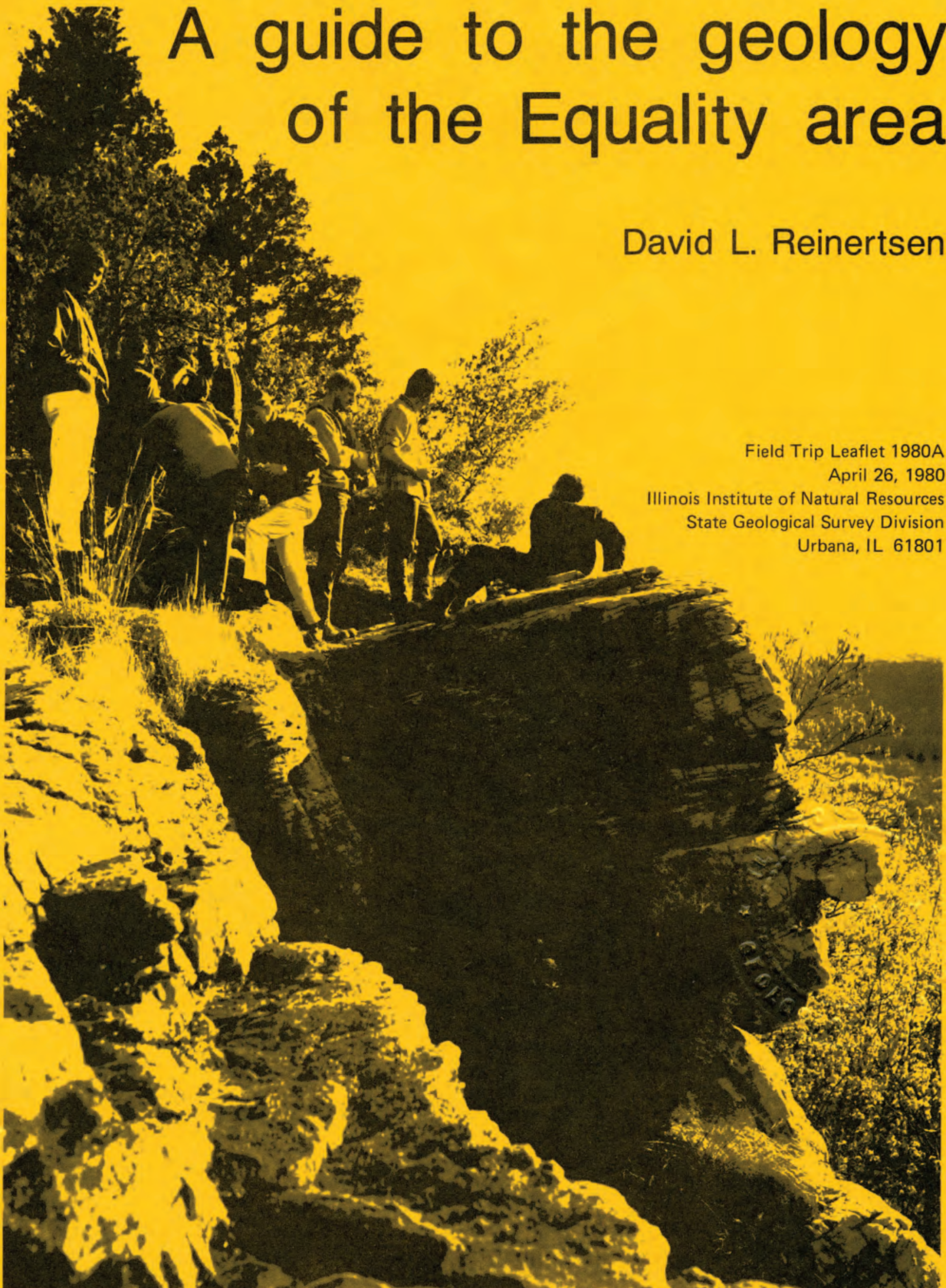
A guide to the geology of the Equality area

David L. Reinertsen



Field Trip Leaflet 1980A
April 26, 1980
Illinois Institute of Natural Resources
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Urbana, IL 61801

Commemorating the 50th Field Trip Season and the Survey's 75th year.

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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 next field trip (to Hillsdale, Rock Island, and Whiteside Counties) is scheduled for May 17, 1980.

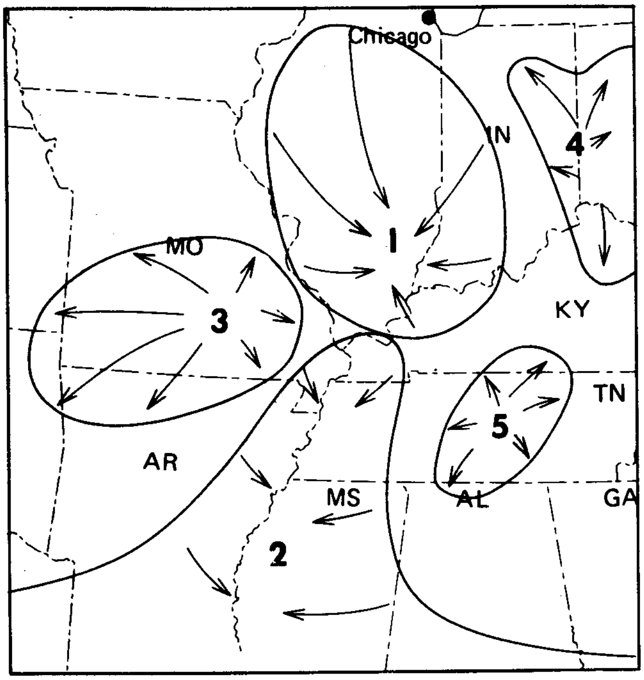


Figure 1. The location of the Illinois Basin and adjacent major structures: (1) Illinois Basin, (2) Mississippi Embayment, (3) Ozark Dome, (4) Cincinnati Arch, and (5) Nashville Dome.

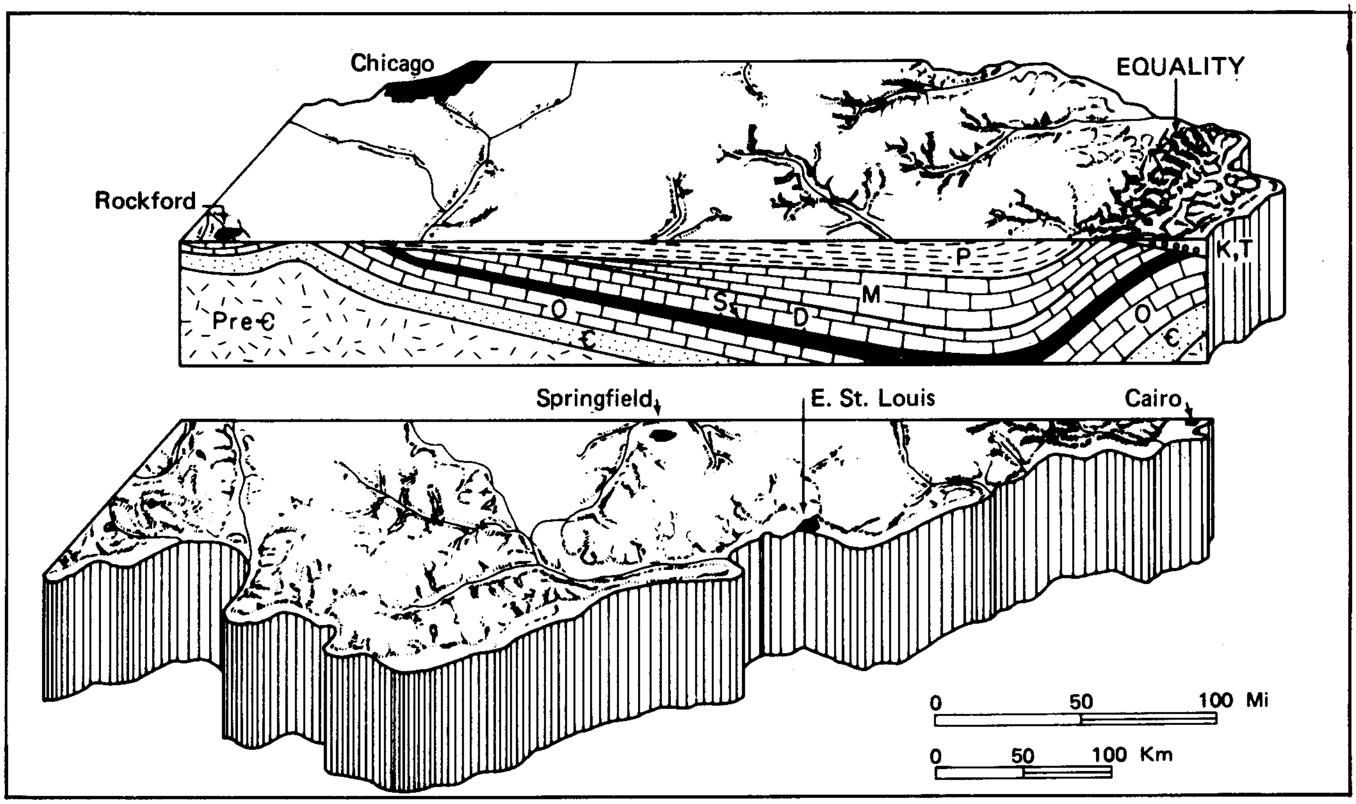


Figure 2. Stylized north-south cross section shows the structure of the Illinois Basin. In order to show detail, the thickness of the sedimentary rocks has been greatly exaggerated and the younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-C) granites. 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.

the geologic framework

The Equality area straddles the boundary between the Mt. Vernon Hill Country and the northeastern edge of the Shawnee Hills known as the "Illinois Ozarks." This region of rugged, scenic landforms extending across extreme southern Illinois is one of great topographic contrasts, with the flat, aluviated plain of Saline River bordering the sharp hills that mark the northern and western rim of Eagle Valley. The highest parts of the hills are at mean sea level (m.s.l.) elevations greater than 925 feet. The lowest elevation along the Saline River in the field trip area is less than 330 feet m.s.l. The surface relief of the area, therefore, is about 600 feet.

The field trip area lies on the southern flank of the Illinois Basin, a broad, oval bedrock depression formed by gentle downwarping of sedimentary layers (strata) beneath much of Illinois and adjacent parts of Indiana and Kentucky (figs.1 and 2). The Equality area is about 40 miles south of the deepest part of the basin, which is located in Wayne County.

Bedrock in the field trip area consists of approximately 12,000 feet of Paleozoic sedimentary rocks ranging in age from late Cambrian (about 550 million years old) to middle Pennsylvanian (about 290 million years old). The Cambrian rocks rest on an ancient surface of Precambrian igneous and metamorphic rocks more than 1 billion years old. This great thickness of sedimentary strata, consisting of sandstone, shale, limestone, and coal, was deposited layer upon layer in the ancient shallow seas that invaded the Illinois Basin and the midcontinent during the Paleozoic Era.

Approximately 5,000 feet of Paleozoic rocks are exposed in the field trip area (fig. 3). These rocks range in age from late Devonian (about 350 million years old) to middle Pennsylvanian (about 290 million years old). The area is an excellent place to study the lower half of the Pennsylvanian System, as an almost complete section of these rocks is exposed here. Pennsylvanian strata contain several important coals which have been mined for many years. Other mineral resources include sand and gravel and limestone.

The bedrock structure in the Equality area is very complex. Three major sets of faults are present in the area—the Shawneetown Fault Zone, the Wabash Valley Faults and the Fluorspar Area Fault Complex (see attached Geologic Map of Illinois). The major fault in the field trip area is the Shawneetown Fault, a high-angle reverse fault along which the strata have been displaced vertically as much as 3,500 feet. North of the fault, the Paleozoic strata are tilted gently northward into the Illinois Basin. South of the fault, bedrock strata are bent sharply into a downwarp called the Eagle Valley Syncline.

SYSTEM	SERIES	GROUP, STAGE	FORMATION OR MEMBER	ROCK UNIT	THICKNESS (feet)	GENERAL DESCRIPTION
Quat.	Pleist.	Wisconsinan			80	Lake sediments, dune sand, loess
Pennsylvanian	Desmoinesian	Kewanee	Carbondale: Anvil Rock, No. 6 Coal, No. 5A Coal, No. 5 Coal, No. 4 Coal, No. 2 Coal		380±	Alternating sequences of shales, limestones, thick coals, sandstones, and underclays
			Spoon: De Koven Coal, Davis Coal, Curlew Ls.		250±	Alternating sequences of shales, sandstones, coals, underclays, and thin limestones.
		McCormick	Abbott: Murray Bluff, Willis Coal, Grindstaff		500±	Sandstone, sandy shales, siltstone, thinner coals, limestones rare
	Atokan		Caseyville: Pounds		80	Pure quartz sandstones with quartz pebbles, thin coals, sandy shales, siltstones
			Caseyville: Battery Rock		250±	
						U
Mississippian	Chesterian		Kinkaid		146	Alternating sandstones, limestones, and shales
			Degonia		28	
			Clore		99	
			Palestine		57	
			Menard		109	
			Waltersburg		64	
			Vienna		6	
			Tar Springs		101	
			Glen Dean		58	
			Hardinsburg		83	
			Haney		57	
			Fraileys		76	
			Beech Creek		9	
			Cypress		92	
			Ridenhower		41	
			Bethel		86	
			Downey's Bluff		27	
			Yankeetown		34	
			Renault		25	
	Valmeyeran		Aux Vases		25	Sandstone
			Ste. Genevieve		225±	Limestone, oolitic
			St. Louis		350±	Limestone, some dolomite
			Salem		250±	Limestone with some chert
			Harrodsburg		80-300	
			Fort Payne		270-615	Limestone, siltstone, chert
Devonian			New Albany		400±	Black Shale

ISGS 1980

Figure 3. Generalized geologic column of strata exposed in Equality area. "U" indicates a major unconformity.

During Illinoian time (nearly 300,000 years ago) North American continental glaciers reached their southernmost limit of advance, about 30 miles to the southwest of the Equality area. Equality is about 6 miles south of the glacial margin in this area. Here, however, extensive sediments of glacial Lake Saline and thick loess (pronounced "luss") deposits record the effects of the glaciations that took place just a few miles to the north and to the west.

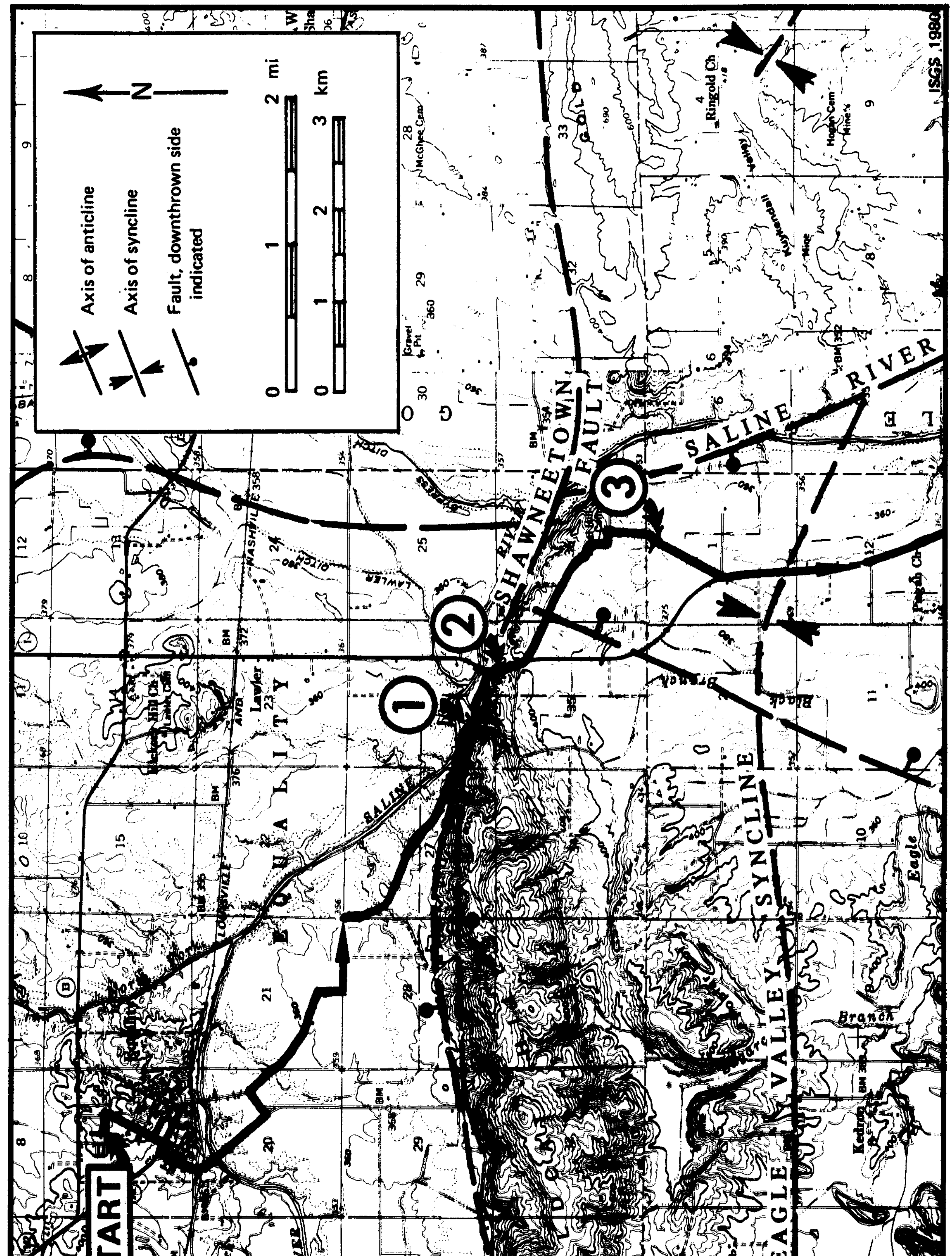
Mineral Production

Ninety-nine of the 102 counties in Illinois reported mineral production during 1978, the last year for which totals are available. The estimated total value of all mineral production in Illinois was more than $1.6 billion In 1978, coal, crude oil, sand and gravel, and natural gas produced in Gallatin County had a total value of more than $29 million. Coal, crude oil, and natural gas produced in Saline County was valued at more than $30 million.

Eight coal mines in four different coal seams in Saline County produced more than 1.3 million tons of coal valued at more than $28 million in 1978. Two mines in two different coal seams in Gallatin County produced more than 1.1 million tons of coal valued at more than $23 million. Total tonnage of coal produced in 22 Illinois counties was nearly 48.75 million tons valued at more than $997.3 million.

Approximately 434,000 barrels of crude oil valued at nearly $6 million were produced in Gallatin County during 1978. Oil production in Saline County amounted to about 150,000 barrels valued at more than $2 million. Crude oil produced in 43 Illinois counties was slightly less than 23.4 million barrels, with an estimated value of more than $322.4 million.

One sand and gravel operation was reported in Gallatin County during 1978. Nearly 43.5 million tons of sand and gravel having a value of more than $127.9 million were produced in 59 Illinois counties that year.


Axis of anticline
Axis of syncline
Fault, downthrown side indicated
N
0 1 2 mi
0 1 2 3 km
START
1
2
3
SHAWNEETOWN FAULT
EAGLE VALLEY SYNCLINE
SALINE RIVER
EQUALITY
ISGS 1980

guide to the route

Assemble, heading east on Davis Street, in front of Equality High School in the north part of town.

Miles to next point	Miles from starting point	
0.1	0.1	STOP, 3-way. TURN RIGHT (south) on McHenry Street.
0.45	0.55	STOP, 2-way. TURN RIGHT northwest on Lane Street (State Route 142) and prepare to turn left.
0.1	0.65	TURN LEFT (southwest) on Walnut Street at sign to Glen O. Jones Lake.
0.3	0.95	CAUTION: unguarded railroad crossing (Louisville & Nashville RR). CONTINUE AHEAD and BEAR LEFT (southeast).
0.1	1.05	Saline River bridge. CONTINUE AHEAD (southeast).
0.35	1.4	Prepare to turn left.
0.1	1.5	TURN LEFT (northeast) on gravel road.
0.2	1.7	TURN RIGHT (southeast) at Y-intersection.
0.3	2.0	To the right of the relatively flat Saline River valley we are now crossing is an erosional escarpment (cliff) along the north side of Wildcat Hills, the highest elevation of which is 768 feet m.s.l. Vertical displacement along the Shawneetown Fault has produced the Wildcat Hills.

Miles to next point	Miles from starting point	
2.1	4.1	To the right in the bluff is an abandoned quarry in Mississippian Ste. Genevieve Limestone.
0.3	4.4	The itinerary follows along the trace of the Shawneetown Fault for the next 0.85 miles.
0.45	4.85	Stop along road.

STOP 1

Negro Spring Salt Well in small clearing about 150 feet north of road (NW¼SE¼SW¼ Sec. 26, T. 9 S., R. 8 E., 3rd Principal Meridian, Gallatin County; Equality 7.5-minute Quadrangle).

Negro Spring is one of several salt springs in this area. Another is reported to occur about 250 feet to the east, but it has apparently been filled in with sediment and cannot be seen. Several small springs occur higher on the bluff to the south, each becoming less salty than those below (indicating that the brines are diluted by fresh water as they near the surface).

The springs are emerging along the Shawneetown Fault, a zone of crushed and shattered rock which permits deep saline-formation waters to migrate to the surface. Most water in deep bedrock formations is brackish or salty, and the salinity of these waters usually increases with depth. Most oil produced from deep wells is accompanied by salt water. The salt water is not, as commonly believed, ancient sea water that was trapped in the sedimentary rocks when they were being deposited on the sea floor: these waters were long ago squeezed out during compaction and hardening of the sediments to rock. However, small amounts of various soluble salts were deposited with the sediments. Water percolating from the surface down through the sedimentary rocks over millions of years has dissolved these salts and concentrated them in the formation waters. Under hydrostatic pressure, these waters sometimes escape to the surface when permeable, water-bearing formations are cut by faults or are penetrated by drilling.

According to historical reports, Negro Spring was used by the Indians as a source of salt. Numerous pottery fragments with ornate patterns can be found around the springs in this area, and the curvature of these fragments indicates that some of the pots were very large. These were probably used as evaporating pots to extract the salt.

The Illinois Historical Society sign on the highway suggests that Negro Spring was used for commercial salt production in the early 1800s. Stories persist locally that slaves and indentured servants from the Slave House were used to produce the salt. However, early reports of the Illinois State Geological Survey state that the only profitable production of salt was from wells and springs south of Equality on the north side of Saline River in Sec. 19, T. 9 S., R. 8 E. and from an area known as the "Half Moon," the exact location of which was not given. The latter was described as a semi-circular excavation, 100 yards long and 6 to 8 feet deep, "that was made by the buffalo and other wild animals that congregated in vast herds to lick the muriatiferous earth." Fragments of Ice Age mammoths and mastodons were found near this excavation, indicating that this salt lick had been in existence for a long time.

In the early 1800s, 125 to 280 gallons of brine were needed to produce 1 bushel (50 pounds) of salt at the Equality salt works. Production was 80 to 100 bushels per day. When operations became uneconomical because of competition from the east in Virginia and Ohio, two men, named Temple and Castle, purchased the area in 1850 to drill a deeper well. When the well reached a depth of 1,100 feet in the top of the Mississippian (Chesterian) rocks, brine capable of yielding a bushel of salt from 75 gallons was found. The Equality salt works were finally abandoned in 1875.

Analyses of brine samples from the Equality well and from Negro Spring, made in 1856 and 1941 respectively show the following salts and their concentrations. For further comparison, sea water contains 35,000 parts per million (ppm) of dissolved solids.

	Equality Well	Negro Spring
Sodium Chloride ($NaCl$)	62,431 ppm	18,659 ppm
Calcium Chloride ($CaCl_2$)	3,996 ppm	719 ppm
Magnesium Chloride ($MgCl_2$)	2,124 ppm	1,006 ppm
Calcium Sulfide ($CaSO_4$)	3,448 ppm	1,844 ppm
	71,999 ppm	22,228 ppm

These analyses support the early Survey report that salt could not be produced profitably from Negro Spring. In migrating upward along the fault the brine is diluted by fresh water near the surface.

Miles to next point	Miles from starting point	
0.0	4.85	Leave Stop 1. CONTINUE AHEAD (southeast).
0.05	4.9	CAUTION: cross ford.
0.35	5.25	STOP, 2-way. Intersection with (old) SR-1. Park along edge of gravel road and cross old highway to Stop 2.

STOP ②

Abandoned quarry in Caseyville sandstone (NE¼NW¼NE¼ Sec. 35, T. 9 S., R. 8 E., 3rd P.M., Gallatin County; Equality 7.5-minute Quadrangle).

In this abandoned quarry, about 90 feet of the lower Pennsylvanian Caseyville Formation is exposed (fig. 4). The exposed strata are mainly sandstone, but some shale is present. A thin 6-inch coal bed and an underclay in the lower part of the thickest shale indicates that swampy conditions prevailed for a while in this locality after deposition of the lower sandstone. The strata are steeply tilted toward the southwest at an angle of about 75 degrees. Originally horizontal when deposited, these strata have been tilted by the crustal forces that formed the Eagle Valley Syncline and the Shawneetown Fault, which passes just to the northeast of here.

The enormous crustal forces involved in folding and faulting the earth's crust can be fully appreciated by observing highly disturbed rocks such as these. The sandstone is intensely fractured and crushed as a result of the movements that occurred along the Shawneetown Fault.

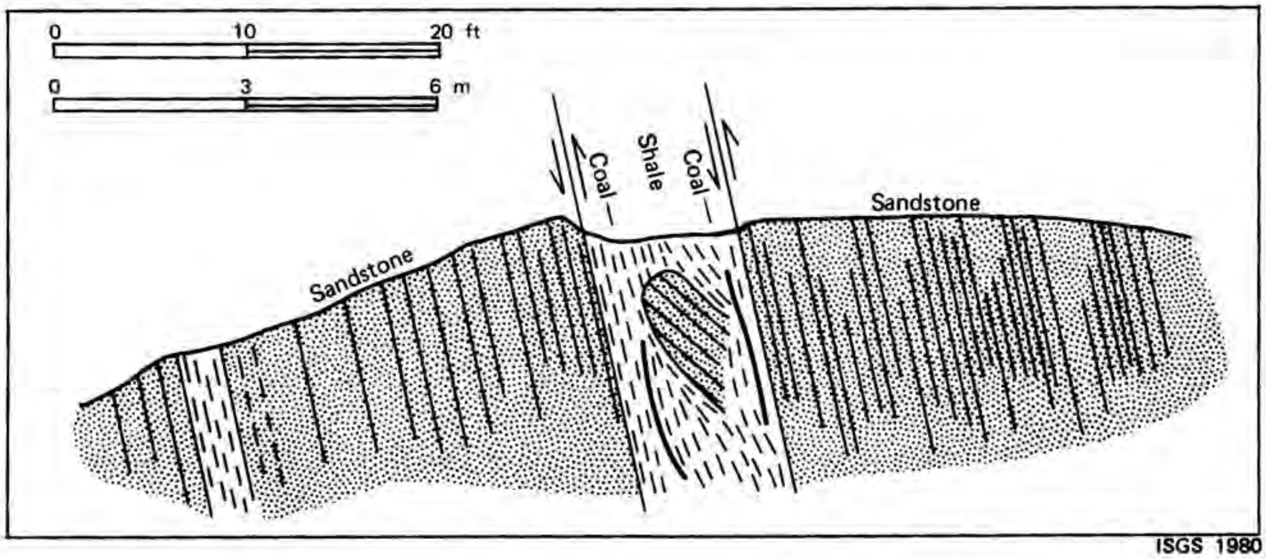


Figure 4. Diagram of strata exposed in small roadstone quarry at Stop 2. The section is drawn at a right angle to the fault (perpendicular to strike). The fault zone within the shale interval is shown by lines representing the bounding fault planes. Arrows indicate inferred relative movements.

A fault is a fracture in the earth's crust along which there has been relative movement of the opposing blocks. A fault is usually an inclined plane, and when the hanging wall (the block above the plane) has moved up relative to the footwall (the block below the fracture), the fault is a reverse fault (fig. 5). When the hanging wall has moved down relative to the footwall, the fault is a normal fault.

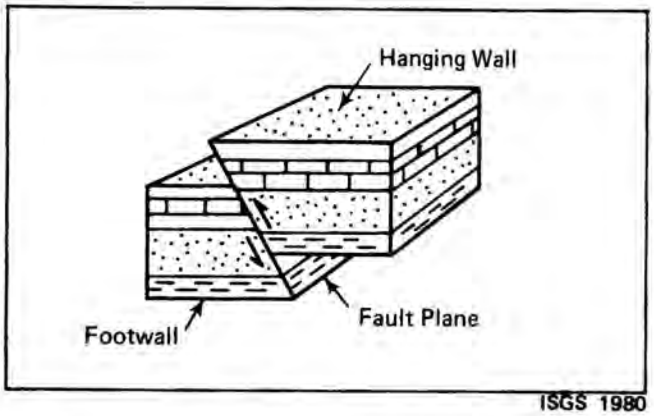


Figure 5. Block diagram illustrating the parts of a reverse fault.

The Shawneetown Fault, one of the largest in Illinois, is a high-angle reverse fault with stratigraphic displacements as great as 3,500 feet. The fault plane dips steeply southward. The south side or hanging wall of the fault has moved up relative to the north side. The fault crosses the field trip area from east to west along the front of Gold Hill and Wildcat Hills, passing north of Horseshoe, beyond which it turns abruptly southward along the front of Cave Hill. It gradually dies out southward into a sharp anticline called the Shawneetown Anticline.

The Shawneetown Fault is not simply a single fracture, but rather a zone of intensely crushed rock and branching faults a half mile or more wide. The compound nature of the fault is shown by the long, narrow blocks of Mississippian strata that were pushed upward hundreds of feet between branches of the fault in several places.

At Stop 2, a narrow zone of intense crushing and squeezing can be seen in the shale beds on the south side of the pit (fig. 4). A large block of sandstone has been pushed upward into the shale, and the shale and thin coal, which are weak, have sheared. What appears to be two coal beds actually is the same one, part of which has been sheared off and pushed upward from below. The shearing action took place when the sandstone block above the shale was pushed upward relative to the sandstone block below the shale. Movements also occurred along some of the bedding planes in the sandstone, and some of these surfaces exhibit polished surfaces with scratches called slickensides. The slickensides and polished surfaces were formed when the sandstone beds slid over one another. Heat and pressure generated during faulting also caused recrystallization and pressure-welding of the sandstone to quartzite, which is much harder than ordinary sandstone. This is probably the reason that the quartzite was quarried for use as roadstone, although it is a poor quality stone for this purpose. The quartzite crushes into sharp, angular fragments and is also very hard on crushing equipment, causing it to wear out rapidly.

Miles to next point	Miles from starting point	
0.0	5.25	Leave Stop 2. TURN RIGHT (south) and ascend hill.
0.3	5.55	STOP, 2-way; (new) SR-1. CONTINUE AHEAD (southeast) on gravel road.

Miles to next point	Miles from starting point	
1.05	6.6	T-intersection, TURN RIGHT (south).
0.3	6.9	Park along road and stand on small knoll to east of road.

STOP (3)

Discussion of Eagle Valley Syncline (NE¼NW¼NW¼NE¼ Sec. 1, T. 10 S., R. 8 E., 3rd P.M., Gallatin County; Equality 7.5-minute Quadrangle).

This vantage point affords an almost complete view of the sharp sandstone ridges that completely rim Eagle Valley on the north, west, and south sides (see itinerary map). Directly south is the Pounds, and slightly to the west is High Knob with its fire tower. Far in the distance, at the west end of the valley, is Horton Hill, the highest point on the horizon. Cave Hill can be traced northward to the Wildcat Hills, which extend eastward along the skyline to the north. The cemetery is located at the east end of Wildcat Hills. Saline River flows southward through the ridge via a gap that was developed in shattered rocks along a fault (see itinerary map). Gold Hill, the wooded area on the far right, is a continuation of the north ridge eastward to the Ohio River. The south ridge is not as well defined on its eastern end.

These sandstone ridges outline a large bedrock trough or syncline called Eagle Valley Syncline (fig. 6). A syncline is a fold in which the bedrock layers have been bent downward by compressive forces acting within the earth's crust. The strata on both sides or limbs of a syncline dip (tilt) inward toward the axis or lowest part of the fold. Along the axis or central part of an eroded syncline, the youngest folded rocks are exposed. The opposite of a syncline is an anticline, in which the strata are bent upward into an arch.

Eagle Valley Syncline is an asymmetrical fold in which the strata on the north limb dip more steeply than the strata on the south limb. Average dips are about 5 degrees on the south and 20 degrees on the north. The ridges that outline the syncline are formed by the eroded, upturned edges of resistant lower Pennsylvanian sandstones. These sandstones consist principally of massive sandstones of the Caseyville Formation, which form steep, outward-facing cliffs along much of their outcrop belt. The top of this erosional escarpment is capped by the Grindstaff Sandstone Member of the Abbott Formation. Eagle Valley itself is eroded in the softer shales and shaly sandstones that occur above the Grindstaff. The Anvil Rock Sandstone Member of the Carbondale Formation is also resistant to erosion and forms the low hills in the central part of the valley along the axis of the syncline (fig. 7).

The axis of the syncline plunges (is tilted downward) eastward, and thus the syncline is deepest and widest near the Ohio River. The syncline gradually dies out eastward into Kentucky. Near the western end of Eagle Valley,

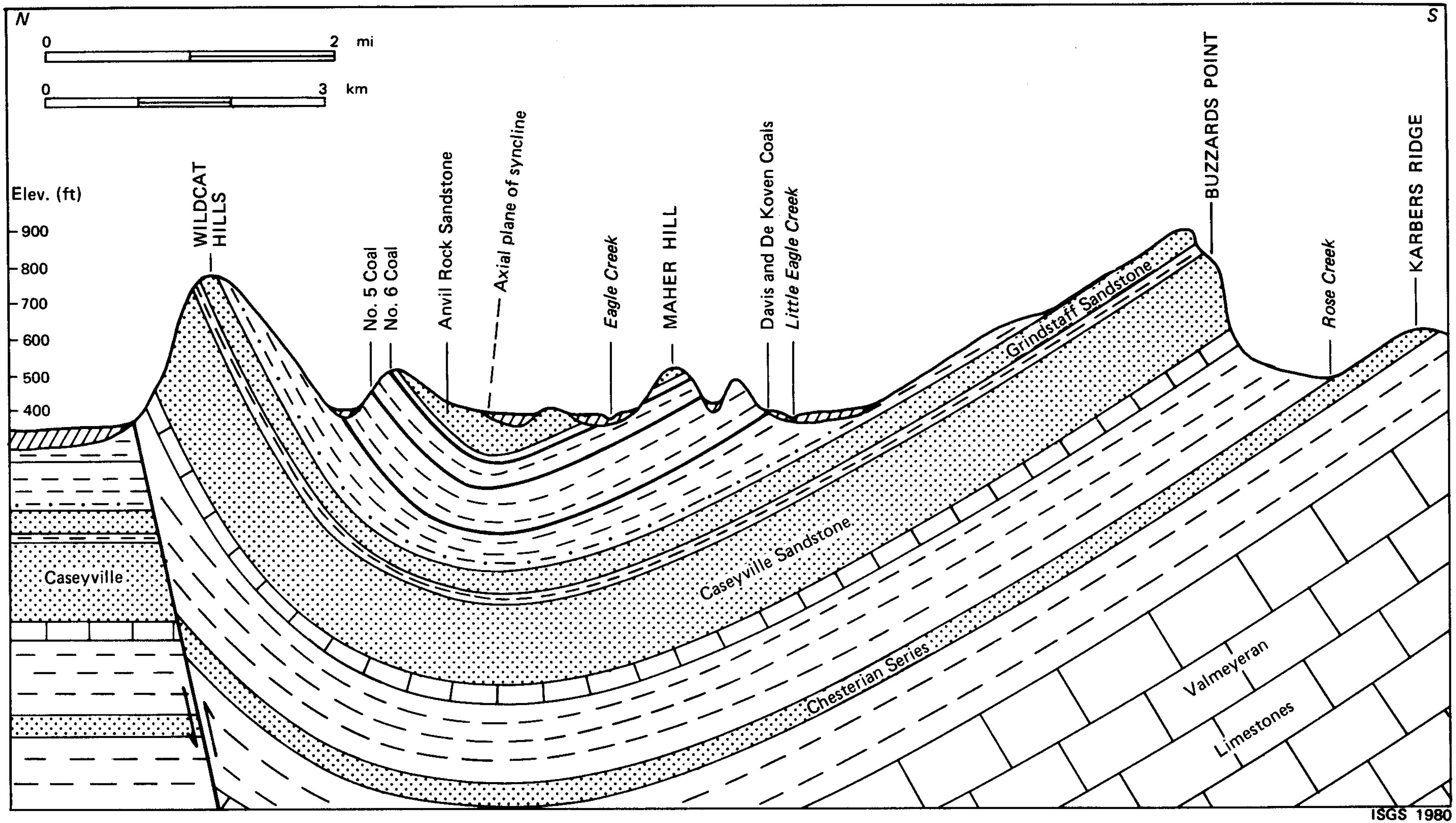


Figure 6. Generalized cross section through Eagle Valley Syncline from just south of Equality to Buzzards Point. Vertical scale and dips of strata are greatly exaggerated.

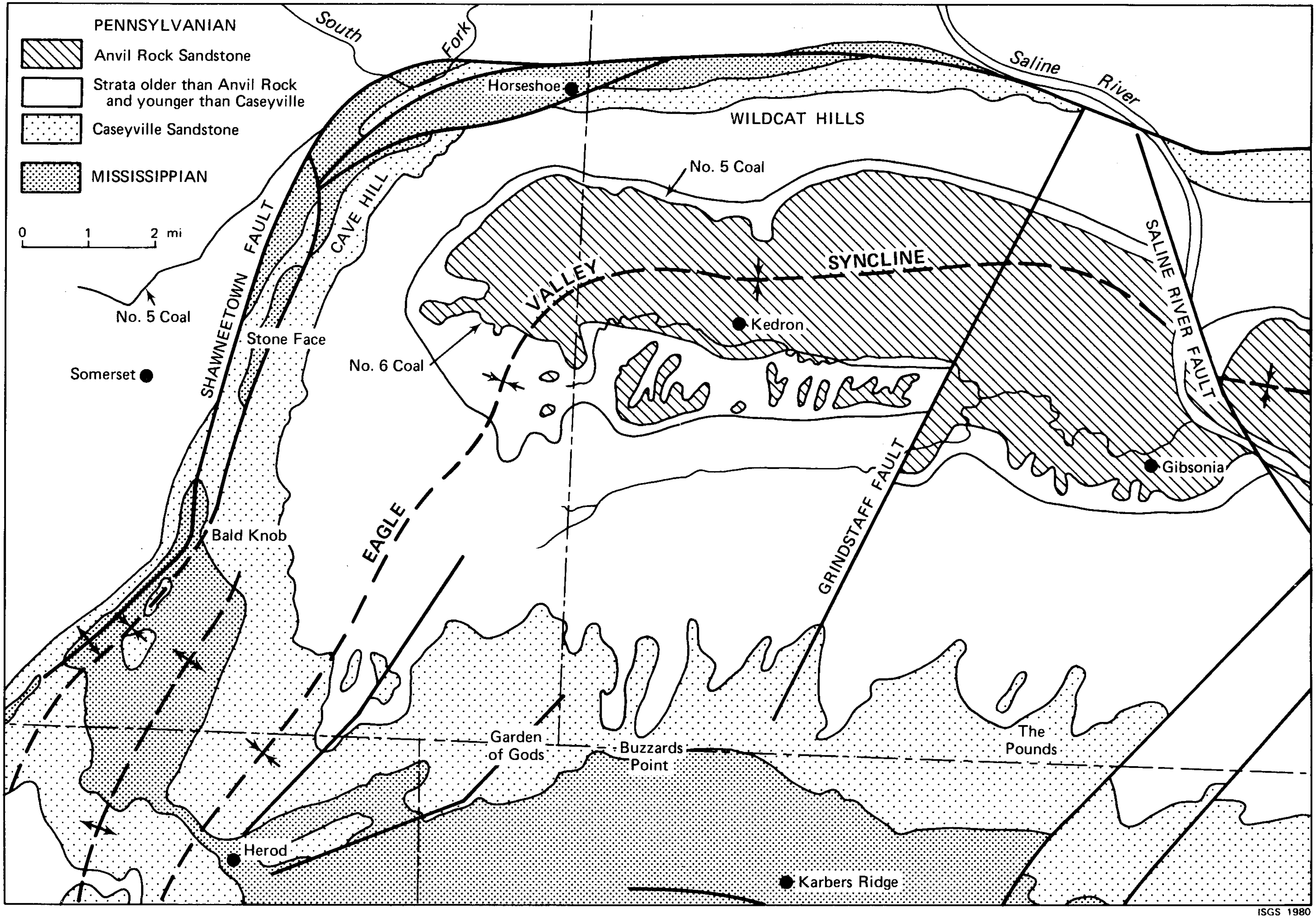


Figure 7. Generalized geologic map of Eagle Valley Syncline.

the axis bends sharply to the southwest, and the fold dies out in the vicinity of Herod. As the syncline becomes shallower and narrower westward, the sandstone ridges along its north and south limbs converge toward the axis at the nose of the syncline.

The Shawneetown Fault, a major fracture in the crust, bounds the syncline on the north and west. The Grindstaff and Saline River Faults cut across the syncline and bound a large block that has dropped down relative to the rocks on the east and west. Eagle Valley Syncline and the faults in the field trip area form part of a region of intensely disturbed Paleozoic strata that crosses southern Illinois and western Kentucky. This region, which includes the Illinois Fluorspar District, is cut by many high-angle faults.

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

Although earthquake recording began in the Midwest in 1909, it wasn't until 1962 that a serious attempt was made to keep detailed records. In 1976, a micro-earthquake network was begun, which facilitated the recording of most earth shocks, including quarry blasting. On November 9, 1968 an earthquake centered near Broughton in Hamilton County (about 15 miles to the northwest of the Equality area), was the largest magnitude earthquake ever recorded in Illinois (5.5 on the Richter Scale).

Miles to next point	Miles from starting point	
0.0	6.9	Leave Stop 3 and CONTINUE AHEAD (south).
0.55	7.45	STOP, 1-way; SR-1 BEAR LEFT (south) on SR-1.
0.35	7.8	Cross axis of Eagle Valley Syncline.
2.0	9.8	Cross Eagle Creek and ascend ridge at Gobsonia. This ridge has been strip-mined for the Harrisburg (No. 5) and Herrin (No. 6) Coals.
0.75	10.55	CAUTION: heavy truck crossing; Peabody Coal Company mine haulage road. CONTINUE AHEAD (south).
0.9	11.45	Prepare to turn right.

Miles to next point	Miles from starting point	
0.2	11.65	TURN RIGHT (southwest) on Karbers Ridge Road (County Road 13).
1.85	13.5	Entrance to Pounds Hollow Recreation Area to right. CONTINUE AHEAD (southwest).
1.0	14.5	Prepare to turn right.
0.15	14.65	TURN RIGHT (north) at entrance to Rimrock Forest Trail road.
0.2	14.85	Rimrock Forest Trail and Indian Wall Picnic Area parking lot.

STOP 4

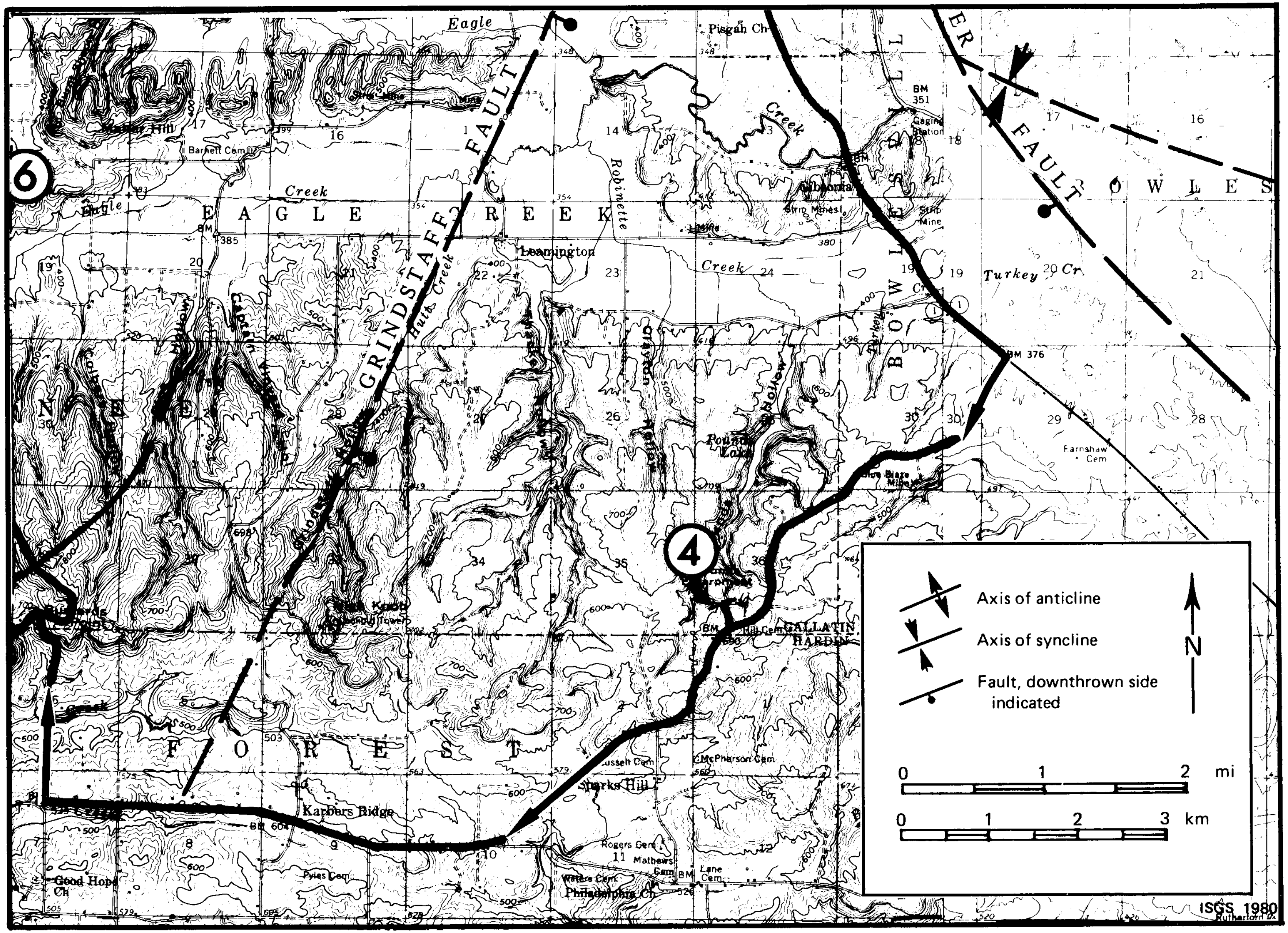
The Pounds Escarpment (N½NE¼SW¼SW¼ Sec. 36, T. 10 S., R. 8 E., 3rd P.M., Gallatin County; Karbers Ridge 7.5-minute Quadrangle).

The name "Pounds" is derived from the elongate pile of rocks extending across part of the south end of the rock promontory just to the north of the parking lot. Prehistoric man erected seven known rock structures in southern Illinois. At first these rock structures were thought to be defensive fortifications, but later research indicates that they probably were traps for catching large animals, particularly buffalo. It seems likely that before early man had perhaps even the bow and arrow and the use of the horse, wild animals may have been driven into these impoundments and then stampeded over the cliffs to their death.

The Pounds is a circular lower Pennsylvanian sandstone cliff that has been detached by erosion from adjacent, steep sandstone bluffs except for the one narrow access area just to the north. The Pounds Escarpment, about 80 feet high, encompasses an area of about 50 acres.

This is the type section of the Pounds Sandstone Member of the lower Pennsylvanian Caseyville Formation. That is, the area along Pounds Hollow contains exposures of this sandstone that are regarded as typical of its character and development. The rock exposed here is a durable massive, cross-bedded, rather clean quartz sandstone that has scattered quartz pebbles throughout, a characteristic of the Pennsylvanian McCormick Group sandstones.

The Pounds Sandstone is one of the important ridge makers in southern Illinois. Several of the lower Pennsylvanian resistant sandstones form a conspicuous south-facing cuesta (a ridge with a gentle slope on one side and a steep slope on the other) of high elevation and rugged topography stretching from east to west across southern Illinois. The Pounds



GRINDSTAFF FAULT
SHAWNEETOWN FAULT
COWLES
BOWLESVILLE
EAGLE CREEK
FOREST
Eagle Creek
Robinette
Leamington
Turkey Cr
Pisgah Ch
Barnett Cem
Karbers Ridge
Sparks Hill
Rogers Cem
Mathews Cem
Philadelphia Ch
Waters Cem
Pyles Cem
Good Hope Ch
Russell Cem
McPherson Cem
Farnshaw Cem
Pounds Lake
GALLATIN
HARDIN
Axis of anticline
Axis of syncline
Fault, downthrown side indicated
N
0 1 2 mi
0 1 2 3 km
ISGS 1980

Escarpment is located about 1/2 mile north of the south-facing Pennsylvanian escarpment. The Pounds is developed in the backslope of the Pennsylvanian cuesta where strata are tilted gently northward into the Eagle Valley Syncline with dips of 5 to 10 degrees. Here the north-flowing streams have been incised deeply into the dip slopes and have eroded downward through the sandstone into the underlying Drury Shale Member of the Caseyville Formation. The shale has been undercut, causing large sandstone blocks bounded by joints to lose their support and slowly creep down dip (mass wasting) which is responsible for most of the huge, detached rock masses in the valley below. Of particular interest is "Fat Man's Squeeze," a narrow open joint produced by this process along the north side of the Pounds. A few small rock shelters are found near the base of the sandstone where erosion has undercut the cliff face and weathering of a weak area of sandstone has produced an overhanging ledge that affords some protection from the weather; Ox Lot Cave at the north end of the Pounds is an example.

Miles to next point	Miles from starting point	
0.0	14.85	Leave Stop 4. Retrace route southward to County Road 13.
0.2	15.05	STOP, 1-way; County Road 13. TURN RIGHT (southwest).
0.1	15.15	Enter Hardin County.
0.6	15.75	Crest of Pennsylvanian escarpment, approximately 740 feet m.s.l. Lower land surface ahead (south) is developed on Mississippian strata.
1.1	16.85	The brown material exposed in the road-cuts is loess.
0.2	17.05	Loess exposure to the right is about 15 feet thick.
0.2	17.25	Mississippian Tar Springs Sandstone exposure.
0.8	18.05	Karbers Ridge School to right. Exposure on Mississippian Hardinburg Sandstone to right. View of Pennsylvanian Caseyville escarpment to right (north).
0.7	18.75	CAUTION: enter hamlet of Karbers Ridge. CONTINUE AHEAD (west).
1.75	20.5	Prepare to turn right.

Miles to next point	Miles from starting point	
0.15	20.65	TURN RIGHT (north) toward Garden of the Gods Recreation Area. The route crosses upper Chesterian formations that dip northward about 7°.
0.2	20.85	Caseyville escarpment ahead (north).
0.4	21.25	Mississippian Menard Limestone exposed along Rose Creek to right.
0.2	21.45	Mississippian Palestine Sandstone exposure to right.
0.2	21.65	Mississippian Clore Formation exposure in deep gully to right.
0.2	21.85	Mississippian Clore Formation and basal Pennsylvanian Caseyville Formation (Lusk Shale Member) contact is concealed on right by rock debris (talus) from the overlying Battery Rock Sandstone Member.
0.2	22.05	CAUTION: TURN LEFT (west) on Garden of the Gods access road.
0.3	22.35	View to right (north) of Eagle Valley Syncline.
0.25	22.6	Enter Saline County and Garden of the Gods Recreation Area.
0.75	23.35	Road intersection: Pharoah picnic area to right; Garden of the Gods trail ahead and to the left. Resume mileage from this intersection when you leave.

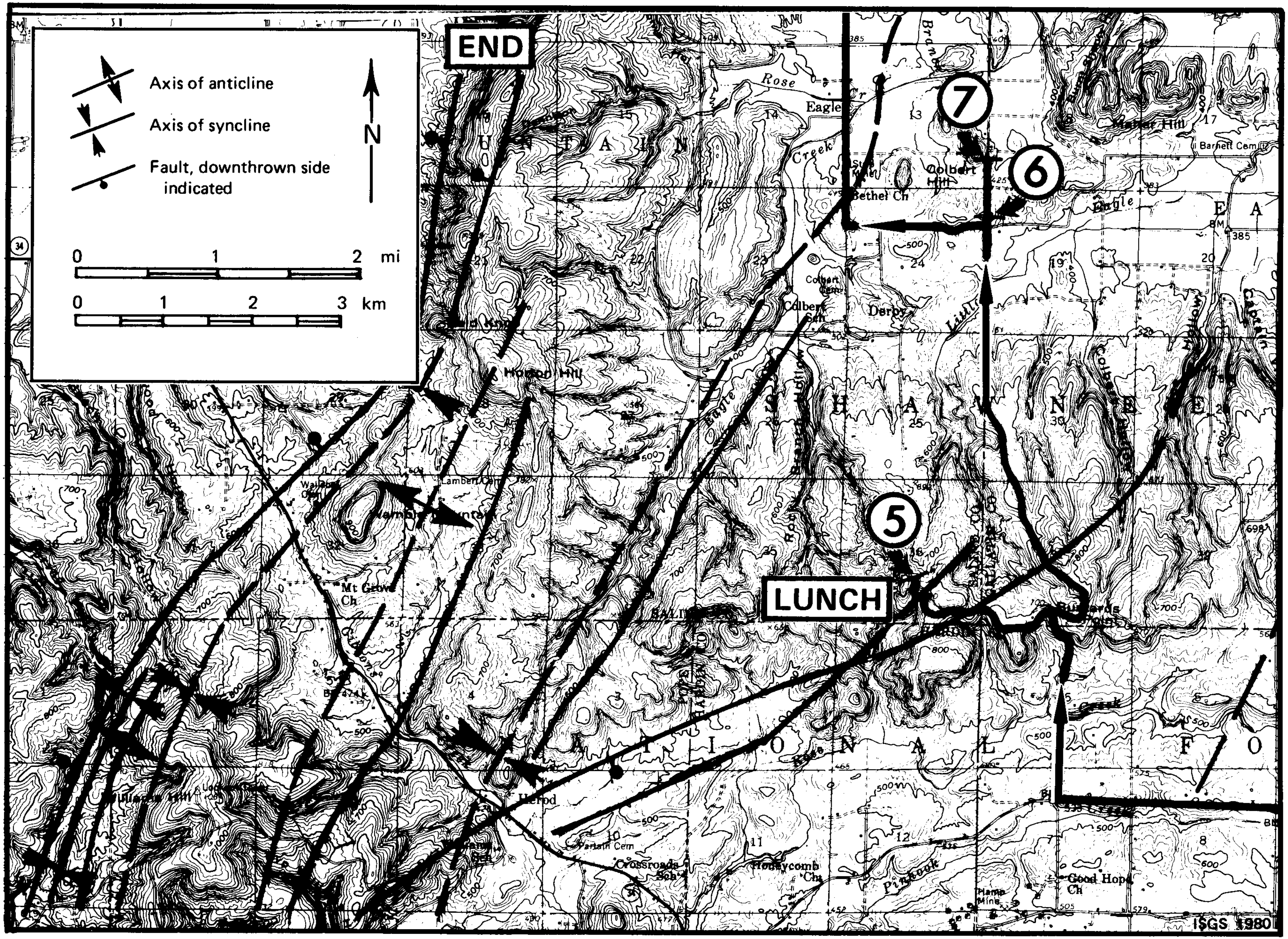
STOP 5

Lunch (Near center W½SE¼Sec. 36, T. 10 S., R. 7 E., 3rd P.M., Saline County; Herod 7.5-minute Quadrangle).

STOP 5 A.

Garden of the Gods trail (NE¼SE¼SW¼ and SE¼NE¼SW¼ Sec. 36, T. 10 S., R. 7 E., 3rd P.M., Saline County; Herod 7.5-minute Quadrangle).

The rock layer exposed here is the Pounds Sandstone Member of the Pennsylvanian Caseyville Formation. The sandstone dips northward about 8°. Weathering and erosion of the resistant sandstone has produced a variety of bizarre erosional remnants which have given the area its name.



END
LUNCH
5
6
7
Axis of anticline
Axis of syncline
Fault, downthrown side indicated
N
0 1 2 mi
0 1 2 3 km
Rose
Eagle
Creek
Bethel Ch
Colbert Hill
Derby
Barnett Cem
Good Hope Ch
Crossroads Sch
Honeycomb Ch
Herod
Mt Grove Ch
Lambert Cem
ISGS 1980

The Pounds Sandstone exposed here is massive, ripple marked, and cross-bedded, and not as coarse grained and conglomeratic here as in other areas nearby. The joints are widely spaced and large blocks of the sandstone have slumped because of undercutting of the weak underlying Drury Shale.

An interesting feature of the Pounds Sandstone here is the strangely contorted appearance of the exposure surfaces. These contortions are large-scale Liesegang rings which are common in sedimentary rocks. They form by diffusion of salts (in this case, iron oxide) through the body of the rock. Migration occurs along several fronts from numerous centers, and the salts become concentrated in a series of concentric bands as noted here. These bands are more resistant to weathering than the normal sandstone, and they stand out in bold relief on outcrop surfaces. On the scarp face immediately south of "Fat Man's Squeeze" the bands are beautifully developed, and one can actually walk along some of them across the cliff face.

If you examine the exposures carefully, you will see that the bands cut across primary structures such as cross-bedding.

The western part of the Eagle Valley Syncline is visible from the higher sandstone pinnacles of the Garden of the Gods. To the north there are areas of disturbed land from strip mining of the David, De Koven, Harrisburg (No. 5), and Herrin (No. 6) Coals (see fig. 3).

Miles to next point	Miles from starting point	
0.0	23.35	Leave Stop 5 and retrace route to access road entrance.
0.25	23.6	In the bluff to the left are several small rock shelters that have developed along some vertical joints in less resistant parts of the sandstone. CONTINUE AHEAD (easterly).
0.3	23.9	In the cliff face to the left is a natural bridge that has developed through the intersection of a large open joint (fracture) and a less resistant zone in the sandstone that was easily eroded back into the face. CONTINUE AHEAD (easterly).
0.75	24.65	STOP, 1-way. Observe the northward-tilted Battery Rock Sandstone across the road. TURN LEFT (north) and ascend the hill.
1.9	26.55	Slightly to the right (north) is a view of the inner part of Eagle Valley Syncline. In the far distance is Cave Hill

Miles to next point	Miles from starting point	
		and Wildcat Hills that form the northern rim of the syncline.
0.8	27.35	Cross Little Eagle Creek.
0.2	27.55	To the right is an exposure of siltstone that probably occurs just above the Davis Coal Member.
0.25	27.8	De Koven Coal Member exposed in bank to right.
0.1	27.9	Crossroad. CONTINUE AHEAD (north).
0.05	27.95	Stop along east side of road.

STOP 6

Colchester (No. 2) Coal Member and associated strata exposed in roadcut (SW¼NW¼NW¼ Sec. 19, T. 10 S., R. 8 E., 3rd P.M., Gallatin County; Equality 7.5-minute Quadrangle).

The Colchester (No. 2) Coal Member is probably the most widespread coal in the Midwest. However, in this part of Illinois, the No. 2 Coal is too thin to mine. The coal marks the base of the Carbondale Formation.

PENNSYLVANIAN SYSTEM	
Desmoinesian Series	
Kewanee Group	
Carbondale Formation	
Pleasantview Sandstone Member - weathered yellow brown, fine- to medium-grained, highly jointed, beds up to 15" thick	4'+
Siltstone—weathered yellow brown	35'±
Mecca Quarry Shale Member - black weathered	10"
Francis Creek Shale Member - medium gray, weathered	4"
Colchester (No. 2) Coal Member - badly weathered, soft	4"-5"
Spoon Formation	
Underclay - light to medium gray, contains rootlets	6"+

Across the road to the southwest the Davis and De Koven Coal Members were strip mined about 15 years ago. On the north side of the highwall, 29 inches of weathered De Koven Coal is exposed about 9 feet above water level. In this area, the two coals usually are about 17 to 25 feet apart. The Davis Coal averages about 4 feet thick in this part of Illinois.

Miles to next point	Miles from starting point	
0.0	27.95	Leave Stop 6. CONTINUE AHEAD (north).
0.4	28.35	TURN LEFT (west) into abandoned strip mine area.

STOP 7

Abandoned strip and auger mine in the Harrisburg (No. 5) Coal Member (NE¼SE¼SE¼ Sec. 13, T. 10 S., R. 7 E., 3rd P.M., Saline County; Equality and Rudement 7.5-minute Quadrangles).

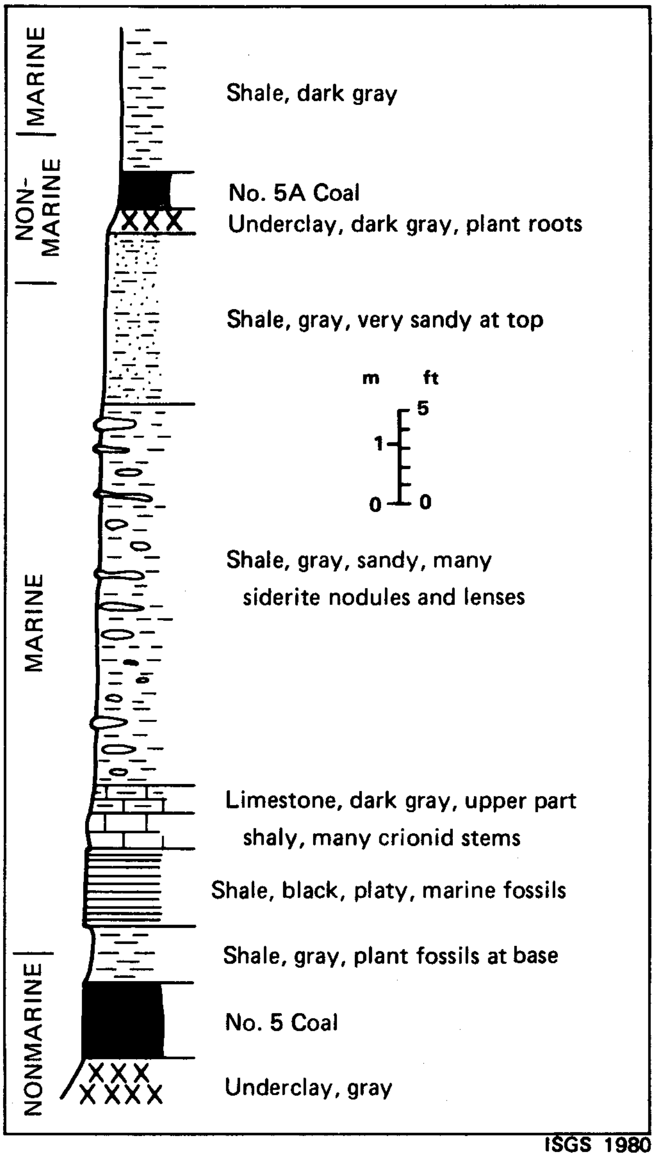
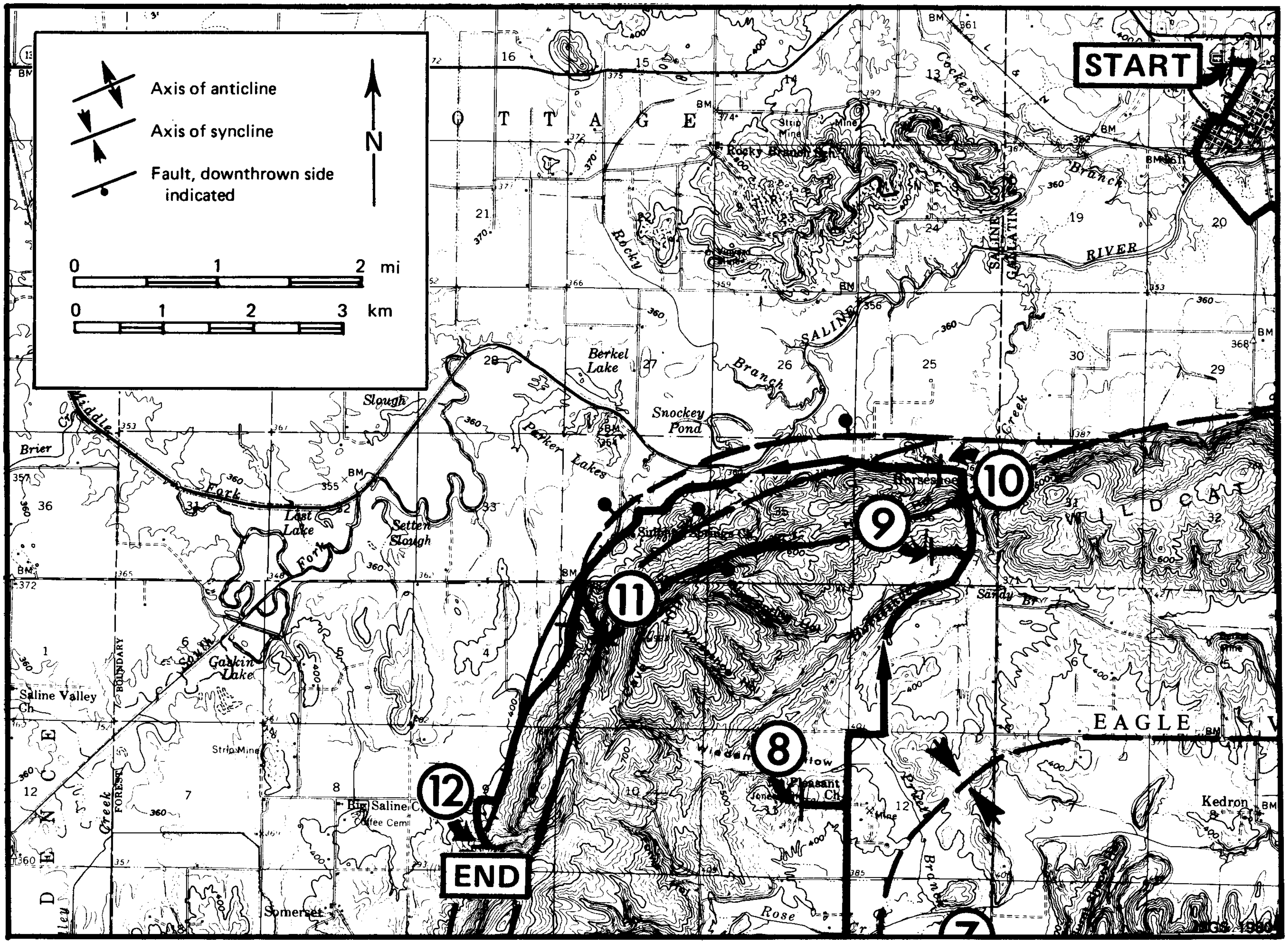


Figure 8. Strata exposed at Stop 7. Scale: one inch = 10 feet.

The No. 5 Coal is exposed at the bottom of the pit, and the No. 5A Coal is exposed on the highwall above. Only the No. 5 Coal was mined in this pit (fig. 8). The interval between the coals is 41 feet here.

The St. David Limestone above the No. 5 Coal is extremely fossiliferous in this pit. Note how quickly the limestone changes in character laterally along the pit face. Within a few feet, it changes from massive limestone to fossiliferous shale with abundant crinoid stem fragments. The gray shale immediately above the coal contains impressions of plant fossils. The slaty black shale contains abundant marine fossils, including brachiopods, bivalves, and gastropods. The brachiopods and bivalves are pyritized and are flattened along the shale laminae. By splitting the shale, interesting specimens can be collected. Many of the brown siderite nodules in the shale above the St. David Limestone contain well-crystallized calcite, pyrite, and sphalerite.



START
END
Axis of anticline
Axis of syncline
Fault, downthrown side indicated
N
0 1 2 mi
0 1 2 3 km
Berkel Lake
Snockey Pond
Parker Lakes
Setten Slough
Last Lake
Gaskin Lake
Saline Valley Ch
SALINE RIVER
Rocky Branch
Cockerel Creek
EAGLE
Kedron
Somerset
Big Saline Ch
Horseshoe
Pleasant Ch

Miles to next point	Miles from starting point	
0.0	28.35	Leave Stop 7. TURN AROUND AND HEAD SOUTH to the crossroad.
0.45	28.8	TURN RIGHT (west) on gravel road.
0.75	29.55	Y-intersection. CONTINUE AHEAD (west and then north).
0.7	30.25	Cross axis of Eagle Valley Syncline (see route map). To the right, note abandoned contour strip mining around the hill tops.
0.2	30.45	CAUTION: narrow culvert across Eagle Creek.
0.2	30.65	CAUTION: narrow bridge across Rose Creek.
0.5	31.15	The route here is about 2.4 miles due east of Old Stone Face which is beyond the ridge to the left in the distance.
0.45	31.6	CAUTION: crossroad at Mt. Pleasant Church. The Social Brethren Church was organized here on August 27, 1867. TURN LEFT (west).
0.3	31.9	Stop and park at the southwest corner of Jones Cemetery. NOTE: do NOT attempt to drive through the cemetery—the road does NOT make a loop.

STOP 8

Abandoned strip mine area in No. 5, No. 5A, and No. 6 Coals (Center and SW¼SE¼NE¼ Sec. 11, T. 10 S., R. 7 E., 3rd P.M., Saline County; Rudement 7.5-minute Quadrangle).

The rocks exposed in the lower strip pit to the west are essentially the same as those exposed at Stop 7. Although this stop is only 1.8 miles northwest from Stop 7, some differences are noted between the sections exposed at both places. The interval between coals 5 and 5A is 53 feet here, while it is 41 feet at Stop 7. Black shale and limestone are present above the 5A Coal here, but absent at Stop 7. The No. 5A Coal is minable thickness here.

A thick section of strata in the Pennsylvanian Carbondale Formation is exposed in this abandoned strip mine. Three coal beds and portions of four cyclothems (a total of more than 160 feet of strata) can be seen in a composite section in two strip pits. The upper part of the section is exposed in the smaller of the two pits that is located east of the cemetery. The section is illustrated in figure 9. The strata are tilted

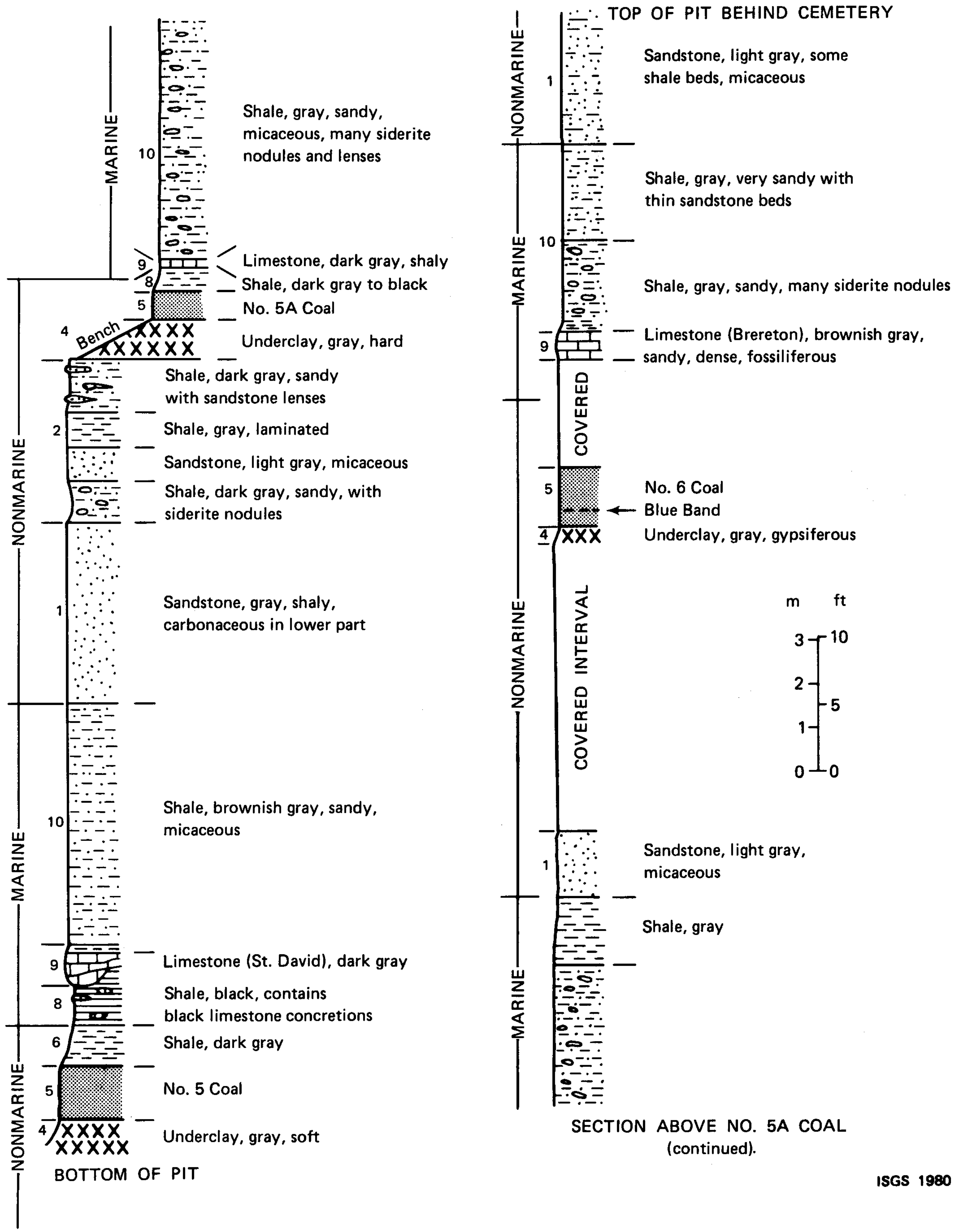


Figure 9. Composite section of strata exposed at Stop 8. Scale: one inch = 10 feet.

gently eastward at about 4 degrees toward the axis of the syncline. This locality is near the west end of Eagle Valley, where the axis of the syncline turns sharply southward (see itinerary map).

The section exposed here offers a remarkable opportunity to examine the extremely variable character of the Pennsylvanian sedimentary rocks and thus to envision the diversity of sedimentary conditions that existed during their deposition. Figure 9 shows the inferred intervals of marine and nonmarine sediments.

Several of the Pennsylvanian coals in Illinois are officially designated by numbers, as are the Harrisburg (No. 5) Coal, the Briar Hill (No. 5A) Coal, and the Herrin (No. 6) Coal exposed here at Stop 8. These numbers were assigned by early geologists in the middle 1800s when they recognized that the coals were widespread and easily recognized. They numbered the coal beds in an attempt to better understand and interpret the Pennsylvanian strata. The coals were numbered consecutively from the oldest (lowest) to youngest (highest). However, later it was discovered, after more refined field studies, that there were other coal beds that had not been previously recognized, thus adding confusion to the numbering system. Letter designations, such as 5A, were added for a while, but it was finally decided to use geographic names for the coal beds in accordance with the standard practice of stratigraphic nomenclature. Because of long usage, however, the numbers, along with geographic names, are still used for the more widespread, commercially important coals.

The No. 5A Coal is not as thick or as widespread as the underlying No. 5 Coal or the overlying No. 6 Coal. The No. 5A Coal is of minable thickness in this area (24 inches), but it is not as good a coal as the other two. The underclay below the No. 5A Coal contains abundant molds and casts of tree roots known as *Stigmaria*.

The No. 5 and No. 6 Coals have been extensively mined by stripping and augering in Eagle Valley. The outcrop belt of these coals extends completely around the inner part of the syncline. Because of the steep dip of the strata toward the axis of the syncline, the coals can only be contour-mined along the outcrop.

The No. 6 Coal is a widespread, commercial coal in Illinois, is characterized by the presence of a clay band, called the "blue band," in its lower half. This clay band, which might possibly represent a volcanic ash fall, is extremely persistent, even being found with associated rocks in areas where the coal is missing. It occurs over thousands of square miles in the Midwest. The Brereton Limestone above the No. 6 Coal is one of the most laterally persistent Pennsylvanian limestones, and it serves as an important marker bed for stratigraphic studies.

The shaly limestone above the No. 5A Coal and the St. David Limestone above the No. 5 Coal are both fossiliferous. The limestone above the No. 5A Coal is quite shaly, indicating that the sea was muddy during its deposition, but crinoids apparently found this environment quite suitable, because the limestone is literally filled with their stem fragments. None of the sandstones exposed here is a channel sandstone. However, the sandstones are crossbedded and ripple marked, indicating very shallow-water conditions of deposition. Carbonaceous or coaly streaks in the sandstones and sandy shales also indicate nearshore marine or shallow-water nonmarine conditions.

Miles to next point	Miles from starting point	
0.0	31.9	Leave Stop 8 and return to main road.
0.3	32.2	STOP, 1-way. CAUTION: TURN LEFT (north).
0.05	32.25	The area on both sides of the road has been strip mined for the No. 6 Coal.
1.0	33.25	Roadcut through shale occurring above the Anvil Rock Sandstone Member. This shale is in the Carbondale Formation and is the youngest bedrock that will be seen on this field trip.
0.6	33.85	Anvil Rock Sandstone crops out along the road in this vicinity.
0.6	34.45	TURN LEFT (west) at entrance to Saline County Conservation Area.
0.1	34.55	BEAR LEFT (west) at Y-intersection toward concession stand parking lot.
0.1	34.65	Steeply tilted beds of Murray Bluff Sandstone Member in bank north of driveway. The sandstone is light gray, medium-grained, and micaceous.
0.1	34.75	Concession stand parking lot.

STOP 9

Structure at Glen O. Jones Lake (S½SW¼NW¼SE¼ Sec. 36, T. 9 S., R. 7 E., 3rd P.M., Saline County; Rudement 7.5-minute Quadrangle).

Jones Lake lies in a strike valley eroded in Pennsylvanian shales and shaly sandstones of the Pennsylvanian Spoon and Carbondale Formations. Steeply dipping beds of the Murray Bluff Sandstone, exposed north of the parking lot, form the north side of the valley, and the resistant Anvil Rock Sandstone caps the ridge along the south side. The lake, which was formed by damming Horseshoe Creek, serves as a State recreational camping and fishing area.

Miles to next point	Miles from starting point	
0.0	34.75	Leave Stop 9. Return to gravel road.
0.3	35.05	STOP, 1-way. TURN LEFT (north).
0.1	35.15	Murray Bluff Sandstone exposed in roadcut on left. The sandstone beds are dipping 10 degrees south into the Eagle Valley Syncline.
0.45	35.6	STOP, 1-way. Abandoned village site of Horseshoe. TURN LEFT (west).
0.15	35.75	Stop at lane just beyond white house on right. Walk down lane to the right (north) about 1/5 mile to the north side of the wooded hill.

STOP 10

Abandoned roadstone quarry in Mississippian Fort Payne Formation in hill north of road (W½NW¼NE¼ Sec. 36, T. 9 S., R. 7 E., 3rd P.M., Saline County; Rudement 7.5-minute Quadrangle).

About 200 feet of the Mississippian Fort Payne Formation is exposed in this quarry in another fault block within the Shawneetown Fault Zone (fig. 10). Below the Fort Payne, several feet of the Upper Devonian New Albany Shale Group is also exposed at the north end of the quarry. These are the oldest exposed rocks in the field trip area.

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

The greatest amount of displacement along the Shawneetown Fault has occurred at this locality. The New Albany Shale occurs at a depth of about 3,700 feet below the surface on the north side of the fault. This block was pushed up during a great thrusting movement along the fault and tilted backward at the same time. The strata here are dipping at about 75 degrees. The rocks are highly crushed and fractured as a result of the faulting.

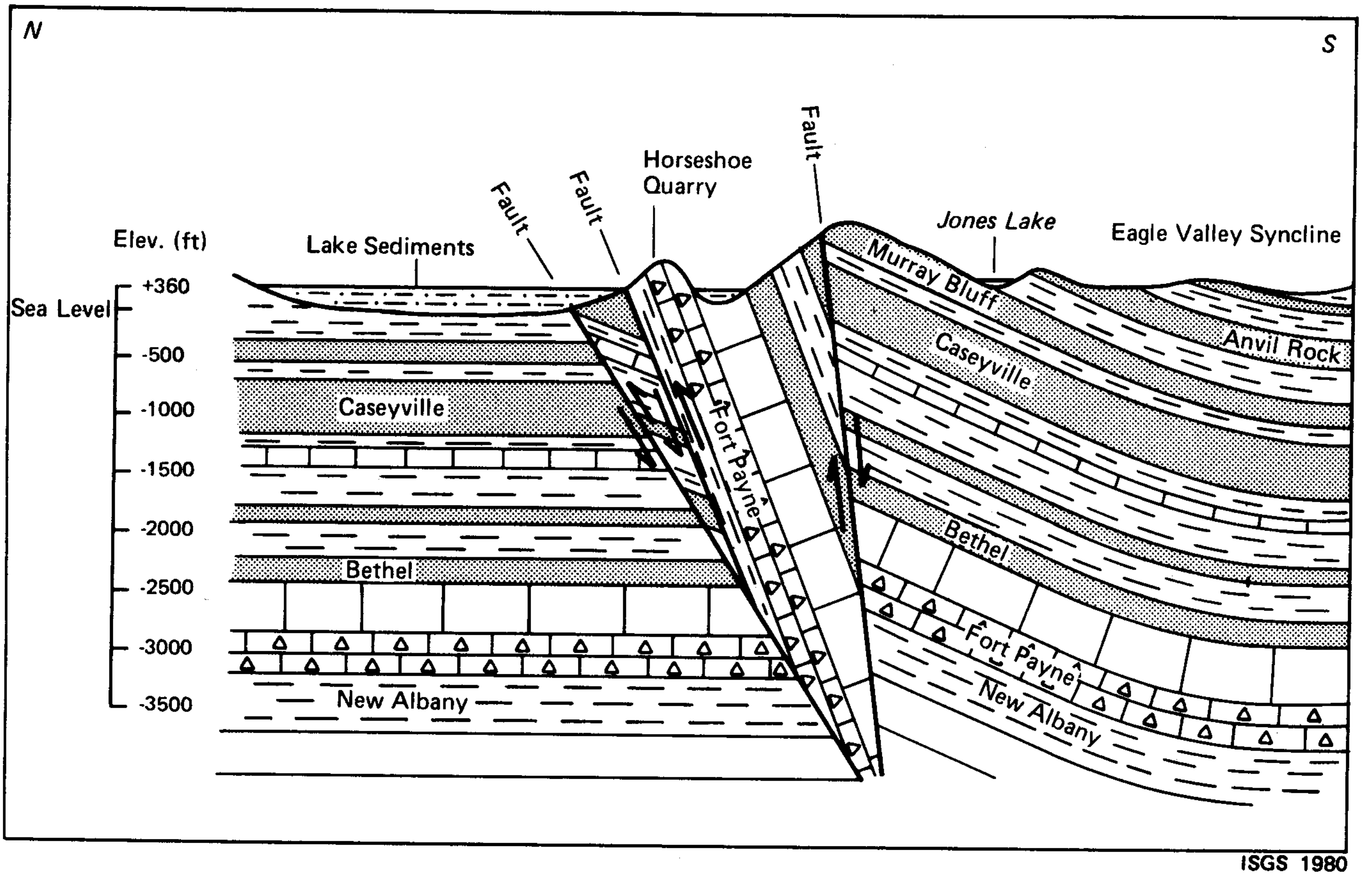


Figure 10. Diagrammatic cross section across the Shawneetown Fault Zone at Horseshoe. Only key formations are shown to illustrate general stratigraphic relationships. Thicknesses not to scale.

Miles to next point	Miles from starting point	
0.0	35.75	Leave Stop 10. Continue ahead (west).
0.15	35.9	Bethel Sandstone in roadcut.
1.15	37.05	Chesterian sandstone (quartzite) in roadcut.
1.15	38.2	Sulphur Springs Baptist Church on left. A cave is developed in the Kinkaid Limestone in the bluff about one-half mile behind the church.
0.1	38.3	Y-road from right. Continue ahead.
0.4	38.7	Y-intersection. Turn left at sign pointing to Old Stone Face. Abandoned strip mine in Davis and De Koven Coals on the right.
0.3	39.0	Y-intersection. Park car and ascend hill 0.4 mile to old quarry.

STOP 11

Abandoned quarry in Chesterian Kinkaid Limestone (NE¼SE¼SW¼ NW¼ Sec. 3, T. 10 S., R. 7 E., 3rd P.M., Saline County; Rudement 7.5-minute Quadrangle).

About 20 feet of the Chesterian Kinkaid Limestone is exposed in this abandoned quarry. The exposure is in still another upthrown fault block along the front of Cave Hill. The block is tilted eastward at about 15 degrees. The Kinkaid is gray, fine to medium grained, thick bedded to massive, and fossiliferous. It is somewhat argillaceous with shale partings along the bedding places. The upper 3 feet of the ledge is coarsely crystalline and very fossiliferous.

The ledge of limestone in this quarry is the lower part of the Kinkaid Limestone. The shale above the bench is also part of the Kinkaid. The lower 3 feet of the shale contains thin limestone beds up to 6 inches thick that are extremely fossiliferous. Excellent specimens of brachiopods (*Composita*), bryozoans (*Archimedes*, *Rhombopora*, and *Fenestrellina*), and crinoid stems can be collected from the shale.

Miles to next point	Miles from starting point	
0.0	39.0	Leave Stop 11. CONTINUE AHEAD (south).
1.45	40.45	T-road to Old Stone Face on left. TURN LEFT (south) and ascend hill.
0.35	40.8	Old Stone Face parking area.

STOP 12

Old Stone Face (NW¼SW¼SE¼ Sec. 9, T. 10 S., R. 7 E., 3rd P.M., Saline County; Rudement 7.5-minute Quadrangle). Follow path and stairs from parking area. Turn right at top of stairs. DO NOT ATTEMPT TO SCALE THE CLIFF. DO NOT GET TOO CLOSE TO THE CLIFF WHEN ON TOP. DO NOT THROW ANYTHING OVER THE EDGE.

The Old Stone Face, one of the best known natural wonders of southern Illinois, is located on the western edge of Cave Hill about 730 feet above sea level. The bluff affords a magnificent view to the north and west overlooking the valley about 350 feet below.

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

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

Cave Hill forms an erosional fault scarp at the west end of Eagle Valley. In this locality, the stratigraphic displacement on the Shawneetown Fault is about 1,000 feet. The Pounds Sandstone lies 500 feet below the valley bottom west of Cave Hill.

End of Field Trip

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PHYSIOGRAPHIC DIVISIONS OF ILLINOIS

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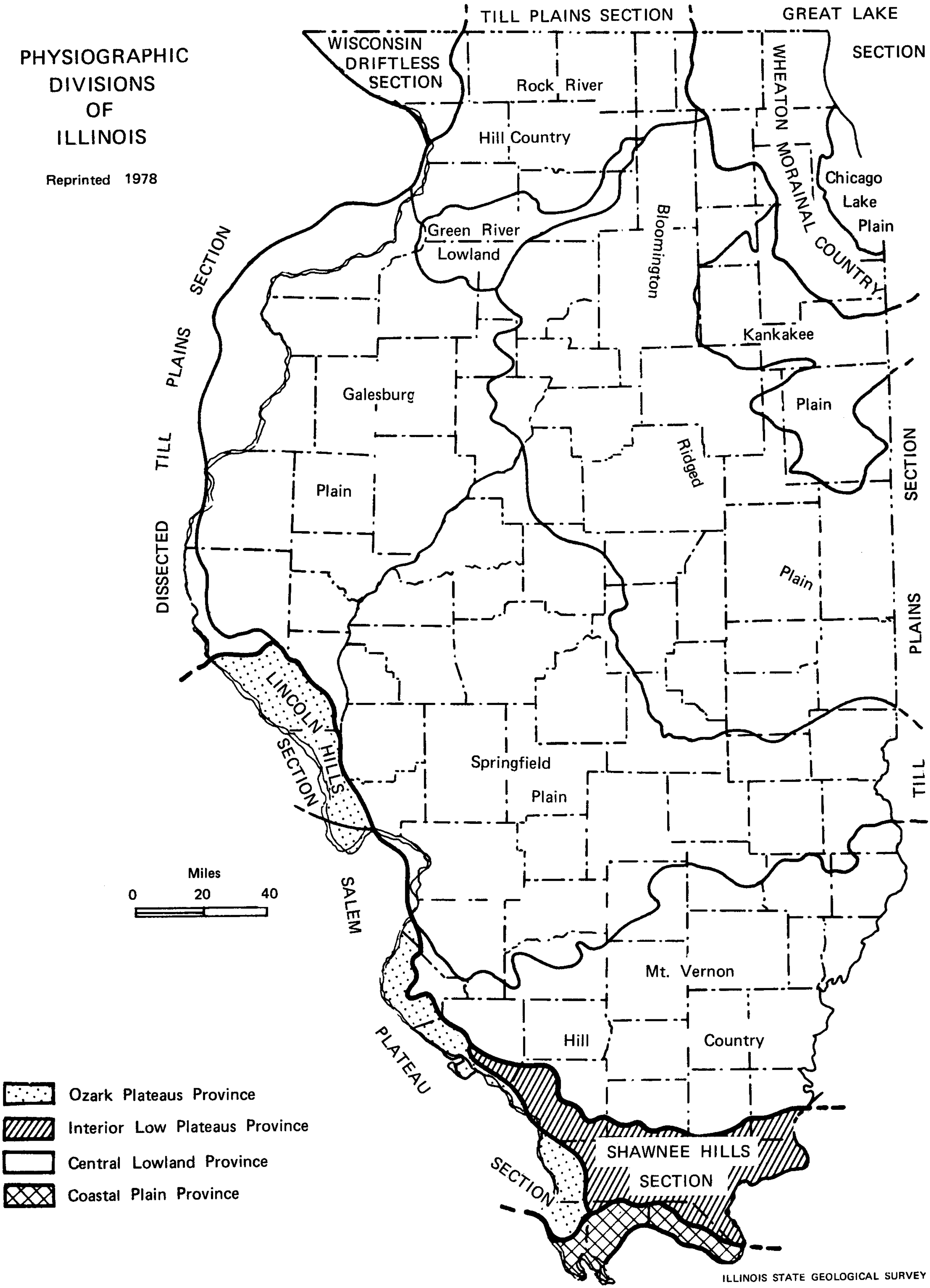


PLEISTOCENE GLACIATIONS IN ILLINOIS

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

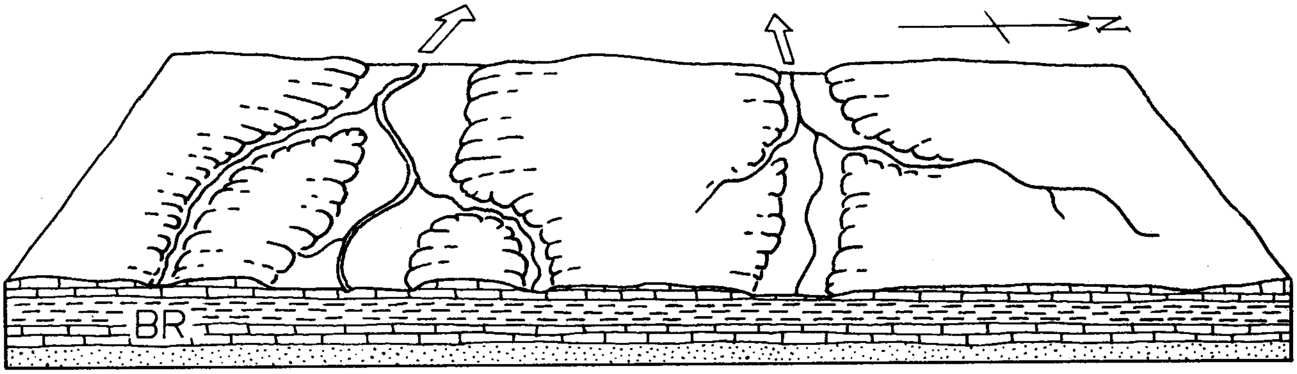
One of the most widespread sediments resulting from glaciation was carried not by ice or water but by wind. Loess is the name given to such deposits of windblown silt and clay. The silt was blown from the valley trains on the floodplains. Most loess deposition occurred in the fall and winter seasons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

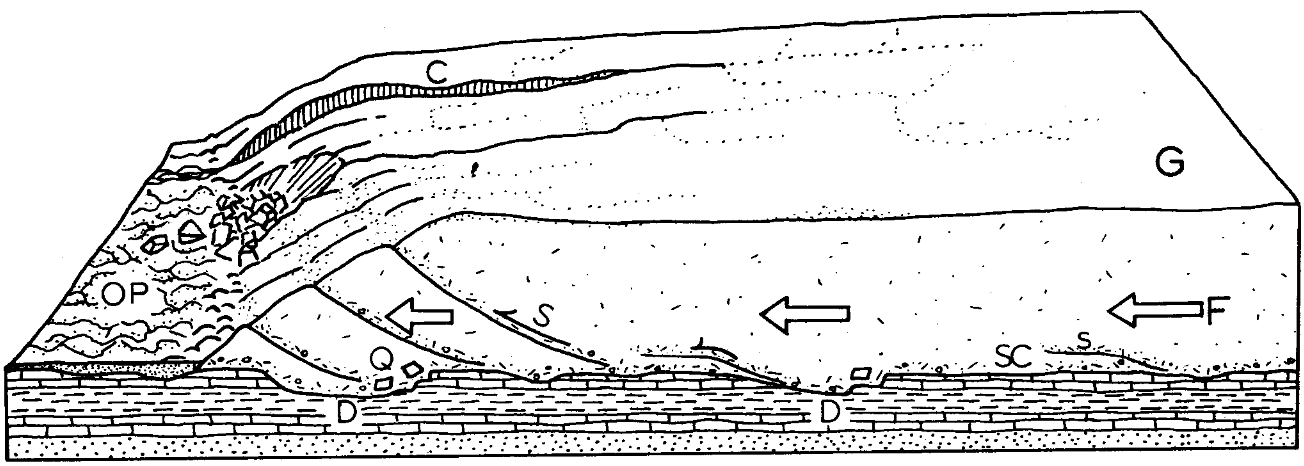
Glaciation in a Small Illinois Region

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.

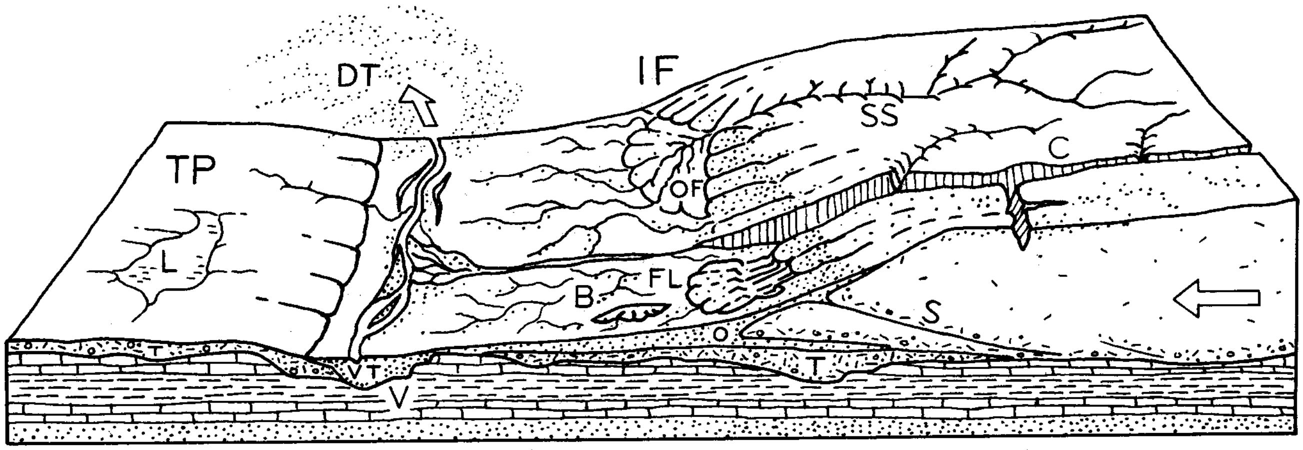
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated--layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



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.



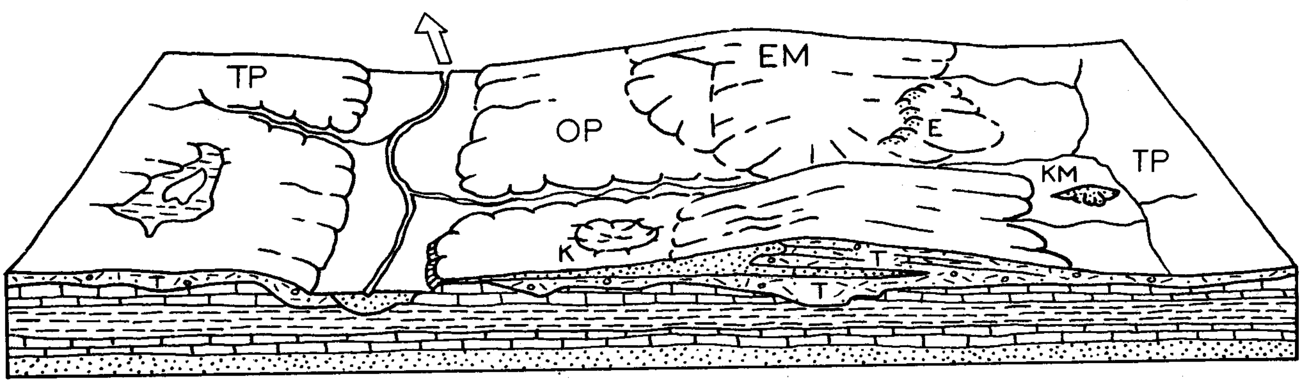
2. The Glacier Advances Southward - As the glacier (G) spreads out from its snowfield, it scours (SC) the soil and rock surface and quarries (Q)--pushes and plucks up--chunks of bedrock. These materials are mixed into the ice and make up the glacier's "load." Where roughnesses in the terrain slow or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

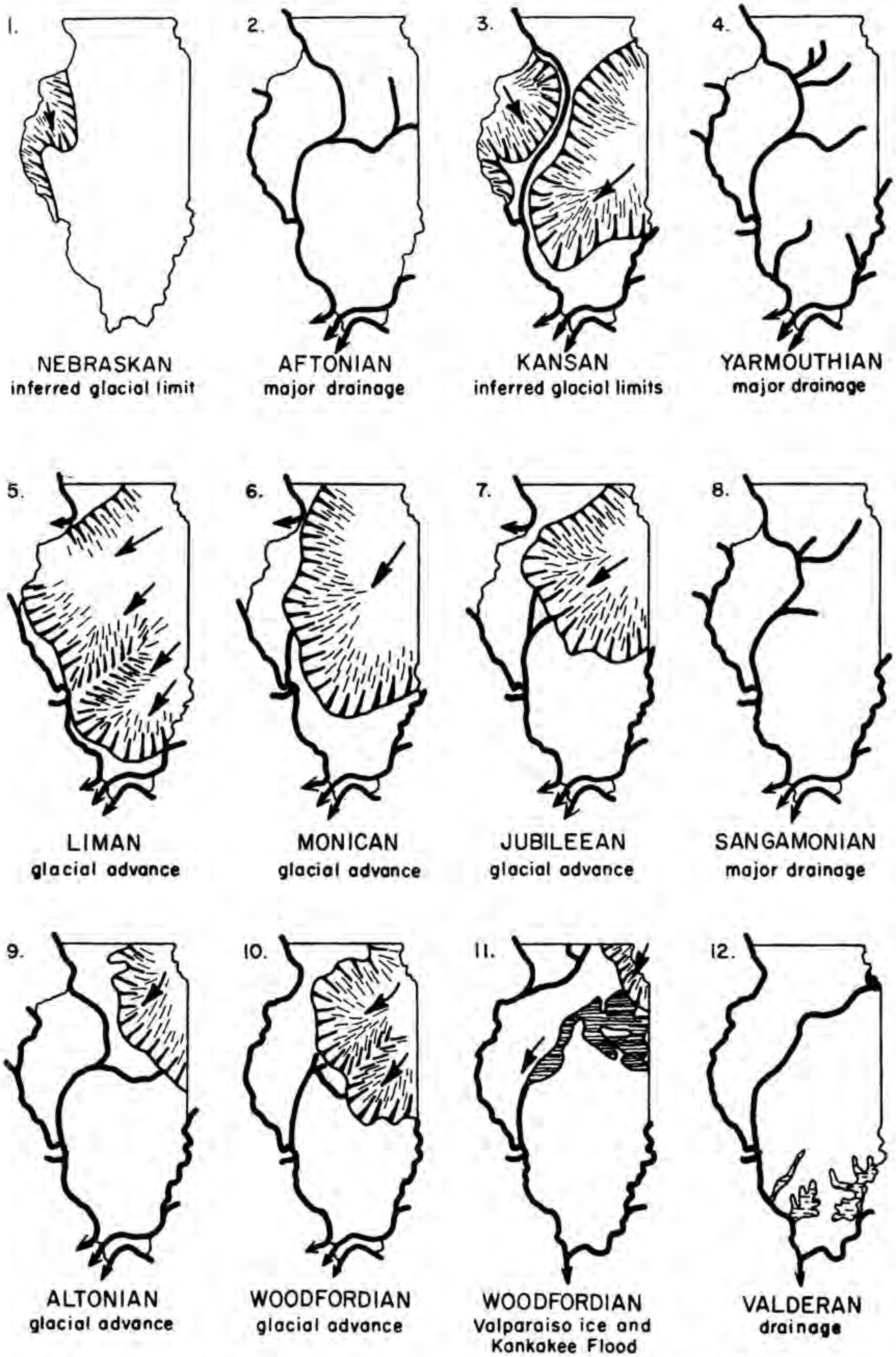
Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left by the ice block's melting has made a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel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

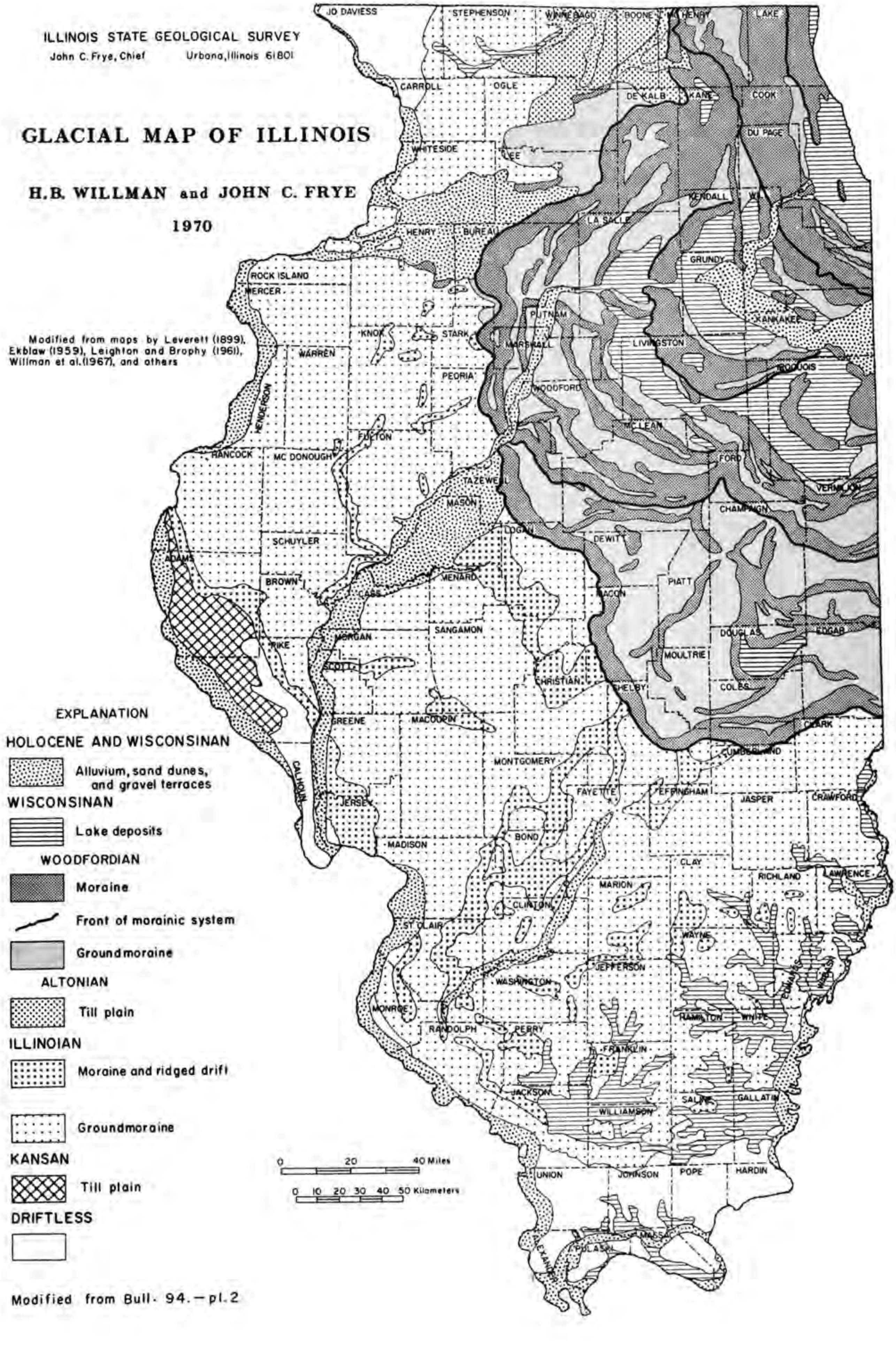
STAGE	SUBSTAGE	NATURE OF DEPOSITS	SPECIAL FEATURES
HOLOCENE	Years Before Present	Soil, youthful profile of weathering, lake and river deposits, dunes, peat	
	7,000		
WISCONSINAN (4th glacial)	Valderan	Outwash, lake deposits	Outwash along Mississippi Valley
	11,000		
	Twocreekan	Peat and alluvium	Ice 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
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
0 20 40 Miles
0 10 20 30 40 50 Kilometers
JO DAVIESS
STEPHENSON
WINNEBAGO
BOONE
LAKE
CARROLL
OGLE
DE KALB
KANE
COOK
DU PAGE
WHITESIDE
LEE
KENDALL
LA SALLE
HENRY
BUREAU
GRUNDY
ROCK ISLAND
MERCER
PUTNAM
KANKAKEE
KNOX
STARK
MARSHALL
LIVINGSTON
WARREN
PEORIA
IROQUOIS
WOODFORD
HENDERSON
FULTON
MC LEAN
HANCOCK
MC DONOUGH
FORD
TAZEWELL
VERMILION
MASON
CHAMPAIGN
LOGAN
DEWITT
SCHUYLER
ADAMS
BROWN
MENARD
CASS
PIATT
MACON
SANGAMON
MORGAN
PIKE
DOUGLAS
EDGAR
SCOTT
MOULTRIE
CHRISTIAN
SHELBY
COLES
GREENE
MACOUPIN
CLARK
CUMBERLAND
MONTGOMERY
CALHOUN
FAYETTE
EFFINGHAM
JASPER
CRAWFORD
JERSEY
BOND
MADISON
CLAY
RICHLAND
LAWRENCE
MARION
CLINTON
ST CLAIR
WAYNE
EDWARDS
WABASH
JEFFERSON
WASHINGTON
MONROE
HAMILTON
WHITE
RANDOLPH
PERRY
FRANKLIN
JACKSON
SALINE
GALLATIN
WILLIAMSON
UNION
JOHNSON
POPE
HARDIN
PULASKI
MASSAC
ALEXANDER

MISSISSIPPIAN DEPOSITION

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

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

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

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

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

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

Sedimentation belts during this time were not symmetrical with respect to the mouth of the Michigan River. They were distorted by the position of the river relative to the Ozark and Cincinnati shoal areas, but of greater importance was sea current or drift to the northwest. This carried off most of the mud contributed by the river, narrowing the shale belt east of the river mouth and broadening it west of the mouth. Facies and isopach maps of individual units show several times as much shale west of the locus of sand deposition as east of it. The facies maps of the entire Chesterian...show maximum sandstone deposition in a northeast-southwest belt that bisects the basin. The total thickness of limestone is greatest along the southern border of the basin and is relatively constant along that entire border. The proportion of limestone, however, is much higher at the eastern end than along the rest of the southern border, because little mud was carried southeastward against the prevailing sea current. Instead, the mud was carried to the northwest and the highest proportion of shale is found in the northwestern part of the basin.

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

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

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

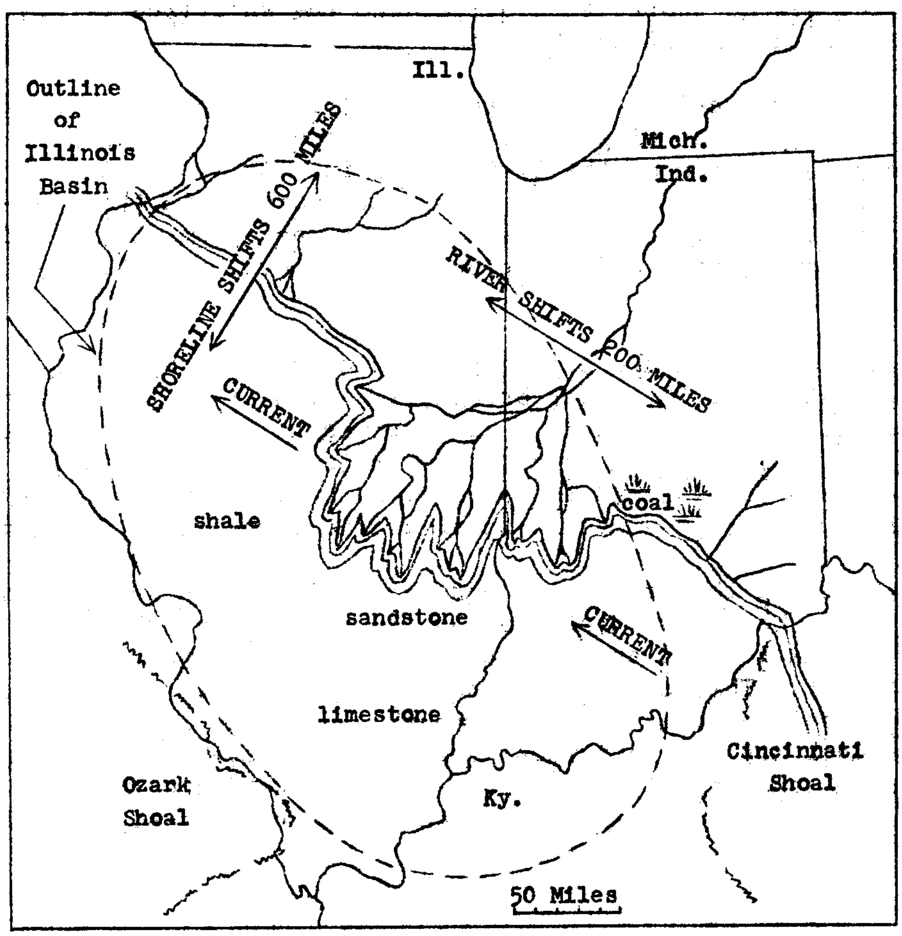
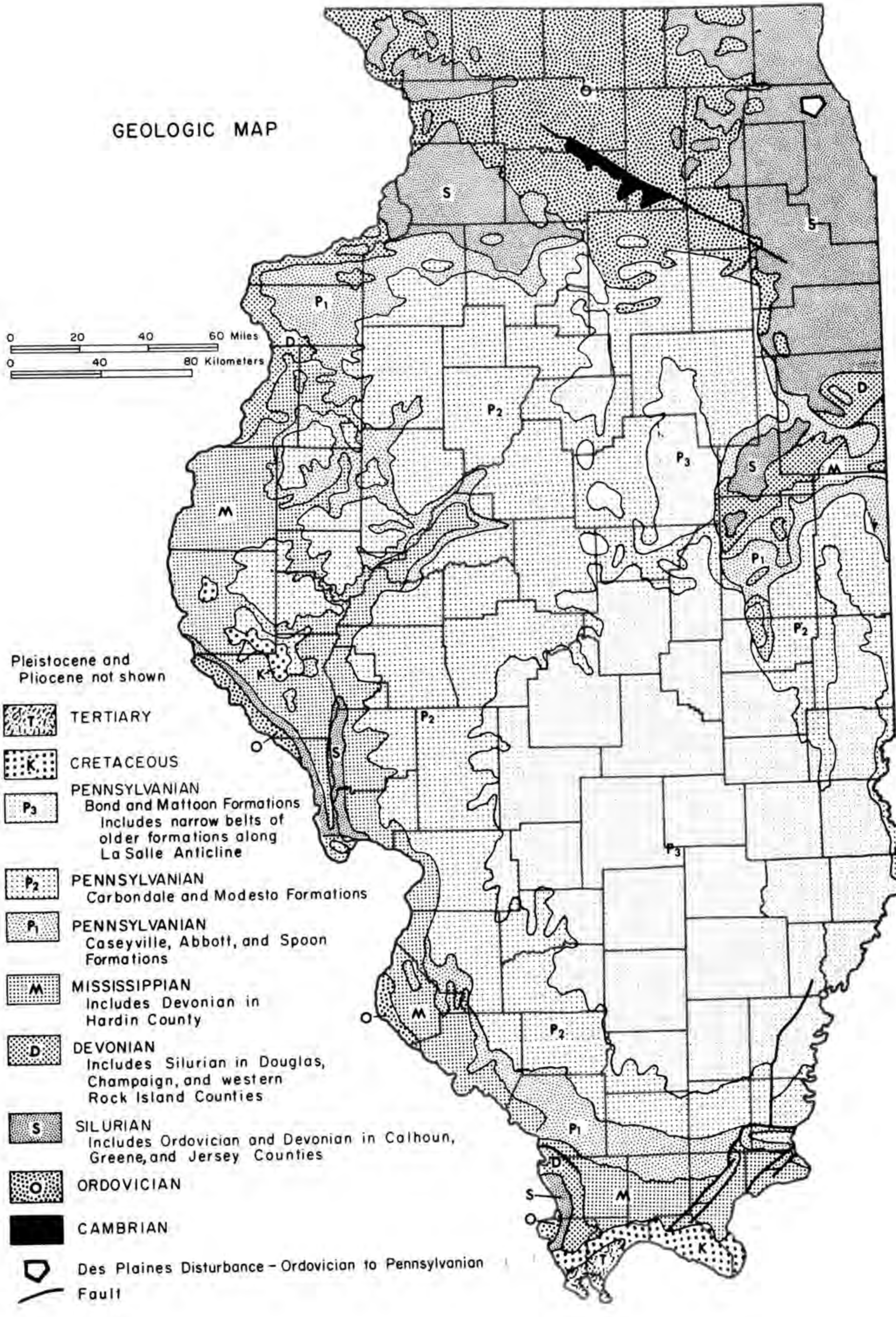


Fig. 4 - Paleogeography at an intermediate stage during Chesterian sedimentation.

GEOLOGIC MAP



DEPOSITIONAL HISTORY OF THE PENNSYLVANIAN ROCKS

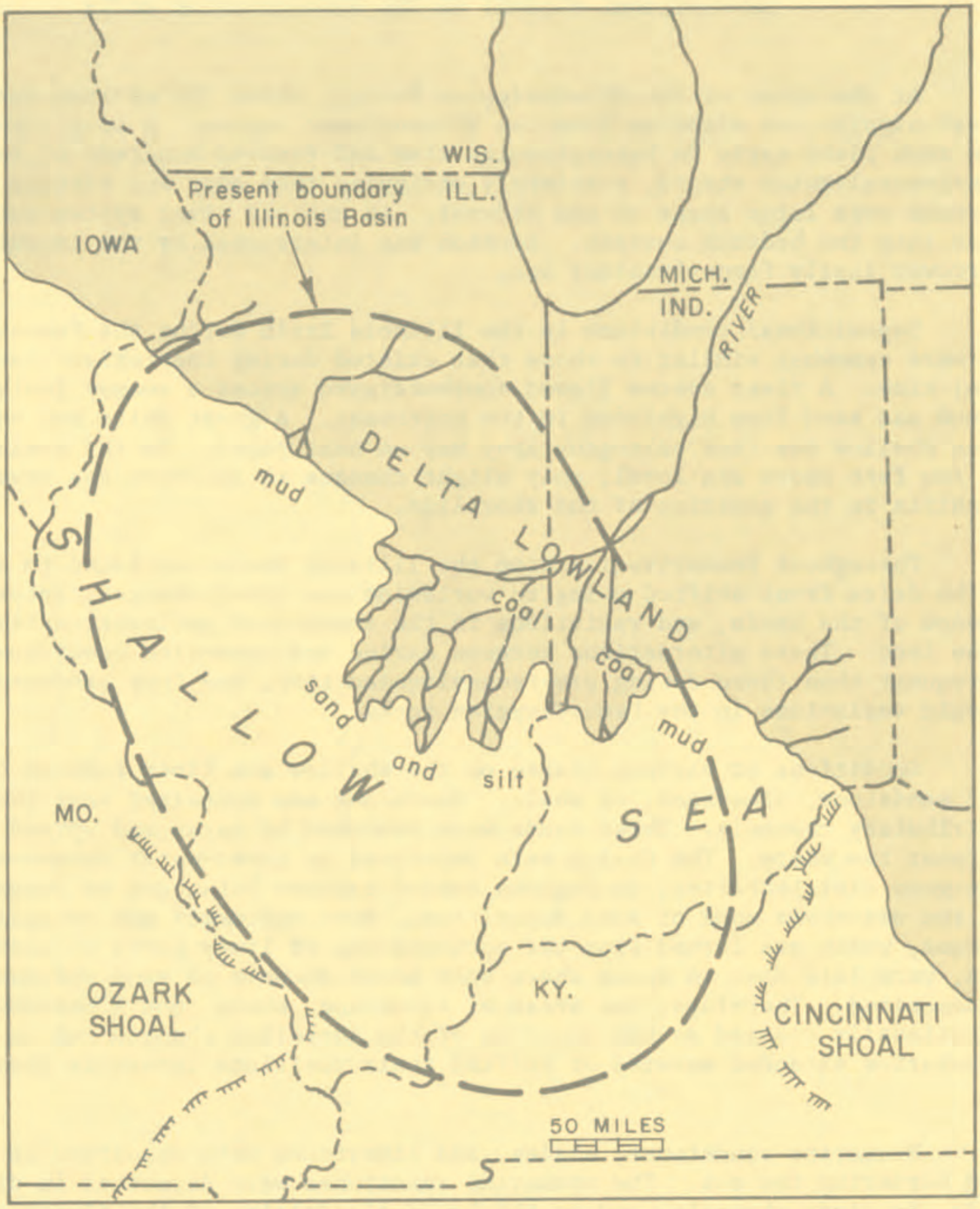
At the close of the Mississippian Period, about 310 million years ago, the Mississippian sea withdrew from the Midcontinent region. A long interval of erosion took place early in Pennsylvanian time and removed hundreds of feet of the pre-Pennsylvanian strata, completely stripping them away and cutting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

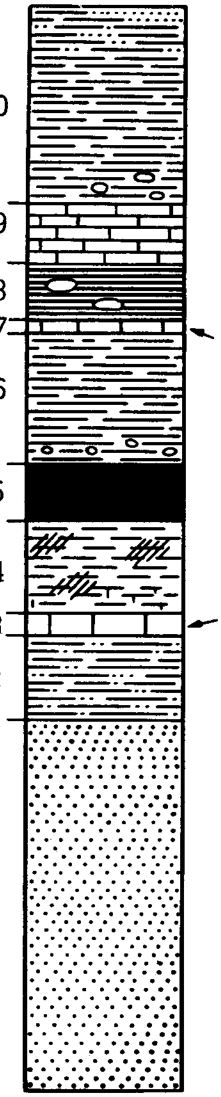
Plant debris from the rapidly growing swamp forests—leaves, twigs, branches, and logs—accumulated as thick mats of peat on the floors of the swamps. Normally, vegetable matter rapidly decays by oxidation, forming water, nitrogen, and carbon dioxide. However, the cover of swamp water, which was probably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

BRACHIOPODS

Juresania nebrascensis 2/3 x

Wellerella tetrahedra 1 1/2 x

Derbya crassa 1x

Composita argentia 1x

Neospirifer cameratus 1x

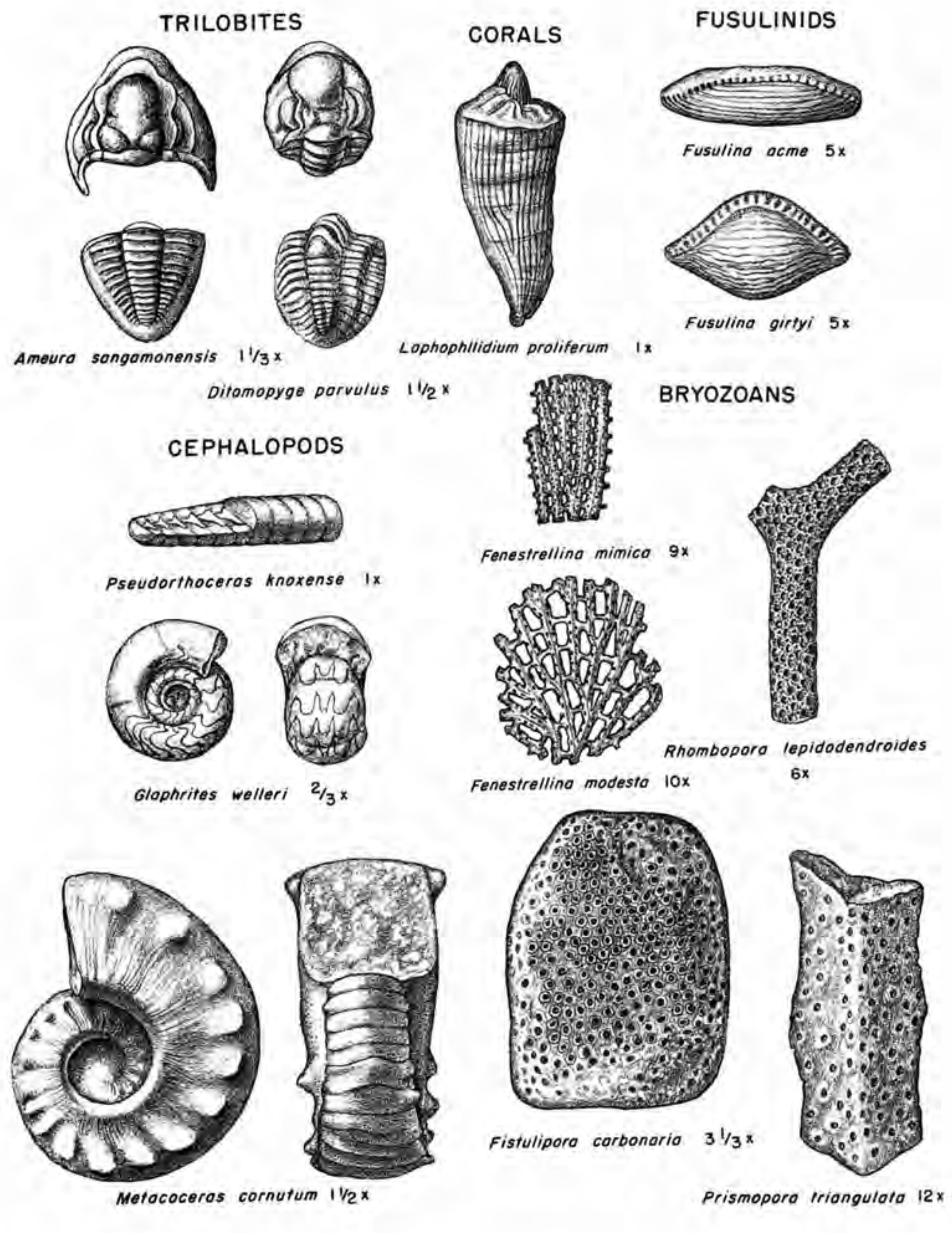
Chonetes granulifer 1 1/2 x

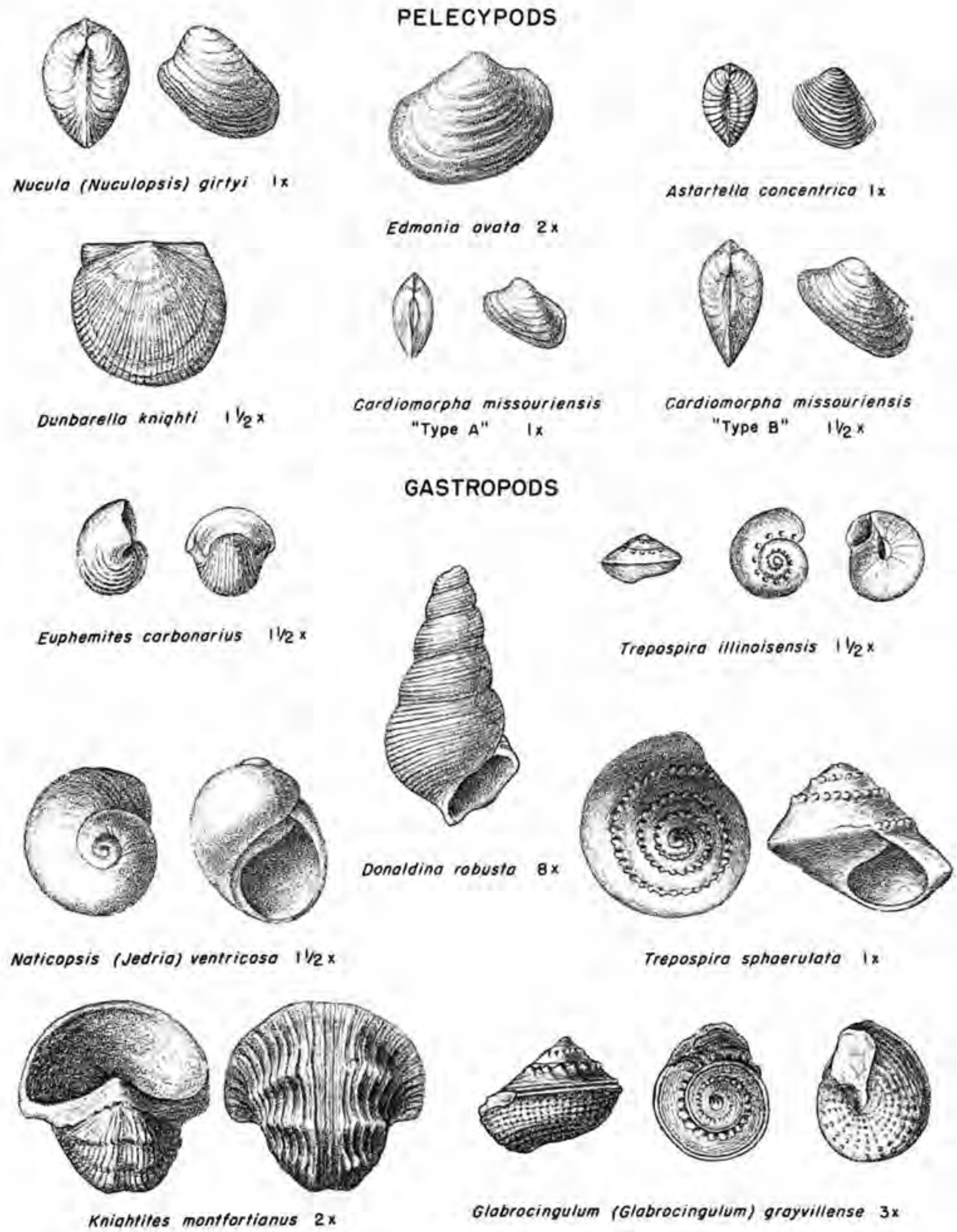
Mesolobus mesolobus var. euampygus 2 x

Marginifera splendens 1x

Crurithyris planoconvexa 2 x

Linoproductus "cora" 1x


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
Glaphrites welleri 2/3 x
Fenestrellina modesta 10x
Fistulipora carbonaria 3 1/3 x
Metacoceras cornutum 1 1/2 x
Prismopora triangulata 12x


PELECYPODS
Nucula (Nuculopsis) girtyi 1x
Edmonia ovata 2x
Astartella concentrica 1x
Dunbarella knighti 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

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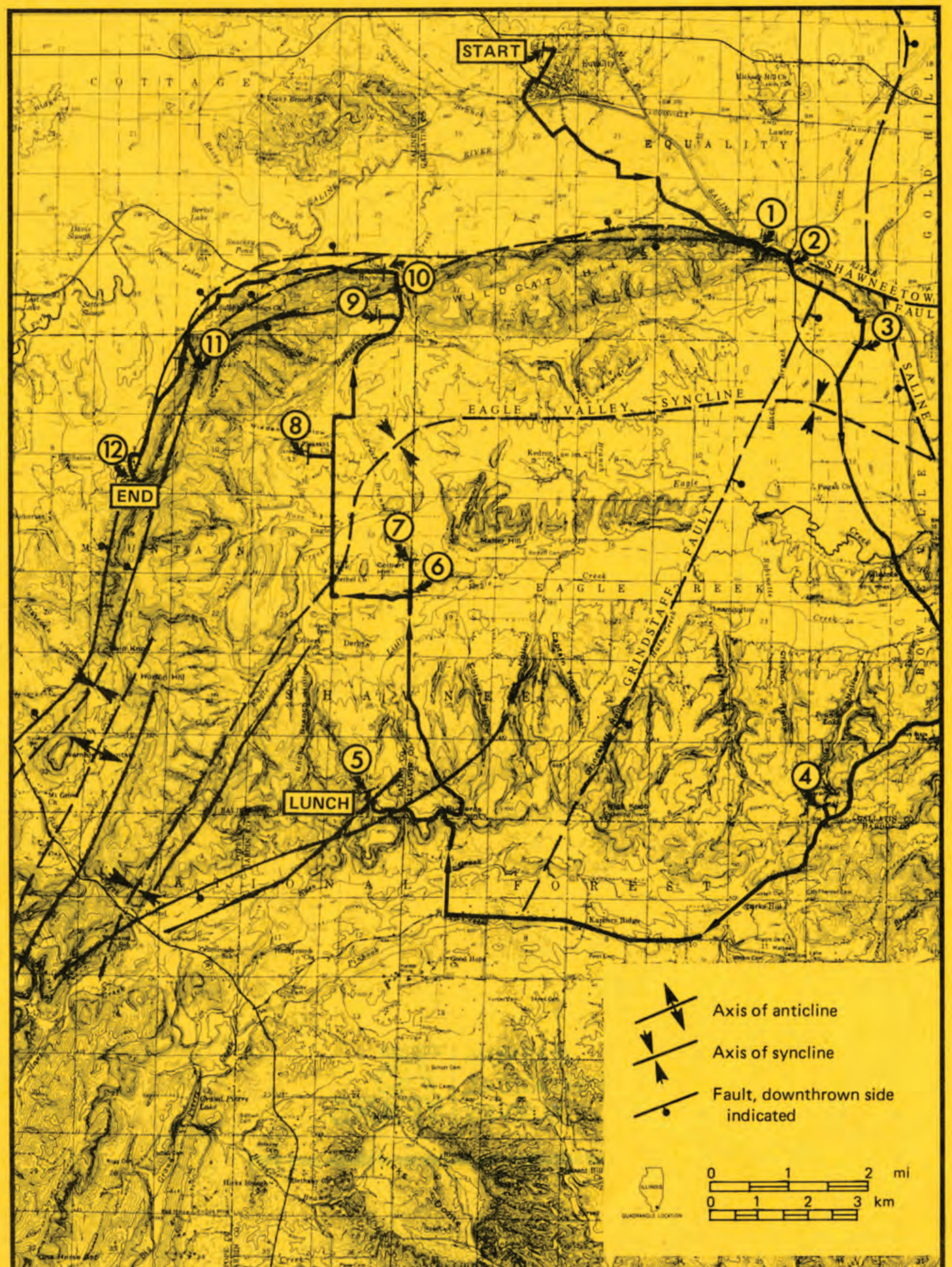

START
END
LUNCH
1
2
3
4
5
6
7
8
9
10
11
12
EAGLE VALLEY SYNCLINE
GRINDSTAFF FAULT
SHAWNEETOWN FAULT
EQUALITY
COTTAGE
WILDCAT HILLS
EAGLE CREEK
SHAWNEE
NATIONAL FOREST
Axis of anticline
Axis of syncline
Fault, downthrown side indicated
0 1 2 mi
0 1 2 3 km
QUADRANGLE LOCATION