a guide to the geology of the Greenville area

Field Trip 1984 A
April 21, 1984

Illinois Department of Energy and Natural Resources
State Geological Survey Division
Champaign, IL 61820

a guide to the geology of the Greenville area

David L. Reinertsen
Robert E. Bergstrom
Philip C. Reed
Leon R. Follmer
Illinois State Geological Survey

Ray Myers
Greenville College

Field Trip 1984 A
April 21, 1984
Illinois State Geological Survey
615 East Peabody Drive
Champaign, IL 61820

Printed by the authority of the State of Illinois/April 1984/300

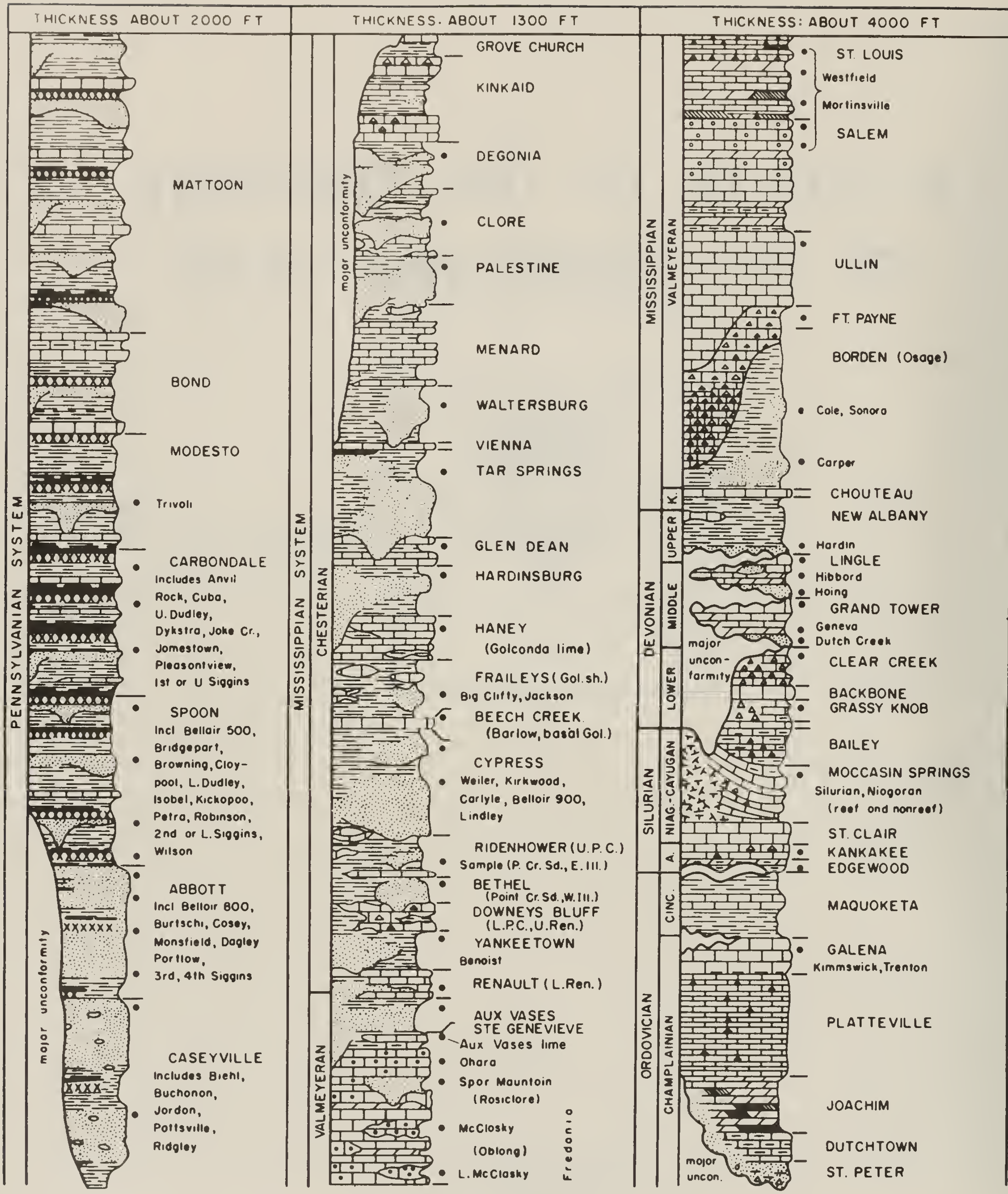


Figure 1. Generalized geologic column of southern Illinois. Solid dots indicate oil and gas pay zones. Formation names are in capitals; other pay zones are not. About 4,000 feet of lower Ordovician and upper Cambrian rocks under the St. Peter are not shown. The names of the Kinderhookian, Niagaran, Alexandrian, and Cincinnatian Series are abbreviated as K., Niag., A., and Cinc., respectively. Variable vertical scale. (Originally prepared by David H. Swann.)

the geologic framework

The Greenville area is part of a belt of low ridges and hills that rise above a broad, flat, physiographic area called the Springfield Plain (see The Physiographic Divisions of Illinois, in appendix). Here the landscape was shaped largely by great, slow-moving continental masses of ice, called glaciers, that covered much of Illinois repeatedly during the past million years or so. In the field trip area, the glaciers left deposits of materials on the irregular bedrock surface; these materials, generally unconsolidated, but sometimes as dense as claystone, include pebbly clay (till), water-laid sand and gravel (outwash), and wind-laid silt (loess). The glacial deposits (drift) are 150 feet or more thick in the Greenville area. The soils here, as well as in most of the rest of Illinois, are developed in the upper portion of the glacial deposits.

Evidence for pre-Illinoian glaciation has been reported in the region of the field trip area. The older glacier came across this area, following about the same path as the Illinoian glaciers, from a region of snow and ice accumulation in northeastern Canada. Remnants of these early deposits have been buried by younger glacial deposits left by Illinoian glaciers that slowly advanced across the state, establishing the southernmost limit of continental glaciation in North America (see Pleistocene Glaciations in Illinois, in appendix). Glaciers of Wisconsinan age reached to within about 45 miles northeast of Greenville. Although Wisconsinan drift did not cover the field trip area, silts and loess of Wisconsinan age do mantle the older Sangamon Soil that had developed on the Illinoian till plain.

Curious features are found on the Illinoian till plain in the Greenville and adjacent areas: elongated ridges and knolls that trend primarily north-northeast. The elongated ridges are composed largely of sand and gravel, and the knolls scattered across the landscape contain gravel, glacial till, and blocks of ice-thrusted bedrock. The origin of these features has been the object of much debate throughout this century, but the latest research indicates that they are the result of deposition from glaciers that, for the most part, were stagnant. These deposits have been of considerable interest for many years because they are one of the most important sources of building and road materials in southern Illinois.

The relatively loose Quaternary deposits in the Greenville area are underlain by consolidated, layered bedrock strata of late Pennsylvanian age that were deposited in shallow seas that some 275 million years ago repeatedly covered this part of what is now the Midcontinent Region of North America. Relatively

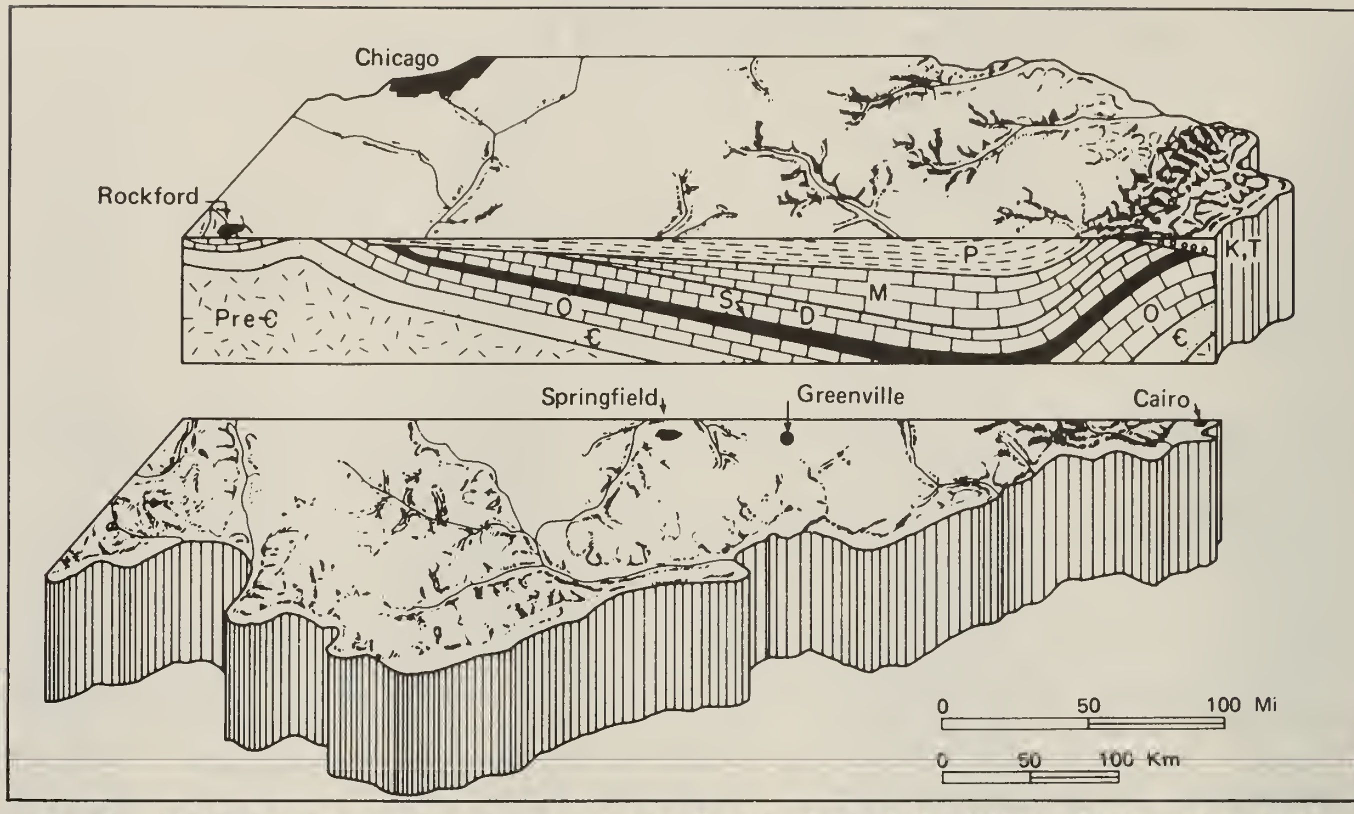
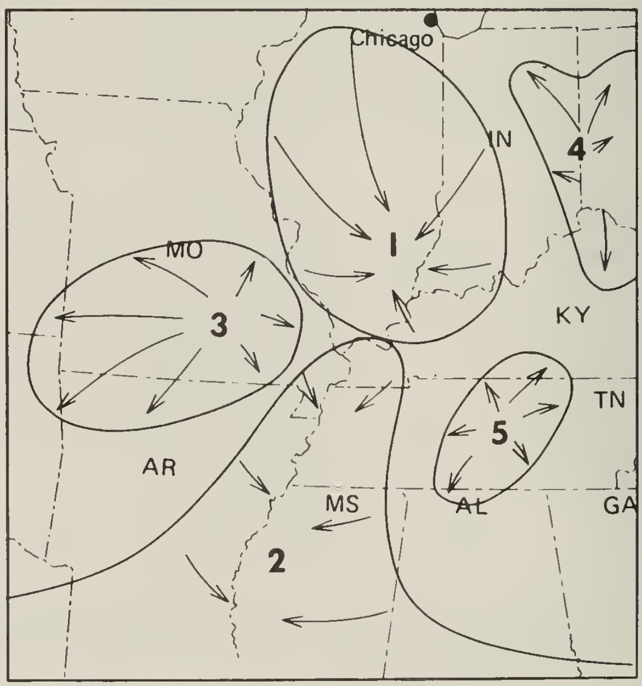


Figure 2. Stylized north-south cross section shows the structure of the Illinois Basin. In order to show detail, the thickness of the sedimentary rocks has been greatly exaggerated and the younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-C) granites. They form a depression that is filled with layers of sedimentary rocks of various ages: Cambrian (C), Ordovician (O), Silurian (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). The scale is approximate.

Figure 3. The location of the Illinois Basin and adjacent major structures: (1) Illinois Basin, (2) Mississippi Embayment, (3) Ozark Dome, (4) Cincinnati Arch, and (5) Nashville Dome.



thin layers of rock, such as shale, limestone, coal, and sandstone, are exposed only at a few places along stream banks and in quarries and roadcuts. Older strata, known from water, oil, and gas prospect wells, have an aggregate thickness here of between about 6,000 and 7,000 feet (fig. 1). These strata dip down gently to the south and east (fig. 2) into the deeper parts of the Illinois Basin (fig. 3), a broad, shallow, spoon-shaped bedrock depression that underlies much of southern Illinois and adjacent portions of southwestern Indiana and western Kentucky.

MINERAL PRODUCTION

The value of minerals produced in Bond County during 1982, the most recent year for which production information is available, totaled more than 2 million dollars.

Oil, the principal mineral commodity of the area at present, is produced from bedrock reservoirs 570 to 3,170 feet deep, ranging in age from Pennsylvanian to Ordovician. During 1982, about 53,000 barrels of oil, valued at about $1,670,000, and slightly more than 9 million cubic feet of natural gas, valued at more than $24,000, were produced in the field trip area. More than 35,000 tons of clay, valued at approximately $120,726, and an undisclosed amount of sand and gravel were produced in the area.

In past years, the Shoal Creek Limestone Member of the Pennsylvanian Bond Formation was quarried for use as building stone, aggregates, and agricultural lime. The Herrin (No. 6) Coal Member of the Pennsylvanian Carbondale Formation was mined at three localities in Bond County. Approximately 7,355,569 tons of coal were mined in Bond County from 1882, when records were first kept, through 1942 when mining ceased.

Groundwater is a mineral commodity frequently overlooked in assessments of an area's mineral potential. Groundwater is obtained from underground reservoirs occurring in beds of saturated glacial sand and gravel or stream alluvium, or in porous or creviced bedrock layers.

The source of all potable water in Bond County is precipitation that eventually filters down into underground reservoirs that are tapped by wells ranging from 50 to 150 feet deep. Below 200 feet, groundwater is too salty for most uses. Groundwater is released slowly into creeks, lakes, and ponds during dry periods, replenishing water lost through evaporation, outflow, and withdrawal.

The original municipal water supply for Greenville was obtained from shallow sand and gravel wells located in the southern part of the city, that tapped the Hagarstown Member of the Glasford Formation. In 1923, this location was abandoned when eight new wells ranging from 45 to 60 feet deep were put into service just north of the depot between Second and Third Streets. The combined yield of these new wells was about 195 gallons per minute (gpm). In 1927, seven new wells (average depth, 62 feet) were opened north of the stockyard; they had a total yield of about 300 gpm. Additional exploration, only partially successful, for sand and gravel well sites was undertaken as water demands increased in the 1940s and 1950s. In the mid-1960s, Governor Bond Lake was formed by damming the Kingsbury Branch north of Greenville. This lake covers about 770 acres, and some 814,000 gallons per day of treated water from it is distributed to around 8,000 people in Greenville, Donnellson, Mulberry Grove, Panama, Royal Lake, and Sorento.

guide to the route

Miles to next point	Miles to starting point	
		Assemble at Greenville High School, 1 Vandalia Road, Greenville.
0.0	0.0	Head north on the high school driveway on the east side of the school.
		CAUTION: TURN RIGHT (east) onto State Route (SR) 140 (1100N).
0.45	0.45	Prepare to turn right at the crest of the knoll just ahead.
0.15	0.6	TURN RIGHT (south; 400N onto 1325E) and ascend Ridge Road.
0.1	0.7	For the next 0.25 mile, there are several opportunities to view the generally flat upland area below Ridge Road. Scattered across this upland surface are ridges and elongated kames. Greenville, to the right (west), is situated on a ridge of outwash sands and gravels along the East Fork of Shoal Creek.
0.5+	1.2+	STOP (1-way); T-road intersection. TURN LEFT (south) on Idler Lane and ascend ridge.
0.7-	1.9	STOP (1-way); T-road intersection at curve. CAUTION: TURN LEFT (southerly) on SR 127.
0.55-	2.45-	STOP (4-way); U.S. 40. CONTINUE AHEAD STRAIGHT (south) on SR 127.
0.25+	2.7	CAUTION: Approaching Interstate (I)-70 interchange.
0.35	3.05	I-70 overpass. CONTINUE AHEAD (southeasterly) on SR 127.

Miles to next point	Miles to starting point	
1.0	4.05	Prepare to turn left.
0.2-	4.25-	CAUTION: TURN LEFT (east) at south end of highway curve at T-road intersection onto 800N from 1400E.
0.7+	4.95	STOP 1. DISCUSSION OF NORTHWEST-SOUTHEAST TRENDING RIDGES OF GLACIAL ORIGIN. (NOTE THESE RIDGES ON THE TOPOGRAPHIC ROUTE MAP.)
0.0	4.95	Leave Stop 1 and CONTINUE AHEAD (east on 800N).
0.5	5.45	CAUTION: unguarded crossroad. TURN RIGHT (south on 1500E).
0.3	5.75	Crest of northeast elongate ridge. View to the right at about 1:30 is of the crest of the parallel ridge on the southwest side of the valley. The slope immediately to the right has been terraced to prevent erosion of the ridge front.
0.7	6.45	STOP (1-way); T-road intersection. TURN RIGHT (west; 1500E onto 700N).
0.15+	6.6+	Cross the small stream. This is an excellent example of an underfit stream—one too small to have eroded the large valley it now occupies. Prepare to make a left turn part way up the west valley wall.
0.35-	6.95	TURN LEFT (south; 700N onto 1460E).
0.1	7.05	You are crossing the crest of the west ridge.
1.35+	8.4+	CAUTION: narrow, 1-lane bridge. CONTINUE AHEAD (south).
0.05-	8.45	STOP (1-way); T-road intersection. TURN LEFT (east; 1460E onto 550N).
1.0	9.45	TURN RIGHT (south; 550N onto 1550E) at T-road intersection. Notice how flat the ground surface is to the left.

Miles to next point	Miles to starting point	
0.75	10.2	You are at the crest of another ridge also oriented northwest-southeast. The back slope you have just ascended is relatively gentle; ahead of you the steeper slope is the ice-contact side of this feature. This feature does not appear to be the same as the previous ridges. That is, because of its streamlined shape, it appears likely that it may be a catastrophic bar deposit due to torrential flooding that resulted from rapid release of meltwater. To the right, this landowner also has terraced his field. Some of the rounded tree-covered knolls that you see in the distance, to the south and southeast in particular, are probably kames.
0.25	10.45	STOP (1-way); T-road intersection (450N). CONTINUE AHEAD (south on 1550E).
0.25	10.7	TURN RIGHT (west; 425N).
0.5	11.2	TURN LEFT (south; 425N onto 1500E) at T-road intersection.
0.1	11.3	CAUTION: narrow bridge without siderails or markers.
0.55-	11.85-	STOP 2. ILLINOIS POWER COMPANY COMPRESSOR STATION FOR HOOKDALE GAS STORAGE FIELD.
0.0	11.85-	Leave Stop 2. CONTINUE AHEAD (south; on 1500E).
0.6+	12.45	STOP (2-way); crossroad (300N). CONTINUE AHEAD (south; 1500E).
1.0	13.45	T-road from left (200N). CONTINUE AHEAD (south; on 1500E). You are now crossing a Pleistocene lake bottom.
0.25	13.7	TURN RIGHT (west; on 175N).
1.25+	14.95+	STOP (1-way); T-road intersection with SR 127. TURN RIGHT (north; 175N onto 1400E). Prepare to turn left onto SR 143 ahead.

Miles to next point	Miles to starting point	
0.25	15.2+	CAUTION: TURN LEFT (west; 1400E onto 200N) onto SR 143.
1.75-	16.95	Cross Beaver Creek.
2.85	19.8	Prepare to turn right.
0.2+	20.0+	TURN RIGHT (north; 200N onto 925E) at crossroad.
2.35-	22.35	Prepare to turn left part way through the curve ahead.
0.2	22.55	CAUTION: TURN LEFT (west; 930E onto 450N) at crossroad.
0.75	23.3	T-road from left (860E). CONTINUE AHEAD (west) and prepare to stop.
0.05	23.35	STOP 3. DISCUSSION OF PLEISTOCENE EXPOSURE IN ROADCUT AND IN HOG LOTS TO THE NORTH AND TO THE WEST.
0.0	23.35	Leave Stop 3 and CONTINUE AHEAD (west; on 450N).
0.15	23.5	Notice the slumping in the roadcut on the right.
0.15	23.65	To the left and ahead, notice a complete denudation of the land surface by the hog lots; the area has been over-rooted and stirred up by large numbers of pigs.
0.65-	24.3-	Entrance to Buehne Sand and Gravel Company pit to the right. CONTINUE AHEAD (west) and descend hill into Shoal Creek bottoms.
0.2	24.5-	Cross Shoal Creek bridge.
0.15+	24.65	STOP 4. DISCUSSION OF POCAHONTAS SOUTH WATER-WELL FIELD.
0.0	24.65	Leave Stop 4 and CONTINUE AHEAD (west). CAUTION: rough road ahead.
0.35	25.0	Note the pumpjacks and oil tank batteries to the right across the ditch; Stubblefield Gas Storage Field.

Miles to next point	Miles to starting point	
0.2	25.2	CAUTION: twin fords that are not indicated on the map.
0.4+	25.6+	Ascend west valley wall.
0.2-	25.8	Valleys tributary to Shoal Creek and numerous gullies have produced a strong surface relief here close to Shoal Creek.
1.15-	26.95-	STOP (2-way); crossroad. TURN RIGHT (north; 450N onto 500E).
0.75+	27.7	CAUTION: enter Pocahontas.
0.2-	27.9-	Railroad underpass; CONTINUE AHEAD on Acadamy Street.
0.45+	28.35	STOP (1-way); T-road intersection. TURN LEFT (west) on State Street.
0.25+	28.6+	At road curve to the left, CONTINUE AHEAD briefly and then TURN RIGHT (north; onto 475E) toward I-70.
0.05	28.65+	STOP (3-way); T-road intersection. CONTINUE AHEAD STRAIGHT (north) and enter I-70 interchange.
0.2-	28.85	Cross I-70, CONTINUE AHEAD (north; on 475E).
1.75	30.6	To the right is another terraced hill slope.
2.15+	32.75+	STOP (2-way); crossroad. TURN RIGHT (east; 450E onto 1000N) on SR 140.
1.05-	33.8	Descend west valley wall into Shoal Creek bottoms. The part of the valley to the northwest is much narrower than it is here, probably because resistant bedrock is close to the surface, whereas here, where the valley is so broad, bedrock is less resistant to erosion.
1.7	35.5	Ascend east valley wall of Shoal Creek Valley.
3.3+	38.8+	CAUTION: prepare to turn right at park entrance.
0.15	38.95+	TURN RIGHT (south) at entrance to Patriot's Park, Kingsbury Park District.

Miles to next point	Miles to starting point	
0.1+	39.1-	STOP 5. LUNCH NEAR PAVILLION; DISCUSSION AND DEMONSTRATION OF EARTH RESISTIVITY SURVEYING METHODS.
0.0	39.1-	Leave Stop 5, CONTINUE AHEAD and BEAR LEFT on first park road southeast of pavillion.
0.2+	39.3	STOP (2-way); intersection with SRs 127 and 140. TURN RIGHT (east) toward Greenville.
0.9+	40.2+	Cross East Fork Shoal Creek and bear left and ascend hill on SR 140 East.
0.75-	40.95	CAUTION: hospital entrance to the left. CONTINUE AHEAD (east).
0.45-	41.4-	STOP (2-way); crossroad. CAUTION, CONTINUE AHEAD past Greenville High School on SR 140 East.
0.35	41.75-	Prepare to turn left.
0.15	41.9-	CAUTION: TURN LEFT (north; 1100N onto 1300E) onto Idler Lane.
1.0	42.9-	CAUTION: 3-way stop at crossroad (1200N). TURN LEFT (west) through gate into McCasland Sand and Gravel Company pit. STOP.
		STOP 6. QUATERNARY DEPOSITS EXPOSED IN OPERATING PIT.
0.0	42.9-	Leave Stop 6 and resume mileage at entrance gate. STOP (3-way); crossroad. CONTINUE AHEAD (east; on 1200N).
0.15+	43.05	CAUTION: narrow bridge.
0.35	43.4	CAUTION: unguarded T-road intersection; TURN RIGHT (south; 1200N onto 1350E).
0.5	43.9	TURN LEFT (east). Ahead and slightly to the right is the flat area that separates the ridge behind you (in which the gravel pit was located) and the elongated kame ahead of you (on which the golf course has been developed).

Miles to next point	Miles to starting point	
0.3-	44.2-	STOP (1-way); T-road intersection with 1380E. CONTINUE AHEAD (east on 1150N).
0.2+	44.4	BEAR LEFT (north on 1400E).
1.4	45.8	BEAR RIGHT (northeast at 1290N).
0.45-	46.25-	CAUTION, Burlington Northern Railroad crossing. CONTINUE AHEAD (northeasterly).
0.6+	46.85	To the left and right are abandoned gravel pits in small kame-like deposits.
0.35-	47.2-	CAUTION: road crosses narrow causeway at eastern end of Governor Bond Lake.
1.0+	48.2	CAUTION: hamlet of Woburn. CONTINUE AHEAD (northeasterly on 1520E).
1.95	50.15	In the distance on the right are some of the pumpjacks and oil tank batteries that belong to the Woburn Consolidated Oil Field.
0.65	50.8	Prepare to turn right.
0.2	51.0	TURN RIGHT (east; 1675E onto 1700N) at T-road intersection.
0.45	51.45	You are now crossing the Woburn Consolidated Oil Field.
0.55	52.0	CAUTION: FADED STOP SIGNS. STOP (2-way); crossroad. TURN RIGHT (south; 1700N onto 1775E).
1.0	53.0	STOP (1-way); T-road intersection. TURN RIGHT (west; 1775E onto 1600N).
0.75	53.75	STOP 7. DISCUSSION OF WOBURN CONSOLIDATED OIL FIELD NEAR POND ON NORTH SIDE OF ROAD.
0.0	53.75	Leave Stop 7 and CONTINUE AHEAD (west on 1600N).
1.15	54.9	STOP (2-way); crossroad (Woburn Road, 1590E). CONTINUE AHEAD (west on 1600N).
1.0	55.9	Cross Dry Branch.

Miles to next point	Miles to starting point	
1.65	57.55	STOP (2-way); crossroad. TURN RIGHT (north; 1600N onto 1350E) on Red Ball Trail.
0.5+	58.05+	CAUTION: TURN LEFT (west; 1350E onto 1650N) and leave Red Ball Trail.
1.6-	59.65	Cross East Fork of Shoal Creek.
2.4	62.05	Note the gently rolling uplands in this area.
0.8+	62.85+	STOP (2-way); SR 127. CAUTION: FAST CROSS TRAFFIC. TURN RIGHT (north; 1650N onto 0875E) on SR 127.
2.95	65.8+	CAUTION: enter village of Donnellson and prepare to turn left.
0.25	66.05+	CAUTION: TURN LEFT (west) on Bond-Montgomery County line road. Sign points to Panama.
1.6-	67.65-	CAUTION: BUMP at Norfolk and Western Railroad crossing.
0.95-	68.6-	Cross Bearcat Creek. To the right is the abandoned Cosgrove and Meehan Coal Company No. 5 Mine. No. 6 Coal averaged 7 feet thick and 164 feet deep in this shaft mine which operated from 1905 to 1934.
0.15-	68.75-	Ascend west wall of Bearcat Creek valley and enter village of Panama.
0.15+	68.9-	STOP (3-way); "Y" intersection at top of hill. BEAR LEFT (west) and then curve left (south).
0.2-	69.1-	TURN RIGHT (west) at the Methodist Church corner. Follow arrow pointing to Sorento (west and then south).
0.1+	69.2-	TURN RIGHT (west); T-road intersection. Follow arrow westward toward Sorento.
0.5+	69.7	Descend east valley wall of Shoal Creek.
0.2	69.9	Cross Shoal Creek. Note how narrow the valley is here. It is strikingly different from the valley that has been developed along SR 140 west of Greenville.

Miles to next point	Miles to starting point	
0.1	70.0	In the ditch below the west end of the guard-rail on the south side of the road is an exposure of the upper part of the Shoal Creek Limestone Member (Pennsylvanian). This resistant rock is the reason for the valley being so narrow in this immediate area.
0.35	70.35	CAUTION: crossroad. CONTINUE AHEAD (west).
0.5	70.85	This roadcut is through glacial materials that appear to be quite similar to those seen at Stop 6. The groundcover planted here has been broken through by erosion to expose the gravelly till.
0.5	71.35	STOP 8. SHOAL CREEK LIMESTONE MEMBER. PARK AS FAR OFF OF THE BLACKTOP AS YOU CAN SAFELY. CAUTION: FAST TRAFFIC. YOU MUST HAVE PERMISSION TO COLLECT FROM THE SPOIL PILES AROUND THIS ABANDONED QUARRY.

END OF FIELD TRIP

To leave the last stop:

- You can go south through Sorento to Old Ripley and SR 140; about 10 miles.
- Retrace itinerary back through Panama to Donnellson and SR 127.
- For I-55: Go south for a little over 3 miles (through Sorento) and turn right on the New Douglas blacktop; then it is about 10 miles west to the Livingston/I-55 interchange.

You Must have permission to enter the following properties:

- Stop 6—McCasland Sand and Gravel Company, 1325 South Fourth, Greenville, Illinois 62246
- Stop 8—Mr. Robert Collmann, R.R. 1, Sorento, Illinois 62086.

FIELD TRIP STOPS

1 Discussion of northwest-southeast trending valley (N edge NE$\frac{1}{4}$ NE$\frac{1}{4}$ NE$\frac{1}{4}$ NW$\frac{1}{4}$ Sec. 30, T. 5 N., R. 2 W., 3rd P. M., Bond County; Pleasant Mound 7.5-minute Quadrangle).

Here the view to the southeast is along what appears to be a subglacial channel that was formed beneath an ice mass of Illinoian age (see appendix). The stream now occupying this broad, U-shaped, southeast trending valley is much too small to have formed the valley. The parallel ridges on either side of the valley extend only for about 2 miles to the southeast and have crests 30 to 35 feet above where we are standing. The geomorphic expression of the ridges with their gentle slopes away from the valley resembles a natural levee. However, the exact origin of this feature is difficult to determine partly because a long interval of erosion has modified the area since the feature was deposited.

The relationship of these parallel ridges with other features upslope to the north and northwest is also difficult to determine now, mostly because that area has little surface relief for at least 2 miles (except for the ridge on the northeast side of this valley, which extends north northeastward for slightly more than a mile). The ridges might be related to the sags on either side of the ridge on the east side of Greenville (the ridge we crossed between State Routes (SR) 140 and 127 just after leaving the high school). Perhaps these two sags were smaller subglacial channels that were tributary to the larger channel here. The orientation of this valley, which is nearly at right angles to the deposits to the northwest along the East Branch of Shoal Creek, may have been due to jointing in the glacier.

Another possible explanation for the origin for this valley is that it may have resulted from the detachment and subsequent stagnation of a long, relatively clean block of ice that was then partially buried by debris that accumulated along the parallel flanks of the ice block. Some of the debris may then have slumped toward the ice block as it melted to form the gentle slopes of the valley walls while the rest of the material along the flanks remained as a pair of parallel ridges. This alternative may be a better means of explaining the presence of the small stream that cuts across the south end of the southeast valley wall and is tributary to Little Beaver Creek.

Evidence that these ridges are the result of stagnant ice is the stratified nature of the weak deposits in the ridges; these deposits would have been destroyed by even a small amount of movement by a glacier. Other ridges, some oriented at various angles to this valley, and kames scattered across the landscape in this region also suggest stagnant ice conditions; none of these features could have survived any shoving by a moving body of glacial ice.

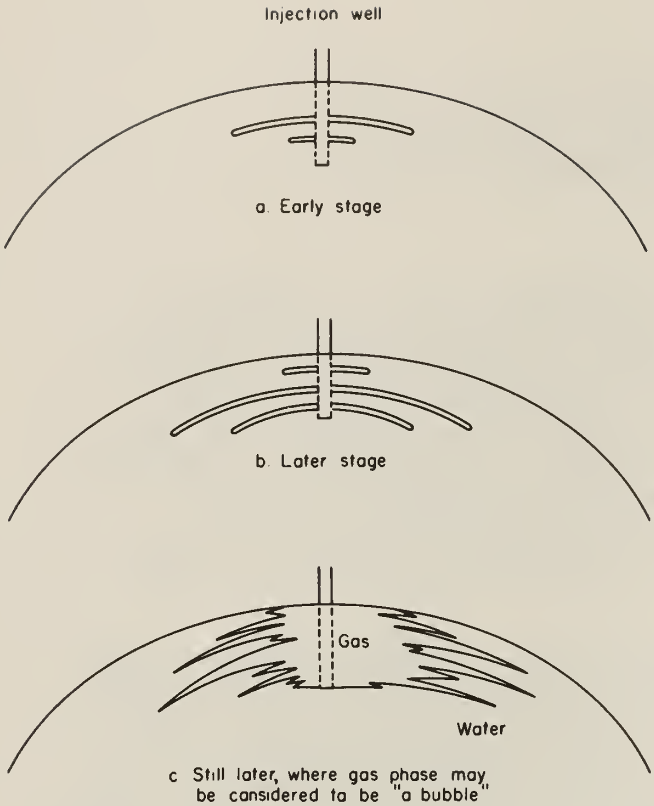
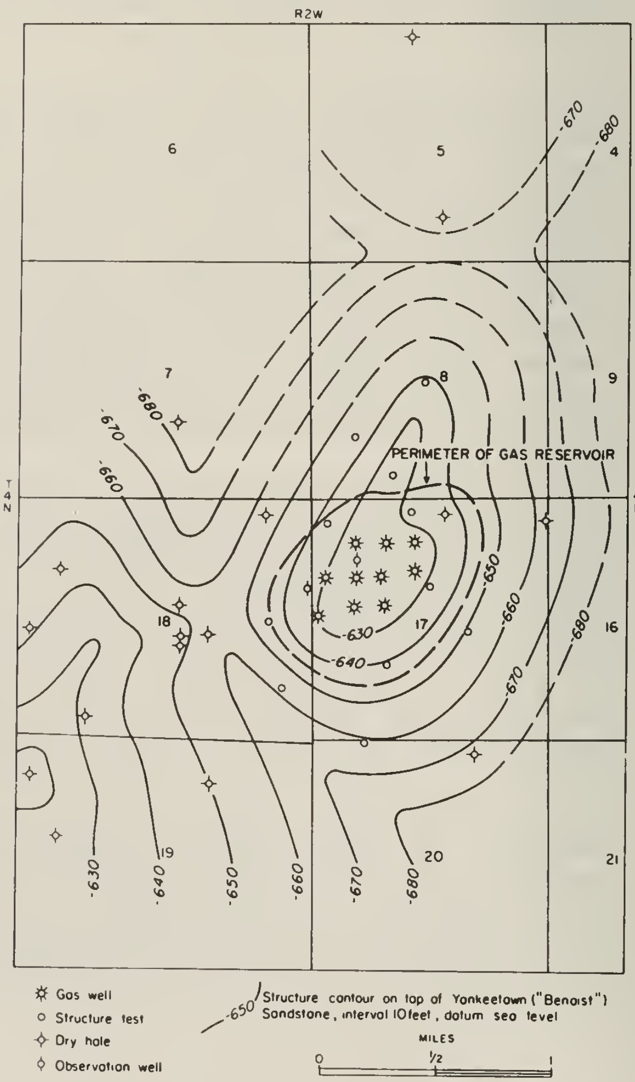


Figure 4. Development of gas bubble in an aquifer (Katz et al., 1963, p. 130).

Figure 5. Top of Yankeetown ("Benoist") Sandstone at Hookdale, Bond County (Illinois Power Company).



2 Discussion of Hookdale Underground Gas Storage Project, Illinois Power Company (NE¼ SE¼ SE¼ NE¼ Sec. 18, T. 5 N., R. 2 W., 3rd P. M., Bond County; Pleasant Mound 7.5-minute Quadrangle).

In 1982 natural gas was stored in underground reservoirs at 43 locations in Illinois. Storage of natural gas underground during the summer enables utility companies to provide the large amounts of gas required for heating during peak-use periods in the winter.

Locating an underground storage reservoir is a time-consuming process requiring the combined efforts of geologists, engineers, and drillers. When a suitable dome-shaped structure has been located by geologic exploration, an injection well is drilled into the structure, and pipeline gas is introduced into the water-filled reservoir rock (fig. 4). At a later stage several water zones within the porous, permeable reservoir rock are displaced with gas; eventually the injected gas displaces a large amount of water in the reservoir and a gas bubble is formed, ready for use. (Information on Illinois underground gas storage reservoirs can be obtained at the Illinois State Geological Survey.)

An underground storage reservoir operated by the Illinois Power Company is located near Hookdale, 6 miles southeast of Greenville. The Hookdale reservoir is a former gas field discovered in 1961. Gas from the Natural Gas Pipeline of America is stored in the Hookdale reservoir (fig. 5) at a depth of 1125 feet in the Yankeetown ("Benoist") Sandstone. Ten wells are used for injection and withdrawal of gas, and four wells are used for observation.) The reservoir extends over 414 acres, has a closure of 28 feet, and is overlain by a caprock of Mississippian shale. Withdrawals from the reservoir totaled 213 million cubic feet (MMcf) in 1981 with a peak daily withdraw of 31 MMcf. At the latitude of Greenville the average home may require as much as 20,000 cubic feet of gas per month during cold weather.

3 Discussion of Quaternary deposits exposed in new roadcut and nearby hog lots (Center Sec. 7, T. 4 N., R. 3 W., 3rd P. M., Bond County; Beaver Creek 7.5-minute Quadrangle).

Many road cuts and stream bank exposures in the Illinoian till plain area show profiles similar to the one exposed in this fresh roadcut. In the roadcut and in the fields north of the gravel road 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 presented in figure 6. The black and gray colors in the buried soils indicate this was a wet, poorly drained area before the Peoria Loess was deposited. The 4C2 horizon in till is exposed in the road ditch. It is oxidized and altered somewhat in comparison to the unaltered gray till that we think, on the basis of observations in other places, underlies this horizon. The 4C1 horizon is best seen in the hog lot north of the road where the dissolved iron moved down and precipitated in the orange colored zone (4C1).

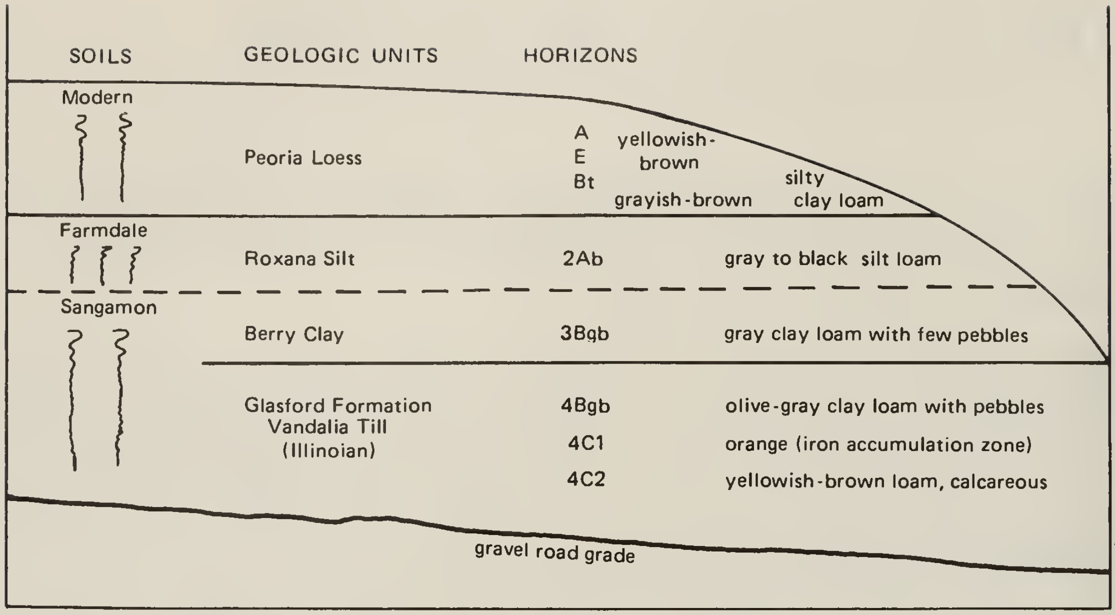


Figure 6. Typical weathering profile on the flat Illinoian till plain of south-central Illinois (scale is exaggerated).

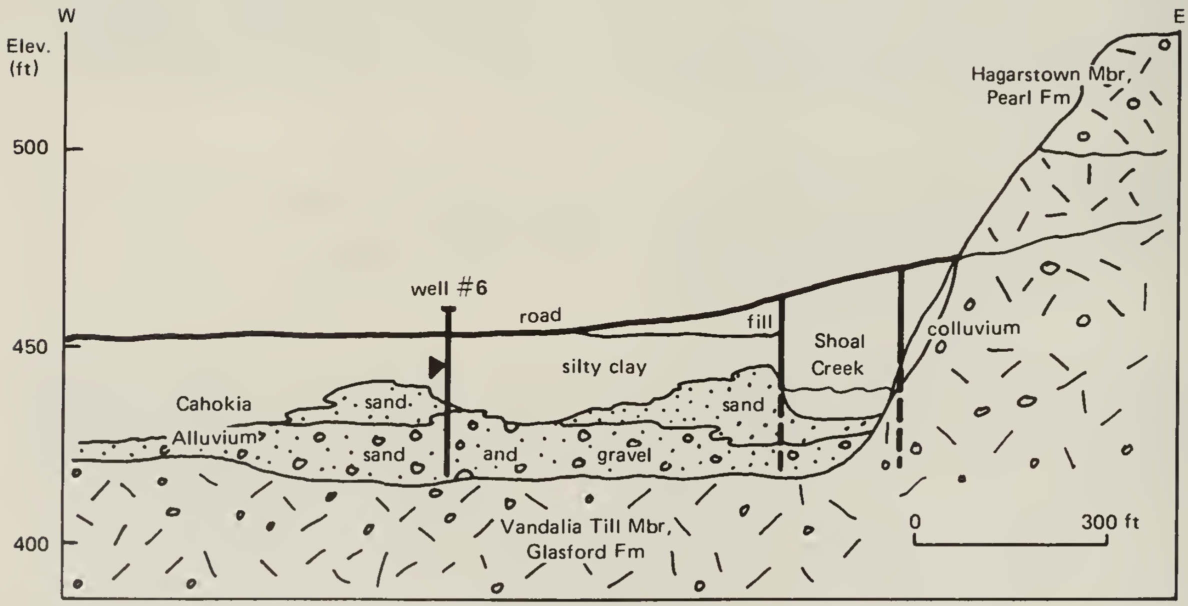


Figure 7. Hydrogeologic cross-section, Pocahontas South well field.

The 4Bgb is the lower part of the gleyed zone 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 gravel occurs at this contact, which is evidence for an erosion surface. When the climate returned to warm conditions, the Sangamon Soil formed on the ground surface of the time. 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, which came largely by wind transport, 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 clearly was the top soil of a former land surface and is designated here as the 2Ab horizon; this is 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. 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 the hog lots. Soil loss from sloping hog lots in similar areas are as high as 25 tons per acre (about 1 inch in 7 years).

4 Discussion of Pocahontas South water well field (NE¼ NW¼ SW¼ Sec. 12, T. 4 N., R. 4 W., 3rd P. M., Bond County; Beaver Creek 7.5-minute Quadrangle).

The Pocahontas South water well field is located in the lowland of the East Branch of Shoal Creek (Sec. 12, T. 4 N., R. 4 W., Bond County). The well field consists of two wells (nos. 6,7) 34.5 and 31 feet deep and 500 feet apart. They supply Pocahontas (population 866) about 2 miles northwest with approximately 80,000 gallons of good quality water each day. A cross section showing the distribution of earth materials along the field trip route in the valley of Shoal Creek at the south well field is shown in figure 7.

The North well field, located one mile northeast of Pocahontas in Sections 34, 35, T. 5 N., R. 4 W., consists of wells nos. 1, 2, 4, and 5, with depths of

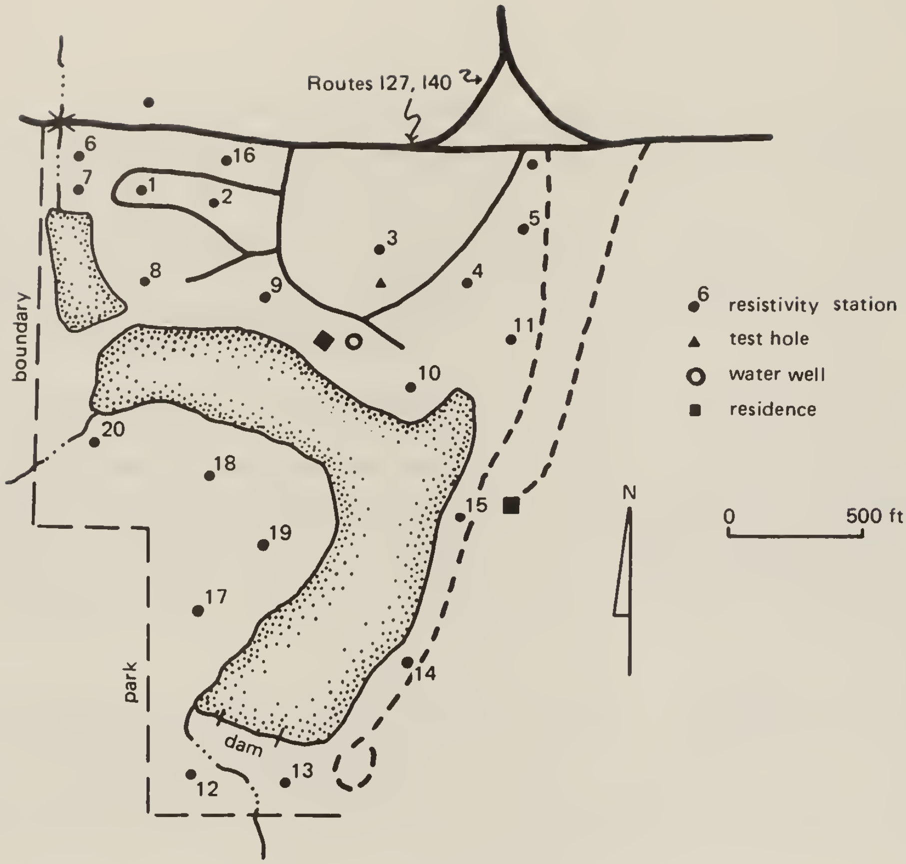


Figure 8. A reconnaissance electrical earth resistivity survey of the Kingsbury Park District.

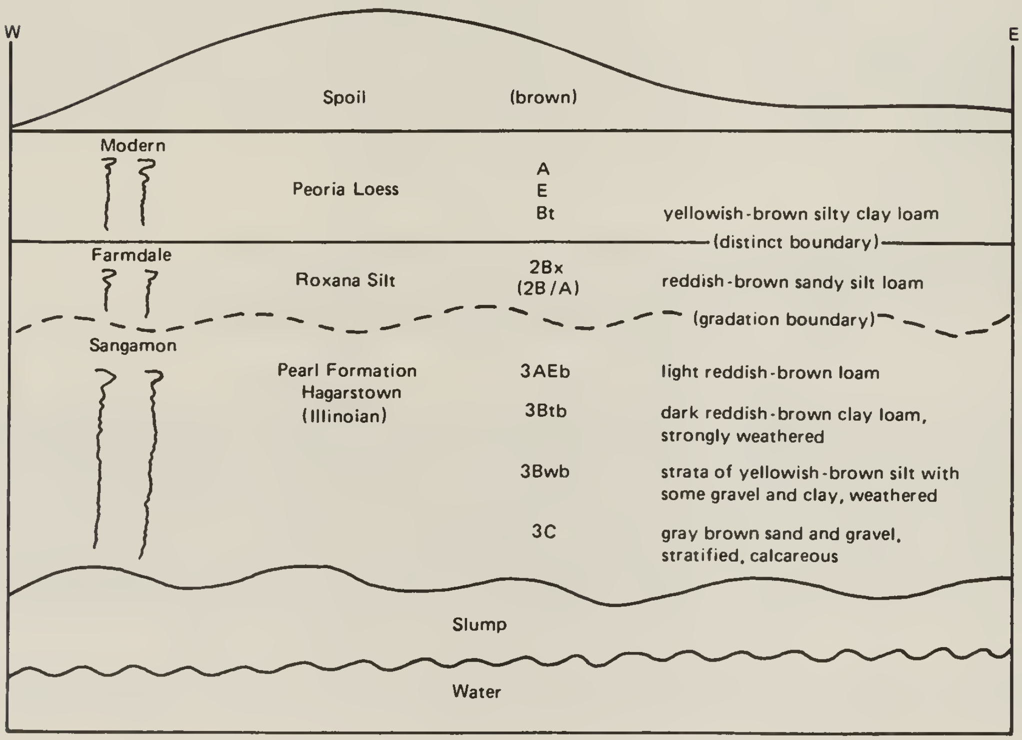


Figure 9. Typical weathering profile on drift hills in south-central Illinois (west end of north face in gravel pit; scale is exaggerated).

63, 36, 34, and 35 feet respectively. This field was abandoned in 1978, because of excessively high iron content in the water, and supplanted by the Pocahontas south field, but it is still operating on a standby basis. The north and south water-well fields at Pocahontas were located by means of electrical earth resistivity surveys conducted by the Illinois State Geological Survey. Exploration drilling in the valley of Shoal Creek was undertaken with the assistance of the Geological Survey in 1948, 1977, and 1982.

5 Lunch in Patriot Park and discussion and demonstration of electrical earth resistivity survey for Kingsbury Park District (W½ SE¼ NW¼ Sec. 9, T. 5 N., R. 3 W., 3rd P. M., Bond County; Greenville 7.5-minute Quadrangle).

The Geological Survey conducts electrical earth resistivity surveys as part of a free groundwater service program to help locate public groundwater supplies. Resistivity surveys are useful in prospecting for buried water-bearing sand and gravel deposits of the glacial drift and alluvium above bedrock. By using general geologic information about an area and information obtained by an electrical earth resistivity survey, predictions can be made as to the water-bearing properties of earth materials. Since 1932, the ISGS has made more than 2000 resistivity surveys in the state, covering areas ranging in size from one acre (for farms) to many square miles (for municipal, industrial, and irrigation supplies). In 1980 an electrical earth resistivity survey was made for the Kingsbury Park District at Patriot Park. The ISGS also obtained geophysical log data from test holes and analyzed the solution gas contained in the water of the finished well.

The Patriot Park survey consisted of 20 resistivity stations distributed in a circular manner around Greenville Lake (fig. 8). The data indicated that the sandiest earth materials were present at station 18 on the south shore of the west end of the lake, a considerable distance away from the point of greatest use near stations no. 9 and 10. Then the park officials decided to drill a test at one of the more favorable resistivity stations, no. 9. In 1980, a test hole was completed to a depth of 138 feet. The testing was performed with cable tool rig with percussion tools through a 6-inch casing; consequently, as drilling progressed, the yield of the water-bearing zone could be determined immediately. At a depth of 133-134.5 feet, a water-filled limestone crevice was encountered. The well eventually constructed was pumped at a rate of 12 gallons per minute for a period of 26 hours, with a drawdown of 17.4 feet. Gas was also released as the well was pumped.

6 Discussion of Quaternary deposits in active pit of McCasland Sand and Gravel Company (SE¼ SE¼ SE¼ SE¼ Sec. 35, T. 6 N., R. 3 W., 3rd P. M., Bond County; Greenville 7.5-minute Quadrangle). You MUST have permission to enter this property.

The mining of sand and gravel at this pit exposes a typical weathering profile found on the Hagarstown hills of the region. The general sequence of soils and glacial stratigraphy (fig. 9) is similar to the sequence seen at Stop 3, except for differences in drainage classification and grain size and permeability of materials.

The lower horizon exposed here (3C) is relatively unweathered sand and gravel. Above this are strata of silt, sand, and some clay that are more or less contained in a zone described here as the 3Bwb, which is less weathered than the 3Btb above. The 3Bwb, mostly silt with some clay, represents relatively quiet water conditions such as a lake. Near the waterworks to the north, a 5-meter section of lacustrine silt and clay can be seen (only the upper 2 meters visible now) in a borrow pit that we think correlates with the silt beds here.

The 3Btb is the clay enriched horizon of the Sangamon Soil; however, it still contains a large amount of pebbles, which indicates that a condition of faster flowing water occurred after the silt beds were deposited. After deposition of the Hagarstown Member was completed, the Sangamon Soil formation caused clay to accumulate in the Bt (becomes 3Btb after burial by two loess deposits). The uppermost part of the Hagarstown, the 3AEb, contains fossilized surface soil characteristics, such as root traces and aggregated granules.

The Roxana Silt is interpreted here as the second geologic layer, with fragipan characteristics (extremely compact), and is designated as the 2Bx in USDA-SCS nomenclature. The soil characteristics throughout most of this layer contain both A and B horizon features. In geological usage we can interpret this layer as a 2B/A, a B horizon now which has been superimposed on a former A horizon. This layer forms a very gradual boundary with the Hagarstown deposits because of the mixing caused by organisms in the now fossilized soil.

The contact between the Peoria Loess and Roxana Silt is quite distinct. The Peoria has less sand and a different color. The sharpness of the boundary indicates rapid burial which inhibited the mixing processes. The Modern Soil (an Alfisol) is expressed in the Peoria Loess with an A horizon, E horizon, and a Bt horizon. Several feet of spoil covers the Peoria Loess in most parts of the exposure. The whole profile is well-drained and is thoroughly oxidized. The weathered portion is suitable for fill material; the unweathered sand and gravel is also used for fill and can be cleaned and sorted for use in concrete, aggregate mixes, and other construction applications.

7 Discussion of Woburn Consolidated oil field (SE cor. Sec. 9, T. 6 N., R. 2 W., 3rd P. M., Bond County; Mulberry Grove 7.5-minute Quadrangle).

The Woburn field is the largest of 12 oil fields (fig. 10) that have been discovered in Bond County. Since its discovery in 1940, the Woburn has produced more than 4½ million barrels of oil—more than half of the 8 million

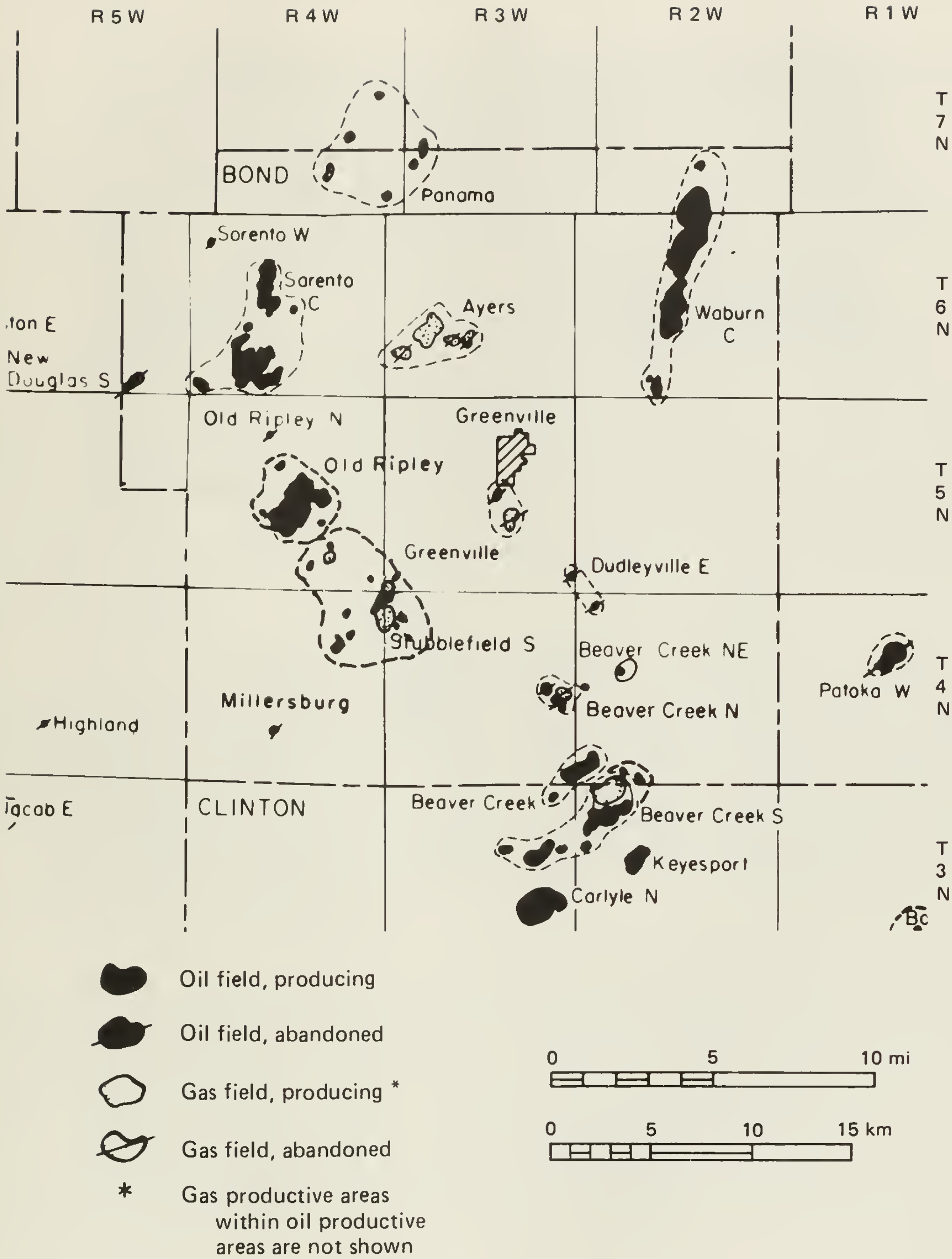


Figure 10. Oil and gas fields of Bond County and vicinity.

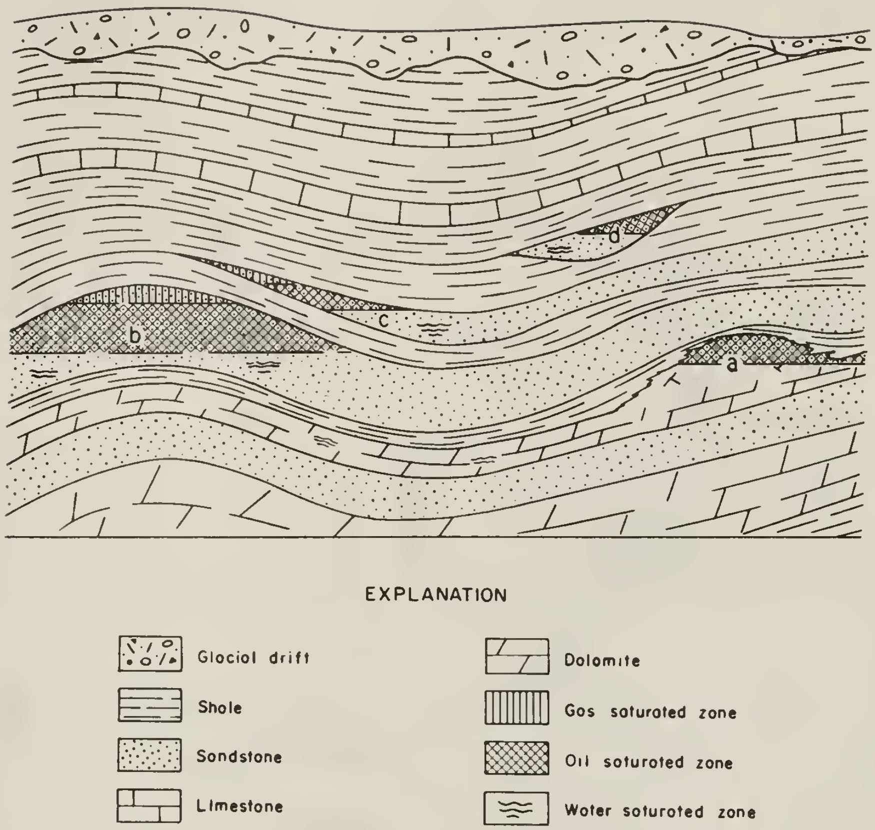


Figure 11. Types of structures in which oil is found in Illinois; (a) coral reefs, (b) anticlines, (c) pinch-outs, and (d) channel sandstones.

barrels yielded by all fields in the county. The current yield of all the fields is about 55 thousand barrels per year. The Woburn, Beaver Creek South, Old Ripley, and Stubblefield South fields are currently producing most of this oil.

The Woburn field is some 8 miles long and 1 to 2 miles wide. The proven area of the field is 1450 acres. Pay zones in the field range from 865 to 3170 feet deep and include the Cypress, Benoist, Renault, and Aux Vases (Mississippian), Lingle (Devonian), and the Trenton (Ordovician) (fig. 1). These pay zones, which act as reservoir rocks for the oil and gas, are porous sandstones and limestones that formed as soft sediments on the bottom of shallow seas that covered much of Illinois during the Paleozoic Era 600- to 225-million years ago.

Oil and gas are organic substances that originate from organic material that settle on the sea floor and become buried with accumulations of sand, silt, clay, and carbonate. As the sea floor subsides, a thick pile of organic-rich, sediments accumulates. Continued burial, rising temperature, and pressure cause the large, complex molecules in the organic matter to break down into simple ones. These simpler ones form crude oil and natural gas and are called hydrocarbons. The breakdown begins at depths of around 1500 feet and continues with burial. It is similar to the cracking process carried out in oil refineries where heavy crude oils are broken into lighter components like gasoline and kerosene.

Several conditions are necessary for the development of an oil field: a sedimentary source rock in which hydrocarbons form, a porous and permeable reservoir rock where they can accumulate, and a geologic structure that traps and concentrates the accumulation. Some typical conditions for trapping oil are shown in figure 11. Anticlines are common structures for trapping oil and have been sought from the very early days of oil exploration. Many of the oil fields in Bond County (including the Woburn) are anticlinal traps. In the Woburn field, the rocks have been warped into a low arch which has formed traps in six reservoir beds.

Exploration for oil and gas is a sophisticated procedure because favorable conditions for oil reservoirs may occur at great depth and bear no relationship to geologic conditions indicated at the land surface. Once geological and geophysical studies are made, the only way to prove whether oil and gas are present is by drilling. On an average, for each exploratory hole that finds a new field or significantly enlarges an old field, about 10 unsuccessful wells are drilled. Records of these drill holes in Illinois are kept at the State Geological Survey, and are the main source of information on the subsurface geology of the state. More than a quarter million drill hole records are on file.

In the Woburn field, 142 wells (from 700 to 3200 feet deep) have been completed to reach the pay zones. The pay zones are only 10 to 12 feet thick, so the wells must be constructed carefully so that the well is open at the proper depth. When the wells are completed, they are fitted with pumps that bring the oil to the surface. The minimum spacing of wells in oil fields in

Illinois is governed by law to prohibit the drilling of an excessive number of wells—which would waste reservoir pressure. The minimum distance between wells is 660 feet.

Recovering oil from a reservoir is a relatively inefficient process: generally only 25 to 30 percent of the oil in place in the reservoir is recovered during the primary phase of production. An additional 20 to 25 percent of the original oil in place is commonly produced by waterflooding, a practice of secondary recovery that accounts for about one third of the present production of oil in Illinois. Waterflooding has been used in the Woburn field and other fields in Bond County. Tertiary methods of recovery are in use and under investigation to gain an additional increment of oil, but even after all methods of recovery have been used, a quarter to a third of the oil still remains in the reservoir.

8 Exposure of Shoal Creek Limestone in lane west of county highway and in abandoned, water-filled quarry to the east (N½ SW¼ NW¼ Sec. 29, T. 7 N., R. 4 W.; 3rd P. M., Bond County; Sorento N 7.5-minute Quadrangle).

The great thickness of overburden was a major problem in the operation of this quarry. Most of the limestone produced here was used for agricultural lime. Limestone is one of the major sources of Illinois' mineral wealth.

GENERALIZED SECTION AT QUARRY EXPOSURE

PLEISTOCENE
5-6 feet loess
20 feet Illinoian till

PENNSYLVANIAN
9 feet gray fossiliferous shale

1 foot limestone coquina 4 inches gray shale 5 inches fossiliferous limestone	This is known as the cap rock and is the best source of fossils

1 foot gray shale
1½ foot dark gray to black shale
10 feet Shoal Creek Limestone
1-2 feet black fissile shale exposed in sump area at north end of quarry.

The best collecting area is on the spoil piles north of the quarry lake. The bedrock is upper Pennsylvanian in age. Fossils which may be found here include:

PELECYPODS
Aviculopina --- clams
Myalina
Pecten --- scallop

BRACHIOPODS
Composita
Productids
Marginifera
Hustedia
Neospirifera
Punctospirifera

GASTROPODS: not abundant

CRINOIDS: numerous fragments

TRILOBITES: rare

END OF FIELD TRIP

PLEISTOCENE GLACIATIONS IN ILLINOIS

Origin of the Glaciers

During the past million years or so, the period of time called the Pleistocene Epoch, most of the northern hemisphere above the 50th parallel has been repeatedly covered by glacial ice. Ice sheets formed in sub-arctic regions four different times and spread outward until they covered the northern parts of Europe and North America. In North America the four glaciations, in order of occurrence from the oldest to the youngest, are called the Nebraskan, Kansan, Illinoian, and Wisconsinan Stages of the Pleistocene Epoch. 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 during periods 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 cooler periods 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 probably enough to lower sea level more than 300 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 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 unstratified (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.

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.

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. Cone-shaped mounds of coarse outwash, called kames, were formed where meltwater plunged through crevasses in the ice or into ponds along the edge of 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 quickly lost speed and almost immediately dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sand and silts were moved across 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 trains may be both extensive and thick deposits. For instance, the long valley train of the Mississippi Valley is locally as much as 200 feet thick.

Loess and Soils

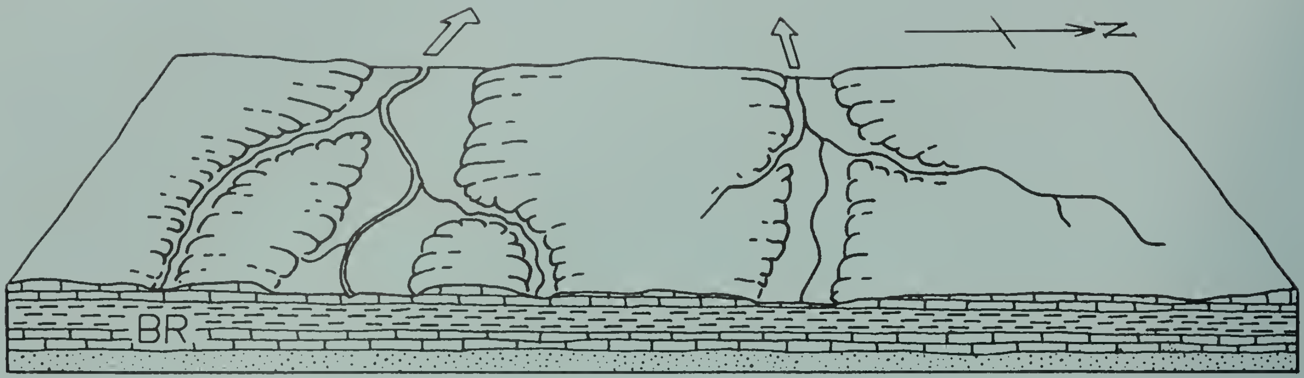
One of the most widespread sediments resulting from glaciation was carried not by ice or water but by wind. Loess is the name given to such deposits of windblown silt and clay. The silt was blown from the valley trains on the floodplains. Most loess deposition occurred in the fall and winter seasons when 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 those that survive serve as keys to the identity of the beds and are evidence of the passage of a long interval of time.

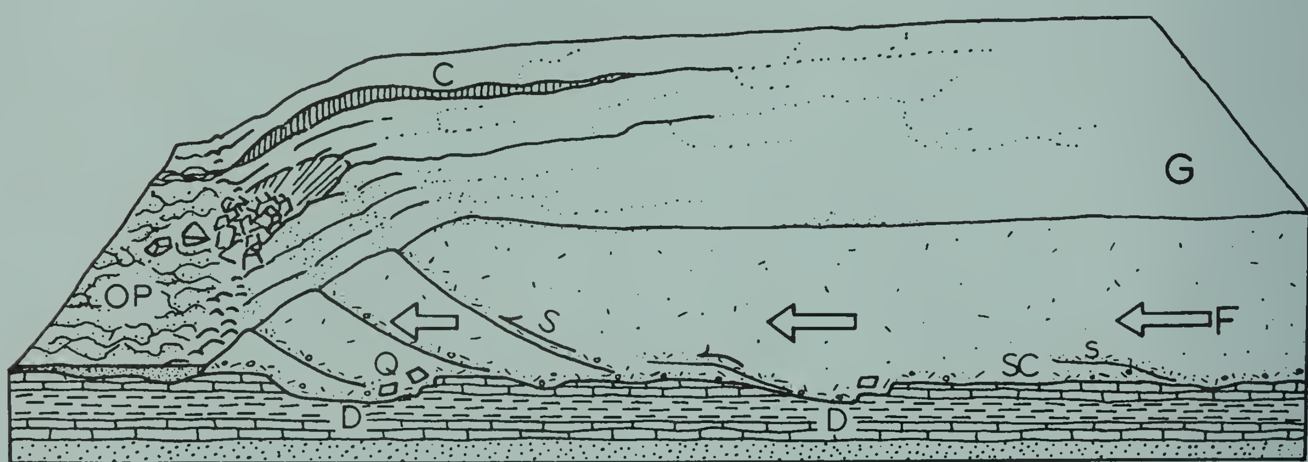
Glaciation in a Small Illinois Region

The following diagrams show how a continental ice sheet might have looked 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.

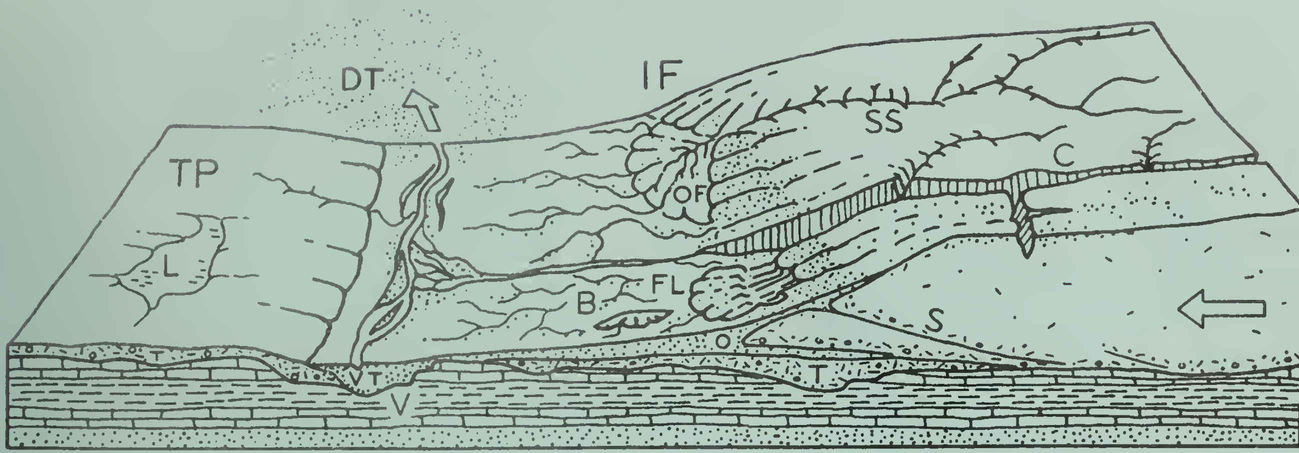
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated--layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



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.



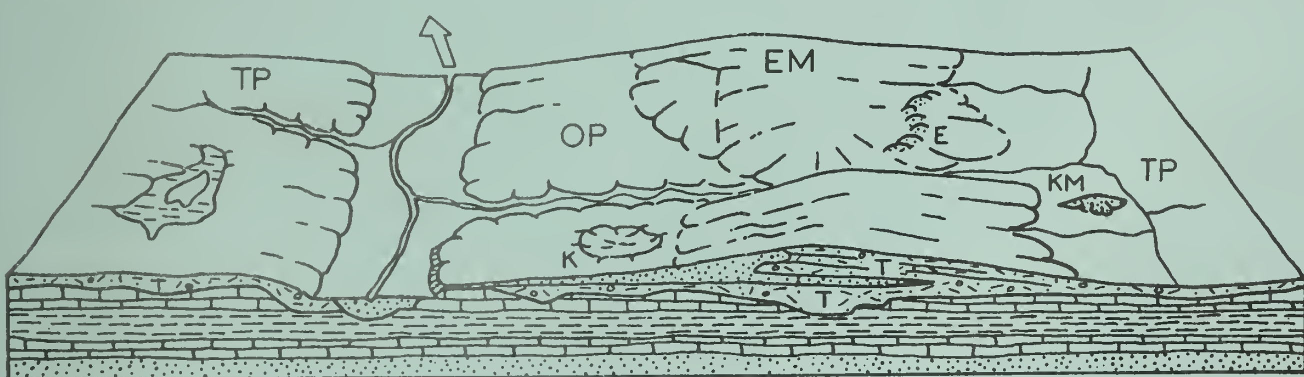
2. The Glacier Advances Southward - As the glacier (G) spreads out from its snowfield, it scours (SC) the soil and rock surface and quarries (Q)--pushes and plucks up--chunks of bedrock. These materials are mixed into the ice and make up the glacier's "load." Where roughnesses in the terrain slow or 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 the 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 , except near its margin. Its ice front advances perhaps as much as a third of a mile per year.



3. <u>The Glacier Deposits an End Moraine</u> - After the glacier advanced across the area, the climate warmed and the ice began to melt as fast as it advanced. 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 was 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 superglacial 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) was left 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) remained a low spot in the terrain. As soon as its ice cover melted, meltwater drained down the valley, cutting it deeper. Later, outwash partly refilled 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.



4. <u>The Region after Glaciation</u> - The climate has warmed even more, the whole ice sheet has melted, and the glaciation has ended. 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.

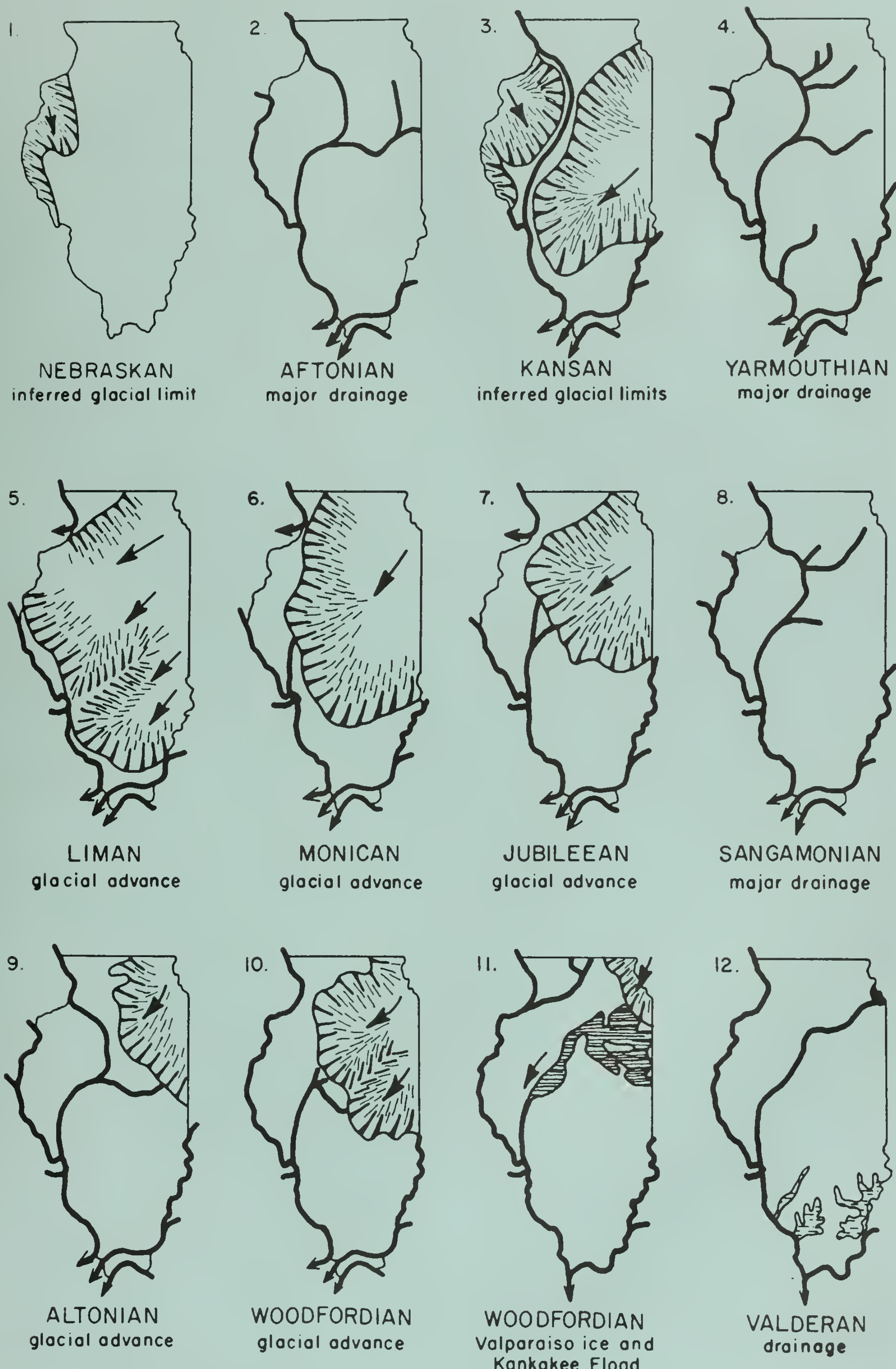
Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left by the ice block's melting has made a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel 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
HOLOCENE	Years Before Present	Soil, youthful profile of weathering, lake and river deposits, dunes, peat	
	7,000		
WISCONSINAN (4th glacial)	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
	22,000		
	Farmdalian	Soil, silt, and peat	Ice withdrawal, weathering, and erosion
	28,000		
	Altonian	Drift, loess	Glaciation in northern Illinois, valley trains along major rivers
	75,000		
SANGAMONIAN (3rd interglacial)		Soil, mature profile of weathering	
	175,000		
ILLINOIAN (3rd glacial)	Jubileean	Drift, loess	Glaciers from northeast at maximum reached Mississippi River and nearly to southern tip of Illinois
	Monican	Drift, loess	
	Liman	Drift, loess	
	300,000		
YARMOUTHIAN (2nd interglacial)		Soil, mature profile of weathering	
	600,000		
KANSAN (2nd glacial)		Drift, loess	Glaciers from northeast and northwest covered much of state
	700,000		
AFTONIAN (1st interglacial)		Soil, mature profile of weathering	
	900,000		
NEBRASKAN (1st glacial)		Drift	Glaciers from northwest invaded western Illinois
	1,200,000 or more		

(Illinois State Geological Survey, 1973)

SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



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

ILLINOIS STATE GEOLOGICAL SURVEY

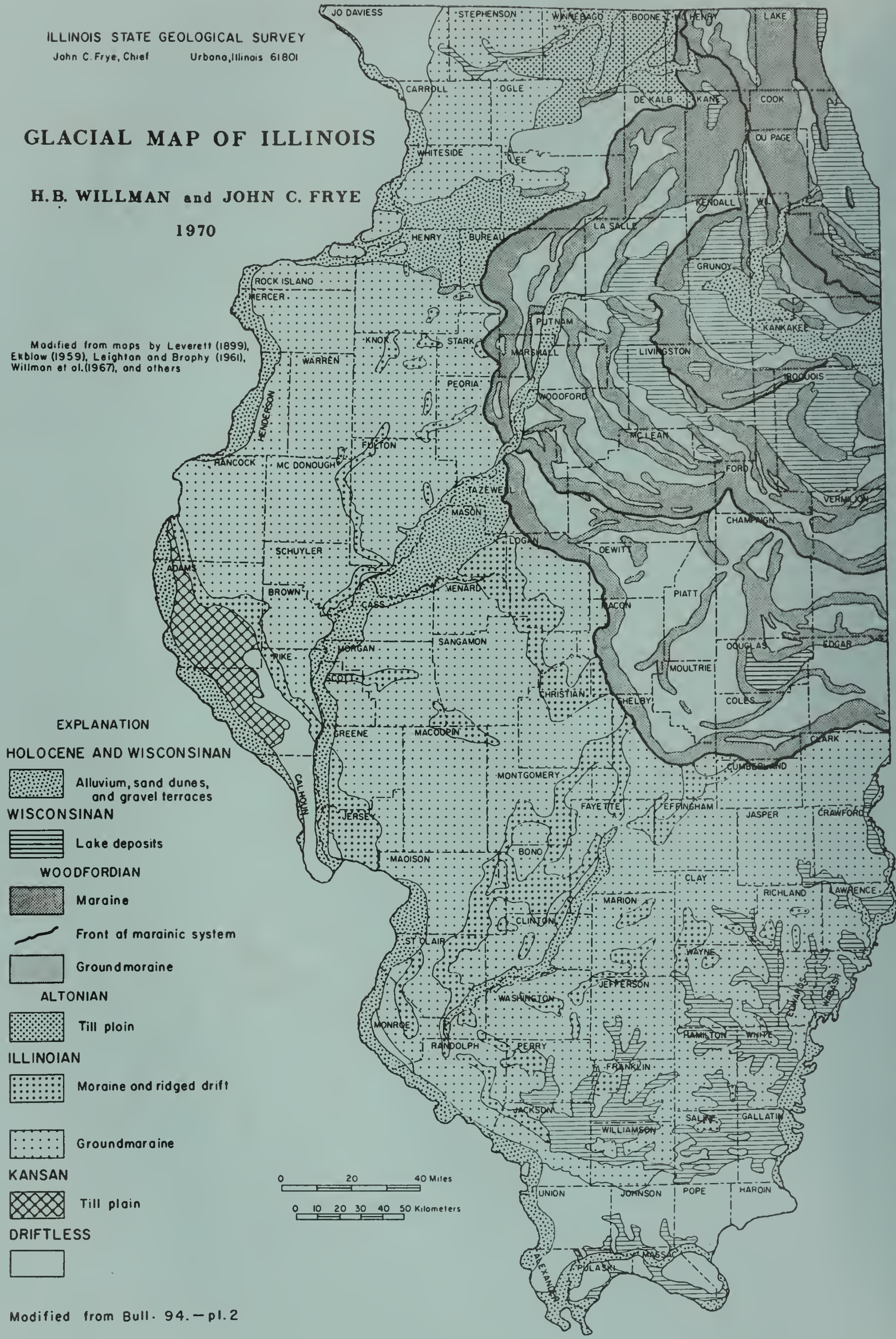
John C. Frye, Chief Urbana, Illinois 61801

GLACIAL MAP OF ILLINOIS

H.B. WILLMAN and JOHN C. FRYE

1970

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



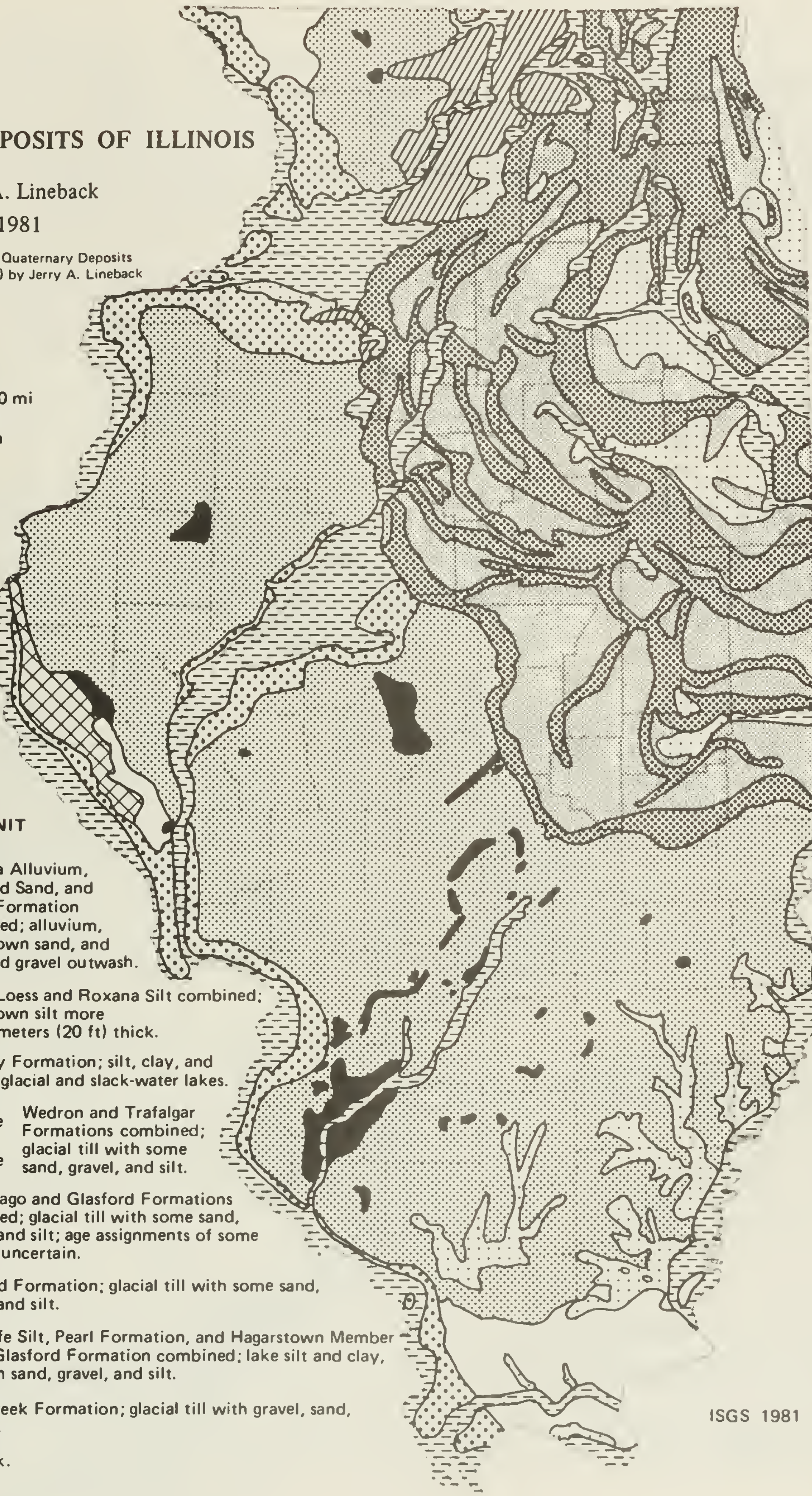
Modified from Bull. 94.—pl.2

QUATERNARY DEPOSITS OF ILLINOIS

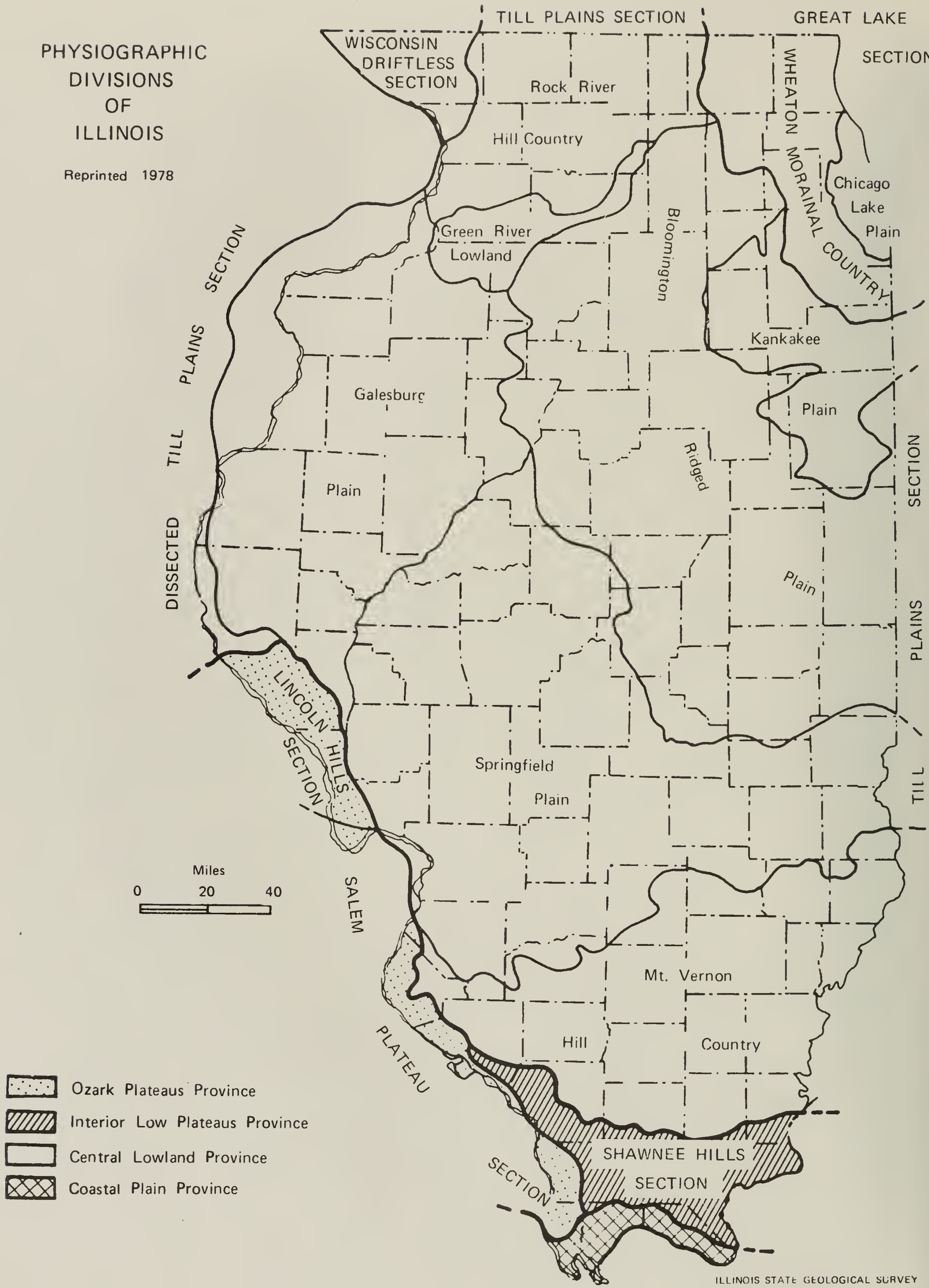
Jerry A. Lineback

1981

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



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


PHYSIOGRAPHIC DIVISIONS OF ILLINOIS
Reprinted 1978
TILL PLAINS SECTION
GREAT LAKE SECTION
WISCONSIN DRIFTLESS SECTION
Rock River
Hill Country
WHEATON MORAINAL COUNTRY
Chicago Lake Plain
Green River Lowland
Bloomington
Kankakee
Plain
Galesburg
Plain
Ridged
Plain
DISSECTED TILL PLAINS SECTION
TILL PLAINS SECTION
LINCOLN HILLS SECTION
Springfield
Plain
SALEM PLATEAU SECTION
Mt. Vernon
Hill
Country
SHAWNEE HILLS SECTION
Miles
0
20
40
Ozark Plateaus Province
Interior Low Plateaus Province
Central Lowland Province
Coastal Plain Province
ILLINOIS STATE GEOLOGICAL SURVEY

DEPOSITIONAL HISTORY OF THE PENNSYLVANIAN ROCKS

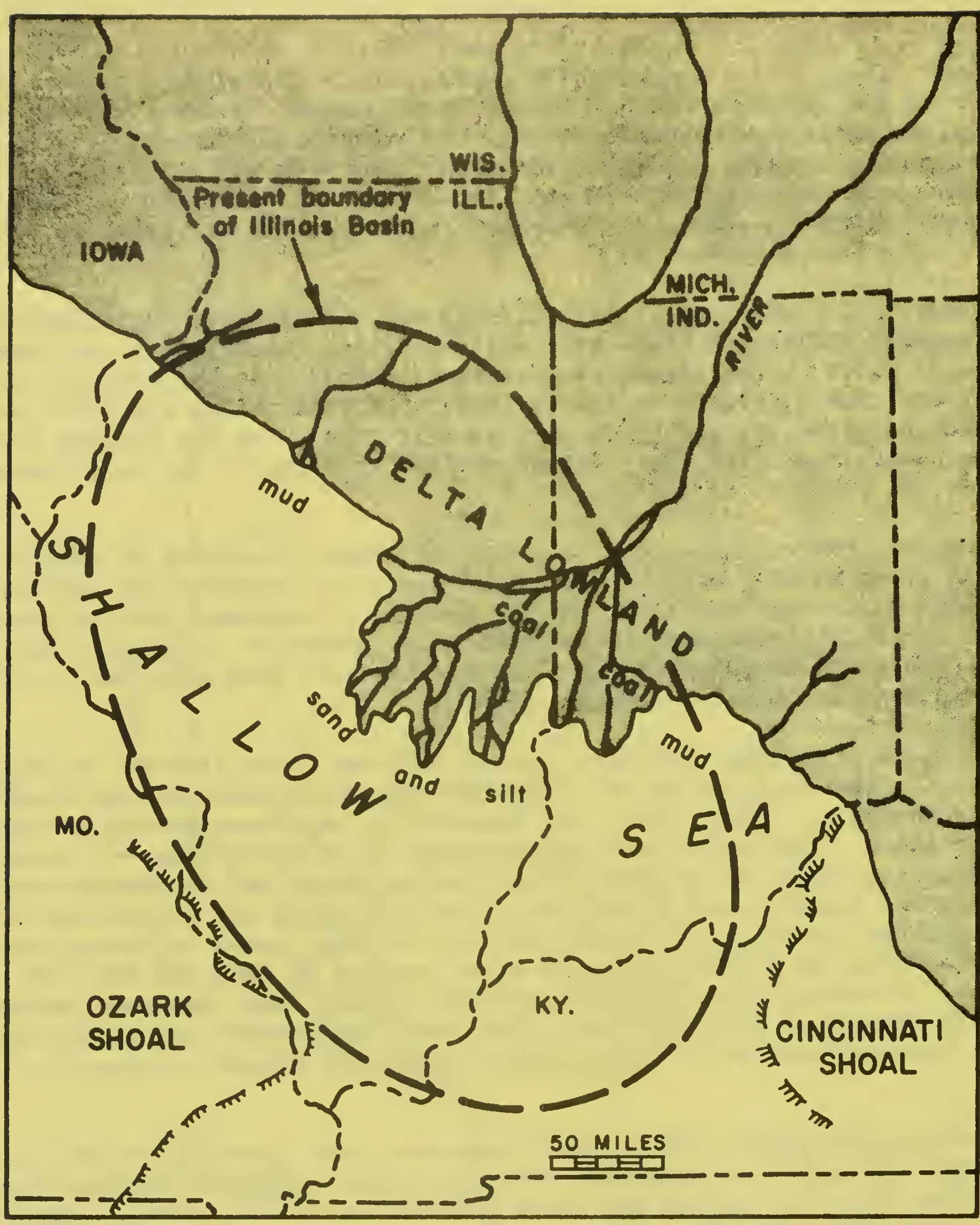
At the close of the Mississippian Period, about 310 million years ago, the Mississippian sea withdrew from the Midcontinent region. A long interval of erosion took place early in Pennsylvanian time and removed hundreds of feet of the pre-Pennsylvanian strata, completely stripping them away and cutting into older rocks over large areas of the Midwest. An ancient river system cut deep channels into the bedrock surface. Erosion was interrupted by the invasion of the Morrowan (early Pennsylvanian) sea.

Depositional conditions in the Illinois Basin during the Pennsylvanian Period were somewhat similar to those that existed during Chesterian (late Mississippian) time. A river system flowed southwestward across a swampy lowland, carrying mud and sand from highlands in the northeast. A great delta was built out into the shallow sea (see paleogeography map on next page). As the lowland stood only a few feet above sea level, only slight changes in relative sea level caused great shifts in the position of the shoreline.

Throughout Pennsylvanian time the Illinois Basin continued to subside while the delta front shifted owing to worldwide sea level changes, intermittent subsidence of the basin, and variations in the amounts of sediment carried seaward from the land. These alternations between marine and nonmarine conditions were more frequent than those during pre-Pennsylvanian time, and they produced striking lithologic variations in the Pennsylvanian rocks.

Conditions at various places on the shallow sea floor favored the deposition of sandstone, limestone, or shale. Sandstone was deposited near the mouths of distributary channels. These sands were reworked by waves and spread as thin sheets near the shore. The shales were 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. Most sediments now recognized as limestones, which are formed from the accumulation of limey parts of plants and animals, were laid down in areas where only minor amounts of sand and mud were being deposited. Therefore, the areas of sandstone, shale, and limestone 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 sandstones, shales, and limestones were deposited on the deltaic lowland bordering the sea. The nonmarine sandstones were deposited in 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 many of the underlying rock units. The shales were deposited mainly on floodplains. Freshwater limestones and some shales were deposited locally in fresh-water lakes and swamps. The coals were formed by the accumulation of plant material, usually where it grew, beneath the quiet waters of extensive swamps that prevailed for long intervals on the emergent delta lowland. Lush forest vegetation, which thrived in the warm, moist Pennsylvanian climate, covered the region. The origin of the underclays beneath the coals is not precisely known, but they were probably deposited in the swamps as slackwater muds before the formation of the coals. Many underclays contain plant roots and rootlets that appear to be in their original places. The formation of coal marked the end of the nonmarine portion of the depositional cycle, for resubmergence of the borderlands by the sea interrupted nonmarine deposition, and marine sediments were then laid down over the coal.



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

Pennsylvanian Cyclothems

Because of the extremely varied environmental conditions under which they formed, the Pennsylvanian strata exhibit extraordinary variations in thickness and composition, both laterally and vertically. 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 limestones, however, display remarkable lateral continuity for such thin units (usually only a few feet thick). Coal seams have been traced in mines, outcrops, and subsurface drill records over areas comprising several states.

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 front of the delta lowland. Each series of alternations, called a cyclothem, consists of several marine and non-marine 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 10 sedimentary units. The chart on the next page shows the arrangement. Approximately 50 cyclothems have been described in the Illinois Basin, but only a few contain all 10 units. 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 portion (the lower 5 units) of each cyclothem is nonmarine and was deposited on the coastal lowlands from which the sea had withdrawn. However, some of the sandstones are entirely or partly marine. The units above the coal are marine sediments and were deposited when the sea advanced over the delta lowland.

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 deltaic 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 Pennsylvanian climate. Today's common deciduous trees were not present, and the flowering plants 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. Many of the Pennsylvanian plants, such as the seed ferns, eventually became extinct.

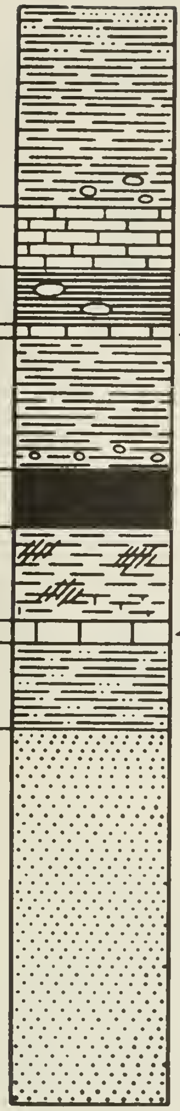
Plant debris from the rapidly growing swamp forests—leaves, twigs, branches, and logs—accumulated as thick mats of peat on the floors of the swamps. Normally, vegetable matter rapidly decays by oxidation, forming water, nitrogen, and carbon dioxide. However, the cover of swamp water, which was probably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

The periodic invasions of the Pennsylvanian sea across the coastal swamps killed the Pennsylvanian forests and initiated marine conditions of deposition. The peat deposits were buried by marine sediments. Following burial, the peat deposits were gradually transformed into coal by slow chemical and physical 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 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 shales that occur above many coals is uncertain. The black shales probably are deposits formed under restricted marine (lagoonal) conditions during the initial part of the invasion cycle, when the region was partially closed off from the open sea. In any case, they were deposited in quiet-water areas where very fine, iron-rich muds and finely divided plant debris were washed in from the land. The high organic content of the black shales is also in part due to the carbonaceous remains of plants and animals that lived in the lagoons. Most of the fossils represent planktonic (floating) and nektonic (swimming) forms—not benthonic (bottom dwelling) forms. The depauperate (dwarf) fossil forms sometimes found in black shales formerly were thought to have been forms that were stunted by toxic conditions in the sulfide-rich, oxygen-deficient waters of the lagoons. However, study has shown that the "depauperate" fauna consists mostly of normal-size individuals of species that never grew any larger.



10 Shale, gray, sandy at top; contains marine fossils and ironstone concretions, especially in lower part.

9 Limestone; contains marine fossils.

8 Shale, black, hard, laminated; contains large spheroidal concretions and marine fossils.

7 Limestone; contains marine fossils.

6 Shale, gray; pyritic nodules and ironstone concretions common at base; plant fossils locally common at base; marine fossils rare.

5 Coal; locally contains clay or shale partings.

4 Underclay, mostly medium to light gray but dark gray at top; upper part noncalcareous, lower part calcareous.

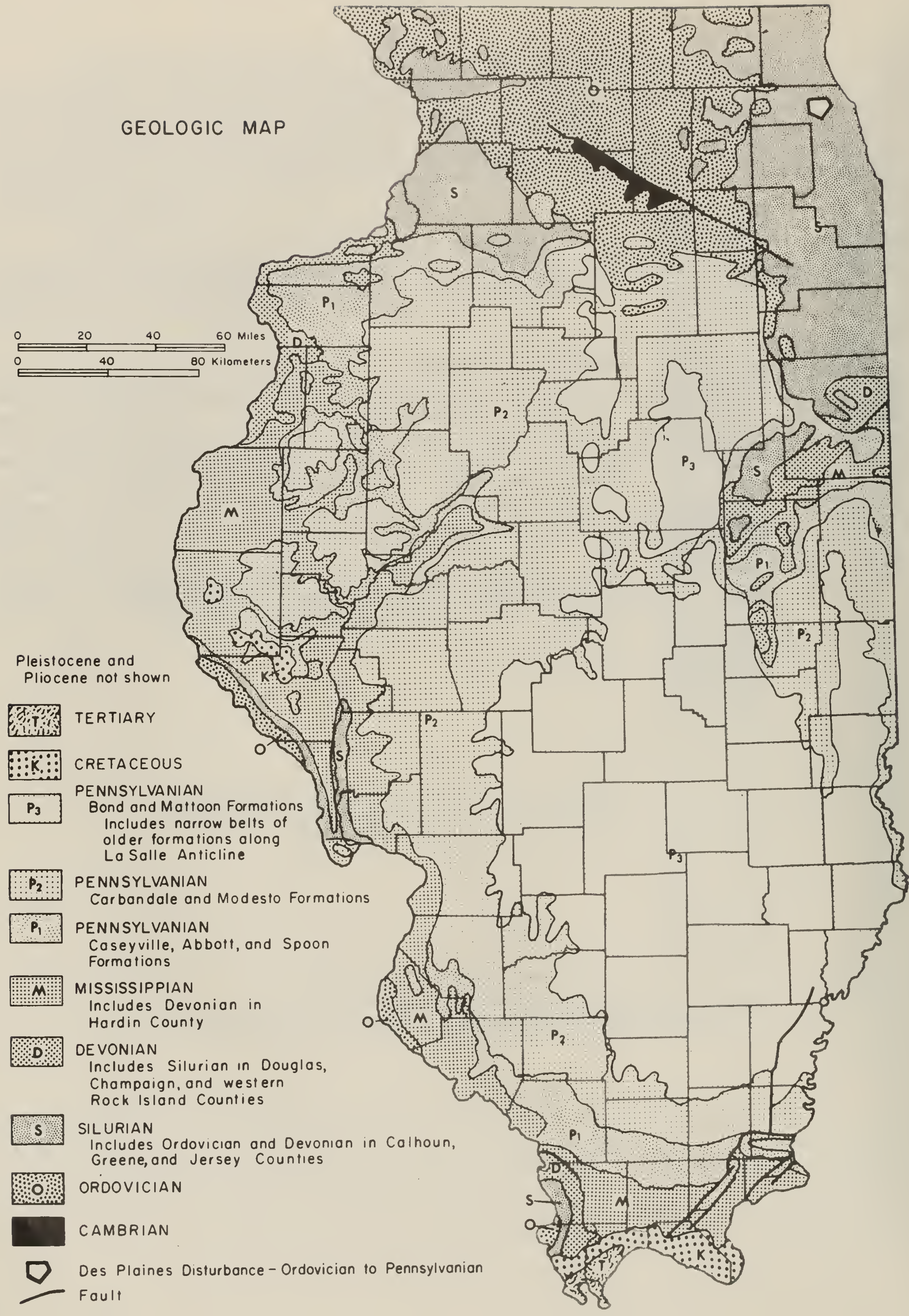
3 Limestone, argillaceous; occurs in nodules or discontinuous beds; usually nonfossiliferous.

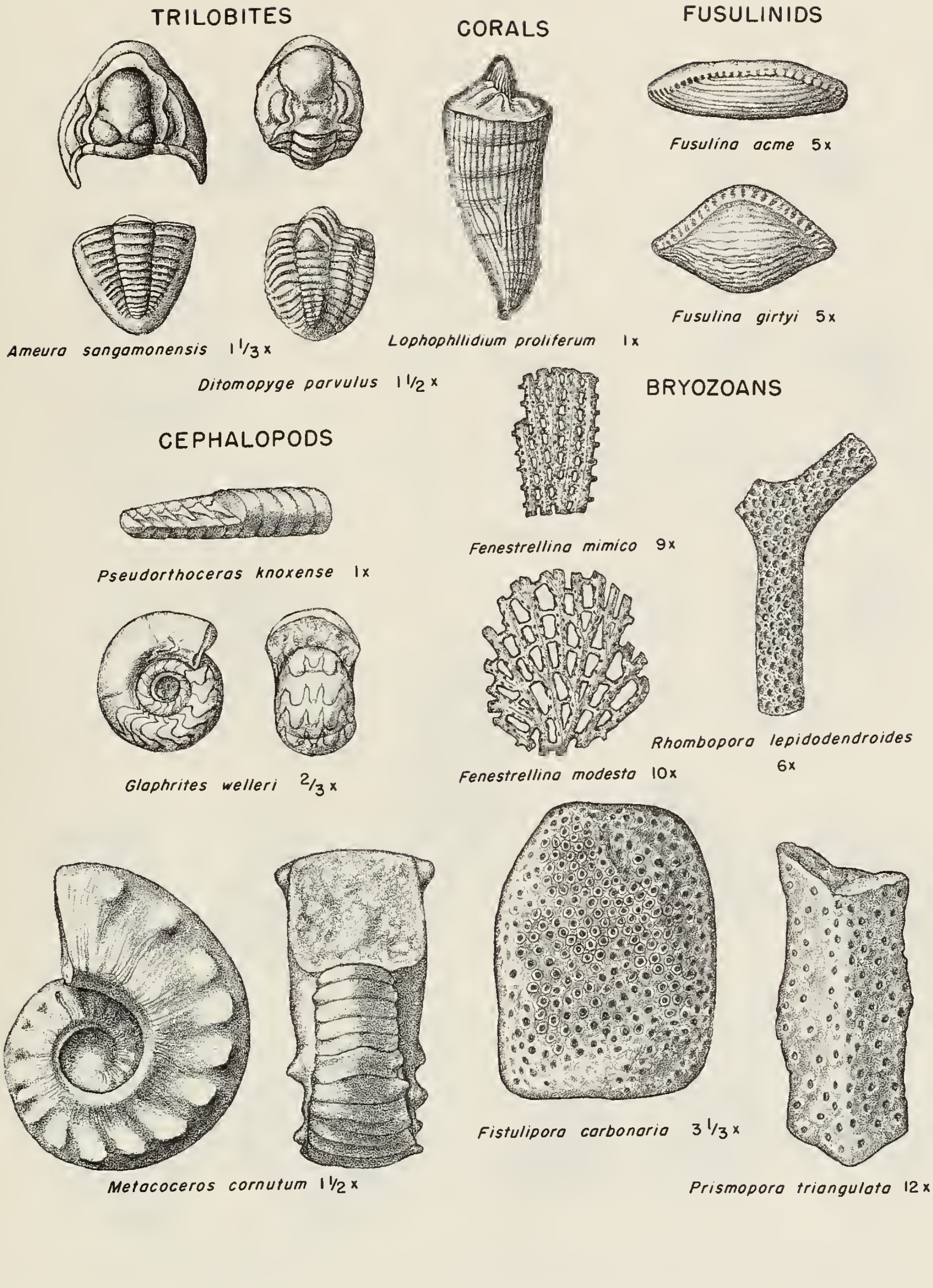
2 Shale, gray, sandy.

1 Sandstone, fine grained, micaceous, and siltstone, argillaceous; varies from massive to thin bedded; usually has an uneven lower surface.

AN IDEALLY COMPLETE CYCLOTHEM

(Reprinted from Fig. 42, Bulletin No. 66, Geology and Mineral Resources of the Marseilles, Ottawa, and Streator Quadrangles, by H. B. Willman and J. Norman Payne)


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


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
Fenestrellina mimica 9x
Pseudorthoceras knoxense 1x
Rhombopora lepidodendroides 6x
Fenestrellina modesta 10x
Glaphrites welleri 2/3 x
Fistulipora carbonaria 3 1/3 x
Metacoceros cornutum 1 1/2 x
Prismopora triangulata 12x

PELECYPODS

Nucula (Nuculopsis) girtyi 1x

Edmonia ovata 2x

Astartella concentrica 1x

Dunbarella knighti 1½x

Cardiomorpha missouriensis
"Type A" 1x

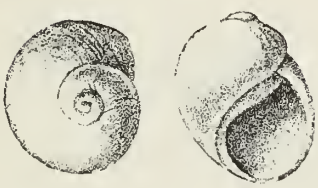
Cardiomorpha missouriensis
"Type B" 1½x

GASTROPODS

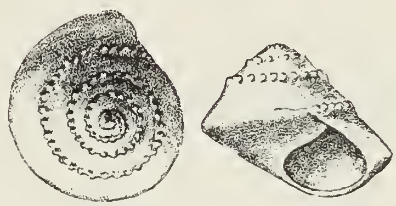
Euphemites carbonarius 1½x

Donaldina robusta 8x

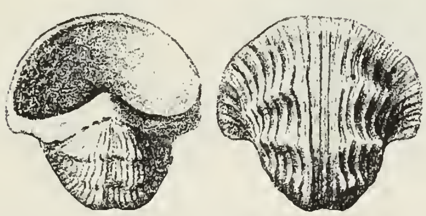
Trepospira illinoisensis 1½x



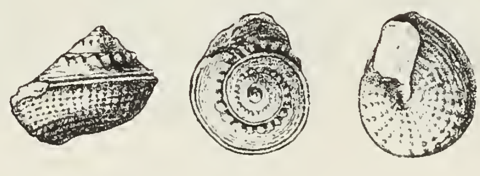
Naticopsis (Jedria) ventricosa 1½x



Trepospira sphaerulata 1x



Knightites montfortianus 2x



Glabrocingulum (Glabrocingulum) grayvillense 3x

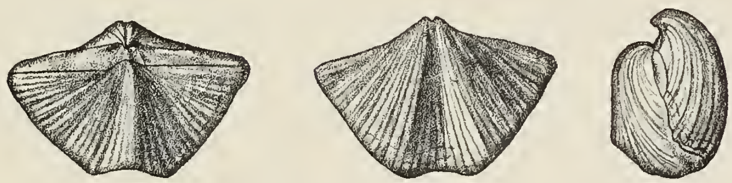
BRACHIOPODS

Juresania nebrascensis 2/3 x

Wellerella tetrahedra 1 1/2 x

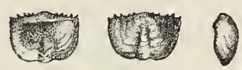
Derbya crassa 1 x

Composita argentia 1 x



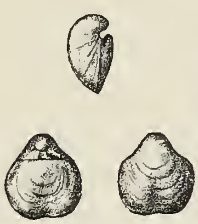
Neospirifer cameratus 1 x

Chonetes granulifer 1 1/2 x

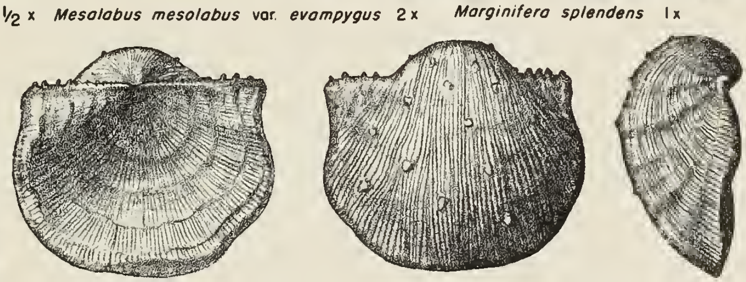


Mesolobus mesolobus var. *evampygus* 2 x

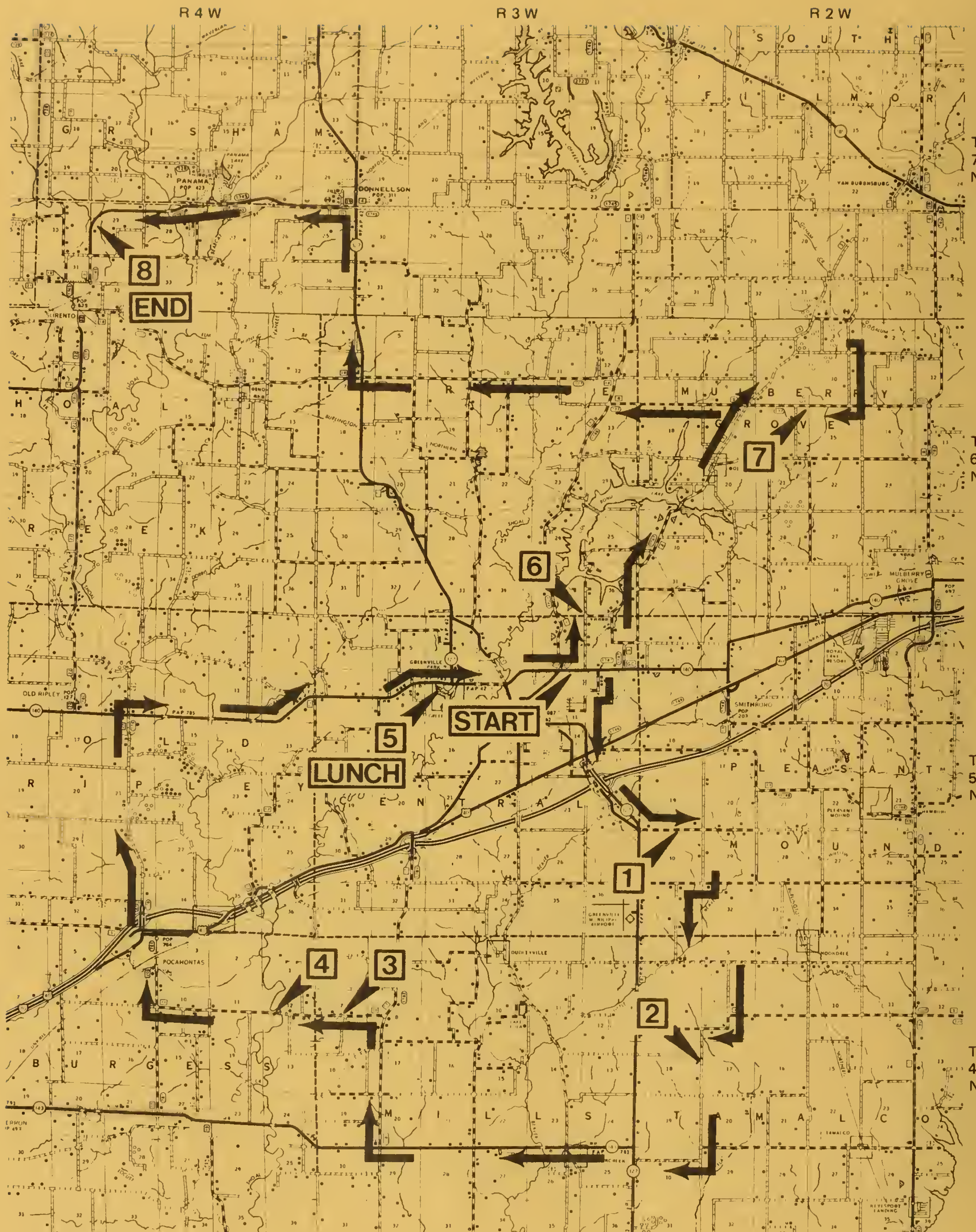
Marginifera splendens 1 x



Crurithyris planoconvexa 2 x



Linoproductus "cora" 1 x


R4W
R3W
R2W
T7N
T6N
T5N
T4N
PANAMA
DONNELLSON
VAN BURENSBURG
8
END
6
7
MULBERRY GROVE
OLD RIPLEY
GREENVILLE PARK
START
5
LUNCH
SMITHBORO
1
POCAHONTAS
4
3
2