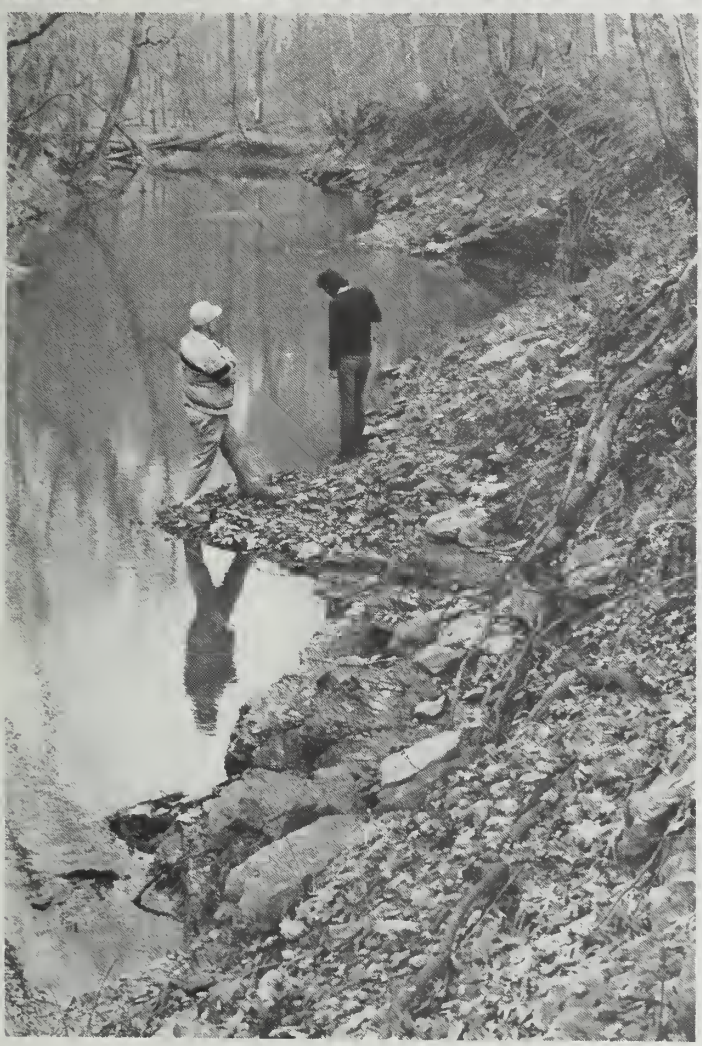
GUIDE TO THE GEOLOGY OF THE NEWTON AREA JASPER COUNTY



Geological Science Field Trip

C. Pius Weibel
David L. Reinertsen
Philip C. Reed

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Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
Champaign, IL 61820

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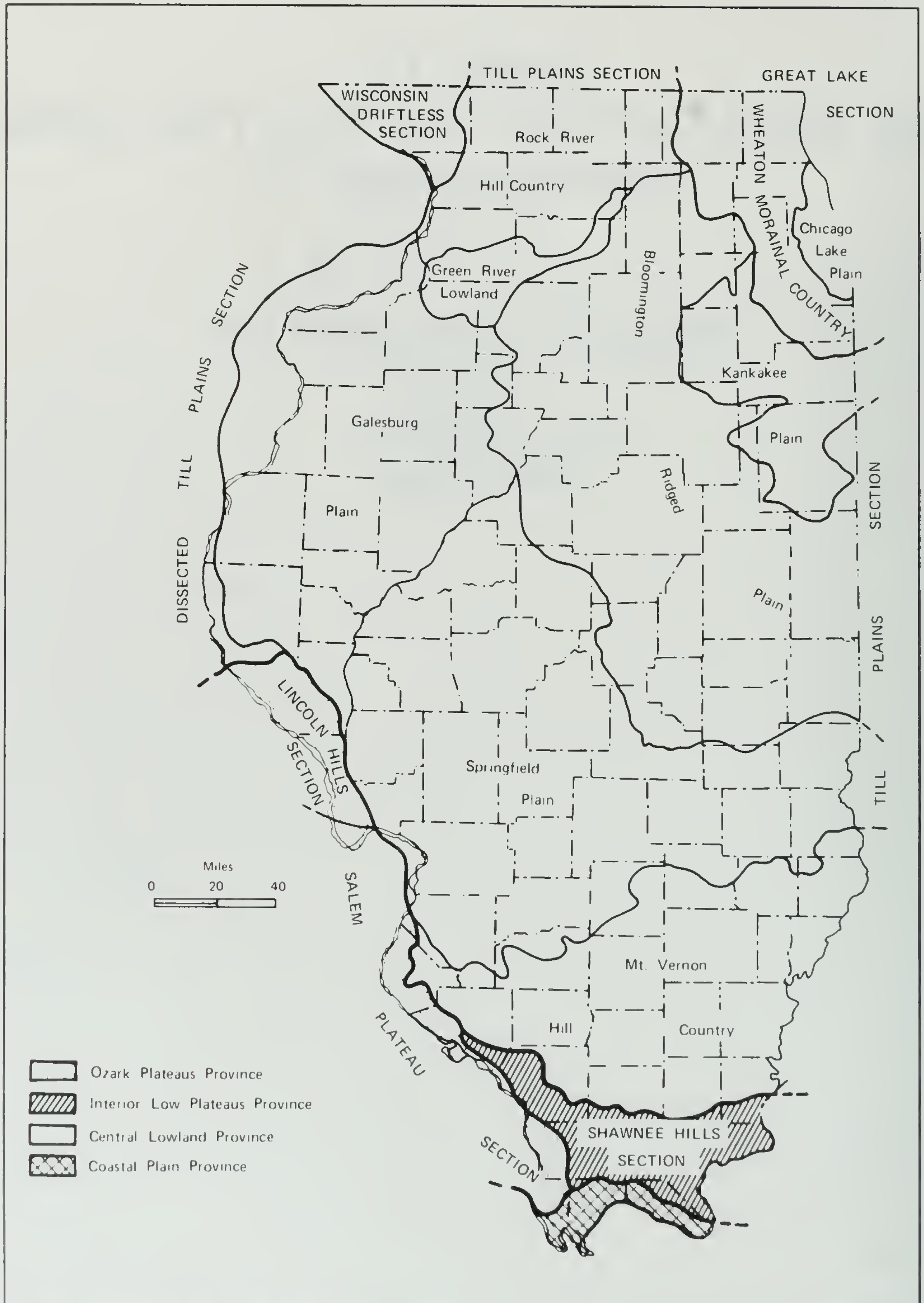


Figure 1 Physiographic divisions of Illinois.

GEOLOGY OF THE NEWTON AREA

GEOLOGIC FRAMEWORK OF THE NEWTON AREA

Surficial Deposits

The area covered by the Newton field trip in southeastern central Illinois was repeatedly buried under slow-moving, ponderous continental glaciers or ice sheets during the geologically recent Ice Age. This period, known to geologists as the Pleistocene Epoch, lasted in Illinois from at least 1.6 million years until about 10,000 years before the present (B.P.). The glaciers may have first covered the area about 700,000 years B.P., during what is known as Pre-Illinoian time, and the last ice sheet melted from the northern part of the field trip area about 190,000 years B.P., at the end of the Monican advance (Illinoian) (see *Pleistocene Glaciations in Illinois,* in appendix).

Ice sheets covered the state several times during the Illinoian Glacial Stage from perhaps 300,000 to 175,000 years B.P. During Illinoian time, North American continental glaciers reached their southernmost extent, advancing from Canada as far as the northern part of Johnson County in southern Illinois. Although the Illinoian glaciers built morainic ridges similar to those of the later Wisconsinan glaciers, Illinoian moraines are apparently not so numerous, and they have been exposed to weathering and erosion for thousands of years longer than their younger Wisconsinan counterparts. Consequently, their topographic expression is generally more subdued.

The northernmost point of the Newton area field trip is about 24 miles south-southeast of the southernmost point reached some 20,000 years B.P. by the younger Woodfordian continental glaciers (Wisconsinan Stage). Although these ice sheets did not reach the Newton area, windblown silt called loess (pronounced "luss"), of late Wisconsinan age, blankets the poorly sorted till or ground moraine (glacial drift) left behind by the Illinoian and Pre-Illinoian glaciers. Over much of the area, the loess ranges from about 2 feet to a little more than 4 feet thick. In some places, especially near some of the streams, erosion has removed all but a few inches. The highly productive soils that cover much of Illinois were formed by the weathering of these extensive loess deposits over a period of several thousands of years following the retreat of the last glaciers.

Physiography

The Newton area is in the eastern part of the Springfield Plain (fig.1), which includes the level area of the sheet of Illinoian glacial drift in this part of the state. Although the Springfield Plain generally is flat and has tabular uplands, its surface is gently undulating in places, and modern drainage is shallowly entrenched in it. Although glacial deposits are thinner in the Springfield Plain than in the lobate Wisconsinan moraines just a few miles to the north, the surface topography is essentially the result of glacial deposition and subsequent erosion by streams. The drift is generally less than 25 feet thick beneath the tabular uplands, but exceeds 100 feet in the buried bedrock valleys. Scattered across the Springfield Plain are some low, conical hills called kames, which are thought to be mounds of gravel deposited by water that melted from the glaciers. These landforms built by the Illinoian glaciers have been eroded and weathered and then mantled by Wisconsinan loess.

Drainage

The Embarras (pronounced "Ambraw") River is the major drainageway in the field trip area. Turkey and Mint Creeks and a number of smaller tributaries flow eastward into the Embarras. Wolf and Lick Creeks and other small tributaries flow southwestward to the Embarras. Crooked Creek, by far the largest Embarras tributary, drains the north-north-

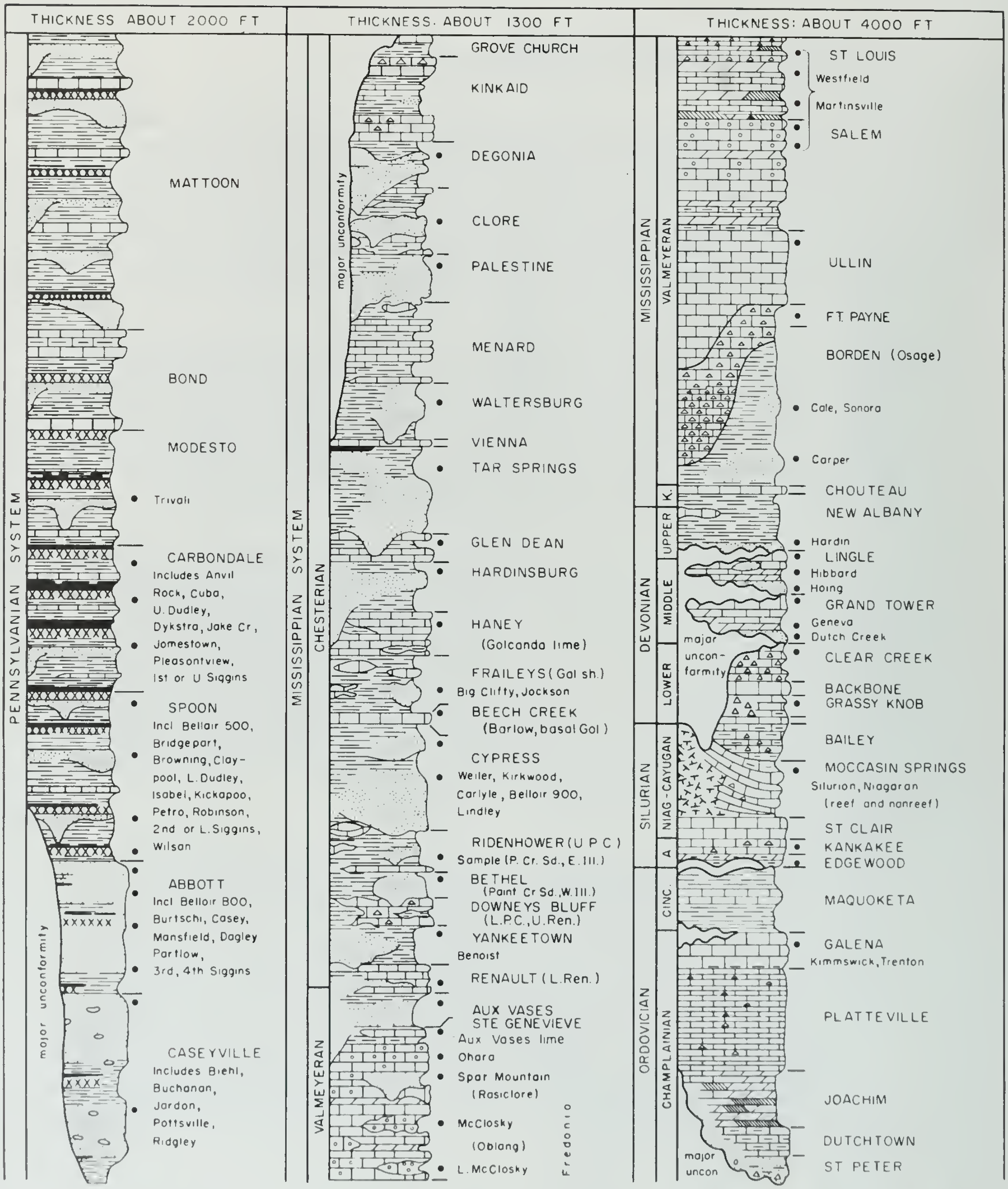


Figure 2 Generalized geologic column of southern Illinois. Black dots indicate oil and gas pay zones. Formation names are in capitals; other pay zones are not. About 4,000 feet of lower Ordovician and upper Cambrian rocks under the St. Peter are not shown. The names of the Kinderhookian, Niagaran, Alexandrian,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

east part of the field trip area southward. Brush Creek flows north-northeastward in the southeastern part of the area. All these streams developed courses across low areas in the glacial surface.

Relief

The highest point along the Newton field trip route is in the northwestern part of the area, about 2.75 miles southeast of Island Grove, where the surface elevation is slightly more than 590 feet above msl (mean sea level). The lowest point on the route is at the confluence of Brush Creek and Embarras River in the southeast part of the area, where the elevation is about 480 feet msl. The regional relief is therefore approximately 90 feet. Local relief is slightly more than 60 feet.

Bedrock

The bedrock below the glacial deposits was formed from ancient sediments deposited layer upon layer in shallow seas and swamps that repeatedly covered the Midcontinent region millions of years ago. Sediments that form the youngest known bedrock strata in this area were deposited during the Pennsylvanian Period of the Paleozoic Era, some 285 million years ago (figs. 2 and 3). These strata contain Illinois' valuable coal resources and are often referred to as the "Coal Measures." In the field trip area, rocks of the Pennsylvanian System range in thickness from about 900 feet in the northeast to more than 2000 feet in the southwest. An unknown thickness of younger Pennsylvanian and perhaps still younger Permian strata may have been deposited above the rocks that now form the bedrock surface; however, all traces of these younger rocks apparently have been removed by weathering and erosion during the 225 million years or so that elapsed between their deposition and the slow advance of the glaciers across the area. Details concerning the Pennsylvanian sedimentary rocks are included in the section on *Depositional history of the Pennsylvanian rocks* at the back of the guide leaflet.

Some bedrock exposures noted by early geologists and residents in the field trip area are no longer easily found, mostly because of human activities. For instance, as farming became more mechanized in the l930s, trees and the sod cover on hillsides were removed to increase the size of farm fields in order to take advantage of the efficiency of larger farm equipment and gain more tillable acres. As a result, the hillsides eroded much more

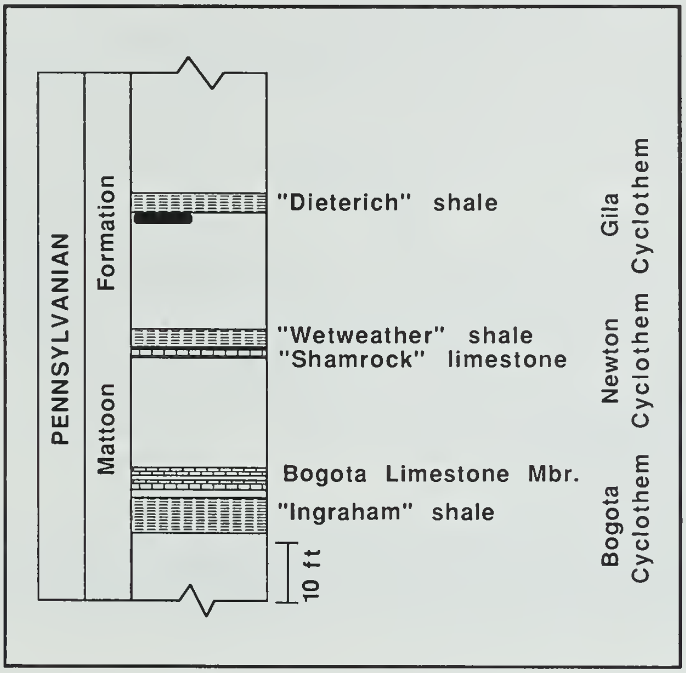


Figure 3 Generalized column of bedrock exposures in Newton area.

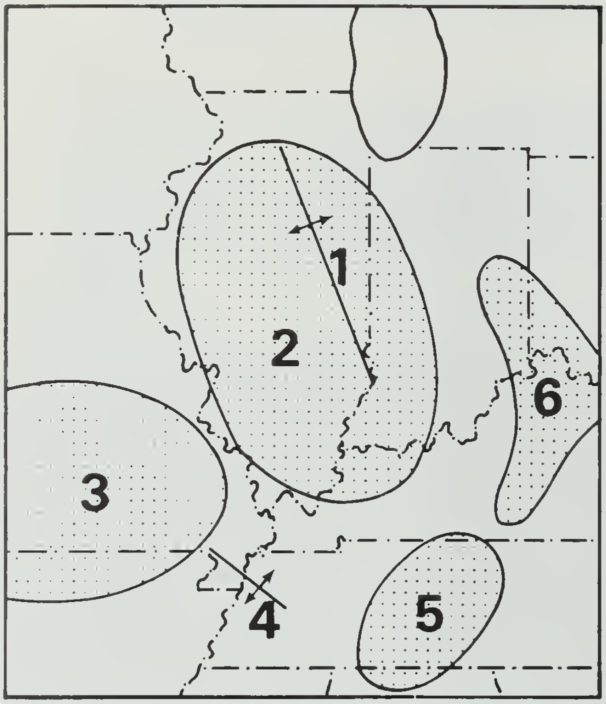


Figure 4 The location of some of the major structures in the Illinois region: (1) LaSalle Anticlinal Belt, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, and (6) Cincinnati Arch.

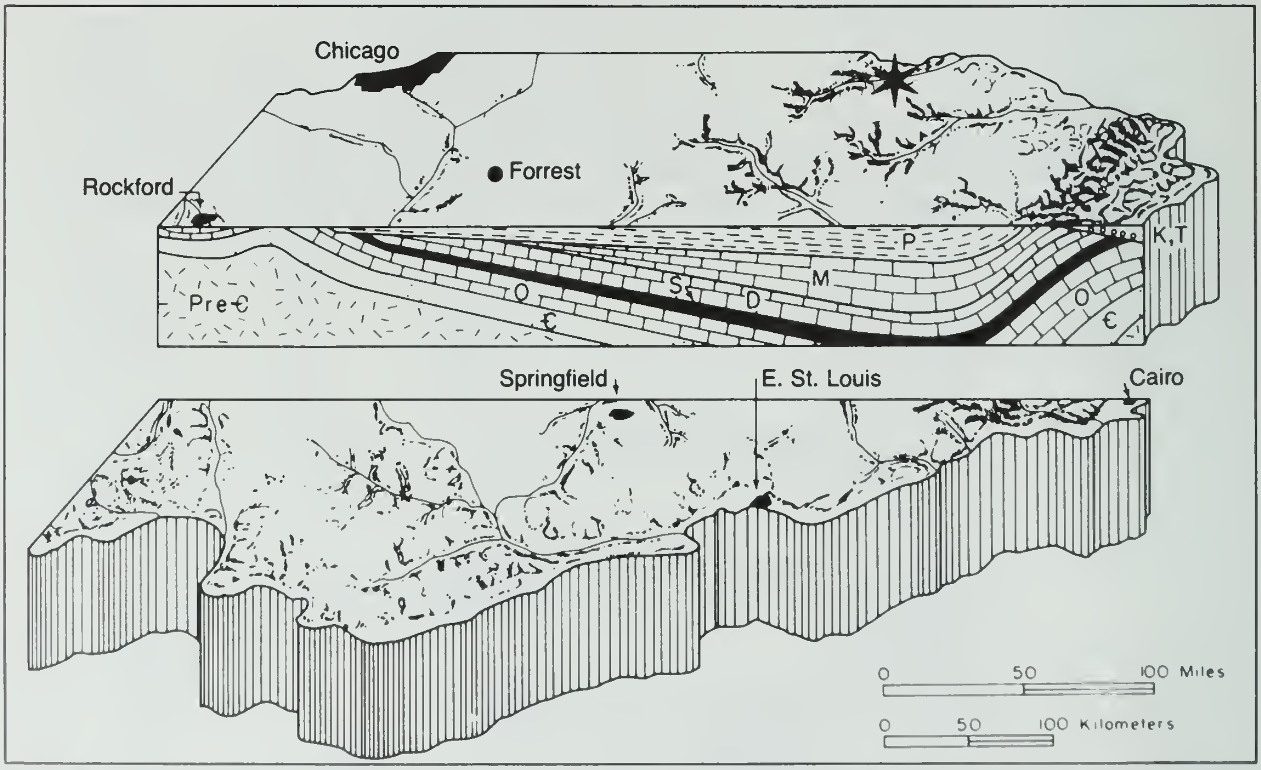


Figure 5 Stylized north-south cross section shows the structure of the Illinois Basin. In order to show detail, the thickness of the sedimentary rocks has been greatly exaggerated and the younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-C) granites. 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 Teritary (T). The scale is approximate.

readily and many of the streams became choked with silty sediments. Thus, bedrock strata formerly exposed along valley walls are now buried beneath modern sediments washed from the uplands.

Deep oil wells in nearby areas have penetrated strata of the Mississippian, Devonian, Silurian, and Ordovician Systems (fig. 2). Elsewhere in Illinois, deep wells have penetrated several thousand feet of sandstone, siltstone, shale, limestone, and dolomite that occur between the Ordovician rocks and the much more ancient igneous and metamorphic crystalline rocks of Precambrian age that form the so-called "basement complex." Nearly 10,500 feet of sedimentary rocks occur above the Precambrian basement here.

In Illinois, the Precambrian rocks consist mainly of granite and rhyolite that give radiometric ages ranging from 640 million to nearly 1.4 billion years ago. Granite and other Precambrian igneous and metamorphic rocks occur at the earth's surface around the upper Great Lakes and in Canada, and pieces of these exposed rocks were carried into the field trip area by the glaciers during the Ice Age.

Structural and depositional history

Erosion of the Precambrian basement rocks resulted in a landscape similar in form to parts of the present-day Missouri Ozarks. In southernmost Illinois near what is now the Kentucky-Illinois Fluorspar Mining District, evidence from surface mapping, gravity and magnetic field measurements, and seismic exploration for oil indicates that rift valleys like those in east Africa formed during a period when plate tectonic movements were beginning to rip apart the early North American continent. These rift valleys, now referred to as the Rough Creek Graben and the Reelfoot Rift, filled with sands and gravels shed from the adjacent uplands, and with sediments deposited in lakes that formed in the valley floors. Around the begining of the Paleozoic Era, some 525 million years ago, the rifting stopped and the hilly Precambrian landscape began to slowly sink on a broad, regional scale. This permitted the invasion of a shallow sea from the south and southwest. During the several hundred millions of years of the Paleozoic Era, southern Illinois continued to receive sediments and sink until at least 15,000 feet of sedimentary rocks accumulated (figs. 4 and 5). At times during the Paleozoic Era, however, the seas withdrew and the deposits were subjected to weathering and erosion. As a result, there are some gaps in the sedimentary record in Illinois.

Near the close of the Mississippian Period, gentle arching of the rocks in eastern Illinois initiated the development of the La Salle Anticlinal Belt (fig. 4). Further gradual arching continued through Pennsylvanian time. Because of the absence of the youngest Pennsylvanian strata from the area of the anticlinal belt, we cannot know just when movement along the belt ceased--perhaps by the end of the Pennsylvanian or a little later near the close of the Paleozoic Era during the Permian Period.

The La Salle Anticlinal Belt is a complex structure; in the field trip region, and throughout its extent from Lawrence County in the south to La Salle County in the north, many smaller structures, such as domes, anticlines, and synclines, are superimposed on the broad upwarp of the belt. Some of these smaller structures have oil fields associated with them in strata of Pennsylvanian, Mississippian, Devonian, and Ordovician age at depths as great as 2000 feet. In the field trip area, the bedrock strata generally dip southwestward and south away from the crest of the La Salle Anticlinal Belt and toward the deeper parts of the Illinois Basin.

Following the Paleozoic Era, during the Mesozoic Era, the rise of the Pascola Arch (fig. 4) in southeastern Missouri and western Tennessee separated the Illinois Basin from other basins to the south. Development of this arch in conjunction with the earlier sinking of the deeper part of the Illinois Basin gave the Illinois Basin its present spoon configuration.

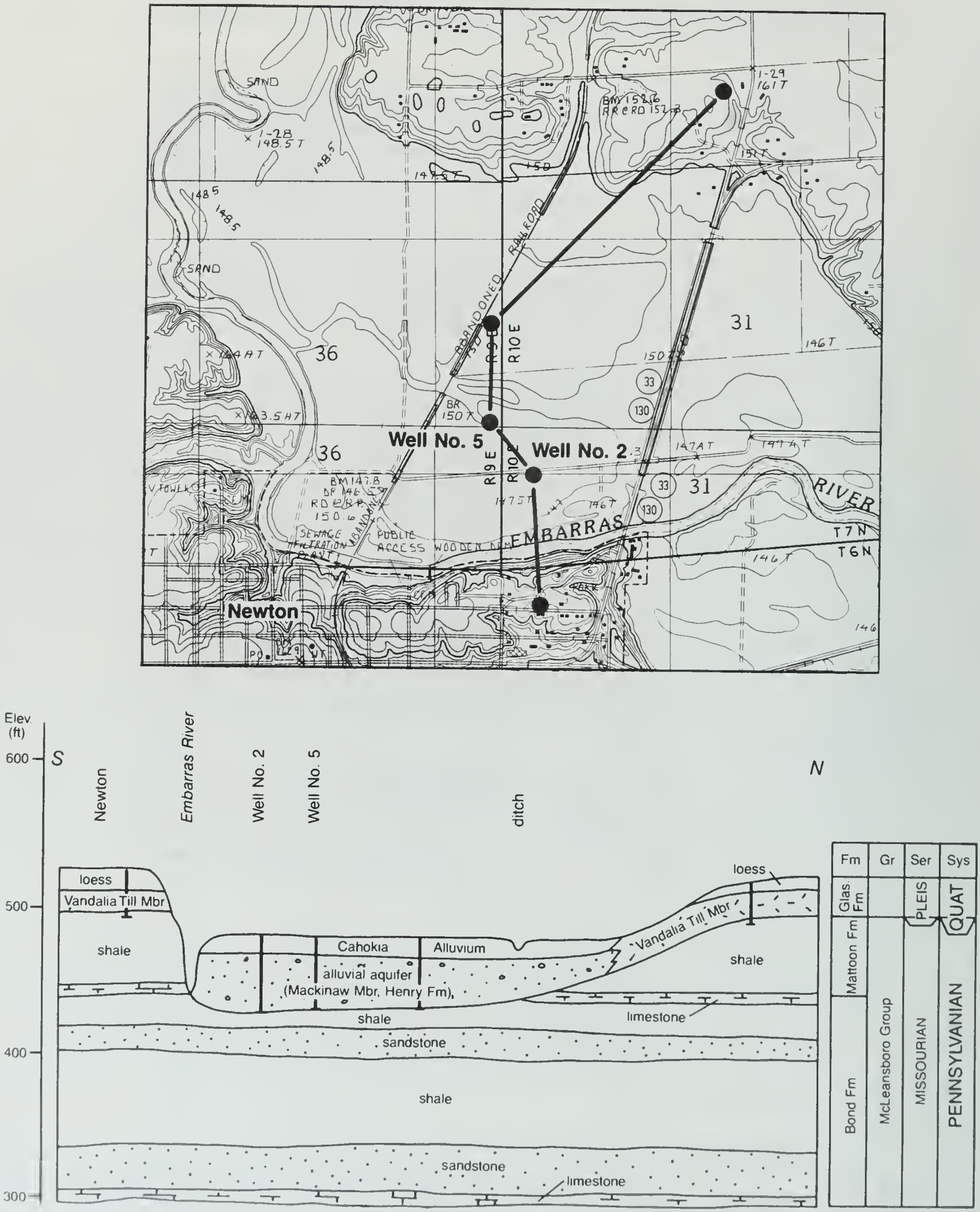


Figure 6 Sandstone aquifers in Newton area.

MINERAL PRODUCTION

Of the 102 counties in Illinois, 98 reported mineral production during l986, the last year for which complete records are available. The total value of all minerals extracted, processed, and manufactured was $3,268,100,000, a decline of nearly $490 million from the previous year and the lowest recorded total value since 1978. In Illinois, coal continued to be the leading commodity, followed by oil, stone, sand and gravel, and clays. In U.S. production of nonfuels, Illinois advanced its position from 17th to 16th, leading other U.S. producers in fluorspar, industrial sand, tripoli, and iron-oxide pigments.

Jasper County ranked 39th among all Illinois counties on the basis of the value of its production of crude oil, which amounted to more than $14.9 million.

GROUNDWATER

Groundwater is a mineral resource frequently overlooked in the assessment of an area's natural resource potential. The availability of this mineral resource is essential for orderly economic and community development. In Illinois more than 48 percent of its 11 million citizens depend on groundwater for their water supply. Throughout Illinois, groundwater is derived from underground formations called aquifers. An aquifer is a body of rock that contains enough water-saturated porous and permeable materials to release economically significant quantities of water into an open well or spring. The water-yielding capacity of an aquifer can be evaluated by drilling wells into it. The wells are then pumped to determine the quality and quantity of groundwater available for use.

Municipal groundwater sources in Illinois tap aquifers exceeding 2200 feet deep in Kane County west of Chicago to less than 50 feet in several downstate locations, including Newton in Jasper County. The source of most potable water in Jasper County is precipitation, which occurs about 40 times each year in the form of rain, hail, or snow. Although most of the precipitation that falls is lost through evaporation, transpiration from the leaves of plants, and surface runoff, some 12 to 20 percent of it migrates downward into the ground and eventually reaches the saturated zone or water table, the zone where all the pores in the soil or rock are filled with water. Wells tapping aquifers in the field trip area are open to sedimentary rock units of Quatemary and Pennsylvanian age, which occur at depths less than 50 feet to as much as 295 feet beneath the surface.

Groundwater conditions vary throughout most of Jasper County. Quaternary glacial deposits are comparatively thin, and Pennsylvanian bedrock crops out at many locations, particularly in the central part of the county. High capacity well development is only possible in parts of the Embarras River lowland where sand and gravel deposits up to 40 feet thick are fairly continuous. Sandstone aquifers up to 75 feet thick can be found in the Pennsylvanian bedrock in the eastern and northwestern parts of the county. Near Newton these sandstones are 100 to 300 feet below land surface (fig. 6), whereas in the northwestem part of the county, wells draw water from aquifers in the upper 100 to 150 feet of bedrock.

Public water supplies tapping these groundwater resources have been developed at Newton, Ste. Marie, Willow Hill, and in the area served by the West Liberty-Dundas Water District in Jasper County.

The city of Newton (population 3186) is located near the geographical center of Jasper County along the beautiful Embarras River. A public surface water supply system utilizing Embarras water was in operation when the first electrical earth resistivity survey (a geophysical method for characterizing buried sand and gravel deposits)[1] was conducted in the Embarras River lowland in 1963. The resistivity work was undertaken to develop a new groundwater supply after cyanide had been dumped into Kickapoo Creek, a tributary to the Embarras. This work resulted in the eventual development of three elevated platform wells open to the sand and gravel deposits that underlie the Embarras River Valley to depths of 50 or 60 feet (fig. 6) in many places. In 1981, a fourth elevated platform well was constructed southeast of the 1963 wells. In 1987, another more detailed resistivity survey was conducted north, northwest, and east of the present Newton water well field. In 1988, further testing led to the construction of Well No.5, open to sand and gravel between 23 and 50 feet. Current pumpage at Newton, mainly from Well Nos. 4 and 5, ranges between 290,000 and 460,000 gallons per day (gpd).

The village of Ste. Marie (population 312) installed a public water supply in 1954. Two wells, both 54 feet deep and finished in sand and gravel, pump an average of 12,000 gpd to supply the village; in 1988, two wells were constructed approximately 50 feet deep into sand and gravel. The wells have a capacity of 115 gpm.

The village of Willow Hill (population 292) installed a public water supply in 1965. Three wells supplying the community open into Pennsylvanian sandstones and have an average depth of 286 feet. The wells reportedly have an average pumpage of 5400 gpd.

The West Liberty-Dundas Water District (612 water users) was established for public water supply in 1970. The system serves West Liberty in Jasper County and Dundas in Richland County to the south. Average pumpage from the four Pennsylvanian sandstone wells supplying the system is 24,000 gpd. Average depth and yield from each of the four wells is 174 feet and 6 gpm.

[1]The Geological Survey conducts electrical earth resistivity surveys as part of a free groundwater service program to help locate industrial, public, and private groundwater supplies. Resistivity surveys are useful in prospecting for buried, waterbearing sand and gravel deposits of glacial drift and alluvium above the bedrock. By using general geologic information about a locality and information obtained by an electrical earth resistivity survey, geologists can predict the waterbearing potential of earth materials. Since 1932 the ISGS has made more than 2000 resistivity surveys in the state, covering areas ranging in size from about an acre to many square miles.

GUIDE TO THE ROUTE

Miles/ next point	Miles/ starting point	
0.0	0.0	Assemble in parking lot on north side of Newton Community High School, West End Avenue, on the south side of Illinois (IL) Route 33 (NE SW NE sec.2, T6N, R9E, 3rd P.M., Newton 7.5-minute Quadrangle. EXIT north using east entrance. CAUTION: TURN LEFT (west) onto IL 33.
0.6	0.6	Prepare to turn right.
0.1	0.7	TURN RIGHT (north) at 975N/1000E onto winding paved road.
0.75+	1.45+	TURN LEFT (west) at 1050N/1000E.
0.3	1.75+	Note tank battery, part of Newton West oilfield (fig. 7). The discovery well of this oilfield was drilled in 1947 and produced from the "McClosky Lime" (Fredonia Limestone Member) at a depth of about 2900 feet. The field was abandoned in less than a year, revived in 1952, and abandoned again in 1953. The field was again revived in 1961. The next year a second producing horizon, the Spar Mountain Sandstone Member, was discovered at a depth of about 3000 feet, and the field has been producing oil ever since. The Spar Mountain Sandstone and the Fredonia Limestone ("McClosky Lime") (fig. 2) are members of the Mississippian Ste. Genevieve Limestone. As of early 1988, 50 wells have been completed in this field, but most have been abandoned. Nineteen wells in this field produced only 1460 barrels of oil in 1987.
0.95+	2.75+	Another tank battery of the Newton West oilfield. Approximately 0.5 mile to the northeast is the site of one of the earliest coal mines in Jasper County. Little is known about the mine except that the shaft was 150 feet deep and the coal was 3 to 4 feet thick at a depth of 136 feet. The mine was abandoned in 1910.
0.05	2.8+	Brick Cemetery lies on the right.
0.1	2.9+	Road curves north.
0.9+	3.9+	You are now coming onto the floodplain of the Embarras River.
0.2	4.1	PARK along right road shoulder. Do NOT block bridge or field entrances.

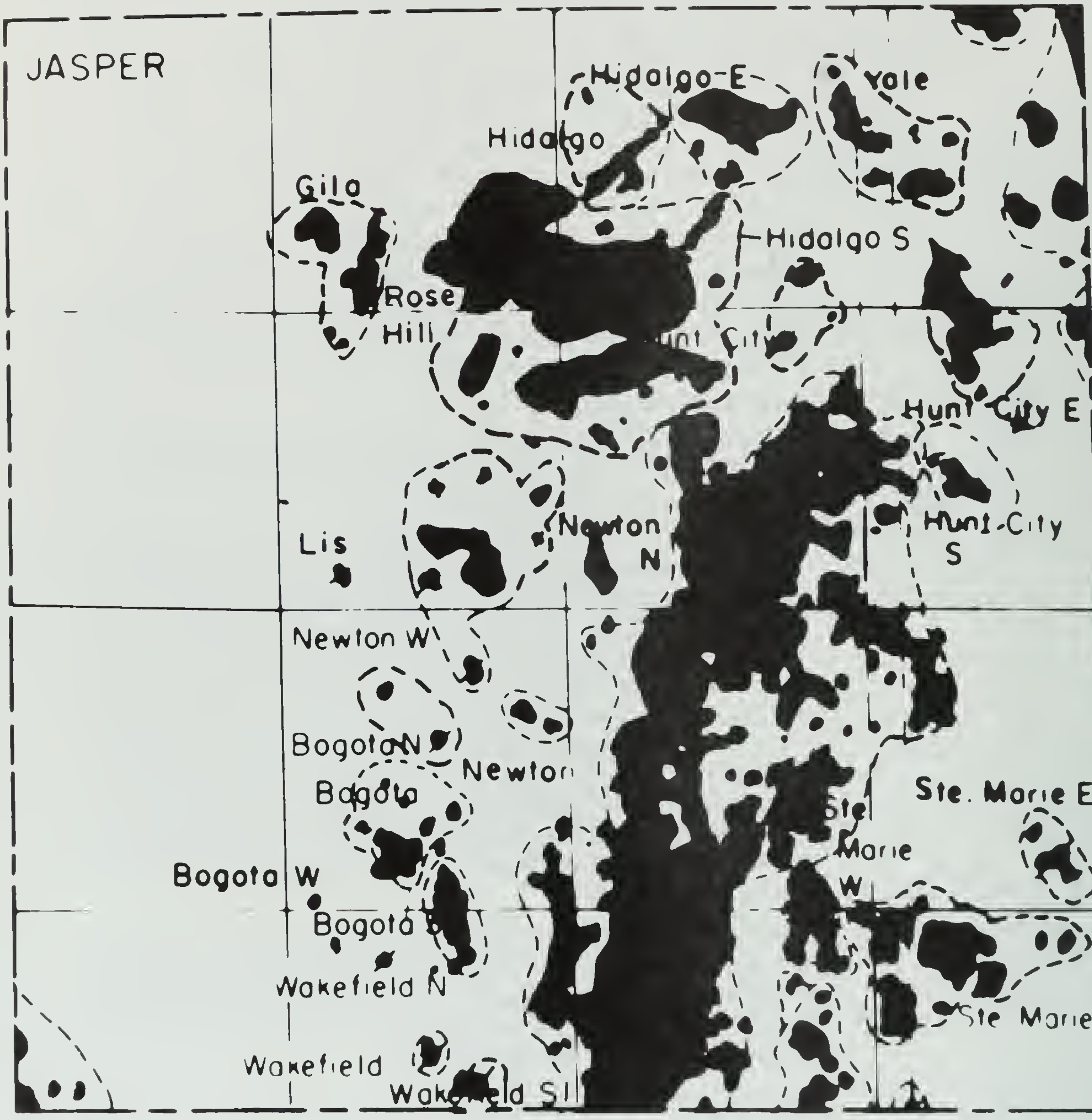


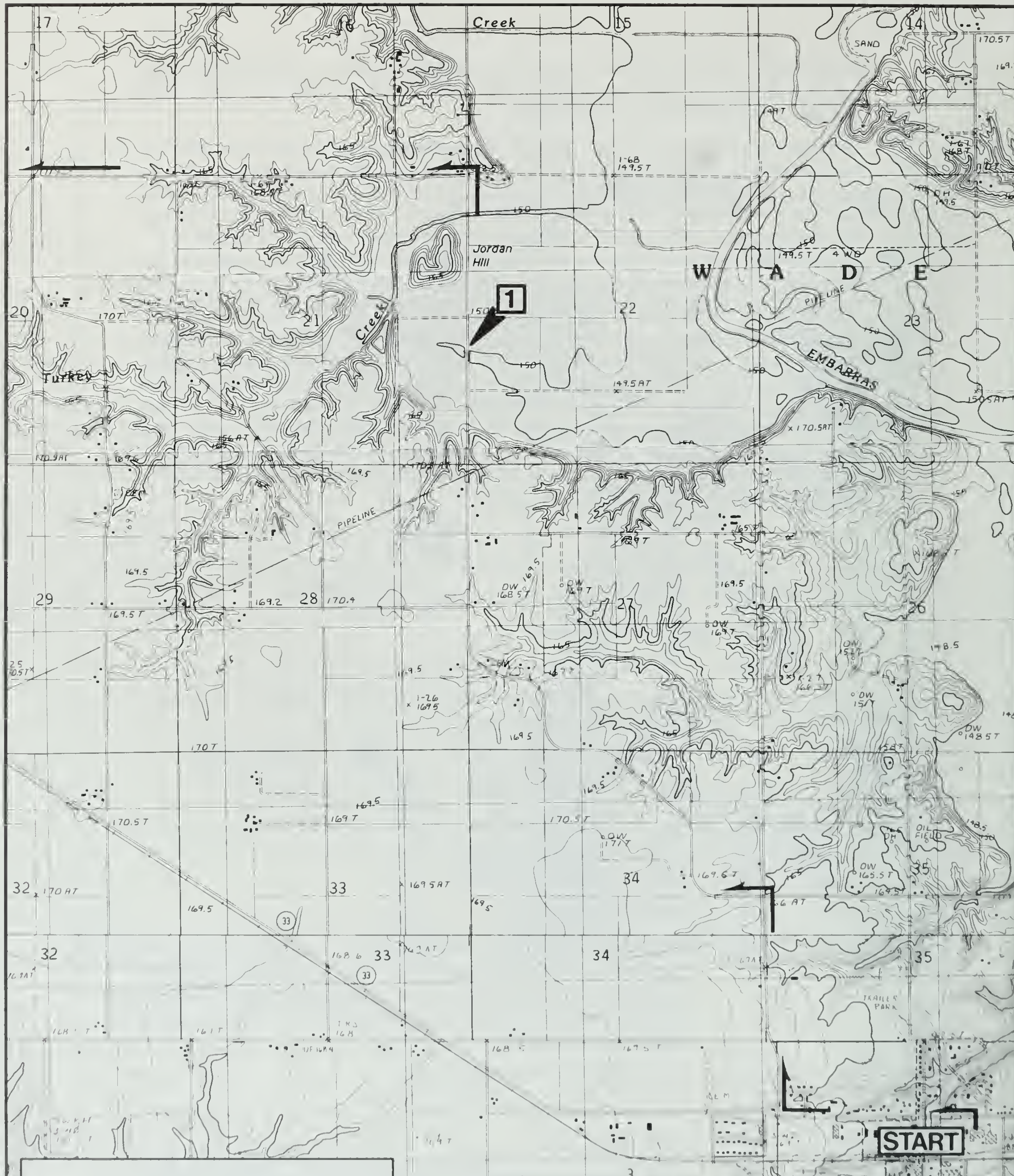
Figure 7 Oil and gas fields of Jasper County as of January 1987.

STOP 1. View and discussion of Jordan Hill, an isolated "island" hill in the alluviated Embarras River Valley (center, west edge, NW NW SW sec. 22, T7N, R9E, 3rd P.M., Jasper County; Rose Hill 7.5-minute Quadrangle).

The origin of the Embarras River has been attributed to the breaching of a low area in a terminal moraine (Reinertsen et al., 1986), probably during the melting and retreat of the last Wisconsinan glacier. Glacial meltwater that had ponded behind the moraine flowed out through the breach and began to cut into the glacial outwash, forming this large valley. In some areas, bedrock was exposed as the valley deepened. As the glaciers continued to melt northward the amount of meltwater flowing down the valley began to decrease and the valley gradually filled with sand and gravel. The downcutting of the Embarras River into this alluvium indicates that the river was rejuvenated after the Pleistocene.

The prominent "island," Jordan Hill, is an erosional remnant that survived water erosion by both Turkey Creek and the Embarras River. During the Pleistocene, when the creek and the river were much larger than they now are, a large meander of the Embarras existed along the edge of the floodplain to the west and south. This meander was actively eroding the hills and slopes at the edge of the floodplain. At the same time, Turkey Creek, which flows northeasterly into the Embarras, was eroding its own bank. The area between the creek and the river was gradually reduced to a narrow ridge that eventually was breached just to the southwest of Jordan Hill.

0.0	4.1	Leave Stop 1 and PROCEED AHEAD (north).
0.25	4.35	Jordan Hill lies to left. CONTINUE AHEAD (north).
0.2	4.55	Cross Turkey Creek.
0.1+	4.65+	TURN LEFT (west) at 1300N/900E.
0.25	4.9+	T-road from right at 1300N/875E. CONTINUE AHEAD (west) crossing Turkey Creek tributary.
0.75+	5.7	T-road from left at 1300N/800E. CONTINUE AHEAD (west).
0.5	6.2	STOP: 2-way at 1300N/750E. CONTINUE AHEAD (west).
0.7	6.9	The upland here is relatively flat and has gentle slopes in all directions toward streams and drainageways.
0.55+	7.45+	TURN RIGHT (north) at 1300N/600E.
0.05-	7.5	TURN LEFT (west).
0.25	7.75	In the distance, the tall smoke stacks to the left (south) belong to the Central Illinois Public Service (CIPS) power plant at Newton Lake. This coal-burning power plant reportedly was built at that site to be a mine-mouth plant above coal seams some 1000 to 1200 feet deep. To date, no shaft has been sunk.
0.5	8.25	TURN RIGHT (north) at 1300N/525E.
0.2	8.45	View flat till plain to the northwest.
0.65+	9.1+	Cross Slate Creek
0.05-	9.I5	PARK along right road shoulder. Do NOT park on bridge. WALK to outcrop on south side of Slate Creek bridge on the west side of the road.



Creek
Jordan Hill
1
W A D E
EMBARRAS
PIPELINE
Turkey
Creek
SAND
OIL FIELD
TRAILER PARK
START
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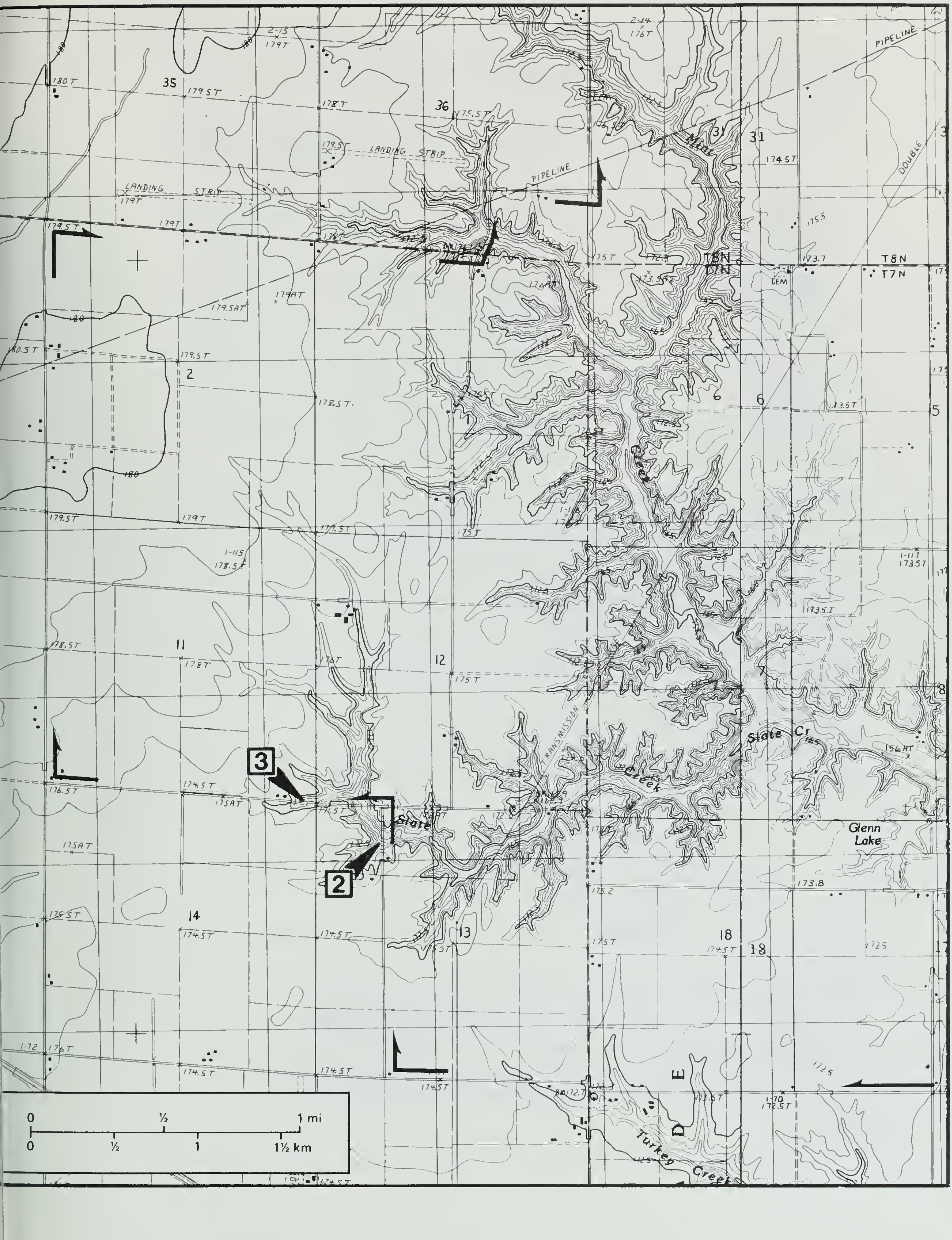
0 ½ 1 1½ km


PIPELINE
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LANDING STRIP
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STOP 2. Examination of outcrop of the Gila cyclothem (SE NE SW NW sec. 13, T7N, R8E, 3rd P.M., Jasper County; Wheeler 7.5-minute Quadrangle).

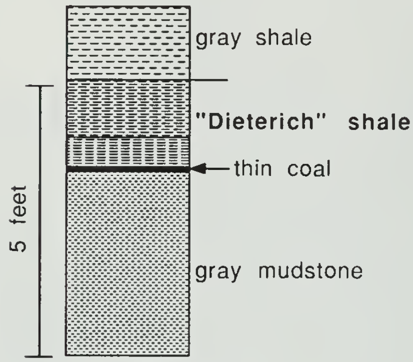


Figure 8 Gila Cyclothem.

The term "cyclothem " denotes a series of beds resulting from a single sedimentary cycle; generally, nonmarine deposits in the lower part of the sequence are overlain by marine sediments in the upper part. The Gila cyclothem (fig. 8) was named by Newton and Weller (1937) for strata exposed along Mint Creek, south of Gila. The cyclothem also crops out along Embarras River tributaries southeast of Gila, along Turkey Creek (between here and Newton), and here along Slate Creek. These rocks are the youngest bedrock in the field trip area. Older strata examined on this field trip are at lower elevations and closer to the Embarras River; their positions indicate that erosion by present-day streams, not geological structure, is primarily responsible for exposing the three cyclothems examined on this field trip.

The distinctive unit of this cyclothem is the black, sheety shale, which is less resistant to erosion than the softer shales above and below. Because the shale has a strong tendency to split into thin, brittle sheets (like the metamorphic rock, slate), miners and other laymen often referred to the rock as slate. Slate Creek acquired its name because the "Dieterich" shale is well exposed in and along its creek bed. The shale is sparsely fossiliferous, containing fish fragments and carbonaceous plant fragments. Unlike other cyclothems in the area, the Gila cyclothem does not contain a laterally extensive marine limestone. However, in some places the base of the "Dieterich" shale has a gray, dense layer consisting of interbedded thin, calcareous laminae and black shale layers. Microscopic examination of the calcareous laminae indicates that they consist mostly of algae but include other microfossils. The shale overlies a very thin coal layer. This coal is laterally discontinuous in the vicinity of the Mint Creek-Gila area, where it attains a thickness of about 0.35 feet; it is shaly along Turkey Creek. This coal, equivalent to the coal that was mined along Brush Creek just southeast of Newton, will be discussed at Stop 8.

0.0	9.15	Leave Stop 2. PROCEED AHEAD (north)
0.1	9.25+	TURN LEFT (west) at 1400N/525E.
0.1	9.35+	Cross Slate Creek.
0.2-	9.55	PARK along road shoulder. BEWARE of narrow culvert when parking.

STOP 3. View and discussion of Illinois till deposits (Center, south edge, SE SE SE sec. 11, T7N, R8E, 3rd P.M., Jasper County; Wheeler 7.5-minute Quadrangle).

The glacial till exposed along the road is composed largely of irregular shale fragments derived from the local bedrock. Pebbles that were transported long distances (erratics) generally are characterized by more rounded shapes and striations. Erratics are not common here.

Many road cuts and stream bank exposures in the Illinoian till plain area show soil profiles similar to the exposures here in the road cut and to the north in the stream cuts. The stratigraphy of the upper part of the Quaternary deposits is easily recognized. A generalized interpretation of the soil horizons and glacial stratigraphy of this site is shown in figure 9. The black and gray colors in the buried soils indicate that this was a wet, poorly drained area before the Peoria Loess was deposited. The 4C1 horizon is best seen where the dissolved iron has moved down and precipitated in the orange-colored zone.

The 4Bgb is the lower part of the gleyed zone of gray, mottled soil developed in till and is also the top of the Vandalia Till Member. The contact at the top was the ground surface at the end of the time of glacial activity. In some places a lag (residual) gravel occurs at this contact, which is evidence for an erosion surface. When the climate became warm again the Sangamon Soil formed on what was then the ground surface. At this location slope wash continued to accumulate, causing the soil to build upward. This zone of accretionary material, called Berry Clay, forms the present day 3Bgb horizon.

Later, during early Wisconsinan time, another deposit covered the surface soil. This material, transported mostly by wind, forms the zone designated Roxana Silt; it appears to have accumulated slowly, because the lower boundary is obscured and the new materials have characteristics of a wetland soil (Cumulic Haplaquoll). This silty zone is nearly black in places because of its original high organic content. This zone clearly was the top soil of a former land surface and is designated here as the 2Ab horizon, commonly referred to as a "buried soil."

The organic-rich horizon is the top of the Farmdale Soil. During the time of formation of the Farmdale, the former Ab horizon of the Sangamon Soil was transformed into the 3Bgb horizon. This means that the Farmdale inherited the Sangamon (i.e., grew down into it). The profile below Peoria Loess is commonly referred to as a paleosol, or technically as compounded buried soil designated as the Farmdale-Sangamon Soil.

In late Wisconsinan time, from about 12,000 to 25,000 years ago, the Peoria Loess was generated by wind erosion and deposition. It covered the Illinoian till plain beyond the glacial margin marked by the Shelbyville Morainic System that occurs some 20 miles to the

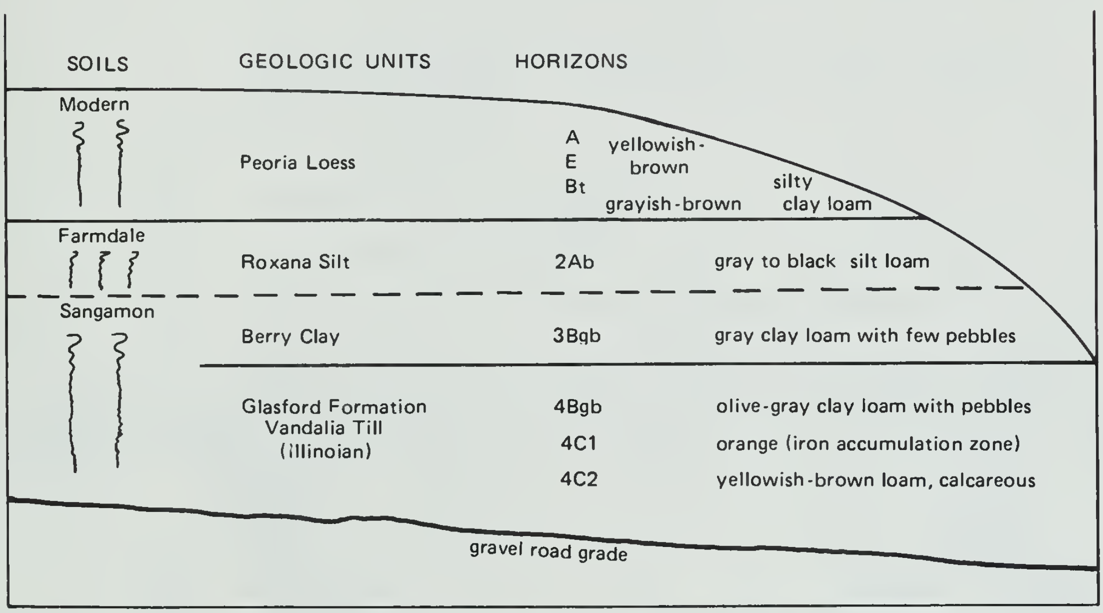
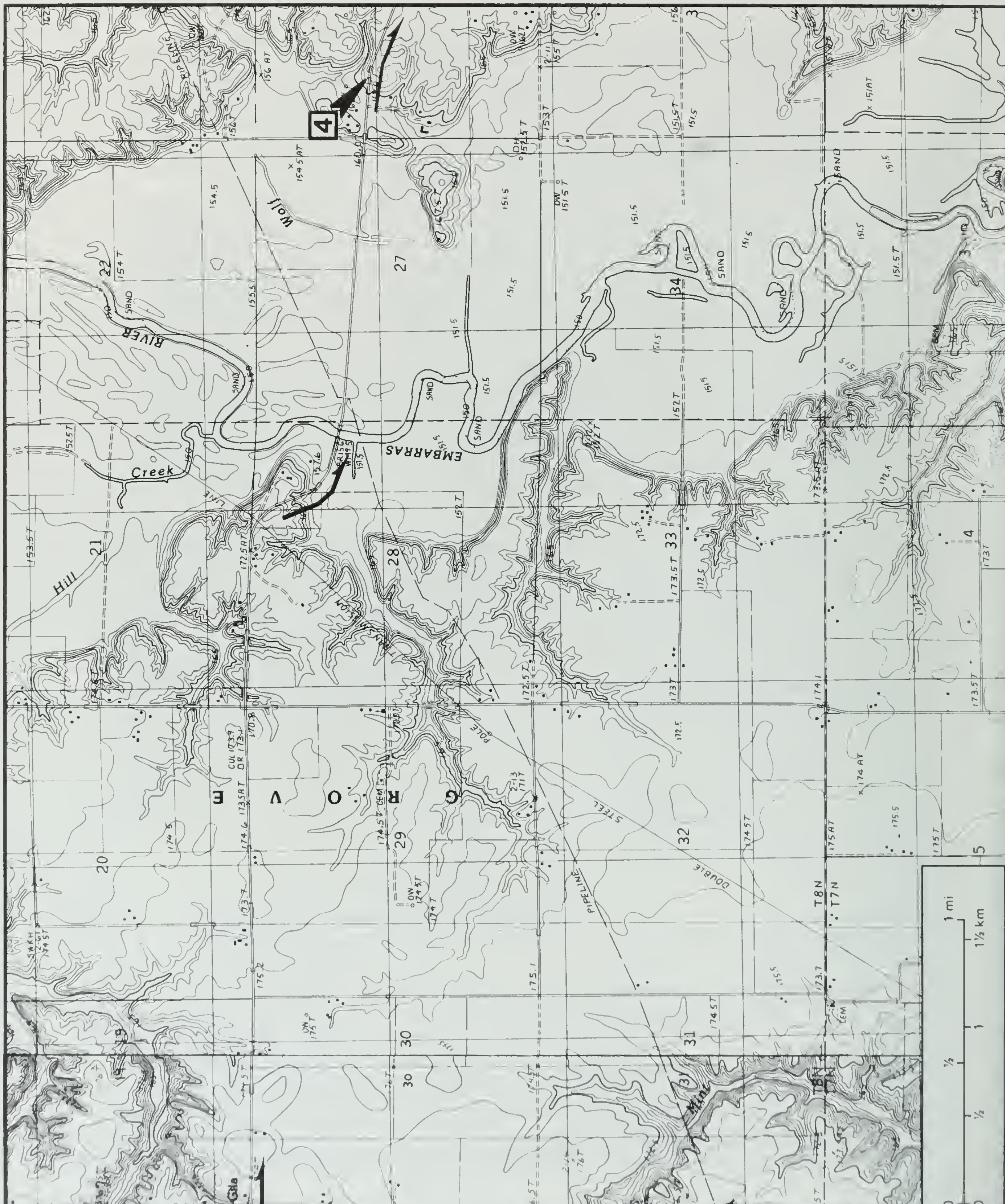


Figure 9 Typical weathering profile on the flat Illinoian till plain of south-central Illinois (scale is exaggerated).


EMBARRAS
RIVER
Wolf
Hill
Creek
G R O V E
Mint
PIPELINE
STEEL
DOUBLE
POLE
LINE
SAND
4
T8N
T7N
0
½
1 mi
1½ km
21
22
27
28
29
30
31
32
33
34
20
3
4
5

north. A typical Modern Soil (Hapludalf) formed in the Peoria interval during the last 12,000 years. Much of the hill and valley character at this site was created by normal (geologic) erosion during the last 12,000 years or so, but human activity caused accelerated erosion in the area, particularly in hog lots. Soil losses from sloping hog lots in similar areas are as high as 25 tons per acre (about 1 inch in 7 years).

0.0	9.55	Leave Stop 3. PROCEED AHEAD (west).
0.95+	10.5+	STOP: 2-way at 1400N/400E. TURN RIGHT (north) onto paved road.
0.75	11.25+	T-road from right at 1475N/400E. CONTINUE AHEAD (north).
0.35	11.6+	View of Illinoian till plain to the northwest. Note the overall flatness of the till plain. The low hill in the distance at Island Grove, easily located by the prominent church steeple, may be adjacent to a remnant of an abandoned glacial channel. Such channels were occupied by flowing meltwater streams during the Wisconsinan glaciation.
0.3	11.9+	This is the highest part of our route (slightly more than 590 feet msl elevation).
0.7	12.6+	TURN RIGHT (east) at 1600N/400E.
0.7	13.3+	The tank battery to the northeast behind the garage is probably inactive because no oil wells have been completed in this area.
0.3+	13.6+	T road at 1600N/500E. CONTINUE AHEAD (east).
0.35+	13.95+	CAUTION: narrow bridge.
0.1+	14.1+	CAUTION: narrow culvert. Glacial till is exposed along road just to east.
0.1	14.2+	TURN LEFT (north) at 1600N/560E onto paved road.
0.05-	14.25	Pennsylvanian shale of the Gila cyclothem is exposed in bank on both sides of road.
0.05	14.3	CAUTION: bridge across Mint Creek tributary. Just ahead to the right (east) side in the roadcut is another exposure of the Pennsylvanian shale, mostly slumped.
0.15	14.45	BEAR RIGHT (east).
0.35+	14.8+	BEAR LEFT (north) at 1625N/600E.
0.5+	15.35	Narrow bridge over Mint Creek.
1.2+	16.55+	STOP: 4-way at Gila. TURN RIGHT (east) at 1800N/600E.
0.75+	17.3	Tank battery lies to right at 1800N/700E. The route crosses the northern edge of the Gila oilfield. The discovery well of this field was drilled in 1957. Since then, 35 wells have been completed; all have produced from the "McClosky Lime" (Fredonia Limestone Member) at a depth of about 2850 feet. In 1987 only one well produced oil (1076 barrels).
1.0+	18.35+	CAUTION: cross road at 1800N/800E. CONTINUE AHEAD (east).


Rose Hill
CROOKED CREEK
Crooked
West Crooked Cr
5
Falmouth
OIL FIELD
ABANDONED
RAILROAD
T8N
T7N
130
0 ½ 1 mi
0 ½ 1 1½ km

1.05+	19.45	Cross Embarras River.
0.1+	19.55+	Note width and flatness of the Embarras River floodplain.
0.9+	20.5	T road at 1760N/1000E. CONTINUE AHEAD (east).
0.15	20.65+	PARK along road shoulder.

STOP 4. View and discussion of Pleistocene sand dunes (center, SW NW sec. 26, T8N, R9E, 3rd P.M., Jasper County; Rose Hill 7.5-minute Quadrangle).

The presence of sand dunes in east-central Illinois is generally a surprise to most people, who probably associate sand dunes with deserts and beaches. Most deserts actually consist of barren rock that is only partly covered by sand. Sand dunes form wherever a source of unconsolidated sand grains exists and persistent winds blow from one direction. During and after the melting and retreating of the glaciers, the Embarras River became deeply incised, exposing large areas of fine-grained sediment that had been transported and deposited by the meltwater streams. Prevailing westerly winds eroded, transported, and deposited the sand-sized grains in small dune fields along the river valley. Vegetation stabilized these deposits and reduced or terminated eolian (wind) activity. Most of the sand dunes, except for local "blow-outs," have long been stabilized in their present positions, and most have been modified by agricultural practices or quarried for use in construction. One of the most common types of sand dunes here is the barchan dune, a crescent-shaped dune that is a product of limited sand supply. The absence of sand dunes on the west side of the valley indicates the dominantly westerly wind. The dune sand deposits become thinner and finer grained to the east and in some places grade into loess. Loess consists of silt-sized grains that have been eroded, transported, and deposited by eolian processes. Because of its finer grain size, loess is carried much farther by the wind, and is widespread throughout the state. Generally, eolian deposits mantle topography irrespective of relief, unlike water-laid sediments. Dune sands and loess are commonly associated with glacial outwash and glacial lake deposits.

0.0	20.65+	Leave Stop 4. PROCEED AHEAD (east). Note tank battery to left, pump jack just beyond. This is the western edge of the Rose Hill oilfield.
0.05	20.7+	The road has been cut through a sand dune; the sand is well exposed in the right bank but poorly exposed in the left.
0.1+	20.8+	For the next 0.2 miles the road heads eastward through the Pleistocene dune field. The dune topography is particularly evident to the right (south). Notice that the lighter color and sandy texture of the soil here differs from that of the fields you saw earlier in the Embarras river valley.
0.2	21.0+	BEAR LEFT (east) slightly at intersection (1750N/1050E) and tank battery.
0.1	21.1+	The large number of tank batteries and pump jacks indicates that we are within the Rose Hill oilfield.
0.9	22.0+	TURN RIGHT (south) at "T" road (1750N/1150E).
0.65	22.65+	Tank battery. In the well to the right the well-head gas is flared.
0.35	23.0+	TURN LEFT (east) at T-road (1650N/1150E).

0.15+	23.2	Exposure of Pennsylvanian shale from the middle portion of the Newton cyclothem.
0.05	23.25	Park along road, NOT ON THE BRIDGE.

STOP 5. Examination of outcrops of Newton cyclothem and overlying Illinois glacial deposits (E1/2, SW NE sec. 36, T8N, R9E, 3rd P.M., Jasper County; Rose Hill 7.5-minute Quadrangle).

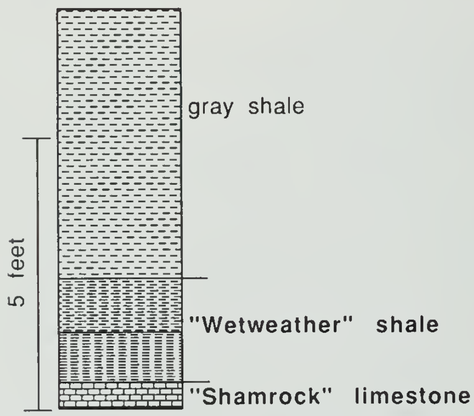


Figure 10 Newton Cyclothem.

Until the senior author of this field guide began work on a doctoral thesis on the geology of the bedrock in east-central Illinois, bedrock in the field trip area had not been studied in detail since the early work by Needham (1931) and Newton and Weller (1937). Many of the named stratigraphic units in the uppermost Pennsylvanian section had been recognized only near their type areas, and the stratigraphic order of these units was controversial. The controversy existed because the rocks had not been studied adequately and because they are poorly exposed, generally thin, and lack guide fossils. With the exception of the "Shamrock" limestone, the named stratigraphic units within quotations are informal names proposed by the senior author. The "Shamrock" limestone was introduced by Needham (1931) and therefore has priority over the names proposed by Newton and Weller (1937) and Kosanke et al. (1960).

The Newton cyclothem was named by Newton and Weller (1937) for strata exposed near the town of Newton. Strata belonging to this cyclothem also are exposed farther downstream along Lick Creek, along the Embarras River just north of Newton (Stop 9), along the East Fork of Crooked Creek, and in the southwest parts of Jasper and Cumberland Counties. At this stop, the distinctive members of this cyclothem, the "Shamrock" limestone, and the "Wetweather"shale, are exposed along with the overlying gray shale. The strata beneath the "Shamrock" limestone are well exposed at Stop 9.

The "Shamrock" limestone (fig. 10) was named by Needham (1931) for rocks exposed along the East Fork of Wetweather Creek (about 6 miles south of Newton), near the hamlet of Shamrock. This limestone has also been referred to as the "Newton Limestone" and the "Reisner Limestone."

The "Shamrock" limestone is gray, argillaceous, and abundantly fossiliferous.Many types of fossils can be found here, but most are fragmented, and whole fossils are difficult to remove from the rock. Brachiopod and pelecypods are the most common fossils, but many gastropods, pelmatozoans, and ostracodes are present. Small trilobites can be found, but unfragmented specimens of trilobites have never been collected from this limestone. The limestone is not well exposed here; the exposure at Stop 9 is better for fossil collecting.

The "Wetweather" shale that overlies the "Shamrock" limestone is named for the creek where the limestone was first studied. The "Wetweather" shale is lithologically similar to the "Dieterich" shale but is generally a little thicker. The lithologic change at the base of the shale is abrupt, whereas the change at the top of the unit intergrades with the succeeding unit (a gray shale at this site).

The shale is moderately fossiliferous in places, but the fossils are generally preserved poorly. Brachiopods and pelecypods may be common near the base and the upper portion may contain pelecypods, carbonaceous plant fragments and fish fragments.

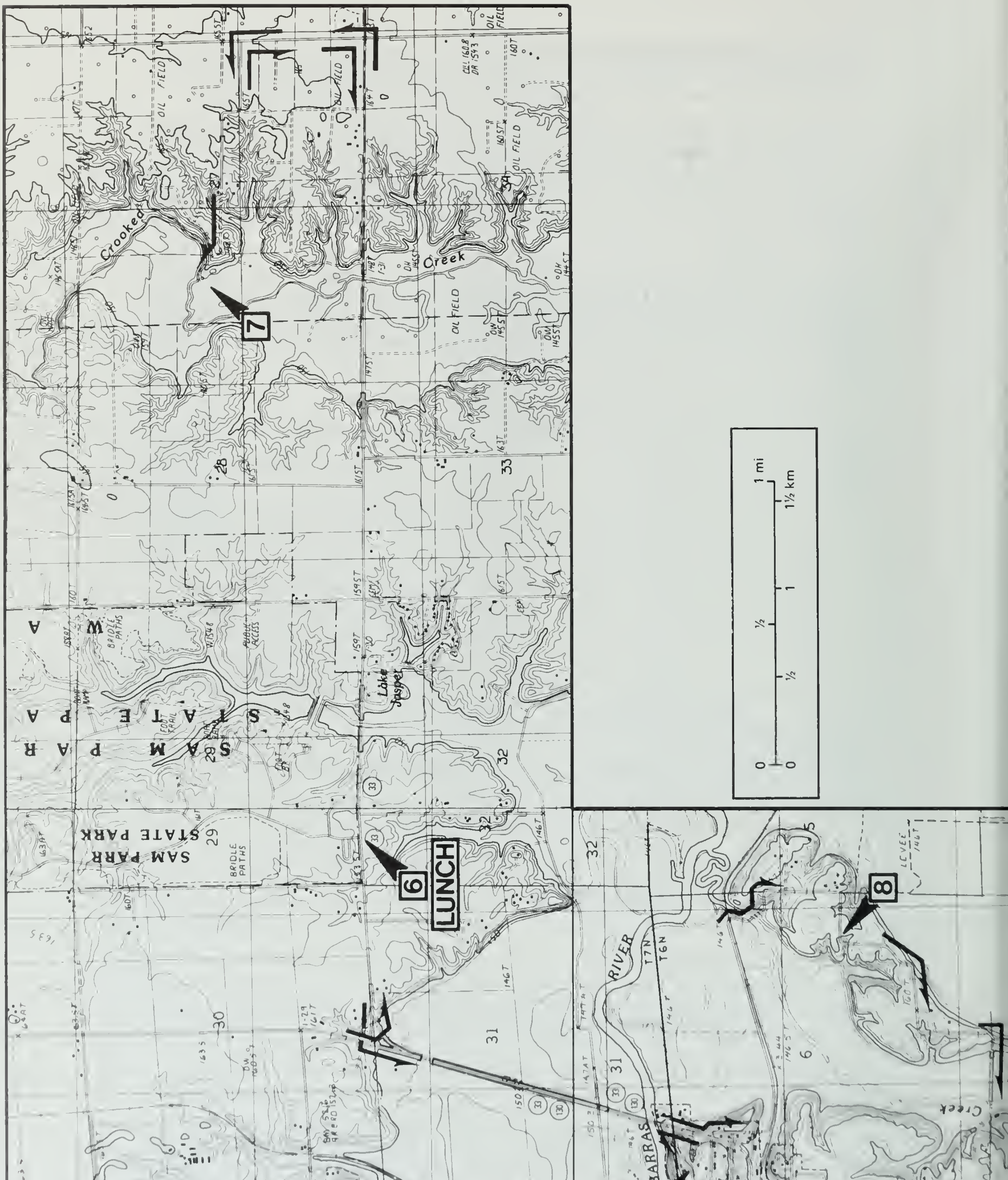
The contact seen here between the Pennsylvanian gray shale bedrock and the overlying Pleistocene deposits is an excellent example of a disconformity. A disconformity is a geological term for the surface or contact between older and younger rocks and represents either a surface of erosion (as it is here) or of nondeposition. The presence of a disconformity indicates that there is a gap in the rock record; at this spot the gap is about 285 million years.

The Pleistocene exposure here consists of a basal 1.5 feet of a poorly consolidated breccia composed of large, angular fragments of limestone, black shale, coal, and brown shale in a matrix of pebbles. Succeeding layers consist of 0.8 feet of poorly consolidated quartz sand, 1.7 feet of gray mudstone containing pebbles, and about 10 feet of covered drift.

0.0	23.25	Leave Stop 5. PROCEED AHEAD (east) and cross Lick Creek.
0.25+	23.5+	CAUTION: cross road at 1650N/1200E. CONTINUE AHEAD (east).
0.6+	24.1+	STOP: 2-way at 1650N/1260E. TURN RIGHT (south) onto IL 130. The Rose Hill oilfield roughly extends from Rose Hill to just south of Falmouth (fig. 7). The discovery well was drilled in 1966; since then 62 wells have been completed. In 1987, 46 wells produced 14,203 barrels of oil from two Mississippian Ste. Genevieve Limestone horizons, the Spar Mountain Sandstone Member and the Fredonia Limestone Member ("McClosky Lime") (fig. 2). These producing horizons are about 2600 to 2800 feet deep. During the "energy crisis" of the late 1970s and early 1980s, drilling activity in this field was quite noticeable along the highway.
2.4+	26.55	Road to Falmouth is to right. CONTINUE AHEAD (south).
2.65	29.2	Pleistocene dunes can be viewed in field to the right (west).
0.35+	29.55+	CAUTION: TURN LEFT (southeast) toward IL 33. This T junction is on the northeast edge of the Embarras River floodplain.
0.05-	29.6+	STOP: 1-way. TURN LEFT (northeast and east) on IL 33.
0.6	30.2	Prepare to turn left.
0.1	30.3+	TURN LEFT (north) to enter Sam Parr State Park. Follow lead vehicle to lunch stop.

STOP 6 (LUNCH). Sam Parr State Park (sec. 20 and 29, T7N, R10E, 3rd P.M, Jasper County; Rose Hill and Yale 7.5-minute Quadrangles).

In 1960 the Illinois Department of Conservation acquired 72 acres of land to form the Jasper County Conservation Area. In 1972, the park was formally dedicated by the General Assembly and named for Sam Parr (1902-1966), a resident of the area as a youth and a long-time state conservationist. The park now includes 1063 acres of land and an artificial 183-acre lake. The "Lincoln Tree," located at the northern boundary of the park, is a hard maple that was planted in 1860, the year that Abraham Lincoln was in-


Crooked Creek
Creek
OIL FIELD
SAM PARR STATE PARK
Lake Jasper
BRIDLE PATHS
PUBLIC ACCESS
LUNCH
6
7
8
9
END
RIVER
T7N
T6N
R9E
R10E
LEVEE
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½
1
1 mi
1½ km

augurated as president. More information about the natural features of this park and its facilities can be obtained at the ranger's office.

0.0	30.3+	Leave Sam Parr State Park entrance. TURN LEFT (east) onto IL 33.
1.3+	31.6+	T-road from right at 1100N/1450E. You are at the approximate west edge of Clay City Consolidated oilfield (fig. 7). CONTINUE AHEAD (east).
0.65	32.25+	Cross Crooked Creek.
0.75	33.0+	Prepare to turn left.
0.1	33.1+	TURN LEFT (north) at crossroad, 1100N/1600E. Fairview drive-in theater in northeast corner of intersection.
0.4+	33.55+	T-road from left at 1150N/1600E. TURN LEFT (west) onto oilfield access road.
0.25	33.8+	TURN RIGHT (north).
0.05+	33.85+	TURN LEFT (west).
0.5-	34.35+	TURN RIGHT (north) at tank battery.
0.05-	34.4	PARK along road here and to the north. Proceed on foot to the left (west), down to the Crooked Creek floodplain.

STOP 7. Examination of outcrop of Bogota cyclothem and view and discussion of an active oil well pumping jack (SE SW NW sec. 27, T7N, R10E, 3rd P.M., Jasper County; Yale 7.5-minute Quadrangle).

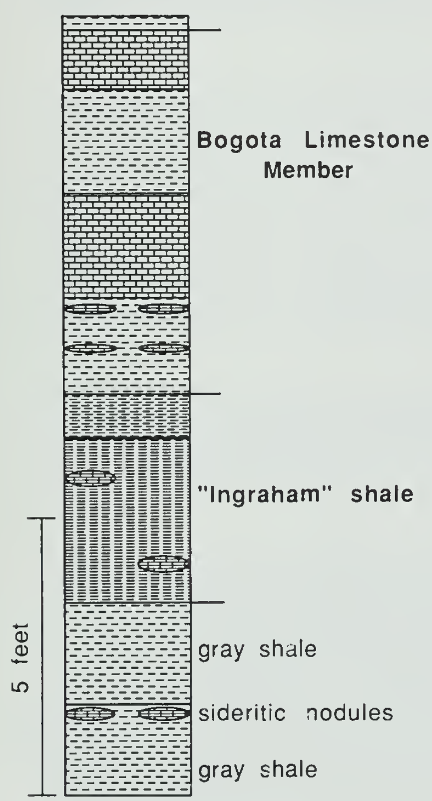

Figure 11 Bogota Cyclothem.

The Bogota cyclothem (fig. 11) was named by Newton and Weller (1937) for the strata cropping out along Muddy Creek near the hamlet of Bogota in the southwestern corner of Jasper County. The cyclothem also is exposed in southeastern Shelby County and in east-central Effingham County. These rocks are the oldest bedrock exposed in the field trip area.

This cyclothem is characterized by two distinctive units, the "Ingraham" shale and the Bogota Limestone Member. The "Ingraham" shale is thicker (5.25 ft here) than the "Dieterich" and "Wetweather" shales and contains large calcareous concretions. These very hard, disc- to cigar-shaped concretions can be as much as 1.5 feet in diameter. The hardness is due to the iron-carbonate composition (the mineral siderite). Concretions such as these form by chemical precipitation around some nucleus or center, such as a fossil or mineral grain within the organic muds, as

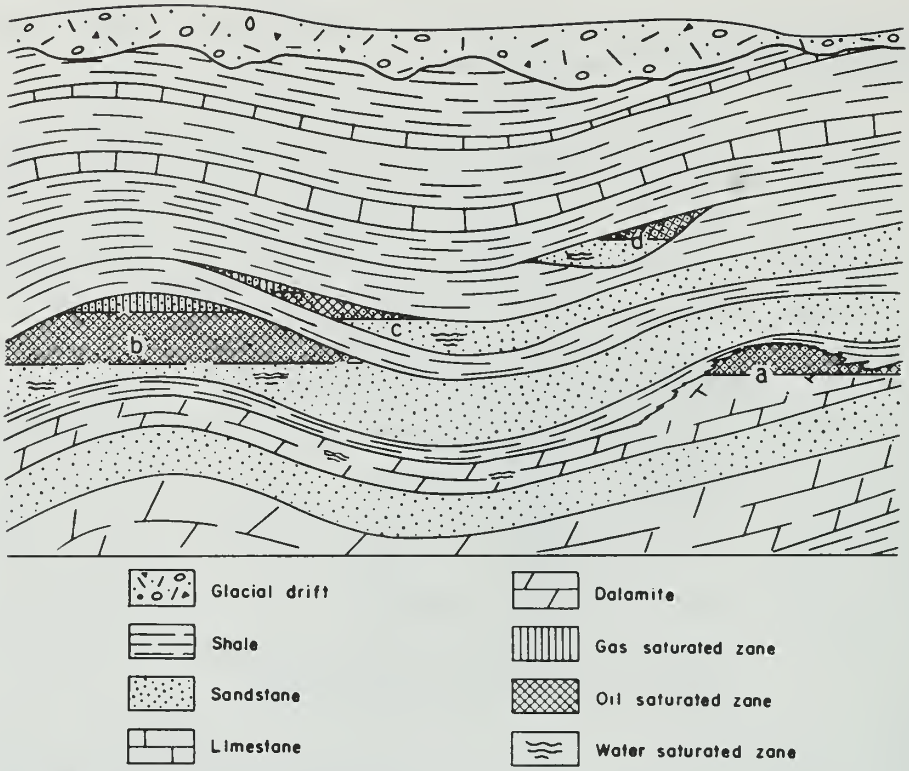

Figure 12 Places where oil is found in Illinois: (a) coral reefs, (b) anticlines, (c) pinch-outs, and (d) channel sandstones.

the sediments are being consolidated into rock. (The famous Mazon Creek fossils in Grundy County are an example of this process.) But concretions found here generally lack fossils.

Kosanke et al. (1960) applied the name Bogota Limestone Member to the overlying marine unit. The limestone at this site overlies a basal calcareous shale and consists of two limestone beds, separated by a calcareous shale. The lower bed is 1 foot thick, the upper about 2 feet thick. Both beds consist of sandy limestone and contain fossils such as brachiopods, pelecypods, pelmatozoans, gastropods, bryozoans, corals, and trilobites. However, most of these fossils except the brachiopods and corals are fragmented and enclosed in the limestone matrix, making them difficult to collect. The calcareous shales, which are not well exposed in many places, also contain fossils. These fossils are easier to collect than those in the limestones.

The lower part of this exposure is presently under water because of the recent construction of the ford downstream. This ford was built to gain access to the oil well on the opposite side of Crooked Creek and to pond its water for use in the water-flooding of oil wells. The water is pumped into the producing horizons of nearby oil wells to force more oil (which floats on water) out of the wells.

The active pumping jack just south of the outcrop and pumping station is the M. Frichtl No. 1-A oil well. This well was drilled in 1966 to a depth of 3021 feet. The well produces oil from the Mississippian St. Louis Limestone at 2972 to 2982 feet below the surface (fig.2). Initial production was 70 barrels of oil and 100 barrels of water per day; only a small amount of natural gas is produced (figs. 12 and 13). The amount of oil pumped to the surface varies, depending upon the depth of the producing horizon, the wellhead pressure, and the size of the pump. A rough estimate of the amount of oil brought to the surface is about a pint per stroke. Yearly production statistics for this well are not available.

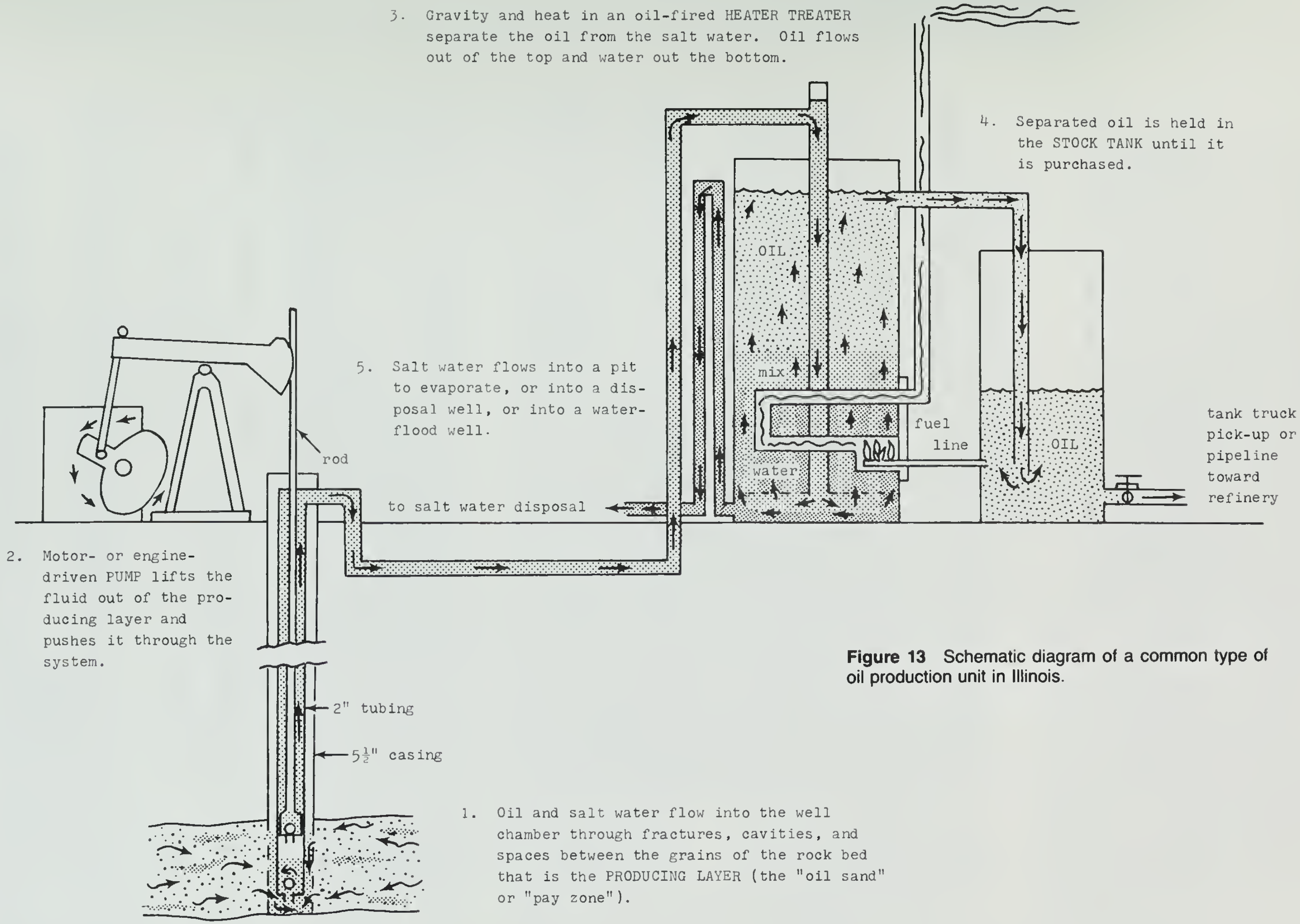

Figure 13 Schematic diagram of a common type of oil production unit in Illinois.

The nearby concrete foundation is the site of the pumping jack of the M. Frichtl No. 1 oil well. This well was drilled in 1960 to a depth of 2723 feet. The initial production was 24 barrels of oil per day from the Mississippian Rosiclare Sandstone at a depth of 2670 to 2675. The depression on the upslope side of the foundation probably formed when the casing pipe was removed after abandonment in 1966.

This well is part of the Clay City Consolidated oil field, one of the largest in Illinois; it consists of 108,180 acres and 3052 wells, which produced 12,657,448 barrels of oil in 1987. By comparison, the Rose Hill oil field of 930 acres has 46 wells, which produced 14,203 barrels of oil in 1987. The Clay City Consolidated oil field is a long, southwest-northeast trending oil field straddling Wayne, Clay, Richland, and Jasper Counties. The field originally consisted of separate, smaller oil fields that were gradually consolidated by infill drilling of oil wells between the various units.

0.0	34.4	Leave Stop 7 and retrace route back to T-road at 1150N/1600E.
0.8+	35.2+	CAUTION: T-road at 1150N/1600E. TURN RIGHT (south) on blacktop road.
0.4+	35.65+	STOP: 2-way at 1100N/1600E. TURN RIGHT (west) on IL 33.
3.5+	39.2	STOP: 1-way. TURN LEFT (south) onto IL 130. Just to the southeast of this intersection is the Newton North oilfield. The discovery well was drilled in 1945, but the field was abandoned 3 years later. In 1960 it was revived and produced oil for 6 years before being abandoned again. In 1976, during the "energy crisis" it was again revived. As of early 1988, only one well was producing (87 barrels of oil during 1987). The field is a small oil field that has only six completed wells. The producing horizon is the "McClosky Lime" (Fredonia Sandstone Member), from 2800 to 2900 feet deep.
0.53	39.7	View to southwest shows Newton's municipal water well field. The five wells discussed earlier can be seen from the highway.
0.5+	40.2+	CAUTION: cross the Embarras River and enter Newton.
0.1	40.3+	Prepare to turn left.
0.1+	40.4+	CAUTION: TURN LEFT (southeast) onto 5th Avenue.
02+	40.6+	BEAR LEFT (east), paralleling railroad.
0.75+	41.4+	CAUTION: cross Illinois Central (IC) Railroad.
0.05+	4l.45+	Cross Brush Creek. Pennsylvanian sandstone is exposed in the stream cutbank to the right (southwest).
0.05-	41.5	The same sandstone bed overlying gray shale is exposed in the ditch on the right side of the road.
0.5	42.0	PARK along road shoulder. Do NOT block field entrances.

STOP 8. View and discussion of site of abandoned coal mine to the south of the road (approximate center of north edge, NE SE sec. 6, T6N, R10E, 3rd P. M., Jasper County; Newton 7.5-minute Quadrangle).

The "Brush Creek" coal formerly mined here is one of the geologically youngest coals mined In Illinois. Many small mines operated in an area of about 1 square mile around

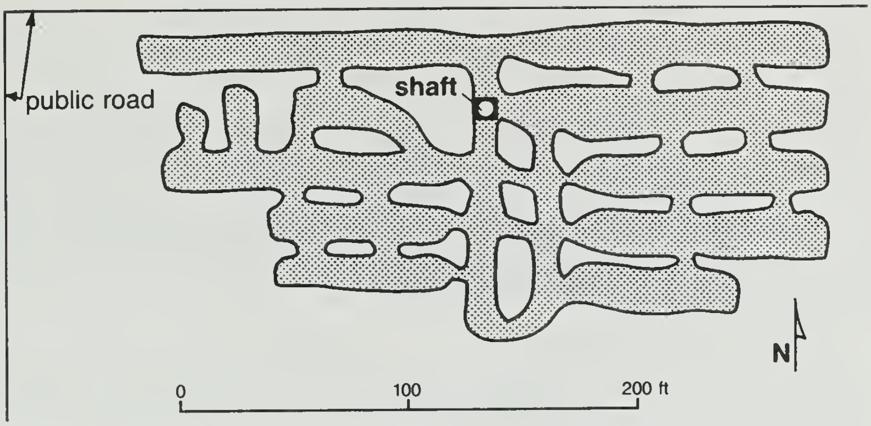

Figure 14 Abandoned "Brush Creek" mine.

Brush Creek, primarily during the depression in the 1930s. According to ISGS records, the "Brush Creek Mine" operated at this site from 1937 to 1940. The thickness of the coal mined here is uncertain. Field notes of Survey geologists from the 1930s reported that 2.25 to 3.15 feet of coal was exposed in a slope mine just to the east of here. Another report describes an exposure of coal approximately 1 foot thick along the west side of Brush Creek valley (west of here). This coal is correlated with the very thin layer of coal beneath the "Dieterich" shale of the Gila cyclothem exposed at Stop 2. Thus it is inferred that the coal at Stop 2 and at this site formed from the plant debris of a contemporaneous coal swamp, but that at this site plant growth was more prolific or the life span of the coal swamp was longer than in the area of Stop 2.

The dump at the coal mines contains abundant pieces of black, sheety shale, reported to be the mine "roof" (the rock that immediately overlies the coal). This shale is the "Dieterich" shale, which was examined at Stop 2. Pieces of black shale scattered in the field and the dark color of the soil here indicate that a dump previously existed near the shaft but was either removed or graded flat. Because of their density and lateral continuity, black, sheety shales like the "Dieterich," "Wetweather," and "Ingraham" make excellent mine roofs in present-day mines extracting older Pennsylvanian coals in other parts of Illinois.

The depression in the foreground is probably from an abandoned shaft (later filled-in) to the "Brush Creek" underground mine. The coal was probably about 25 to 35 feet below the surface. An abandoned mine map dated May 1939 (fig. 14) indicates that the coal was extracted by the "room and pillar method." In this method coal is mined out in interconnecting rooms, and large pillars of undisturbed coal are left behind to support the roof of the mine. Such pillars are susceptible to failure long after the mine is abandoned, and subsidence at the surface can result.

0.0	42.0	Leave Stop 8. PROCEED AHEAD (west and southerly) on the gravel road.
0.3+	42.3+	View to left (south and east) shows large abandoned meander bend of Embarras River.
0.5	42.8+	T-road at 900N/1250E. Abandoned meander bend of Embarras River to left (east). TURN RIGHT (west) and descend ridge. NOTE: this ridge is another erosional remnant that formed, probably during the late Pleistocene, between the Embarras River and Brush Creek. Compare the route map of this area to the route map at

		Stop 1. You can easily imagine that a ridge similar to this one existed on the southwest side of Jordan Hill before it was eroded down to near the floodplain level by Turkey Creek and the Embarras River.
0.1	42.9+	To the right along the east side of the field and about 500 to 600 feet north of the road are several dark exposures. These are remnants of mine dumps from shaft mines just upslope from the dumps. The shaft sites can still be recognized by small, circular depressions. According to field notes by ISGS geologists, the coal was at or just below the floodplain level of Brush Creek.
0.1+	43.05+	Cross Brush Creek.
0.45+	43.5+	STOP: 1-way at 920N/1200E. BEAR RIGHT (north) onto paved road.
0.1-	43.6	CAUTION: enter Newton.
0.45+	44.05+	CAUTION: cross IC RR tracks.
0.05-	44.1	STOP (NOT on tracks): 2-way. TURN RIGHT (east) onto IL 33/130.
0.15+	44.25+	Road bears left (north).
0.2	44.45+	Prepare to turn left.
0.1+	44.6+	TURN LEFT (west) onto Peterson Drive and enter Peterson Park. As the drive ascends the small hill, it cuts through another small Pleistocene dune field. The location of this dune field on the south side of the river suggests that the prevailing winds were probably from the northwest at the time of dune formation.
0.15+	44.75+	TURN RIGHT (north) into shelter house parking area. PARK and proceed on foot (northeast) to the south bank of Embarras River.

STOP 9. Examination of outcrops of Newton cyclothem (S 1/2, SW SW SW Irr. sec. 31, T7N, R9E, 3rd P. M., Jasper County; Newton 7.5-minute Quadrangle).

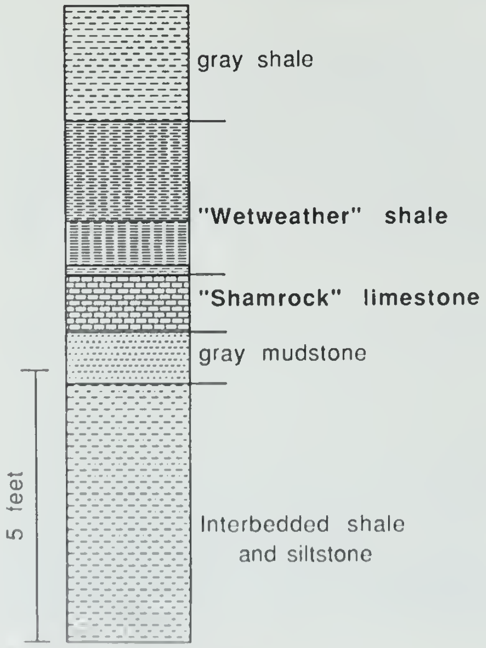

Figure 15 Newton Cyclothem

The final stop of this field trip features another exposure of the Newton cyclothem (fig. 15), one of the best exposures of bedrock in the entire county. At this site you can examine the units below the distinctive members of the cyclothem (the "Shamrock" limestone and the "Wetweather" shale).

Because the "Shamrock" limestone is better exposed, fossils are easier to find; however, most are fragments and difficult to extract.

The "Shamrock" limestone and "Wetweather" shale at Stops 5 and 8 are lithologically similar and occur in the same succession. Because of these similarities, the strata are correlated. (Correlation is the determination of the equivalence, in either stratigraphic position or in geologic age, of rocks exposed in separate areas.)

The younger age and higher position in the bedrock sequence of the Gila cyclothem, which lies above the Newton cyclothem, is readily discerned here; the Gila cyclothem at Stop 7 and along Brush Creek has a higher elevation than this outcrop of the Newton cyclothem. The elevation of the outcrop of the Bogota cyclothem at Stop 6, however, is probably about equivalent to that of the Newton Cyclothem outcrop here. Yet the Bogota cyclothem is thought to be the oldest and lowest in the bedrock sequence. This apparent discrepancy is explained by small changes in the regional structure. Between here and Stop 7, the strata dip gently to the west. Thus to the east the strata exposed are slightly older and lower in the succession, whereas to the west the strata are younger and higher in the succession. Although Stop 8 also is east of here, the amount of topographic relief overrides the effect of the regional dip

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End of Newton Geological Science field trip

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PLEISTOCENE GLACIATIONS IN ILLINOIS

Origin of the Glaciers

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

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

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

Effects of Glaciation

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

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

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

Glacial Deposits

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

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

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

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

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

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

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

Loess, Eolian Sand and Soils

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

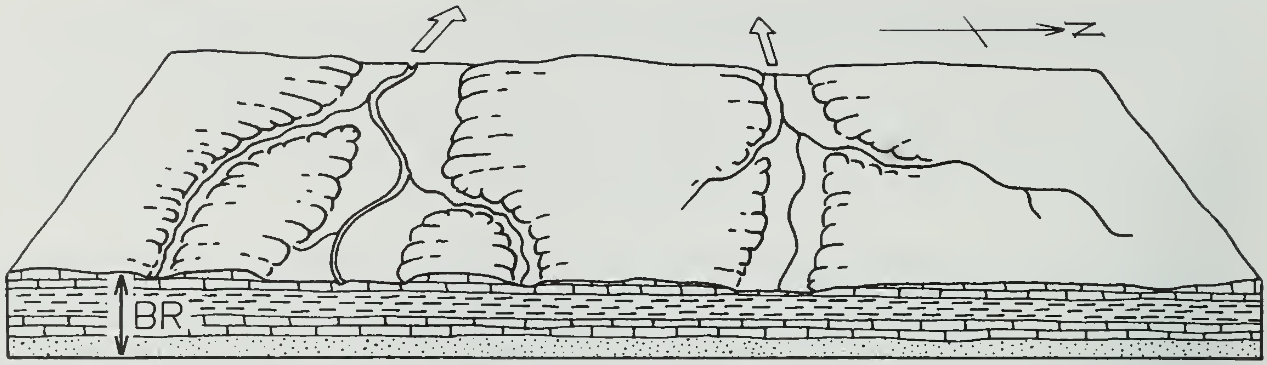
Eolian deposition occurred when certain climatic conditions were met, probably in a seasonal pattern. Deposition could have occurred in the fall, winter or spring season when low precipitation rates and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and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

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

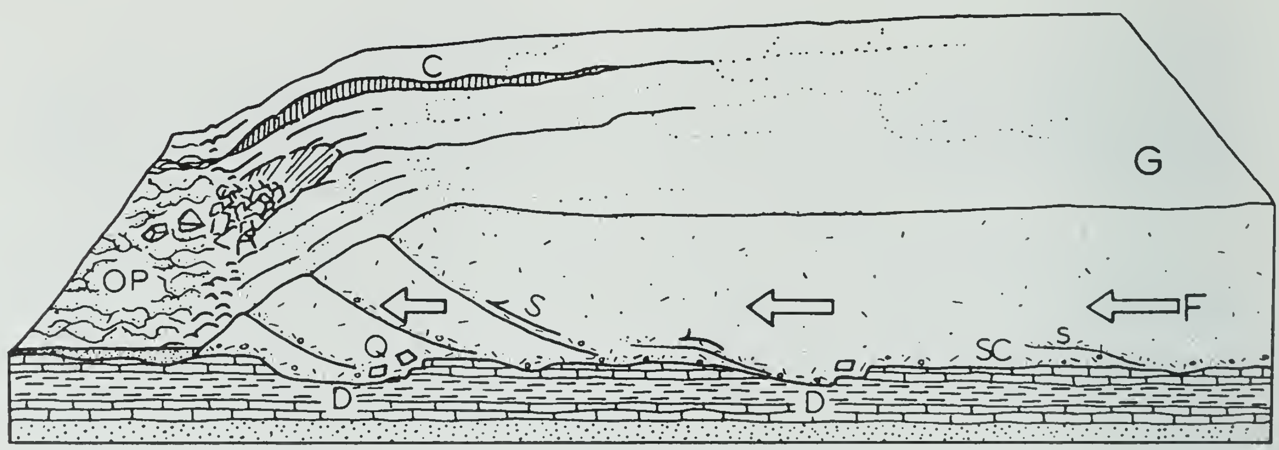
Glaciation in a Small Illinois Region

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

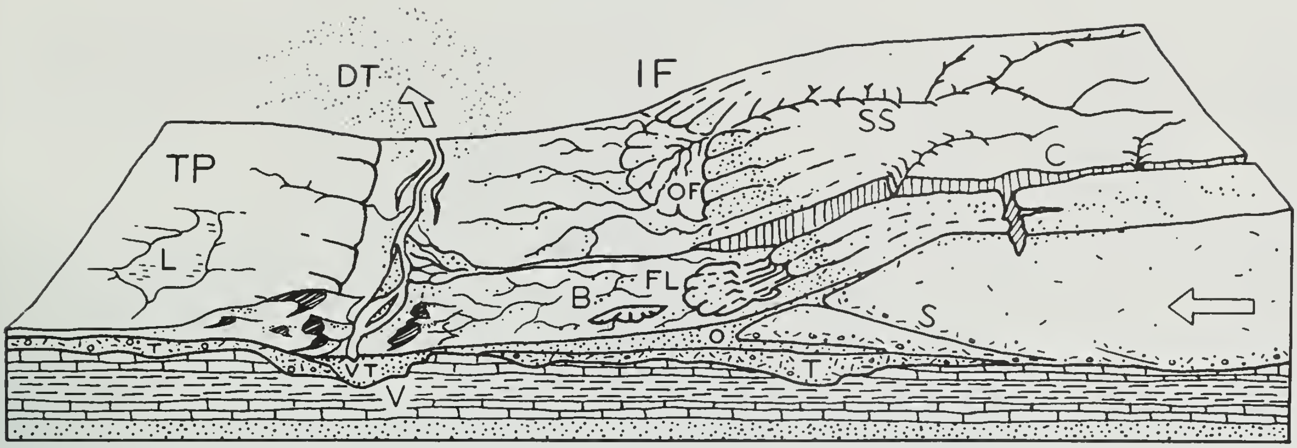
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated—layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



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



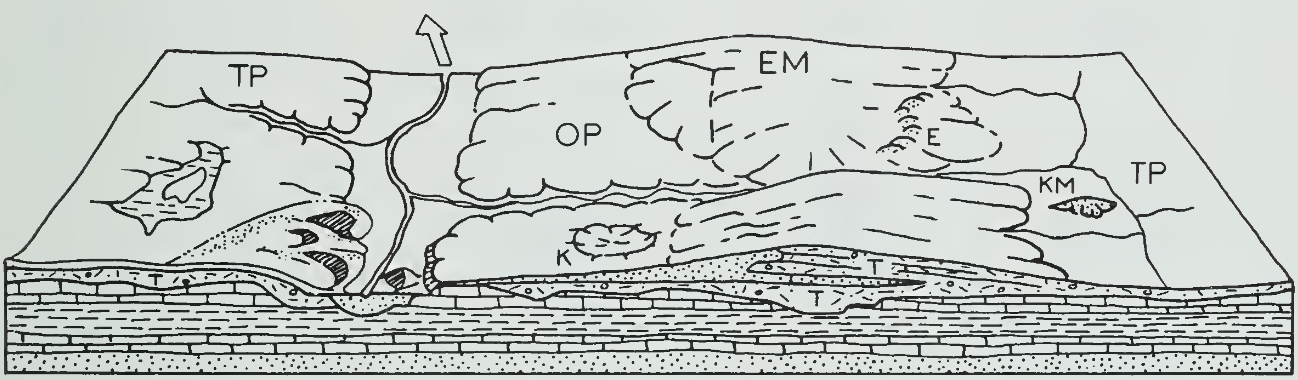
2. **The Glacier Advances Southward** — As the Glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughnesses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



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

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

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



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

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

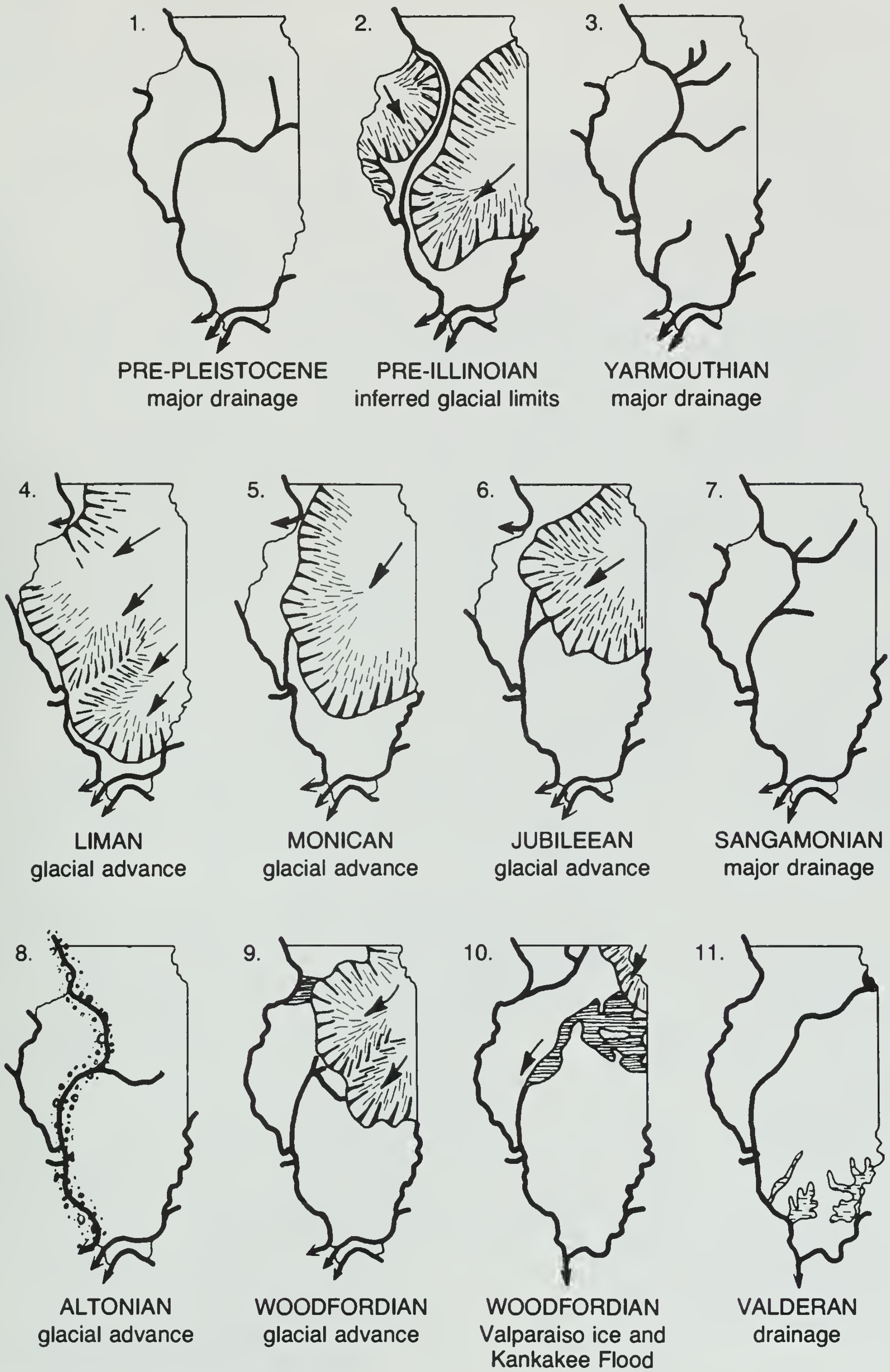
TIME TABLE OF PLEISTOCENE GLACIATION

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

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

(Illinois State Geological Survey, 1973)

SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS

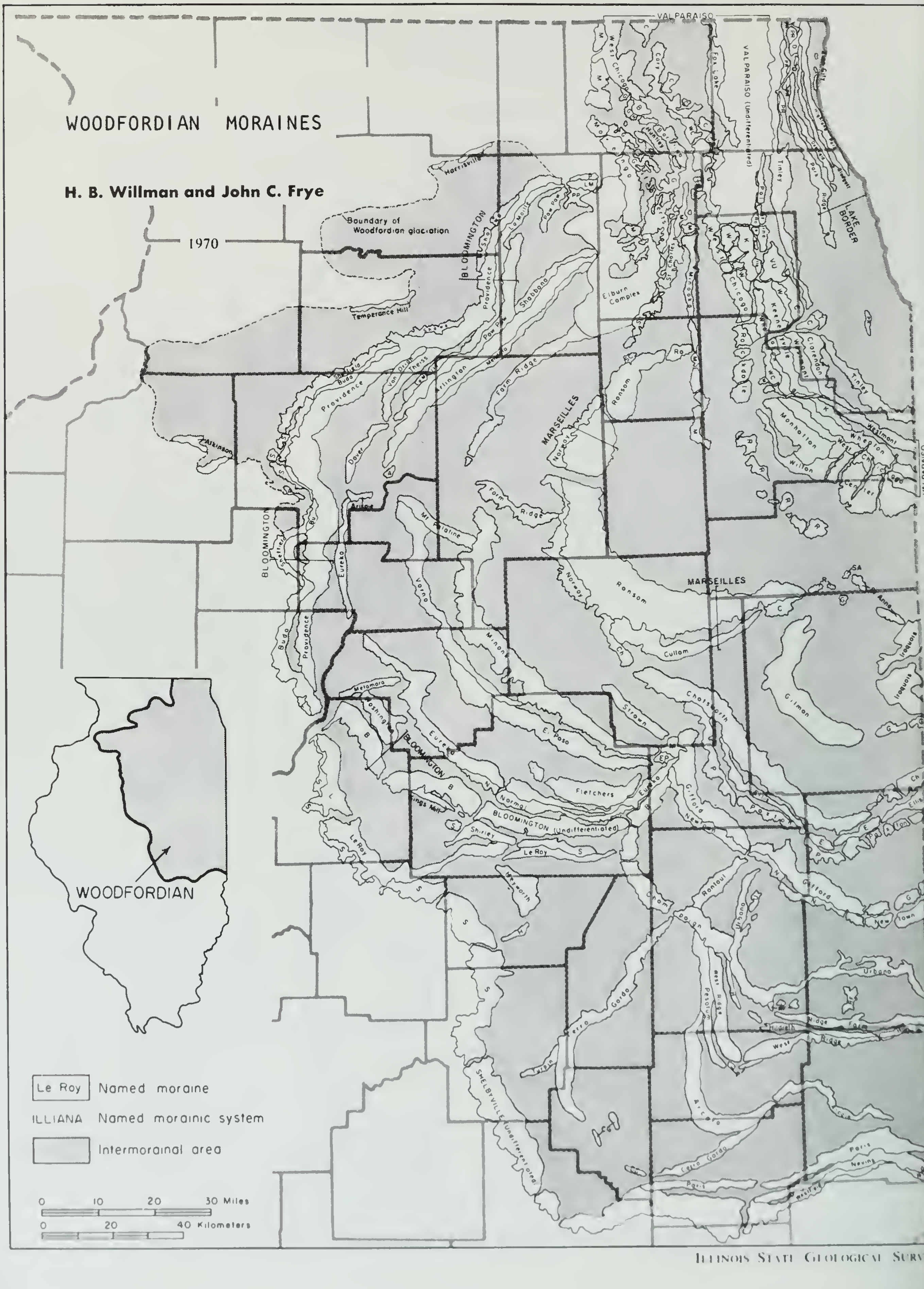


(Modified from Willman and Frye, "Pleistocene Stratigraphy of Illinois," ISGS Bull. 94, fig. 5, 1970.)

WOODFORDIAN MORAINES

H. B. Willman and John C. Frye

1970



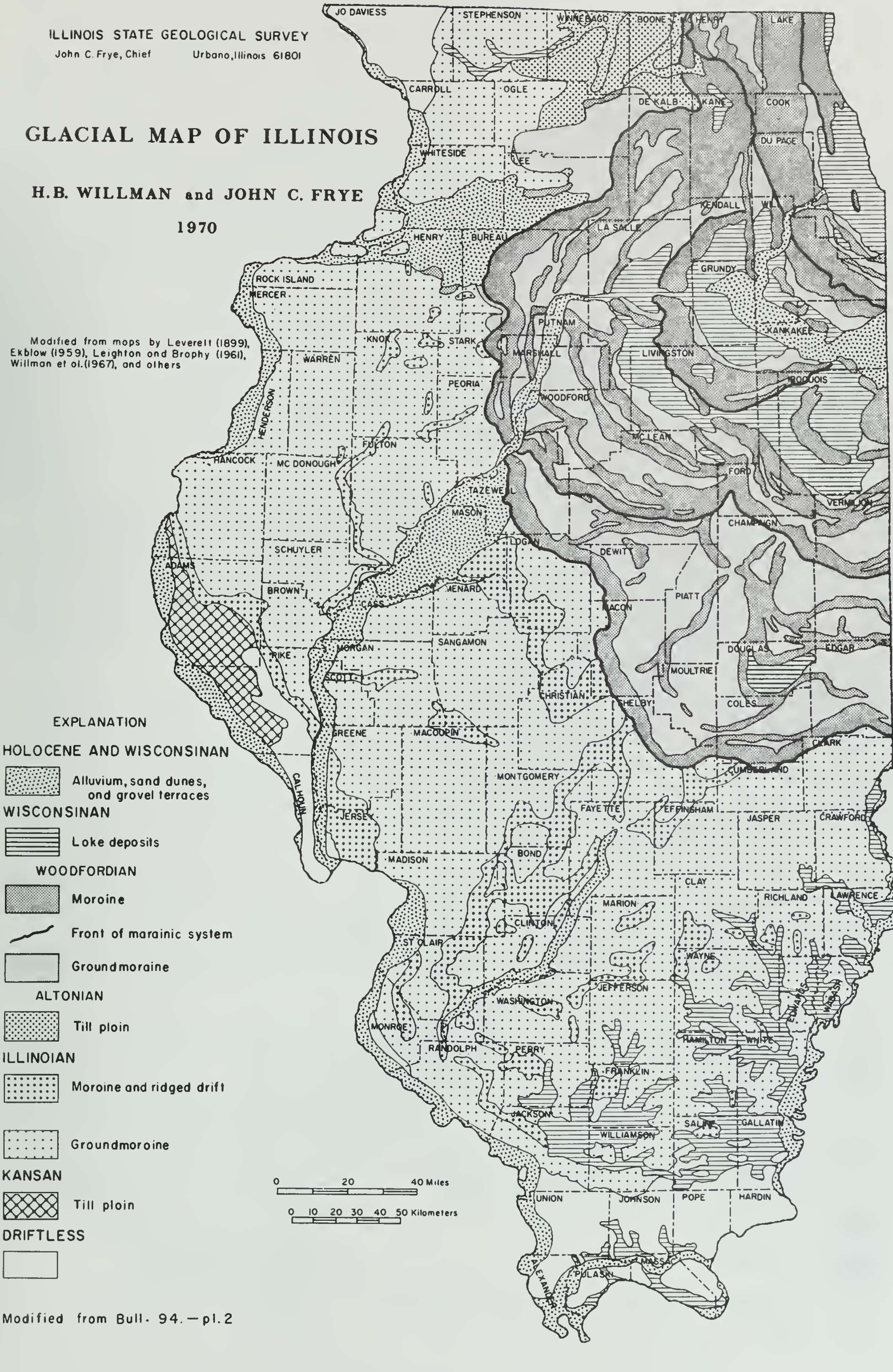
ILLINOIS STATE GEOLOGICAL SURVEY
John C. Frye, Chief Urbana, Illinois 61801

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



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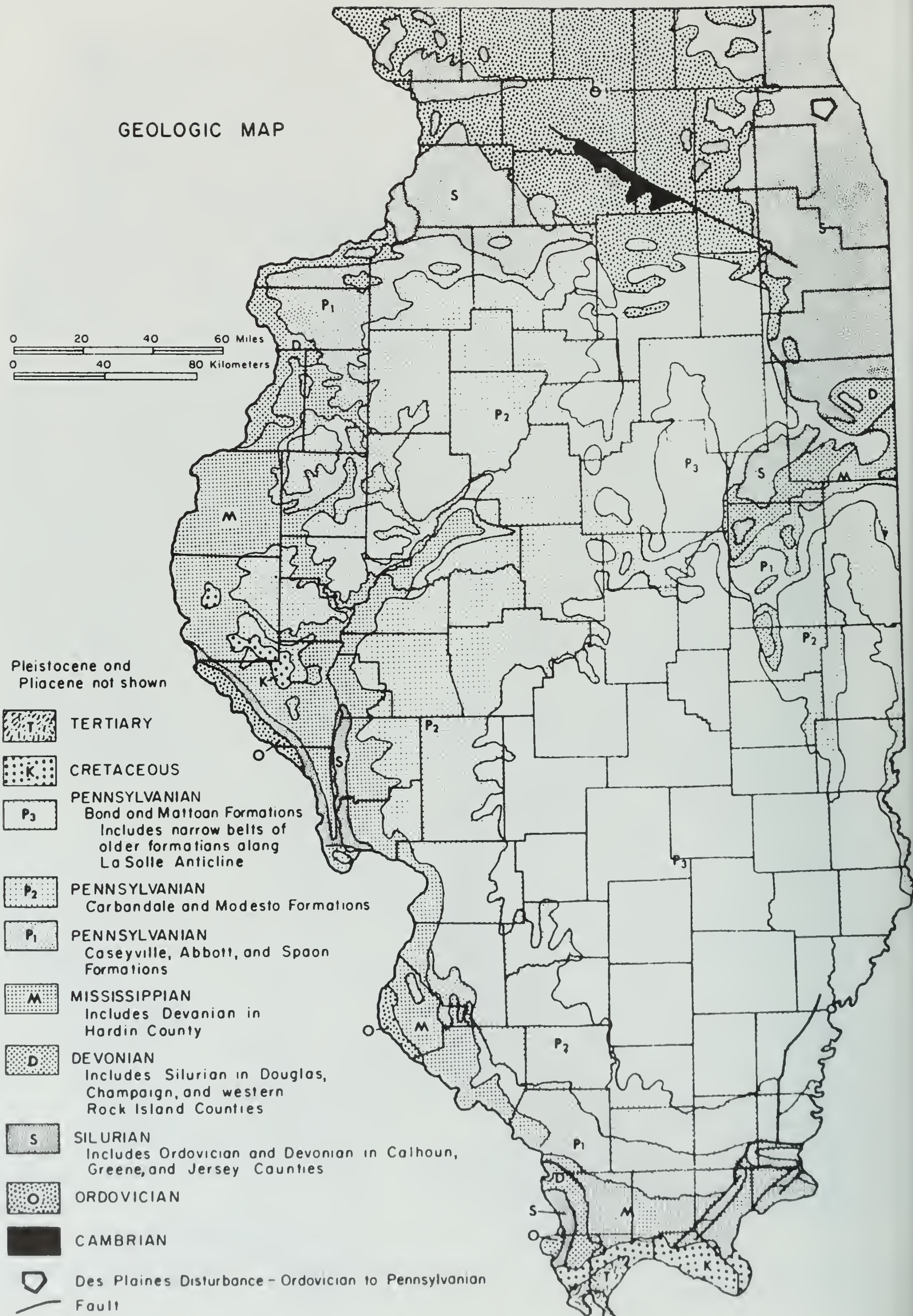

GEOLOGIC MAP
0 20 40 60 Miles
0 40 80 Kilometers
Pleistocene and Pliocene not shown
T TERTIARY
K CRETACEOUS
P3 PENNSYLVANIAN Bond and Mattoon Formations Includes narrow belts of older formations along La Salle Anticline
P2 PENNSYLVANIAN Carbondale and Modesto Formations
P1 PENNSYLVANIAN Caseyville, Abbott, and Spoon Formations
M MISSISSIPPIAN Includes Devonian in Hardin County
D DEVONIAN Includes Silurian in Douglas, Champaign, and western Rock Island Counties
S SILURIAN Includes Ordovician and Devonian in Calhoun, Greene, and Jersey Counties
O ORDOVICIAN
CAMBRIAN
Des Plaines Disturbance - Ordovician to Pennsylvanian
Fault

DEPOSITIONAL HISTORY OF THE PENNSYLVANIAN ROCKS IN ILLINOIS

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

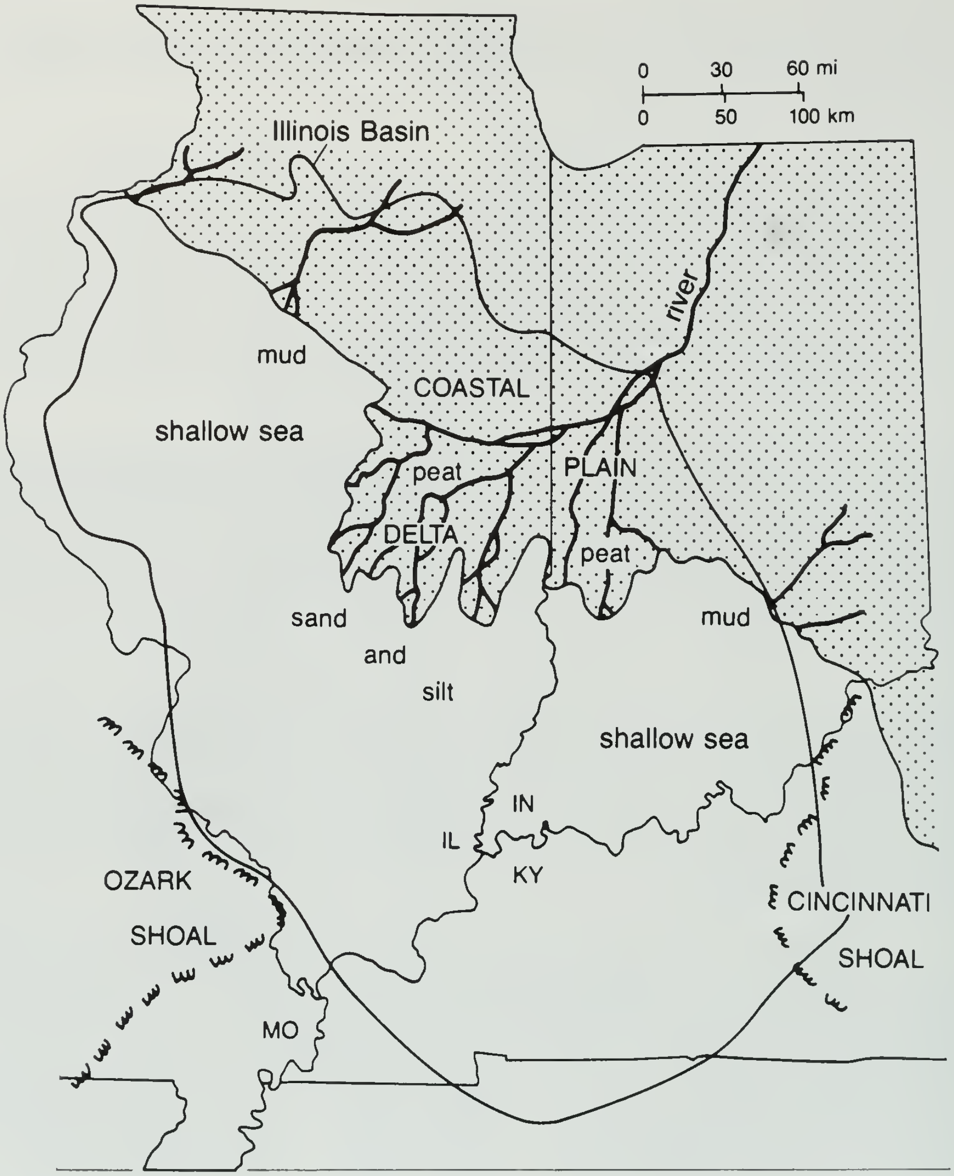
Depositional conditions in the Illinois Basin during the Pennsylvanian Period were somewhat similar to those of the preceding Chesterian (late Mississippian) time. A river system flowed southwestward across a swampy lowland, carrying mud and sand from highlands to the northeast. This river system formed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

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

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

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

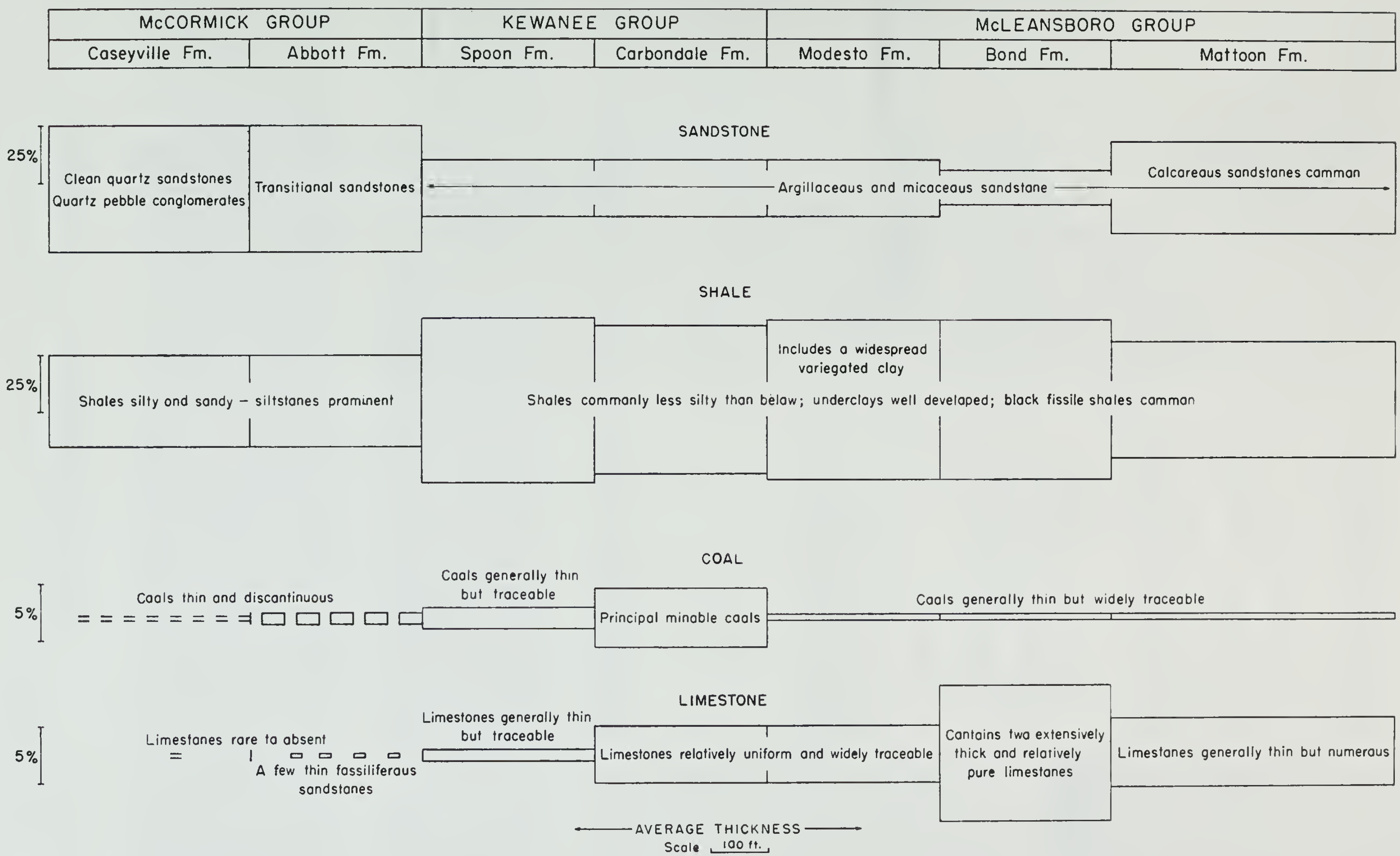
Beneath the quiet water of extensive swamps that prevailed for long intervals on the emergent coastal lowland, peat was formed by accumulation of plant material. Lush forest vegetation covered the region; it thrived in the warm, moist Pennsylvanian-age climate. Although the origin of the underclays beneath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



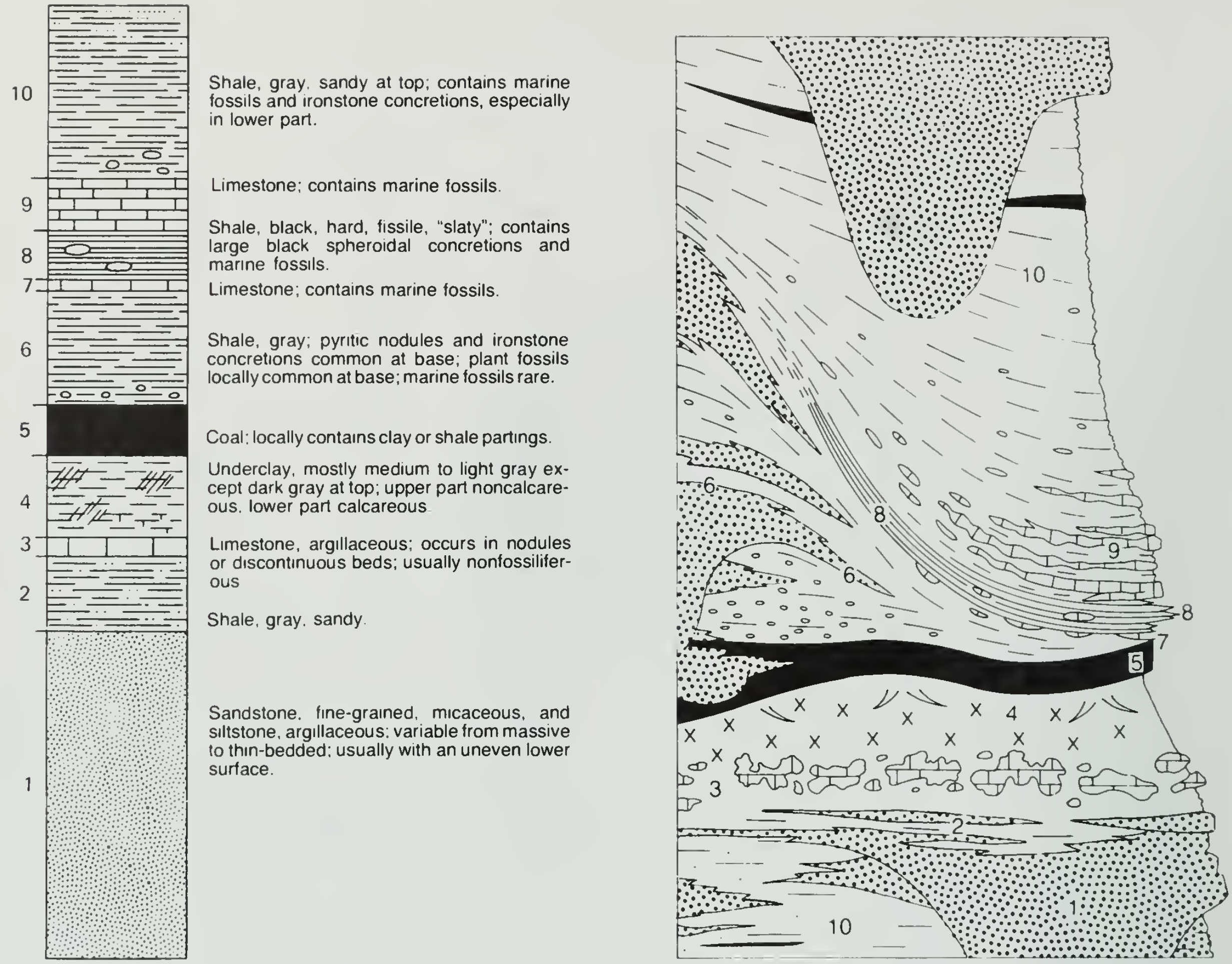
Paleogeography of Illinois-Indiana region during Pennsylvanian time. The diagram shows a Pennsylvanian river delta and the position of the shoreline and the sea at an instant of time during the Pennsylvanian Period.

Pennsylvanian Cyclothems

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



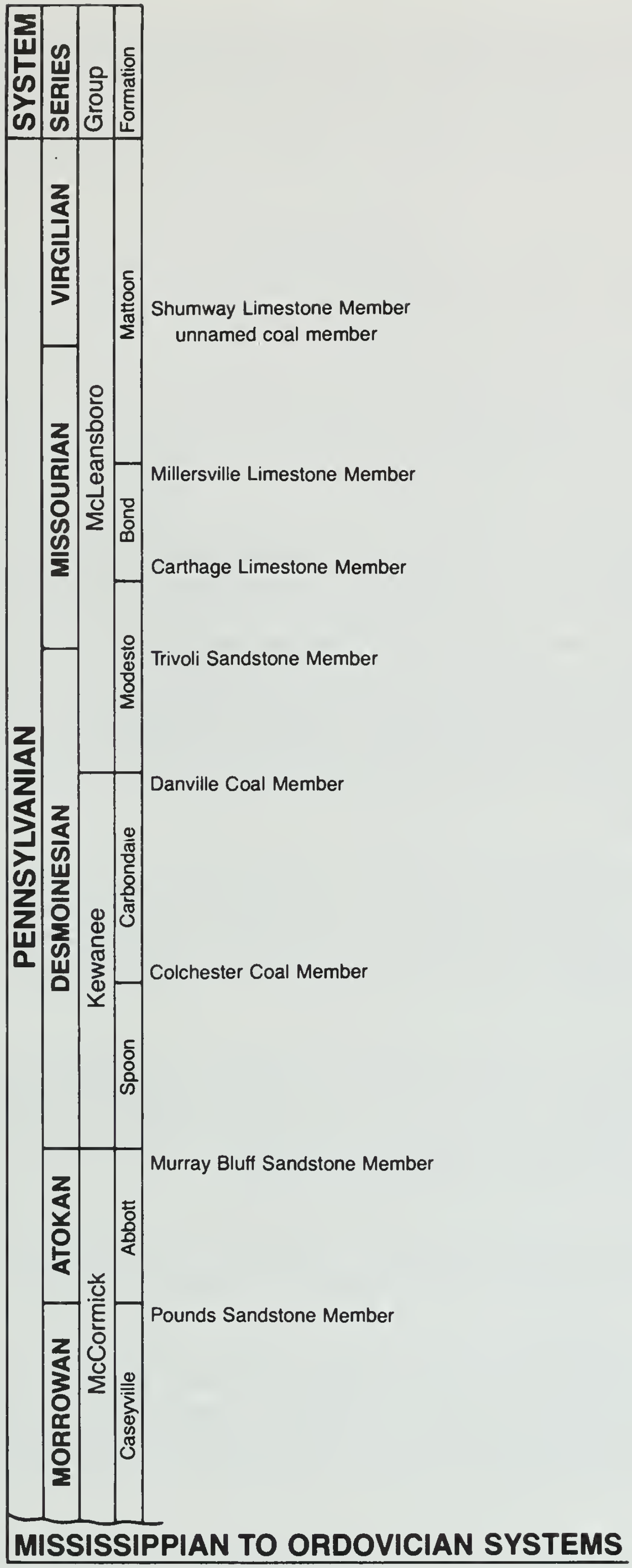
General distribution of the four principal lithologies in Pennsylvanian strata of Illinois.



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

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

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



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

Origin of Coal

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

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

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

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

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

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

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

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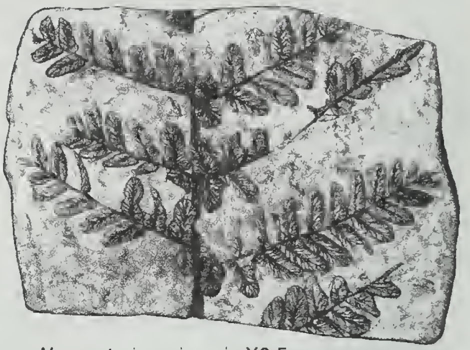
Common Pennsylvanian plants: seed ferns and cordaiteans

Alethopteris serlii X0.63

Alethopteris ambigua X0.63



Neuropteris rarinervis X0.5

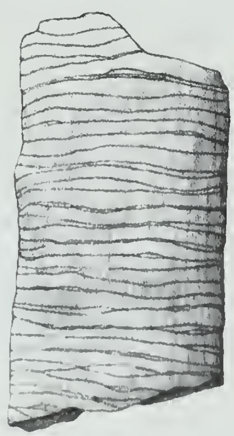
Mariopteris nervosa X0.8

Neuropteris scheuchzeri X0.63

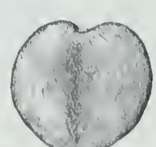
Sphenopteris rotundiloba X0.8

Trigonocarpus parkinsonii X1.25

Cordaicladus sp. X1.0



Artisia transversa X0.63

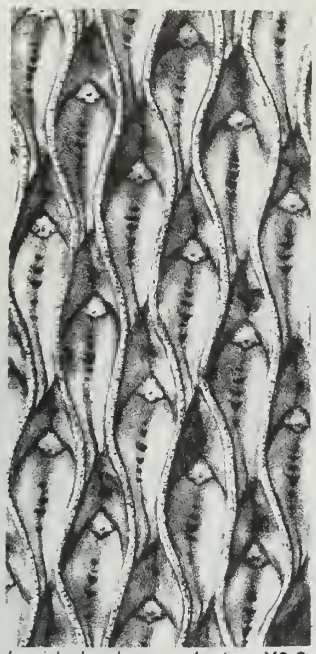


Cordaicarpon major X2.0

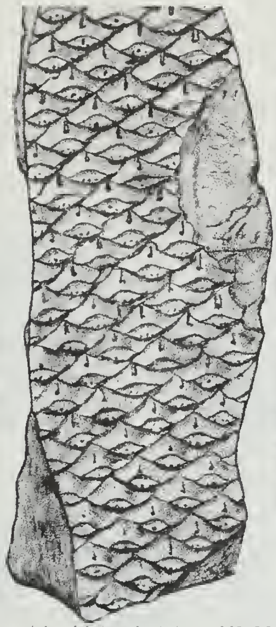
Cordaites principalis X0.63

J. R. Jennings, ISGS

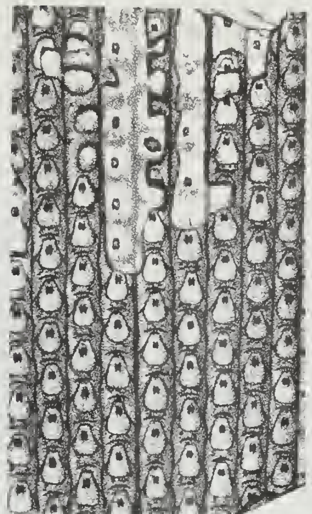
Common Pennsylvanian plants: lycopods, sphenophytes, and ferns



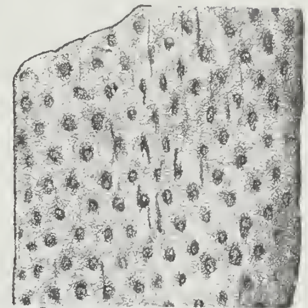
Lepidodendron aculeatum X0.8



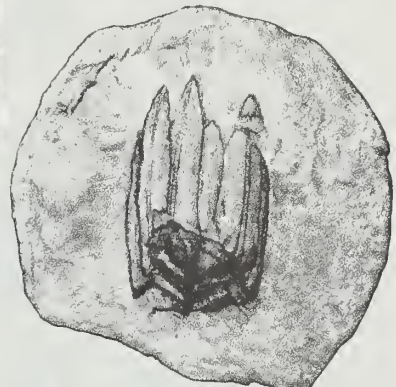
Lepidophloios laricinus X0.63



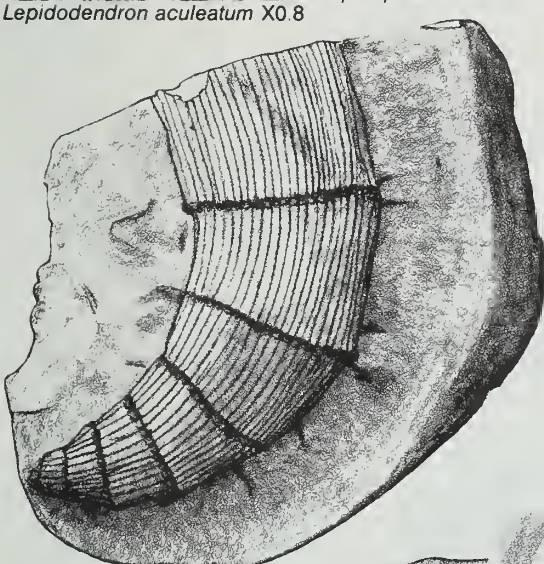
Sigillaria mammilaris X0.5



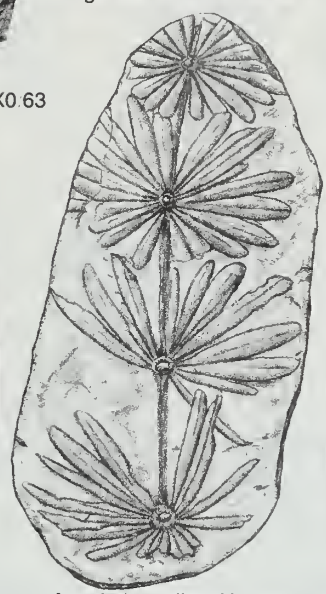
Stigmaria ficoides X0.32



Lepidostrobus ovatifolius X0.8



Calamites suckowii X0.5

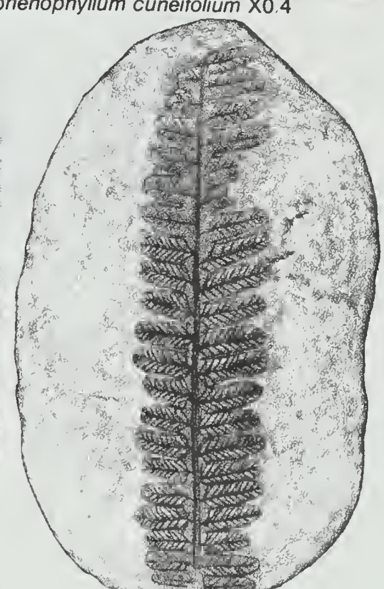


Annularia stellata X0.63

Sphenophyllum cuneifolium X0.4

Pecopteris sp. X0.32

Pecopteris miltonii X2.0



Pecopteris hemitelioides X1.0

J. R. Jennings, ISGS

BRACHIOPODS

Wellerella tetrahedra 1½x

Juresania nebrascensis 2/3x

Derbya crassa 1x

Composita argentia 1x

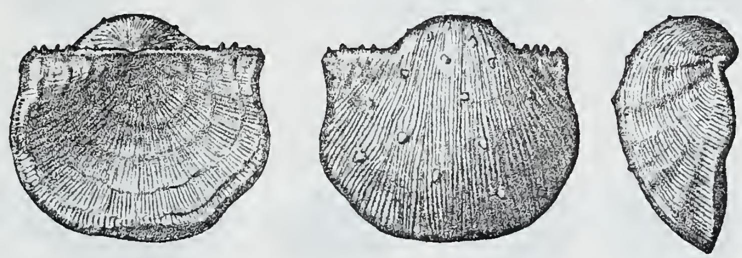
Neospirifer cameratus 1x

Chonetes granulifer 1½x

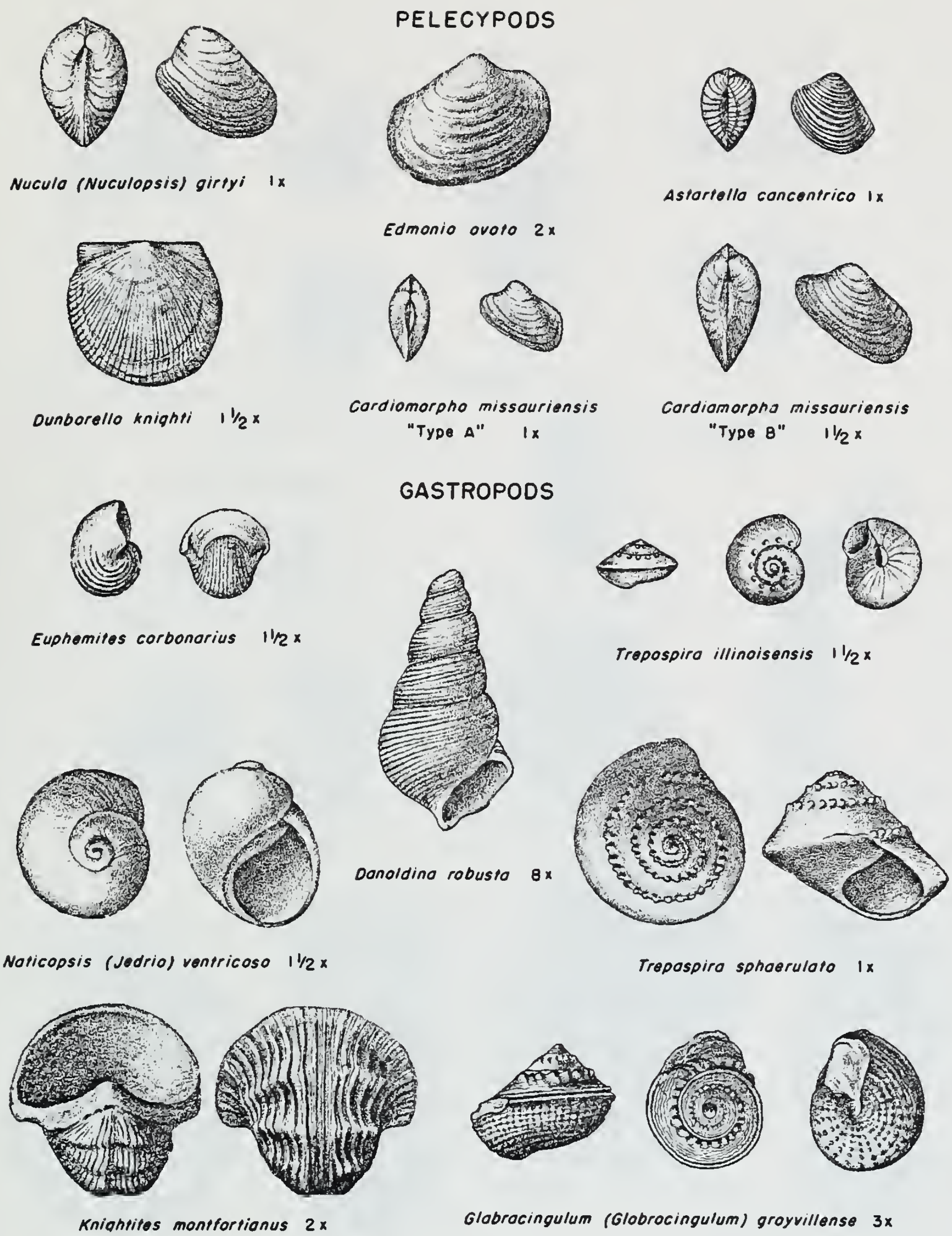
Mesolobus mesolobus var. *evampygus* 2x

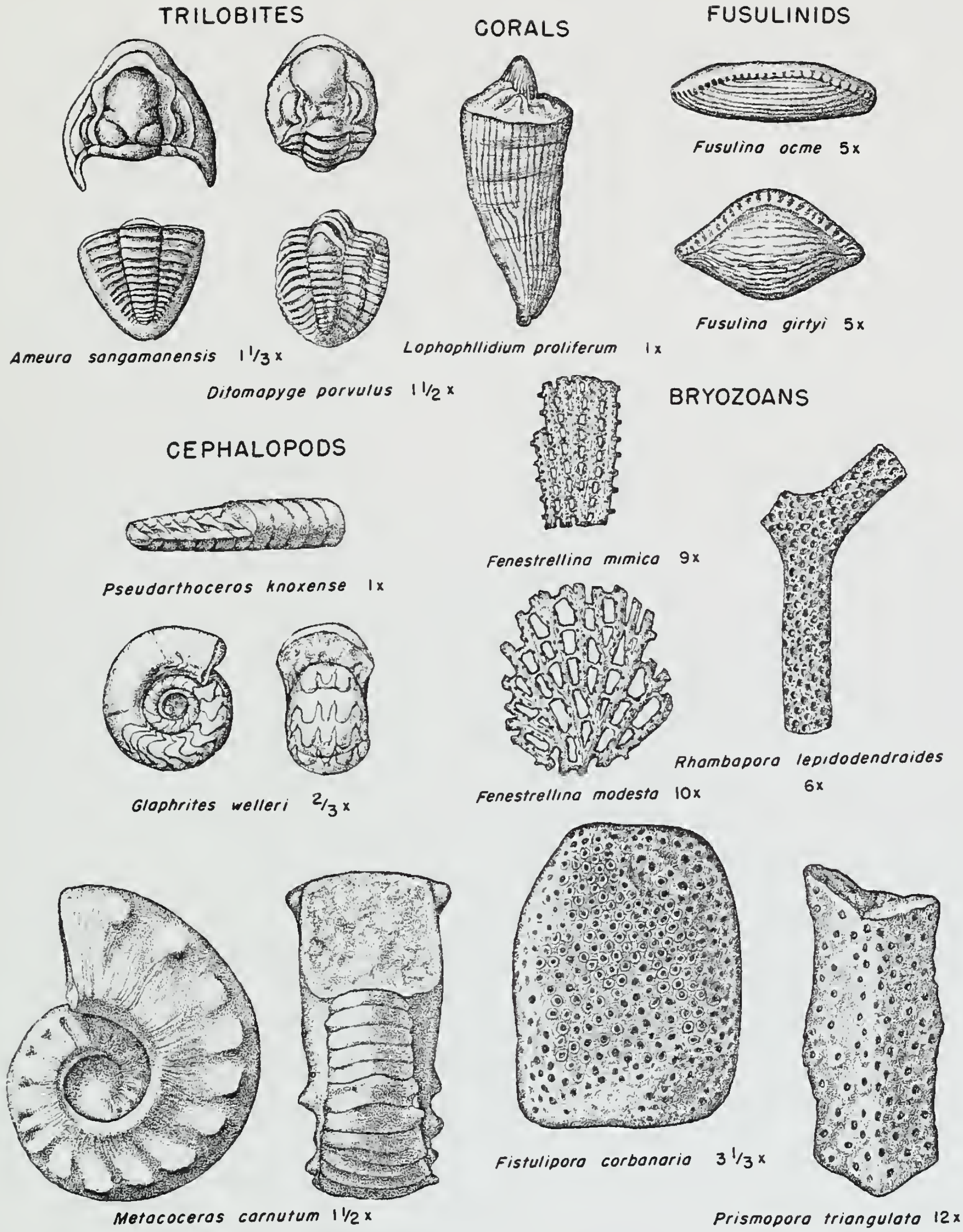
Marginifera splendens 1x

Crurithyris planoconvexa 2x



Linoproductus "cora" 1x


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


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

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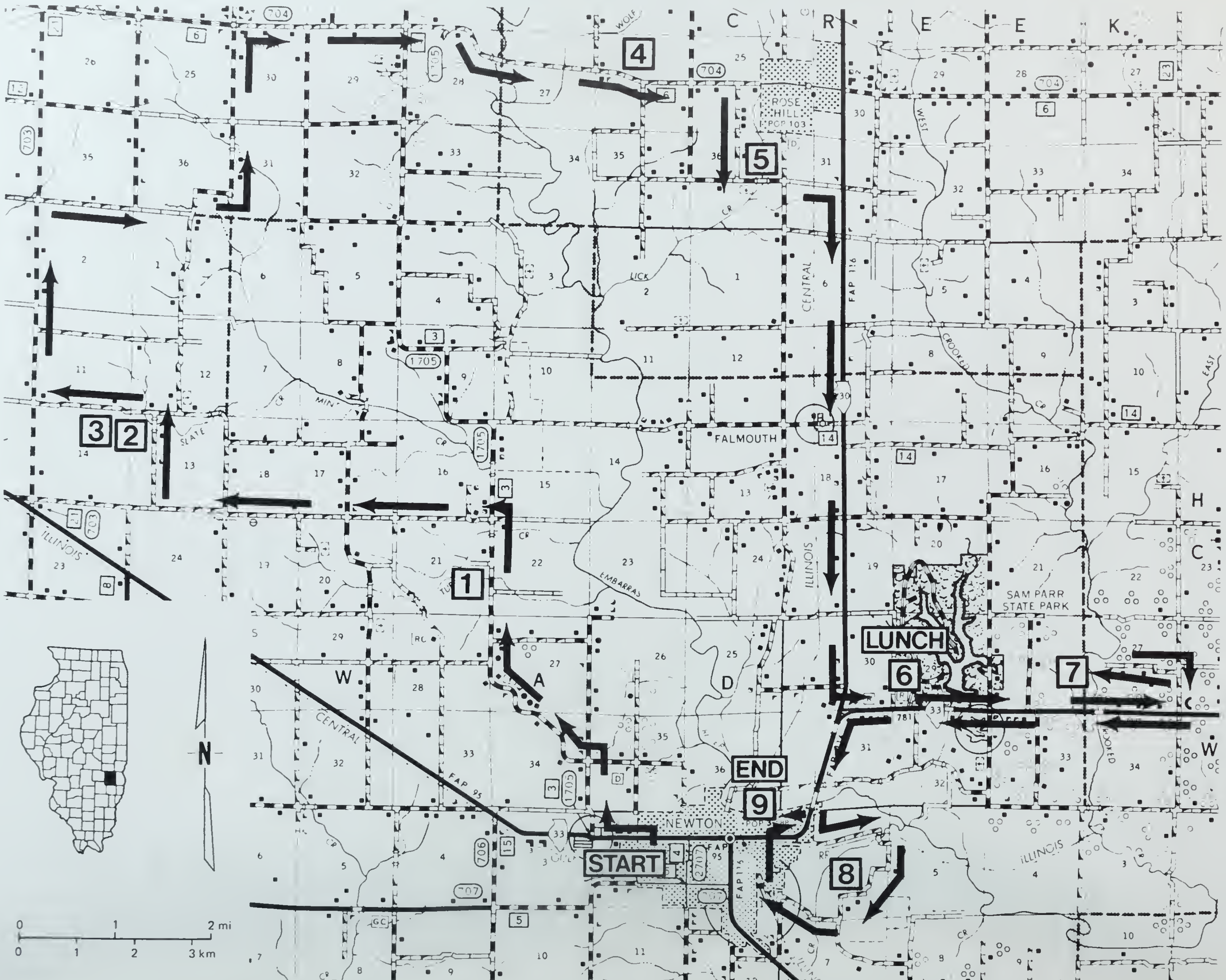
START
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LUNCH
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END
NEWTON
FALMOUTH
ROSE HILL POP 103
SAM PARR STATE PARK
FAP 116
FAP 95
CENTRAL
ILLINOIS
EMBARRAS
CROOKED
WEST
LICK
SLATE
MINT
WOLF
EAST
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