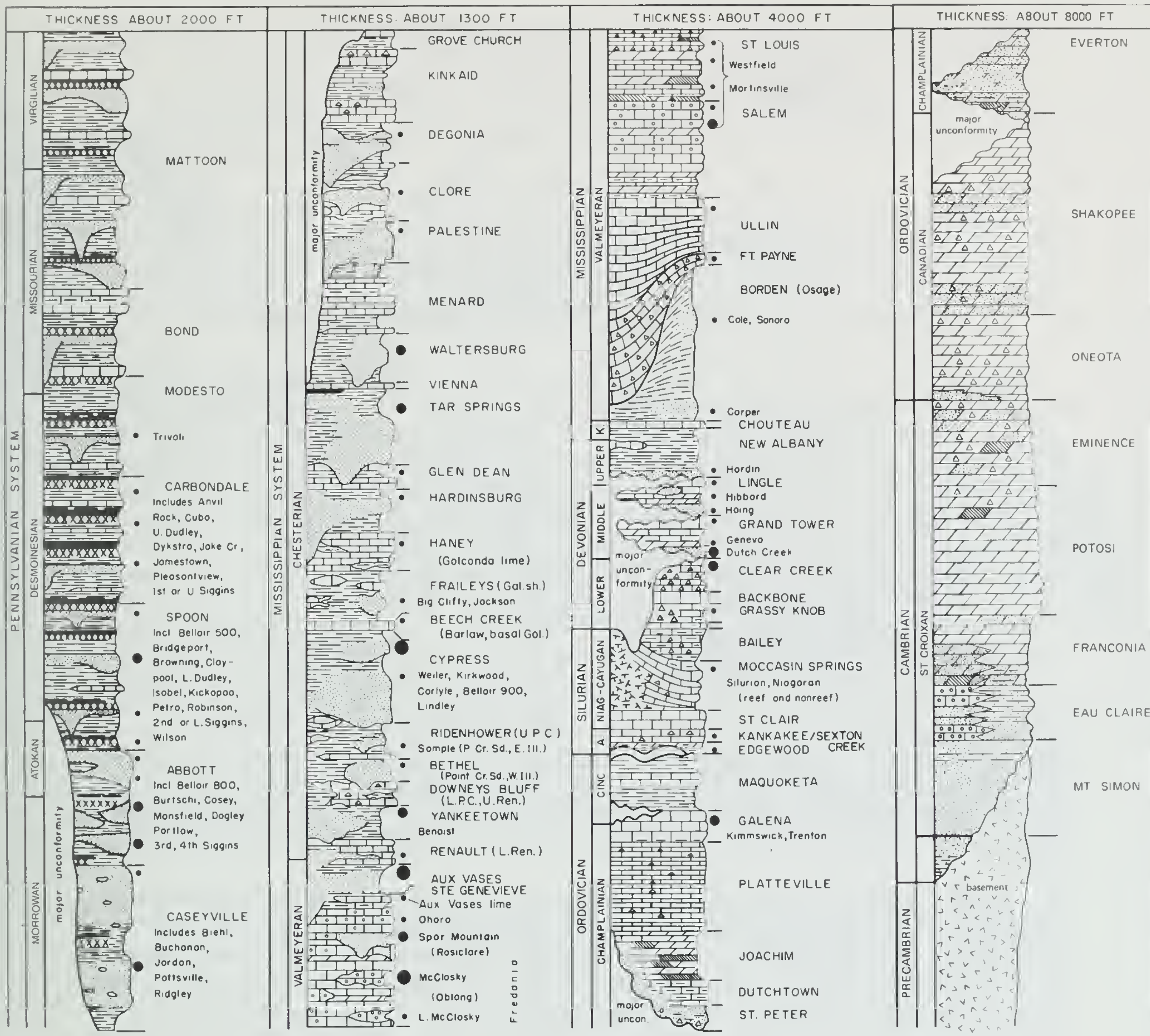


Figure 2 Generalized geologic column of southern Illinois. Black dots indicate oil and gas pay zones. Formation names are in capitals; other pay zones are not. About 4,000 feet of lower Ordovician and upper Cambrian rocks under the St. Peter are not shown. Kinderhookian (K), Niagaran (Niag.), Alexandrian (A), and Cincinnatian (Cinc.) Series are abbreviated. Variable vertical scale. Originally prepared by David H. Swann; modified from ISGS Illinois Petroleum 75.

tal seas were uplifted and exposed to weathering and erosion by rain, wind, and streams, some previously deposited strata were eroded. Consequently, not all geologic intervals are represented in the rock record of Illinois (see generalized geologic column, page iv).

The geologic column Figure 2 shows the succession of rock strata that a drill bit would be likely to encounter in the Harrisburg area. (The oldest *formations* are at the bottom of the column.) Figure 3 shows an interpretation of the general configuration and structure of sedimentary rock strata in Illinois. Sedimentary rocks in Illinois are classified by using formation names. Because of great similarities in appearance and composition, some formations are classified and mapped together in a unit called a *group*. Some formations contain thin, distinctive units called members.

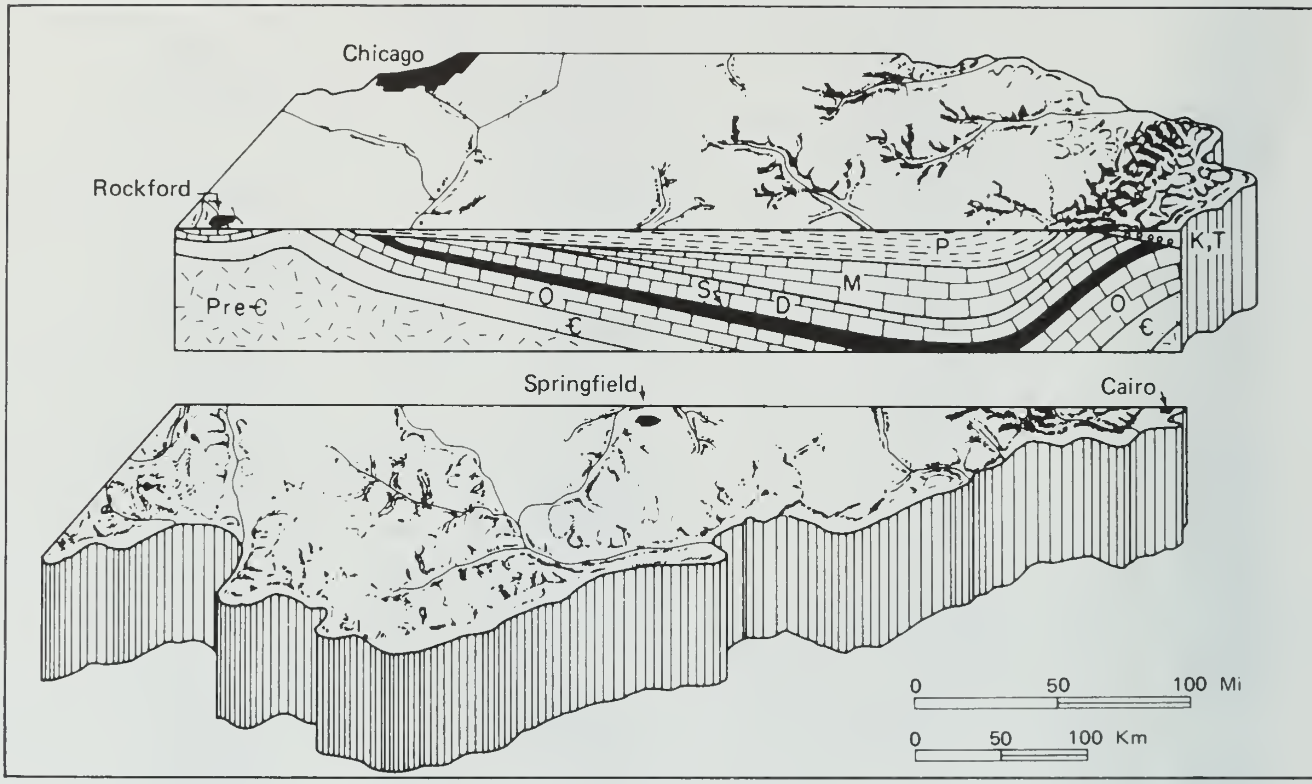


Figure 3 Stylized north-south cross section shows the structure of the Illinois Basin. In order to show detail, the thickness of the sedimentary rocks has been greatly exaggerated and the younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-C) granites. They form a depression that is 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). The scale is approximate.

Many of the formations in groups have conformable contacts, which means that no significant interruptions took place between deposition of the sediments of one formation and the sediments of another (fig. 2). In some cases, the composition and appearance of the rocks change significantly at the contact between two formations, even though the fossils in the rocks and the relationships between the rocks indicate that deposition was essentially continuous. This type of contact is called a *disconformity*. In other cases, the lower formation was subjected to weathering that partly eroded it before sediments of the overlying formation were deposited. When this happens, fossils and other evidence in the formations indicate the existence of a significant gap between the time when the lower unit was deposited and the time when the overlying unit was laid down. This type of contact is called an *unconformity*. If the lower strata were tilted and eroded before the overlying strata were deposited, the contact is called an angular unconformity. (Unconformities are shown as undulating lines across the rock unit column in many geologic columns.)

Geologic framework of the field trip area In Saline County, the field trip area is underlain by some 13,400 feet of Paleozoic *sedimentary* rocks in the northwest to nearly 14,000 feet in the east-central part of the county. These strata range in age from deeply buried rocks of the late Cambrian (about 523 million years old) to surface exposures of middle Pennsylvanian age (about 312 million years old). The oldest Paleozoic rocks exposed in the area are Devonian in age. They formed from sediments that accumulated from about 385 up to 360 million years ago.

Figure 4 shows where the major bedrock units in Illinois would be located if all glacial deposits were scraped off. Bedrock exposures in the field trip area are limited essentially to outcrops along Saline River and its tributaries, roadcuts, abandoned mines and quarries. Rocks of the Pennsylvanian *System* (figs. 2 and 4) occur at or just below the surface throughout the field trip area. Mississippian strata occur in narrow wedges along the Shawneetown Fault Zone (fig. 5) in the southeastern part of the area.

The depositional history of the region is linked with tectonic events. During Late Mississippian and Early Pennsylvanian time, the east coast of the present North American continent was colliding with another continent, creating the Appalachian Mountains. Several major structural features formed in the midcontinent region during this period, including the La Salle Anticlinal Belt (extending from La Salle County to around Lawrence County) (see *anticline* in the glossary).

Mesozoic and Cenozoic Eras

Although Paleozoic rocks are present everywhere in Illinois, younger sediments of the Mesozoic or early Cenozoic Eras occur only in scattered patches in parts of western and southern Illinois. Other than these limited exposures, there is no evidence that younger sediments accumulated during the long interval between deposition of the latest Pennsylvanian rocks and deposition of the Pleistocene glacial *drift*. This "sub-Pleistocene unconformity," the bedrock surface in Illinois, truncates all Tertiary, Cretaceous, and Paleozoic rocks down to the Upper Cambrian rocks exposed at the bedrock surface in the Sandwich Fault Zone of northern Illinois. Cretaceous (and older Mesozoic) rocks are absent from the *stratigraphic* record except in western and extreme southern Illinois. Gravels that are almost certainly Tertiary (Cenozoic) in age occur in scattered exposures in northern, western, and southern Illinois, but Tertiary clays are restricted to the extreme south. Quaternary materials, mostly deposited by continental glaciers, related meltwater streams, and wind, cover most of the state (fig.6).

In the field trip area, except for the glacial deposits, no rocks younger than those of the Pennsylvanian Period are present. The tectonic history (the history of the earth's crustal movements) of the region during the past 570 million years is only partly known and the rest must be inferred from evidence available in other places.

During the Mesozoic and Cenozoic Eras, but before the onslaught of glaciation 1 to 2 million years ago, the land surface of Illinois was exposed to weathering and erosion. Systems of deep valleys were carved into the gently tilted bedrock formations. The rugged *topography* was then considerably subdued by the repeated advance and retreat of glaciers, which scoured and scraped the old erosion surface. Any rock units exposed at the surface were subject to the effects of the glaciers.

Quaternary geology About 1.6 million years ago, during the Pleistocene *Epoch* (commonly called the Ice Age), continental glaciers flowed slowly southward from the northern to the midlatitudes (see appendix, *Pleistocene Glaciations in Illinois*). Several times, ice sheets covered parts of the region we know as Illinois. Continental glaciers reached their southernmost extent in North America during the Illinoian glaciation, about 270,000 years B.P. Evidence of this southernmost limit of glaciation can be seen in northern Johnson County, about 25 miles southwest of Harrisburg (fig. 6). The last of these glaciers melted from the northeastern Illinois area about 13,500 years before the present (B.P.), near the close of Wisconsinan time.

Until recently, glaciologists assumed that ice thicknesses of 1 mile or more were likely for these glaciers. However, the ice may have been, at most, about 2,000 feet thick in the Lake Michigan Basin and on the order of 700 feet thick across most of the land surface. This conclusion is based on the following lines of evidence:

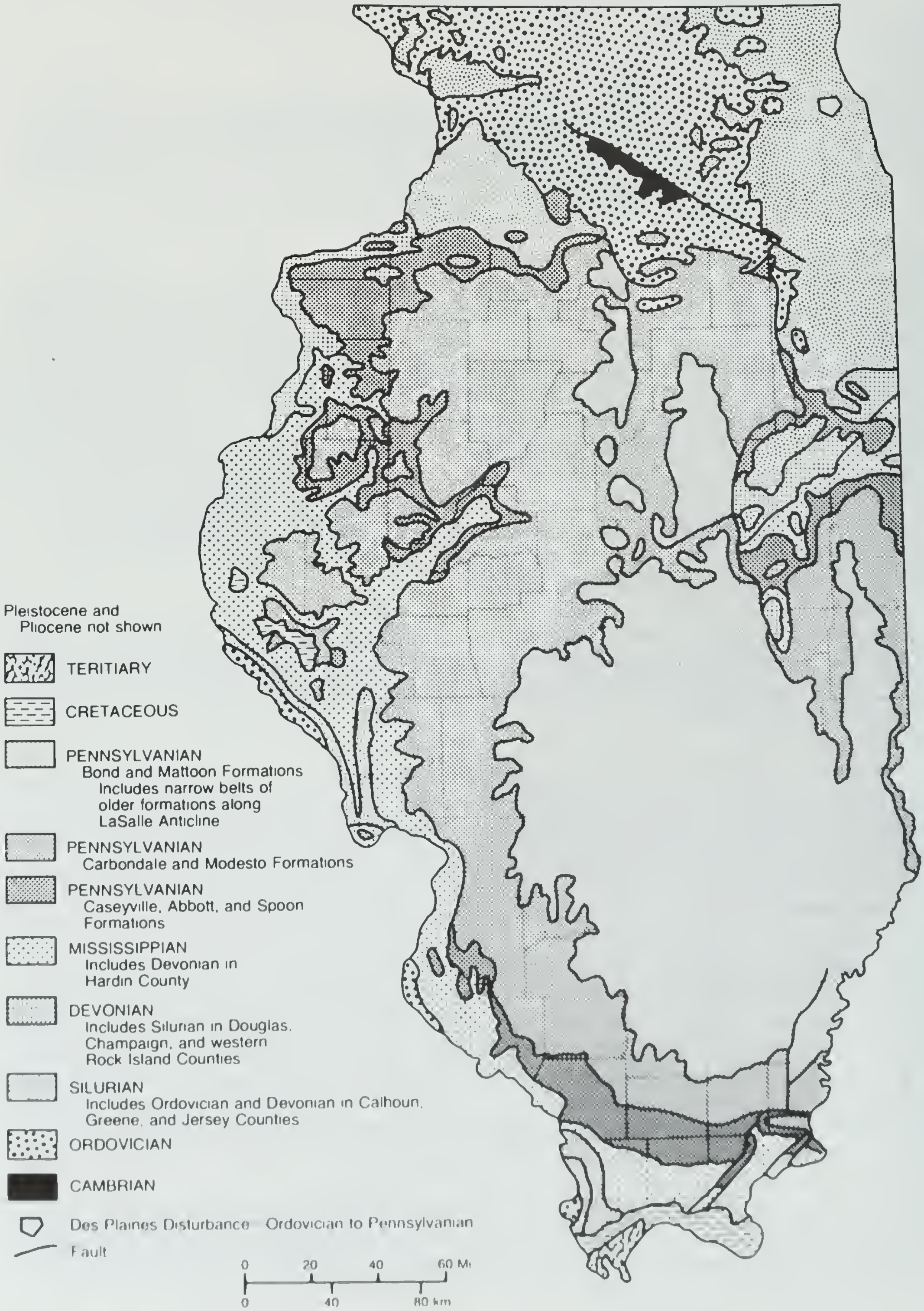


Figure 4 Bedrock geology beneath surficial deposits in Illinois.

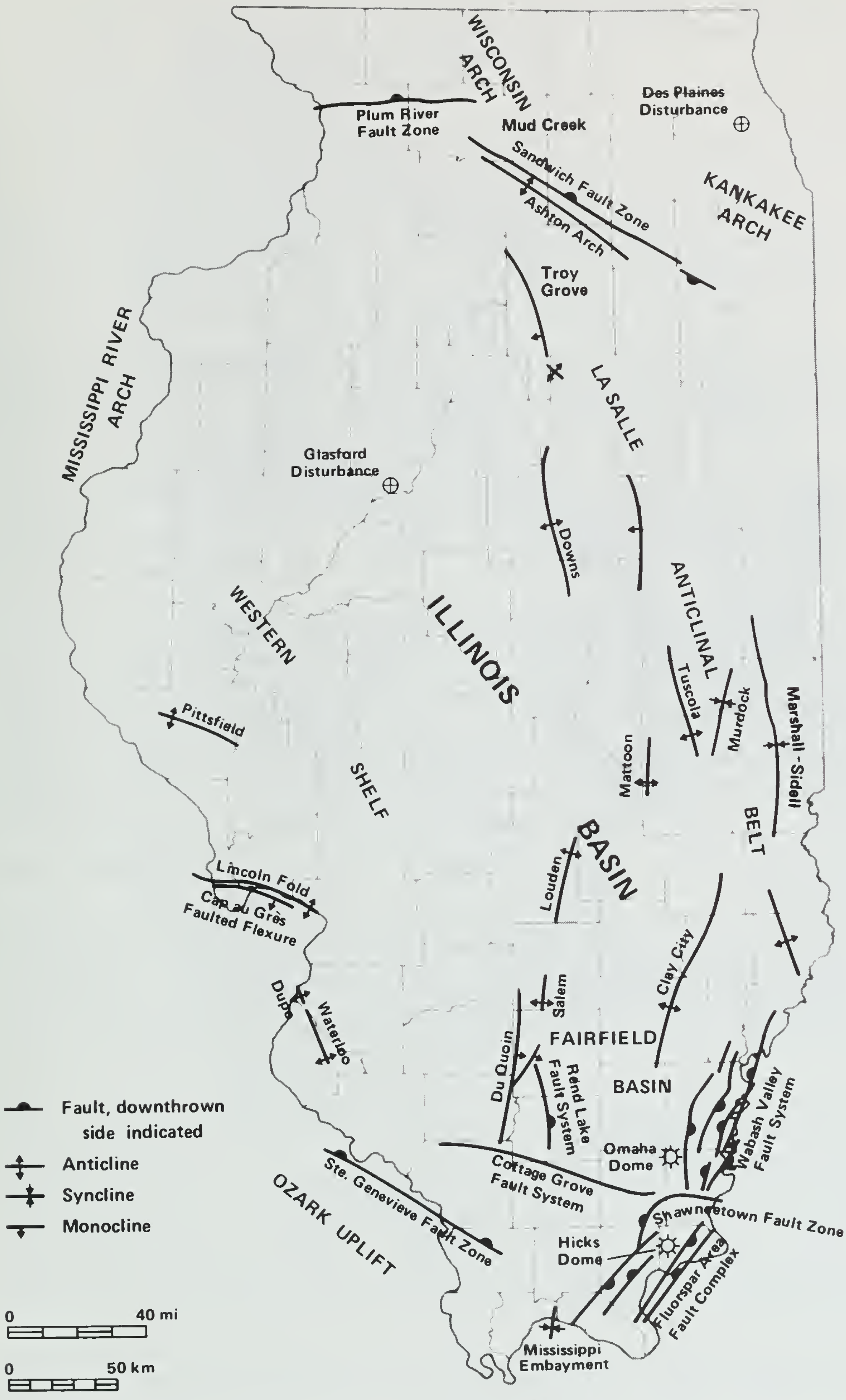


Figure 5 Structural features of Illinois.

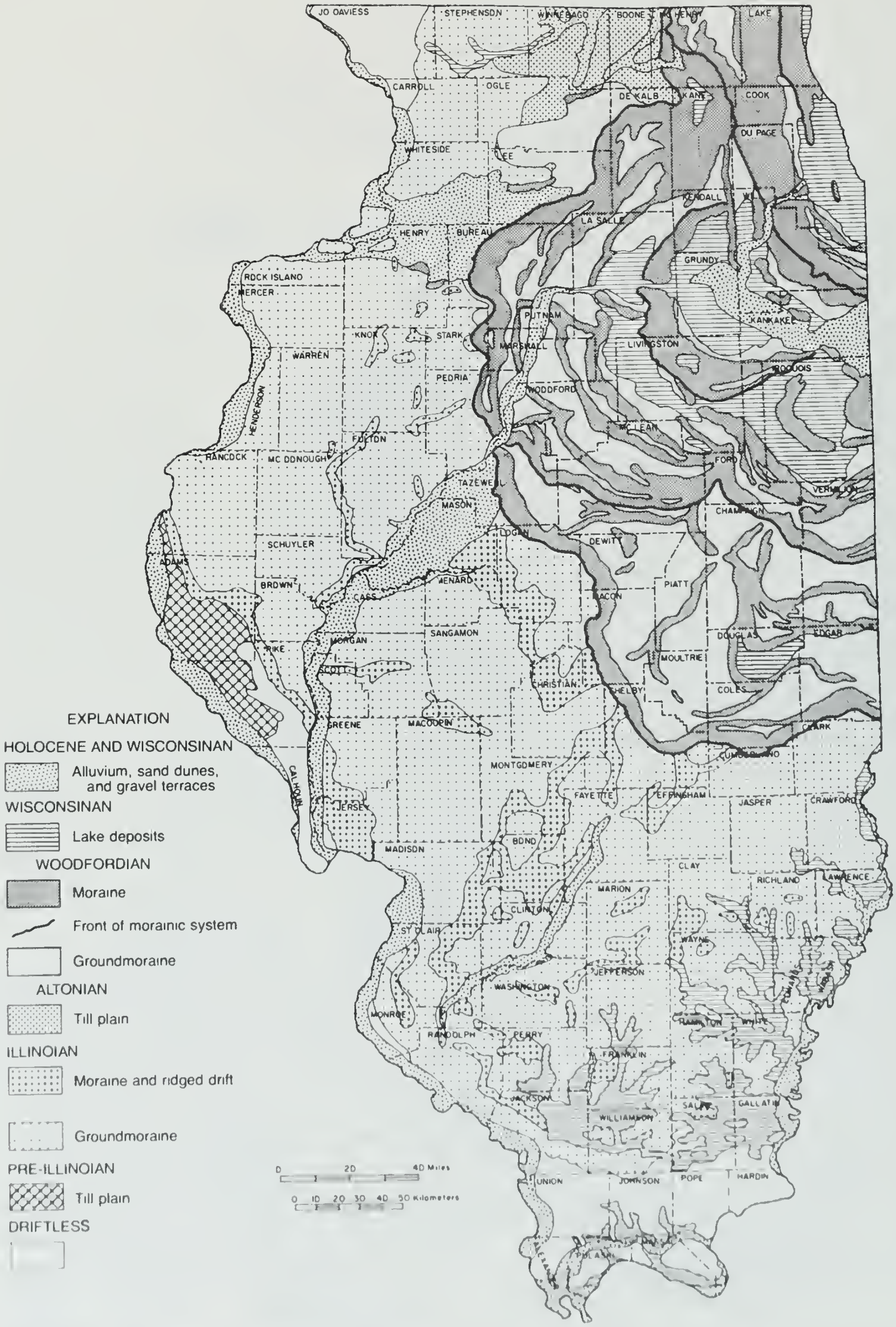


Figure 6 Generalized map of glacial deposits in Illinois (modified from Willman and Frye 1970).

1 inferences about the geometry, configuration, and rates of flow of the ancient ice masses developed from data on the strength and other characteristics of present ice sheets and ice caps, such as those in Greenland and Antarctica,
2 estimates of the thickness of ice masses based on the heights of moraines and the flow directions of the ice,
3 observations about the degree of compaction and consolidation of the drift materials that must have been under the continental glaciers and thus give indications about the weight (and by inference, the thickness) of ice necessary to cause the compaction.

Finally, some workers have suggested that the small amount of rebound of the land surface that apparently has occurred in the Lake Michigan basin area since the ice melted away can only be explained if the weight of the ice in the area did not exceed that of an ice thickness of 2,000 feet. However, the exact amount of postglacial rebound of the region remains controversial.

Ice of various glaciations was active and thick enough to scour and remove part of the bedrock surface. Much of the evidence for pre-Illinoian and early Illinoian glaciations is missing from the northern part of our state. It was removed by the effects of the subsequent Wisconsinan glaciation, the last major glacial advance that began about 25,000 to 22,000 years B.P.

In the northern part of the field trip area, the thickness of material deposited by the glaciers (glacial *drift*) ranges from a few feet to somewhat more than 25 feet. Thicknesses of glacial deposits of slightly more than 50 feet can be found where the preglacial drainages of Saline River and its tributaries are present.

The landscape in the northern part of the Harrisburg field trip area developed on bedrock that is covered by relatively thin Illinoian glacial deposits eroded during and after glaciation. The landscape in the south and east is formed on bedrock that is bare or only thinly covered by glacial lake sediments and loess. Thickness of the loess ranges from about 3 feet in the northwest to somewhat more than 6 feet in the southeast. Although younger Wisconsinan glaciers of the Woodfordian Substage only reached as far south as the Shelbyville area, about 115 miles north-northwest of Harrisburg, outwash materials from the waning ice front were transported seaward by meltwater rivers rushing past this area.

GEOMORPHOLOGY

Physiography

The physiographic contrasts between various parts of Illinois are due to several factors, including the resistance to erosion of formations exposed at the bedrock surface and the topography of the bedrock surface, the extent of the various glaciations, differences in the thickness of the glacial deposits, differences in age of the uppermost glacial drift, and the effects of erosion on bedrock and surface deposits.

The Harrisburg field trip area embraces part of the southeastern margin of the Illinois part of the Mt. Vernon Hill Country. This is a subdivision of the Till Plains Section, a division of the Central Lowland *Physiographic Province* (fig. 7). This province embraces about four-fifths of Illinois. To the south the boundary between the Mt. Vernon Hill Country and the Shawnee Hills Section (a division of the Interior Low Plateaus Province) is marked approximately by the topographic boundary between the edge of the glacial deposits and the underlying Pennsylvanian *cuesta*. The Till Plains Section is characterized by broad *till* plains that are relatively uneroded (a youthful stage of erosion), in contrast with the maturely eroded Dissected Till Plains on older drift sheets in Iowa.

Harrisburg is located in the southeastern part of the Mt. Vernon Hill County, which Leighton and others (1948) describe as a region of mature topography with low relief and limited upland prairies and broad alluviated valleys along the larger streams. Because of the thinness of drift in this

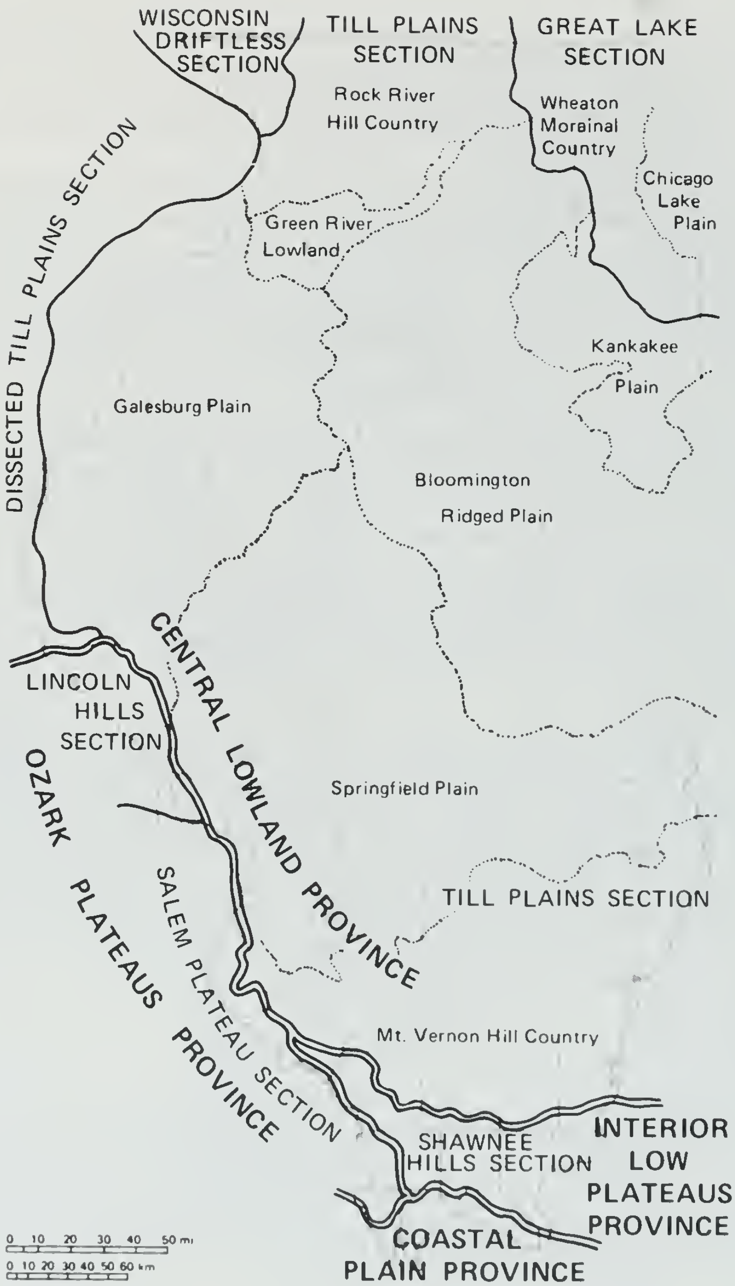


Figure 7 Physiographic divisions of Illinois.

area and its age, glacial landforms (such as moraines or large kames) appear to be lacking or difficult to recognize. No pre-Illinoian drift deposits are known in this field trip area.

According to Horberg (1946) and Leighton and others (1948), prior to glaciation, an extensive lowland called the "central Illinois peneplain" had been eroded into the relatively weak rocks of Pennsylvanian age east and south of the present Illinois River. The surface appears to have been one of low relief and sloped gently southward. Apparently, just before the advent of glaciation, an extensive system of bedrock valleys was deeply entrenched below the level of the central lowland surface. The gross features of the Till Plains Section, as well as local features of the Mt. Vernon Hill Country, are determined largely by this preglacial topography. As glaciation began, streams probably stopped eroding and began to aggrade, that is, the streams began to build up and fill in their channels because they did not have sufficient volumes of water to carry and move the increased quantities of sediments. There is no evidence to date to indicate that the early fills in these preglacial valleys ever were completely flushed out of their channels by succeeding meltwater torrents during deglaciation.

In the northern part of the Shawnee Hills, erosion left scattered low hills dotting the Pennsylvanian cuesta. To the south the topography is much rougher because of the very resistant lower Pennsylvanian sandstones exposed there.

Drainage

Because the Illinoian drift and Wisconsinan loess are relatively thin throughout much of the Harrisburg field trip area, modern drainage closely follows the alluviated preglacial bedrock valleys. Saline River and its branches form the primary drainageways eastward to the Ohio River, several miles south of Shawneetown. Most modern streams in the Harrisburg area have low *gradients* (bottom slopes) so that downcutting of their channels is minimal. They widen their courses by meandering back and forth across the low-lying ancient lake beds until channelization projects are initiated to straighten them for better drainage. The uplands generally have fairly good natural drainage.

Relief

The highest surface elevation along the Harrisburg field trip route is slightly more than 780 feet msl (mean sea level) at the crest of the west wall of Eagle Valley (mileage 49.35+). The lowest elevation is less than 340 feet msl, the water surface of Saline River below the bridge at Equality. Therefore, the maximum relief along the field trip route, calculated as the difference between the highest and lowest surface elevations, is more than 440 feet within a horizontal distance of about 6½ miles. The maximum local relief is about 540 feet from the ridge top 1/2 mile southeast of Old Stone Face to the access road to the latter, about 1/3 mile to the north-northwest. Generally, surface relief is low, ranging from about 45 to 65 feet in the northern and western parts of the area. To the south and southeast, relief increases dramatically as one approaches the dip slope of the Pennsylvanian escarpment and the upthrown side of the Shawneetown–Rough Creek Fault Zone, where several hundred feet of relief are common, as noted previously.

MINERAL RESOURCES

Groundwater

A mineral resource frequently overlooked in assessinq an area's natural resource potential is *groundwater.* Its availability can be essential for orderly economic and community development. Groundwater is the water supply for more than 5 million people who live in 88% of the state. Consequently, studies of groundwater resources are an integral part of the research and service programs at the Illinois State Geological Survey (ISGS).

Groundwater resources are obtained from underground formations called aquifers. *Aquifer* materials (sand and gravel, sandstones, fractured rocks) are water-saturated and permeable enough to transmit usable quantities of water to wells or springs. The source of groundwater is precipitation—rainwater or melting snow—that enters and infiltrates through the soil. Soil moisture that is not evaporated or used by plants percolates or seeps downward (because of gravity) and replenishes the groundwater supply. This process is called recharge. Recharge for most shallow wells occurs within a few miles of the well.

The water-yielding capacity of an aquifer is evaluated by constructing wells into it. Test wells are pumped and water samples collected to determine the quality and quantity of the water supply.

Pryor (1956) reported that the upland in Saline County contains thin glacial deposits that are generally unfavorable for developing drilled wells in sand and gravel. Wells are constructed, however, in the thin, discontinuous deposits of sand and gravel found in the valley fill of the Saline River. Because the unconsolidated materials overlying bedrock are recharged by local precipitation, they are susceptible to surface contamination.

Most domestic wells in the area are constructed in water-yielding sandstones of Pennsylvanian age that occur at depths below 100 feet north of Harrisburg and more than 300 feet south of town. Because these bedrock strata are also recharged by local precipitation, the only filtering of recharge water is through clay that is present in the overlying glacial deposits. Where the glacial units are thin or absent and the bedrock is exposed at the surface, recharge enters directly into the rock units and there is little, if any, filtering of contaminants.

Most municipal water supplies for Saline County residents come from four Saline County Water District wells situated northeast of the village of Junction in Sections 2 and 17, T9S, R9E, Gallatin County. The average pumpage from the four wells, whose total depths range from 135 to 143 feet, is 2.1 mgd (million gallons per day). This water is distributed to some 25,000 people via pipelines to the Eldorado Water Company, Harrisburg, the Illinois Youth Center, Junction, the Liberty–Bedford Public Water District, Muddy, and the Raleigh Water District. Other Saline County towns outside of the field trip area receive water from other water districts.

During the late 1970s and 1980s, much emphasis was placed on the development of water districts to augment and replace existing community water systems in Illinois. ISGS scientists were instrumental in geophysical exploration, test drilling, and development of the Saline County Water District well field in the large flat area covered by sediments deposited in Glacial Lake Saline. Work at the well field was completed in 1980 by members of the ISGS Hydrogeology and Groundwater Protection Section, in cooperation with other governmental agencies and active citizens in those counties. The preliminary location for the well field was originally established through field and subsurface mapping by then ISGS Chief John C. Frye and others (1972).

Mineral Production

Of the 102 counties in Illinois, 97 reported mineral production during 1990, the last year for which totals are available. The total value of all minerals extracted, processed, and manufactured in Illinois was $2.9 billion (Samson 1992).

In 1990, Illinois ranked fifth in the nation in coal production. The value of the 61.7 million tons of coal mined was $1,709.8 million. Although this was a 2.5% increase in tonnage over the previous year, only 19 counties reported coal production, as compared with 21 counties that reported previously. Perry, Saline, Franklin, and Randolph Counties together accounted for 51.8% of the state's total coal production (Samson 1992).

Crude oil production in Illinois decreased for the fifth straight year during 1990. Nearly 20 million barrels of crude oil, valued at $406.5 million, was produced during 1990—a total that placed the state 13th nationally (fig. 8). Less than 0.7 million cubic feet of natural gas, valued at nearly $1.5 million, was produced in the state during 1990.

Saline County ranked third among Illinois counties reporting mineral production during 1990. Coal, crude oil, and natural gas were the primary minerals extracted. The total value of minerals produced amounted to about $202.2 million. In 1990, five mines produced more than 7 million tons of coal valued at more than $201.0 million (based on $27.73 per ton). This tonnage, which was nearly 21% more than that produced during 1989, ranked the county second in coal production in Illinois. Underground mines extracted 6,087,431 tons of coal and surface mines produced 1,161,874 tons. Coal production for Saline County from 1833–1990 totaled 201,023,228 tons.

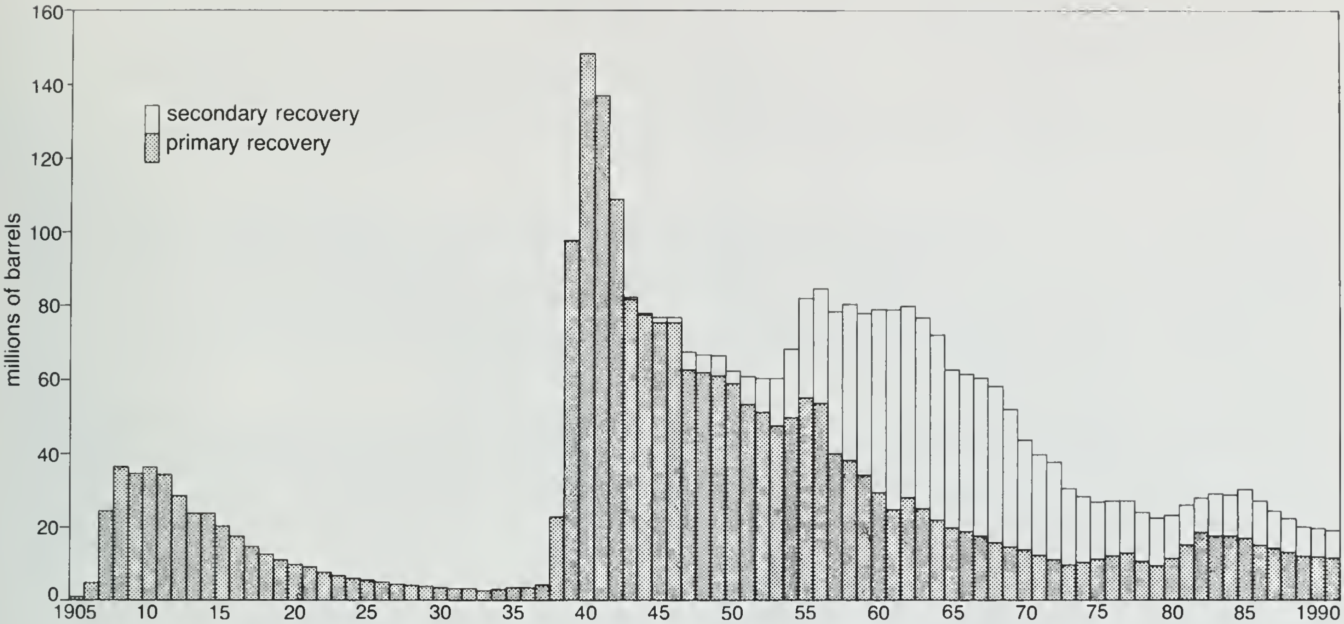


Figure 8 Annual crude oil production in Illinois, 1905-1991.

Saline County oil production in 1990 increased almost 11% above the 1989 total to 326,000 barrels valued at nearly $1.2 million (based on $20.37 per barrel). Cumulative oil production from 1888–1990 in Saline County was 24,977,000 barrels. Natural gas production during 1990 amounted to 12.2 mcf (million cubic feet), a decrease of more than 60% from that of the previous year.

GUIDE TO THE ROUTE

Assemble in the parking area on the south side of Harrisburg High School in the south part of Harrisburg (S½ SE NW NE, Sec. 21, T9S, R6E, 3rd P.M., Saline County; Harrisburg 7.5-Minute Quadrangle [37088F5]*). Mileage calculations will begin at the northeast entrance to the parking lot at Granger Street.

You must travel in the caravan. *Do not drive ahead of the caravan!* Please keep your headlights on while in the caravan. Drive safely but stay as close as you can to the car in front of you. Please obey all traffic signs. If the road crossing is protected by an emergency vehicle with flashing lights and flags, then obey the signals of the ISGS staff directing traffic. When we stop, park as close as possible to the car in front of you and tum off your lights.

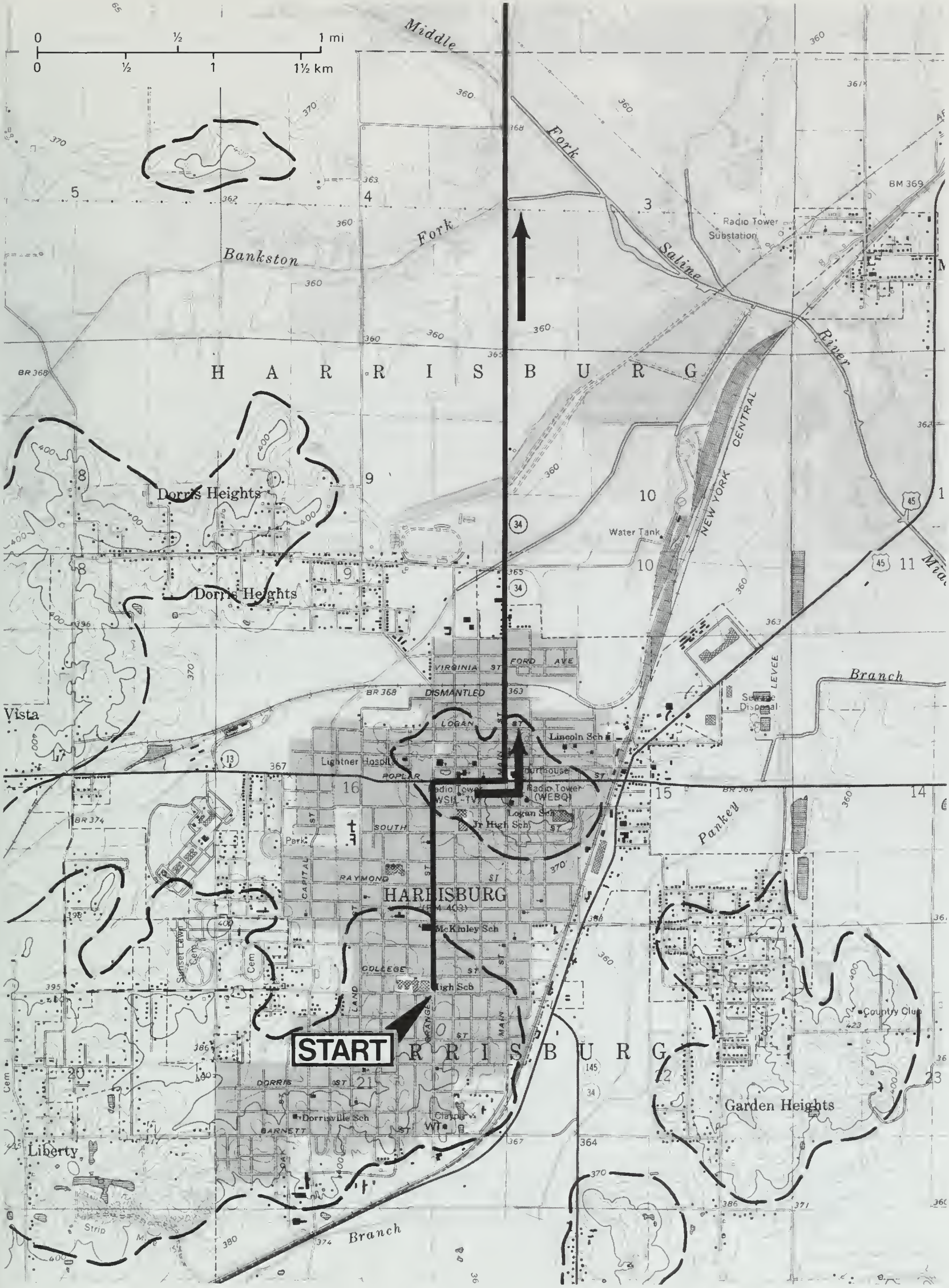
Some stops on the field trip are on private property. The owners have graciously given us permission to visit on the day of the field trip only. Please conduct yourselves as guests and obey all instructions from the trip leaders. So that we may be welcome to return on future field trips, please do not litter or climb on fences. Leave all gates as you found them. These simple rules of courtesy also apply to public property.

You may use this booklet for a field trip with your students, youth group, or family some time in the future. 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	EXIT from northeast entrance to parking lot. TURN LEFT (north) on Granger Street.
0.05+	0.05+	STOP: 4-way at West College Street. CONTINUE AHEAD (north).
0.15+	0.25	STOP: 4-way at Sloan Street. CONTINUE AHEAD (north). NOTICE the large cracks in the bricks in the building to the right on the northeast corner of the intersection. Settling of the structure because of inadequate footings has caused cracks to extend from the ground towards the roofline.
0.45+	0.7+	STOP: 2-way at West Poplar Street. and State Route (SR) 13. TURN RIGHT (east) on SR 13.
0.2+	0.95	Prepare to turn left ahead.
0.05	1.0	CAUTION: TRAFFIC LIGHT at Main Street (Junction of SR 13 and 34). TURN LEFT (north) on SR 34. The Saline County Courthouse is on the northeast corner of the intersection.
1.0+	2.0+	Leave Harrisburg's north city limits through the floodgate in the levee.

---

* The number in brackets [37088F5] 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
½
1 mi
0
½
1
1½ km
Middle
Fork
Saline
River
Bankston
Fork
Radio Tower
Substation
BM 369
H A R R I S B U R G
NEW YORK CENTRAL
Dorris Heights
Dorris Heights
Water Tank
Vista
VIRGINIA ST
FORD AVE
DISMANTLED
LOGAN ST
Lincoln Sch
Lightner Hospital
POPLAR
Courthouse
Radio Tower
(WSIL-TV)
Radio Tower
(WEBQ)
Logan Sch
Jr High Sch
SOUTH
Park
RAYMOND
CAPITAL
HARRISBURG
McKinley Sch
COLLEGE
High Sch
START
R R I S B U R G
Sewage
Disposal
LEVEE
Branch
Pankey
Country Club
Garden Heights
DORRIS
Dorrisville Sch
BARNETT
Liberty
Strip
Branch

0.75	2.75+	Drainage ditches have been installed to drain the low-lying, flat, poorly drained areas on both sides of the highway.
0.25+	3.05	Cross Bankston Fork.
0.35	3.4+	Cross Middle Fork Saline River.
2.0	5.4+	Prepare to turn right.
0.15	5.55+	TURN RIGHT (east) on Union Grove Road (1400N) from SR 34 (900E).
0.1+	5.7	CAUTION: narrow concrete culvert.
0.1+	5.8+	TURN LEFT (north) on Hale Rd. (925E). To the north, notice the oil well pumpjacks and the tank batteries.
0.4+	6.25	PARK along the roadside as far off on the shoulder as you can safely. WATCH for traffic and don't block the road.

STOP 1 At this location, we'll discuss the occurrence of oil in Illinois and the Raleigh South Oil Field. The tank battery on the west side of the road belongs to the McFarland Energy, Inc., Blakeley Lease (SE NE NW SW, Sec. 22, T8S, R6E, 3rd P.M., Saline County; Galatia 7.5-Minute Quadrangle [37088G5]).

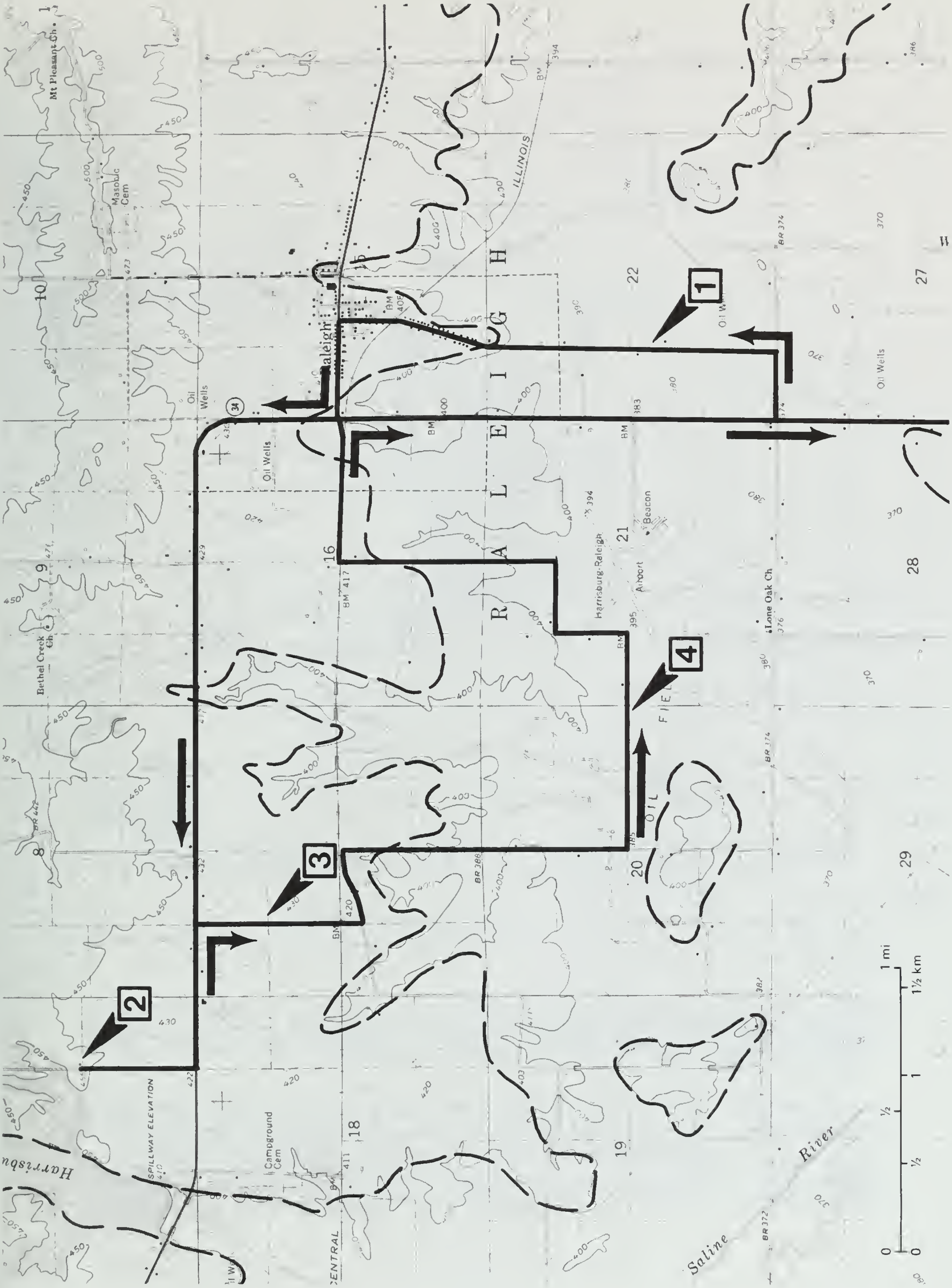
Oil fields in Saline County produce from a variety of formations. Each field is situated over an area where oil has become trapped in porous rocks. Figure 9 is a small scale map of the Illinois Basin oil fields. There are several kinds of oil traps (fig. 10) and they are rarely easy to locate. Geologists must use many techniques to try to determine where to look for an oil trap, what kind of trap they should look for, and how to go about looking for it.

The rocks immediately beneath the surficial deposits at this stop are of Pennsylvanian age. This means they were deposited about 290 million years ago. If we could see these rocks, we would notice that they are arched, or folded, into an *anticline* that trends northwest-southeast. It is common for oil to become trapped in porous rocks along the crest of such structures, and it is for this reason that the C.E. O'Neal No. 1 Wattaw well was drilled in Section 20, T8S, R6E, during 1955. Oil was found in this well, which led to the development of the Raleigh South Oil Field.

Production was originally all from sandstones in the Mississippian Aux Vases Formation (fig. 2) at a depth of 2,860 feet. Other Mississippian rock units that have produced here (pay zones) include the Waltersburg, Tar Springs, Bethel, O'Hara, Spar Mountain, McClosky, St. Louis, and Salem. By the end of 1992, almost 2.2 million barrels of oil had been produced from 77 wells; secondary recovery methods (waterflooding) began during 1960.

Water that is produced with the oil is removed by using separators—large cylindrical tanks with stacks protruding from the top (fig. 11). Separators work by utilizing the tendency of oil to float on water. The oil and water mixture is pumped into the separator and the oil is skimmed off from the top of the tank. Separators are heated in the winter with gas from the field to bring the oil–water mixture up to summer temperatures so the separation can take place faster.

The Blakely No.1 well is located in NE NW SW near the tank battery. It was completed in August 1984 to a depth of 4,100 feet. The pay zone for the well, the Rosiclare Sandstone Member of the Aux Vases Formation, is 2,966 to 2,968 feet deep. The Blakely No. 2 well lies to the west in NW



1
2
3
4
Raleigh
R A L E I G H
OIL FIEL
ILLINOIS
CENTRAL
Harrisburg-Raleigh Airport
Beacon
Lone Oak Ch
Oil Wells
Bethel Creek Ch
Masonic Cem
Mt Pleasant Ch
Campground Cem
SPILLWAY ELEVATION
Saline River
Harrisbu
0
½
1
1 mi
1½ km

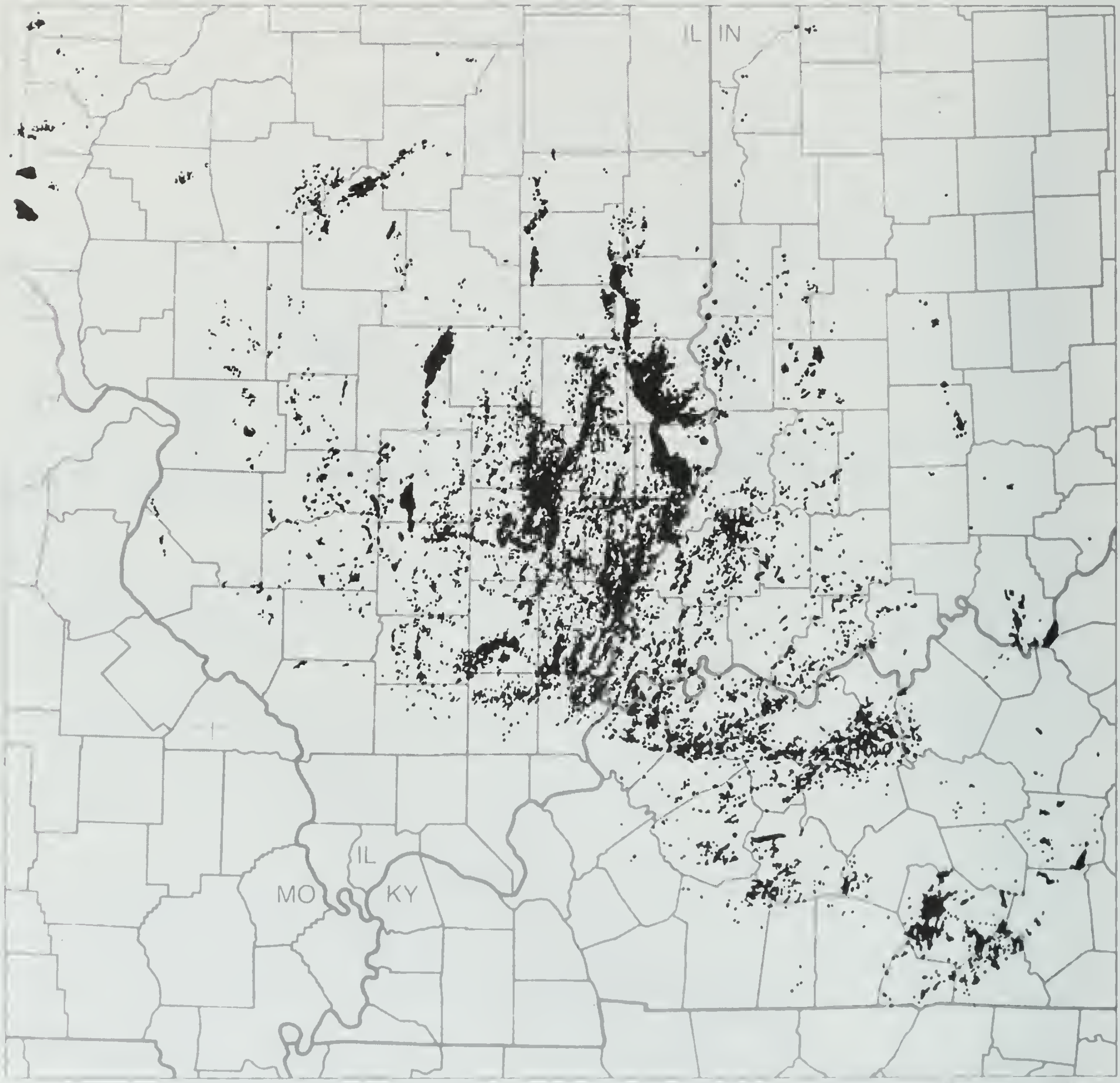


Figure 9 Oil fields of the Illinois Basin.

NW SW. It was completed in December 1984 to a depth of 4,302 feet. Pay zones in this well include the Tar Springs Sandstone at depths of 2,165 to 2,170 and 2,184 to 2,188 feet, and the St. Louis Limestone at depths of 3,273 to 3,279 and 3,862 to 3,868 feet.

0.0	6.25	Leave stop 1 and CONTINUE AHEAD (north). Several tank batteries and a number of pumpjacks are on both sides of the road as we go northward.
0.6+	6.85+	CAUTION: enter village of Raleigh on Main Street.

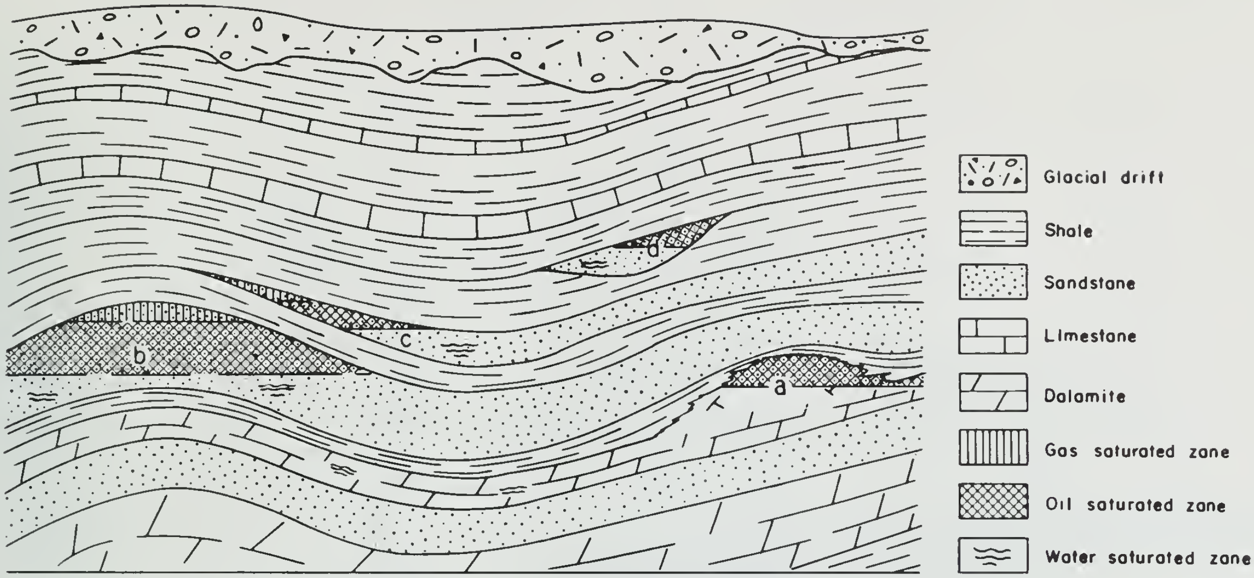


Figure 10 Places where oil is found in Illinois: (a) coral reefs, (b) anticlines, (c) pinchouts, and (d) channel sandstones.

0.3+	7.15+	CAUTION: single unguarded Illinois Central (IC) railroad track.
0.2	7.35+	STOP: 2-way. TURN LEFT (west) on Church Street and Raleigh Road (1550N).
0.35	7.7+	STOP: 2-way at intersection with SR 34 (900E). TURN RIGHT (north) on SR 34.
0.65	8.35+	Texas Eastern Transmission Corporation pipeline crossing. CONTINUE AHEAD (west).
1.85	10.2+	Prepare to turn right.
0.2+	10.45	TURN RIGHT (north) onto Harrisburg Lake Road, 1600N\675E.
0.2+	10.65+	The entrance to the Galatia Mine owned and operated by the Kerr–McGee Coal Corporation lies to the left. CONTINUE AHEAD (north).
0.15+	10.85+	TURN AROUND and head south at the end of the blacktop. PARK along the roadside. Do NOT block the road.

STOP 2 We'll view some of the surface facilities of the Kerr–McGee's Galatia Mine. (SE NE NW SE, Sec. 7, T8S, R6E, 3rd P.M., Saline County; Galatia 7.5-Minute Quadrangle [37088G5]).

During the late 1960s, Kerr–McGee Coal Corporation began acquiring coal rights in the Illinois Basin. Construction of the Galatia Mine began in mid-1981 and the first coal was shipped by unit train 2½ years later. Conceived as a two seam operation in the Herrin (No. 6) and Springfield (No. 5) Coal Members of the Pennsylvanian Carbondale Formation, the first to be developed was the deeper Springfield Coal because of its higher quality (fig. 12). (Locally, the Springfield Coal is still referred to by its former name, Harrisburg Coal.) Coal was produced from the No. 6 Mine in

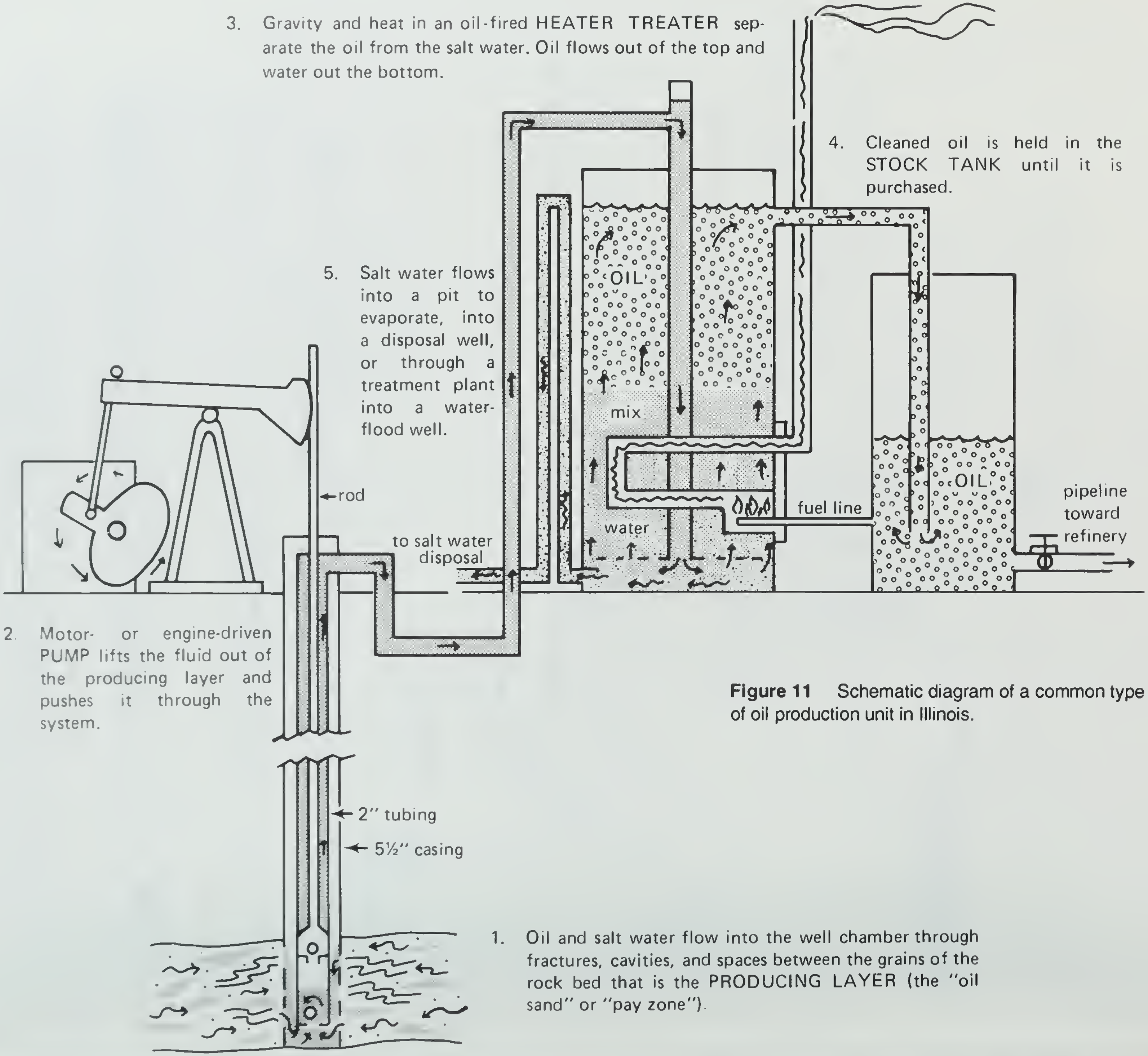


Figure 11 Schematic diagram of a common type of oil production unit in Illinois.

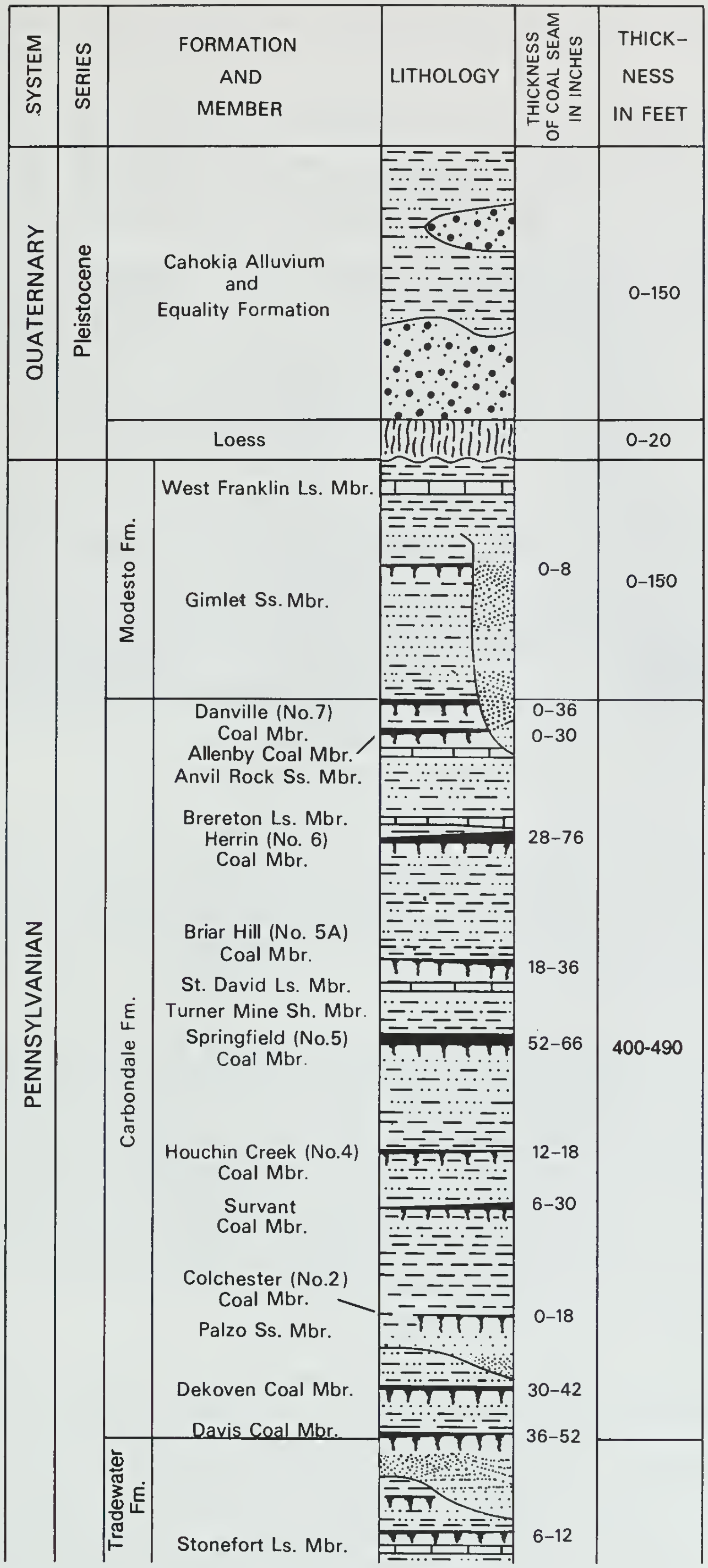


Figure 12 Generalized columnar section showing the Quaternary and the upper portion of the Pennsylvanian strata known from drill holes and exposures in the field trip area (after Nelson and Lumm 1986).

late 1985. As designed, the Galatia Mine was to be capable of producing 4.1 million tons of coal per year and to have a life expectancy of 40 years.

The No. 6 and No. 5 mines are basically separate operations because the coal from each mine is kept separate throughout cleaning and preparation for market. The combined total of production from both seams exceeded 3.5 million tons per year for the last 2 years. Both mines share a slope and a shaft to access the two coal seams. The shaft and slope access each have two compartments. The 14-foot-wide by 16-foot-high slope is inclined 17° from the horizontal; two conveyor belts in the top compartment transport the coal from the two mines, while tracks in the lower compartment carry supplies underground. The conveyor belts emerge from the mine portal on the north side of SR 34 and are carried on elevated covered legs across the highway and south to the raw coal silos. From these silos, the coal goes through the preparation plant where as many impurities as possible are removed, including clay, shale, and pyrite (one of the sources of the deleterious sulfur). The clean coal is stored in other silos while awaiting transfer to unit trains dedicated to carrying the finished product to power plants outside of the area.

The shaft headframe, with the large diameter pulley at the top, is just a few hundred feet south of us and to the right (west) of the road. This 28-foot-diameter concrete, vertical shaft extends to a depth of 574 feet. It is heavily reinforced to withstand any earthquake activity that might occur in the area. A concrete partition down the center of the shaft separates the intake air from the exhaust air. The intake compartment also contains a cage that provides access to the mine. Other buildings behind the berm contain the main offices, the engineering department, classrooms where mine safety is taught, locker rooms for miners' clothing, showers, and mine supplies. Housecleaning throughout the mine is maintained at a high level, even to having a bank of hoses at the shaft bottom so that miners can clean their boots before returning to the bathhouses on the surface. The mine also provides and launders the miners' work clothes.

No. 5 Mine Production began in this mine in November 1983, and by 1984, the mine was producing nearly 1 million tons of Springfield Coal. Production in the last several years has averaged around 2 Million tons. Until 1992, mechanical continuous miners followed a room and pillar mine plan (fig. 13a). They used 20-foot-wide entries and crosscuts with 55-foot-square pillars of coal left behind for roof support. Recently, the No. 5 mine switched to longwall mining (fig. 13b) to maximize recovery of this lower sulfur coal.

The Springfield Coal averages 6½ feet thick and lies at a depth of 550 feet below the surface. As a cleaned product, the Springfield Coal has an average heating value of 11,797 Btu and sulfur content of 1.28%. To satisfy market demands, Kerr–McGee is starting to expand their lower sulfur production at the Galatia Mine. The Springfield Coal reserves in the No. 5 mine are split into a north and south field by an ancient stream channel filled with sandstone and siltstone (the Galatia Channel). This channel, which formed while the peat that formed the coal was accumulating, replaces the coal along a swath approximately 3/4 mile wide. Mining is currently taking place in the southern reserves, but Kerr–McGee is presently driving a 4,400-foot-long tunnel through the rock filling this paleochannel to reach the Galatia North reserves, which have even lower sulfur values than the 1.5% or less found in the southern field.

The immediate roof of the Springfield Coal consists of 60 to 90 feet of gray siltstone and silty shale known as the Dykersburg Shale. This is overlain by about 1.5 feet of Briar Hill Coal, which is in turn overlain by 15 to 20 feet of sandstone, shale, and underclay beneath the Herrin Coal. The thick gray siltstone and silty shale of the Dykersburg that overlie the Springfield Coal are a key to its lower sulfur values and greater marketability. These rocks were deposited as a covering of mud and silt from flooding in the Galatia Channel through breaks in its natural levees. The clays in this thick deposit of mud and silt were impermeable enough that they protected the

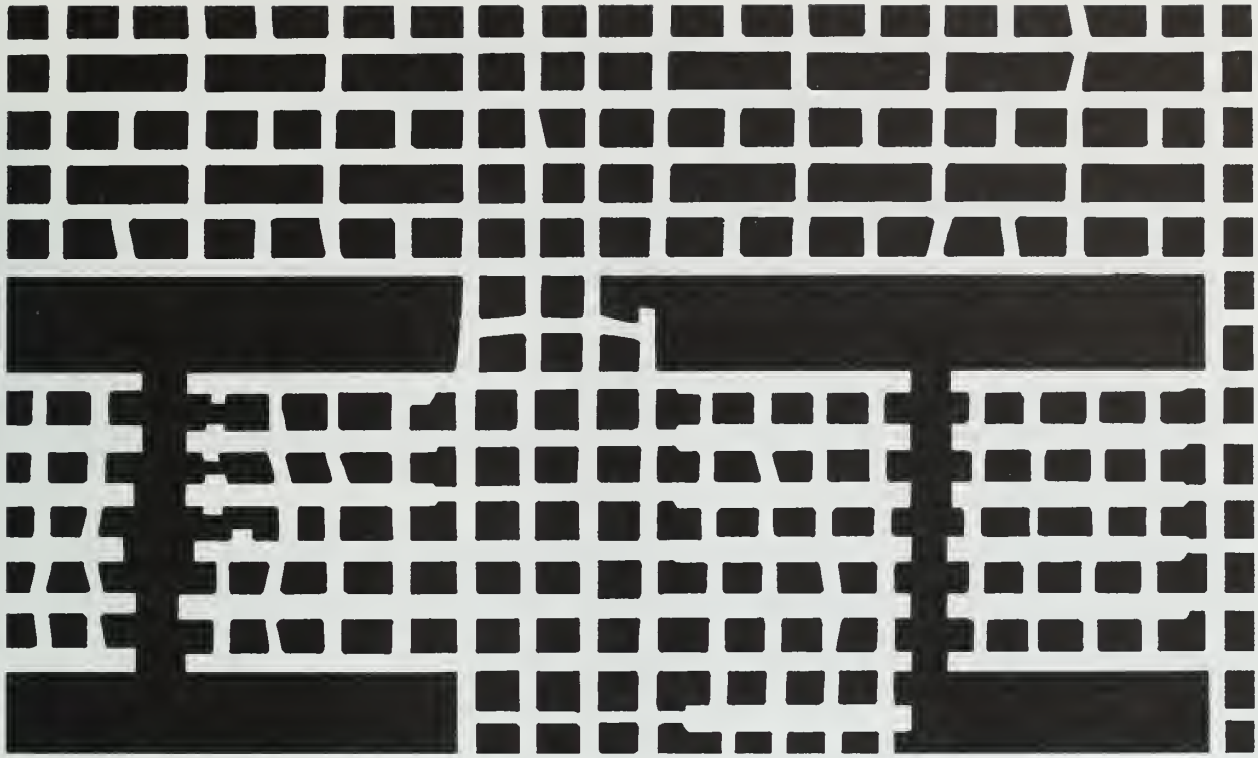


Figure 13a Typical plan of a portion of a room and pillar mine in southern Illinois.

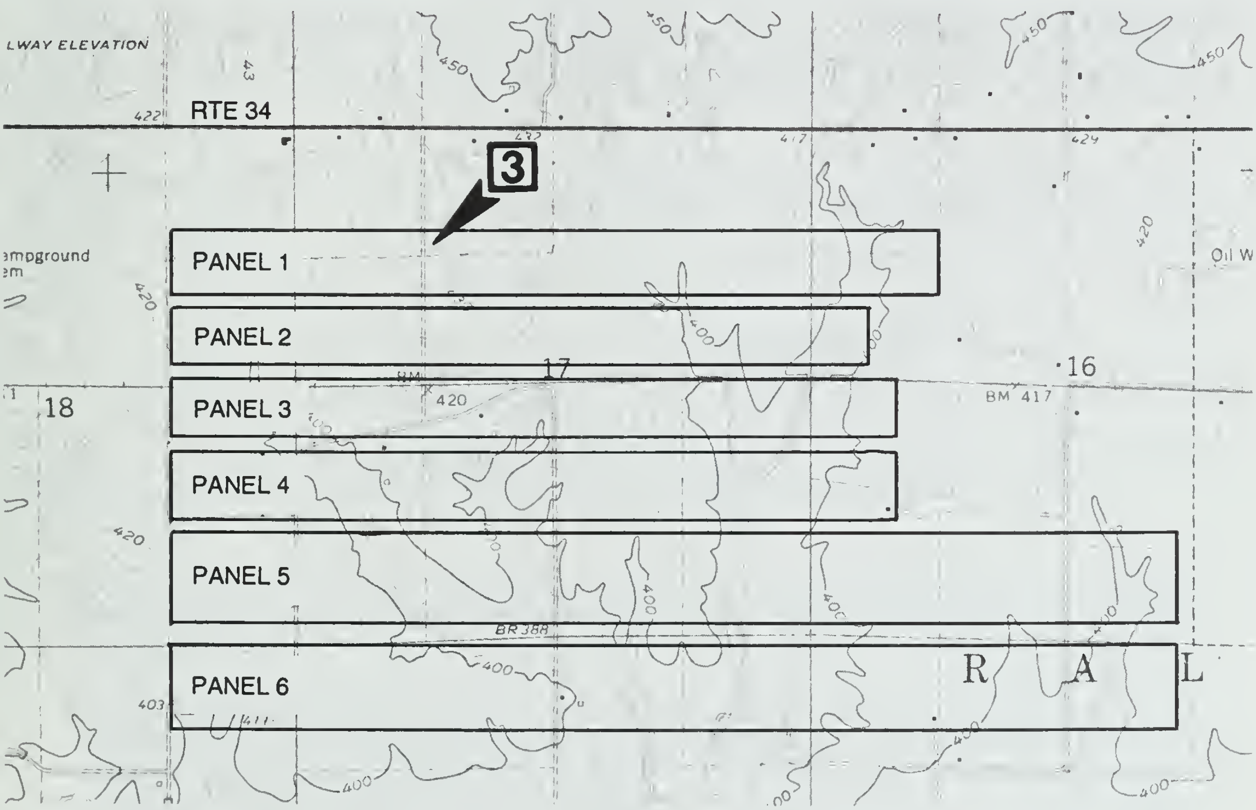


Figure 13b Plan of longwall panels in Mine No. 6, Kerr-McGee Coal Corporation, Galatia Mine.

underlying "Springfield" peat from being contaminated by the sulfur from seawaters that eventually covered the Springfield (and many other coals such as the Herrin).

No. 6 Mine The No. 6 mine started production in September of 1985. The No. 6 mine has used both longwall and room and pillar operations. Room and pillar mining is used in both mines wherever conditions require that subsidence of the roof be prevented. Room and pillar mining leaves about 50% of the available coal resource in the ground, and therefore, is less cost effective than longwall mining. The longwall panels in the No. 6 Mine are 640 by 8,000 feet. Three-foot-deep cuts are taken by the longwall mechanical shearer, and the mining in the panels is done by retreating from the coal face of the initial cut.

The Herrin (No. 6) Coal averages 6 feet thick and is about 450 feet deep, the depth increasing toward the north. The Herrin Coal is a typical high-sulfur Illinois coal (2.4% or more). (The No. 6 coal here is much higher in sulfur content than the No. 5 coal.) Clean coal (as rated by the mine) has a heating value of 11,659 Btu/lb with an average sulfur value of 2.42%. Production from the No. 6 mine averaged 1.5 million tons for the last 3 years.

The immediate roof of the coal consists of black Anna Shale that is 0.5 to 3 feet thick and may be locally underlain by gray Energy Shale, 2 to 10 feet thick. The Brereton Limestone, 4 to 5 feet or more thick, overlies the Anna Shale wherever the Energy Shale is absent. The Brereton Limestone is in turn overlain by the Anvil Rock Sandstone, which is 30 to 40 feet thick. Shales, siltstones, sandstones, and thin coals and limestones make up the remainder of overlying rock up to the surface.

The Anvil Rock Sandstone carries mineralized water, which causes a number of problems for the mining operation, including weakening of the soft underclay floor of the No. 6 mine and the need to pump the water out of the mine. In addition, the dissolved sodium chloride (NaCl) in the water is quite corrosive. In the Herrin Coal, the mine has encountered large limestone inclusions called coal balls. In some places the entire seam is taken up so completely by the coal balls that the mine was forced to leave blocks of coal unmined.

0.0	10.85+	Leave Stop 2 and return to SR 34.
0.4+	11.25+	STOP: 1-way at SR 34. TURN LEFT (east).
0.4	11.7	Prepare to turn right.
0.1+	11.8+	TURN RIGHT (south) at T-intersection (1600N\725E) on Lone Oak Road.
0.25	12.05+	PARK along the roadside. Do NOT block the road.

STOP 3 Ground subsidence above a longwall coal mine will be our topic of discussion. (West side of the road, SE SE NW NW, Sec. 17. T8S, R6E, 3rd P.M., Saline County; Galatia 7.5-Minute Quadrangle [37088G5]).

The ISGS, under the Illinois Mine Subsidence Research Program (IMSRP), has been monitoring bedrock fracturing and changes in hydrogeology associated with longwall coal mining and subsequent planned subsidence over three panels of the No. 6 Mine of the Kerr–McGee Coal Corporation Galatia Mine (fig. 13b panels 1–3). IMSRP staff have installed core holes and wells for testing and monitoring. The various monitoring wells, located several feet east of the road, were drilled into the bedrock or the glacial materials so that water levels could be monitored on a continuing basis. Surveying monuments were also installed so that changes in elevation of the ground surface both during and after subsidence could be recorded.

The Galatia Mine longwall panels are operating in the Herrin No. 6 Coal seam at a depth of 350 to 400 feet. The longwall equipment removes all the coal from panels that are 660 to 940 feet wide by 2 miles long. The machinery sweeps back and forth across the width of the panels. With each pass, it removes a block of coal 3 feet wide by 6 feet high. Where the mining machinery is operating, the mine roof is temporarily supported by moveable shields, providing a safe working area for miners and equipment. When the shields are moved, the roof is intentionally allowed to cave behind the working area. The resulting subsidence of the ground surface is 4.5 to 5 feet at the center of the panel and 1 foot over the pillars left between the longwall panels. Under law, the coal companies are responsible for mitigating problems resulting from subsidence at the ground surface.

Here we are located about on the center line of Panel 1 (fig. 13b). The swales in the surface, to the east and south, were there before mining. The releveled road and enhanced drainage along the roadway are the most visible indicators of surface subsidence in this area.

0.0	12.05+	Leave Stop 3 and CONTINUE AHEAD (south).
0.25+	12.3+	CAUTION: unguarded single track (IC) railroad crossing. CONTINUE AHEAD (south).
0.05+	12.35+	T-road intersection (1550N\725E). TURN LEFT (northeast) on Lone Oak Road.
0.75+	13.15	CAUTION: narrow culvert with unguarded sides.
0.05	13.15+	Texas Eastern Transmission Corporation pipeline crossing.
0.45+	13.65	T-road intersection (1450N\750E). TURN LEFT (east) on Strawberry Lane.
0.2+	13.85+	Cross drainage ditch.
0.25+	14.1+	**PARK** along the roadside. Do NOT block the road.

STOP 4 Glacial lake beds and some topographic features will be discussed at this site. (SE SE SE NE, Sec. 20, T8S, R6E, 3rd P.M., Saline County; Galatia 7.5-Minute Quadrangle [37088G5]).

As noted in the introduction, Illinoian glaciers apparently reached only the northern part of the field trip area. Here we are along the glacial border. Prior to Illinoian glaciation, nearly 300,000 years ago, the Saline River evidently flowed eastward along the north side of the Shawneetown Hills before joining the Ohio River about 16 miles north and east of its present confluence. The Saline River was much deeper then than it is now. The old valley was partly filled with outwash materials from the melting Illinoian glacier, but the river was unable to remove all of that debris. Still later, Wisconsinan glaciers extended southward into Illinois and Indiana to about 115 miles north of here. Tremendous volumes of meltwater coursed down the Wabash River valley from the melting of both the Lake Michigan and Lake Erie glacial lobes, especially the latter. Fidlar

(1948) estimated that the Wabash River must have been at least 5 miles wide and 15 to 20 feet deep throughout part of its course during the summers when melting was at a maximum.

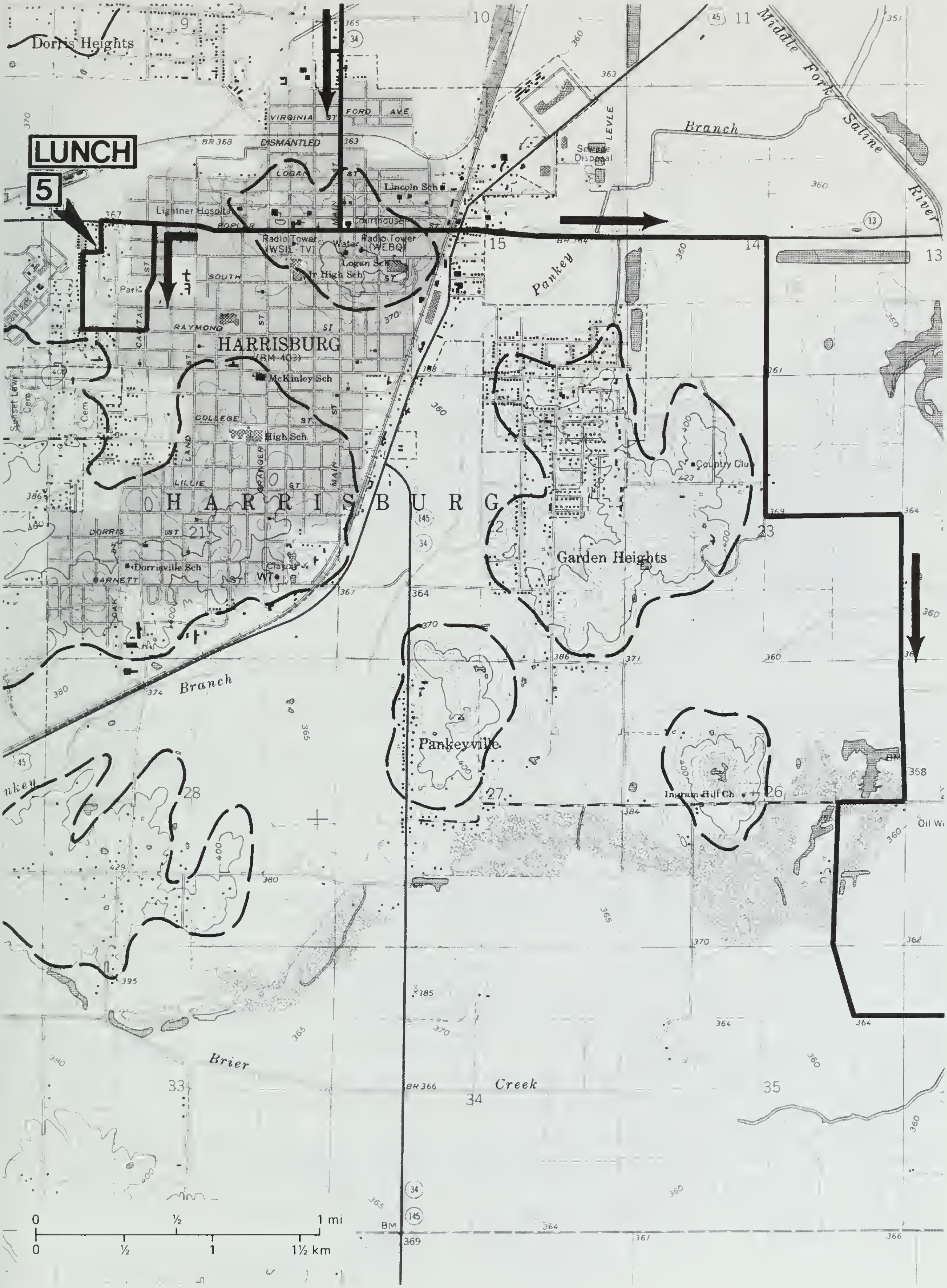
During early Wisconsinan time, meltwater from the glacial lobes in Lakes Erie and Michigan carried large quantities of outwash material down various drainageways. Deposition of these sediments farther downstream caused many of the tributary streams of the large drainageways to pond and form extensive slackwater lakes. A large slackwater lake, Lake Saline, covered parts of five counties in this region (see map of Quaternary Deposits of Illinois in the appendix, *Pleistocene Glaciations of Illinois*). These lakes fluctuated in size throughout Wisconsinan time. Studies of faint terraces along what must have been the Lake Saline shoreline suggest that the highest lake level, nearly 400 feet, was attained during early Woodfordian time (about 20,000 radiocarbon years B.P.). Although the lake held at this level for no more than 1,000 years, the sediment-choked streams flowing into the lake supplied as much as 150 feet of sediment. The lake persisted for 3,000 to 4,000 years. The high-level phase of Lake Saline ended during mid-Woodfordian time when the major streams incised channels through the thick outwash fills, removing the barriers that had produced the slackwater lakes. New drainage across the lake plain was established, including the lower part of Saline River that now passes through the narrow area between Gold Hill and Wildcat Hills.

Although subsequent outwash deposition caused lakes to form again, they never reached the high levels of early Woodfordian time. Glacial Lake Maumee, the precursor to modern Lake Erie, drained westward down the Wabash Valley about 14,000 years B.P. These flood waters eroded a surface called the Maumee Terrace as they passed on both the east and west sides of the Shawneetown Hills several miles east of here.

The former lake bed in the Saline River Valley still floods with Ohio River backwater from time to time with the result that the Pleistocene lake sediments are veneered with thin alluvium of Holocene age. The flood of 1937 is believed to have formed a lake approximately the size of the Wisconsinan glacial lake that existed during the time of the Maumee Torrent.

The tall tower to the south is on the hill at Harrisburg, about 5 miles away. The shorelines of glacial Lake Saline, as denoted on field maps by the late John C. Frye and Harold B. Willman, are shown on the route maps. Here we are standing on the old lake bottom. The large hill barely visible in the distance to the left at about 30 minutes past 10 o'clock is Cave Hill; we will cross the ridge on the south side of Cave Hill this afternoon.

0.0	14.1+	Leave Stop 4 and CONTINUE AHEAD (east).
0.25+	14.35+	VIEW to the right is across the flat, low-lying glacial lake plain beyond the tank batteries in the distance.
1.25+	15.65+	CAUTION: unguarded single track (IC) railroad crossing. T-intersection just beyond tracks (1550N\850E). TURN RIGHT (east) on Strawberry Lane.
0.45+	16.15+	STOP: 2-way at intersection (1550N\900E). TURN RIGHT (south) on SR 34.
0.05	16.2+	CAUTION: guarded single (IC) railroad track. CONTINUE AHEAD (south).
0.5	16.7+	VIEW to the left of some of the tank batteries and pumpjacks in the Raleigh South oil field. To the left at about 30 minutes past 10 o'clock is the location of Stop 1.

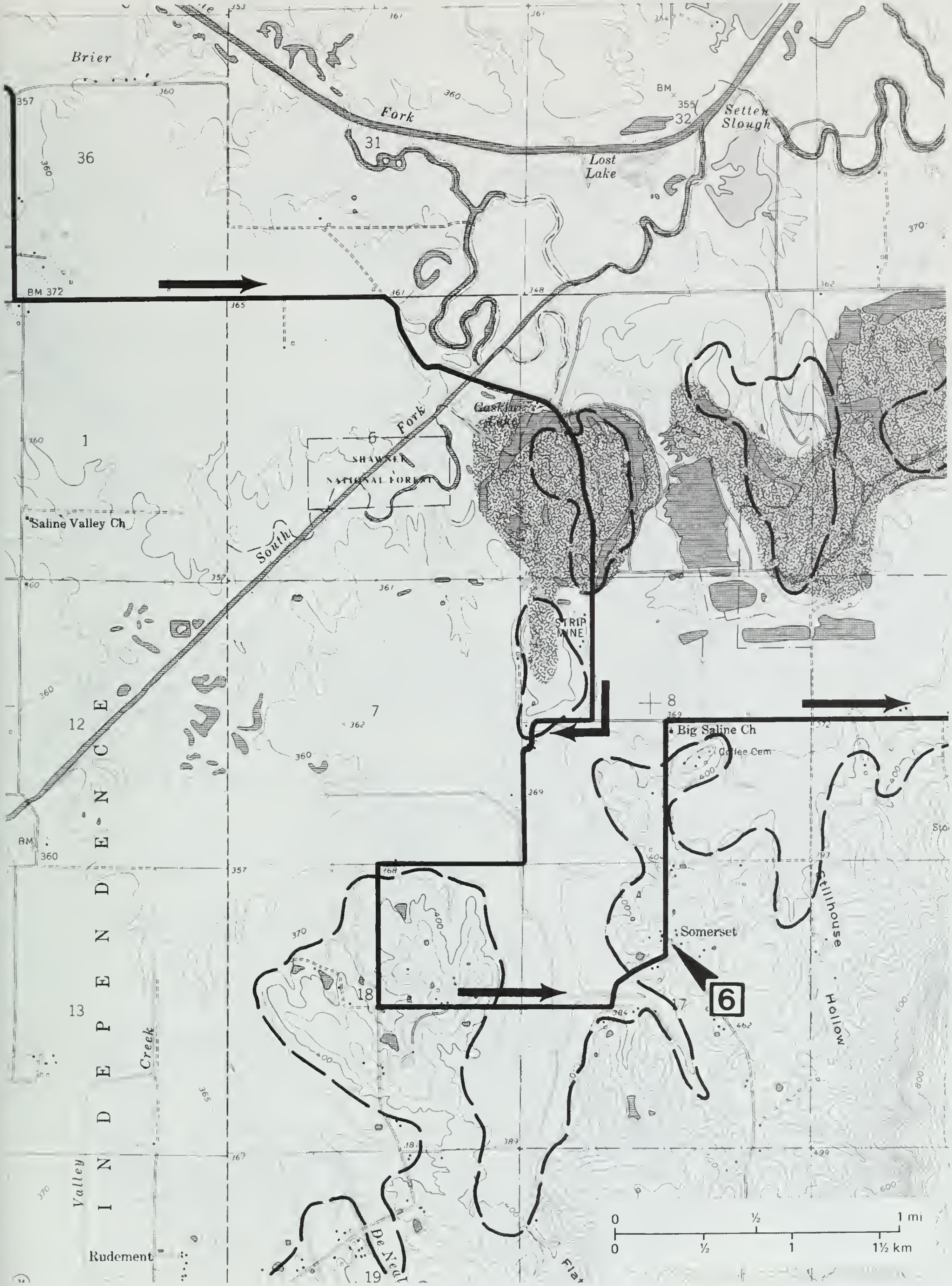


LUNCH
5
Dorris Heights
HARRISBURG
H A R R I S B U R G
Garden Heights
Pankeyville
Lightner Hospital
Lincoln Sch
Courthouse
Radio Tower (WSIL-TV)
Radio Tower (WEBQ)
Logan Sch
Jr High Sch
McKinley Sch
High Sch
Dorrisville Sch
Country Club
Ingram Hill Ch
Sewage Disposal
Middle Fork Saline River
Branch
Pankey
Brier
Creek
0 ½ 1 mi
0 ½ 1 1½ km

3.15+	19.85+	Cross Middle Fork Saline River.
0.35+	20.25	Cross Bankston Fork.
1.0+	21.25+	CAUTION: enter Harrisburg through the levee gate.
1.0+	22.3	CAUTION: TRAFFIC LIGHT at Poplar Street. TURN RIGHT (west) on SR 13 (Poplar Street).
0.65+	22.95+	T-intersection from left. TURN LEFT on South Capital Street.
0.4	23.35	TURN LEFT (west) on West Raymond Street.
0.1	23.45	CAUTION: entering Harrisburg Township District Park.
0.1+	23.55+	STOP: 4-way. TURN RIGHT (north).
0.25+	23.85	T-intersection. TURN RIGHT (east).
0.05+	23.9+	CAUTION: intersection with South Herbert Street. CROSS street and PARK in designated areas at the Tom and Ruth Patton Pavilion. Do NOT block the park roads. Mileage figures resume from this entrance.

STOP 5 Lunch.

0.0	23.9+	Leave Stop 5 and TURN RIGHT (north) on South Herbert Street.
0.1+	24.0+	STOP: 1-way intersection with West Poplar Street (SR 13). TURN RIGHT (east).
0.85	24.85+	CAUTION: TRAFFIC LIGHT at Main Street. CONTINUE AHEAD (east) on SR 13.
0.4+	25.25+	CAUTION: TRAFFIC LIGHT at Commercial Street (US 45). CONTINUE AHEAD (east) on SR 13.
0.1	25.35+	To the left is the site of O'Gara Coal Company Mine No. 2. This shaft mine was 245 feet deep and recovered the Springfield Coal, which averaged some 5 feet thick. The mine operated from 1904 to 1910.
0.45	25.8+	Cross over the top of the Harrisburg levee.
0.4	26.2+	Prepare to turn right.
0.1+	26.35+	TURN RIGHT (south) at T-intersection of Shawnee Hills Road (950N\1050E).
0.4	26.75+	VIEW to left (east-southeast) of Cave Hill that we noted previously.
0.45+	27.2+	T-road from right. CONTINUE AHEAD (south) on Waterhole Road. Just ahead to the left, notice the flatness of the old lake bottom.
1.35	28.55+	The area to the right is a long abandoned coal strip mine.


Brier
Fork
Setten Slough
Lost Lake
Gaskins Lake
Fork
South
SHAWNEE NATIONAL FOREST
Saline Valley Ch
STRIP MINE
Big Saline Ch
Coffee Cem
Somerset
6
Stillhouse Hollow
INDEPENDENCE
Valley Creek
Rudement
De Neal
Flat
BM 372
0
½
1 mi
0
½
1
1½ km

0.25	28.8+	STOP: 1-way at Ingram Hill Road T-intersection (750N\1100E). TURN RIGHT (west).
0.2+	29.05+	TURN LEFT (south) at Brier Creek Road T-intersection (750N\1075E). This area has been strip-mined and at least partially reclaimed.
1.15+	30.2+	CAUTION: narrow concrete culvert and just beyond is South Fork Road T-intersection (675N\1125E). CONTINUE AHEAD (south).
0.7+	30.95+	CAUTION: unguarded T-intersection with Whitesville Road (600N\1125E). The stop sign appears to have been torn down on the southwest corner. TURN LEFT (east).
1.75+	32.7+	Cross South Fork Saline River. This stream was partially straightened a number of years ago.
0.3+	33.05+	Horseshoe Road T-intersection from left (565N\1310E). CONTINUE AHEAD (southeast) on Whitesville Road through an adandoned strip-mined area.
0.45+	33.7+	Saline County Landfill to the right. The landfill is in the abandoned Somerset Coal Mine, Saxton Coal Company. Two coals were exposed in the highwall west of the road. The upper coal was the Dekoven and the lower one was the Davis. Because these two coals are so remarkably persistent in Saline and Gallatin Counties, they were strip-mined wherever they were close to the surface. To the east and north, these coals thin rapidly and become almost unrecognizable. In this area, the Dekoven occurs, on average, about 250 feet deeper than the Springfield Coal. The Dekoven and Davis are brought close to the surface here because of folding and faulting of strata along the Shawneetown–Rough Creek Fault Zone. About 5 miles north of this locality, the Dekoven is about 560 feet below the surface.
0.65	34.15+	T-intersection with Stoneface Road (450N\1325E). TURN RIGHT (west).
0.7+	34.9+	CAUTION: TURN RIGHT and cross drainage ditch.
1.0	35.9+	STOP: 1-way at crossroad (350N\1250E). TURN LEFT (east) on De Neal Road.
1.1+	37.05	PARK along the roadside. CAUTION: there is very little shoulder to park on. Watch out for FAST TRAFFIC. Do NOT block the road. **NOTE:** do NOT cross fences!

STOP 6 We'll examine the upper Tradewater Formation Curlew Limestone (Pennsylvanian). (NE NE SE NW, Sec. 17, T10S, R7E, 3rd P.M., Saline County; Rudement 7.5-Minute Quadrangle [37088F4]).

The Curlew Limestone is exposed on both sides of the road here. Much of this marine limestone has been dissolved away, and a chert residuum has been left behind in this area. The pieces of chert commonly contain excellent molds of fossils, especially brachiopods, bryozoan fragments, and crinoid columnals. Less common are corals, pelecypods, and sponges. (Note the fossil plates in the appendix, *Depositional History of the Pennsylvanian Rocks.)*


7
Horseshoe
Hargrave Hollow
SALINE COUNTY
STATE CONSERVATION AREA
Glen Jones Lake
Snockey Pond
SALINE
Three Springs Hol
Blue Spring Hollow
Horseshoe Hill
Horseshoe Hollow
Cave
Sulphur Springs Ch
Parker Lakes
BM 354
Setter Slough
Branch
Mt Pleasant Ch
Jones Cem
SHAWNEE
Wiedeman Hollow
Forwe Hollow
Stone Face
Big Saline Ch
0 ½ 1 mi
0 ½ 1 1½ km

0.0	37.05	Leave stop 6 and CONTINUE AHEAD (north).
0.05	37.05+	CAUTION: T-intersection from right of Somerset and DeNeal Roads (375N\1350E). CONTINUE AHEAD (north).
0.75	37.8+	CAUTION: T-intersection with Stoneface Road (450N\1350E).
0.95+	38.8	Stoneface Lane to the right (450N\1450E). CONTINUE AHEAD (east and then north).
1.4+	40.25+	Eagle Mountain T-intersection to the right (565N\1510E). CONTINUE AHEAD (northeast).
0.15	40.4+	The area to the left is a reclaimed strip mine.
0.15+	40.55+	STOP: 1-way at Horseshoe Road (600N\1515E). BEAR RIGHT (northeast).
0.4	40.95+	R-intersection with Rocky Branch Road (635N\1540E). CONTINUE AHEAD (northeast) on Horseshoe Road.
0.05+	41.05+	Entrance to Sulphur Springs Baptist Church lies to the right. A cave in the Mississippian Kinkaid Limestone is located in the bluff about 1/2 mile behind the church.
0.85	41.9+	CAUTION: narrow wooden bridge.
0.3+	42.25	Mississippian Chesterian sandstone (quartzite) exposed in a roadcut.
1.15+	43.45	TURN LEFT (north) into the parking area and PARK. Walk north and east following the lane across the creek and around the east end of the small hill; the abandoned quarry is on the north side. CAUTION: luxuriant poison ivy!

STOP 7 Lower Mississippian Fort Payne Formation and Upper Devonian New Albany Shale Group strata are exposed here in the Horseshoe Quarry. The Devonian strata are the oldest rocks exposed on the field trip. (W½ NW NE, Sec. 36, T9S, R7E, 3rd P.M., Saline County; Rudement 7.5-Minute Quadrangle [37088F4]).

About 200 feet of the Mississippian Fort Payne Formation is exposed in this quarry in a fault block within the Shawneetown Fault Zone (fig. 14). Below the Fort Payne, several feet of the Upper Devonian New Albany Shale Group is exposed along the north side of the quarry.

The Fort Payne, as exposed here, consists of highly shattered, siliceous shale and limestone that were quarried here for use as road stone. At depth, however, the Fort Payne consists of calcareous siltstone and limestone. Apparently weathering has resulted in silicification (replacement by silica) of these rocks at the surface. The New Albany, which consists of thin bedded black shale, has also been silicified.

The greatest known amount of displacement along the Shawneetown Fault has occurred at this locality. The New Albany Shale occurs at a depth of about 3,700 feet below the surface on the north side of the fault. This block was pushed up during a great thrusting movement along the

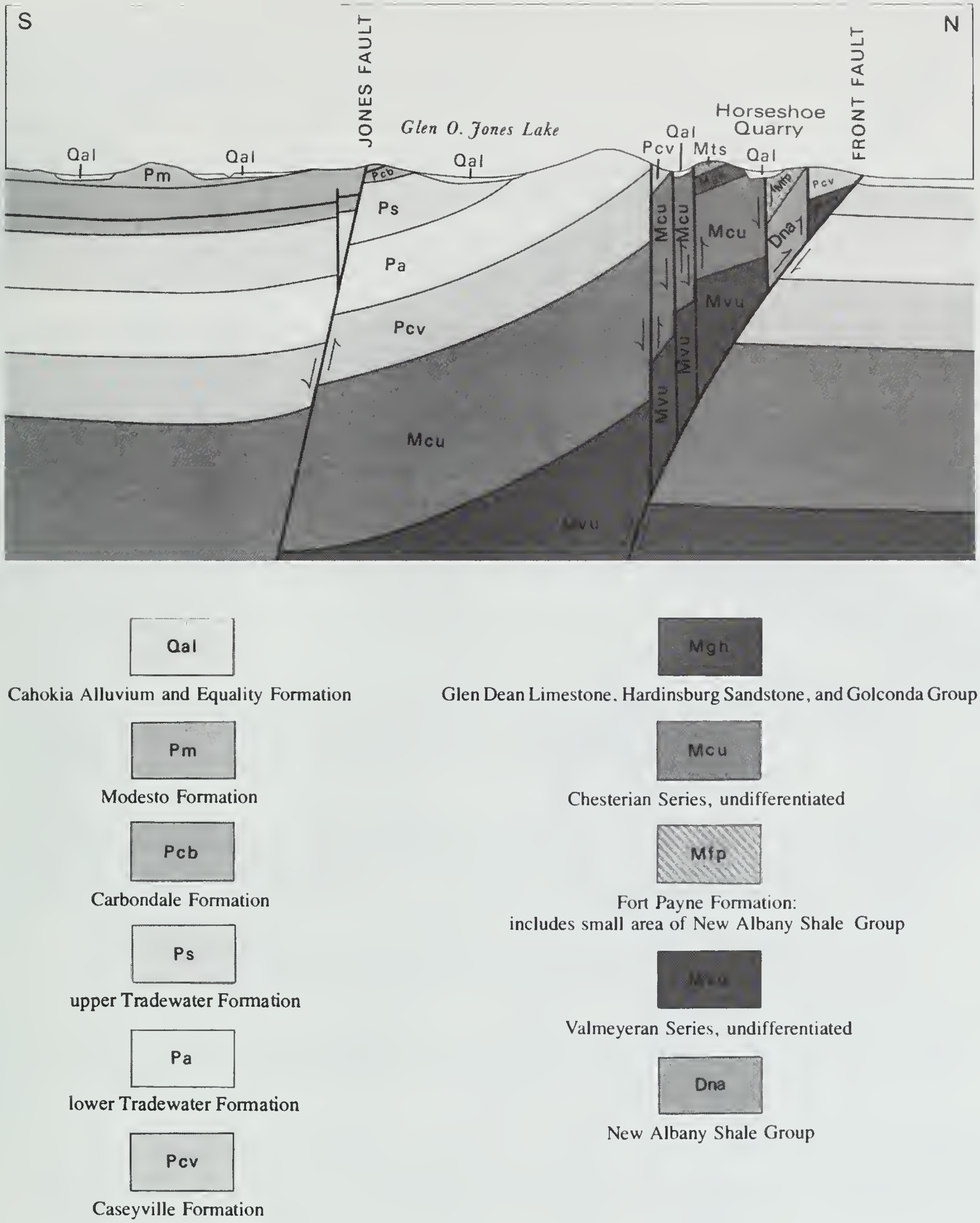


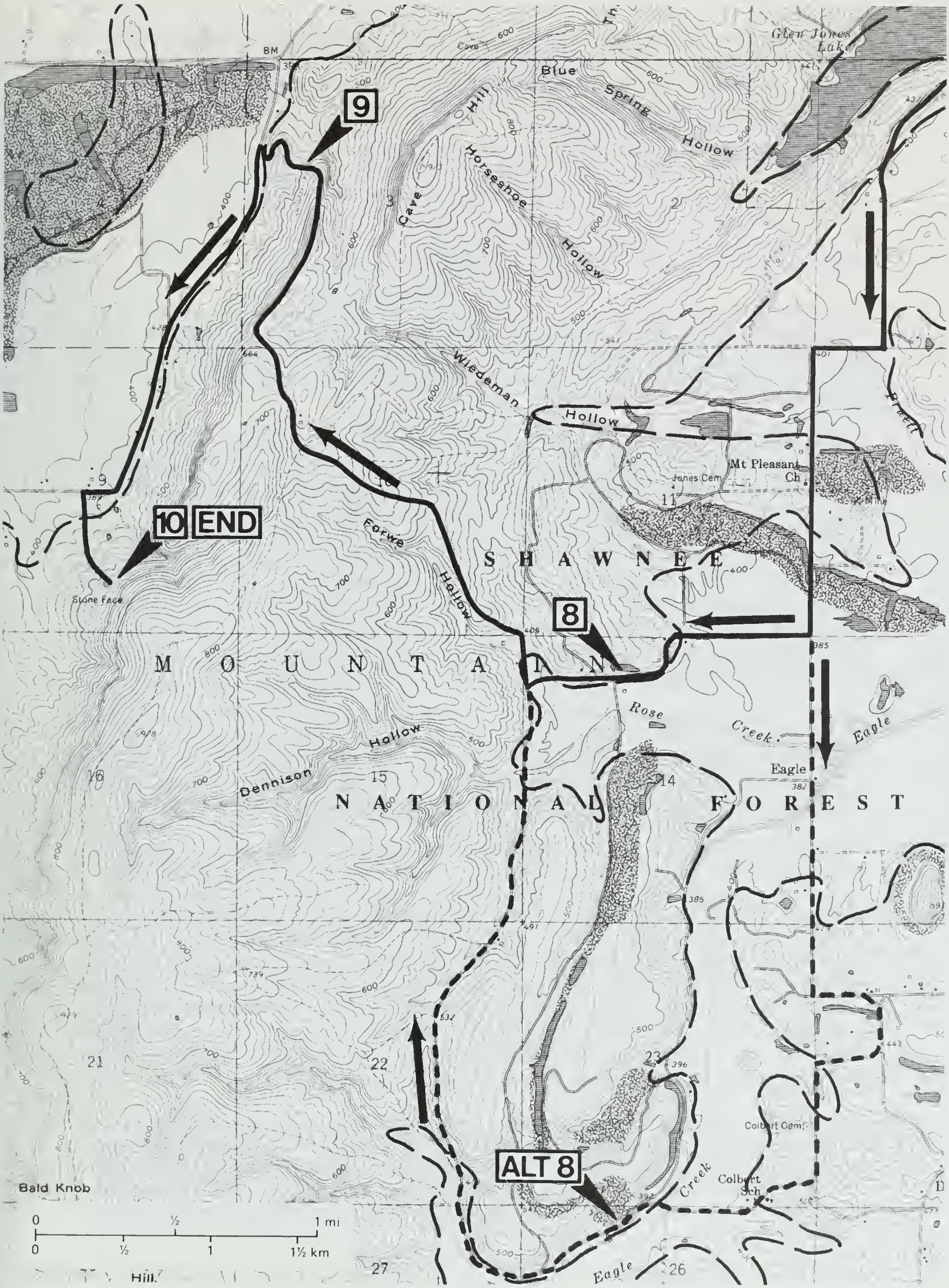
Figure 14 Shawneetown Fault Zone and its effect on the bedrock strata in the Horseshoe Quarry and Glen O. Jones Lake (after Nelson and Lumm 1986).

fault and tilted backward at the same time. The strata here dip at about 75°. The rocks are highly crushed and fractured as a result of the faulting.

0.0	43.45	Leave Stop 7 and CONTINUE AHEAD (east).
0.3+	43.75+	STOP: 1-way at T-intersection with Forest Road (670N\1790E). TURN RIGHT (west and then south) towards Glen O. Jones Lake.
0.4+	44.15+	Pennsylvanian Murray Bluff Sandstone exposed in the roadcut to right. The sandstone dips 10° south into the Eagle Valley Syncline.
0.05	44.2	TURN RIGHT (west-southwest) at T-intersection with Eagle Creek Road (630N\1785E) toward Glen O. Jones Lake.
0.05	44.25	To the right is the entrance (625N\1780E) to the Saline County State Fish and Wildlife area, Glen O. Jones Lake. CONTINUE AHEAD (south) on Eagle Creek Road.
0.05+	44.3+	CAUTION: narrow concrete culvert.
1.1	45.45+	We're crossing the approximate position of the axis of the Eagle Valley Syncline.
0.95	46.4+	The area on both sides of the road has been strip-mined for the Springfield and Herrin Coals.
0.1+	46.55	T-intersection to right, Jones Cemetery Road (450N\1700E). The church to the right on the northwest corner of this intersection is the Social Brethren Church. This is the starting congregation for that denomination. CONTINUE AHEAD (south).
0.5	47.05	T-intersection with Highline Road (400N\1700E). TURN RIGHT (west) on Highline Road. CAUTION: the rough road ahead is slick when wet and may well be impassable.
		NOTE: In the event that weather conditions have made Highline Road impassable, turn to the end of this itinerary for an alternate routing.
0.75+	47.8+	PARK along the primitive roadside. CAUTION: do NOT get stuck. Stay AWAY from the water, it is deep. DO NOT THROW rocks!

STOP 8 Highwall exposure shows the Dekoven Coal and overlying Colchester Coal in the abandoned strip mine of the J. W. Coal Company. (W½ NE NW, Sec. 14, T10S, R7E, 3rd P.M., Saline County; Rudement 7.5-Minute Quadrangle [37088F4]).

J. W. Coal Company operated a strip mine in this area from 1959 to 1965 and left this highwall exposure in their final cut. The mine recovered the Davis and Dekoven Coal Members of the Carbondale Formation. In the highwall, strata from just above the Colchester Coal to just below the Dekoven Coal are exposed. The Davis Coal is somewhere below water level in the flooded pit here.


9
10 END
8
ALT 8
SHAWNEE
MOUNTAIN
NATIONAL FOREST
Blue Spring Hollow
Horseshoe Hollow
Cave Hill
Wiedeman Hollow
Forwe Hollow
Dennison Hollow
Rose Creek
Eagle Creek
Eagle
Mt Pleasant Ch
Jones Cem
Glen Jones Lake
Stone Face
Colbert Cem
Colbert Sch
Bald Knob
0 ½ 1 mi
0 ½ 1 1½ km

The Dekoven (fig. 12), which overlies the Davis by 20 to 30 feet in this area, occurs approximately 200 feet below the Springfield Coal that is being mined by Kerr–McGee Coal Corporation near Galatia (Stop 2). The Dekoven averages 3 feet thick across much of the region including this area. The Davis Coal, which averages 4 feet thick across Gallatin and Saline Counties, locally is more than 5 feet thick. In this vicinity, however, it was fairly close to 4 feet thick. The Davis and Dekoven Coals, which have been surface-mined across much of southeastern Illinois, are economically the next most important coals after the thicker Springfield and Herrin Coals. Because they are primarily high-sulfur coals like the Herrin, they will not likely enjoy much demand in the next few years, as the market place places a premium on cleaner, low sulfur coals. If an economical way is found to deal with their high contents of environmentally damaging sulfur, these three coals may again be utilized as one of the major coal resources in the region.

The Colchester Coal Member is exposed near the top of the cut as a dark bloom or smudge of coal overlain by black shale. Together, they make a black smear just below and into the soil line that marks the erosional surface of the bedrock here. The Colchester is probably the most widespread coal in the Midwest. Although economically important in northern Illinois, it is typically too thin to be mined here in southern Illinois.

This stop also illustrates some important aspects of the regional structure of the Pennsylvanian rocks in the field trip area. We are surrounded on the north, west, and south by massive sandstone ridges that outline a large bedrock trough or *syncline* called the Eagle Valley Syncline. This is an asymmetrical fold, in which the strata on the north limb dip more steeply (10° to 20°) than the strata on the south limb (5° or less). The ridges that outline the syncline are formed by the eroded, upturned edges of resistant lower Pennsylvanian sandstones, These consist principally of massive sandstones of the Caseyville and lower Tradewater Formations that form steep, outward-facing cliffs along much of their outcrop belt. Eagle Valley itself is eroded in the softer shales and shaley sandstones that overlie the more resistant sandstones. The still younger, overlying Anvil Rock Sandstone Member, which is also resistant to erosion, forms the low hills in the central part of the valley along the axis of the syncline.

The axis of the syncline plunges (tilts downward) to the east, and thus the syncline is deepest and widest near the Ohio River. The syncline gradually dies out eastward into Kentucky. Near the western end of Eagle Valley, the axis bends sharply to the southwest and the fold dies out in the vicinity of Herod. As the syncline becomes shallower and narrower westward, the sandstone ridges along its north and south limbs converge toward the axis at the nose of the syncline.

The Shawneetown Fault, a major fracture in the crust, bounds the syncline on the north and west. Eagle Valley Syncline and the faults in the field trip area form part of a region of intensely disturbed Paleozoic strata that crosses southern Illinois and western Kentucky. This region, which includes the Illinois Fluorspar District, is cut by many high-angle faults.

These features were formed during a major episode of folding and faulting that began at the end of the Pennsylvanian Period about 270 million years ago. This was a time when the Appalachian Mountains were forming along the eastern margin of North America. Another episode of faulting occurred later, during the Cretaceous Period, about 100 million years ago. Recurrent movements along faults in this region have occurred since then, and earthquakes within historic time indicate that movements are still taking place.

Here the strata exposed in the highwall can be seen to dip significantly (14°) to the northeast towards the center of the syncline. We are on the western nose of this eastward-plunging syncline. The mine itself operated as a contour type of strip mine essentially mining along the eastward-dipping cuesta of Carbondale bedrock that contained the Davis and Dekoven Coals. The mine continued to operate eastward along this cuesta until the dip of the coals put them at depths that were not economical for recovery. The mining of the Davis and Dekoven has been undertaken all along this cuesta, both to the north and south of here for several miles and then eastward as the cuesta curves to an east-west strike along the south flank of the syncline. Just south of here across Rose Creek, J. J. Track Mining Company operated the Brown Brothers Mine No. 3 from 1985 to 1988 along a portion of the north-south-striking cuesta that J. W. Coal Company had not mined. The dragline from this latter operation can still be seen to the east. South and east of this location, up until 1990, Jader Fuel Company had been mining the Davis and Dekoven in surface operations along the east-striking cuesta of Carbondale strata.

0.0	47.8+	Leave Stop 8 and CONTINUE AHEAD (west). CAUTION: when wet the road can be muddy and slick with deep ruts.
0.2+	48.05	CAUTION: ford tributary to Rose Creek.
0.05+	48.1+	T-intersection with Eagle Mountain Road (385N\1600E). TURN RIGHT (north).
0.1+	48.2+	Cross creek and prepare to ascend the Pennsylvanian cuesta.
1.15	49.35+	Cross the crest of the cuesta. This is the highest elevation on the field trip route, 780+ feet msl. There are several vantage points along the route ahead where you can get a panoramic view to the left (west). CAUTION: the road is rough from rock ledges and erosion. The roadstone is coarse and loose.
1.15	50.5	PARK along the roadside. Do NOT block the road.

STOP 9 An abandoned quarry exposure of the upper Mississippian (Chesterian) Kinkaid Limestone Formation appears at this site. (S½ NE SW NW and SE SW NW, Sec. 3, T10S, R7E, 3rd P.M., Saline County; Rudement 7.5-Minute Quadrangle [37088F4]).

About 20 feet of the Negli Creek Limestone Member, the lowermost member of the Kinkaid Limestone, is exposed in this abandoned quarry. The exposure is in still another upthrown fault block along the front of Cave Hill. The block is tilted eastward at about 15°. The Negli Creek is gray, fine to coarse grained, dense, thick bedded to massive, and fossiliferous. It is somewhat argillaceous with shaly partings along bedding planes. The upper 3 feet of the ledge is coarsely crystalline and very fossiliferous.

The shale above the bench is the Cave Hill Shale Member of the Kinkaid Limestone. The lower 3 feet of the shale contains thin limestone beds that are about 6 inches thick and extremely fossiliferous. Excellent specimens of brachiopods (*Composita*), bryozoans (*Archimedes*, *Rhombopora*, and *Fenestrellina*), and crinoid stems can be collected from the shale. A plate illustrating some typical Mississippian fossils is provided in the back of this guidebook.

0.0	50.5+	Leave Stop 9 and CONTINUE AHEAD (west) downhill with CAUTION!
0.3	50.8+	STOP: 1-way, even though not posted, at T-intersection with Stoneface Road (565N\1510E). CAUTION: poor visibility and fast traffic. TURN LEFT (south) on Stoneface Road.

1.45+	52.25+	T-intersection with Stoneface Lane to left (450N\1450E). TURN LEFT (south). CAUTION: narrow road.
0.35+	52.65	PARK in the parking area or along the roadside. Do NOT block the road. You cannot see Old Stone Face from the parking area. • Leave footprints *only*. • Follow the path to the left to the top of the bluff and Old Stone Face. • Follow the path to the right for a view of Old Stone Face from below if you cannot climb to the top. **DO NOT** try to scale the cliff, stand too close to the edge of the cliff, or throw anything over the edge of the cliff!!

STOP 10 We'll view Old Stone Face and the surrounding countryside from the top of the cliff. (Parking area, NW SW SE, Sec. 9, T10S, R7E, 3rd P.M., Saline County; Rudement 7.5-Minute Quadrangle [37088F4]).

Old Stone Face, one of the best known natural wonders of southern Illinois, is located on the southwestern edge of Cave Hill about 730 feet msl. The cliff affords a magnificent view to the north and west overlooking low-lying areas about 350 feet below.

The sheer cliff into which Old Stone Face has been carved by weathering consists of the massive, crossbedded Pounds Sandstone Member of the Caseyville Formation (Pennsylvanian) (fig. 2). It consists of fairly pure, slightly micaceous, quartz sandstone containing numerous white rounded quartz pebbles. The sandstone is about 100 feet thick in the field trip area.

The sandstones of the Caseyville are very resistant to erosion, and wherever they are exposed, they are cliff-formers. The sandstones are river channel sands laid down by an ancient Pennsylvanian river system that crossed this part of Illinois from northeast to southwest. Structures formed by the river currents, including wedge-shaped crossbedding and ripple marks, are well developed in the Pounds here and may be easily studied along the pathways. The purity and coarseness of the sandstones indicate that the currents were swift.

Cave Hill forms an erosional fault scarp at the west end of Eagle Valley. In this locality, the stratigraphic displacement on the Shawneetown Fault is more than 700 feet. The Pounds Sandstone lies 500 feet below the lowlands west of Cave Hill.

End of the field trip to the Harrisburg area.

Join us on future trips!

NOTE The following is an alternate route for Stop 8, starting at Highline Road, in case of inclement weather.

0.0	0.0	New mileage figure at the T-intersection of Eagle Creek and Highline Roads (400N\1700E). CONTINUE AHEAD (south) on Eagle Creek Road. To the right at about 2 o'clock is a dragline sitting in a large area spoil piles. That area was surface-mined for the Davis and Dekoven Coals.

0.4	0.4	CAUTION: narrow culvert. Cross Rose Creek.
0.15+	0.55+	CAUTION: cross Eagle Creek.
0.85+	1.45+	Y-intersection. BEAR RIGHT (south) down the hill.
0.05+	1.5+	STOP: 1-way at Gape Hollow Road even though not posted. CAUTION: limited visibility. Watch for fast, large coal haulers bearing down from your left. BEAR RIGHT (south) onto blacktop.
0.15+	1.65+	CURVE RIGHT (west) on the blacktop at the intersection (250N\1725E).
0.45	2.1+	Colbert Cemetery to the right.
0.2	2.3+	CURVE RIGHT (west) at intersection (210N\1700E).
0.55	2.85+	CAUTION: unmarked culvert across Eagle Creek. Enter an area just beyond the culvert that has been stripped for Davis and Dekoven Coals.
0.15	3.05+	CAUTION: pull off the road and up the ramp to PARK **(IF YOU HAVE PERMISSION)** at Jader Fuel Company 4, Permit 140. This will be Alternate Stop 8. The elements present here are much the same as at Stop 8 except for the dipping strata.
0.0	3.05+	Leave Alternate Stop 8 and CONTINUE AHEAD (southwest).
0.4	3.45+	Y-intersection on a curve (175N\1600E). BEAR RIGHT (west and then north) on Eagle Mountain Road. NOTE: the road ahead is narrow with narrow, dangerous "shoulders."
1.15	4.6+	CAUTION: unmarked culvert.
0.15	4.75+	CAUTION: unmarked culvert.
0.15+	4.9+	CAUTION: unmarked culvert.
0.2+	5.15+	CAUTION: unmarked culvert.
0.1	5.25+	CAUTION: unmarked culvert.
0.05+	5.3+	CAUTION: unmarked culvert.
0.05+	5.4+	CAUTION: ford creek (a tributary to Rose Creek).
0.05+	5.45+	CAUTION: ford creek (another Rose Creek tributary).
0.3	5.75+	T-road intersection from right (385N\1600E) at Highline Road.
		End of alternate route

BIBLIOGRAPHY

Bhagwat, S. B., 1987, The Future of Illinois Coal: 1994 and Beyond: Illinois State Geological Survey, Illinois Mineral Notes 97, 25 p.

Bonnell, Clarence, 1946, The Illinois Ozarks: (privately published), 156 p.

Cady, G. H., 1952, Minable Coal Resources of Illinois: Illinois State Geological Survey, Bulletin 78, 138 p.

Cote, W. E., D. L. Reinertsen, and M. M. Killey, 1969, Equality Area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1969A and F, 31 p.

Damberger, H. H., et al., 1984, Coal Industry in Illinois: Illinois State Geological Survey Map, scale 1:500,000, size 30'50 inches, color.

Fidlar, M. M., 1948, Physiography of the Lower Wabash Valley: Indiana Geological Survey, Bulletin 2, 112 p.

Frye, J. C., and H. B. Willman, 1970, Pleistocene Stratigraphy of Illinois: Illinois State Geological Survey, Bulletin 94, 204 p.

Frye, J. C., A. B. Leonard, H. B. Willman, and H. D. Glass, 1972, Geology and Paleontology of Late Pleistocene Lake Saline, Southeastern Illinois: Illinois State Geological Survey, Circular 471, 44 p.

Green, P., 1985, Kerr-McGee Mines twin seams: Coal Age, v. 90, no. 2, February, p. 82-85.

Harris, S. E., Jr., C. W. Horrell, and D. Irwin, 1977, Exploring the Land and Rocks of Southern Illinois: Southern Illinois University Press, Carbondale and Edwardsville, 240 p.

Horberg, C. L., 1946, Preglacial erosion surfaces in Illinois: Journal of Geology, v. 54, no. 3, p. 179-192.

Horberg, C. L., 1950, Bedrock Topography of Illinois: Illinois State Geological Survey, Bulletin 73, 111 p.

Howard, R. H., 1967, Oil and Gas Pay Maps of Illinois: Illinois State Geological Survey, Illinois Petroleum 84, 64 p.

Jacobson, R. J., 1992, Geology of the Goreville Quadrangle, Johnson and Williamson Counties, Illinois: Illinois State Geological Survey, Bulletin 97, 32 p.

Leighton, M. M., G. E. Ekblaw, and C. L. Horberg, 1948, Physiographic Divisions of Illinois: Illinois State Geological Survey, Report of Investigations 129, 19 p.

Leighton, M. W., D. R. Kolata, D. F. Oltz, and J. J. Eidel (eds), 1991, Interior Cratonic Basins: American Association of Petroleum Geologists, Tulsa, Oklahoma, Memoir 51, 819 p.

Lineback, J. A., and others, 1979, Quaternary Deposits of Illinois: Illinois State Geological Survey Map, scale 1:500,000, size 40x60 inches, color.

Nelson, W. J., and D. K. Lumm, 1986, Geologic Map of the Equality Quadrangle, Gallatin and Saline Counties, Illinois: Illinois State Geological Survey, Illinois Geologic Quadrangle 2, scale 1:24,000.

Nelson, W. J., and D. K. Lumm, 1986, Geologic Map of the Rudement Quadrangle, Saline County, Illinois: Illinois State Geological Survey, Illinois Geologic Quadrangle 3, scale 1:24,000.

Nelson, W. J., and D. K. Lumm, 1987, Structural Geology of Southeastern Illinois and Vicinity: Illinois State Geological Survey, Circular 538, 70 p.

MacClintock, P., 1929, I. Physiographic Divisions of the Area Covered by the Illinoian Drift Sheet in Southern Illinois: II. Recent Discoveries of Pre-Illinoian Drift in Southern Illinois: Illinois State Geological Survey, Report of Investigations 19, 57 p.

Odom, I. E., and G. Dow, 1960, Harrisburg Area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1960F, 12 p. plus attachments.

Piskin, K., and R. E. Bergstrom, 1975, Glacial Drift in Illinois: Thickness and Character: Illinois State Geological Survey, Circular 490, 35 p.

Pryor, W. A., 1956, Groundwater Geology in Southern Illinois: A Preliminary Geologic Report: Illinois State Geological Survey, Circular 212, 25 p.

Raasch, G. O., 1951, Harrisburg Area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1951A, 13 p. plus attachments.

Raasch, G. O., 1952, Eldorado Area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1952A, 15 p. plus attachments.

Reinertsen, D. L., 1980, A Guide to the Geology of the Equality Area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1980A, 32 p. plus attachments.

Reinertsen, D. L., 1988, A Guide to the Geology of the Shawneetown Area, Gallatin County: Illinois State Geological Survey, Geological Science Field Trip Leaflet 1988A, 35 p. plus attachments.

Samson, I. E., 1992, Illinois Mineral Industry in 1990 and Review of Preliminary Mineral Production Data for 1991: Illinois State Geological Survey, Illinois Minerals 110, 43 p.

Smith, W. H., 1957, Strippable Coal Reserves of Illinois: Part 1—Gallatin, Hardin, Johnson, Pope, Saline and Williamson Counties: Illinois State Geological Survey, Circular 228, 39 p.

Swann, D. H., 1964, Late Mississippian Rhythmic Sediments of Mississippi Valley: American Association of Petroleum Geologists Bulletin, v. 48, no. 5, May, p. 637-658.

Treworgy, C. G., L. E. Bengal, and A. G. Dingwell, 1978, Reserves and Resources of Surface-Minable Coal in Illinois: Illinois State Geological Survey, Circular 504, 44 p.

Treworgy, C. G., and M. H. Bargh, 1982, Deep-Minable Coal Resources of Illinois: Illinois State Geological Survey Circular 527, 65 p.

Treworgy, J. D., 1981, Structural Features in Illinois: A Compendium: Illinois State Geological Survey, Circular 519, 22 p.

Treworgy, J. D., and M. H. Bargh, 1984, Coal Resources of Illinois: Springfield (No. 5) Coal: Illinois State Geological Survey Map, scale 1:500,000, size 30x50 inches, color.

Treworgy, J. D., and M. H. Bargh, 1984, Coal Resources of Illinois: Herrin (No. 6) Coal: Illinois State Geological Survey Map, scale 1:500,000, size 30x50 inches, color.

Treworgy, J. D., and M. H. Bargh, 1984, Coal Resources of Illinois: Davis, Murphysboro, and Seelyville, with Assumption, Bell, Houchin Creek—Formerly Summum (No. 4), Litchfield, Coals near Makanda, Mt. Rorah, New Burnside, Reynoldsburg, Rock Island (No. 1), "Seahorne," Servant—Formerly Shawneetown, Wiley, Willis, and Wise Ridge Coals: Illinois State Geological Survey Map, scale 1:500,000, size 30x50 inches, color.

Wayne, W. J., 1952, Pleistocene evolution of the Ohio and Wabash Valleys: Journal of Geology, v. 60, no. 6, November, p. 575-585.

Willman, H. B., and others, 1967, Geologic Map of Illinois: Illinois State Geological Survey Map, scale 1:500,000, size 40x56 inches, color.

Willman, H. B., J. A. Simon, B. M. Lynch, and V. A. Langenheim, 1968, Bibliography and Index of Illinois Geology through 1965: Illinois State Geological Survey, Bulletin 92, 373 p.

Willman, H. B., E. Atherton, T. C. Buschbach, C. W. Collinson, J. C. Frye, M. E. Hopkins, J. A. Lineback, and J. A. Simon, 1975, Handbook of Illinois Stratigraphy: Illinois State Geological Survey, Bulletin 95, 261 p.

Willman, H.B., and J.C. Frye, 1980, The Glacial Boundary in Southern Illinois: Illinois State Geological Survey, Circular 511, 23 p.

Wright, A., 1985, A $50-million washing machine on-line at Galatia: Coal Age, v. 90, no. 2, February, p. 85-92.

GLOSSARY

Several sources were used for the definitions, but the main reference is the *Glossary of Geology*, edited by Robert L. Bates and Julie A. Jackson (American Geological Institute, 1987).

Age — An interval of geologic time; a division of an epoch.
Alluviated valley — One that has been at least partly filled with sand, silt, and mud by flowing water.
Alluvium — A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material deposited during comparatively recent time by a stream or other body of running water as a sorted or semisorted sediment in the bed of a stream or on its floodplain or delta.
Anticline — A convex upward rock fold in which strata have been bent into an arch; the strata on each side of the core of the arch are inclined in opposite directions away from the axis or crest; the core contains rocks older than those on the perimeter of the structure.
Aquifer — A geologic formation that is water-bearing and transmits water from one point to another.
Argillaceous — Largely composed of clay-sized particles or clay minerals.
Bed — A naturally occurring layer of earth material of relatively greater horizontal than vertical extent; it is characterized by a change in physical properties from overlying and underlying materials. It also is the ground upon which any body of water rests or has rested; the land covered by the waters of a stream, lake, or ocean; or the bottom of a watercourse or stream channel.
Bedrock — The solid rock underlying the unconsolidated (non-indurated) surface materials such as soil, sand, gravel, and glacial till.
Bedrock valley — A drainageway eroded into the solid bedrock beneath the surface materials. It may be completely filled with unconsolidated (non-indurated) materials and hidden from view.
Braided stream — A low gradient, low volume stream flowing through an intricate network of interlacing shallow channels that repeatedly merge and divide, and are separated from each other by branch islands or channel bars. Such a stream may be incapable of carrying all of its load.
Calcarenite — Limestone composed of sand-sized grains consisting of more or less worn shell fragments or pieces of older limestone; a clastic limestone.
Calcareous — Containing calcium carbonate ($CaCO_3$); limy.
Calcite — A common rock-forming mineral consisting of $CaCO_3$; it may be white, colorless, or pale shades of gray, yellow, and blue; it has perfect rhombohedral cleavage, appears vitreous, and has a hardness of 3 on the Mohs' scale; it effervesces (fizzes) readily in cold dilute hydrochloric acid. It is the principal constituent of limestone.
Chert — Silicon dioxide (SiO_2); a compact, massive rock composed of minute particles of quartz and/or chalcedony; it is similar to flint but lighter in color.
Clastic — Fragmental rock composed of detritus, including broken organic hard parts as well as rock substances of any sort.
Closure — The difference in altitude between the crest of a dome or anticline and the lowest contour that completely surrounds it.
Concretion — A hard, compact, commonly rounded (but also disk-shaped or irregular in form) mass or aggregate of mineral matter; usually of a composition widely different from that of the rock in which it is found.
Crystalline — Said of a rock consisting wholly of crystals or fragments of crystals; esp. said of an igneous rock developed through cooling from a molten state and containing no glass, or of a metamorphic rock that has undergone recrystallization.
Cuesta — An asymmetrical hill or ridge with a long, gentle (back or dip) slope conforming with the resistant bed(s) that form it on one side, and a steep (scarp) slope or cliff on the other; formed by the outcrop of the resistant bed(s).
Delta — A low, nearly flat, alluvial land deposited at or near the mouth of a river where it enters a body of standing water; commonly a triangular or fan-shaped plain sometimes extending beyond the general trend of the coastline.
Detritus — Material produced by mechanical disintegration.

Diamictite — A comprehensive, nongenetic term...for a nonsorted or poorly sorted, noncalcareous, terrigenous sedimentary rock that contains a wide range of particle sizes, such as a rock with sand and/or larger particles in a muddy matrix; e.g. a tillite or a pebbly mudstone.

Diamicton — A general term...for the nonlithified equivalent of a diamictite; e.g. a till.

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

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

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

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

Eon — The largest division of geologic time; it consists of two or more eras.

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

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

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

Ferruginous — Pertaining to or containing iron, e.g., a sandstone that is cemented with iron oxide.

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

Fluvial — Of or pertaining to a river or rivers.

Fluviolacustrine — Pertains to sedimentation partly in lake water and partly in streams, or to sediments deposited under alternating or overlapping lacustrine and fluvial conditions.

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

Geologic column — a chart that shows the subdivisions of part or all of geologic time or the sequence of stratigraphic units (oldest at the bottom and youngest at the top) of a given place or region.

Geophysics — Study of the earth by quantitative physical methods.

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

Graben — An elongate, relatively depressed crustal unit or block that is bounded by faults on its long sides. It is a structural form that may or may not be geomorphologically expressed as a rift valley.

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

Ground moraine — A sheet-like accumulation of glacial drift, principally till, deposited beneath a glacier to form an extensive area of low relief devoid of transverse linear features.

Groundwater — Water that is present below the ground surface in the soil and rocks of the earth's outer crust.

Group — A geologic rock unit consisting of two or more formations.

Hydrogeology — The science that deals with subsurface waters and related geologic aspects of surface waters.

Ice sheet — A glacier of considerable thickness and more than 50,000 square kilometers in area, forming a continuous cover of ice and snow over a land surface...and not confined by the underlying topography; a *continental glacier.*

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

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

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

Lacustrine — Produced by or belonging to a lake.

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

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

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

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

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

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

Member — A rock-stratigraphic unit of subordinate rank, comprising some specially developed part of a varied formation (e.g., a subdivision of local extent only, or a unit with the same color, hardness, composition, and other rock properties that distinguish it from adjacent units in the formation). It may be formally defined and named, informally named, or unnamed; it is not necessarily mappable.

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

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

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

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

Overburden — The upper part of a sedimentary deposit, compressing and consolidating the material below; or barren rock material overlying a mineral deposit.

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

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

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

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

Rank — A coal classification based on degree of metamorphism.

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

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

Sedimentary rock — A rock resulting from the consolidation of loose sediment that has accumulated in layers.

Series — A geologic time-stratigraphic unit; the strata deposited during an epoch; a division of a system.

Sluiceway — An overflow channel.

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

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

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

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

Stylolite — A surface or contact, usually occurring in homogeneous carbonate rocks...that is marked by an irregular and interlocking penetration of the two sides; the columns, pits, and teeth-like projections on one side fit into their counterparts on the other. As usually seen in cross section, it resembles a suture or the tracing of a stylus. The seam is characterized by a concentraion of insoluble constituents of the rock — and is commonly parallel to the bedding.

System — the largest, fundamental geologic time-stratigraphic unit; the strata of a system were deposited during a period of geologic time.

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

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

Till plain — The wavey surface of low relief in the area underlain by ground moraine.

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

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

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

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 sediment 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.

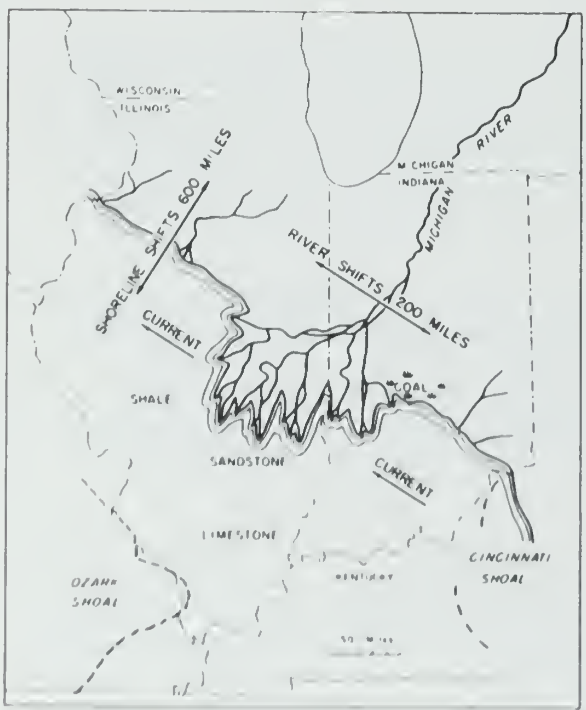
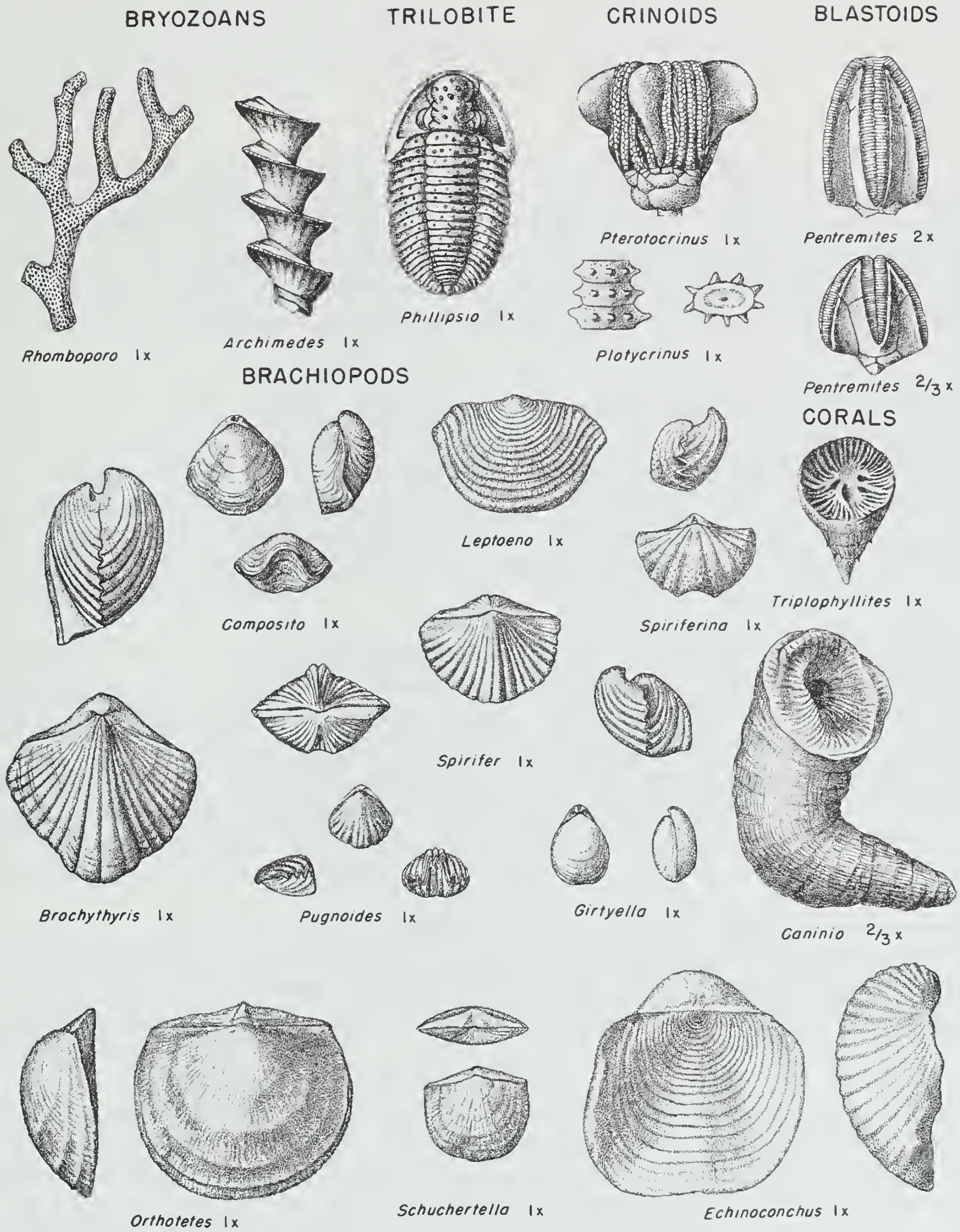


Figure 4: Paleogeography at an intermediate stage during Chesterian sedimentation.


BRYOZOANS
TRILOBITE
CRINOIDS
BLASTOIDS
Rhomboporo 1x
Archimedes 1x
Phillipsio 1x
Pterotocrinus 1x
Plotycrinus 1x
Pentremites 2x
Pentremites 2/3x
BRACHIOPODS
CORALS
Leptoeno 1x
Composito 1x
Spiriferina 1x
Triplophyllites 1x
Spirifer 1x
Brochythyris 1x
Pugnoides 1x
Girtyella 1x
Caninio 2/3x
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.

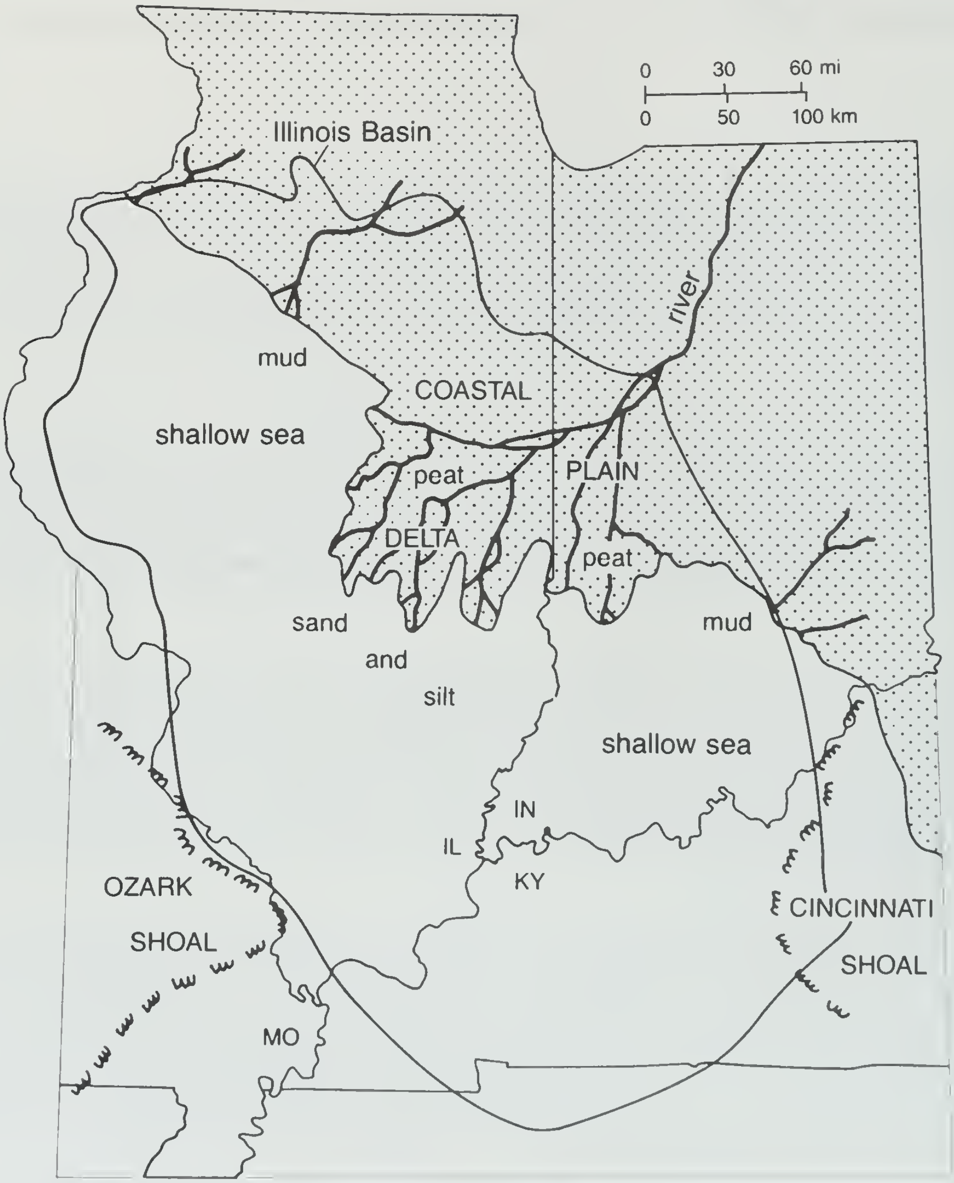
Depositional conditions in the Illinois Basin during the Pennsylvanian Period were somewhat similar to those of the preceding Chesterian (late Mississippian) time. A river system flowed southwestward across a swampy lowland, carrying mud and sand from highlands to the northeast. This river system formed 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.

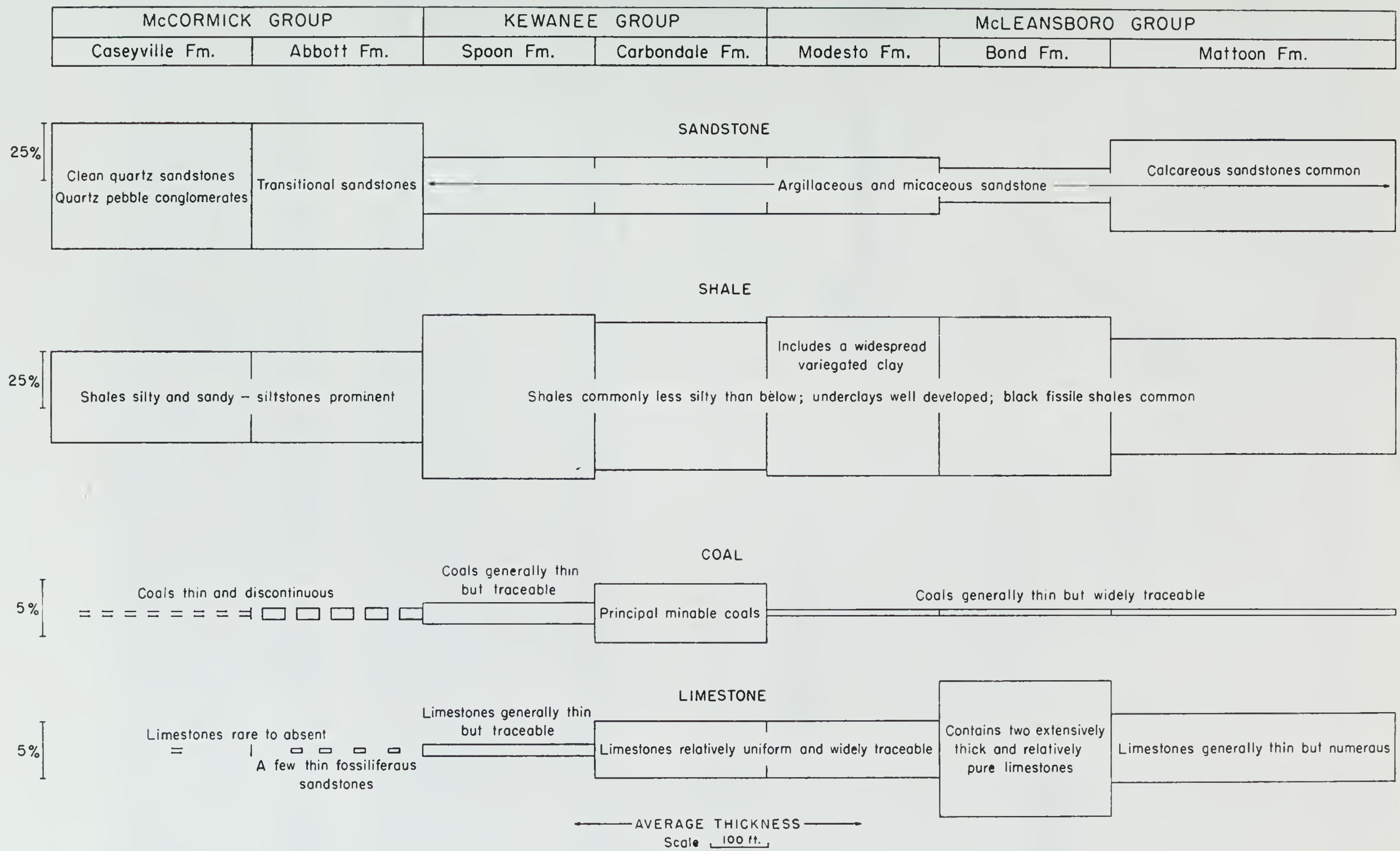
Beneath the quiet water of extensive swamps that prevailed for long intervals on the emergent coastal lowland, peat was formed by accumulation of plant material. Lush forest vegetation covered the region; it thrived in the warm, moist Pennsylvanian-age climate. Although the origin of the underclays beneath 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.



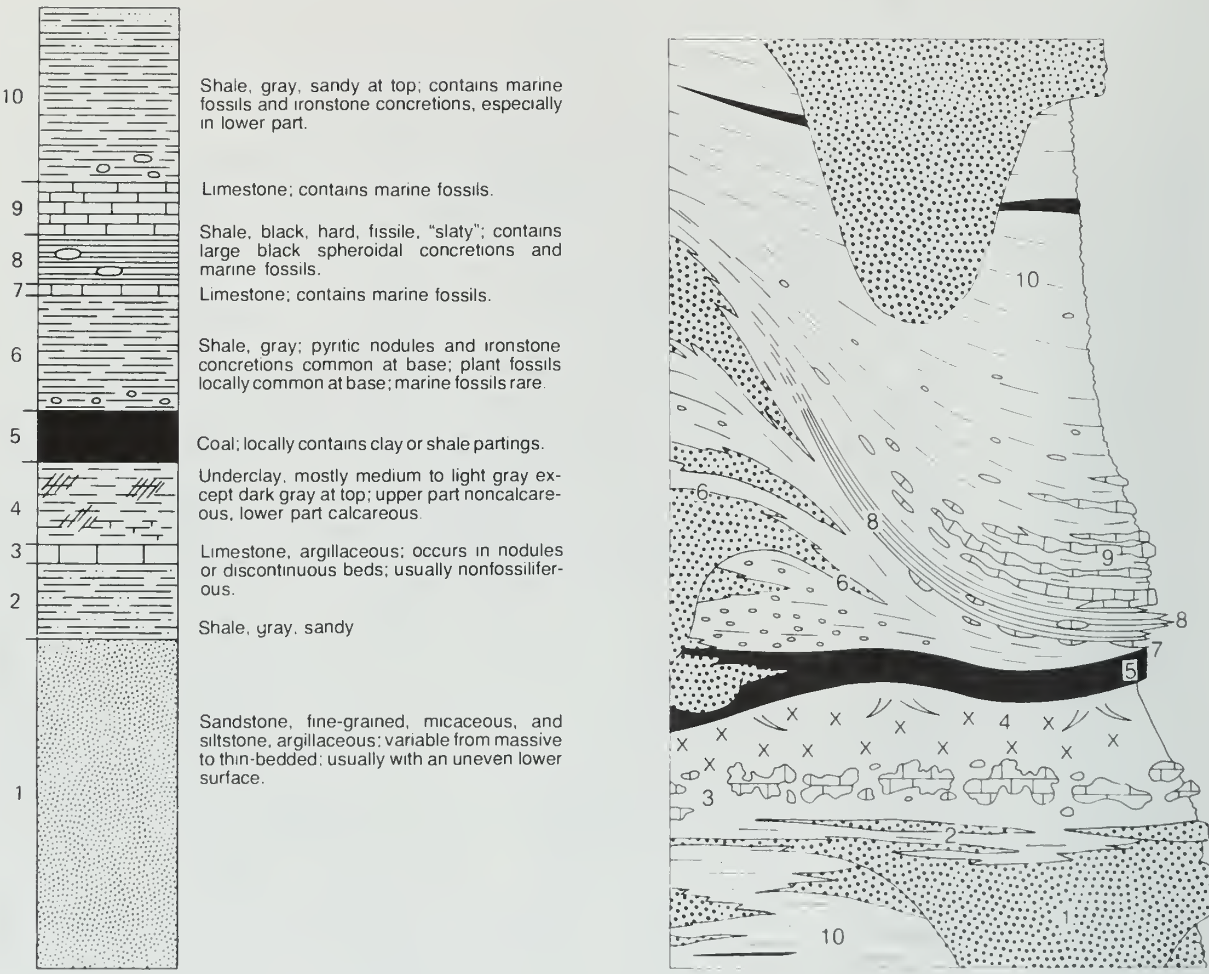
Paleogeography of Illinois-Indiana region during Pennsylvanian time. The diagram shows a Pennsylvanian river delta and the position of the shoreline and the sea at an instant of time during the Pennsylvanian Period.

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.

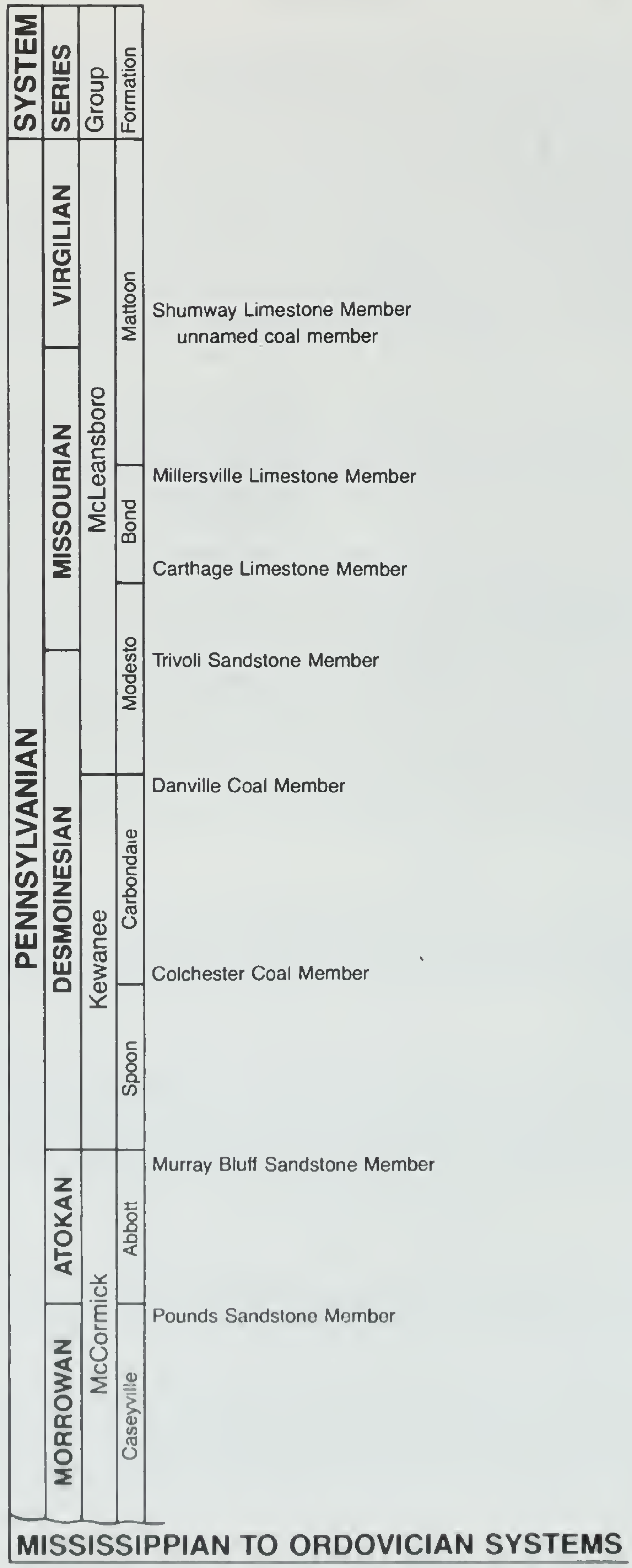
The periodic invasions of the Pennsylvanian sea across the coastal swamps killed the Pennsylvanian forests, and the peat deposits were often buried by marine sediments. After the marine transgressions, peat usually became saturated with sea water containing sulfates and other dissolved minerals. Even 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.

References

Baird, G. C., and C. W. Shabica, 1980, The Mazon Creek depositional event; examination of Francis Creek and analogous facies in the Midcontinent region: *in* Middle and late Pennsylvanian strata on margin of Illinois Basin, Vermilion County, Illinois, Vermilion and Parke counties, Indiana (R. L. Langenheim, editor). Annual Field Conference — Society of Economic Paleontologists and Mineralogists. Great Lakes Section, No. 10, p. 79-92.

Heckel, P. H., 1977, Origin of phosphatic black shale facies in Pennsylvanian cyclothems of mid-continent North America: American Association of Petroleum Geologist Bulletin, v. 61, p. 1045-1068.

Kosanke, R. M., J. A. Simon, H. R. Wanless, and H. B. Willman, 1960, Classification of the Pennsylvanian strata of Illinois: Illinois State Geological Survey Report of Investigation 214, 84 p.

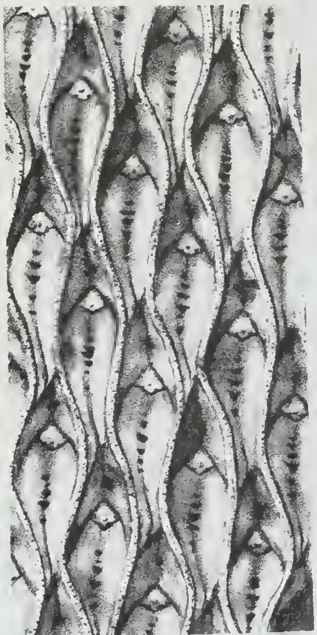
Simon, J. A., and M. E. Hopkins, 1973, Geology of Coal: Illinois State Geological Survey Reprint 1973-H, 28 p.

Willman, H. B., and J. N. Payne, 1942, Geology and mineral resources of the Marseilles, Ottawa, and Streator Quadrangles: Illinois State Geological Survey Bulletin 66, 388 p.

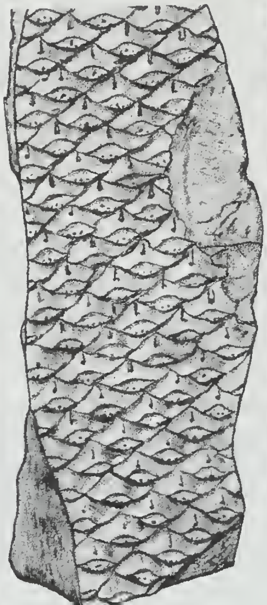
Willman, H. B., et al., 1967, Geologic Map of Illinois: Illinois State Geological Survey map; scale, 1:500,000 (about 8 miles per inch).

Willman, H. B., E. Atherton, T. C. Buschbach, C. W. Collinson, J. C. Frye, M. E. Hopkins, J. A. Lineback, and J. A. Simon, 1975, Handbook of Illinois Stratigraphy: Illinois State Geological Survey Bulletin 95, 261 p.

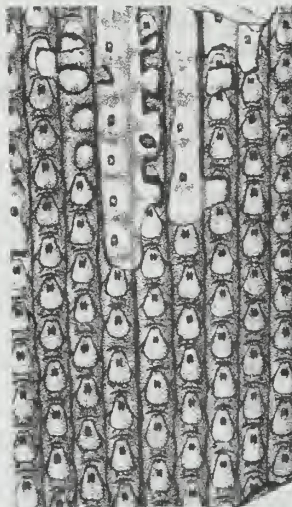
Common Pennsylvanian plants: lycopods, sphenophytes, and ferns



Lepidodendron aculeatum X0.8



Lepidophloios laricinus X0.63

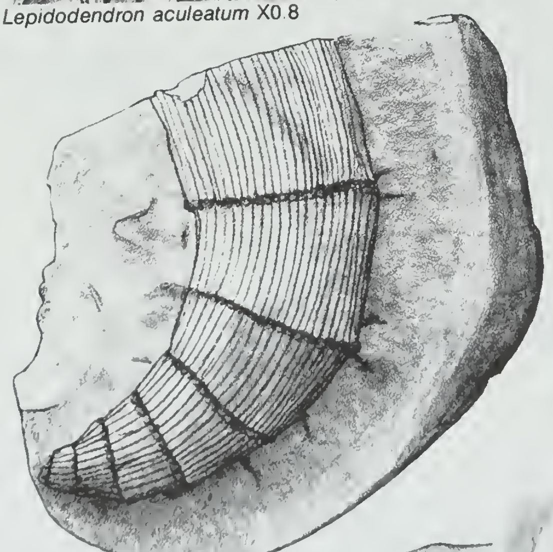


Sigillaria mammilaris X0.5

Stigmaria ficoides X0.32

Lepidostrobus ovatifolius X0.8

Annularia stellata X0.63

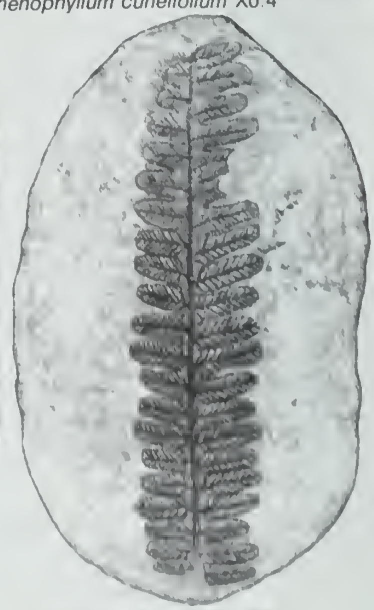


Calamites suckowii X0.5

Sphenophyllum cuneifolium X0.4

Pecopteris sp. X0.32

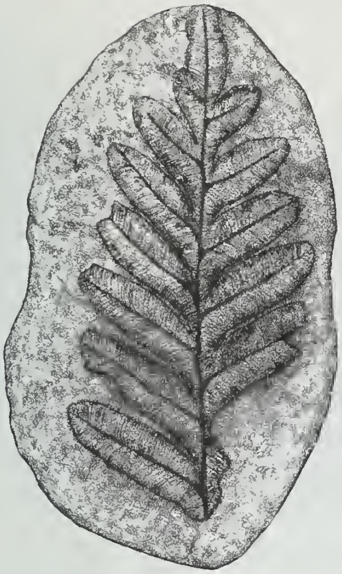
Pecopteris miltonii X2.0



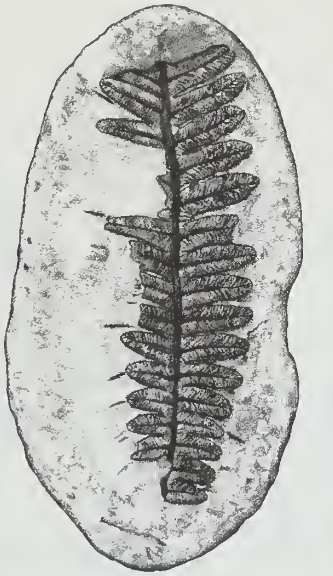
Pecopteris hemitelioides X1.0

J. R. Jennings, ISGS

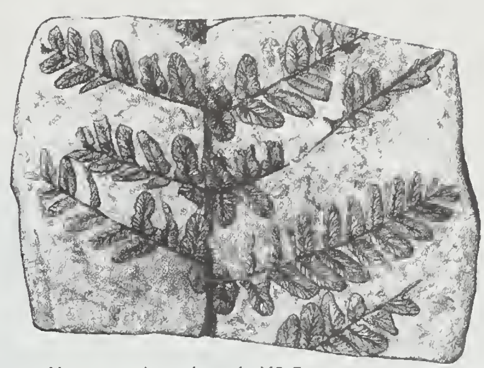
Common Pennsylvanian plants: seed ferns and cordaiteans



Alethopteris serlii X0.63



Alethopteris ambigua X0.63



Neuropteris rarinervis X0.5

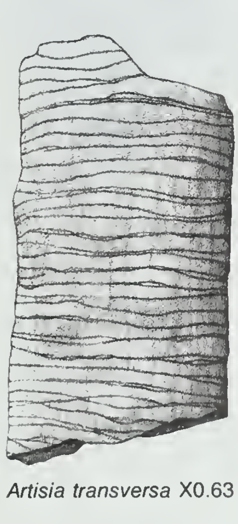
Mariopteris nervosa X0.8

Neuropteris scheuchzeri X0.63

Sphenopteris rotundiloba X0.8

Trigonocarpus parkinsonii X1.25

Cordaicladus sp. X1.0

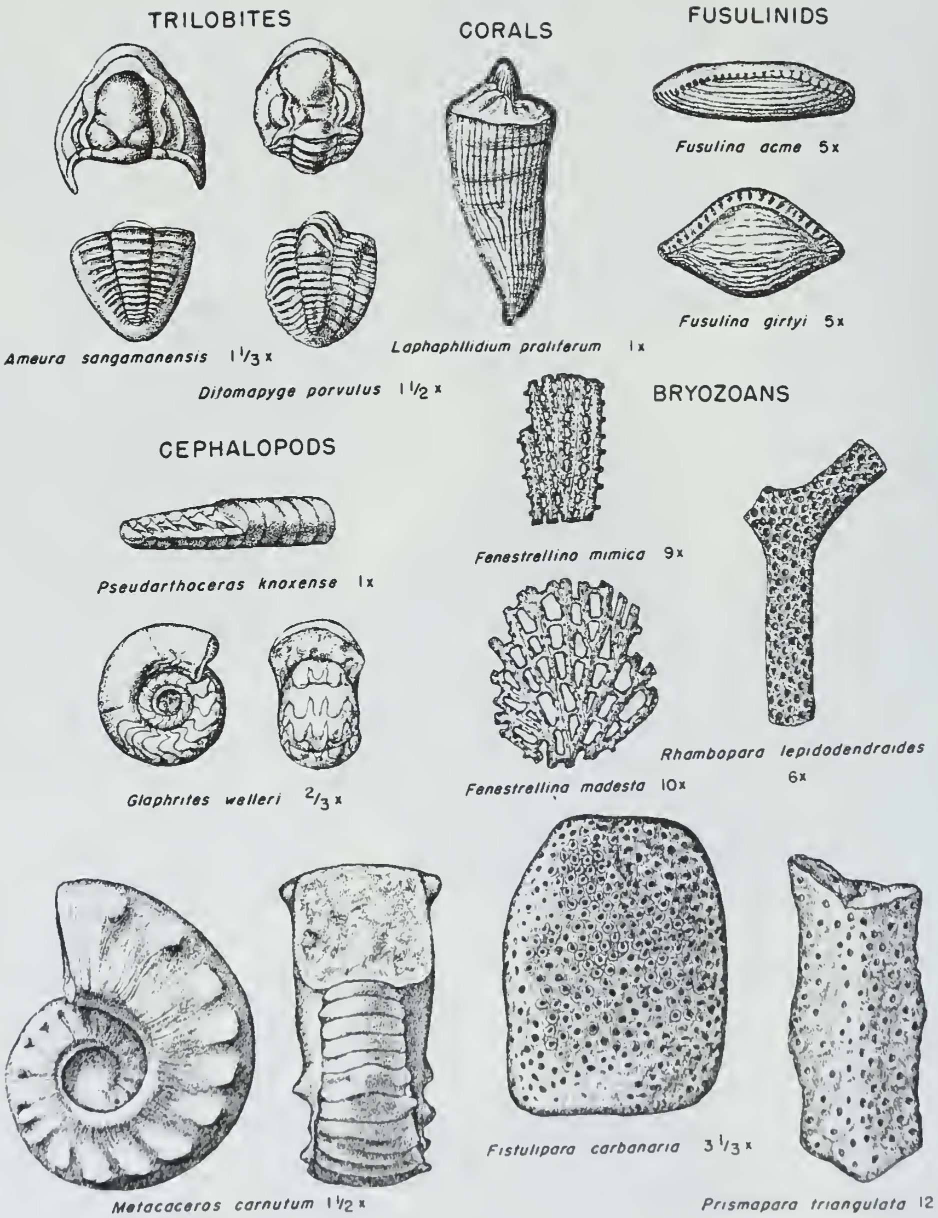


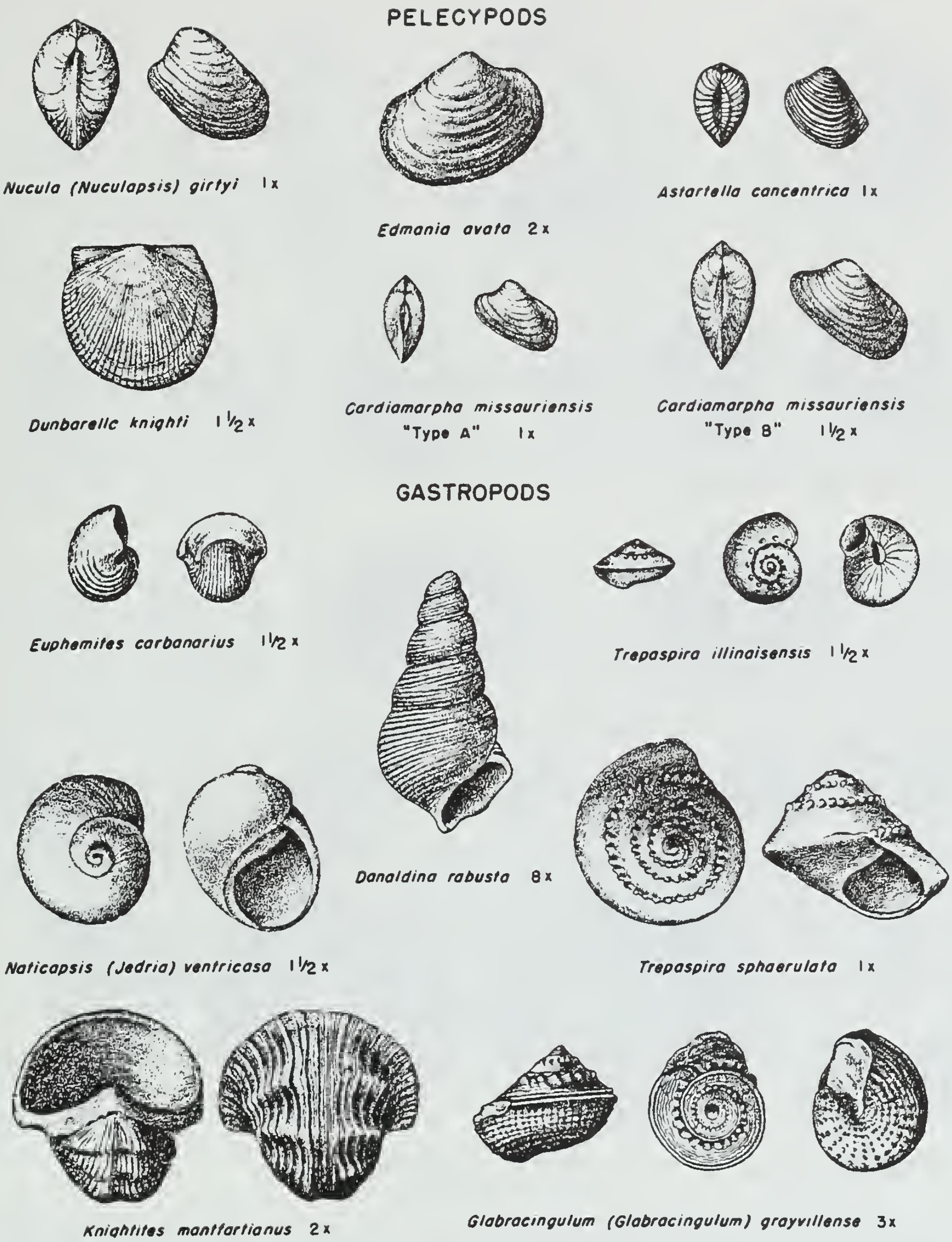
Artisia transversa X0.63

Cordaicarpon major X2.0

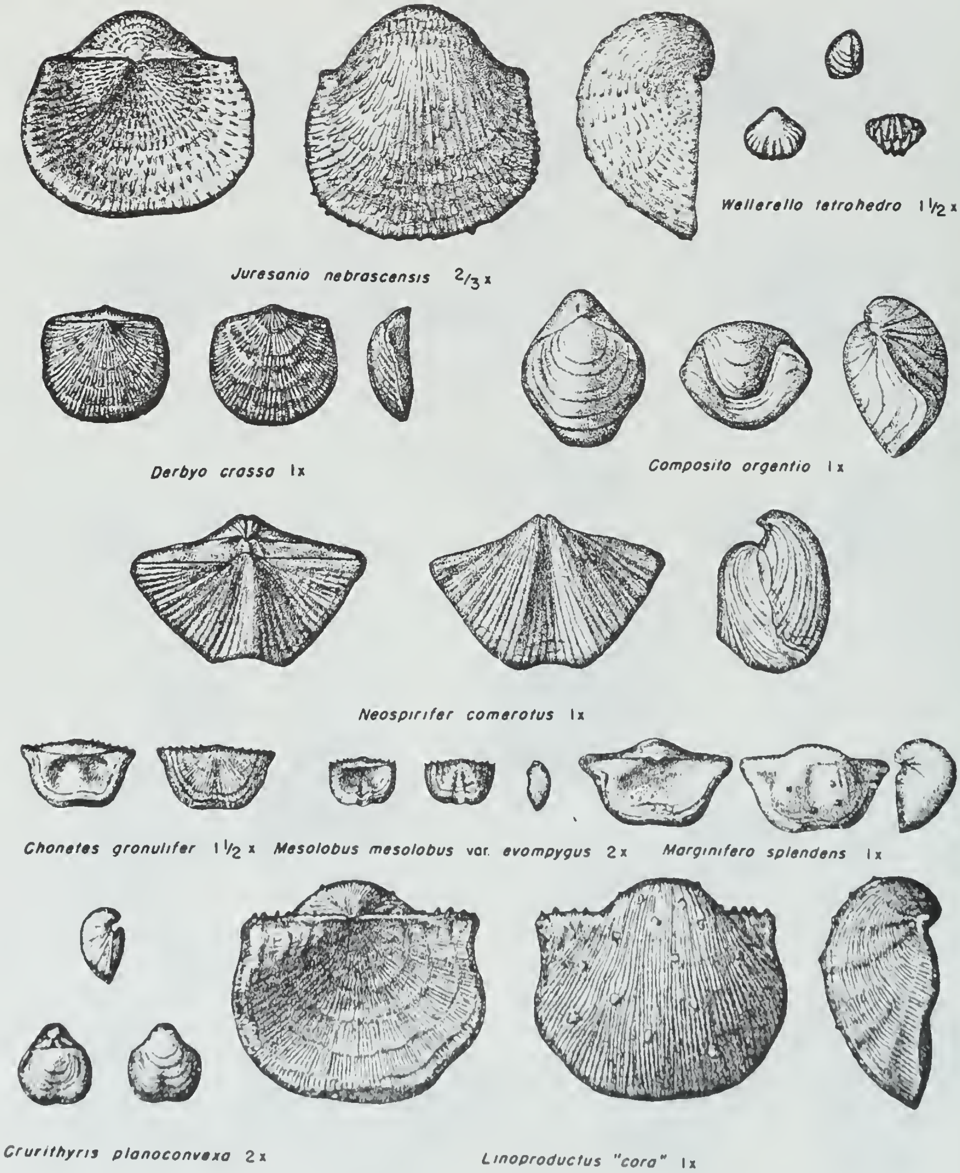
Cordaites principalis X0.63

J. R. Jennings, ISGS


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


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

BRACHIOPODS



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.

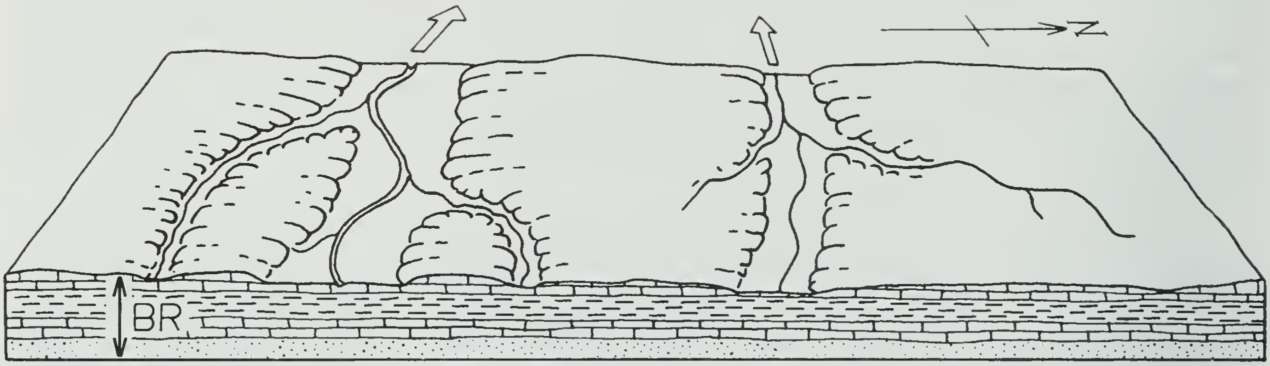
Eolian deposition occurred when certain climatic conditions were met, probably in a seasonal pattern. Deposition could have occurred in the fall, winter or spring season when low precipitation rates and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and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

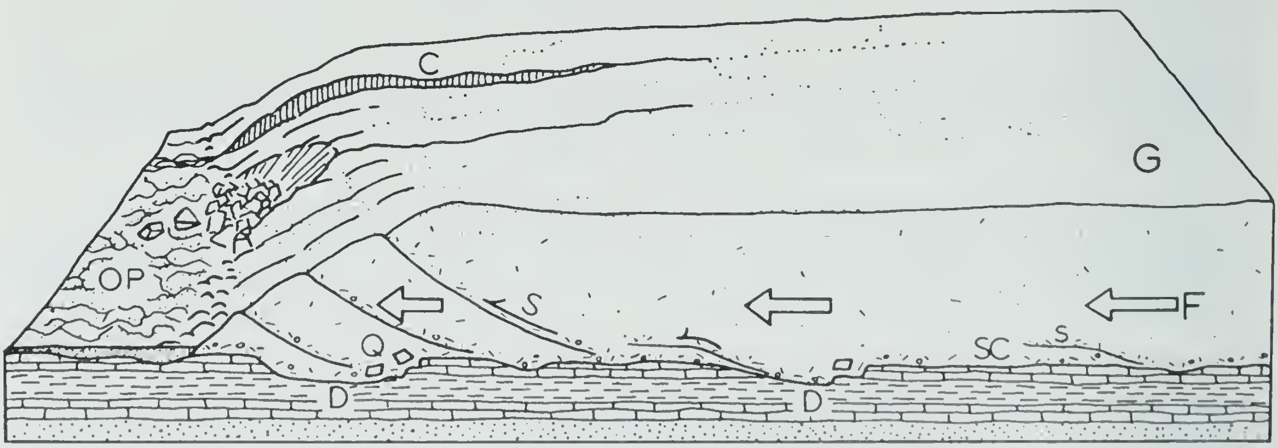
Glaciation in a Small Illinois Region

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.

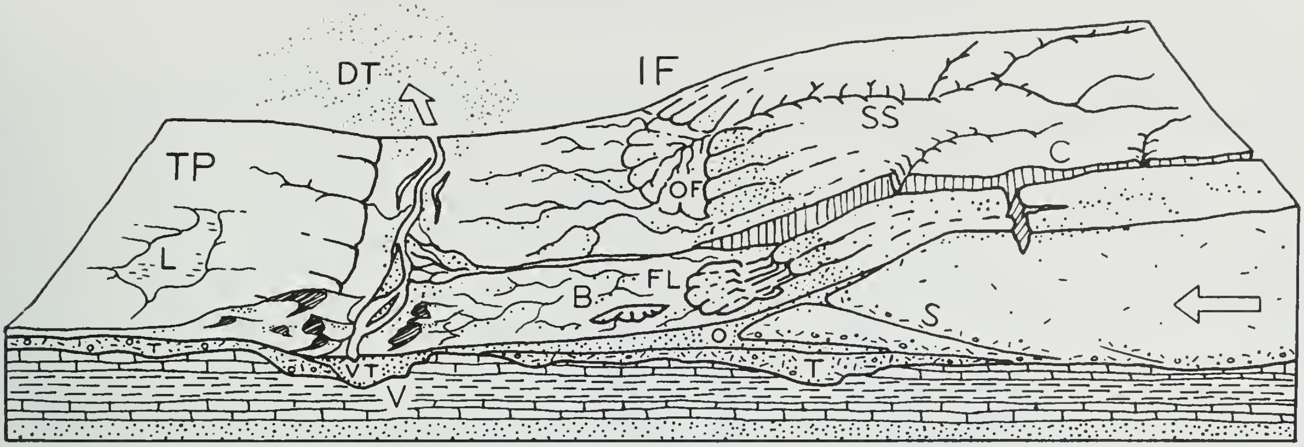
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated—layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



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.



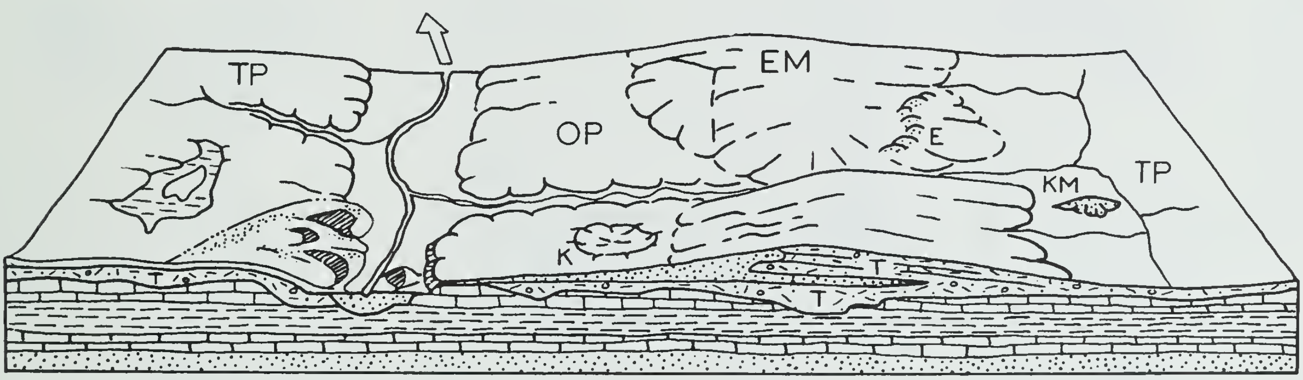
2. **The Glacier Advances Southward** — As the Glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughnesses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

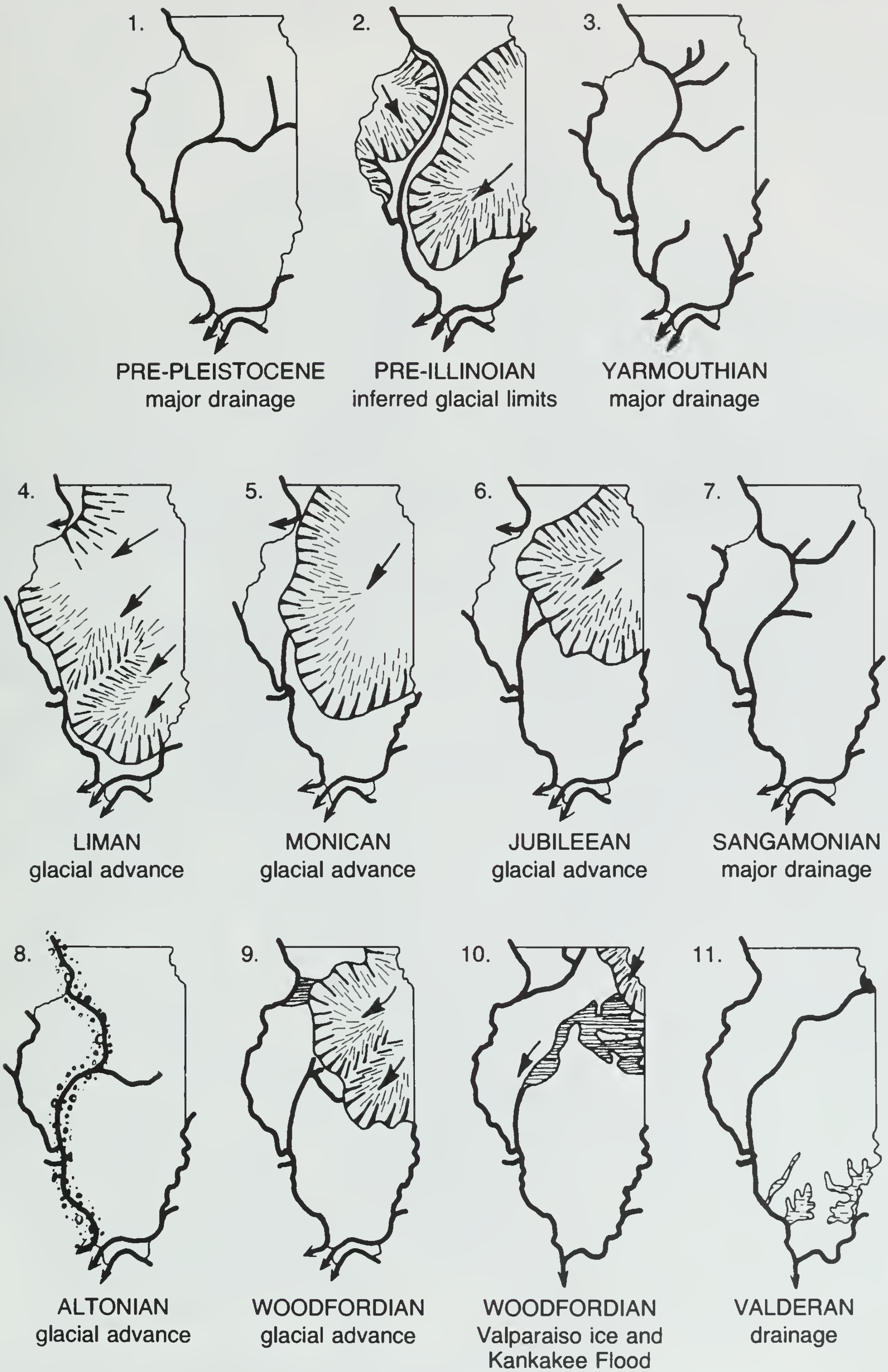
TIME TABLE OF PLEISTOCENE GLACIATION

			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		
QUATERNARY	Pleistocene		WISCONSINAN (glacial)	late	Valderan	Outwash, lake deposits	Outwash along Mississippi Valley
					11,000		
QUATERNARY	Pleistocene		WISCONSINAN (glacial)	late	Twocreekan	Peat and alluvium	Ice withdrawal, erosion
					12,500		
QUATERNARY	Pleistocene		WISCONSINAN (glacial)	late	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		
QUATERNARY	Pleistocene		WISCONSINAN (glacial)	mid	Farmdalian	Soil, silt, and peat	Ice withdrawal, weathering, and erosion
					28,000		
QUATERNARY	Pleistocene		WISCONSINAN (glacial)	early	Altonian	Drift, loess	Glaciation in Great Lakes area, valley trains along major rivers
					75,000		
QUATERNARY	Pleistocene		SANGAMONIAN (interglacial)			Soil, mature profile of weathering	Important stratigraphic marker
					125,000		
QUATERNARY	Pleistocene		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?		
QUATERNARY	Pleistocene		YARMOUTHIAN (interglacial)			Soil, mature profile of weathering	Important stratigraphic marker
					500,000?		
QUATERNARY	Pleistocene	Pre-Illinoian	KANSAN* (glacial)			Drift, loess	Glaciers from northeast and northwest covered much of state
					700,000?		
QUATERNARY	Pleistocene	Pre-Illinoian	AFTONIAN* (interglacial)			Soil, mature profile of weathering	(hypothetical)
					900,000?		
QUATERNARY	Pleistocene	Pre-Illinoian	NEBRASKAN* (glacial)			Drift (little known)	Glaciers from northwest invaded western Illinois
					1,600,000 or more		

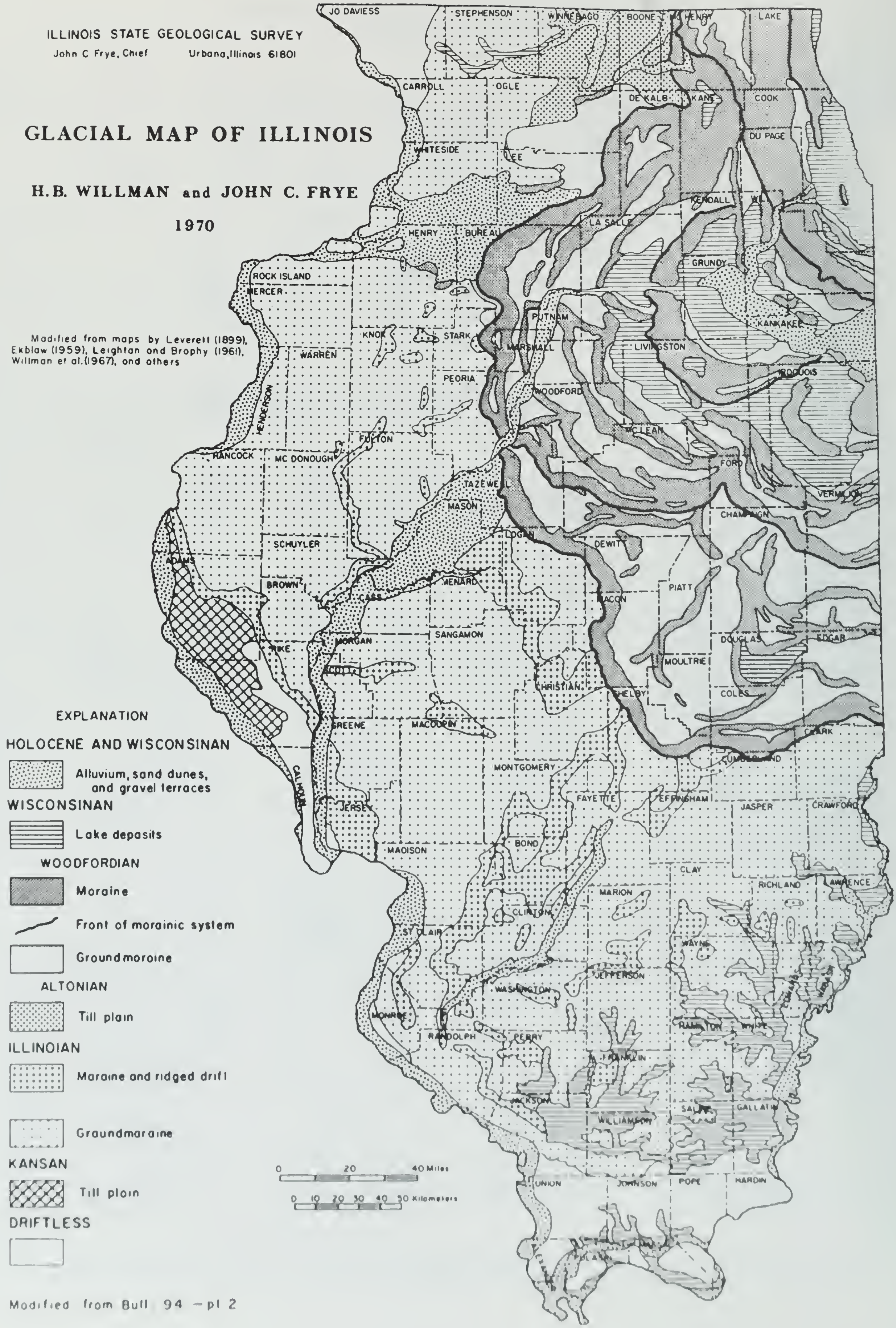
*Old oversimplified concepts, now known to represent a series of glacial cycles.

(Illinois State Geological Survey, 1973)

SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



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

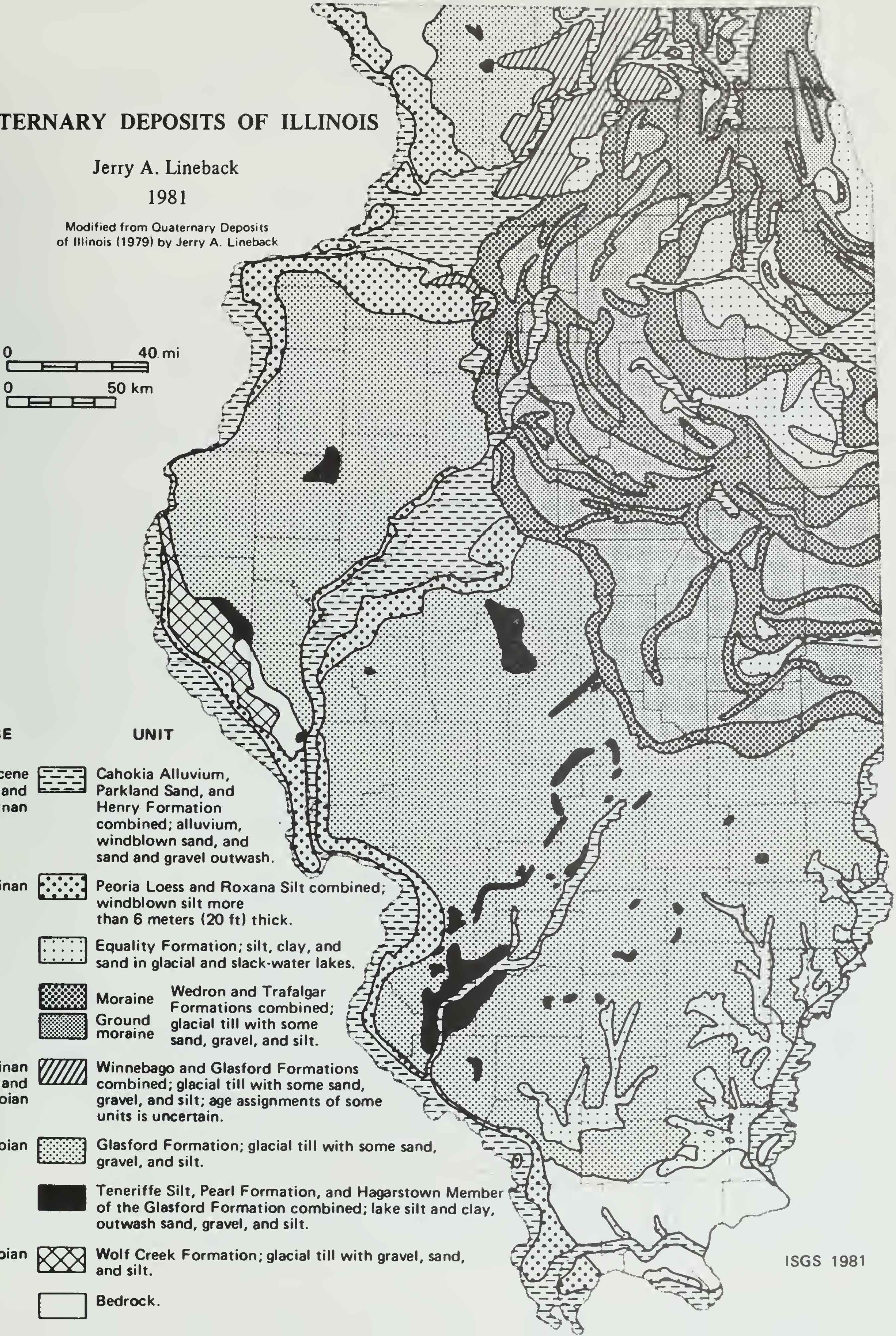

ILLINOIS STATE GEOLOGICAL SURVEY
John C Frye, Chief
Urbana, Illinois 61801
GLACIAL MAP OF ILLINOIS
H.B. WILLMAN and JOHN C. FRYE
1970
Modified from maps by Leverett (1899), Ekblaw (1959), Leighton and Brophy (1961), Willman et al. (1967), and others
EXPLANATION
HOLOCENE AND WISCONSINAN
Alluvium, sand dunes, and gravel terraces
WISCONSINAN
Lake deposits
WOODFORDIAN
Moraine
Front of morainic system
Groundmoraine
ALTONIAN
Till plain
ILLINOIAN
Moraine and ridged drift
Groundmoraine
KANSAN
Till plain
DRIFTLESS
0 20 40 Miles
0 10 20 30 40 50 Kilometers
Modified from Bull 94 – pl 2
JO DAVIESS
STEPHENSON
WINNEBAGO
BOONE
McHENRY
LAKE
CARROLL
OGLE
DE KALB
KANE
COOK
DU PAGE
WHITESIDE
LEE
KENDALL
WILL
LA SALLE
HENRY
BUREAU
GRUNDY
ROCK ISLAND
MERCER
PUTNAM
KANKAKEE
KNOX
STARK
MARSHALL
LIVINGSTON
WARREN
PEORIA
IROQUOIS
HENDERSON
WOODFORD
FULTON
McLEAN
HANCOCK
McDONOUGH
FORD
TAZEWELL
VERMILION
MASON
CHAMPAIGN
SCHUYLER
LOGAN
DEWITT
ADAMS
BROWN
MENARD
PIATT
CASS
MACON
MORGAN
SANGAMON
DOUGLAS
EDGAR
PIKE
SCOTT
MOULTRIE
CHRISTIAN
SHELBY
COLES
GREENE
MACOUPIN
CLARK
CALHOUN
MONTGOMERY
CUMBERLAND
JERSEY
FAYETTE
EFFINGHAM
JASPER
CRAWFORD
MADISON
BOND
CLAY
MARION
RICHLAND
LAWRENCE
CLINTON
ST CLAIR
WAYNE
JEFFERSON
WASHINGTON
MONROE
HAMILTON
WHITE
RANDOLPH
PERRY
FRANKLIN
JACKSON
WILLIAMSON
SALINE
GALLATIN
UNION
JOHNSON
POPE
HARDIN

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.

ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, Illinois 61801

ANCIENT DUST STORMS IN ILLINOIS

Myrna M. Killey

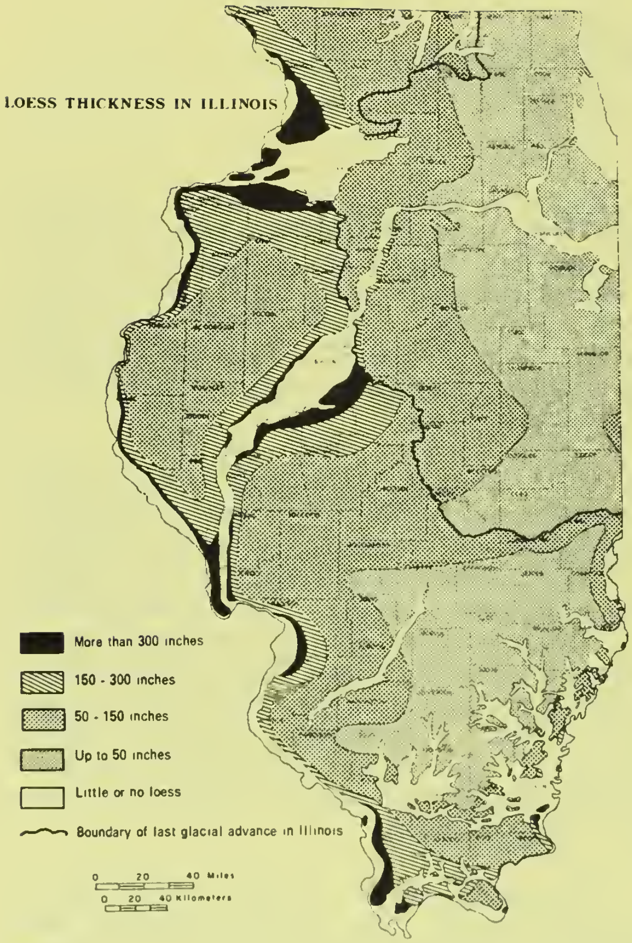
Fierce dust storms whirled across Illinois long before human beings were here to record them. Where did all the dust come from? Geologists have carefully put together clues from the earth itself to get the story. As the glaciers of the Great Ice Age scraped and scoured their way southward across the 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

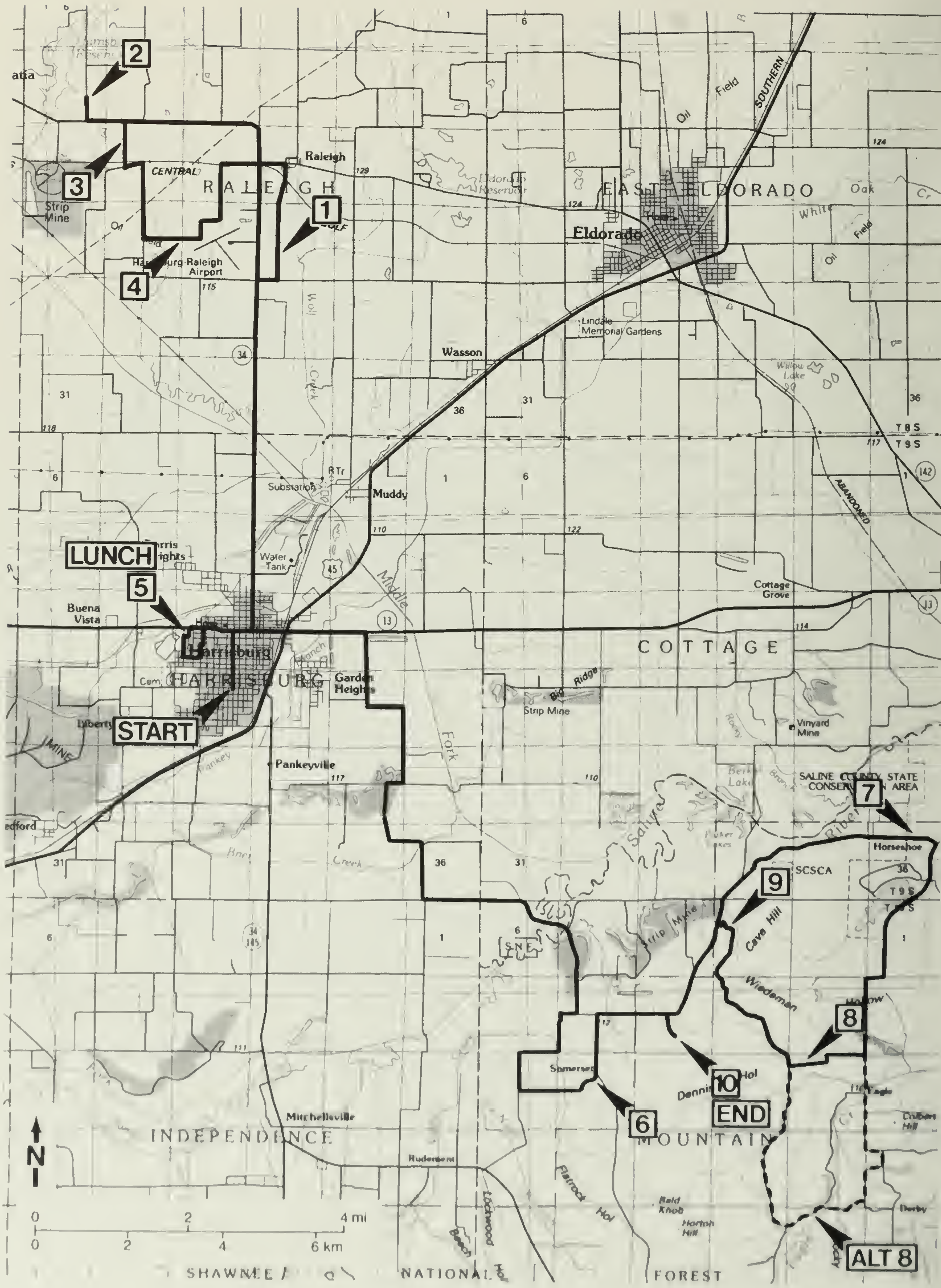


limestone grains. Some of the dissolved minerals later became solid again, gathering around a tiny nucleus or along roots to form the lumpy masses. A few such concretions are shaped roughly like small dolls and, from this resemblance, are called "loess kindchen," a German term meaning "loess children." 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
LUNCH
1
2
3
4
5
6
7
8
9
10
END
ALT 8
Raleigh
RALEIGH
CENTRAL
Strip Mine
Harrisburg-Raleigh Airport
EAST ELDORADO
Eldorado
Eldorado Reservoir
Oil Field
SOUTHERN
Lindale Memorial Gardens
Wasson
Willow Lake
T 8 S
T 9 S
ABANDONED
Substation
Muddy
Water Tank
Middle Fork
Cottage Grove
COTTAGE
Buena Vista
Harrisburg
HARRISBURG
Garden Heights
Cem
Liberty
MINE
Pankeyville
Big Ridge
Strip Mine
Vinyard Mine
SALINE COUNTY STATE CONSERVATION AREA
Saline River
Horseshoe
SCSCA
Cave Hill
Wiedeman Hollow
Somerset
Dennison Hol
MOUNTAIN
INDEPENDENCE
Mitchellsville
Rudement
Flatrock Hol
Bald Knob
Horton Hill
Colbert Hill
Derby
Lockwood Hol
Beech
SHAWNEE NATIONAL FOREST
N
0 2 4 mi
0 2 4 6 km