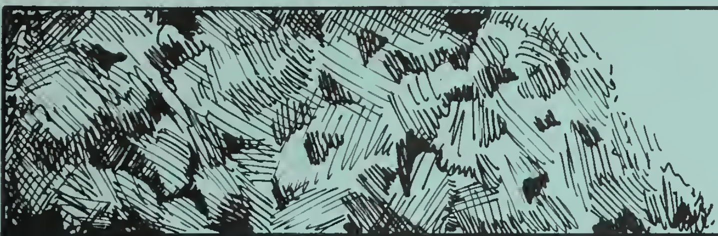
Field Trip Guide Leaflet 1981 B
May 16, 1981
Illinois Institute of Natural Resources
State Geological Survey Division
Champaign, IL 61820

David L. Reinertsen



A guide to the geology of the Danville area

COVER: Horse-drawn scraper of the type used near Grape Creek in 1866 to remove overburden from coal—the first strip-mining in this country. (Based on a cover illustration for "History of Development of Strip Mining Machines" by J. A. Hollingsworth, Jr.) *Sketched by Craig Ronto.*

Printed by authority of the State of Illinois/1981/300

A guide to the geology of the Danville area

David L. Reinertsen

GEOLOGICAL SCIENCE FIELD TRIPS are free tours conducted by the Educational Extension Section of the Illinois State Geological Survey to acquaint the public with the geology and mineral resources of Illinois. Each is an all-day excursion through one or several counties in Illinois; frequent stops are made for explorations, explanations, and collection of rocks and fossils. People of all ages and interests are welcome. The trips are especially helpful to teachers in preparing earth science units. Grade school students are welcome, but each must be accompanied by a parent. High school science classes should be supervised by at least one adult for each ten students. A list of previous field trip guide leaflets is available for planning class tours and private outings.

The Danville area is located along the eastern side of central Illinois. Except where streams have cut into bedrock, relatively thick Pleistocene glacial deposits have buried the bedrock surface. Although earlier continental glacial deposits occur in this area, Wisconsinan glaciers left a series of low, broad moraines across the surface of this part of our state. This region is part of the Bloomington Ridged Plain. Sand and gravel from the Pleistocene deposits are important sources of construction materials here.

Bedrock in this area consists of shale, limestone, coal, siltstone, sandstone, and shale deposited in shallow seas and swamps some 285 million years ago during the Pennsylvanian Period. Coal and shale have been extensively mined for energy sources and construction materials, respectively.

the geologic framework

During the Pleistocene Epoch, commonly called the "Great Ice Age," the Danville area in eastern central Illinois was covered several times by large continental glaciers. The accumulations of these glaciers, deposited during the Kansan, Illinoian, and Wisconsinan Stages (see attached "Pleistocene Glaciations in Illinois"), range from a few feet to more than 100 feet thick over the bedrock surface in the field trip area. No glacial deposits in this area have been identified as Nebraskan in age, and it is probable that the Nebraskan glacier did not enter eastern Illinois.

Physiographically, the Danville area lies within the Bloomington Ridged Plain of the Till Plains Section (see attached map, "Physiographic Divisions of Illinois"). This is a region of gently rolling terrain crossed by many glacial end moraines (see attached map, "Woodfordian Moraines"). This topography was produced by the Woodfordian glacier (mid-Wisconsinan) about 15 thousand years ago and has been only slightly modified by post-glacial erosion and the action of modern streams. The relatively fresh glacial topography, lack of dissection, and poor drainage of the region reflect the recency of its glaciation.

The field trip crosses an area mantled with glacial deposits from the Newtown, Urbana, and Ridge Farm glaciers, which left end moraines that are low hummocky ridges generally trending east to west. The areas between the ridges generally are flat except where cut by stream valleys. Streams draining the area flow southeastward to the Wabash River. The principal stream, Vermilion River, came into existence when the Chatsworth glacier covered the area a little more than 20 miles to the north less than 15 thousand years ago.

Geologically, the Danville area is underlain by about 6,000 feet of sedimentary bedrock strata consisting principally of shale, sandstone, limestone, and coal, which occur beneath the glacial drift. These rocks were laid down layer by layer in and near the ancient seas that periodically covered the Midwest during the Paleozoic Era, between about 550 and 280 million years ago. The rocks immediately beneath the glacial drift belong to the Pennsylvanian System, which contains valuable coal seams (figs. 1 and 2). From 300 to 400 feet of Pennsylvanian strata underlie the field trip area and include two principal coal seams of minable thickness—the Danville (No. 7) Coal and the Herrin (No. 6) Coal Members—both of which have been extensively mined here. Only about 70 to 80 feet of these strata are exposed in this vicinity. Older bedrock strata are known only from deep drill holes. Cambrian strata rest upon an irregular basement of Precambrian igneous and metamorphic rocks more than one billion years old (fig. 3).

STRUCTURE OF THE PALEOZOIC ROCKS

Structurally, the Danville area is situated on the northeastern margin of the Illinois Basin, an oval-shaped area within which the Paleozoic strata are bent gently downward like the bowl of a spoon (fig. 4 and attached map, "Major Geologic Structures of Illinois"). Beginning in late Cambrian time, about 500 million years ago, the Illinois Basin area began to slowly sink, and the subsidence continued intermittently until the end of the Pennsylvanian Period, some 280 million years ago. Paleozoic strata thicken toward the deep part of the basin in extreme southeastern Illinois, where they are more than 17,000 feet thick.

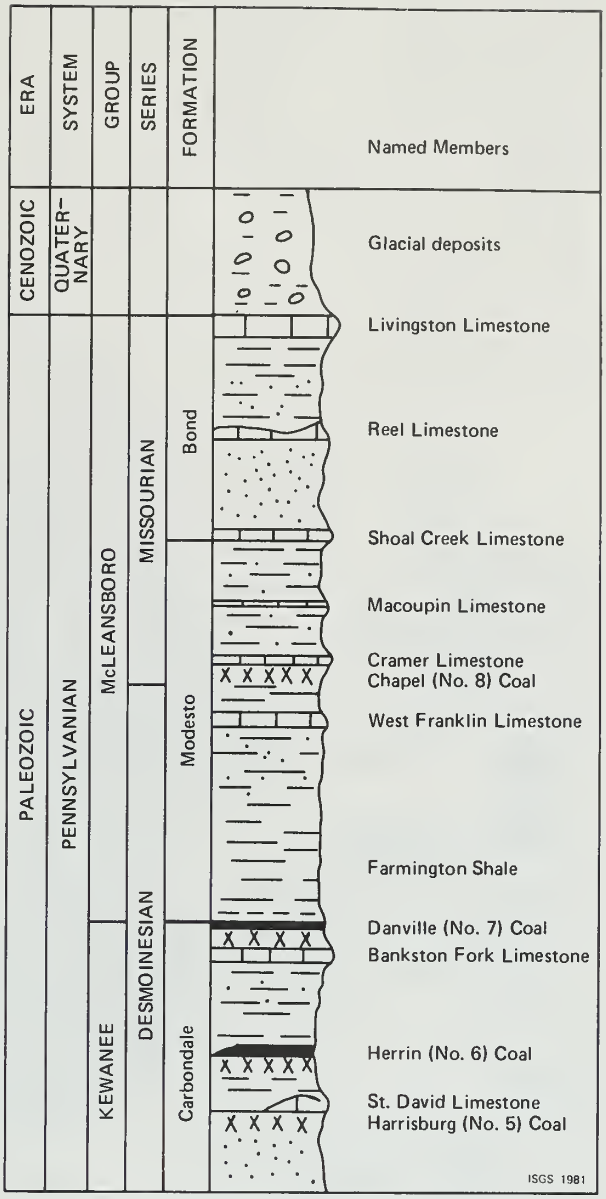


Figure 1. Pennsylvanian column, Vermilion County, Illinois. (Modified after information from R. J. Jacobsen.)

The bedrock strata in the Danville area form a broad, gentle depression, or downwarp, known as the Marshall-Sidell Syncline (fig. 2 and attached structures map). The strata on the east flank of the syncline in east-central Indiana rise onto a broad uplift known as the Cincinnati Arch. On the west, the Marshall-Sidell Syncline is bordered by an upwarp known as the La Salle Anticlinal Belt, which brings strata as old as Silurian to the bedrock surface in western Champaign County (see attached "Geologic Map of Illinois"). The La Salle Anticlinal Belt is not a simple fold but consists of a zone up to 25 miles wide in which strata are deformed into several anticlines and synclines. The Marshall-Sidell Syncline can be traced southward from the southern boundary of Iroquois County into Crawford County, where it merges with the La Salle Anticlinal Belt. The syncline plunges gently southward along its axis as far as Clark County and then rises near its southern extremity.

ECONOMIC GEOLOGY

The Survey's annual report of mineral production in Illinois in 1978, the last date for which complete statistics are currently available, summarized

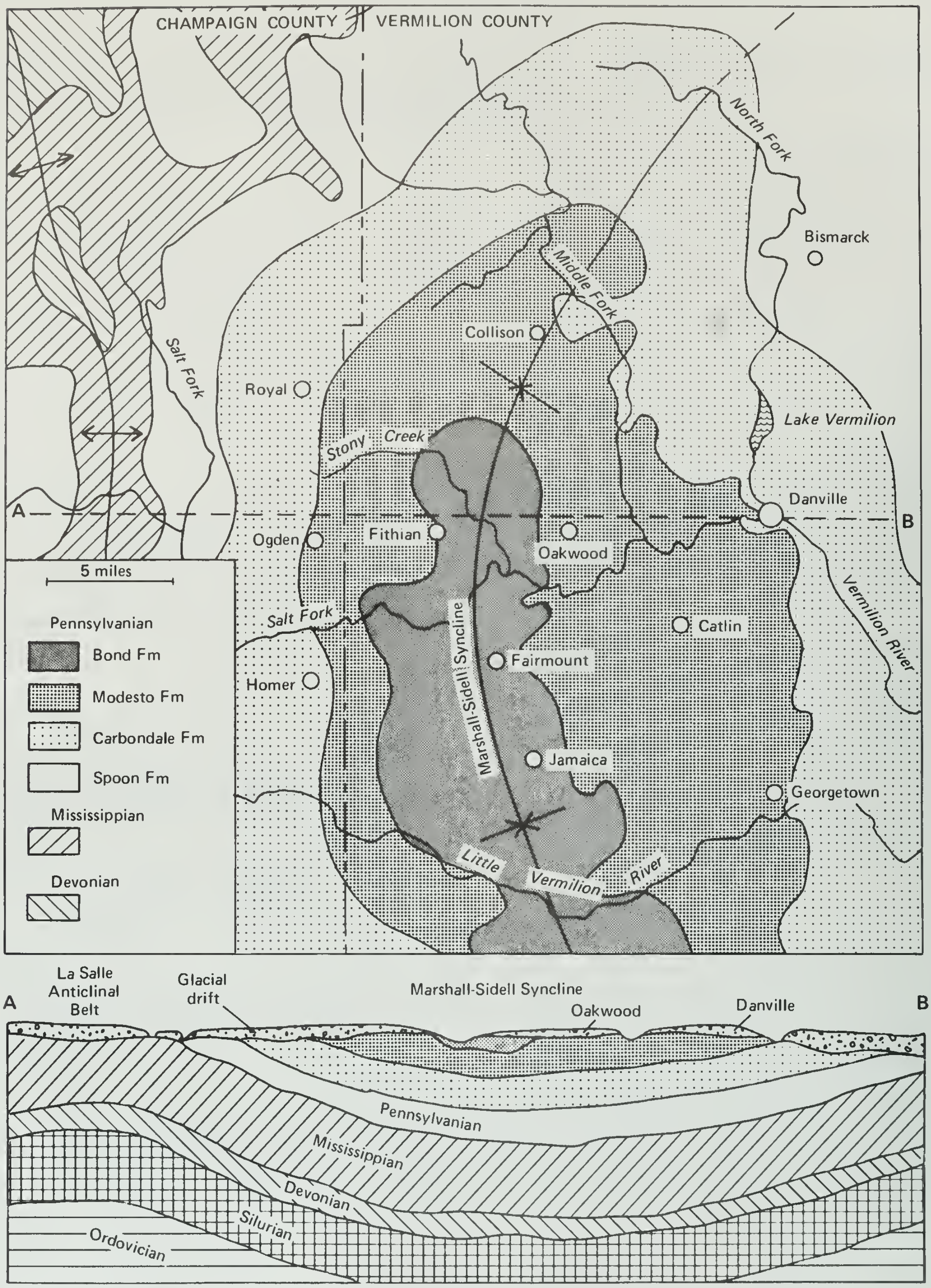


Figure 2. Generalized geologic map of the bedrock strata below the glacial drift in the Oakwood area. The cross section shows the configuration of the bedrock strata in the Marshall-Sidell Syncline. The edge of the La Salle Anticlinal Belt rising toward the west in Champaign County is shown on the left. The vertical scale of the cross section is greatly exaggerated.

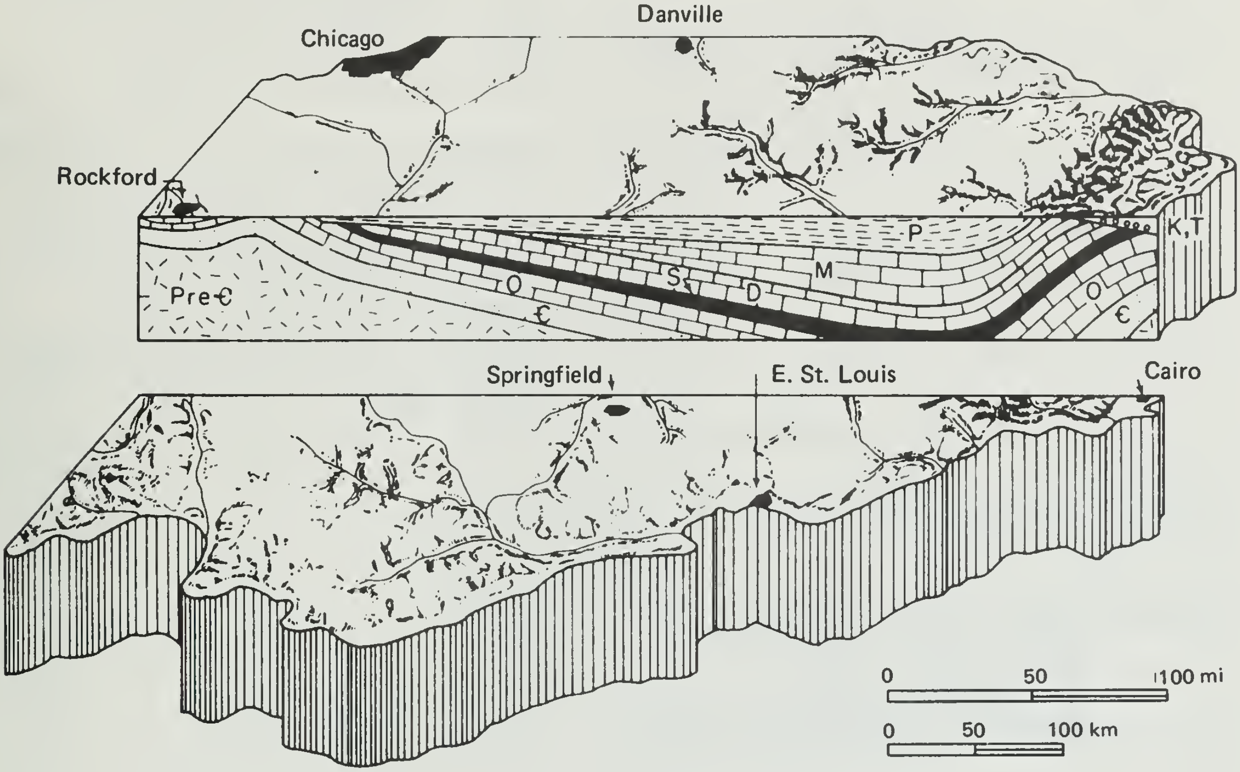


Figure 3. North-south cross section through Illinois showing the Paleozoic strata in the Illinois Basin.

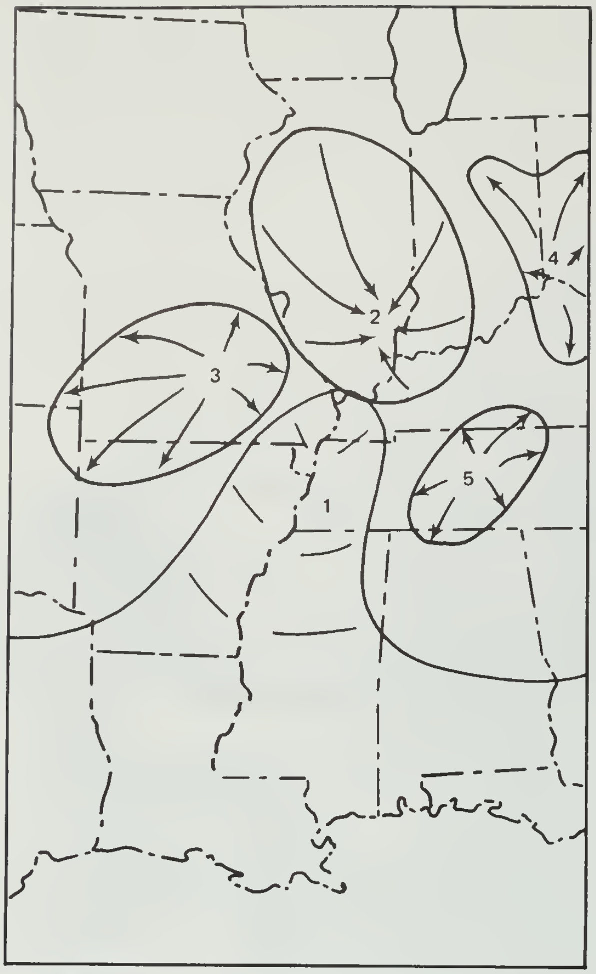


Figure 4. Index map showing the location of the Mississippi Embayment and adjacent major structures: (1) Mississippi Embayment, (2) Illinois Basin, (3) Ozark Dome, (4) Cincinnati Arch, and (5) Nashville Dome.

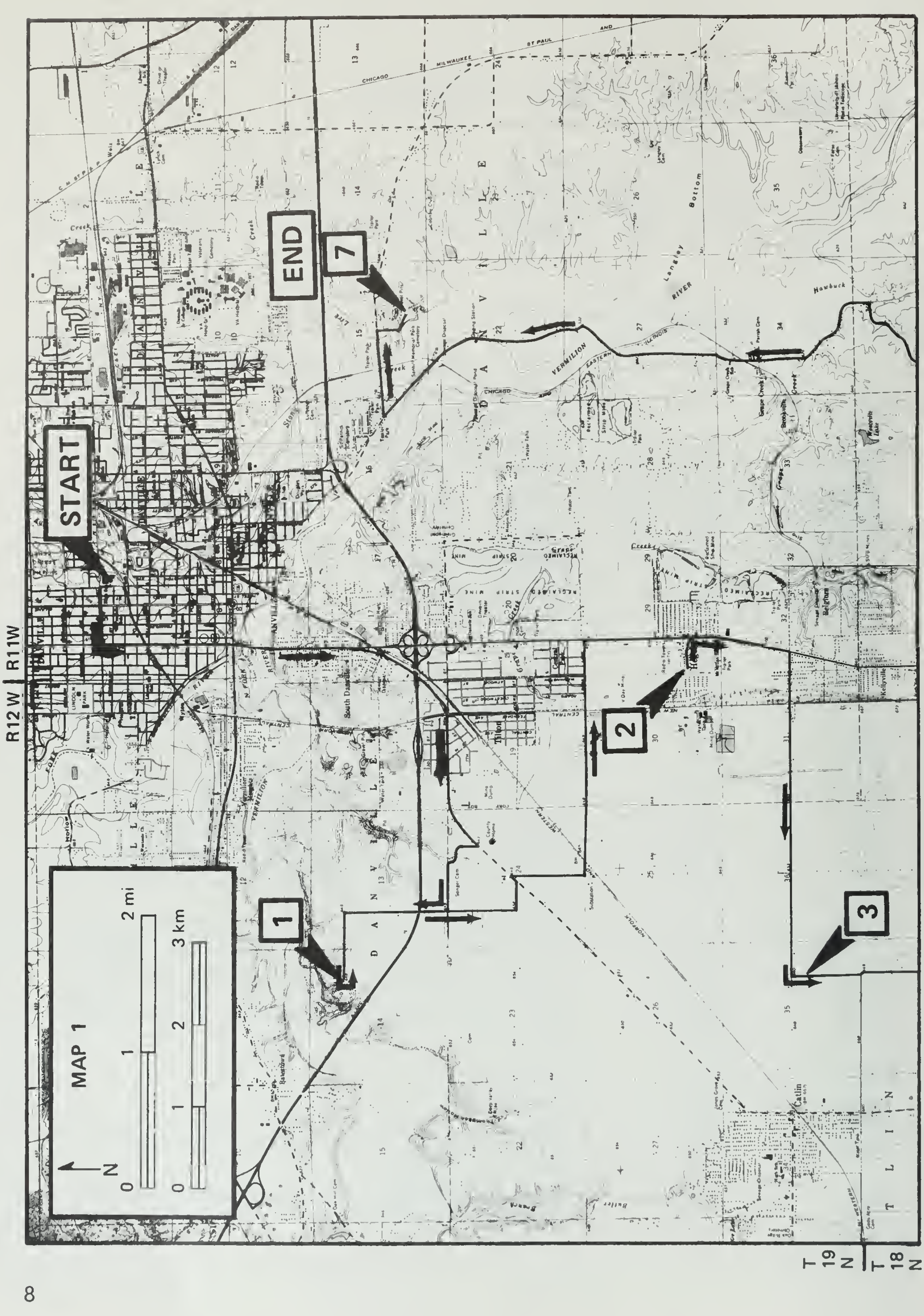
the output and value of minerals produced, minerals processed in Illinois, and mineral products manufactured but not necessarily mined in Illinois, which all totaled about $3,170,700,000. The total value of minerals mined was about $1,637,000,000; the mineral fuels—coal, crude oil, and natural gas—constitute nearly 81 percent of the total. Coal, crushed and broken stone, and sand and gravel (all produced in Vermilion County) had a total value of approximately $1,285,571,735 for the state in 1978.

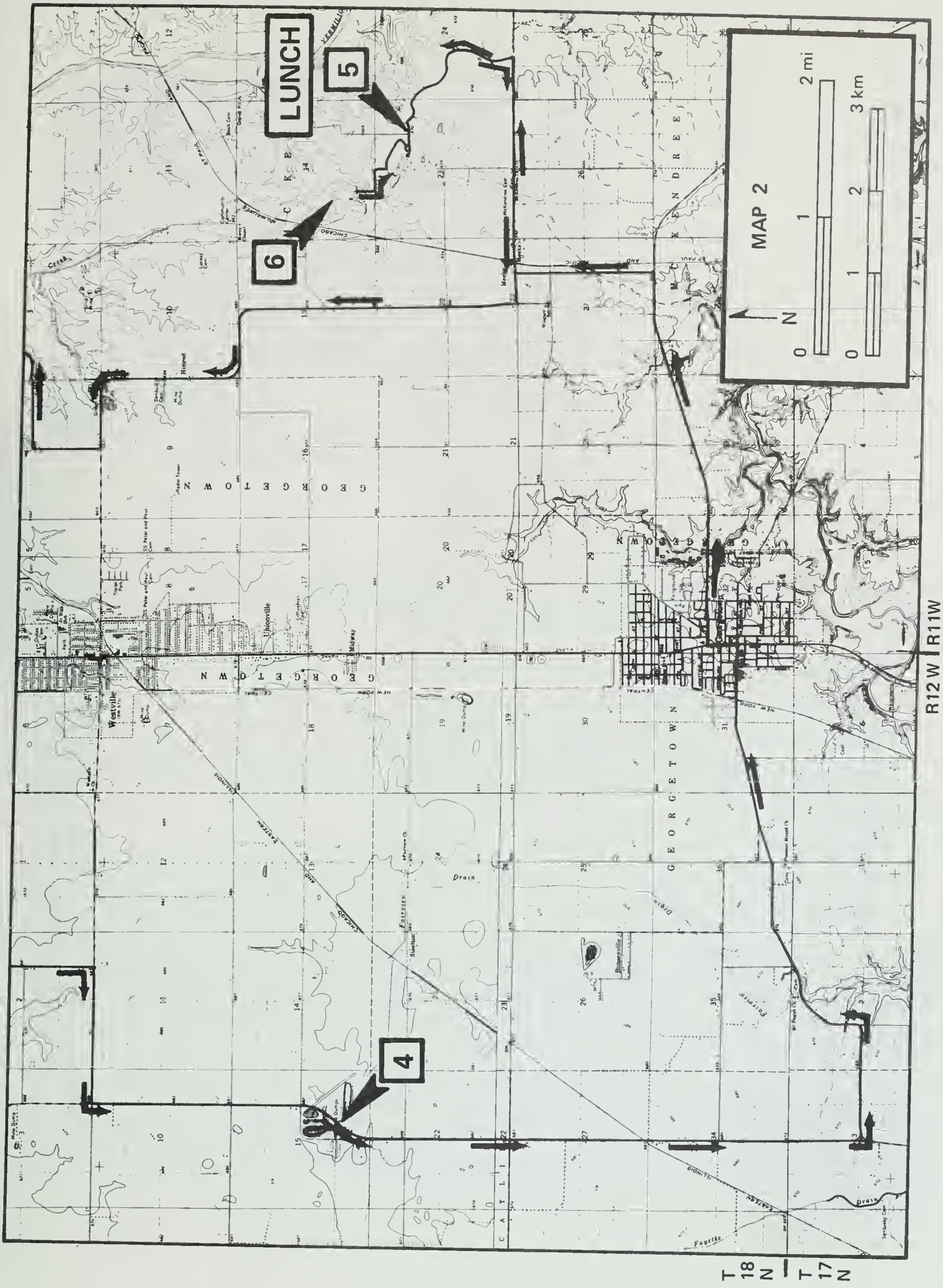
One company produced coal, 4 quarries produced stone products, and 4 companies produced sand and gravel in Vermilion County, which ranked 49th among the 98 mineral-producing counties during 1978. Actual production figures have been withheld to avoid disclosing individual company data.

guide to the route

The field trip begins in the faculty parking lot at Danville High School, southeast corner of Jackson and Fairchild Streets (NE 1/4 NE 1/4 NW 1/4 SE 1/4 Sec. 5, T. 19 N., R. 11 W., 2nd P.M., Vermilion County; Danville NW 7.5-minute Quadrangle).

Miles to next point	Miles from starting point	
0.0	0.0	Leave parking lot and TURN RIGHT (north) on Jackson Street (1-way only). MOVE TO LEFT LANE as soon as possible.
0.1	0.1	CAUTION—STOPLIGHT. TURN LEFT (west) on Fairchild Street.
0.05	0.15	CAUTION—STOPLIGHT. Continue ahead (west).
0.05	0.2	CAUTION—STOPLIGHT. Continue ahead (west) on Illinois Route 1.
0.3	0.5	CAUTION—STOPLIGHT. TURN LEFT (south) on IL 1 (North Gilbert Street).
0.3	0.8	CAUTION—Conrail (CR) crossing.
0.05	0.85	CAUTION—STOPLIGHT. Do not stop on railroad crossing for red traffic light—crossing arm!
0.35	1.2	CAUTION—STOPLIGHT. Continue ahead (south).
0.05	1.25	Vermilion County Museum to right. Continue ahead (south).
0.05	1.3	CAUTION—STOPLIGHT. Continue ahead (south).
0.15	1.45	CAUTION—STOPLIGHT. Intersection with U.S. 150. CONTINUE AHEAD (south) on IL 1.
0.05	1.5	CAUTION—STOPLIGHT. Continue ahead (south) and cross Memorial Bridge over Vermilion River.
0.65	2.15	CAUTION—STOPLIGHT. Continue ahead (south).
0.2	2.35	BEAR RIGHT (southwest) toward Tilton. Leave IL 1.
0.2	2.55	CAUTION—Tilton village limits.
0.25	2.8	Cross I-74.
0.75	3.55	CAUTION—STOPLIGHT. Continue ahead (west) on West 5th Street.
0.1	3.65	CAUTION—UNGUARDED Norfolk and Western (NW) Railroad crossing.


MAP 1
N
0 1 2 mi
0 1 2 3 km
START
END
1
2
3
7
R12W
R11W
T19N
T18N
VERMILION
RIVER
Hawbuck
Langley
Kellyville
Catlin
Tilton
South Danville


MAP 2
0 1 2 mi
0 1 2 3 km
N
LUNCH
4
5
6
Westville
Georgetown
Unionville
Midway
Sidell
Bunsenville
GEORGETOWN
CATLIN
R12 W
R11W
T 18 N
T 17 N

0.25	3.9	Leave Tilton.
0.2	4.1	Prepare to turn right.
0.1	4.2	TURN HARD RIGHT (north) on gravel road toward Songer Cemetery. This is just beyond the VOTEC School and across the road from the Vermilion County Nursing Home.
0.7	4.9	STOP—2-way. TURN RIGHT (north) on 1430E.
0.15	5.05	Cross I-74.
0.3	5.35	Large glacial erratic in yard to left.
0.3	5.65	T-road intersection. TURN LEFT (west) on 1670N and go through entrance gate to Lee Coal Company.
0.45	6.1	Stop 1.

STOP (1)

Lee Coal Company office and scalehouse. SW 1/4 SW 1/4 NE 1/4 NE 1/4 Sec. 14, T. 19 N., R. 12 W., 2nd P.M., Vermilion County; Danville SW 7.5-minute Quadrangle.

Pennsylvanian strata is exposed in the Lee Coal Company strip and underground mines. The following generalized section is from a drill log of the Calefy Mine:

Glacial drift	20 ft
Farmington Shale Member—gray, soft	100 ft
Danville (No. 7) Coal Member	5½-6 ft
Gray shale and clay	5 ft
Limestone	7 ft
Gray shale	1 ft
Black shale	6 ft
Herrin (No. 6) Coal Member	2-10 ft

Mr. Lee first opened this mining property in August 1975 with a strip mining operation. Caterpillar tractors and earthmoving equipment removed the overburden from above the coal so that endloaders could load the No. 7 Coal into trucks for delivery. When the overburden got too thick, Lee used an augering machine to remove additional coal from several tens of feet back into the hillside (fig. 5). After the auger mining ceased several years ago, Lee dug a pit down through the underlying Herrin (No. 6) Coal. From the pit bottom, he opened a drift mine into this lower coal. The coal slanting to the south toward the mine mouth is part of a "roll" that occurs frequently in this coal. That is, there are a number of small upwarps and downwarps to the coal bed. A Joy continuous miner cuts the coal face, and shuttle cars carry the coal to a conveyor belt for transport to the mine portal.

Figure 5. Lee Coal Company highwall shows auger-mining holes in Danville (No. 7) Coal partly covered by face slumping. (Reinertsen, 1976.)

Quite a number of shaft, drift, slope, and strip mines have operated in the Danville area over the years. In 1882, the first yearly reports by the coal operators were made to the state. At that time Vermilion County had 22 operating mines with 1,024 employees and a production of about 343,500 tons of coal. In 1979, by comparison, only 2 mines operated in the county with 15 employees and a production of more than 180,000 tons of coal. More than 165 million tons of coal were mined from Vermilion County from 1882 through 1979, according to the Illinois Department of Mines and Minerals.

A clay pit operated here before Lee opened his coal mines. The clay company mined the No. 7 Coal for a considerable distance to the south. The old works are full of water and separated only by 20 to 30 feet of intervening strata. So far, none of the water has broken through into the lower active mine.

The No. 7 Coal auger holes and old mine works have been filled in at the surface along the slope above the active mine. The area has been seeded and the slope is difficult to recognize as the site of a former coal mine. A lot of the bottom land here had been highly disturbed by the clay mining operation, and spoil piles had been left behind. Lee has inaugurated a reclamation program on the old spoils as well as on his own newer spoil piles (figs. 6 and 7). Before he could mine the coal he has had to file a proposed reclamation program with the State. Federal and state inspectors check his operation frequently to ensure that he is doing the reclamation needed.

Lee has reclaimed some of the old spoil areas so that he can eventually have trailer camping facilities here. The large berm to the west of the haulage road will eventually be a ski slope. Water for the snow will come from a lake that will result from his last stripping operation that is taking place along the west side of the property.

Figure 6. View to east of Lee Coal Company strip mine in No. 7 Coal. Note rough spoil piles and steep highwall face to right. (Reinertsen, 1976).

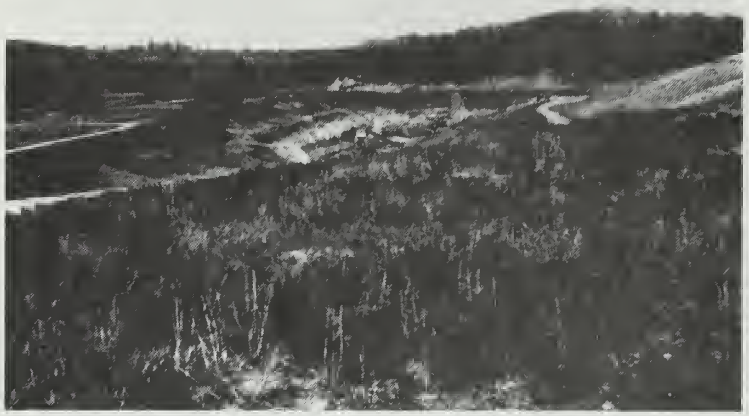


Figure 7. Approximately same view as figure 6 after highwall and spoil piles have been graded and reclaimed. Present drift mine into Herrin (No. 6) Coal is in center of photo. (Reinertsen, 1981.)

Lee had the foresight and determination to adopt a reclamation plan that will benefit the area in the years to come. This program is in stark contrast to the early strip mining spoils that have never been reclaimed in a large part of Vermilion County.

Miles to next point	Miles from starting point	
0.0	6.1	Leave Stop 1. Retrace itinerary eastward.
0.45	6.55	Exit from Lee Coal Company property and TURN RIGHT (south) on 1430E.
0.55	7.1	Cross I-74. Continue ahead (south).
0.2	7.3	Crossroad. Continue ahead (south).

0.5	7.8	T-road intersection. TURN LEFT (east) on 1550N.
0.2	8.0	STOP; Tilton-Catlin Road; 1450E. TURN LEFT (northeast).
0.05	8.05	CAUTION. TURN HARD RIGHT (south) on gravel road.
0.55	8.6	TURN LEFT (east) on Ross Lane, 1500N.
0.1	8.7	CAUTION; unguarded (NWRR) crossing. CONTINUE AHEAD (east).
0.75	9.45	CAUTION; truck terminal and residential area. Continue ahead (east).
0.35	9.8	CAUTION; (CR) crossing. Tilton to left beyond crossing. Continue ahead (east).
0.5	10.3	CAUTION—STOPLIGHT. Intersection IL 1; 1620E. TURN RIGHT (south) on IL 1.
0.75	11.05	CAUTION—STOPLIGHT. TURN RIGHT (west) on Hegeler Lane.
0.2	11.25	TURN RIGHT (north) on WITY Radio Station road.
0.05	11.3	WITY parking area. Stop 2.

Vermilion Broadcasting Corporation studio, WITY Radio.
SW 1/4 SW 1/4 NW 1/4 SW 1/4 Sec. 29, T. 19 N., R. 11 W., 2nd P.M., Vermilion County; Danville SW 7.5-minute Quadrangle.

STOP ②

This locality shows some of the effects of subsidence associated with underground mining of coal. Shortly after noon on Friday, July 21, 1967, WITY Radio staff began hearing strange noises around the station; before 2 p.m. a crack appeared in one of the office floors. Within a short time additional cracks, some nearly 2 inches wide, appeared elsewhere in the building. At 3 p.m., when no further damage appeared, the station returned to the air after 45 minutes of absence. The majority of the ground movements ceased in two days, but the southwest corner of the building was nearly 1.5 feet lower than the northeast corner. The accompanying photos show some of the cracks that had developed in the walls of the structure and driveway (fig. 8).

In addition to damage to the building, the two southernmost radio towers were lowered about 3 feet. One of the concrete anchors, to which support cables are attached, subsided on the north tower. The towers, however, stayed up and were repaired.

Houses that stood on either side of the WITY driveway near Hegeler Lane were so severely damaged that they were torn down, as were two other houses to the west and southwest. Maximum subsidence amounted to about 3.5 feet in

8a. Severe cracking of asphalt driveway. House to right was so severely damaged that it was torn down. (DuMontelle, 1967.)

8b. Cracks that developed in concrete block wall. (DuMontelle, 1967.)

8c. Foundation and concrete-block wall separation and wall cracks. (DuMontelle, 1967.)

Figure 8. Subsidence damage to WITY Radio Station.

this area and the deepest part was located just to the west of the WITY parking lot. After a heavy rain, the lower parts of the subsided areas show up quite well as ponds of water.

In 1945 the V-Day Coal Company opened a slope mine in the SE 1/4 NE 1/4 NE 1/4 Sec. 30, T. 19 N., R. 11 W., 2nd P.M., about a half mile north-northwest of the WITY studios. Approximately 6 feet of Herrin (No. 6) Coal was mined at a depth of about 125 feet. The Danville (No. 7) Coal, also 6 feet thick, occurs about 30 feet above the No. 6 Coal in this area. The mine was abandoned in December 1974.

The V-Day Mine was active during the period of subsidence, and local homeowners reported blasting sounds from the mine had begun 4 to 6 months before the subsidence event; however, the subsidence occurred over an abandoned part of the mine.

Survey geologists who studied the subsidence event felt that the size of the collapsed area, a sag with a diameter of about 300 feet, indicated that pillars and/or the floor of the mine had failed. The amount of subsidence was about 60 percent of the thickness of the coal removed.

Note: Currently, compensation for damage from subsidence is available for property owners through subsidence insurance obtainable from the homeowner's insurance company. Assistance during subsidence emergencies, where life or property is threatened, is available through the Abandoned Mined Lands Reclamation Council in Springfield, Illinois.

Miles to next point	Miles from starting point	
0.0	11.3	Leave Stop 2 and return to Hegeler Lane.
0.05	11.35	STOP. TURN LEFT (east) on Hegeler Lane.
0.2	11.55	CAUTION—STOPLIGHT. TURN RIGHT (southerly) on IL 1.
0.6	12.15	Prepare to turn right.
0.15	12.3	TURN RIGHT (west) on Catlin Road; 1350N.
0.25	12.55	CAUTION; low underpass (CR).
0.1	12.65	CAUTION; low underpass (CR) with signal-guarded grade crossing just beyond. CONTINUE AHEAD (west).
0.25	12.9	Another small gob pile to the southeast.
0.3	13.2	Hummocky surface of Urbana Moraine to the left. The soils here are quite friable and are subject to sheetwash with heavy rains and to erosion by wind when dry.
1.45	14.65	T-road from left. TURN LEFT (south); 1380E.
0.15	14.8	Stop 3.

STOP 3

Urbana Moraine. East line NE 1/4 SE 1/4 NW 1/4 SE 1/4 Sec. 35, T. 19 N., R. 12 W., 2nd P.M., Vermilion County; Danville SW 7.5-minute Quadrangle.

We are now at the backslope of the Woodfordian Urbana Moraine, which forms a continuous ridge 1 to 2 miles wide from near Rantoul southeastward for about 50 miles to the Indiana state line. South of Urbana, where it is most prominent, this Wisconsinan moraine is 50 to 75 feet high. In the field trip area, the gently rolling surface of the Urbana Moraine is 35 to 45 feet high reaching maximum surface elevations of slightly more than 700 feet mean sea level (msl). The view to the southwest is of a kame that has twin tops that are slightly more than 705 feet in elevation (msl). This kame, on the south side of Catlin, looks high because it is situated quite far down the backslope of the moraine. The kame formed when meltwater from the waning Urbana glacier dumped a large quantity of sand and gravel into a depression in the ice surface, probably a crevasse. When the glacier melted away this subcircular hill was left behind.

Northward toward the Newtown Moraine, the southernmost part of the Illiana Morainic System here, the ground moraine from the Urbana glacier is generally quite flat except where eroded by streams. Along the front of the Newtown Moraine, the ground moraine from the Urbana glacier is mantled by sand and gravel outwash deposits from the Newtown glacier (see attached blue pages—"Pleistocene Glaciations in Illinois").

Miles to next point	Miles from starting point	
0.0	14.8	Leave Stop 3. CONTINUE AHEAD (south).
0.35	15.15	CAUTION; jog left and then right. CONTINUE AHEAD (south).
1.05	16.2	STOP; T-road. TURN RIGHT (west) on pavement.
1.0	17.2	STOP; crossroads. Catlin-Indianola Road. TURN LEFT (south).
0.5	17.7	Friable topsoil to right is subject to much wind erosion.
1.3	19.0	Stop 4.

STOP 4

Site of abandoned mine. NW side of road NE 1/4 NW 1/4 SW 1/4 SW 1/4 Sec. 15, T. 18 N., R. 12 W., 2nd P.M., Vermilion County; Danville SW 7.5-minute Quadrangle.

The gob piles here resulted from an underground mine; its shaft was located about 300 feet west of the road and at the south end of the tallest pile, which stands about 150 feet above the general land surface. Excellent plant fossils have been collected from the gob piles at this mine.

The Dering Coal Company opened their No. 4 Mine here in 1905 to mine the Herrin (No. 6) Coal. The coal thickness was reported to range from 4.5 feet to 10.0 feet and averaged 5.75 feet at a depth of 208 feet. Four feet of Danville (No. 7) Coal was reported to occur 100 feet from the surface. This mine changed ownership several times, the last owner being the Chicago Harrisburg Coal Company. More than 18 million tons of coal were produced from this mine before it was abandoned in 1974.

Miles to next point	Miles from starting point	
0.0	19.0	Leave Stop 4. CONTINUE AHEAD (southerly).
0.5	19.5	About 1.9 miles to the southeast is the gob pile from the abandoned Bunsen Mine. Note how flat the till plain is here.
1.75	21.25	CAUTION; unguarded railroad crossing (Chicago and Eastern Illinois Railroad (C&EI RR) now owned by Missouri Pacific Railroad (MoPac RR). CONTINUE AHEAD (south).
1.35	22.6	Prepare to turn left.
0.2	22.8	TURN LEFT (east) on Georgetown Road.
3.4	26.2	CAUTION; enter Georgetown.
0.15	26.35	CAUTION; (CR) railroad crossing; 2 tracks. CONTINUE AHEAD (east).
0.4	26.75	CAUTION—STOPLIGHT, South Main Street and IL 1. TURN LEFT (north) on IL 1.
0.1	26.85	Prepare to turn right.
0.1	26.95	TURN RIGHT (east) on Mill Street.
0.55	27.5	Leave Georgetown limits.
0.15	27.65	An abandoned mine site to the left has been almost completely leveled.
1.85	29.5	Prepare to turn left.
0.2	29.7	TURN LEFT (north) on 1880E toward Forest Glen County Preserve.
1.0	30.7	STOP; T-road. TURN RIGHT (east) on 900N at community of Meeks.
0.05	30.75	CAUTION; rough abandoned railroad crossing (Chicago Milwaukee St. Paul and Pacific). CONTINUE AHEAD (east) on Vermilion County 27 and cross a kame complex on the Urbana Moraine for the next half mile.

1.4	32.15	Prepare to turn left.
0.1	32.25	TURN LEFT (north and then westerly) at entrance to Forest Glen County Preserve and follow marked road toward Ranger Station.
1.2	33.45	TURN RIGHT (north) at entrance to Meadowlark Picnic Shelter parking area.
0.05	33.5	Stop 5. LUNCH.

STOP 5

Meadowlark Picnic Shelter. SW 1/4 SW 1/4 NE 1/4 NE 1/4 Sec. 23, T. 18 N., R. 11 W., 2nd P.M., Vermilion County; Danville SE 7.5-minute Quadrangle.

A lookout tower located 3/4 mile east-northeast from here, provides an excellent panoramic view of this area. Follow the signs to the tower parking area. There is a good, fairly level trail 0.2 mile long to walk to the tower base.

Miles to next point	Miles from starting point	
0.0	33.5	Leave Stop 5. Return to main road.
0.05	33.55	STOP. TURN RIGHT (west) toward Ranger Station.
0.15	33.7	TURN RIGHT (northerly) in front of the Ranger Station.
0.05	33.75	BEAR LEFT (northerly) at Y-intersection.
0.3	34.05	TURN RIGHT (north) toward Interpretive Center.
0.4	34.45	PARK in lot on the left. Cross the road and follow Willow Creek Trail northward.

STOP 6

Pennsylvanian Carbondale Formation strata exposed along Willow Creek. W 1/2 NE 1/4 SW 1/4 Sec. 14, T. 18 N., R. 11 W., 2nd P.M., Vermilion County; Danville SE 7.5-minute Quadrangle.

Bedrock exposures appear about 300 feet north of the parking lot below the trail. Bedrock exposed along Willow Creek (fig. 9) belongs to the Carbondale Formation, which includes all strata from the base of the Colchester (No. 2) Coal up to the top of the Danville (No. 7) Coal.

An interesting feature of this section is its joint pattern, which White (1961) feels is due to the development of syneresis cracks. These cracks form from the spontaneous separation of a liquid from a flocculated sediment suspension during aging. The flocculated material in suspension probably

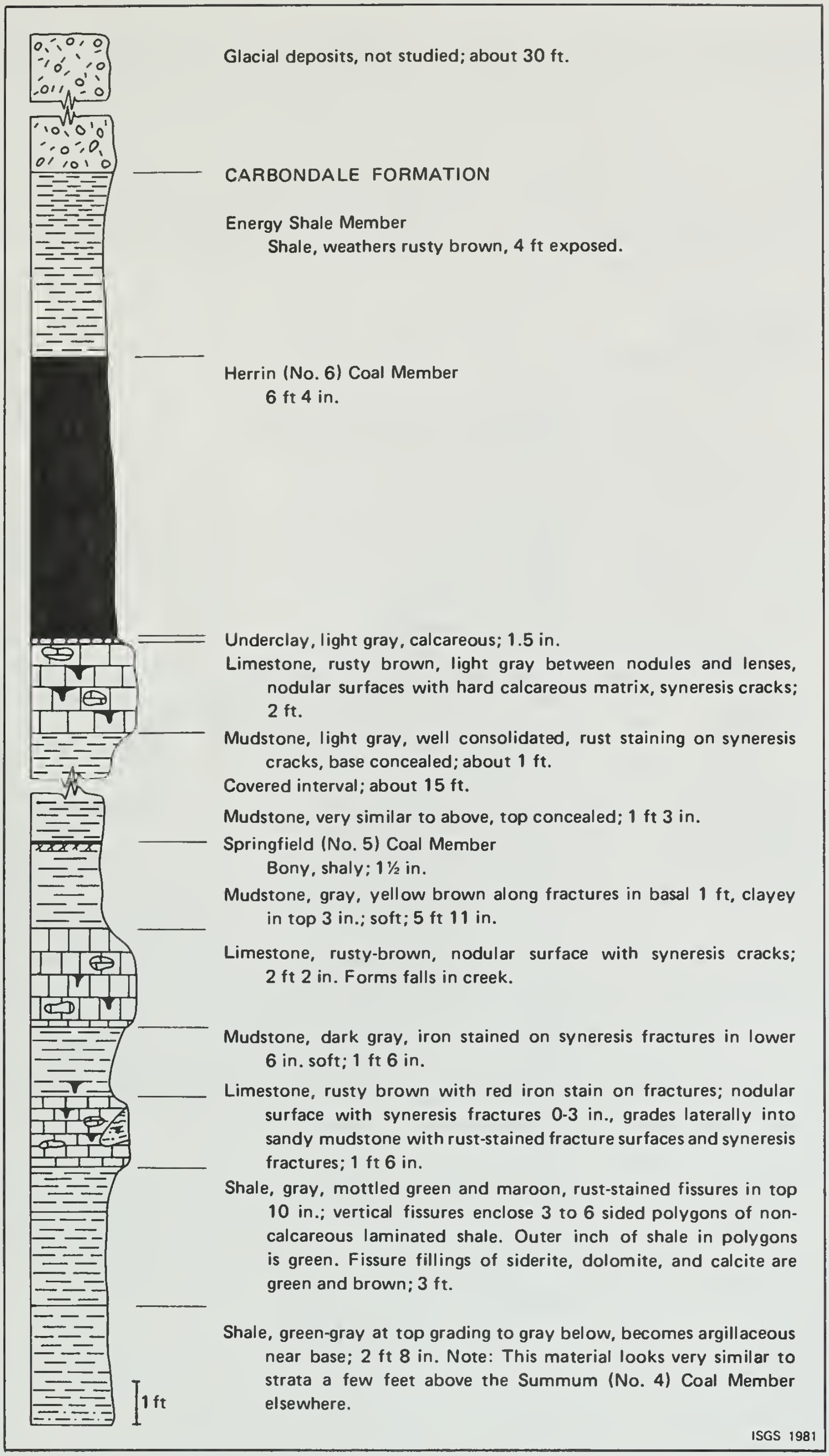


Figure 9. Columnar section of Carbondale formational units at STOP 6. (Adapted from Langenheim et al., 1980.)

resulted from an abnormally high salt concentration in the water. The separation of the liquid results in shrinkage that forms cracks, pits, and other such features, which are visible here in the limestones and mudstones.

A small amount of strip mining in the No. 6 Coal took place many years ago several hundred feet down the trail. Slumping of the valley walls in this vicinity has resulted in poorly exposed bedrock sections. Portions of three cyclothems (see attached "Depositional History of the Pennsylvanian Rocks") are present in these detached sections.

Miles to next point	Miles from starting point	
0.0	34.45	Return to cars and leave Stop 6. Retrace route to park entrance.
0.4	34.85	T-road intersection. TURN LEFT (east).
0.35	35.2	BEAR LEFT (easterly) just east of the Ranger Station and return to the park entrance.
1.3	36.5	STOP; T-road. Exit from park and TURN RIGHT (west) on 900N.
1.45	37.95	CAUTION; rough abandoned railroad crossing at Meeks. CONTINUE AHEAD (west) on 900N.
0.3	38.25	STOP; T-road intersection. TURN RIGHT (north) on 1850E.
1.95	40.2	CURVE LEFT (west) on one-lane concrete road.
0.4	40.6	CURVE RIGHT (north) on one-lane concrete road.
0.45	41.05	To the left and behind the house is a gob pile, which is the site of the abandoned Kelly Coal Company. Although this shaft was sunk in 1897 by the Himrod Coal Company, the first coal production was not reported until 1900. No. 6 Coal was mined at a depth of 180 feet with a thickness of 6.25 feet. More than 2 million tons of coal were produced before the mine was abandoned in 1908.
0.5	41.55	CURVE LEFT (west) on one-lane concrete road.
0.2	41.75	Sand and gravel pit to left. CONTINUE AHEAD (west).
0.25	42.0	Prepare to turn right.
0.1	42.1	TURN RIGHT (north) on gravel road.
0.5	42.6	TURN RIGHT (east).
0.5	43.1	CAUTION; crooked road ahead.
0.2	43.3	Note trash dumping along the road, although only 2 or 3 miles from a landfill site.

0.15	43.45	In 1866, Kirkland, Blakeney, and Groves engaged in the first strip mining for coal in this country at Grape Creek. Probably the first strip mining took place along this hollow, which is about a mile south of Grape Creek, as the property in this vicinity has been owned by the Blakeney family for many years. The area to the left of the road was strip mined, certainly many years ago. You will note that these very old strip mine spoil piles can be seen for some distance down the hollow on both sides of the road. The coal was uncovered by a team of horses pulling a scraper (see cover illustration). Waste overburden was loaded on the scraper and then carried out of the immediate area where the coal was. When the overburden got too thick for these teams to handle, miners drifted back in under the hills in drift mines. Many drift mines have been operated along these valley walls in years past. According to the miners here, roof conditions in these mines were quite good and it was not uncommon to drift back for hundreds of feet without needing to use any timbering for roof support.
0.5	43.95	STOP, T-road intersection. TURN LEFT (northerly).
0.7	44.65	BEAR RIGHT (north) on oiled road.
0.1	44.75	Cross Grape Creek. The area to the left is the village of Grape Creek. In the late nineteenth and early twentieth centuries, this was a busy town. When the mines closed most of the people left the area.
0.2	44.95	STOP; crossroads. CONTINUE AHEAD (north) on 1830E. The higher flat areas on both sides of the road are a terrace level that is just above the floodplain of the Vermilion River.
1.0	45.95	The flat area to the right appears to be a higher terrace level than the one previously noted.
0.15	46.1	A lower terrace level here is just above the floodplain of the Vermilion River.
0.05	46.15	Cross Vermilion River.
0.2	46.35	BEAR LEFT (north) and ascend spur that separates Vermilion River on the left from Stony Creek on the right.
0.65	47.0	Vermilion River is through the trees to the left.
0.4	47.4	The Danville Wastewater Treatment Plant is on both sides of the road.
0.65	48.05	STOP; crossroads. Perryville Road; TURN RIGHT (easterly).

0.3	48.35	Stony Creek. Note how small the stream is.
0.25	48.6	Prepare to turn right.
0.1	48.7	TURN RIGHT (south).
0.15	48.85	BEAR LEFT (southeast).
0.1	48.95	STOP. You MUST have permission to enter this property.

STOP 7

Office of Lewis and Company. Wisconsinan Woodfordian outwash deposits in the Lewis sand and gravel pit. SE 1/4 NW 1/4 SW 1/4 SE 1/4 Sec. 15, T. 19 N., R. 11 W., 2nd P.M., Vermilion County; Danville SE 7.5-minute Quadrangle.

Gravel pits here are developed in outwash sands and gravels that were flushed away from the melting Woodfordian Newtown glacier when it stood less than 6 miles to the north. The east side of the pit shows an interbedded silty clay and fine gravel that is overlain by 10 to 15 feet of coarser gravel with loess and soil at the top. After periods of rain, a springline develops at the contact of the coarser materials with the underlying silty clay. The latter does not transmit water readily. To the west side of the pit, sand is worked to a depth of about 30 feet before water becomes a problem in the pit floor. The coarse gravel at the top contains boulders up to 3 feet in diameter; this indicates that the ice front was not too far away from this locality.

Lick Creek flows southwestward across the northern part of Section 15 to join Stony Creek which flows southeastward from north of Danville. After joining north of the Perryville Road, these two creeks occupy a valley that is much too large for their size; this indicates that a much larger stream once eroded the valley here.

Ground water resources (personal communication, Philip C. Reed). Sand and gravel layers similar to those exposed in the pit extend to more than 110 feet lower within the main channel of the Ancient Vermilion River, which flowed westward from Indiana to the Langley Bottoms, about 2.5 miles south of here. The river then turned northward to join the ancient Mahomet (Teays) Bedrock Valley northwest of Danville. This Ancient Vermilion River Valley was part of the preglacial drainage that had been eroded into the Pennsylvanian bedrock surface of this area. Here this ancient valley extends to as much as 75 feet below the present Vermilion River floodplain and ranges from 1/2 to 3/4 mile in width. The ancient valley parallels the present Vermilion River Valley for about 3 miles in this vicinity. Moderate supplies of ground water can be obtained from the thicker sand and gravel deposits within the ancient valley. Individual wells are capable of yielding as much as 50 to 100 gpm (gallons per minute) for fairly long periods of time if properly constructed. Most wells in the area that are located away from the ancient valley tap thin, upland glacial deposits and yields generally range between 5 to 10 gpm.

End of field trip—have a safe journey home!

We hope to see you again in the fall.

BIBLIOGRAPHY

Bradley, F. H., 1870, Geology of Vermilion County, *in* A. H. Worthen, Geology and palaeontology: Geological Survey of Illinois, v. 4, p. 190-275.

Cote, W. E., and others, 1967, Oakwood area: Illinois State Geological Survey Geological Science Field Trip Guide Leaflet 1967 E, 35 p.

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

Langenheim, R. L., Jr., and C. J. Mann [editors], 1980, Middle and late Pennsylvanian strata on margin of Illinois Basin, Vermilion County, Illinois, and Vermillion and Parke Counties, Indiana: Society of Economic Paleontologists and Mineralogists, Tenth Annual Field Conference, Great Lakes Section, University of Illinois, Urbana, 241 p.

Leighton, M. M., and others, 1948, Physiographic divisions of Illinois: Illinois State Geological Survey Report of Investigations 129, 19 p.

Lineback, J. A., and others, 1979, Quaternary deposits of Illinois (map): Illinois State Geological Survey, scale 1:500,000.

Odom, I. E., and G. M. Wilson, 1961, Georgetown area: Illinois State Geological Survey Geological Science Field Trip Guide Leaflet 1961 E, 20 p.

Raasch, G. O., 1948, Danville area: Illinois State Geological Survey Geological Science Field Trip Guide Leaflet 1948 B, 9 p.

Reinertsen, D. L., and others, 1972, Potomac-Danville area: Illinois State Geological Survey Geological Science Field Trip Guide Leaflet 1972 E, 40 p.

Simon, J. A., 1954, Danville area: Illinois State Geological Survey Geological Science Field Trip Guide Leaflet 1954 G, 10 p.

White, W. A., 1961, Colloid phenomena in sedimentation of argillaceous rocks: Journal of Sedimentary Petrology, v. 31, p. 560-570.

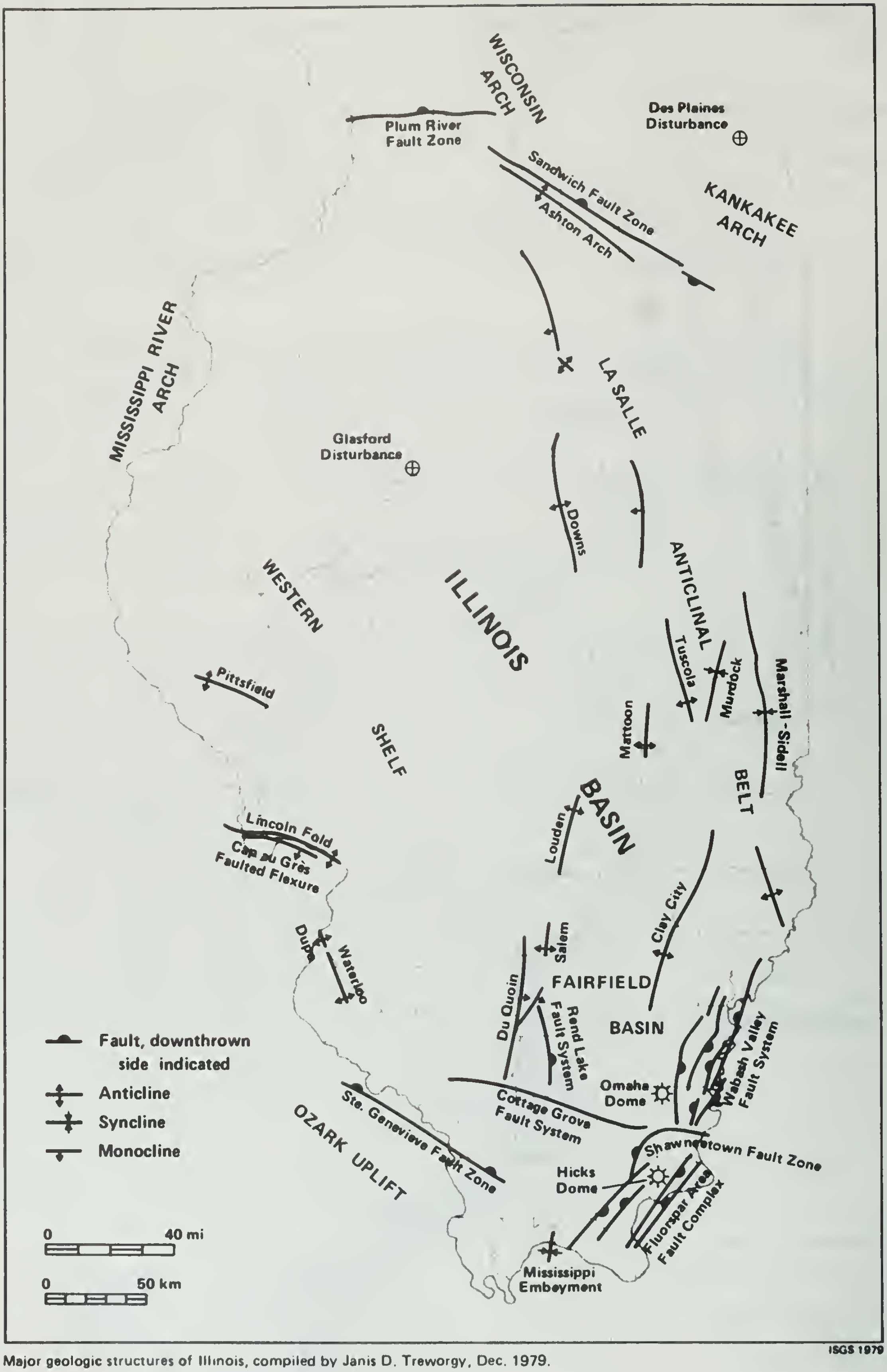
Willman, H. B., 1975, Handbook of Illinois stratigraphy: Illinois State Geological Survey Bulletin 95, 261 p.

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

Willman, H. B., and others, 1967, Geologic map of Illinois: Illinois State Geological Survey, scale 1:500,000.

PHYSIOGRAPHIC DIVISIONS OF ILLINOIS

Reprinted 1978



Major geologic structures of Illinois, compiled by Janis D. Treworgy, Dec. 1979.

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

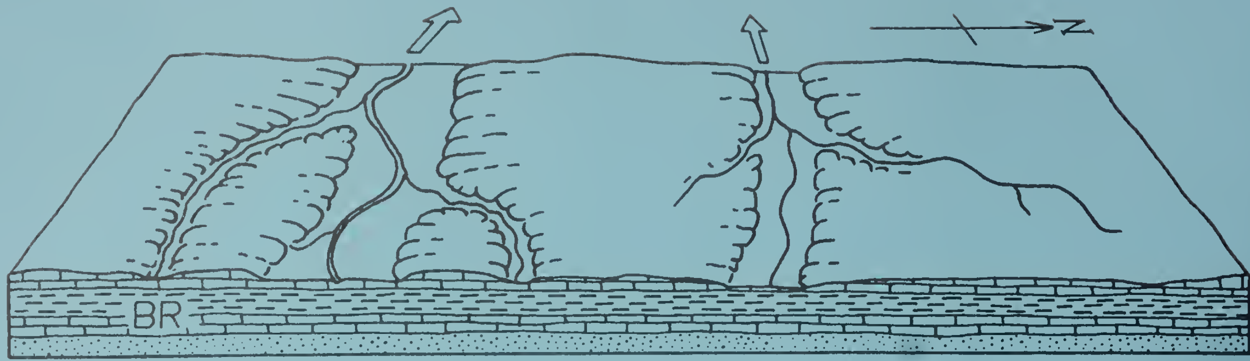
One of the most widespread sediments resulting from glaciation was carried not by ice or water but by wind. Loess is the name given to such deposits of windblown silt and clay. The silt was blown from the valley trains on the floodplains. Most loess deposition occurred in the fall and winter seasons 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.

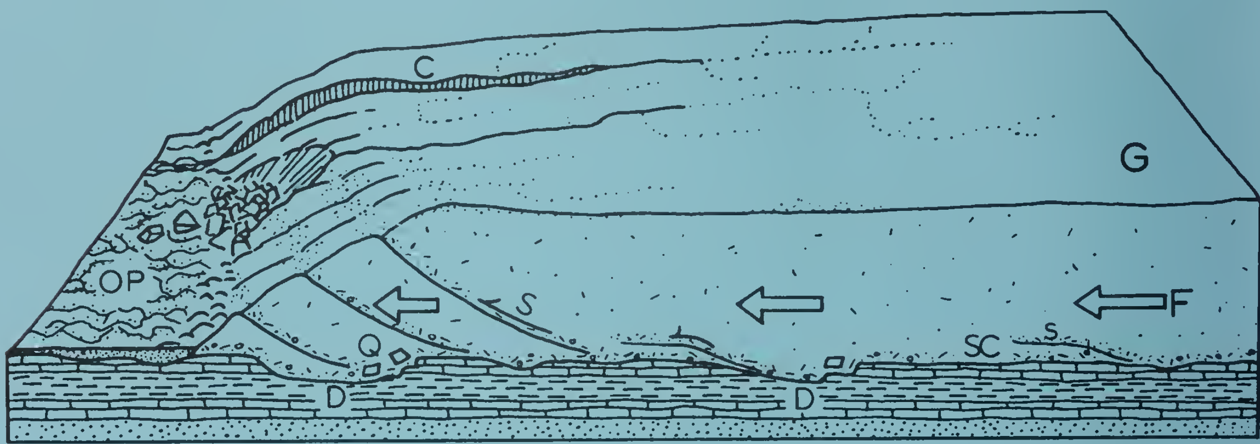
Glaciation in a Small Illinois Region

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.

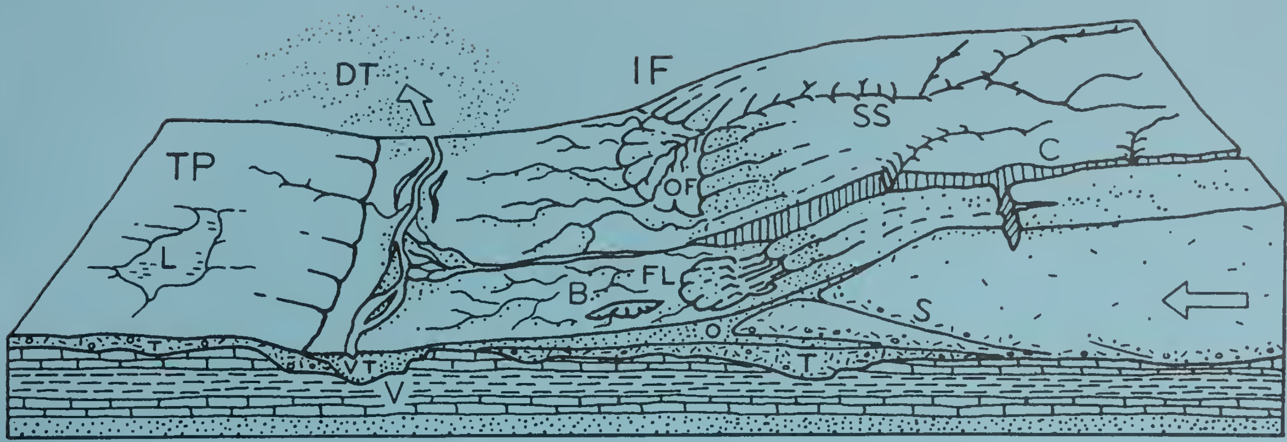
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated--layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



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.



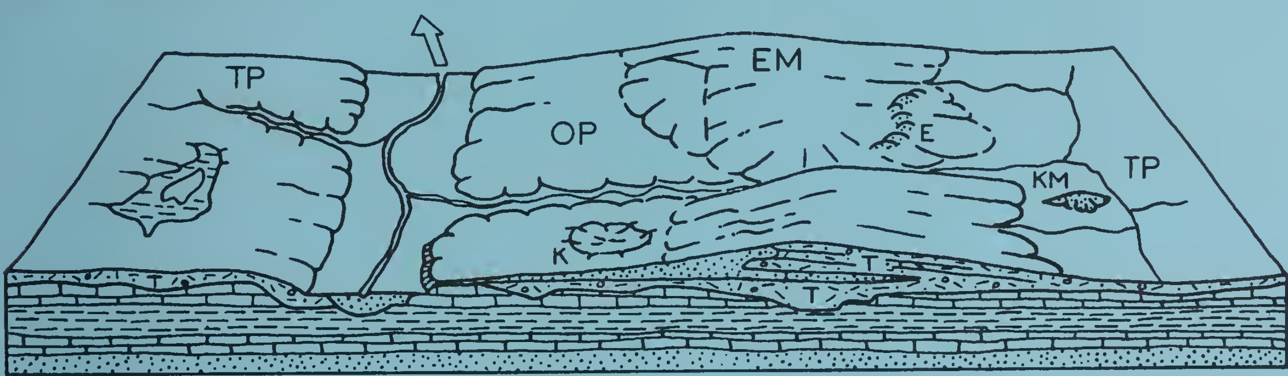
2. The Glacier Advances Southward - As the glacier (G) spreads out from its snowfield, it scours (SC) the soil and rock surface and quarries (Q)--pushes and plucks up--chunks of bedrock. These materials are mixed into the ice and make up the glacier's "load." Where roughnesses in the terrain slow or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

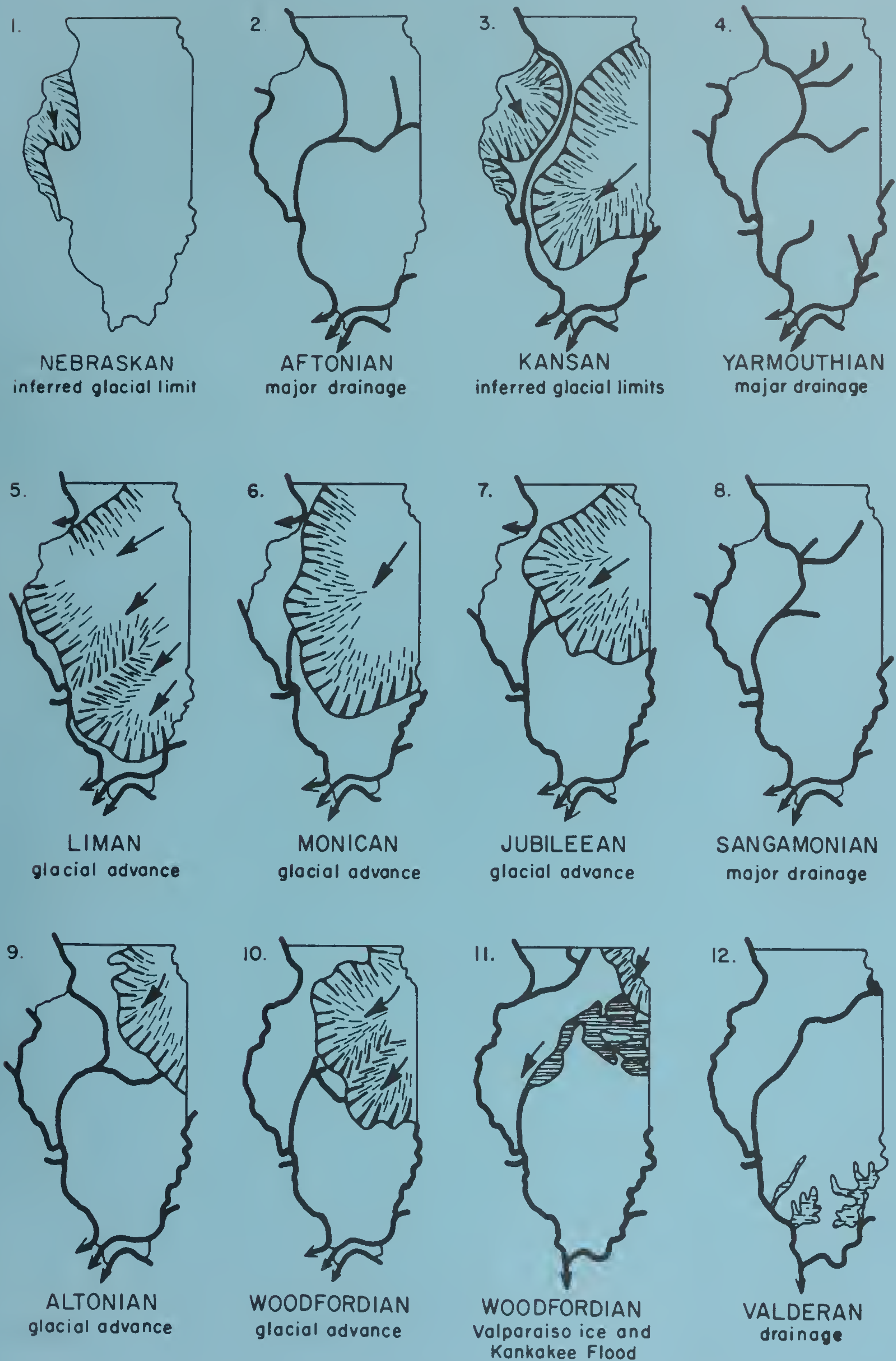
Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left by the ice block's melting has made a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel 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

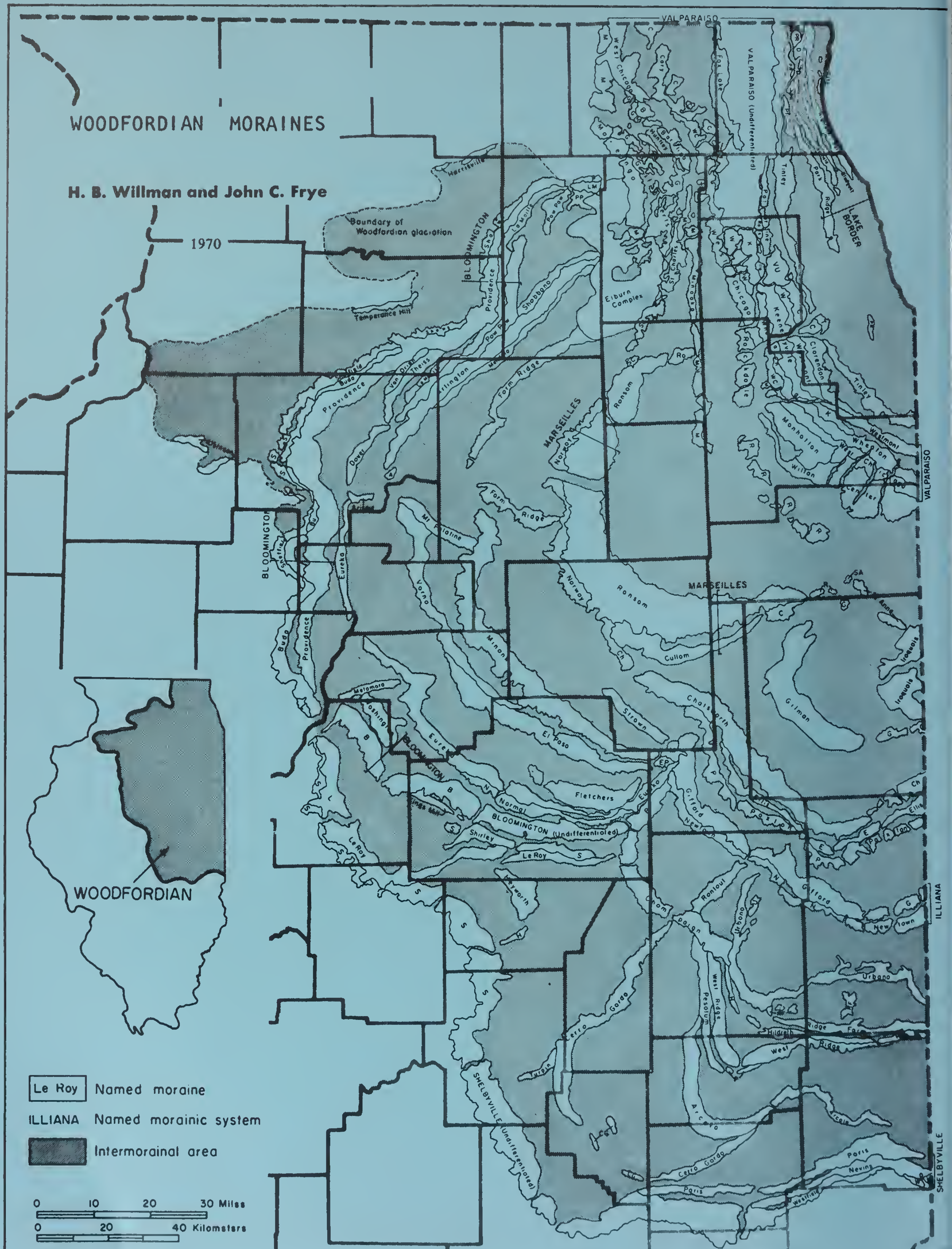
STAGE	SUBSTAGE	NATURE OF DEPOSITS	SPECIAL FEATURES
HOLOCENE	Years Before Present	Soil, youthful profile of weathering, lake and river deposits, dunes, peat	
	7,000		
WISCONSINAN (4th glacial)	Valderan	Outwash, lake deposits	Outwash along Mississippi Valley
	11,000		
	Twocreekan	Peat and alluvium	Ice 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 Monican Liman	Drift, loess Drift, loess Drift, loess	Glaciers from northeast at maximum reached Mississippi River and nearly to southern tip of Illinois
	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)	1,200,000 or more	Drift	Glaciers from northwest invaded western Illinois

(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.)


WOODFORDIAN MORAINES
H. B. Willman and John C. Frye
1970
Boundary of Woodfordian glaciation
VALPARAISO
VALPARAISO (Undifferentiated)
LAKE BORDER
BLOOMINGTON
MARSEILLES
BLOOMINGTON (Undifferentiated)
ILLIANA
SHELBYVILLE
SHELBYVILLE (Undifferentiated)
WOODFORDIAN
Le Roy Named moraine
ILLIANA Named morainic system
Intermorainal area
0 10 20 30 Miles
0 20 40 Kilometers

ILLINOIS STATE GEOLOGICAL SURVEY

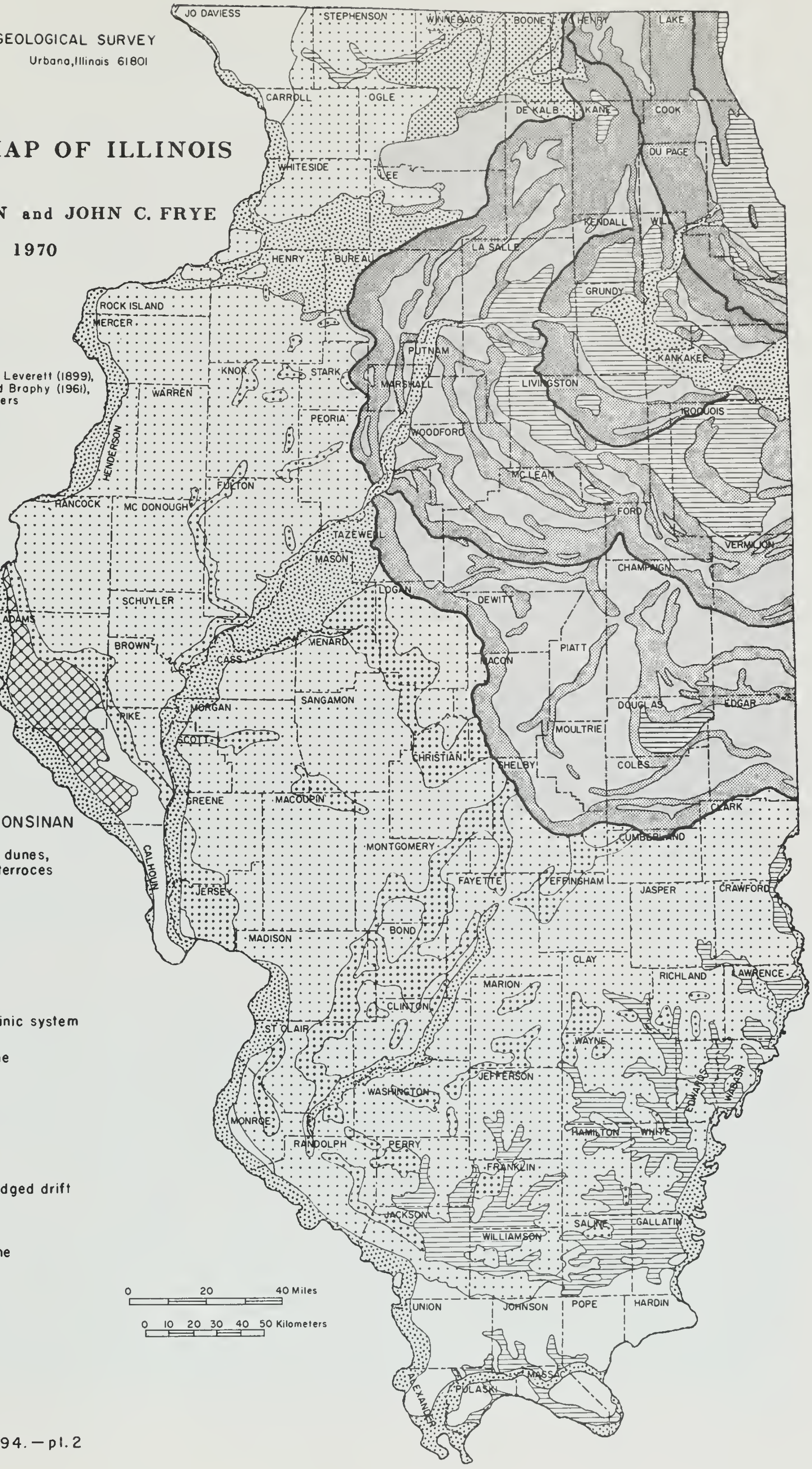
John C. Frye, Chief   Urbana, Illinois 61801

GLACIAL MAP OF ILLINOIS

H.B. WILLMAN and JOHN C. FRYE

1970

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



EXPLANATION

HOLOCENE AND WISCONSINAN

Alluvium, sand dunes, and gravel terraces

WISCONSINAN

Lake deposits

WOODFORDIAN

Moraine

Front of morainic system

Groundmoraine

ALTONIAN

Till plain

ILLINOIAN

Moraine and ridged drift

Groundmoraine

KANSAN

Till plain

DRIFTLESS

Modified from Bull. 94.—pl. 2

DEPOSITIONAL HISTORY OF THE PENNSYLVANIAN ROCKS

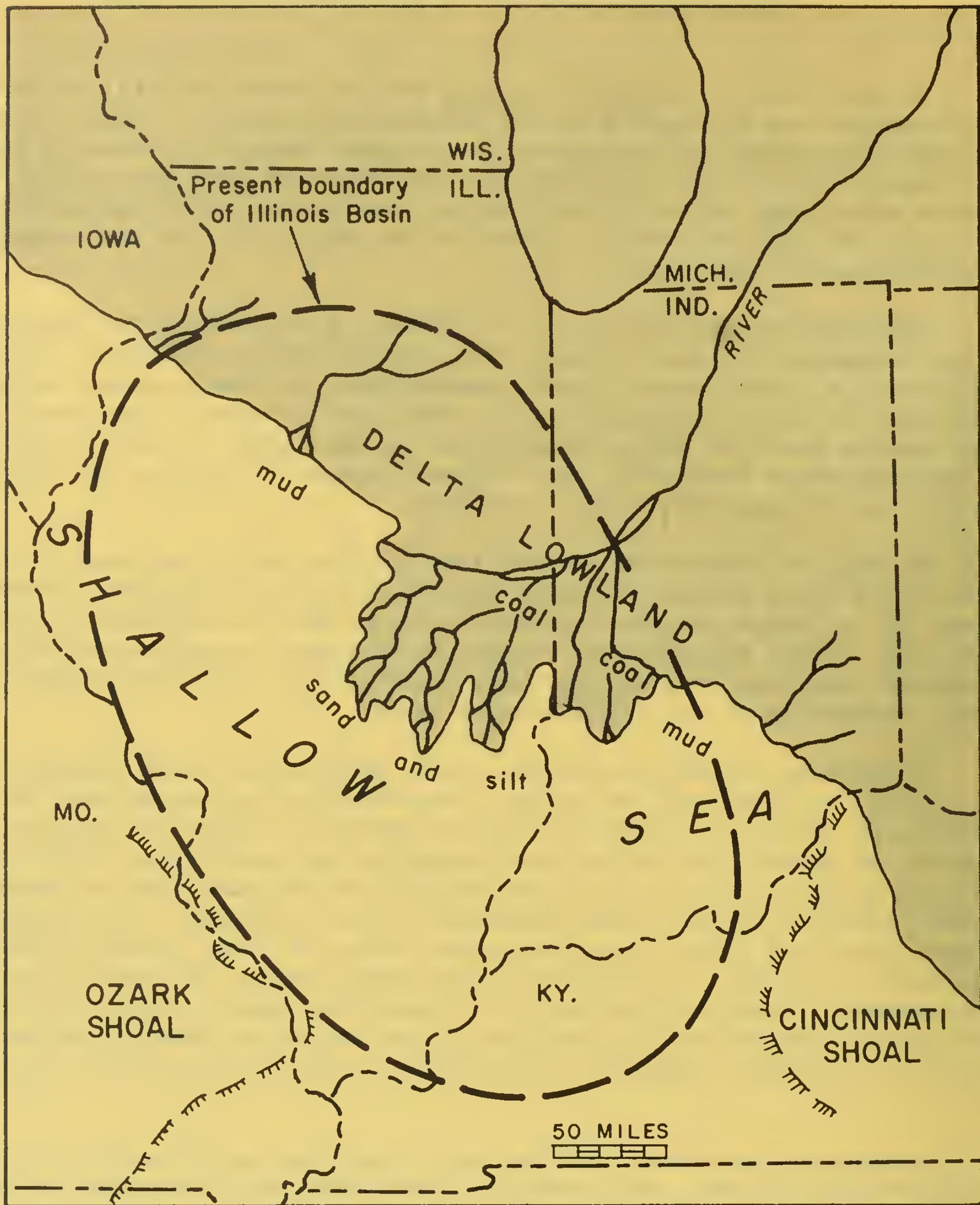
At the close of the Mississippian Period, about 310 million years ago, the Mississippian sea withdrew from the Midcontinent region. A long interval of erosion took place early in Pennsylvanian time and removed hundreds of feet of the pre-Pennsylvanian strata, completely stripping them away and cutting 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.

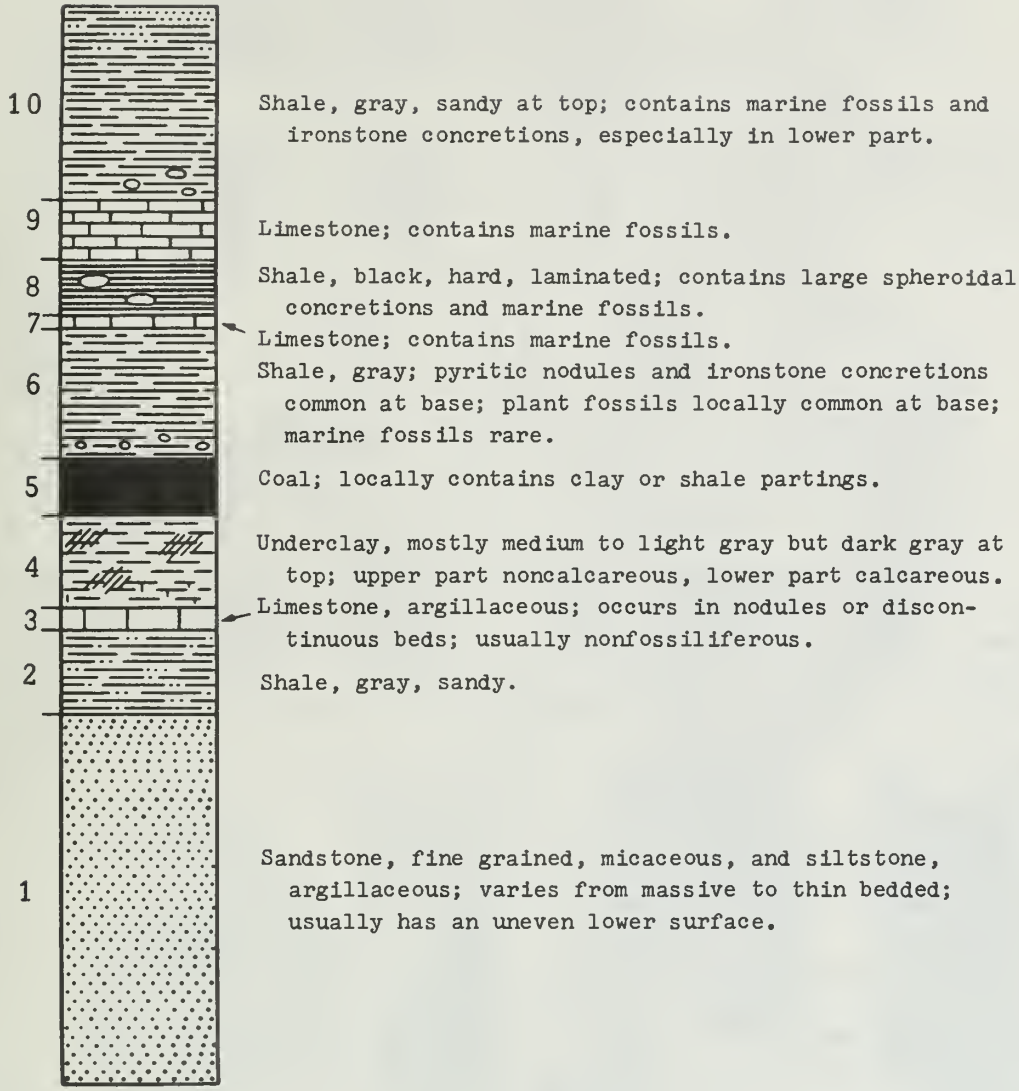
Plant debris from the rapidly growing swamp forests—leaves, twigs, branches, and logs—accumulated as thick mats of peat on the floors of the swamps. Normally, vegetable matter rapidly decays by oxidation, forming water, nitrogen, and carbon dioxide. However, the cover of swamp water, which was probably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

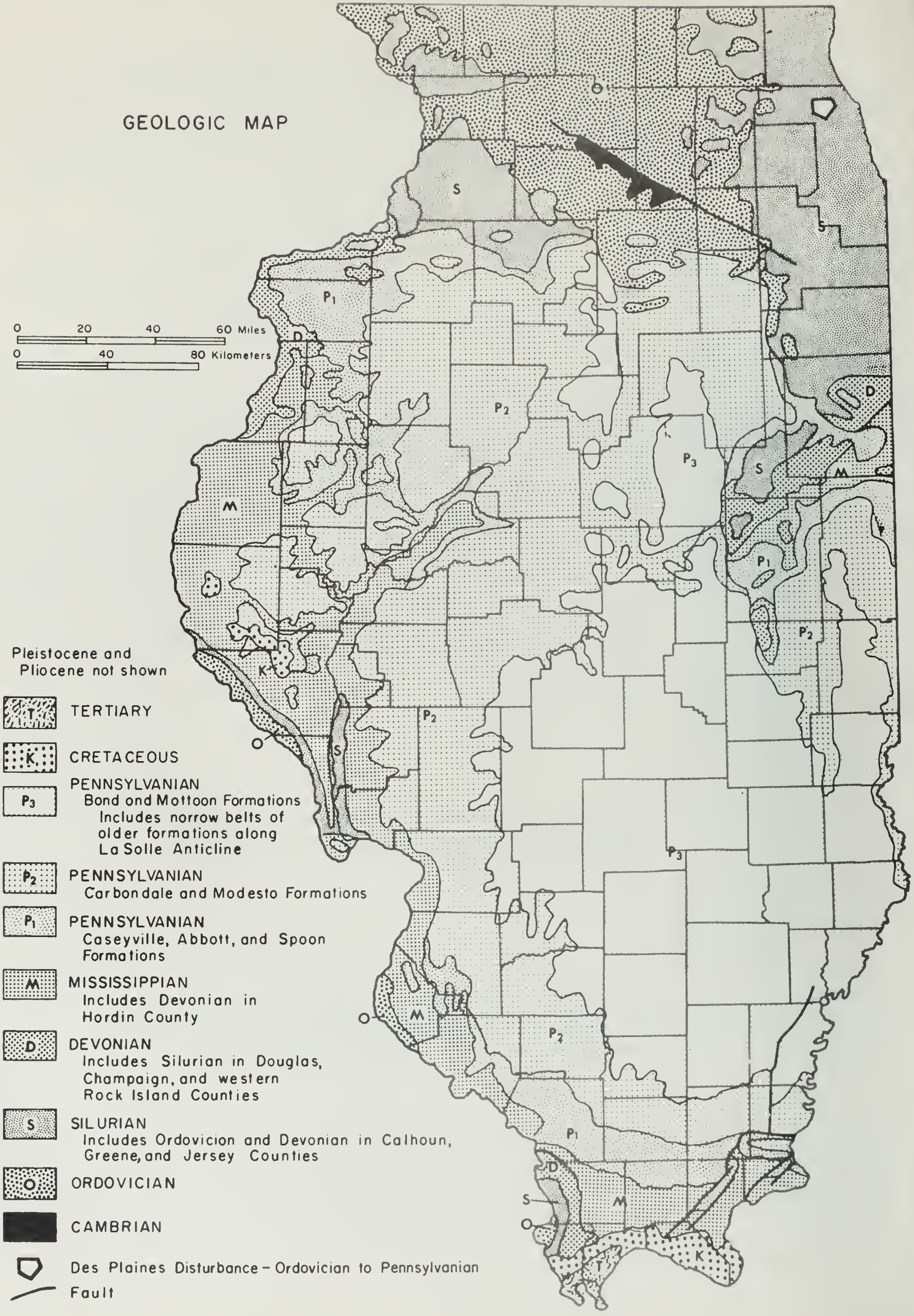
The exact origin of the carbonaceous black shales that occur above many coals is uncertain. The black shales probably are deposits formed under restricted marine (lagoonal) conditions during the initial part of the invasion cycle, when the region was partially closed off from the open sea. In any case, 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.

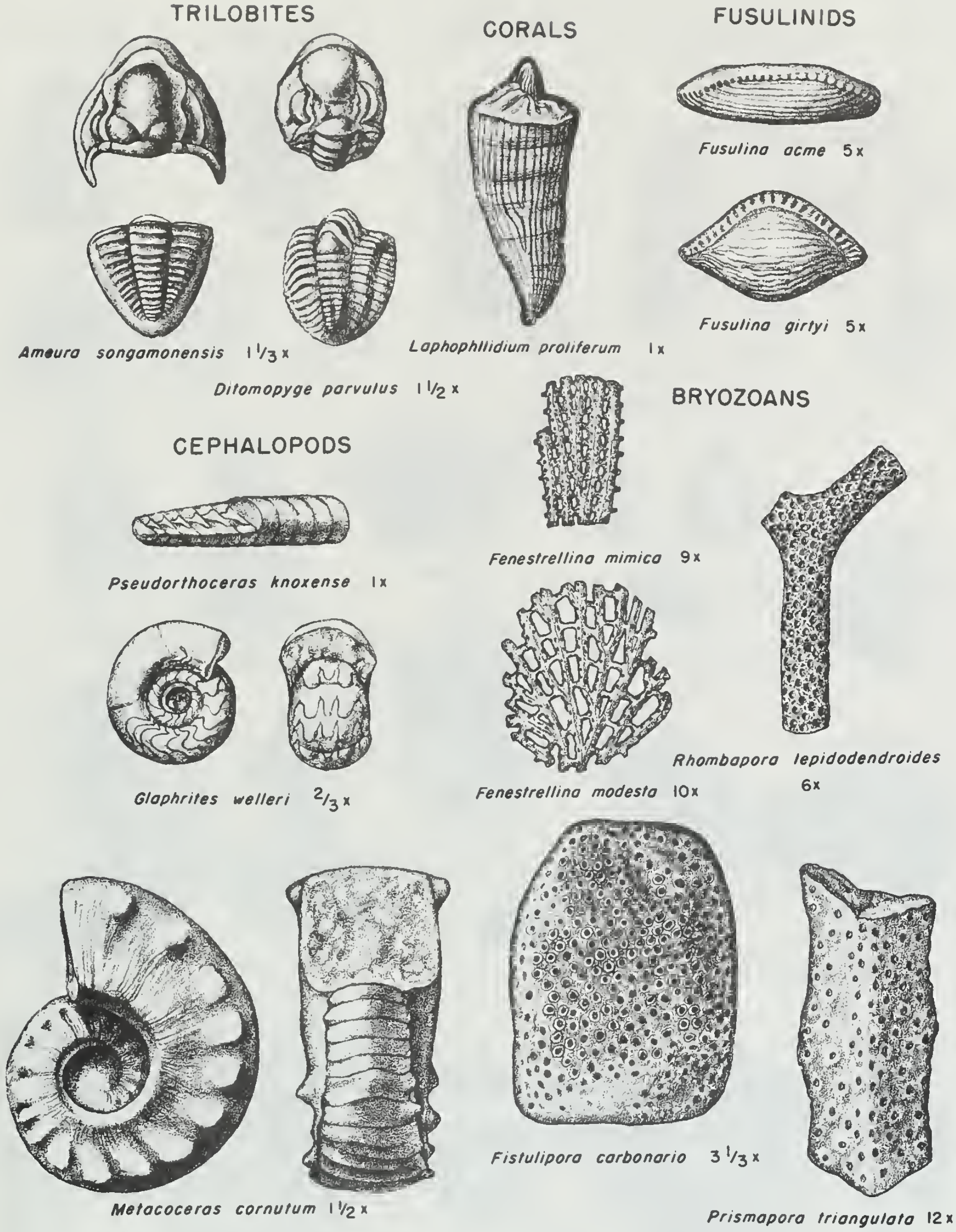


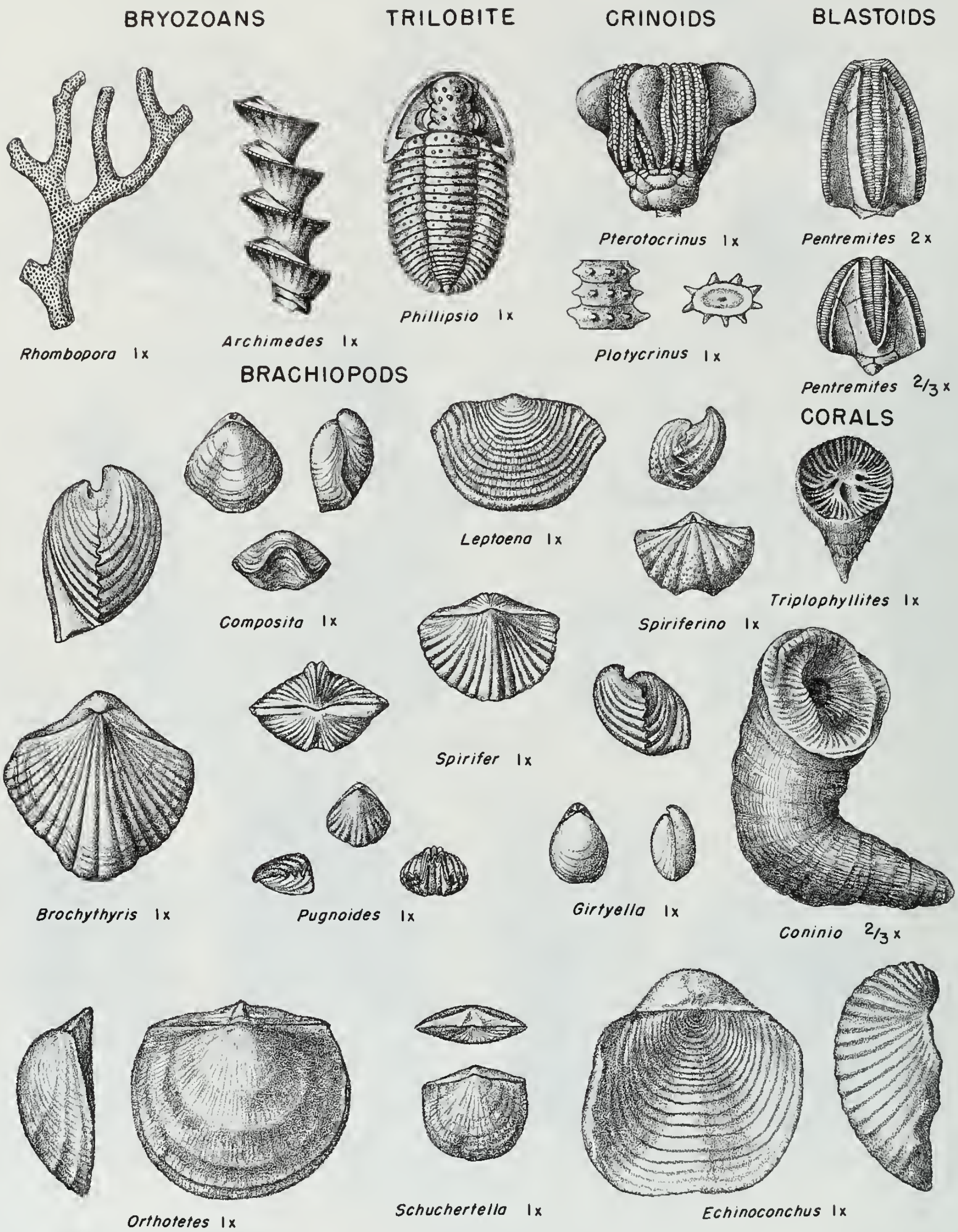
AN IDEALLY COMPLETE CYCLOTHEM

(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




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


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

PELECYPODS

Nucula (Nuculopsis) girtyi 1x

Edmonia ovata 2x

Astartella concentrica 1x

Dunbarella knighti 1½x

Cardiomorpha missouriensis "Type A" 1x

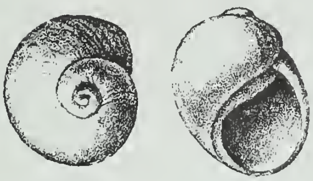
Cardiomorpha missouriensis "Type B" 1½x

GASTROPODS

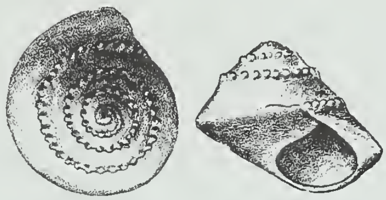
Euphemites carbonarius 1½x

Trepospira illinoisensis 1½x

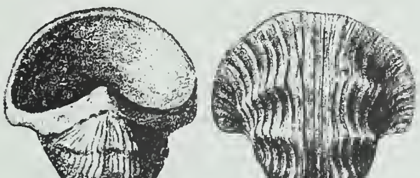
Donaldina robusta 8x



Naticopsis (Jedria) ventricosa 1½x

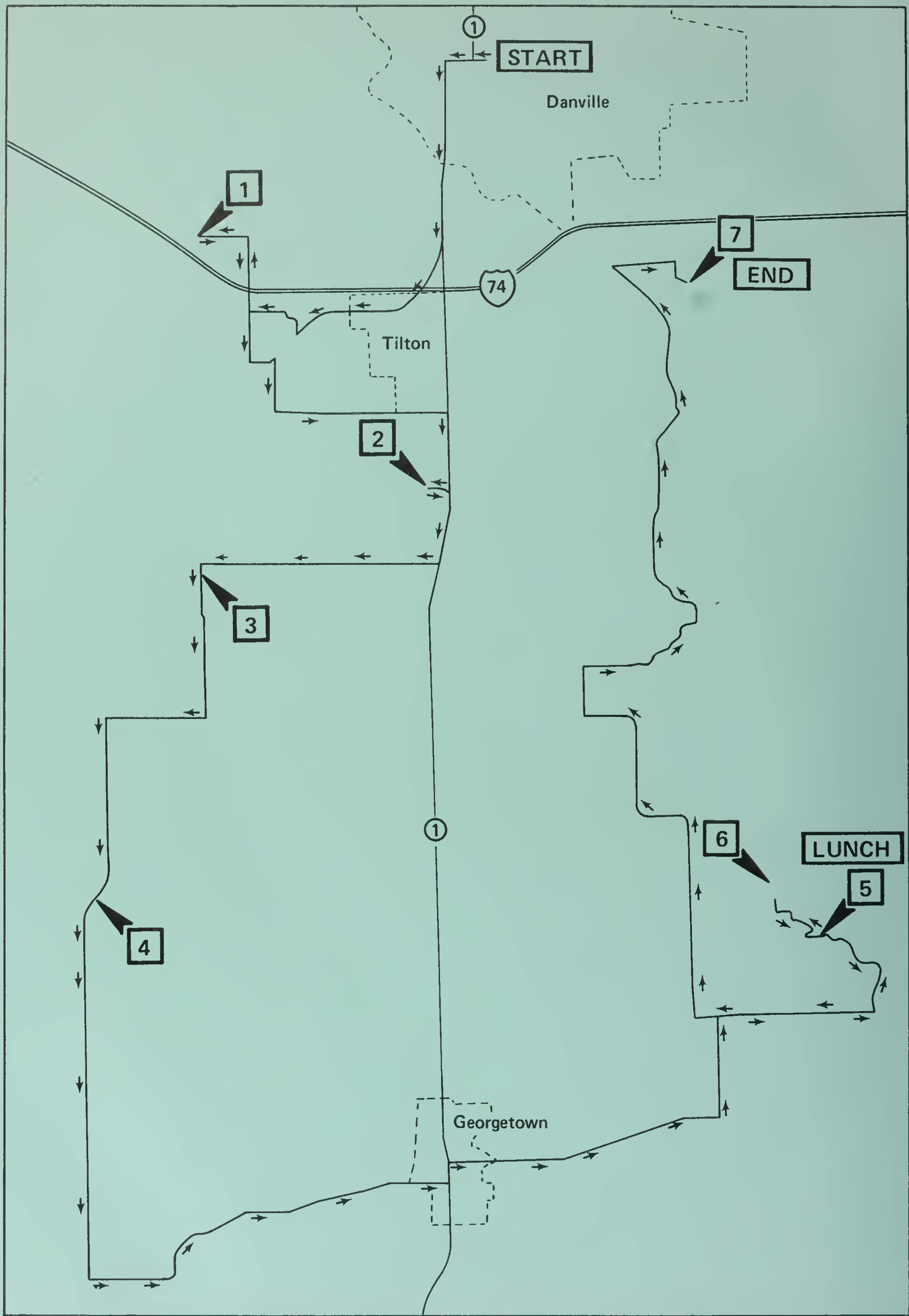


Trepospira sphaerulata 1x



Knightites montfortianus 2x

Glabrocingulum (Glabrocingulum) grayvillense 3x



1
START
Danville
1
7
END
74
Tilton
2
3
1
6
LUNCH
5
4
Georgetown