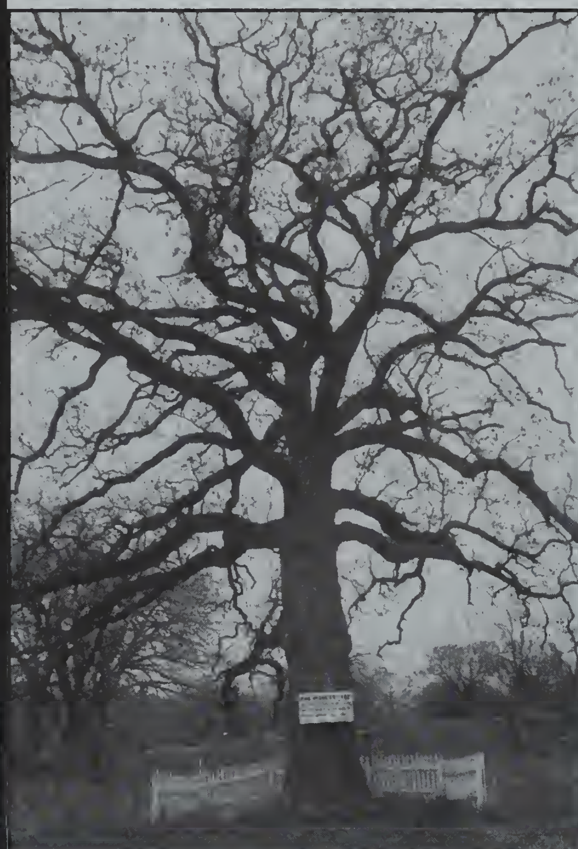
GUIDE TO THE GEOLOGY OF THE KEWANEE AREA HENRY AND BUREAU COUNTIES

David L. Reinertsen



Field Trip Guide Leaflet 1991B, May 18, 1991
Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

Cover photos by D. L. Reinertsen

Winter view (left) of highwall exposure at Stop 6.
"Witness Tree" (right) between Stops 6 and 7.

GEOLOGICAL SCIENCE FIELD TRIPS The Educational Extension Unit of the Illinois State Geological Survey conducts four free tours each year to acquaint the public with the rocks, mineral resources, and landscapes of Illinois. Each field trip is an all-day excursion through one or more Illinois counties. Frequent stops are made to explore interesting phenomena, explain the processes that shape our environment, discuss principles of earth science, and collect rocks and fossils. People of all ages and interests are welcome. The trips are especially helpful to teachers preparing earth science units. Grade school students are welcome, but each must be accompanied by a parent or other responsible adult. High school classes should be supervised by at least one adult for each ten students.

A list of earlier field trip guide leaflets for planning class tours and private outings may be obtained by contacting the Educational Extension Unit, Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820. Phone: (217) 244-2407 or 333-7372.

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David L. Reinertsen

Field Trip Guide Leaflet 1991B, May 18, 1991
ILLINOIS STATE GEOLOGICAL SURVEY
Morris W. Leighton, Chief

Natural Resources Building
615 E. Peabody Drive
Champaign, Illinois 61820

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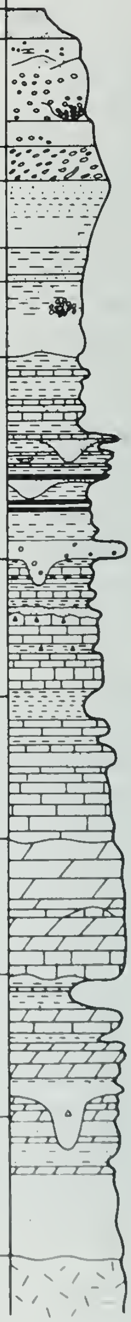
CONTENTS

FIGURES

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



Rock succession chart

GEOLOGIC FRAMEWORK OF THE KEWANEE AREA

The landscape, geology, and mineral resources of parts of Henry and Bureau Counties in the western part of northern Illinois are the focus of the Kewanee field trip. The field trip area is about 35 miles southeast of Rock Island/Moline, about 105 miles north-northwest of Springfield, and slightly more than 130 miles southwest of Chicago.

Structural and Depositional History

Precambrian Era The area of Henry and Bureau Counties, like the rest of present-day Illinois, has undergone many changes throughout the several billion years of geologic time (see rock succession column, facing page). The oldest rocks beneath us on the field trip belong to the ancient Precambrian basement complex. We cannot directly observe these rocks because they are not exposed at the earth's surface anywhere in Illinois. These ancient rocks, which were deeply weathered and eroded when exposed at the surface up to 0.6 billion years ago, formed a landscape that must have been quite similar to the present-day Missouri Ozarks. Only about 30 drill holes have reached deep enough in Illinois for geologists to collect samples from the Precambrian rocks; depths range from 2,100 to 5,400 feet in northern Illinois to 13,000 to more than 15,000 feet in southern Illinois. From the samples, however, we know that these ancient rocks consist mostly of granitic igneous (formed from deep-seated molten material) and possibly metamorphic, crystalline rocks some 1.5 to 1.0 billion years old. You will note that the long interval from the time the Precambrian rocks were formed until the Cambrian sediments accumulated, and for which we have no rock record in Illinois, is almost as long as all recorded geologic time from the Cambrian to the present.

Although geologists seldom see the Precambrian rocks, except as cuttings from drill holes, they can determine some characteristics of the basement complex through various techniques. For example, in southernmost Illinois near what is now the Kentucky-Illinois Fluorspar Mining District, evidence from surface mapping, measurements of the earth's gravity and magnetic fields, and seismic records gathered for oil exploration and research indicates that rift valleys like those in east Africa formed during the late Precambrian Era. These rift valleys in the midcontinent region are referred to as the Rough Creek Graben and the Reelfoot Rift (fig. 1). These rift valleys formed when plate tectonic movements (slow global deformation) began to rip apart an ancient *supercontinent* that had formed earlier when various ancient continents slowly came together. (Collision of continents is going on today as the Indian subcontinent moves northward against Asia, lifting and folding the Himalayas.) The slow fragmentation of

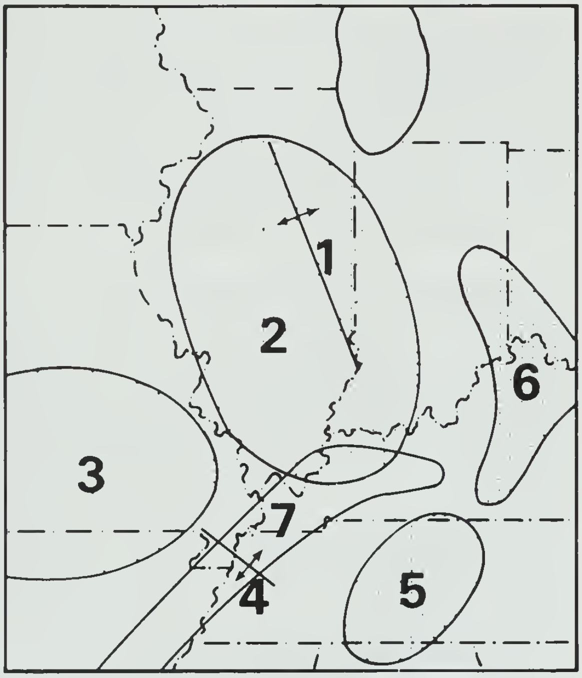


Figure 1 Location of some major structures in the Illinois region: (1) La Salle Anticlinal Belt, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, and (6) Cincinnati Arch.

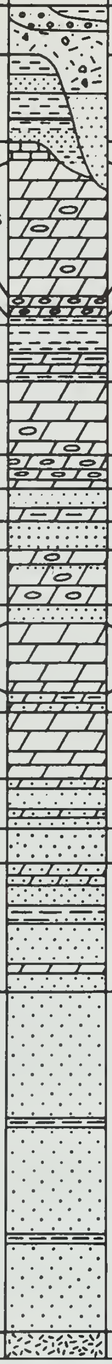
the Precambrian supercontinent eventually isolated a new continental plate called Laurasia, which included much of what is now the North American continent.

Near the beginning of the Paleozoic Era, some 570 million years ago, the rifting stopped and the hilly Precambrian landscape began to slowly sink on a broad, regional scale. This permitted the invasion of a shallow sea from the south and southwest. During the several hundred million years of the Paleozoic Era, what is now southern Illinois continued to accumulate sediments deposited in shallow seas that repeatedly covered the area as it continued to slowly sink. At least 15,000 feet of sedimentary strata accumulated during the 325 million years of the Paleozoic era. Along with the Precambrian rocks, these sediments, when compacted and hardened (indurated), comprise the bedrock succession. (*Bedrock* refers to the rock units, commonly solid and strongly cemented sediments, that underlie the soils or other relatively loose, crumbly, materials at and near the surface of the earth.) The geologic column in figure 2 shows the succession of rock strata that a drill bit might encounter, if all the formations were present in this area.

Paleozoic Era In Henry and Bureau Counties, Paleozoic sedimentary strata reach total thicknesses of about 3,500 feet in the northwest and about 4,300 feet in the southeast. Strata deposited during the Cambrian, Ordovician, Silurian, Devonian, and Pennsylvanian Periods (fig. 2) underlie all or parts of these two counties. These strata range from about 523 million years old (Middle Cambrian), to perhaps 295 million years old (Middle Pennsylvanian). Pennsylvanian-age bedrock strata, consisting of sandstone, siltstone, shale, limestone, coal, and underclay deposited as sediments in shallow seas and low-lying coastal swamps between about 320- and 295-million years ago, occur immediately beneath the cover of glacial till. In the field trip area some of these rocks are exposed in scattered roadcuts and stream banks.

During the Paleozoic Era, when shallow seas encroached upon the slowly sinking landmass that underlies what is now Illinois and adjacent states, sediments accumulated on the sea floor. Because of the stresses, such as compression, stretching, and compaction, that built up from time to time, the earth's thin crust was frequently flexed and warped from place to place. This movement repeatedly caused the shallow seas to drain from the region and later, to slowly readvance. Former sea floors were thus occasionally exposed to erosion by wind and streams, which caused some marine sediments to be eroded and lost from the sedimentary record.

Many sedimentary units, called *formations*, have conformable contacts—that is, no significant interruptions took place in the deposition of the sediments that formed into rock units (fig. 2). In such instances, even though the composition and appearance of the rocks changes significantly at the contact between two formations, the fossils in the rocks and the relationships between the rocks at the contact indicate that deposition was essentially continuous. At other contacts, however, the lower formation was subjected to weathering and at least partly eroded before the overlying formation was deposited. In these cases, the fossils and other evidence in the formations indicate a significant gap between the time when the lower unit was deposited and the time when the overlying unit was laid down. This type of contact is called an *unconformity*. Where the beds above and below an unconformity are essentially parallel, the unconformity is called a *disconformity*; where the lower beds were tilted and eroded before the overlying beds were deposited, the contact is called an *angular unconformity*. Major unconformities, shown as undulating lines across the rock columns of fig. 2), each represent long intervals of time during which a considerable thickness of the rock record, known from other nearby regions, is missing from parts of the area. In addition, some smaller unconformities are present, representing a shorter time interval, for which less material is known to be missing from the rock record, either because of nondeposition or erosion.



SYSTEM	FORMATION	ROCK COLUMN	THICKNESS (FEET)	GENERAL CHARACTER
PLEISTOCENE SERIES			0-500	Till, gravel, sand, silt, peat
PENNSYLVANIAN			0-550	Shole, sandstone, coal, clay, limestone
DEVONIAN			0-60	Limestone
SILURIAN	Niagaran series		300-400	Dolomite, port cherty
	Kankakee		50	Dolomite, very cherty
	Edgewood		20	Dolomite, silty
ORDOVICIAN	Maquoketa		175-200	Shole, dolomite
	Galena		225	Dolomite, medium-groined, portly cherty
	Platteville		110	Dolomite, fine-grained, cherty
	Glenwood		100	Sondstone, dolomite, shole
	St. Peter		85	Sandstone
	Shokopee		100-150	Dolomite, cherty, few sand-stone beds
	New Richmond		50	Sondstone
	Oneata		200	Dolomite, cherty
	Gunter		50	Dolomite, sondy, silty
CAMBRIAN	Trempealeau		200	Dolomite, drusy quortz
	Fronconia		150	Sondstone, glaucanitic, dolomite
	Galesville		100	Sondstone
	Eou Cloire		400	Sandstone, dolomite, shole
	Mt. Simon		1000-2000	Sondstone, few shole beds
PRECAMBRIAN				Gronite

Figure 2 Generalized sequence of strata in the Buda Quadrangle.

You will note from figure 2 that Mississippian-age rocks are missing from the field trip area; either they were never deposited or they were eroded. Near the close of the Mississippian Period (320 million years ago), gentle arching of the bedrock in the area that is now eastern Illinois initiated the broad upwarp of the La Salle Anticlinal Belt (figs. 1 and 3). This is a complex structure consisting of smaller structures such as domes, anticlines (upwarped rocks), and synclines (downwarped rocks) superimposed on the broad general upwarp. This gradual arching continued through the Pennsylvanian Period. Because the youngest Pennsylvanian

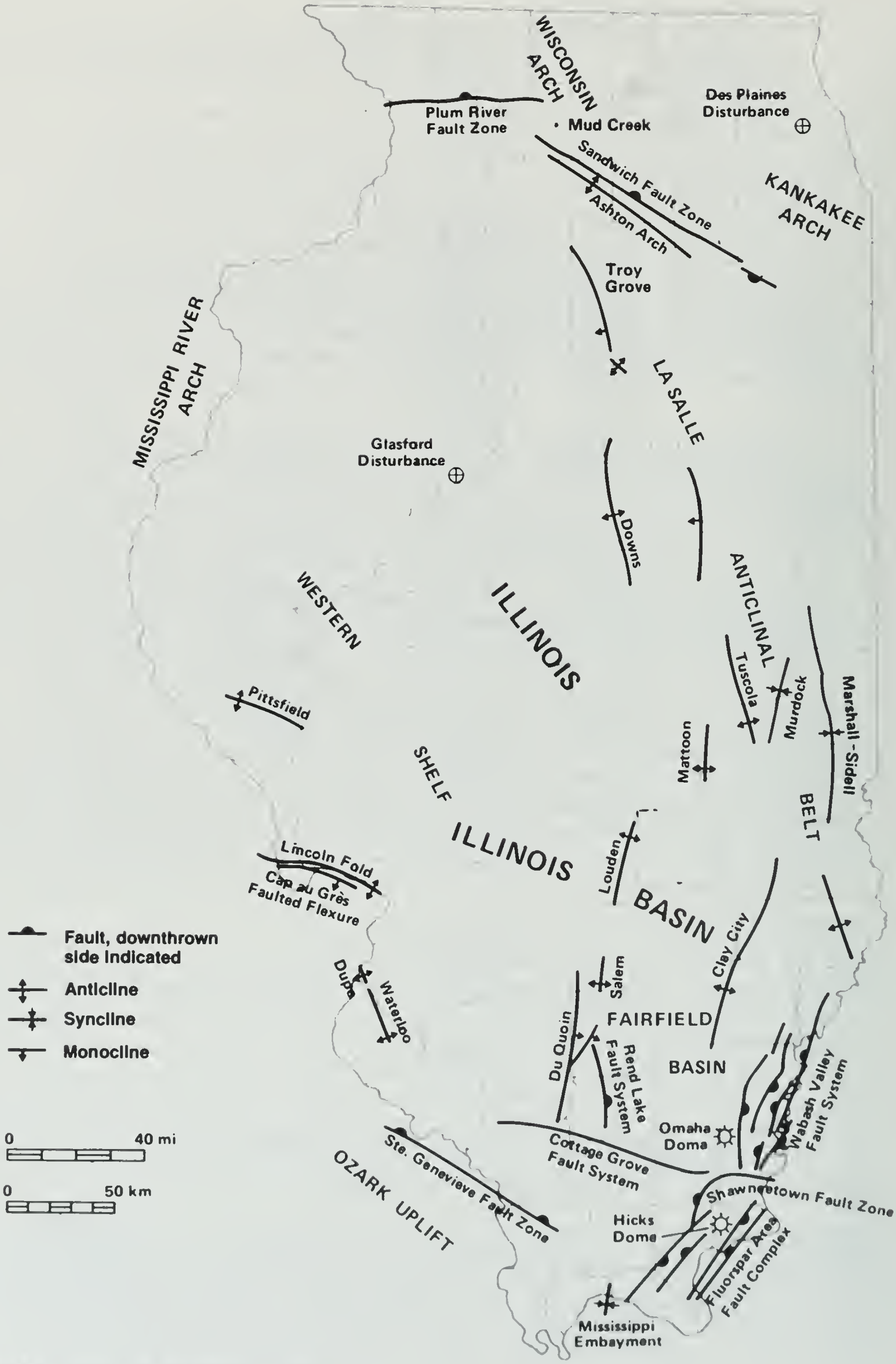


Figure 3 Structural features of Illinois.

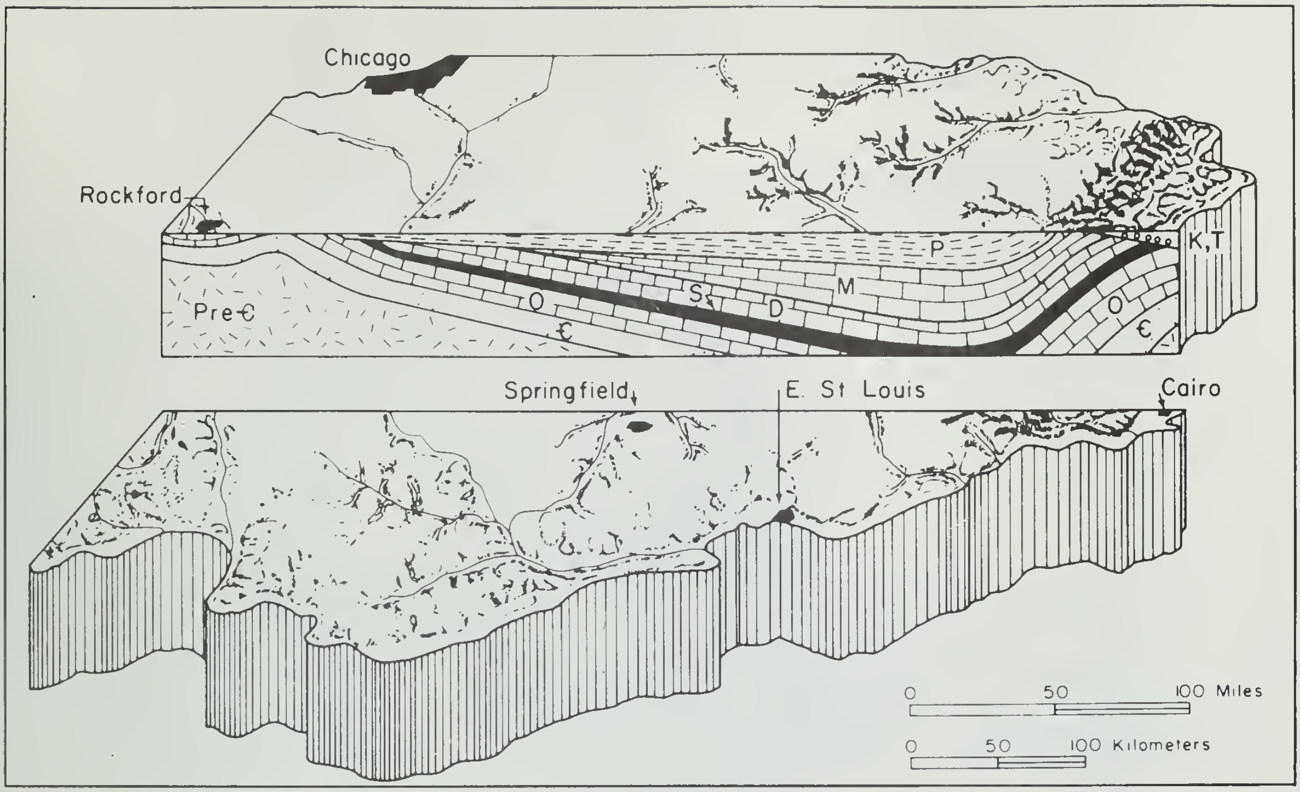


Figure 4 Stylized north-south cross section shows structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks has been greatly exaggerated and younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-C) granites. They form a depression 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). Scale is approximate.

strata are absent from the area of the anticlinal belt, either as a result of nondeposition or erosion, we cannot know just when movement along the belt ceased—perhaps by the end of the Pennsylvanian or a little later during the Permian Period, the youngest rock system of the Paleozoic Era.

The thickness of Pennsylvanian strata in southeastern Henry County decreases to the north and east from nearly 500 feet to zero in some places, except for small outliers. In Illinois, Pennsylvanian strata contain important coal resources. In years past, coal was strip-mined from part of Henry County. A description of these rocks and their occurrence may be found in *Depositional History of the Pennsylvanian Rocks* (at the back of the guide leaflet).

Mesozoic and Cenozoic Eras Following the Paleozoic Era, during the Mesozoic Era, the rise of the Pascola Arch (fig. 1) in southeastern Missouri and western Tennessee formed the Illinois Basin and separated it from other basins to the south. The Illinois Basin is a broad downwarp covering much of Illinois, southern Indiana, and western Kentucky (figs. 1 and 4). Development of the Pascola Arch in conjunction with the earlier sinking of deeper parts of the area gave the basin its present asymmetrical, spoon-shaped configuration. The geologic map (fig. 5) shows the distribution of various rock systems as they occur at the bedrock surface—assuming all glacial, windblown, and surface materials were removed.

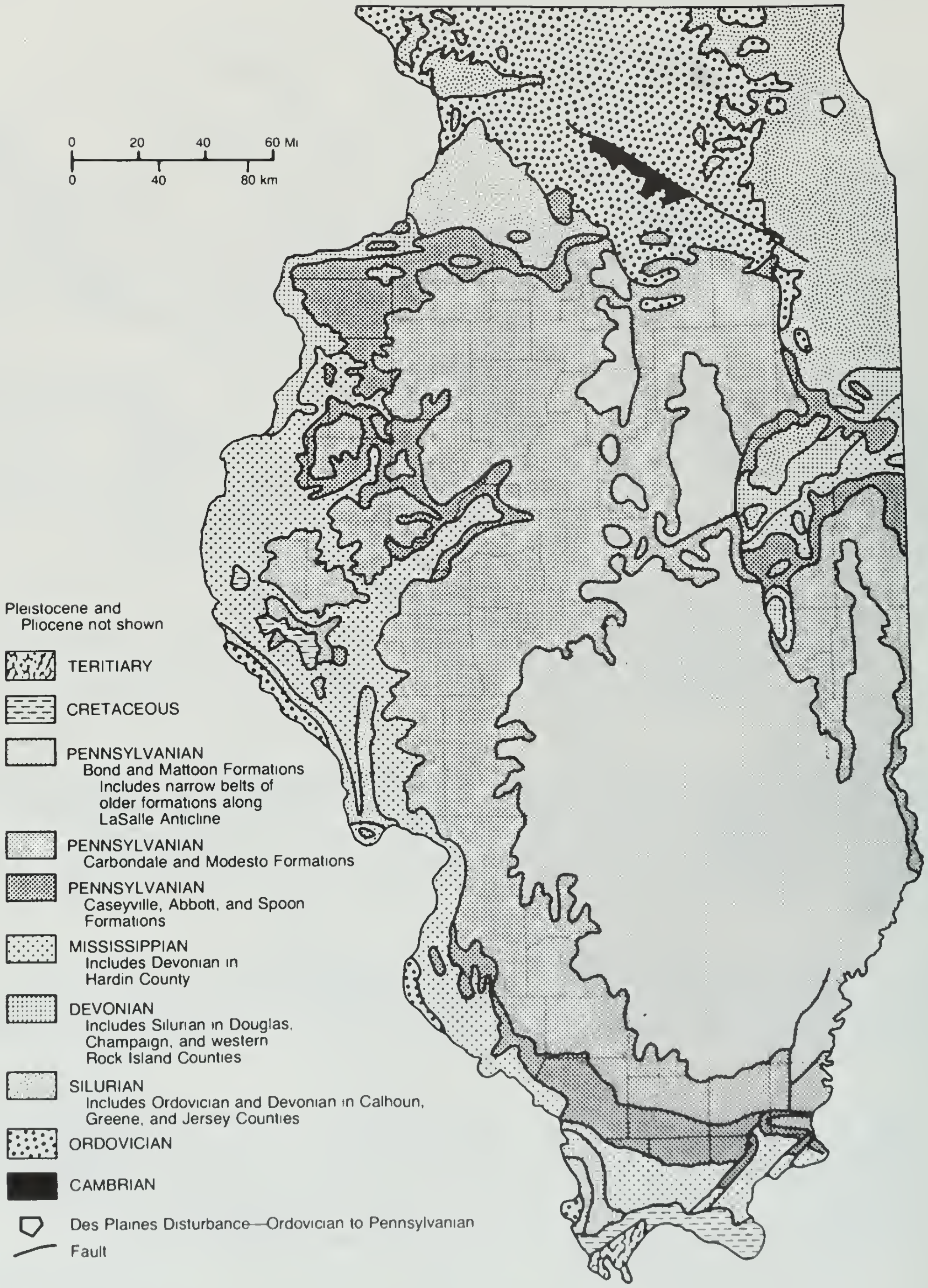


Figure 5 Bedrock geology of Illinois.

The Kewanee field trip area is located on the northwestern shelf area of the Illinois Basin, where smaller subsidiary structures were superimposed on the larger basin structure at different times during the geologic past. Henry and Bureau Counties lie just east of the Mississippi River Arch, the divide between the Forest City Basin to the west in western Iowa and Missouri, and the Illinois Basin to the southeast. Because tilting of the bedrock layers took place several times during the Paleozoic Era, dips of successive strata are not always parallel to one another. In southeastern Henry and northwestern Stark Counties, during drilling into Ordovician strata for a compressed-air energy storage field, data were collected that indicate the presence of three small domes, collectively called the Toulon Dome (Treworgy 1981). The northern dome in Henry County just south of Kewanee has a vertical *closure* of about 100 feet and covers approximately 5 square miles.

On the basis of evidence from outcrops and drill holes elsewhere in Illinois, geologists have concluded that younger rocks of latest Pennsylvanian and perhaps Permian age may have at one time covered parts of what is now northern Illinois. Even younger rocks of Mesozoic and Cenozoic age could have been present. On the basis of the degree of metamorphism (rank) of coal deposits and other indirect evidence, it is thought that perhaps as much as 1 mile of latest Pennsylvanian and younger rocks once covered this northern area. However, during the 243 million years or so between the close of the Paleozoic Era and the onslaught of glaciation 1 to 2 million years ago, ample time passed to erode as much as several thousands of feet of strata. In the area that is now Illinois, all rocks except those of Precambrian age were subjected to erosion. Furthermore, all traces have been erased of any post-Pennsylvanian bedrock that may have been present.

During the Mesozoic and part of the Cenozoic Eras, before the start of glaciation 1 to 2 million years ago, the ancient Illinois land surface was exposed to long, intense weathering and erosion. This produced a series of deep valley systems carved into the gently tilted bedrock formations. The topography was then considerably subdued by the repeated advance and melting back of the glaciers, which scoured and scraped the old erosion surface, affecting all bedrock exposed at the surface. When the last of the continental glaciers finally melted away, it left nonindurated deposits of sand, gravel, till, and silt behind. Modern soils developed in these materials.

Glacial History A brief history of glaciation in North America and a description of the deposits commonly left by glaciers may be found in *Pleistocene Glaciations in Illinois* at the back of the guide booklet.

Beginning about 1.6 million years ago, during the Pleistocene Epoch, massive sheets of ice, thousands of feet thick—continental glaciers—flowed slowly southward from centers of snow and ice accumulation in the far north. Although ice sheets covered parts of present-day Illinois several times during the Pleistocene Epoch, drift deposits of the oldest glaciers ("pre-Illinoian") are known only from the deeper parts of the bedrock valleys. During the Illinoian glaciation, around 270,000 years before the present, North American continental glaciers not only reached westward into the Kewanee area but also reached their southernmost extent, advancing as far south as the northern part of present-day Johnson County, Illinois, about 250 miles south-southeast of Kewanee (figs. 6 and 7). Kewanee is about 12 miles southwest of the late Wisconsinan Bloomington Morainic System, one of the most prominent features of the Woodfordian Substage in this part of Illinois. The last of these glaciers melted from the region that is now northeastern Illinois about 13,500 years before the present.

Until recently, glaciologists thought the ice in these glaciers was 1 mile thick or more. More recent studies have indicated, however, that the ice may have been only about 2,000 feet thick at its maximum in the Lake Michigan Basin and about 700 feet thick across most of what is now Illinois. These conclusions are based on several lines of research evidence including (1) the degree of consolidation and compaction of rock and soil materials that must have been under the ice; (2) comparisons between the inferred geometry and configuration of the ancient ice masses and those of present-day glaciers and ice caps; (3) comparisons between the mechanics of ice-flow in modern-day glaciers and ice caps and those inferred from detailed studies of the ancient glacial deposits; and (4) the amount of rebound of the Lake Michigan Basin from being depressed by the mass of the glacial ice.

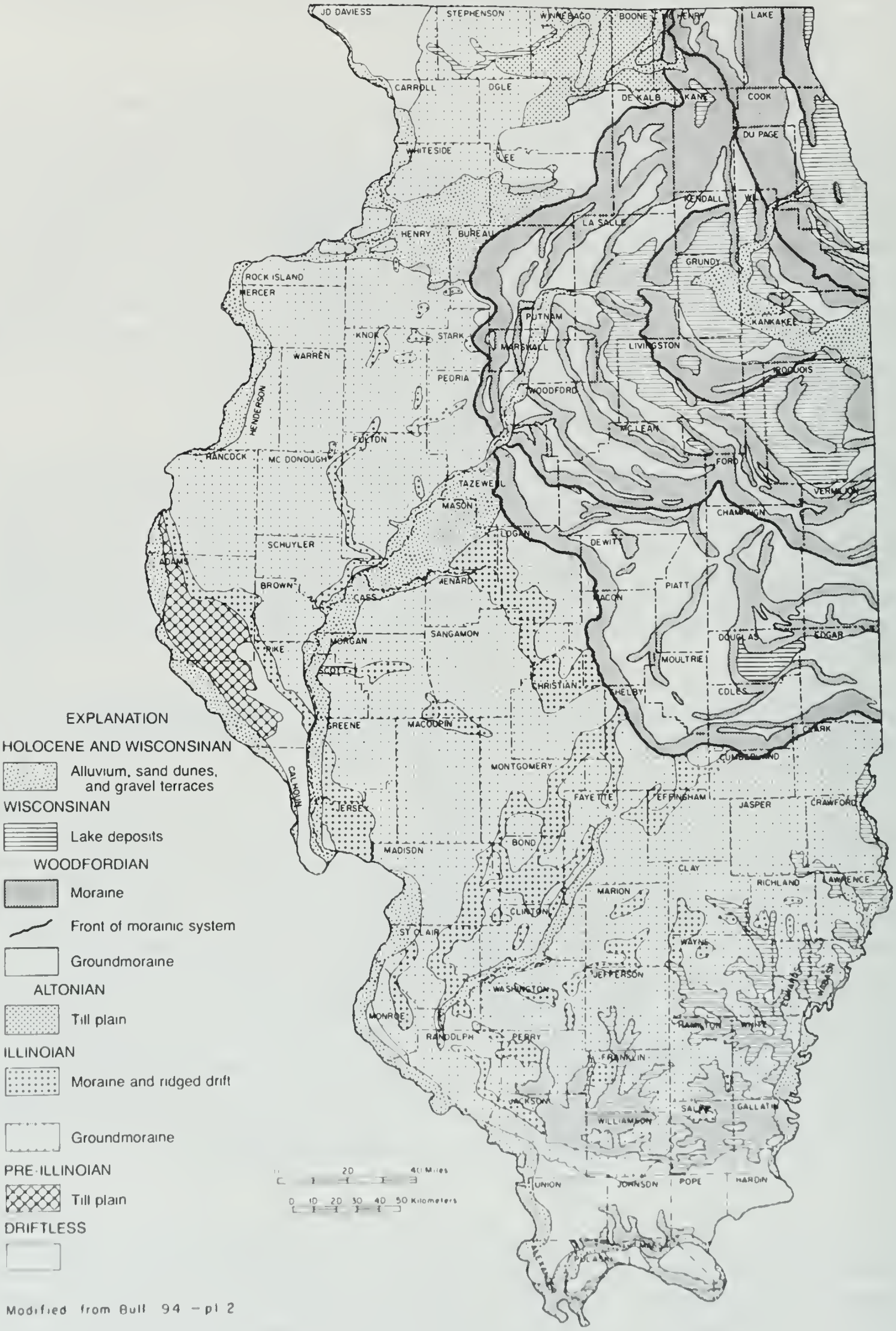


Figure 6 Generalized map of glacial deposits in Illinois (modified from Willman and Frye 1970).

Illinoian glaciers built moraines—that is, ridges or mounds of unsorted rock materials carried along and then left by the ice. Although Illinoian moraines were probably similar to those of the later Wisconsinan glaciers, they were not so numerous, and today, not nearly so prominent. Also, they have been exposed to weathering and erosion for thousands of years longer than their younger Wisconsinan counterparts.

The topography of the bedrock surface throughout much of Illinois is largely hidden from view by glacial deposits (drift), except along the major streams. As noted earlier, erosion in the present Kewanee area occurred long before the glaciers advanced; it left a network of valleys carved into the bedrock surface. Partly because of the irregular bedrock surface and partly because of erosion, glacial drift is unevenly distributed across Henry and Bureau Counties. In the buried bedrock valley below the Green River Lowland, glacial drift is more than 300 feet thick; but the highest uplands generally have less than 25 feet of drift. Studies of mine shafts, water-well logs, and other drill-hole information coupled with observations of scattered bedrock exposures in some stream valleys and roadcuts, show that the present land surface of the field trip area partly reflects the underlying bedrock surface. Thus, the preglacial bedrock surface has been modified and subdued.

A cover of windblown silt called Woodfordian loess (pronounced "luss") mantles the glacial drift in Henry and western Bureau Counties. These fine-grained dust deposits of Wisconsinan age are about 13 feet thick in the southwestern part of the area, but are only about 7 feet thick to the north in the Green River Lowland. Soils in Henry and western Bureau Counties have developed in the loess and the underlying glacial tills.

Physiography

The Kewanee field trip will take us to the northern boundary of the Galesburg Plain with the Green River Lowland (fig. 8). Both physiographic divisions are located in the northern and western part of the Till Plains Section of the Central Lowland Province. The Galesburg Plain is level to undulatory and in a late-youth stage of erosion (Leighton, Ekblaw, and Horberg 1948). That is, level to gently rolling upland prairies, generally of low relief, are being dissected by streams to produce fairly narrow, steep-walled valleys. The larger streams generally have somewhat wider alluviated (sediment-filled) valleys. Because of the thinness of Illinoian drift in this area and its age, glacial landforms such as moraines or large kames are either lacking or difficult to recognize.

The present gross features of the Till Plains Section are determined largely by preglacial topography. As glaciation began, the streams flowing in deeply eroded bedrock valleys changed from erosion to aggradation—that is, the streams began to build up and fill in their channels because the flow and volume of water was insufficient to carry increasing loads of sediments. During times of deglaciation, vast quantities of meltwater and sediments were released from the waning ice front. No evidence indicates, however, that pre-Illinoian fills in the preglacial valleys were ever completely flushed out of their channels by succeeding deglaciation meltwater torrents.

Kewanee is situated on a bedrock drainage divide that extends from southwest to northeast across the southeast part of Henry County into southwestern Bureau County. The north segment of the field trip traverses a small part of the Green River Lowland. A low, poorly drained plain with prominent sand ridges and dunes, the lowland lies south of the Rock River Hill Country and west of the Bloomington Morainic System (fig. 8). Most of it is a modified outwash plain, the result of Woodfordian glaciation in Wisconsinan time, during which the Bloomington Morainic System developed.

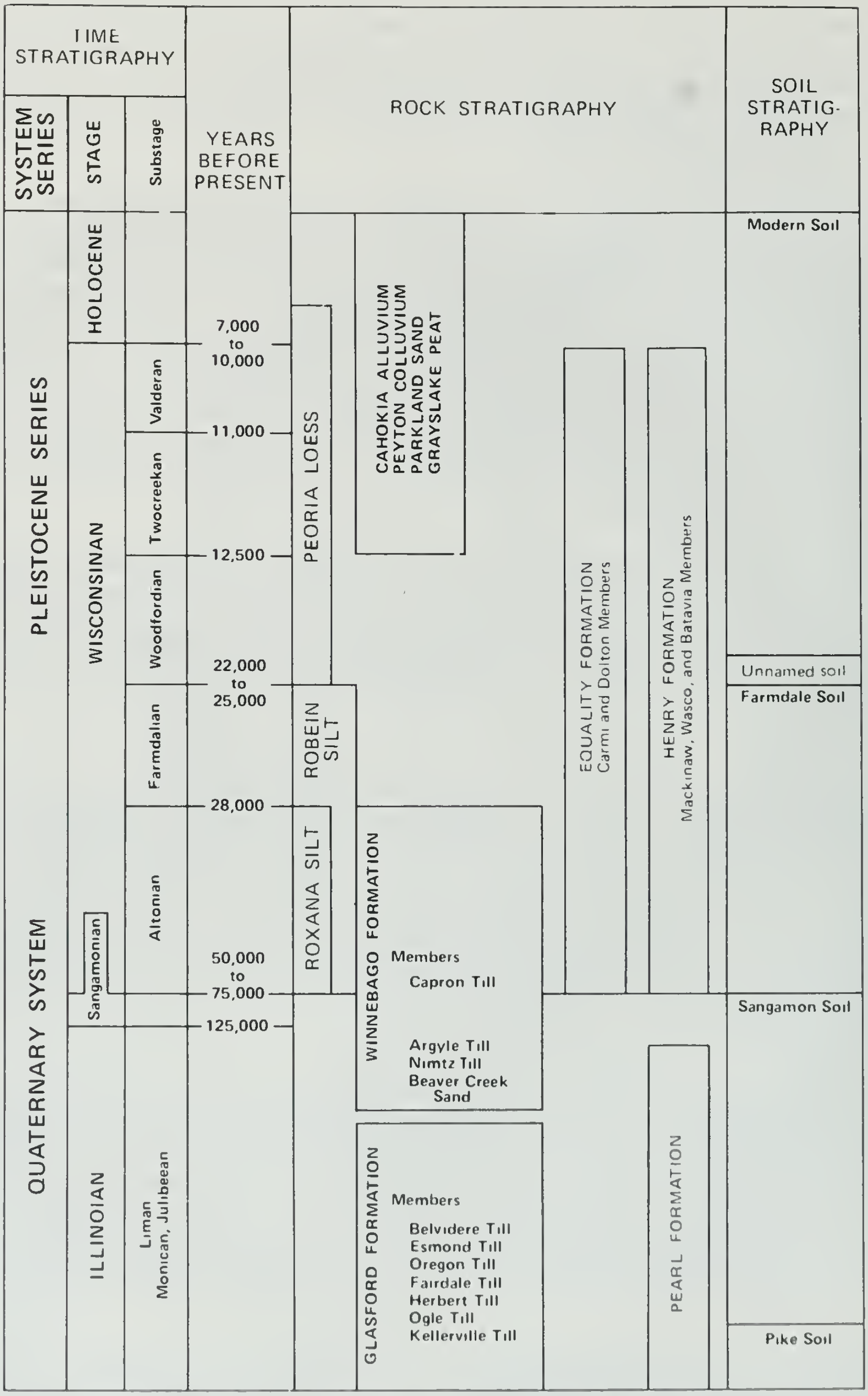


Figure 7 Stratigraphic classification of Quaternary deposits of central northern Illinois.

Drainage

The present-day drainage system is relatively complete; the larger streams have broad valleys and low gradients (bottom slopes) in their lower courses. The uplands generally have fairly good natural drainage, but the lower parts of the larger valley bottoms are poorly drained. The drainage divide for part of the field trip area extends from Kewanee northeastward to Neponset.

Walker, Mud, and Coal Creeks and their tributaries drain northwestward to Green River, which flows westward to the Rock and Mississippi Rivers. These sluggish streams mostly occupy preglacial bedrock valleys. From the divide, Spoon River and its tributaries drain southeast and southward in front of the Bloomington Morainic System. This modern stream network occupies parts of several buried bedrock valleys and a Pleistocene channel throughout its long course to the Illinois River in Fulton County near Havana.

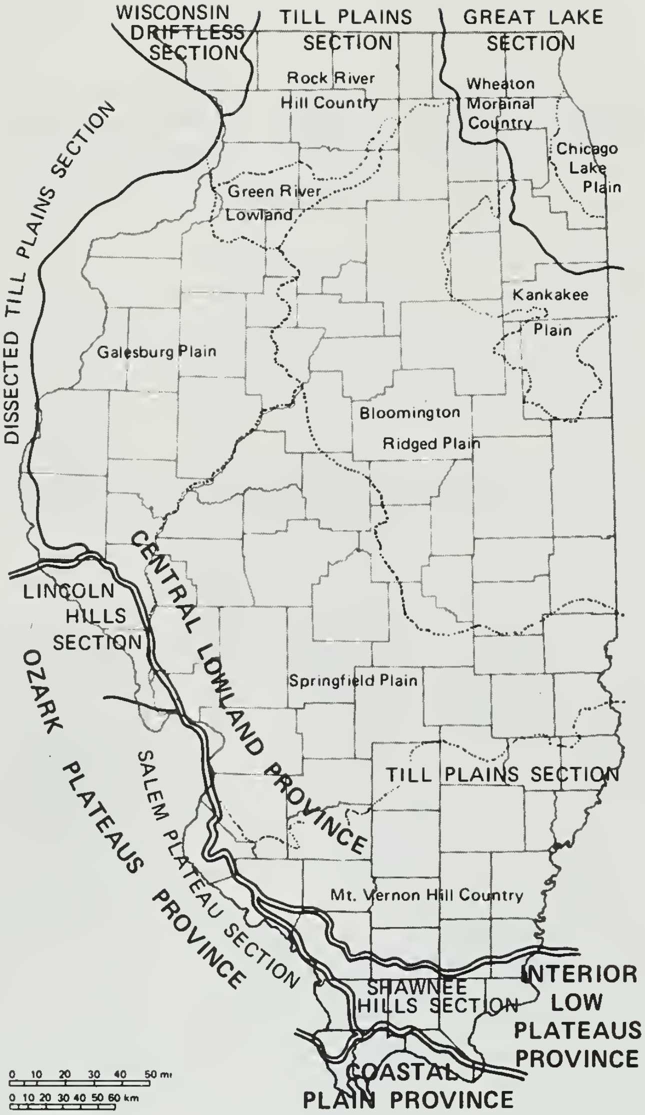


Figure 8 Physiographic divisions of Illinois.

Relief

The highest land surface on the field trip route is at the intersection of 3rd Street and SR 78 near downtown Kewanee, where the elevation is slightly more than 850 feet above mean sea level (msl). The highest surface elevation in the field trip area is about 872 feet msl approximately 1 mile south of the "Witness Tree" noted in the Guide to the Route at 43.7 miles from the starting point. The lowest elevation is less than 605 feet msl in the drainage ditches north of Stop 3. The surface relief of the field trip route, calculated as the difference between the highest and lowest elevations, is thus slightly more than 245 feet. For the area, the relief is nearly 270 feet. Local relief generally ranges from 20 to 70 feet except for a few scattered areas in the southwest along Mud Creek, where the relief may be slightly more than 120 feet within a short distance, and in the southeast, where it may be slightly more than 100 feet overlooking the East Branch Spoon River.

MINERAL PRODUCTION

Among all counties in Illinois, Henry County ranked 94th in 1988 for total value of minerals extracted—stone, and sand and gravel. Bureau County ranked 89th in 1988 for its total value of clay products and minerals extracted—sand and gravel.

Of the 102 counties in Illinois, 99 reported mineral production during 1988, the last year for which complete records are available. (Stone production is reported only for odd-numbered years, and sand and gravel production is reported only for even-numbered years). The total value of all minerals extracted, processed, and manufactured in Illinois during 1988 was $2,807,600,000, a decline of some $418 million from the previous year.

SYSTEM	SERIES AND MEGAGROUP	GROUP AND FORMATION	HYDROSTRATIGRAPHIC UNITS Aquigroup	HYDROSTRATIGRAPHIC UNITS aquifer/aquitard	LOG	THICKNESS (ft)	DESCRIPTION
Quaternary	Pleistocene	Undifferentiated	Prairie	Pleistocene		0 – 600	Unconsolidated glacial deposits pebbly clay (till) silt and gravel Loess (windblown silt) and alluvial silts sands and gravels
Tertiary & Cretaceous		Undifferentiated	Prairie			0 – 100	Sand and silt
Carboniferous: Pennsylvanian		Undifferentiated	Upper Bedrock / Mississippi Valley	Pennsylvanian		0 – 500	Mainly shale with thin sandstone limestone and coal beds
Carboniferous: Mississippian	Valmeyeran	St Louis Ls Salem Ls Warsaw Ls Keokuk Ls Burlington Ls	Upper Bedrock / Mississippi Valley	St Louis - Salem aquifer Keokuk – Burlington aquifer		0 600	Limestone, cherty limestone, green brown and black shale, silty dolomite
Carboniferous: Mississippian	Kinderhookian	Undifferentiated	Upper Bedrock / Mississippi Valley				
Devonian		Undifferentiated	Upper Bedrock / Mississippi Valley	Devonian		0 – 400	Shale, calcareous limestone beds, thin
Silurian	Niagaran	Port Byron Fm Racine Fm Waukesha Ls Joliet Ls	Upper Bedrock / Mississippi Valley	Silurian dolomite aquifer		0 – 465	Dolomite, silty at base, locally cherty
Silurian	Alexandrian	Kankakee Ls Edgewood Ls	Upper Bedrock / Mississippi Valley	Silurian dolomite aquifer			
Ordovician	Cincinnatian	Maquoketa Shale Group	Midwest Bedrock	Maquoketa confining unit		0 – 250	Shale, gray or brown locally dolomite and or limestone, argillaceous
Ordovician	Mohawkian (Ottawa Ls Megagroup)	Galena Group Decorah Subgroup Platteville Group	Midwest Bedrock	Galena-Platteville unit		0 – 450	Dolomite and/or limestone, cherty Dolomite, shale partings, speckled Dolomite and or limestone, cherty sandy at base
Ordovician	Mohawkian (Ottawa Ls Megagroup)	Ancell Gr: Glenwood Fm	Upper Bedrock	Ancell aquifer		100 – 650	Sandstone, fine- and coarse-grained, little dolomite, shale at top.
Ordovician	Chazyan	Ancell Gr: St Peter Ss	Upper Bedrock	Ancell aquifer		100 – 650	Sandstone, fine to medium-grained, locally cherty red shale at base
Ordovician	Canadian (Knox Megagroup)	Prairie du Chien Group: Shakopee Dol New Richmond Ss Oneota Dol Gunter Ss	Midwest Bedrock	Middle confining unit: Prairie du Chien		100 – 1300	Dolomite, sandy cherty (oolitic), sandstone Sandstone, interbedded with dolomite Dolomite, white to pink, coarse-grained, cherty (oolitic), sandy at base
Cambrian	St Croixian (Knox Megagroup)	Jordan Ss Eminence Fm Potosi Dolomite	Midwest Bedrock	Middle confining unit: Eminence-Potosi		100 – 1300	Dolomite, white fine-grained, geodic quartz sandy at base
Cambrian	St Croixian (Knox Megagroup)	Franconia Fm	Midwest Bedrock	Middle confining unit: Franconia		100 – 1300	Dolomite sandstone, and shale glauconitic green to red, micaceous
Cambrian	St Croixian	Ironton Ss Galesville Ss	Midwest Bedrock	Ironton-Galesville aquifer		0 – 270	Sandstone fine- to medium-grained well sorted upper part dolomitic
Cambrian	St Croixian	Eau Claire Fm	Basal Bedrock	Eau Claire		0 450	Shale and siltstone dolomite glauconitic sandstone dolomitic glauconitic
Cambrian	St Croixian	Mt Simon Fm	Basal Bedrock	Elmhurst Mt Simon aquifer		0 2600	Sandstone coarse grained white red in lower half lenses of shale and siltstone red micaceous
Pre Cambrian			Crystalline				No aquifers in Illinois

Note The rock stratigraphic and hydrostratigraphic unit classifications follow the usage of the Illinois State Geological Survey

Figure 9 Stratigraphy and water-yielding properties of the rocks and character of the groundwater in the study area.

DRILLING AND CASING CONDITIONS	WATER-YIELDING PROPERTIES	CHEMICAL QUALITY OF WATER	WATER TEMPERATURE °F
Boulders, heaving sand locally; sand and gravel wells usually require screens and development, casing in wells into bedrock	Sand and gravel, permeable. Locally, wells yield as much as 3000 gpm. Specific capacities vary from about 0.1 to 5600 gpm/ft.	TDS generally between 400 and 600 mg/L. Hardness 300–400 mg/L. Iron generally 1–5 mg/L.	50 – 64
Shale requires casing.	Extremely variable. Sandstone and limestone units generally yield less than 10 gpm.	TDS extremely variable regionally and with depth. North-central Illinois, 500–1500 mg/L, southern, 500–3000 mg/L. Hardness: 150–400 mg/L north, 150–1000 mg/L south. Iron generally 1–5 mg/L.	53 – 57
	In southern two-thirds of state yields generally less than 25 gpm	TDS ranges between 400 and 1000 mg/L. Hardness is generally between 200 and 400 mg/L. Iron: 0.3–1.0 mg/L.	53 – 59
Upper part usually weathered and broken; crevicing varies widely	Yields inconsistent. Major aquifer in NE and NW Illinois. Yields in fractured zones more than 1000 gpm.	TDS: 350–1000 mg/L; Hardness 200–400 mg/L; Iron: 0.3–1.0 mg/L.	52 – 54
Shale requires casing	Shales generally not water yielding. Crevices in dolomite units yield small local supplies.		
Crevicing commonly where formations underlie drift. Top of Galena usually selected for hole reduction and seating of casing.	Where overlain by shales, crevicing and well yields small. Where overlain by drift wells yield moderate quantities of water	For Midwest Bedrock Aquigroup as a whole, TDS ranges from 400 to 1400 mg/L in NW and up to 2000 mg/L in south. Hardness ranges from 175 mg/L in northern recharge areas to 600 mg/L in E. Cook and S. Fulton Counties. Iron generally less than 1.0 mg/L.	52 – 73
Lower cherty shales cave and are usually cased. Friable sand may slough.	Small to moderate quantities of water. Transmissivity approximately 15 percent of that of the Midwest Bedrock Aquigroup.		
Crevices encountered locally in the dolomite, especially in the Eminence-Potosi. Casing not required	Crevices in dolomite and sandstone yield small to moderate quantities of water. Transmissivity approximately 35 percent of that of the Midwest Bedrock Aquigroup.		
Amount of cementation variable. Lower part more friable. Sometimes sloughs.	Most productive unit of the Midwest Bedrock Aquigroup. Yields over 500 gpm common in northern Illinois. Transmissivity approximately 50 percent of that of the Midwest Bedrock Aquigroup.		
Casing not usually necessary. Locally weak shales may require casing	Shales generally not water yielding		
Casing not required	Moderate quantities of water in upper units. Comparable in permeability to the Glenwood-St. Peter Sandstone.	Varies northwest to southeast and with depth. At shallower depths, TDS: 235–4000 mg/L, Hardness: 220–800 mg/L, Iron: 0.1–20 mg/L. High chloride concentrations with depth.	51 – 62 in the north 80 or more in the south

Figure 9 *continued*

During 1988, the value of minerals extracted in Illinois was $2,492,200,000, a decline of 4.9 percent from 1987. Mineral fuels (coal, crude oil, and natural gas) made up 82 percent of the total value. Illinois ranked 17th among the 50 states in total production of nonfuel minerals, but continued to lead all other states in production of fluorspar, industrial sand, and tripoli. The state ranked 15th of 31 oil-producing states in 1988. Oil was produced from 47 counties, mainly in southern Illinois. Nine counties produced more than 1 million barrels each, which accounted for about 66 percent of the state's total oil production.

Groundwater

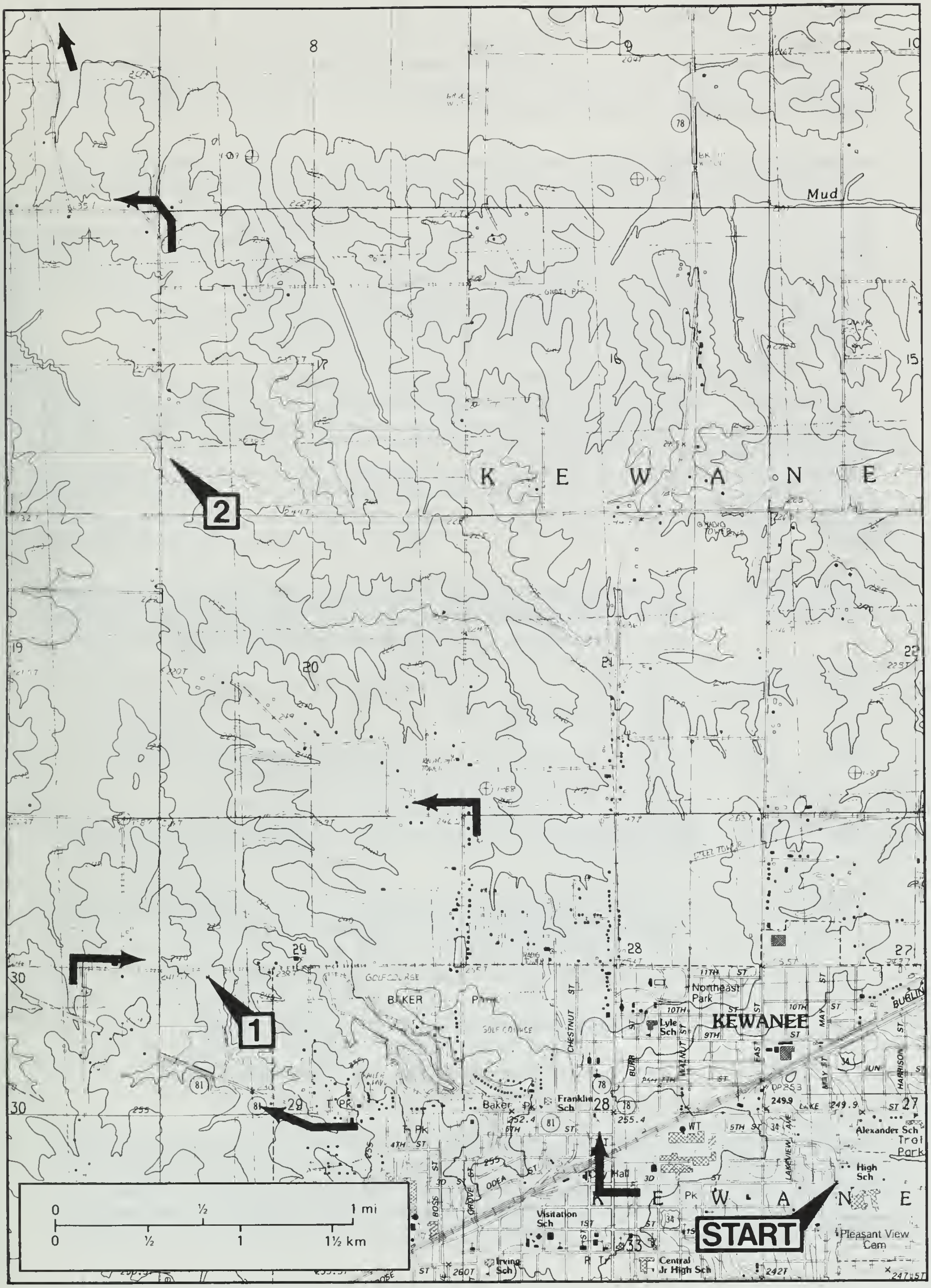
Most of us generally do not think of groundwater as a mineral resource in assessing the natural resource potential of an area. Yet the availability of groundwater is essential for orderly economic and community development. More than 48 percent of the state's 11 million citizens depend on groundwater for their water supply.

The source of groundwater in Illinois is precipitation that infiltrates into the soil and percolates downward into the groundwater system, which lies below the water table in the zone of saturation. Groundwater is stored in and transmitted through saturated earth materials called *aquifers*. An aquifer is any body of saturated earth materials that will yield sufficient water to serve as a water supply for some use. The pores and other void spaces in the earth materials of an aquifer must be permeable; that is, they must be large enough and interconnected so that water can overcome confining friction and move readily toward a point of discharge, such as a well, spring, or seep. Generally, the water-yielding capacity of an aquifer can be evaluated by constructing wells into it. The wells are then pumped to determine the quantity and quality of groundwater available for use.

Because glacial deposits are relatively thin throughout southern Henry County and western Bureau County, deposits of water-yielding sand and gravel generally are also thin. Scattered lenses of sand and gravel are most likely to be found in tracts of thicker drift. Permeable sand and gravel deposits that are 100 to 300 feet thick and potential sources of groundwater for municipalities and industries, occur in the bottomlands to the north along Green River and in the buried valley of the Ancient Mississippi River.

About 300 feet of Pennsylvanian bedrock underlies the glacial drift through most of Henry County. Locally, water-bearing strata consisting of fractured thin limestones, sandstones, and shales occur in the Pennsylvanian and may yield sufficient supplies for domestic use (fig. 9). Silurian-age dolomite is the main source of domestic groundwater supplies and the source of the municipal supply for Annawan and other small communities. Wells into the Ordovician Glenwood-St. Peter, some 1,500 feet deep at Kewanee, commonly yield about 200 gallons per minute (gpm) with approximately 1,200 parts per million (ppm) total dissolved minerals. Also at Kewanee, the county's deepest aquifer is the Upper Cambrian Ironton-Galesville Sandstone at a depth of about 2,450 feet. Wells into this aquifer yield 600 to 900 gpm of water with about 1,700 ppm total dissolved minerals.

In Bureau County, water-yielding sand and gravel deposits occur at various depths. Deposits more than 400 feet deep lie within the buried Mississippi and lower Rock valleys. Because glacial deposits locally are thin in the southwestern part of the county, drilling penetrated into the underlying Pennsylvanian bedrock formations, of which only the more permeable sandstone beds yield water.


8
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Mud
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GOLF COURSE
BAKER
Park
11TH ST
Northeast Park
10TH
9TH
CHESTNUT ST
WALNUT ST
BURR
Lyle Sch
KEWANEE
1
Baker Pk
Franklin Sch
LAKE
5TH ST
4TH ST
6TH
ODEA
GROVE
ROSE ST
City Hall
WT
Alexander Sch
High Sch
LAKEVIEW AVE
HARRISON
K E W A N E E
START
Pleasant View Cem
Visitation Sch
Irving Sch
Central Jr High Sch
0 ½ 1 mi
0 ½ 1 1½ km

GUIDE TO THE ROUTE

Assemble at Kewanee Community High School (NW NW SE NW Sec. 34, T15N, R5E, 4th P.M., Kewanee South 7.5-Minute Quadrangle [41089B8]*). Line up in the parking lot on the west side of the school. The starting point is just northwest of the building. Mileage calculations start at the intersection of East 3rd and May Streets.

Please note—you must travel in the caravan. Some stops on our field trip itinerary are on private property. The owners have graciously given us permission to visit their property on the day of the field trip only. Please obey all instructions from the trip leaders and conduct yourselves as guests. So that we may be welcome to return on future field trips, please do not litter or climb on fences. Leave all gates as you found them. These simple rules of courtesy also apply to public property. If you plan to use this booklet for a field trip with your students, youth group, or family, because of trespass laws and liability constraints, you *must* get permission from property owners or their agents, before entering private property.

Please drive with your headlights on while in the caravan. Drive safely but stay as close as you can to the car in front of you. Please obey all traffic signs unless the road crossing is protected by an emergency vehicle with flashing lights and flags. When we stop, park close to the car in front of you and turn off your lights.

Miles to next point	Miles from start	
0.0	0.0	T-road intersection of East 3rd Street and May Street, which runs south into the parking lot on the west side of Kewanee High School, the home of the Boilermakers. We will head west on East 3rd Street.
0.15+	0.15+	STOP: 4-way at East 3rd Street and North Lake View Avenue. CONTINUE AHEAD (west).
0.1	0.25+	STOP: 2-way at East 3rd Street and North East Street (US Route 34 East). CONTINUE AHEAD (west).
0.5	0.75+	CAUTION: STOPLIGHT at Main Street. TURN RIGHT (north) on State Route (SR) 78.
0.05+	0.85	CAUTION: guarded 2-track Burlington Northern (BN) Railroad crossing. CONTINUE AHEAD (north) and prepare to turn left.
0.1+	0.95+	TURN LEFT (west) on SR 81 and West 6th Street.
1.05	2.0+	Leave Kewanee city limits. CONTINUE AHEAD (west).
0.3	2.3+	To the right is the entrance to the Kewanee landfill.

* The number in brackets [41089B8] after the topographic map name is the code assigned to that map as part of the National Mapping Program. The state is divided into 1° blocks of latitude and longitude. The first two numbers refer to the latitude of the southeast corner of the block; the next three numbers designate the longitude. The blocks are divided into sixty-four 7.5-minute quadrangles; the letter refers to the east-west row from the bottom, and the last digit refers to the north-south column from the right.

0.4	2.7+	Prepare to turn right just over the crest of the hill.
0.1	2.8+	TURN RIGHT (north) at 740N/2480E.
0.3	3.1+	T-road from left. CONTINUE AHEAD (east) down the hill and prepare to stop.
0.15+	3.25+	The area to the right has been scraped off and the material has been used for cover over the landfill trenches.
0.15+	3.4+	PARK along the roadside. Do not block the road or the gate to the right. Walk to the right (south) for about 200 feet, turn right and walk west into an open pit that exposes Pennsylvanian bedrock. DO NOT CLIMB the face of the exposure. CAUTION: be careful where you stand when you are on the upper ledge as the rocks have large cracks under foot and could possibly break loose, especially if the ground is very wet.

STOP 1 View and study part of the Pennsylvanian Carbondale Formation (fig. 10) exposed in the northwest part of the Kewanee Sanitary Landfill operation (back entrance: near center N edge NE NW SW Sec. 29, T15N, R5E, 4th P.M., Henry County; Kewanee North 7.5-minute Quadrangle [41089C8]). CAUTION: stay away from the edge of the bedrock ledge. It is cracked and could be unstable, especially if it is wet.

Pleistocene material has been disturbed, perhaps several times, across the top of the pit. The remaining material is highly weathered, as is the bedrock immediately below. The following is a general section for this immediate area:

	Thickness
Pennsylvanian System	
Kewanee Group	
Carbondale Formation	
Herrin (No. 6) Coal Member	
Coal, highly weathered with thin clay streaks, top eroded	2+ ft
Clay, gray, soft, weathered; "blue-band"	2-3 in.
Coal, weathered with clay partings up to nearly 1 inch thick	1 ft 5 in.
Underclay, dark gray	9 in.
Underclay (?), brownish gray	10 in.
Clay, tan	1 ft 2 in.
Limestone, gray, conglomeratic or brecciated	1 ft
Limestone, tan to rusty brown, massive, nodular downward	2 ft
Clay, very calcareous with numerous limestone nodules	1 ft
Vermilionville Sandstone Member	
Sandstone, tan, micaceous, soft, slightly calcareous, downward becomes noncalcareous, thin-bedded, shaly	12 ft
Canton Shale Member	
Shale, gray, soft, sandy, base concealed	4+ ft

The Herrin Coal was formerly mined in shaft mines throughout the area where it averaged about 4 feet thick. Some of the first mines opened in the 1850s to furnish coal for railroads and the home trade. Most early mines were underground operations, but where the coal lay close to the surface, stripping operations were carried out on a limited scale. Large stripping operations began about 1941 and continued until 1964 when the mines were abandoned.

The Kewanee Sanitary Landfill operator dug through the coal while constructing trenches for disposal of nonhazardous wastes. Refuse materials are dumped into the trenches, compacted, and then covered daily with newly dug materials. Because the trenches are in shale, which is relatively impermeable, water movement through the site should be at a minimum, and any aquifers beneath the site should be fairly well protected from any seeping leachate, which would tend to move laterally along bedding planes. This leachate would then mix with and be diluted by surface water; if toxic, it would have to be collected and treated.

Soil from higher slopes at the facility is used to "top dress" the operation so that a grass cover can more readily be established to reduce surface erosion. As you can see, not much acreage is left at this site for landfilling.

0.0	3.4+	Secure entrance gate and leave Stop 1. CONTINUE AHEAD (east).
0.05	3.45+	Cross Walker Creek.
0.25	3.7+	STOP at Y-intersection from right. CAUTION: visibility is poor. CONTINUE AHEAD (east).
0.1	3.8+	To the right is Kewanee's Baker Park and golf course.
0.4+	4.25+	STOP: 1-way. T-intersection of West 11th Street and Cambridge Road. TURN LEFT (north).
0.45+	4.75	CAUTION: T-road from left (800N/2600E). TURN LEFT (west).
0.45+	5.2+	STOP: 1-way. T-road intersection (830N/2570E). TURN LEFT (west). CAUTION: visibility to the right is poor.
1.5+	6.7+	PARK along the roadside as far off the roadway as you safely can. CAUTION: the ditch is deep, and traffic is fast.

STOP 2 View and study Pleistocene glacial drift and overlying loess, especially where it is exposed in east roadcut (near center W edge extended NW SW SW Sec. 17, T15N, R5E, 4th P.M., Henry County, Kewanee North 7.5-Minute Quadrangle [41089C8]).

The soil has developed in the Wisconsinan Peoria Loess, which is about 5 feet thick here. Maps indicate expected thicknesses greater than 15 feet for this area. Slope wash and farming practices undoubtedly have contributed to some loss of loess; however, it appears to thicken somewhat to the east. Beneath the loess is weathered, leached Illinoian glacial till at least 10 feet thick. The rusty-looking contact between the loess and the till represents the Sangamon Soil, a weathering (soil) profile developed in the top part of the Illinoian till. Lower till or perhaps even shale bedrock is protected by a layer of rock armor that extends 8 to 9 feet above the ditch bottom.

The till contains a wide assortment of erratics, both as to size and rock types. Some larger erratics are more than 1 foot across. Some types of sedimentary rock appear to be of local origin, as they are only partially rounded, indicating that they did not travel far in the ice. Quite a number of large igneous and metamorphic erratics have been used for landscaping in the area. I suspect that most have been collected from nearby creeks.

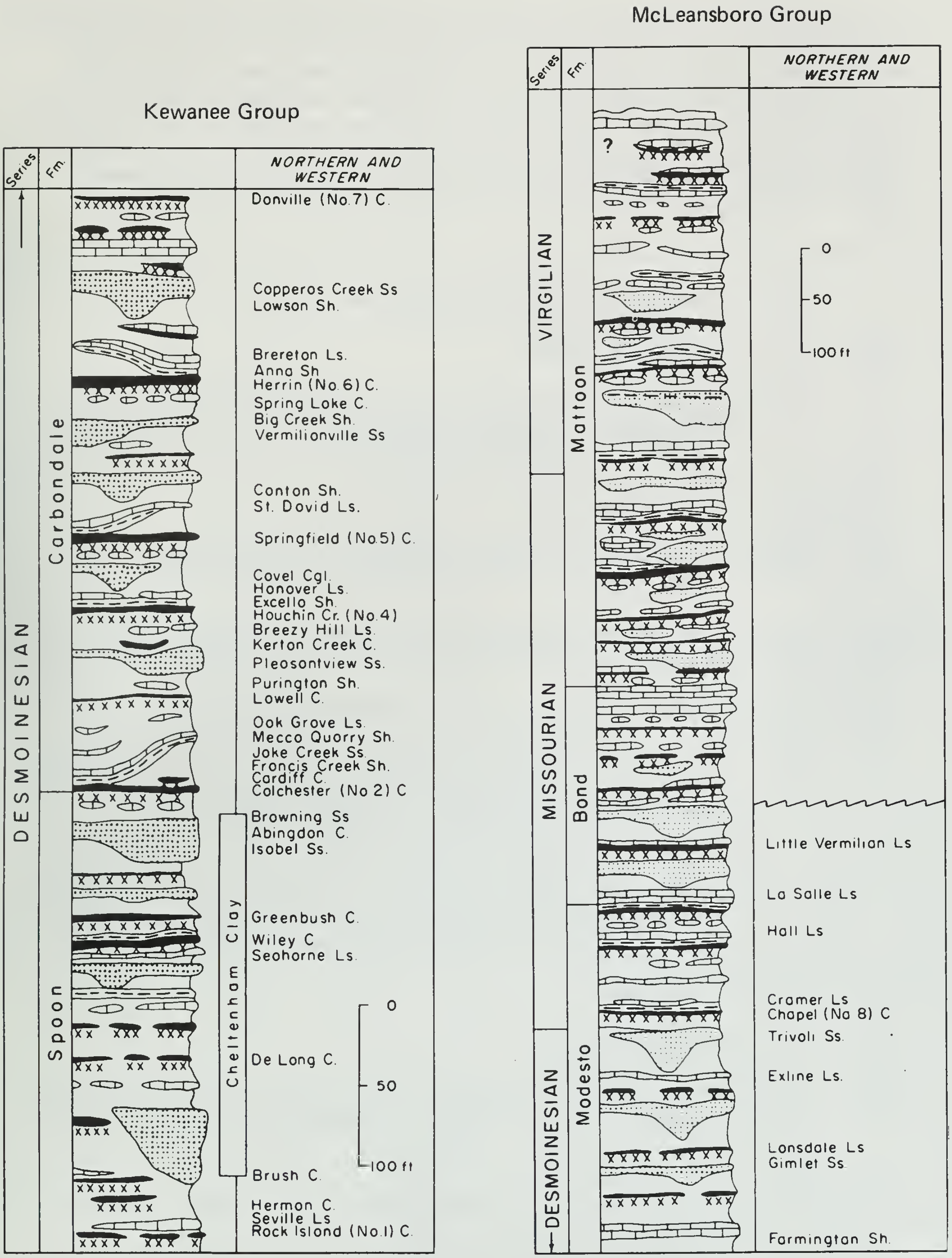
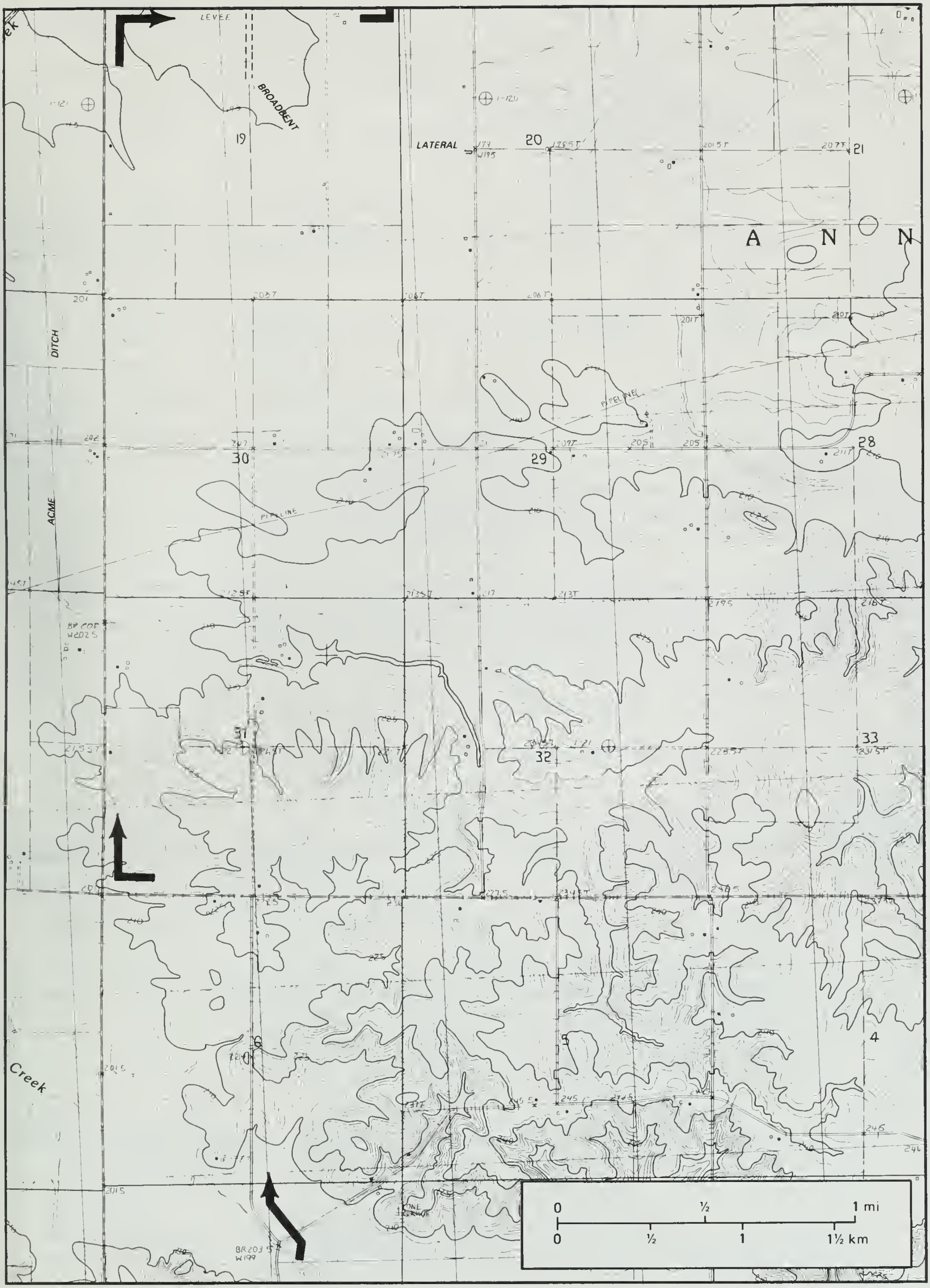


Figure 10 Generalized geologic column of Kewanee and McKeansboro Group strata for northern and western Illinois. (Not all units are present in the field trip area.)

The landscape along this part of the route is more deeply dissected than what we will see later. Because the area is considerably above *base level*, the level below which streams cannot erode their beds, streams are actively downcutting their beds and extending themselves headward into the upland remnants. Under these conditions, valley walls are steep-sided. Here the Illinoian till has been more deeply weathered. As we travel northward, you will see that the topography becomes more subdued. The Illinoian till that underlies the area about 4.5 miles ahead is younger and was not as deeply weathered as the till is here. Later, Wisconsinan meltwater torrents stripped away the weathered till before Wisconsinan loess blanketed the area.

0.0	6.7+	Leave Stop 2 and CONTINUE AHEAD (north).
0.95+	7.7+	Prepare to turn right.
0.1	7.8+	TURN RIGHT (north) at T-road intersection (1000N/2470E). Note the configuration of the land surface in this area. Contrast this topography with what you see later along the route.
0.8+	8.6+	Cross Mud Creek.
0.05-	8.65	TURN LEFT (northwest) at unguarded T-road intersection (1080N/2460E).
1.15+	9.8+	CAUTION: unguarded T-road intersection (1200N/2450E). TURN LEFT (west).
0.5	10.35	STOP: 2-way at crossroad (1200N/2400E). TURN RIGHT (north).
0.1	10.45	Notice how much gentler the slopes are on the moraine than the slopes were in the vicinity of Stop 2. The younger Illinoian drift in this area had the Sangamon Soil stripped off the top by Wisconsinan meltwater torrents gushing across the lowland just to the north. The drift sheet here has not been exposed to erosion as long as the older drift closer to Kewanee, so a rugged terrain has not developed on it. This area is also closer to base level and the streams are not downcutting as forcefully as they do where the land stands high above base level.
0.8+	11.25+	Cross ditch.
0.15	11.45	Pipeline crossing.
0.4	11.85	STOP: 2-way (1350N/2400E). CAUTION: CONTINUE AHEAD carefully. Visibility is somewhat limited because of a curve on a slight rise to the east.
1.5	13.35	CAUTION: unguarded offset crossroad (1500N/2400E). TURN RIGHT (east).
0.45+	13.8	Cross ditch. CAUTION: 1 lane.
0.5	14.3+	TURN LEFT (north) at T-intersection (1500N/2500E).



LEVEE
BROADBENT
LATERAL
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PIPELINE
Creek
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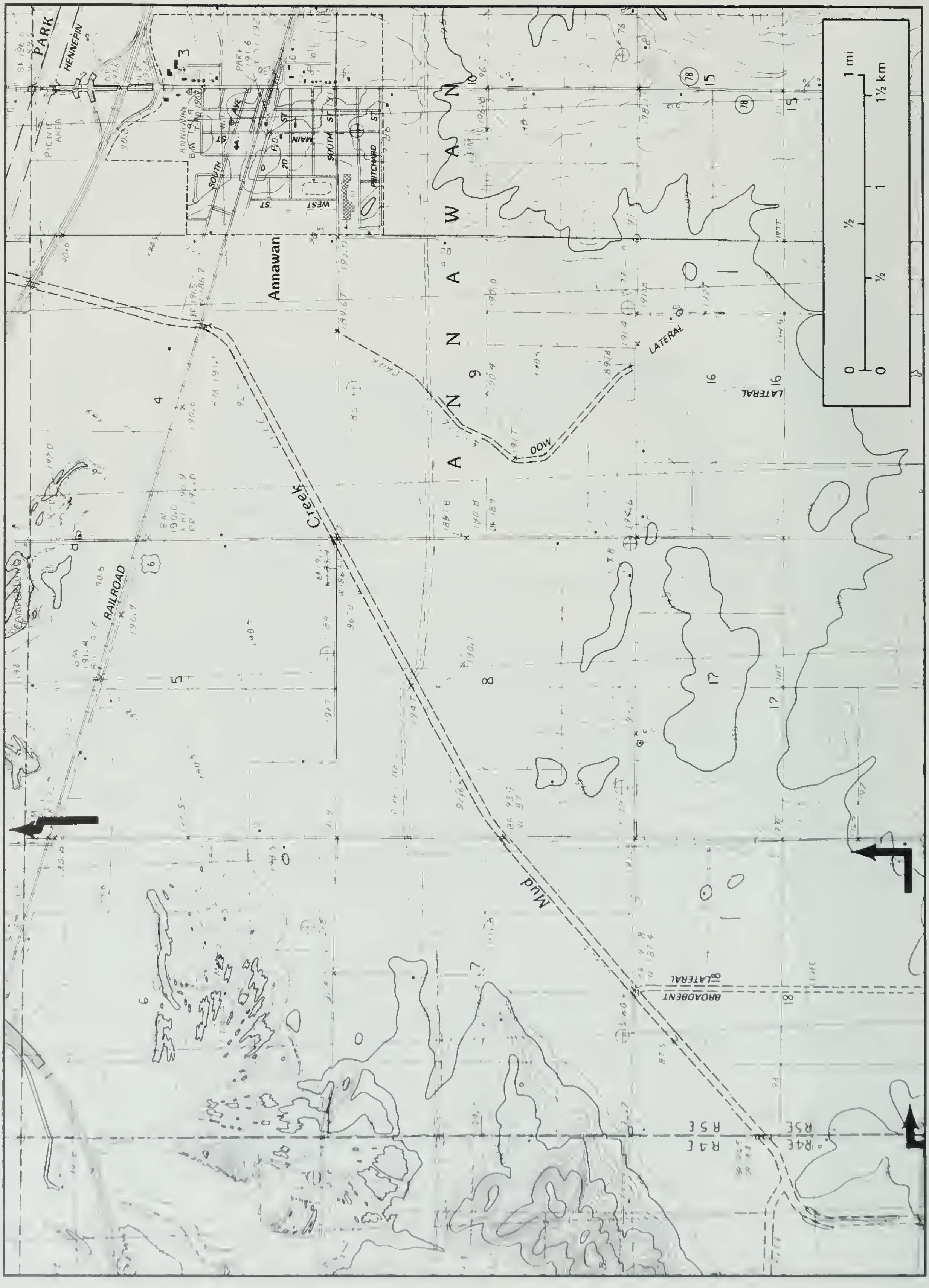
0 ½ 1 1½ km

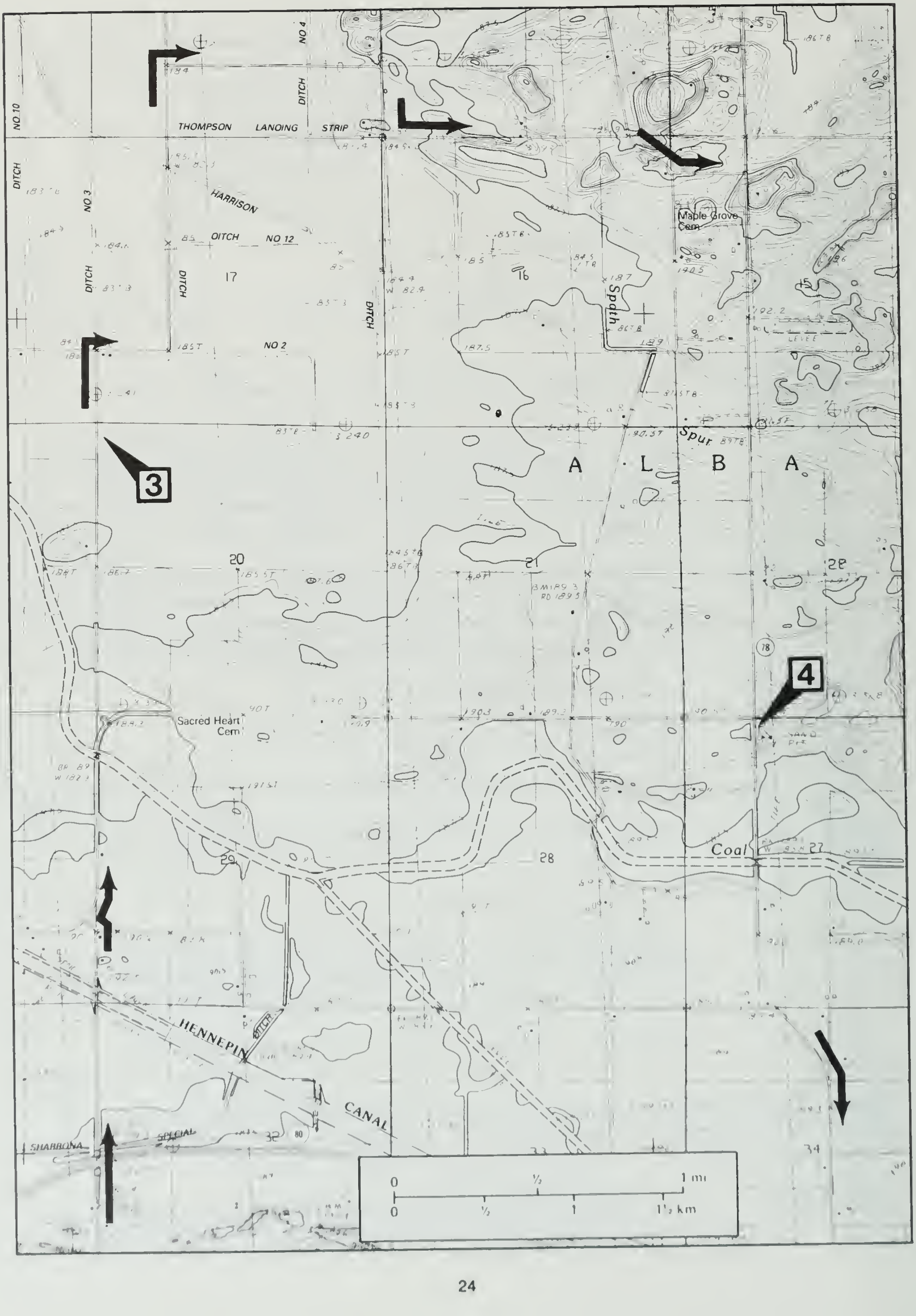


Annawan
Mud Creek
RAILROAD
PARK
HENNEPIN
PICNIC AREA
SOUTH ST
MAIN
PRITCHARD ST
WEST ST
DOW
LATERAL
BROADBENT LATERAL
R4E R5E
0 ½ 1 mi
0 ½ 1 1½ km

0.5	14.8+	The gentle, undulating surface in this area is part of an old lake bottom from a lake that formed when the Wisconsinan glacier stood a few miles to the east and blocked the east-flowing drainage. The hills about 1 mile to the left consist of the younger part of the Illinoian drift.
0.5	15.3+	CAUTION: unguarded crossroad (1600N/2500E). CONTINUE AHEAD (north).
0.4	15.75+	Cross Mud Creek.
0.3+	16.1	Pipeline crossing.
0.2+	16.3+	CAUTION: unguarded crossroad (1700N/2500E). CONTINUE AHEAD (north).
0.35	16.65+	The area to the left was strip mined for coal in the 1940s to 1950s.
0.55+	17.25+	STOP: T-road intersection with US 6 (1790N/2500E). CAUTION: TURN LEFT (northwest) and then RIGHT (north) over the unguarded, single-track Iowa Railroad (IR) crossing. This once was the main line of the Chicago, Rock Island, and Pacific Railroad. Some of the area to the north has also been stripmined and reclaimed for pasture.
0.55+	17.85+	Cross I-80. Soil on the north side of I-80 is black, which indicates that it contains a lot of organic matter. This material is muck, a mixture of finely divided plant debris and silt that accumulated in a poorly drained site. Once the muck has been drained by tiles and ditches, it can be farmed.
0.55+	18.4	CAUTION: cross the Hennepin Canal Parkway.
0.1+	18.55	Note the very sandy soil in the low roadcut on the left.
0.1	18.65	CAUTION: the wide intersection is unguarded. BEAR LEFT (northwest).
0.05+	18.7+	STOP: 1-way at T-road intersection on a curve (1920N/2500E). TURN RIGHT (north).
0.55+	19.25+	Cross Mud Creek and prepare to turn left.
0.1+	19.4	TURN LEFT (north) at T-intersection (2000N/2500E) on the curve. The fields to the right are very sandy and silty. When they have been plowed, you can see the fine silt in the air above them: loess blowing in the wind.
1.0	20.4	PARK along the roadway. DO NOT BLOCK the road or field gates.

STOP 3 View and discuss part of the Green River Lowland from the roadside (near SW corner NW NW NW Sec. 20, T17N, R5E, 4th P.M., Henry County, Annawan 7.5-minute Quadrangle [41089D8]).

For the last several miles we have been traveling across a relatively flat area that is part of the Green River Lowland. As noted in the introduction, this lowland is essentially an outwash plain


THOMPSON LANDING STRIP
HARRISON
DITCH NO 12
DITCH
NO 10
NO 3
NO 4
NO 2
Maple Grove Cem
Spath
Spur
LEVEE
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Sacred Heart Cem
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HENNEPIN CANAL
SHARRONA
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formed when the Bloomington glacier, which stood about 15 miles east from here, was melting away. The Ancient Mississippi River flowed in a deep bedrock valley southeastward from the Fulton area to the Princeton area via the Meredosia Bedrock Channel and the Princeton Bedrock Valley. The axis of the ancient channel is 8 miles northeast from here. The bedrock valley is 1.5 to 2 miles wide at an elevation of 300 feet msl, which is about 300 feet lower than the elevation here. Not all Pre-Wisconsinan glacial drift had been flushed out of the old valley when Wisconsinan glaciers invaded the area to the east and blocked the ancient channel. Meltwater from the Bloomington glacier was funneled to this low area, adding to the thickness of materials from earlier glaciations. More than 300 feet of sand and gravel outwash filled the ancient bedrock valley and produced a vast swamp. These deep, thick, permeable sands and gravels are good sources of large quantities of groundwater for municipal and industrial purposes.

The Bloomington glacier blocked the Ancient Mississippi Valley long enough for the low, bedrock divide at Cordova to be topped and breached, thus establishing a new channel for the river to the south and west past the site of the present-day Quad Cities. As we may observe with interest, this area is not much higher than the present Mississippi River. During times of extremely high water, people have had to erect temporary earthen and sandbag dams to keep the river from flooding eastward into the Green River Lowland.

We are on the bedrock uplands of the ancient valley and some 4 miles from it. Glacial deposits here are less than 25 feet thick; the upper part is sand containing a high percentage of organic debris. The dark color appearing in some places is due to a high content of organic debris; some small areas contain muck and peat where the drainage is poor. On your route maps, note the straight drainage lines (ditches) with sharp angled corners that have been dug to drain the area. The Green River, a rather small stream for which the lowland is named, occupies an artifical channel about 1.6 miles north of this site.

0.0	20.4	Leave Stop 3 and CONTINUE AHEAD (north).
0.25+	20.65	CAUTION: unguarded T-intersection (2125N/2500E). TURN RIGHT (east).
0.25	20.9+	TURN LEFT (NORTH) along Ditch No. 2.
0.6+	21.55+	Cross Harrison Ditch.
0.35	21.9+	TURN RIGHT (east) at T-intersection (2225N/2525E).
0.45+	22.4+	Cross Ditch No. 4.
0.45+	22.9	TURN LEFT (east) at T-intersection (2100N/2600E). The route crosses several sand hills in this area.
0.85	23.75	TURN RIGHT (southeast) at Y-intersection (2085N/2683E).
0.2	23.95	TURN LEFT (east) at Y-intersection (2085N/2700E).
0.25	24.2	STOP: 1-way at T-intersection with SR 78 (2085N/2725E). CAUTION: traffic fast. TURN RIGHT (south).
1.75	25.95	Prepare to park ahead.

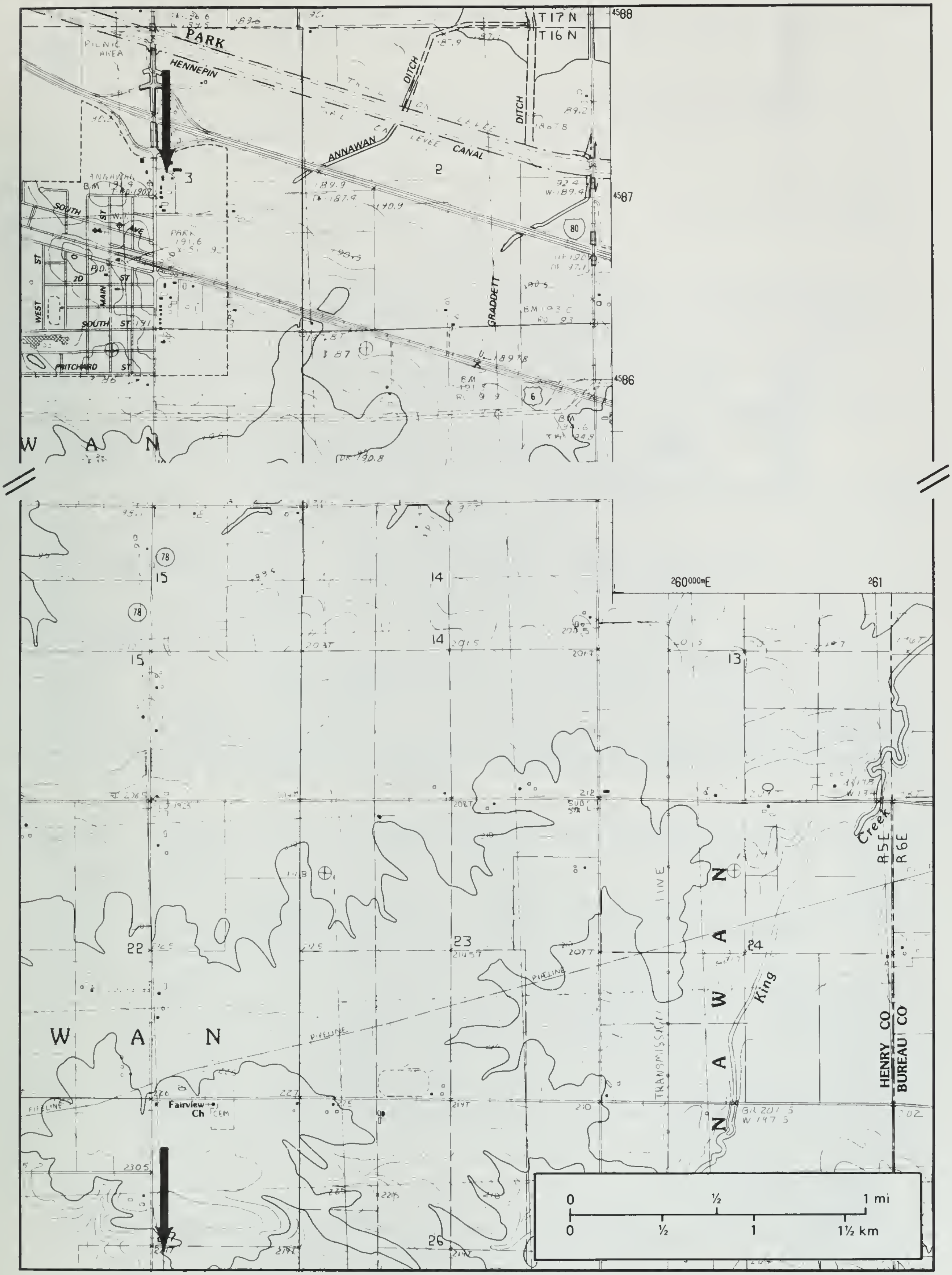
0.1+	26.05+	T-road intersects (2000N/2730E) from the right. CONTINUE AHEAD to park.
0.05-	26.1	PARK off the road as far as you can. DO NOT BLOCK roads or driveways. CAUTION: traffic is fast.

STOP 4 View and examine a hill of Pleistocene Parkland Sand on the Green River Lowland (E side SR 78 in W/2 NW NE NW Sec. 27, T17N, R5E, 4th P.M., Henry County, Annawan 7.5-Minute Quadrangle [41089D8]).

Sand was removed from part of this 15-foot-high hill many years ago. The hill is partly protected from the prevailing wind by a thin cover of vegetation. Unless covered by vegetation, the very fine sand drifts and blows in strong winds, especially on the higher hills. Trails made by offroad vehicles make maintaining a vegetative cover on these sand hills extremely difficult.

Sand pits, such as this one, have frequently been used for refuse disposal sites in the past. Some are still being used illegally. When this kind of a site is used for refuse, leachates can readily enter the groundwater system and carry pollution into many local and municipal water-supply wells. This site is slated to be used for concrete disposal later this year when SR 78 is improved through this area. Unless special care is taken, the site may also be the disposal area for "empty" oil cans and grease cartridges from construction equipment. The site also could become a place where others may dispose of refuse because they believe that as it will soon be covered by highway debris, the extra refuse should be nothing to worry about.

0.0	26.1	Leave Stop 4. CONTINUE AHEAD (south). Use CAUTION pulling back onto the highway.
0.45	26.55	Cross Coal Creek.
1.5	28.05	CAUTION: you are approaching I-80.
0.1+	28.15+	Cross Hennepin Canal and ascend I-80 interchange.
0.25+	28.4+	Cross I-80. CONTINUE AHEAD (south) into Annawan on SR 78 (North Canal Street).
0.5	28.9+	CAUTION: guarded, single track railroad crossing. CONTINUE AHEAD.
0.05-	28.95+	STOP: 4-way (US 6). CONTINUE AHEAD (south) on SR 78 and S. East Street.
0.35	29.3+	Leave Annawan.
0.1+	29.45	Pipeline crossing. Compressor station on the right. Ascend the Illinoian moraine ahead.
4.55+	34.0+	Prepare to turn left at Johnson-Sauk Trail Road. CAUTION: a divided highway lies just ahead.



T17N
T16N
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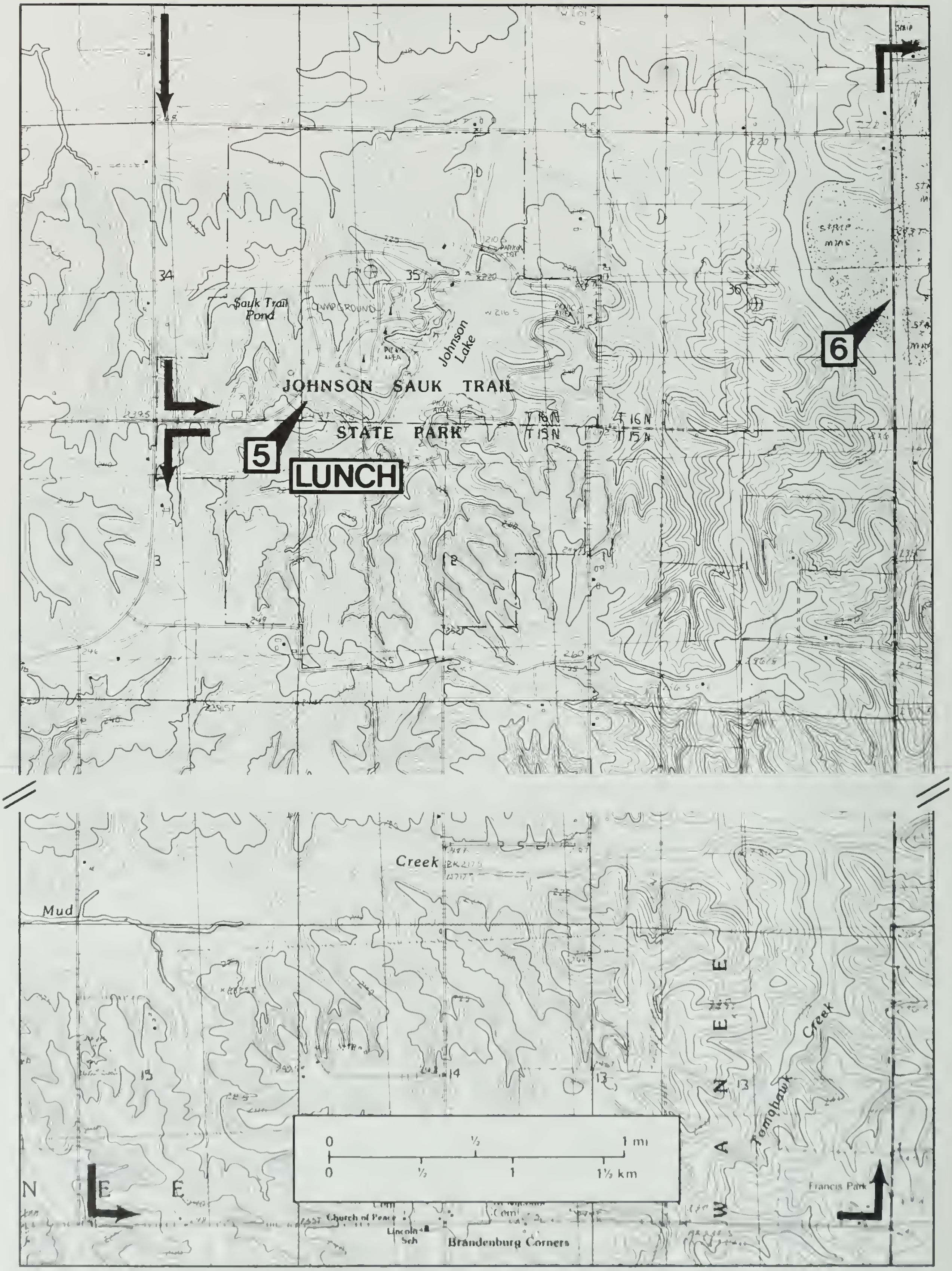
JOHNSON SAUK TRAIL
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0.15	34.15+	TURN LEFT at the entrance to Johnson-Sauk Trail State Recreation Area (1200N/2750E).
0.5+	34.65+	T-road intersects from left. It leads to a picnic area just south of the big red barn. Several other picnic areas are available, but mileage calculations will resume from this point.

STOP 5 Lunch at picnic area (entrance: NE SE SE SE Sec. 34, T16N, R5E, 4th P.M., Henry County, Kewanee North 7.5-Minute Quadrangle [41089C8]).

Johnson-Sauk Trail State Park, located on the slopes above the Green River Lowland, was known as the "Great Willow Swamp" by early settlers and probably the Indians. The park was named in honor of Frank P. Johnson from Kewanee, who worked hard to develop the park. Sauk Trail honors the Indian trail used by Black Hawk, chief of the Sauk Tribe. They lived and hunted in the area. A park brochure will provide you with an interesting history of the area.

0.0	34.65+	Leave Stop 5 and retrace your route west to SR 78.
0.5+	35.15+	STOP: 2-way at the crossroad with SR 78. Highway divides. TURN LEFT (south) in the far lane (1200N/2750E).
0.75+	35.9+	Prepare to turn left on the far side of the curve to the west.
0.1+	36.05+	TURN LEFT (south) at T-intersection (1120N/2720E).
0.2+	36.25+	To the left, a fence line is sticking out almost horizontally because of soil creep on that embankment. CONTINUE AHEAD (south).
0.45	36.7+	Note the number of grass waterways that you see in the surrounding area. These have been established to help control erosion of the fields on these steep hillsides.
0.5	37.2+	CAUTION: narrow concrete buttressed bridge crosses Mud Creek. CONTINUE AHEAD (south).
0.15+	37.4	To the right, a small gully is trying to develop southward in the field. The landowner is trying to hold it back with bales of straw, but should create a grass waterway in that spot.
0.3	37.7	To the left over the bank is an abandoned sand and gravel pit that has been used for random dumping of garbage, hence the no-dumping signs. CONTINUE AHEAD (south).
0.2	37.9	This roadcut has slumped quite a lot on both sides. The ditches have not been well maintained, so drainage has been poor. The till and the little bit of loess cover on top have slumped toward the road.
0.35	38.25+	STOP: 1-way at T-intersection (900N/2725E). TURN LEFT (east).
1.2+	39.45+	STOP: 2-way at crossroad at Brandenburg Corners (900N/2850E). CONTINUE AHEAD toward Francis Park.

0.75	40.2+	Power transmission line crossing.
0.05+	40.3+	CAUTION: narrow concrete culvert.
0.55	40.85+	To the left is the Woodland Palace in Francis Park. The following information is displayed on an historical marker in front of the home, Woodland Palace: "This was the home of Fred Francis, inventor and innovator, artist and poet. Born near Kewanee in 1856, he graduated from the Illinois Industrial University, Urbana, in 1878. While there, he was one of the designers and builders of the "Class of '78" Clock, now in the north tower of the Illini Union. In this home, which he built, he incorporated many innovations, including a water purification system and air conditioning. Francis died in 1926 and bequeathed his estate to the city of Kewanee, to be maintained as a city park and museum. CONTINUE AHEAD (east).
0.1+	41.0+	T-intersection. You have reached the east boundary of Henry County. TURN RIGHT (north). You're in Bureau County on the east side of the road. CAUTION: bumpy road lies ahead.
0.45+	41.45+	To the left is a partly earth-sheltered home.
0.8+	42.3+	CAUTION: cross Mud Creek. CONTINUE AHEAD (north).
1.1+	43.4+	CAUTION: left side of the roadcut has slumped down onto the road.
0.65	44.05+	CAUTION: 2 narrow creek crossings just ahead.
0.15	44.2	You're entering an abandoned strip-mine area.
0.2	44.4+	PARK along the roadside just beyond the north end of the guard rail.

STOP 6 View strata exposed in abandoned strip mine highwall (E side of County Line Road: NW NW NW SW Sec. 31, T16N, R6E, 4th P.M., Bureau County, Neponset 7.5-Minute Quadrangle [41089C7]).

The Herrin (No. 6) Coal Member of the Carbondale Formation was strip mined from this area during the 1940s to early 1960s. The highwall across from us shows some of the undisturbed Pennsylvanian bedrock and the overlying Pleistocene deposits. The latter consists of about 12 feet of Peoria Loess overlying about 8 feet of Illinoian glacial till. The Modern Soil is developed in the top of the loess.

Because the glacial materials have slumped over the bedrock face, the thickness of the Farmington Shale Member of the Modesto Formation (fig. 10) present here is difficult to see; but it probably is no more than 2 or 3 feet thick. Elsewhere in western and northern Illinois, if it has not been eroded, it may be as much as 50 feet thick. It has been extensively mined for clay.

The underlying Danville (No. 7) Coal Member is the uppermost member of the Carbondale Formation and the Kewanee Group. Although only about 2 feet thick here, it is 6 feet thick in the type area near Danville, Illinois, where commercial mining began in the latter part of the

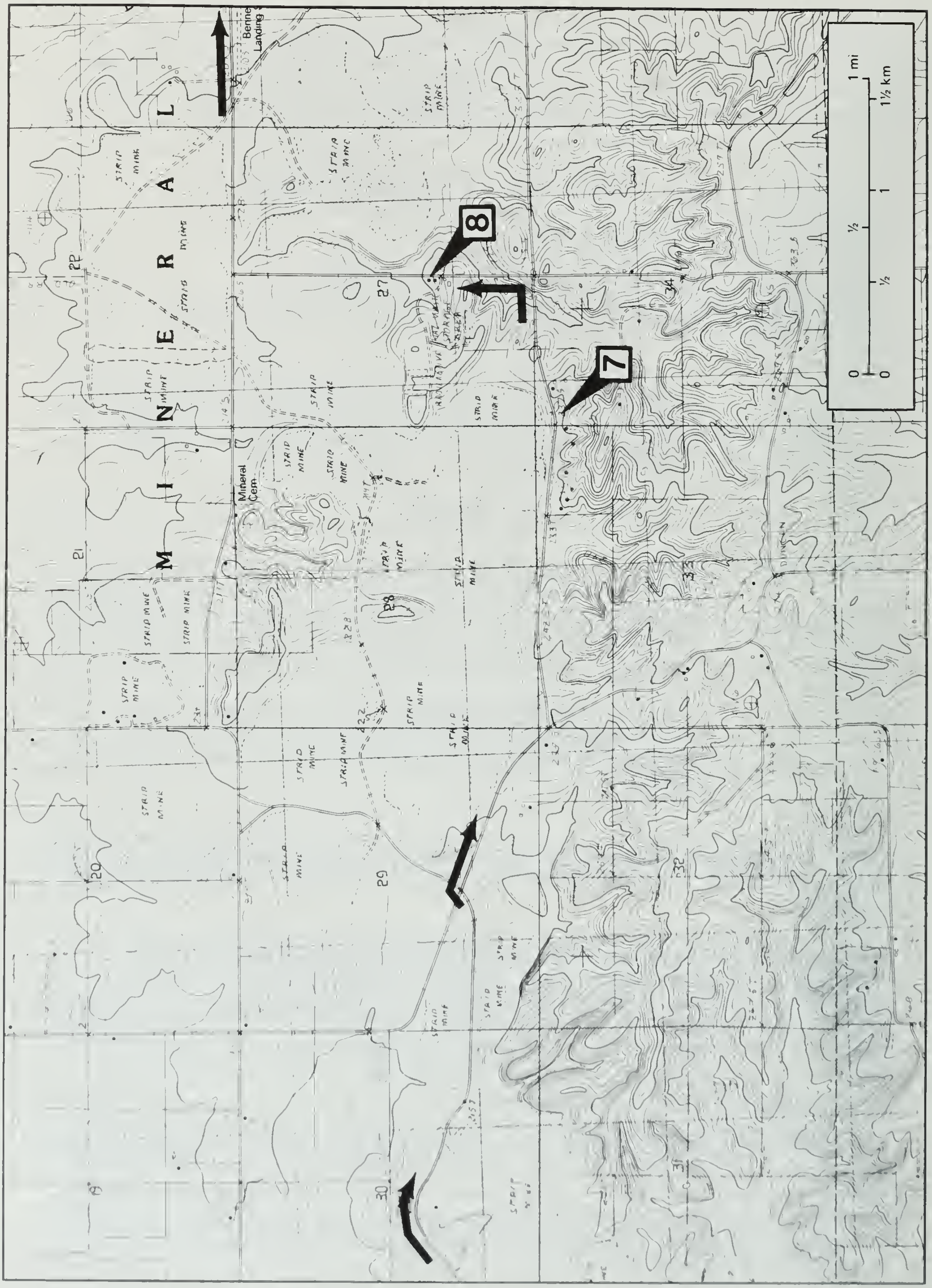
1800s. It was an important minable coal in Livingston, McLean, La Salle, Marshall, and Vermilion Counties as well. There has also been some production from Peoria County. In the type area (Vermilion County), the Danville Coal occurs about 20 feet above the Herrin Coal. However, in this vicinity, it occurs approximately 45 feet above the Herrin. About 2 to 3 feet of underclay and claystone occur here between the Danville Coal and water level.

0.0	44.4+	Leave Stop 6 and CONTINUE AHEAD (north).
0.7	45.1+	Prepare to turn right.
0.05	45.2+	TURN RIGHT (east) at T-intersection (2585N/00E).
1.5+	46.75+	STOP: 2-way at crossroad (1325N/145E). TURN RIGHT (east).
0.5	47.3	Prepare to turn left at the curve ahead. Just before the curve, a large oak tree stands on the east side of the road inside a white picket fence. It is known as the "Witness Tree" The sign in front of the tree reads, "This oak tree was the reference point to survey the railroad in Mineral Township, 1851-1853."
0.1	47.4	TURN LEFT (east) at 1300N/200E.
1.05	48.45	PARK along the roadside. To the left, we can see capped pipes for checking water levels and instruments for monitoring weather at a site for an infiltration control project conducted by the Illinois State Geological Survey several years ago. Trenches that were lined and filled with waste materials have long since been covered over and seeded with grass.
		Toward the back of the property, you can see a first-class weather station established by the Illinois Department of Nuclear Safety in 1990 to replace an older weather station operated by the U.S. Geological Survey.

STOP 7 View the ISGS test storage facility for low-level radioactive waste (N side of road: NW NW NW NW Sec. 34, T16N, R6E, 4th P.M., Bureau County, Neponset 7.5-Minute Quadrangle [41089C7]).

When the Sheffield low-level radioactive waste site was being closed, the Illinois State Geological Survey (ISGS) proposed the use of an "infiltration-minimizing cover" (fig. 11) (Cartwright et al. 1988). In 1980, in cooperation with the U.S. Nuclear Regulatory Commission (NRC), the ISGS began a laboratory study of layered cover designs and followed up with field trials of the most promising designs. After starting this study—the first of its type in the United States—the U.S. NRC, U.S. Environmental Protection Agency, and the U.S. Department of Energy began experiments at other locations.

The experimental covers at Sheffield were completed and instrumented in the summer of 1983 and monitored until the end of 1986. The experimental design is shown in figures 12 and 13. Three layered covers were built of different materials, and a fourth "standard thickened cover" was built for control and comparison. The relative performance and amount of water allowed to infiltrate to the "waste level" are listed below. Design cover 1 reduced infiltration to 1/25 of that of the normal cover design (cover 4).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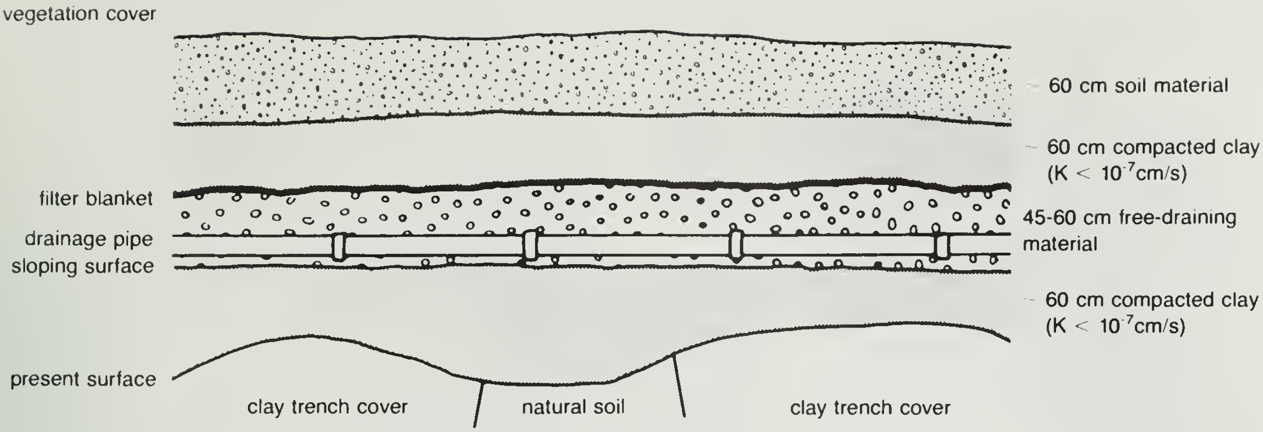


Figure 11 Design of an infiltration-limiting cover (Cartwright et al. 1988).

Performance rank	*Relative infiltration of water*
cover 1	0.3 cm/yr
cover 3	2.1 cm/yr
cover 2	4.2 cm/yr
cover 4	7.5 cm/yr
natural recharge	7.8 cm/yr

These covers are now 8 years old and have not been monitored since 1986. In the fall of 1991, the ISGS will install instruments within the covers and begin monitoring again to determine the effects of long-term exposure to weather.

0.0	48.45	Leave Stop 7. CONTINUE AHEAD (east).
0.45+	48.9+	STOP: 2-way at crossroad (1300N/350E). CAUTION: visibility is very limited to the right. TURN LEFT (north).
0.35	49.25+	PARK along the roadway opposite the office of the USEcology, Inc., Illinois facility.

STOP 8 View USEcology Nuclear containment facility (office: NE SE NE SW Sec. 27, T16N, R6E, 4th P.M., Bureau County, Neponset 7.5-Minute Quadrangle [41089C7]).

This is the site office for USEcology Nuclear, a company that accepts and manages solid low-level radioactive waste (LLRW). Why do we need this type of facility? Why not have it somewhere else? These and many other questions concerning radioactive waste have come forth since World War II.

States are mandated by federal law to manage their LLRW. A state may do this on its own, or make arrangements with adjoining states. Most of the material in storage at this site is from Illinois, although some wastes came from outside the state. Radioactive elements decay at known rates; thus the longer materials are stored at the site, the less radioactive they become.

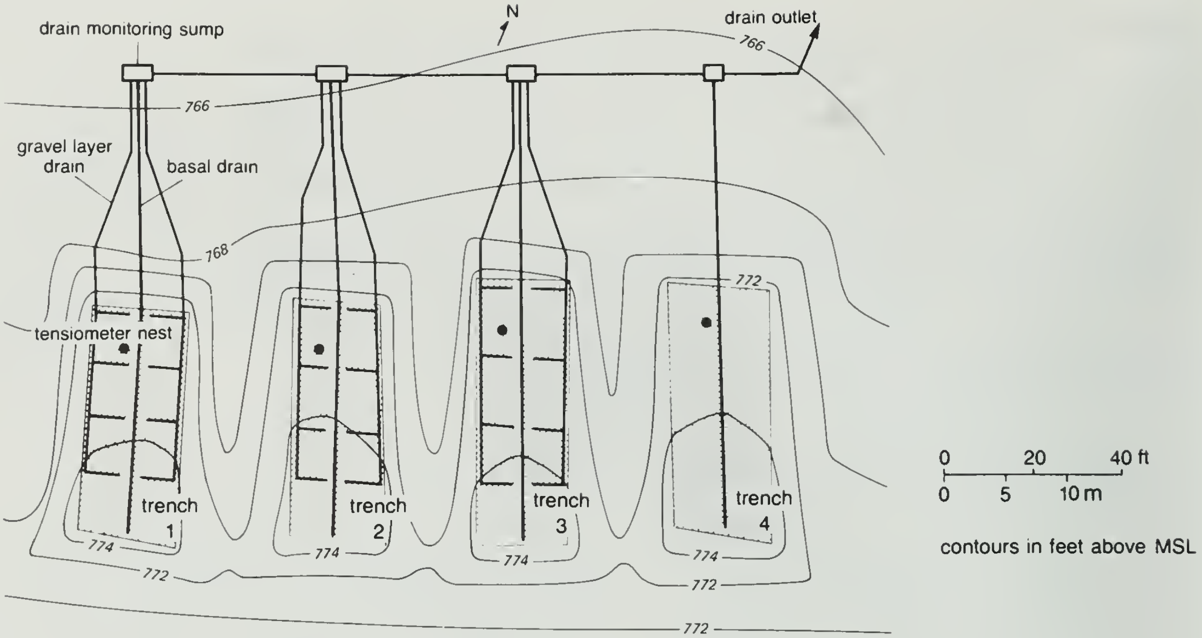


Figure 12 Plan view of experimental trench covers at the Sheffield study site.

Twenty years after the site is closed, the radioactivity will only be 32 percent of what it was when the facility was operating. After 30 years, it will be somewhat less than 20 percent. After 100 years, only an estimated 3-percent radioactivity will remain.

The following types of solid LLRW may be stored here:

- *nonmedical industry:* wastes from manufacturing smoke detectors, luminous watch dials, weld inspection and well logging devices, protective gloves and clothing, waste paper;
- *utility:* tools and obsolete equipment from nuclear power plants, filter wastes from coolant systems, protective gloves and clothing, waste paper;.
- *medical:* waste from patient diagnosis and treatment, protective gloves and clothing, waste paper, and waste from hospital and scientific research supplier industries;
- *academic:* protective gloves, clothing, and waste paper; glassware, filters and other wastes from scientific research;
- *government:* non-weapons-related waste, similar to that produced by industry, research and utility generators.

Standards established by the U.S. Nuclear Regulatory Commission regulate the disposal of all LLRW. USEcology Nuclear assumed management of this facility late in 1979. The last wastes were emplaced during 1981-82. Their personnel remained on the site to ensure that closure procedures were complete and effective. After USEcology Nuclear leaves the site, it will be monitored by the state for at least 100 years—the costs being paid from a fund established and set aside while the facility was operating.

This type of facility was designed and is operated for complete containment; only naturally occurring radioactivity will be detectable. A 25-millirems radiation release at the property fenceline is all that regulations permit. The average annual exposure from natural and medical uses is 200 millirems: dental technicians, airline pilots and others who are occupationally

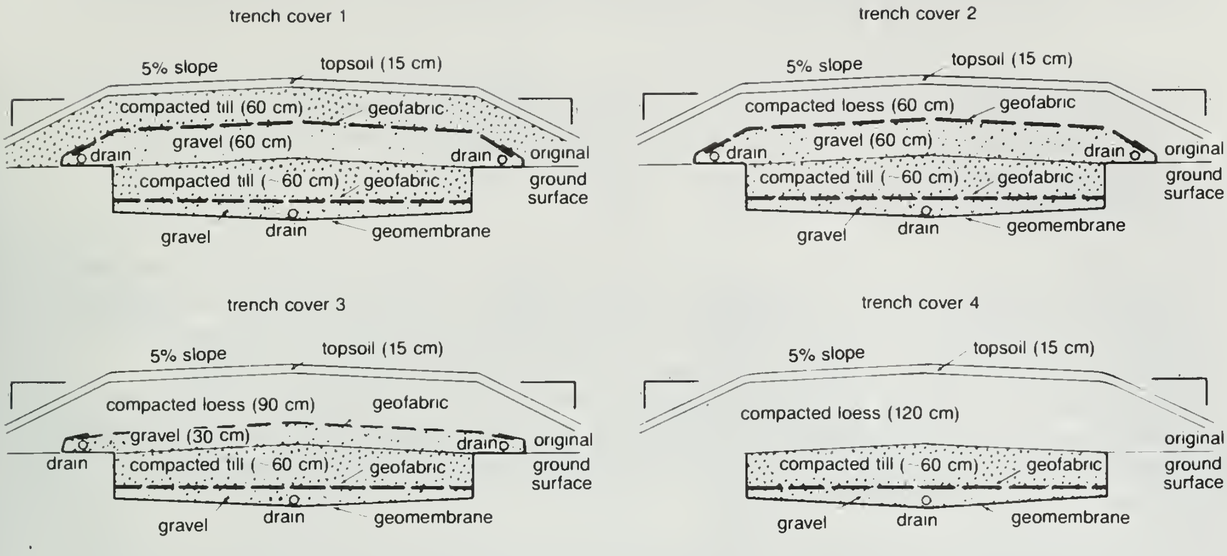


Figure 13 Cross sections of each experimental trench cover at the Sheffield study site.

exposed are permitted an annual exposure of 5,000 millirems; a brick home yields 45 millirems, and using a gas stove exposes one to 2 millirems annually.

0.0	49.25	Leave Stop 8 and CONTINUE AHEAD (north).
0.65+	49.9+	CAUTION: unguarded T-intersection (1400N/350E). TURN RIGHT (east).
2.0	51.9+	STOP: 2-way at cross road with US 34 (1400N/550E). CAUTION: traffic is fast. TURN RIGHT (south).
2.0	53.9	Prepare to turn left on the curve ahead.
0.1+	54.05+	TURN LEFT (east) onto Buda Road (1200N/525E). CAUTION: traffic on US 34 moves fast coming around the curve from the south and the west.
1.35	55.4+	T-road intersects from the right on the curve (1170N/650E). TURN RIGHT (south). Notice the difference in the topography here as compared with areas closer to Kewanee.
1.0	56.45+	CAUTION: cross ROUGH (I mean good-bye gizzard!), guarded 2-track BN Railroad. CONTINUE AHEAD (south).
0.2	56.65+	STOP: 2-way at crossroad. CONTINUE AHEAD (straight).
0.2	56.9+	CAUTION: narrow culvert.
0.85	57.8+	T-road intersects from left. TURN LEFT (east).
0.1	57.95	PARK along the roadside. DO NOT BLOCK the intersection or gates.

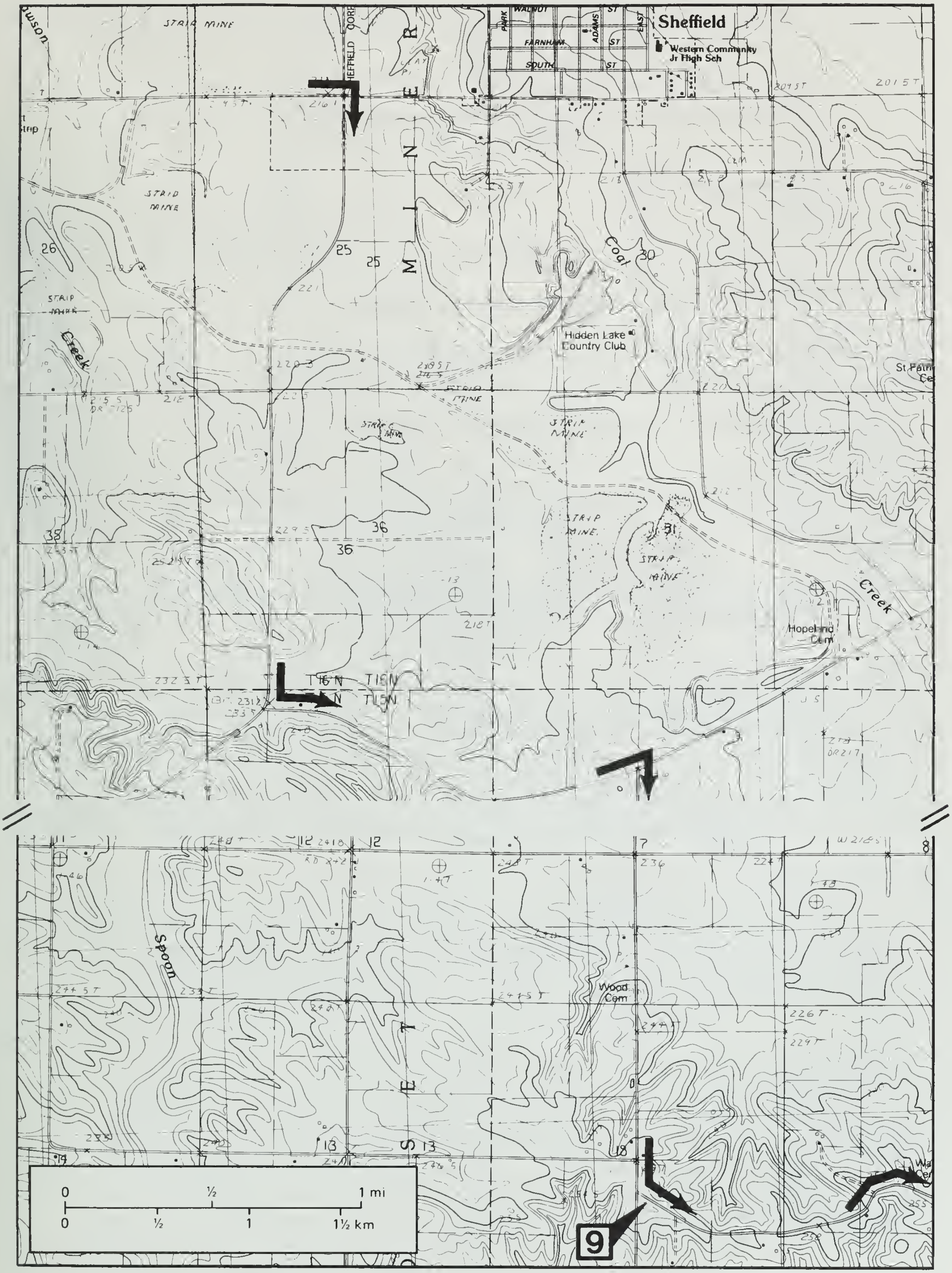
STOP 9 View Illinoian till plain from high ridge roadside (SW side of road in NE SW NW SE Sec. 18, T15N, R7E, 4th P.M., Bureau County, Buda 7.5-Minute Quadrangle [41089C6]).

This ridge consists of nearly 200 feet of some older Illinoian glacial deposits, as observed near Kewanee. The younger Illinoian deposits occur about 3 miles to the east and consist of thick outwash sands and gravels. The Illinoian till plain to the south is an area of relatively low surface relief due to erosion by Wisconsinan meltwater torrents and partial burial by Wisconsinan outwash deposits and loess.

This vantage point, which is a little more than 100 feet above the East Fork Spoon River about 1 mile to the southwest, gives an excellent sweeping view from the southwest to the southeast. The high land about 8 miles to the southeast is the Wisconsinan Providence Moraine, a part of the Bloomington Morainic System. It stands about 50 feet higher than our elevation of approximately 845 feet msl at this site. The East Fork Spoon River originates some 5 miles to the northwest of here and about 2 miles northwest of Neponset, and it flows south and west for nearly 70 miles (as the crow flies) to join the Illinois River in Fulton County across from Havana.

A bedrock valley lies buried about 1.5 miles to the south. This valley trends about 3 miles east and then about 10 miles north to join the Princeton Bedrock Vallley through which the Ancient Mississippi River flowed. Wisconsinan moraines and outwash deposits conceal the locations of these ancient valleys.

0.0	57.95	Leave Stop 9 and CONTINUE AHEAD (east).
1.15	59.05+	Note the view to the south and the east. In the east, the high ridge is the Providence Moraine of Wisconsinan age.
1.1	60.15+	Ascend the youngest Illinoian moraine.
0.25	60.4+	STOP: 1-way at T-intersection (925N/900E). TURN LEFT (north) on SR 88. CAUTION: visibility to the south is a little obstructed. Traffic can be fast.
1.0	61.4+	Route comes down off the youngest Illinoian moraine.
0.85	62.25+	CAUTION: cross ROUGH, guarded single-track of the Northwestern (NW) Railroad. CONTINUE AHEAD (north).
0.35	62.6+	Ascend the Wisconsinan Sheffield Moraine.
0.5+	63.15	Enter Buda and cross main line of BN Railroad overpass.
0.75+	63.9+	The route crosses onto the overlying Wisconsinan Buda Moraine.
0.5	64.4+	Notice the more gentle slopes on the hillsides in this area. Small kettles dot the surface and water has been standing for a considerable time.
0.5	64.9+	The route passes through a large kettle where a large mass of ice that was partly buried subsequently melted and left this depression with no outlet. Other smaller kettles occur nearby. Note the sandy soils. CONTINUE AHEAD (north).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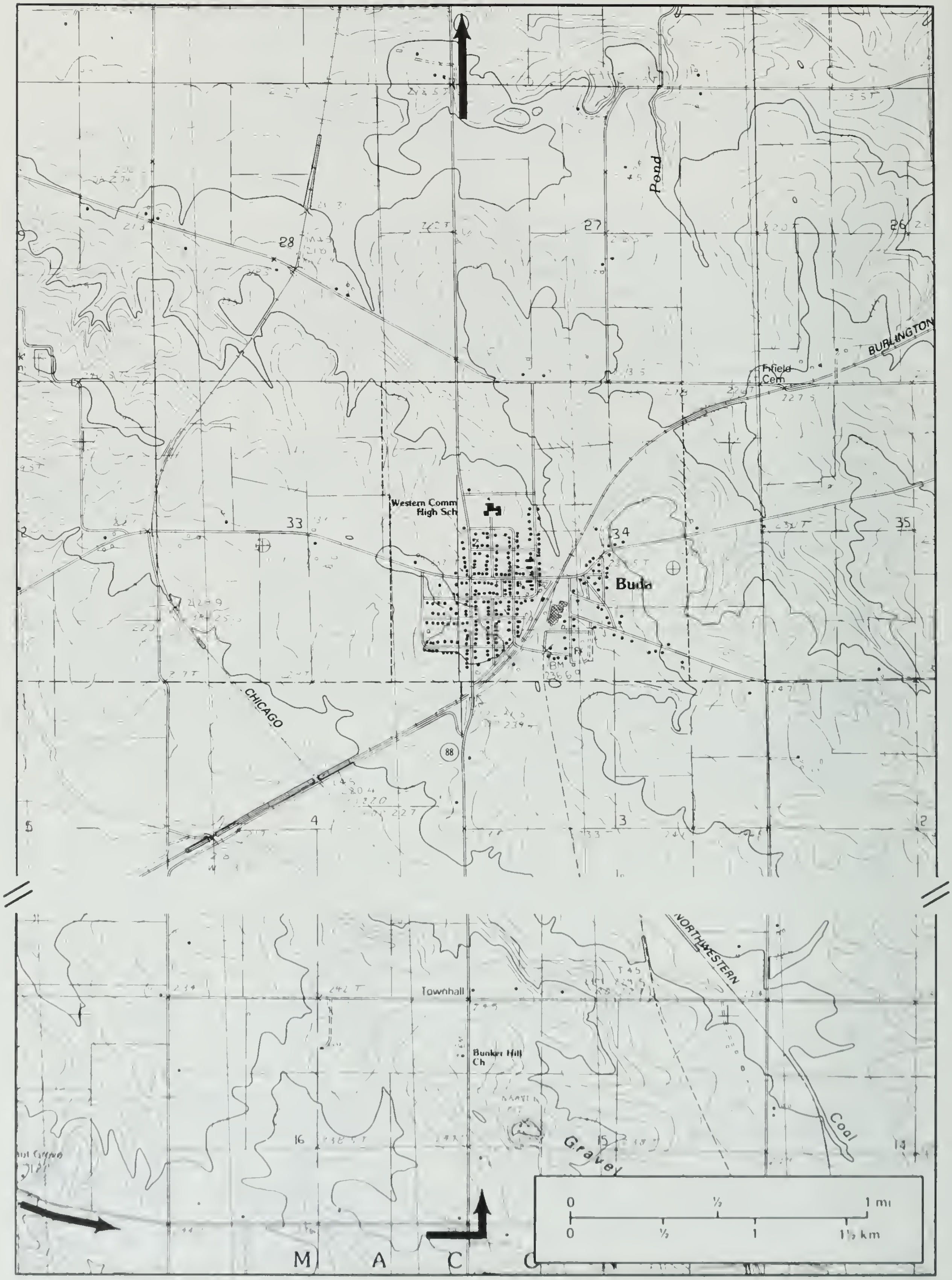

Pond
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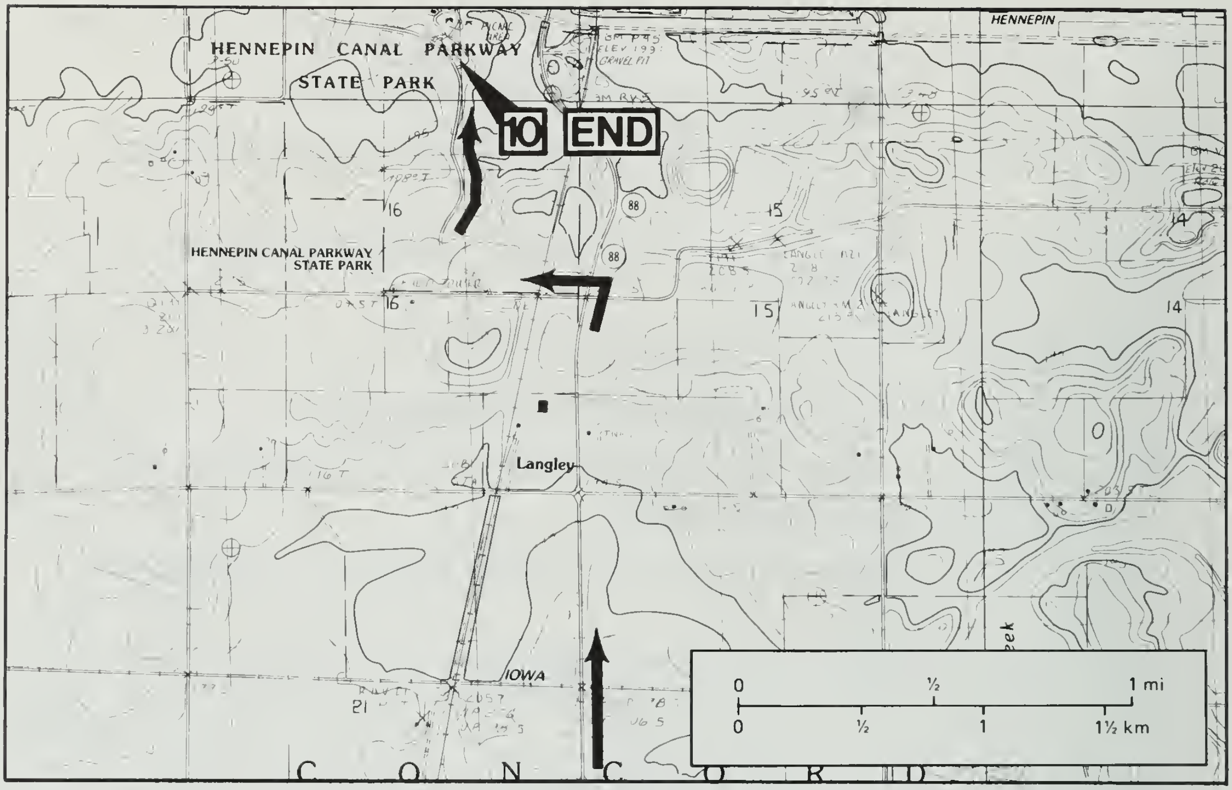
0.15+	65.1	The route crosses onto the Wisconsinan Providence Moraine.
0.6	65.7	CAUTION: guarded single-track Iowa Railroad crossing.
0.45	66.15+	STOP: 4-way intersection with SR 88, US 6, and US 34. CONTINUE AHEAD (north) on SR 88 (1500N/900E).
0.35	66.5+	Prepare to turn left ahead toward the Hennepin Canal Parkway Information Center.
0.15	66.65+	TURN LEFT at crossroad (1550N/900E).
0.1	66.8+	CAUTION: guarded single-track NW Railroad crossing.
0.1	66.9+	T-road intersects from right. TURN RIGHT toward the Hennepin Canal Parkway Visitors Center.
0.2+	67.15	The route crosses from the Providence Moraine to the underlying Buda Moraine.
0.4+	67.55+	Entrance to the Hennepin Canal Parkway and the State Park Visitors Center is to the right. Enter and PARK.

STOP 10 Visit Hennepin Canal Parkway State Park Visitors Center (parking lot entrance: N/2 SE SW SE Sec. 9, T16N, R7E, 4th P.M., Bureau County, Manlius 7.5-Minute Quadrangle [41089D6]).

The Hennepin Canal Parkway State Park Visitor Center is located about 5 miles southwest of the axis of the buried Princeton Bedrock Valley through which the Ancient Mississippi River flowed. In this area, two tributary bedrock valleys joined before entering the Princeton Valley, which had an elevation of less than 300 feet msl. This site had an elevation of about 375 feet msl. The buried bedrock valley entering from the right is the one that was mentioned at Stop 9. Glacial drift thickness in the vicinity of the Visitors Center is just under 300 feet. The Buda Moraine of the Wisconsinan Bloomington Morainic System mantles the surface here.

The Hennepin Canal, completed in 1907, was very important in helping to develop commerce and industry in northwestern Illinois and adjacent states. In conjunction with the Illinois and Michigan Canal, completed almost 60 years earlier, this waterway helped link Chicago and Lake Michigan with the Rock Island and upper Mississippi region. The Hennepin Canal, which was nearly 105 miles long and spanned 5 counties (Bureau, Henry, Lee, Whiteside, and Rock Island), reduced the waterway distance between Chicago and Rock Island by 419 miles. The entire Hennepin Canal is listed on the National Register of Historic Places.

Men dreamed of building a canal linking the Illinois and Mississippi Rivers as early as 1834, but both the state and the federal government had financial problems that disrupted many public projects. Railroads were built through the area, but they proved to be too expensive for the early settlements and small industries to use. Congress finally authorized preliminary surveys of the area for a canal in 1871 and construction began in 1890. The canal was nearly obsolete by the time it was completed because it was too small to handle the larger barges needed to compete with the railroads—which had by this time decreased their shipping costs. By the 1930s, the Hennepin Canal was used mainly for recreation. It only stayed open to boat traffic until 1951.



The Hennepin was the first canal in America to be constructed of concrete without stone facings. Many engineering innovations, developed during its construction, proved to be useful to the construction industry and provided the basis for some of the building techniques employed in the construction of the Panama Canal. The first of 33 locks on the canal was constructed on the Illinois River, and it is the only one no longer visible. A unique feature of the Hennepin was the use of Marshall gates, which are like rural mail boxes and operate on a horizontal axis; 14 were used. Although five locks have been restored to working order, they are not used. Gates from the remaining locks have been replaced with concrete walls to create a series of waterfalls.

Originally, the Hennepin had nine concrete aqueducts that carried the canal traffic across the larger rivers and streams. Only 6 remain.

The visitors center at the Hennepin Canal Parkway State Park has an excellent collection of photographs taken during construction of the canal. Pieces of the equipment used are on display, as are models of canal boats and locks. Native wildlife species are displayed in dioramas.

End of the Kewanee geological science field trip.

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DEPOSITIONAL HISTORY OF THE PENNSYLVANIAN ROCKS IN ILLINOIS

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

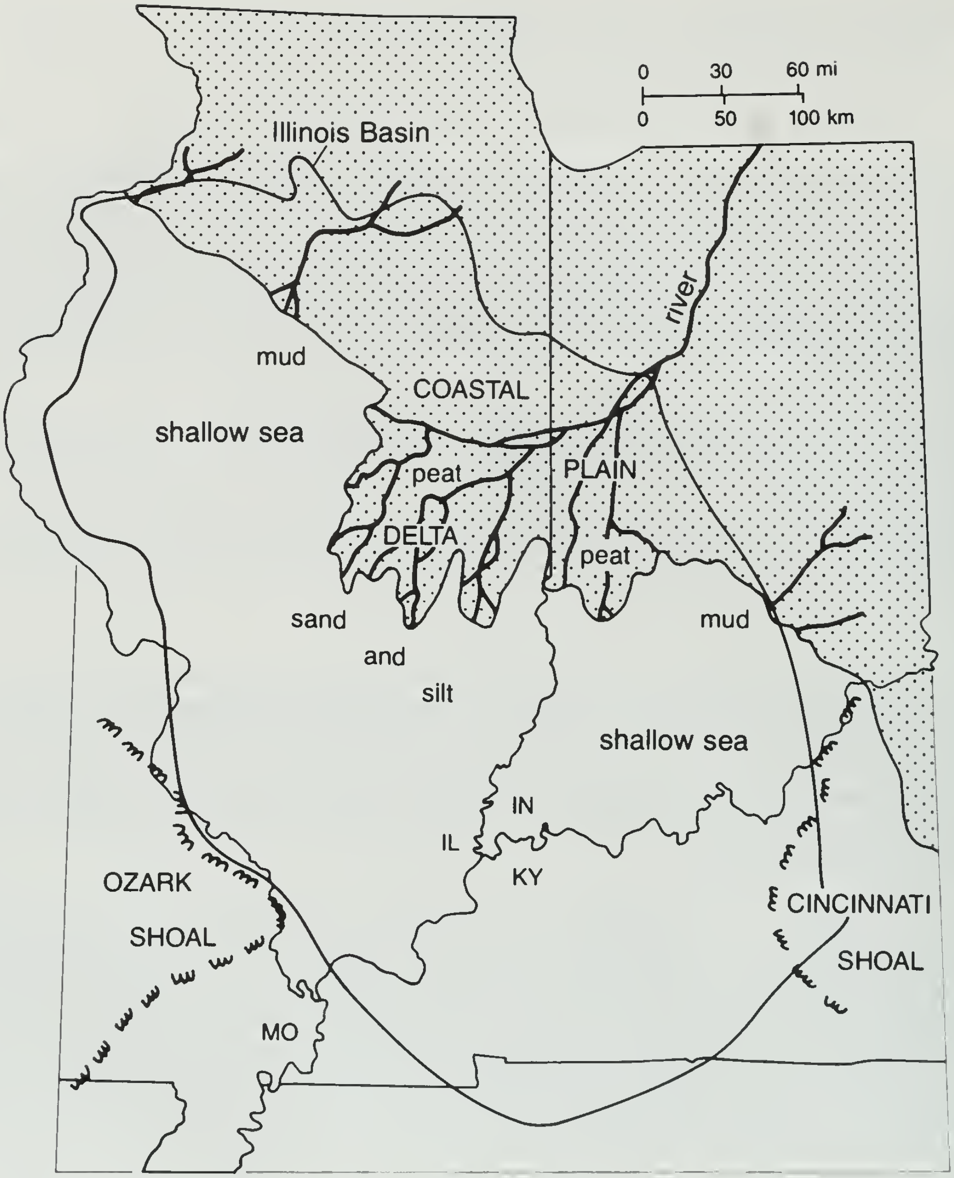
Depositional conditions in the Illinois Basin during the Pennsylvanian Period were somewhat similar to those of the preceding Chesterian (late Mississippian) time. A river system flowed southwestward across a swampy lowland, carrying mud and sand from highlands to the northeast. This river system formed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

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

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

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

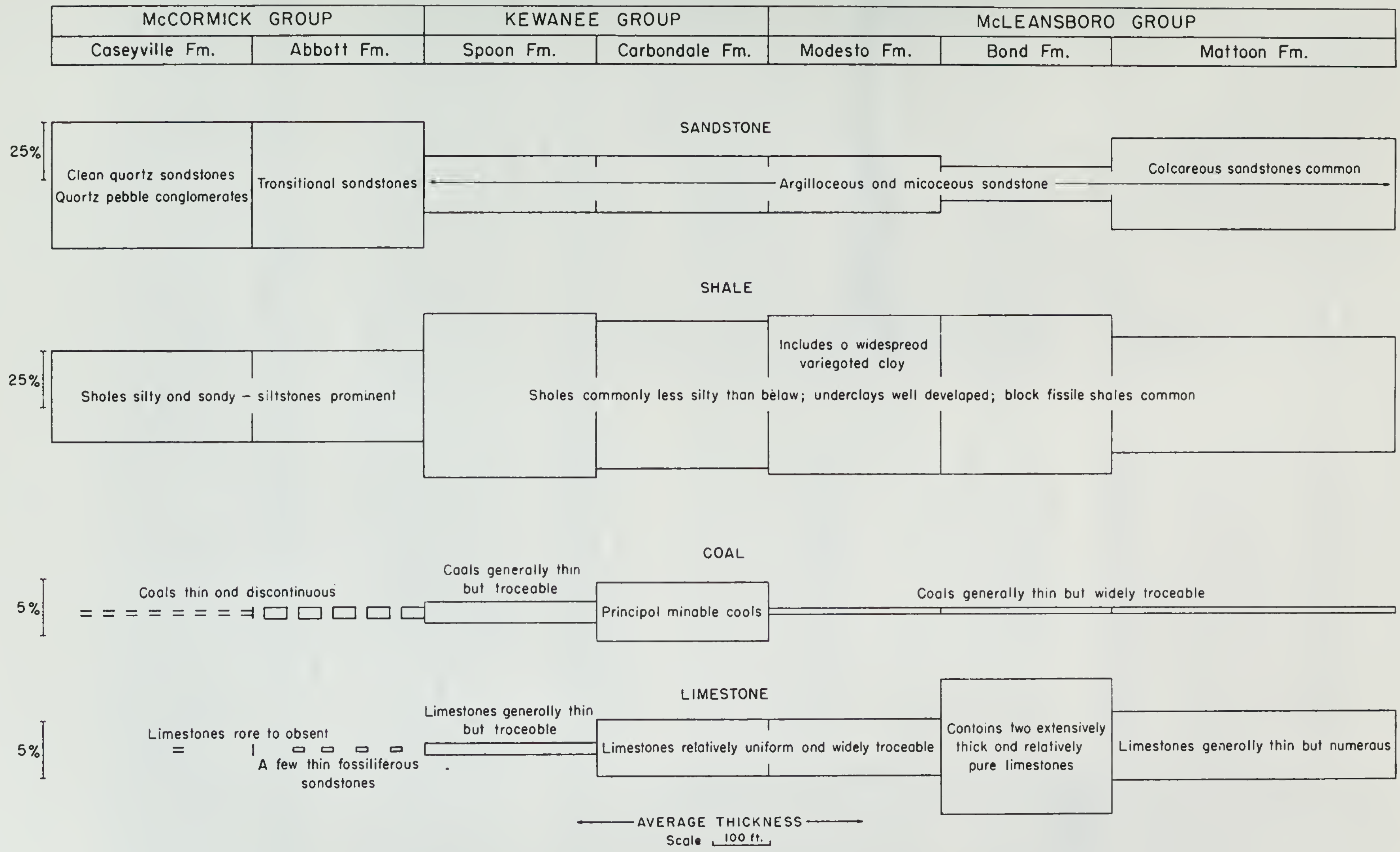
Beneath the quiet water of extensive swamps that prevailed for long intervals on the emergent coastal lowland, peat was formed by accumulation of plant material. Lush forest vegetation covered the region; it thrived in the warm, moist Pennsylvanian-age climate. Although the origin of the underclays beneath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



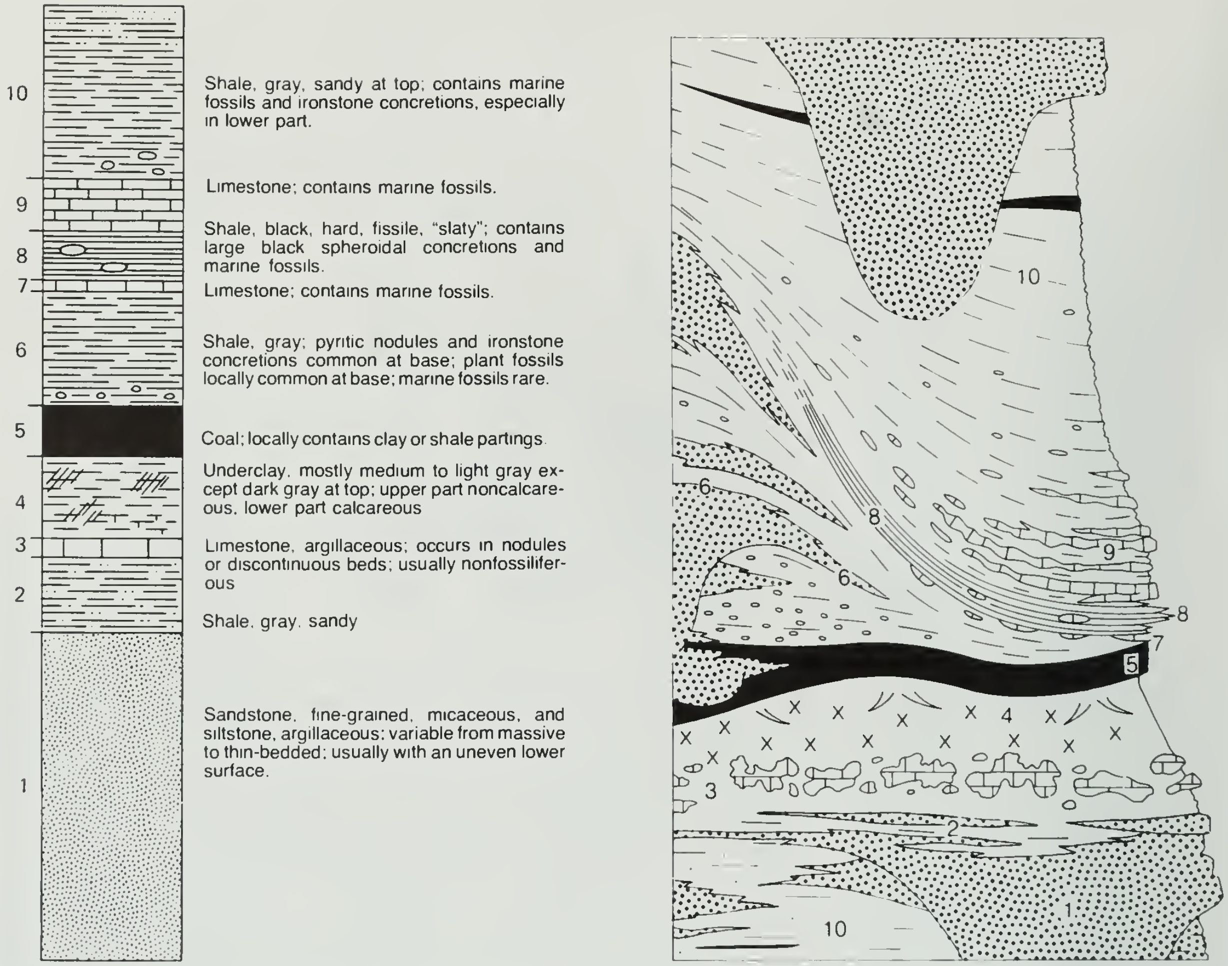
Paleogeography of Illinois-Indiana region during Pennsylvanian time. The diagram shows a Pennsylvanian river delta and the position of the shoreline and the sea at an instant of time during the Pennsylvanian Period.

Pennsylvanian Cyclothems

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



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



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

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

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

Origin of Coal

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

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

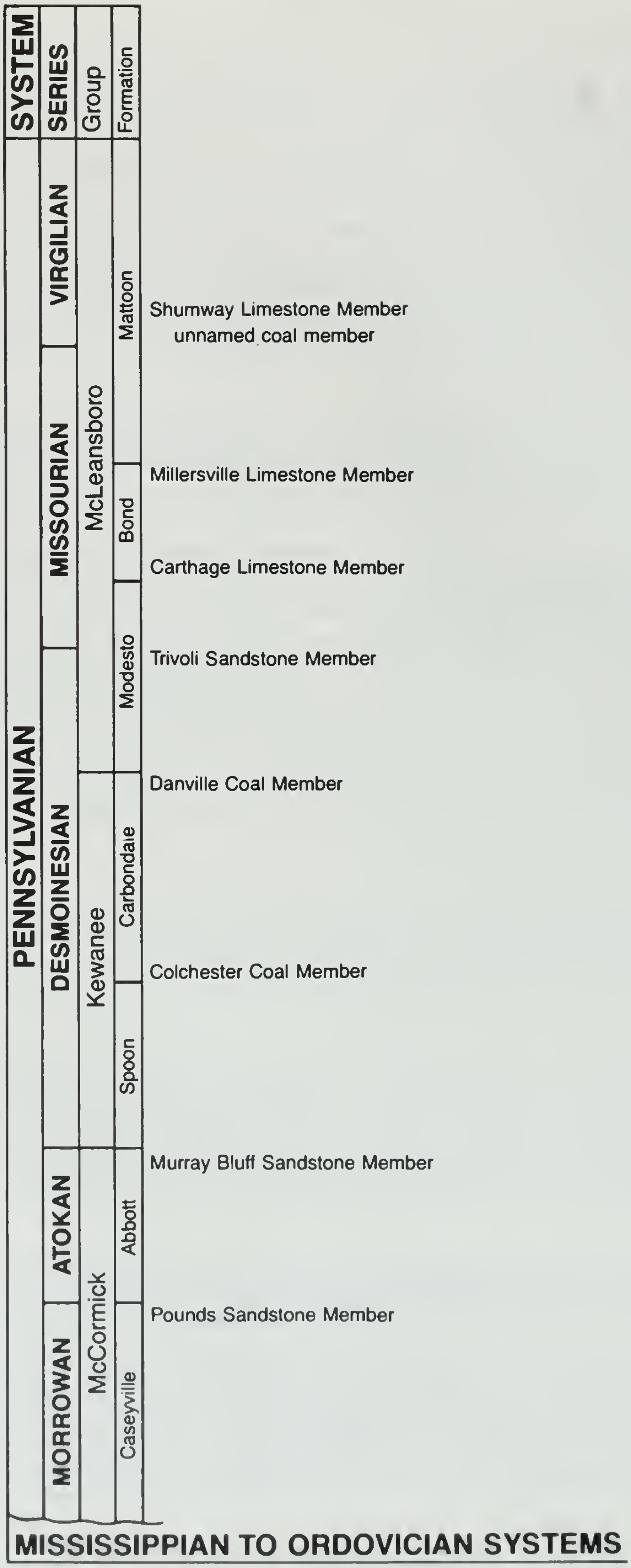
The periodic invasions of the Pennsylvanian sea across the coastal swamps killed the Pennsylvanian forests, and the peat deposits were often buried by marine sediments. After the marine transgressions, peat usually became saturated with sea water containing sulfates and other dissolved minerals. Even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

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

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

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

The exact origin of the carbonaceous black shale that occurs above many coals is uncertain. Current thinking suggests that the black shale actually represents the deepest part of the marine transgression. Maximum transgression of the sea, coupled with upwelling of ocean water and accumulation of mud and animal remains on an anaerobic ocean floor, led to the deposition of black organic mud over vast areas stretching from Texas to Illinois. Deposition occurred in quiet-water areas where the very fine-grained iron-rich



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

mud and finely divided plant debris were washed in from the land. Most of the fossils found in black shale represent planktonic (floating) and nektonic (swimming) forms — not benthonic (bottom-dwelling) forms. The depauperate (dwarf) fossil forms sometimes found in black shale formerly were thought to have been forms that were stunted by toxic conditions in the sulfide-rich, oxygen-deficient water of the lagoons. However, study has shown that the "depauperate" fauna consists mostly of normal-size individuals of species that never grew any larger.

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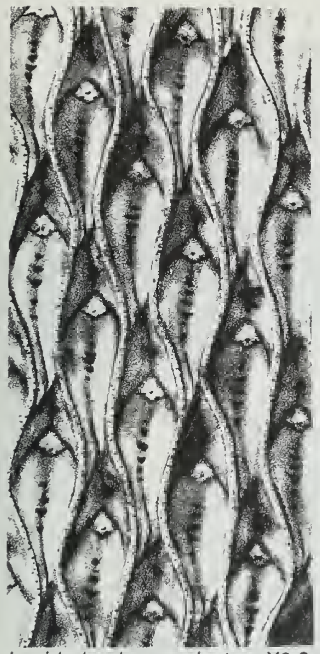
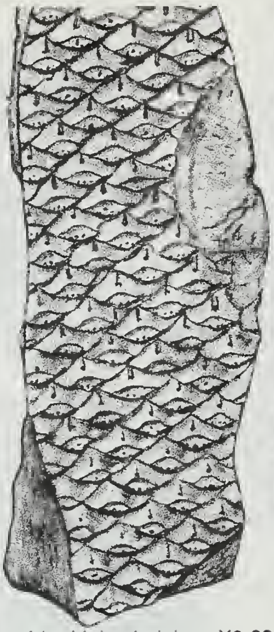
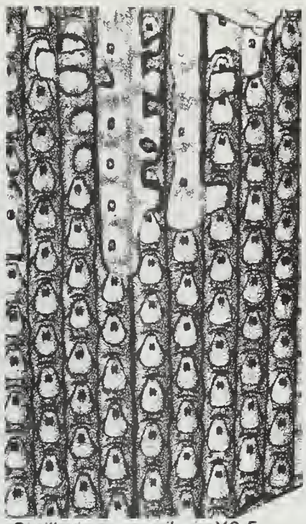
Common Pennsylvanian plants: lycopods, sphenophytes, and ferns



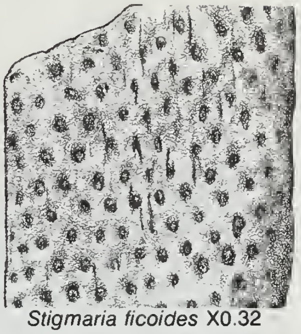
Lepidodendron aculeatum X0.8



Lepidophloios laricinus X0.63



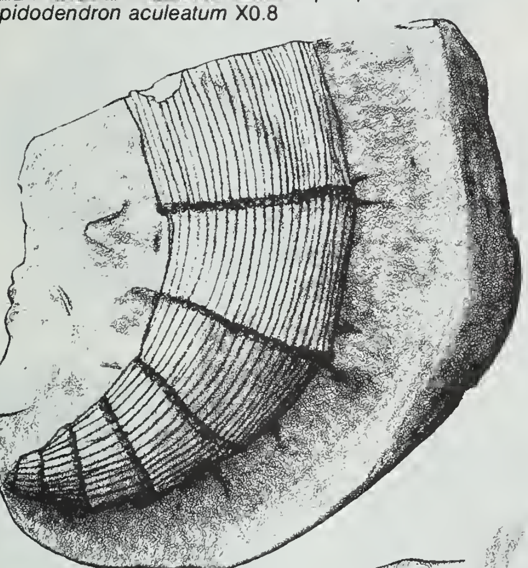
Sigillaria mammilaris X0.5



Stigmaria ficoides X0.32

Lepidostrobus ovatifolius X0.8

Annularia stellata X0.63

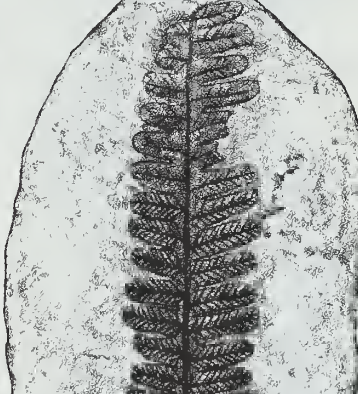


Calamites suckowii X0.5

Sphenophyllum cuneifolium X0.4

Pecopteris sp. X0.32

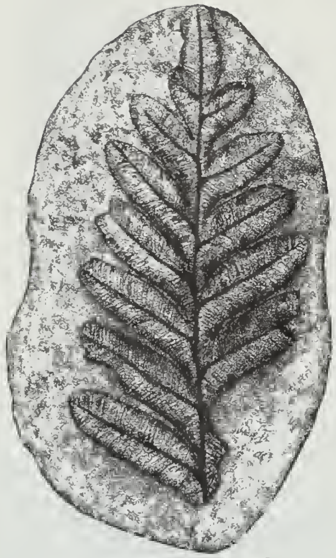
Pecopteris miltonii X2.0



Pecopteris hemitelioides X1.0

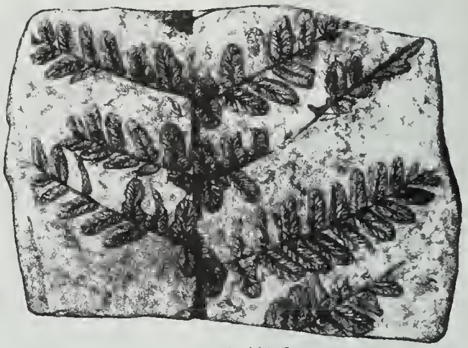
J. R. Jennings, ISGS

Common Pennsylvanian plants: seed ferns and cordaiteans



Alethopteris serlii X0.63

Alethopteris ambigua X0.63



Neuropteris rarinervis X0.5

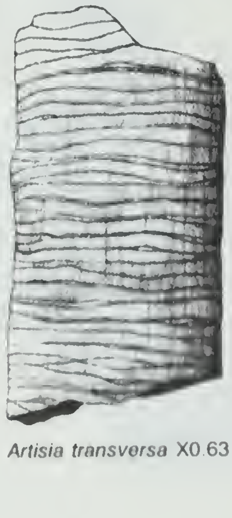
Mariopteris nervosa X0.8

Neuropteris scheuchzeri X0.63

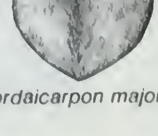
Sphenopteris rotundiloba X0.8

Trigonocarpus parkinsonii X1.25

Cordaicladus sp. X1.0



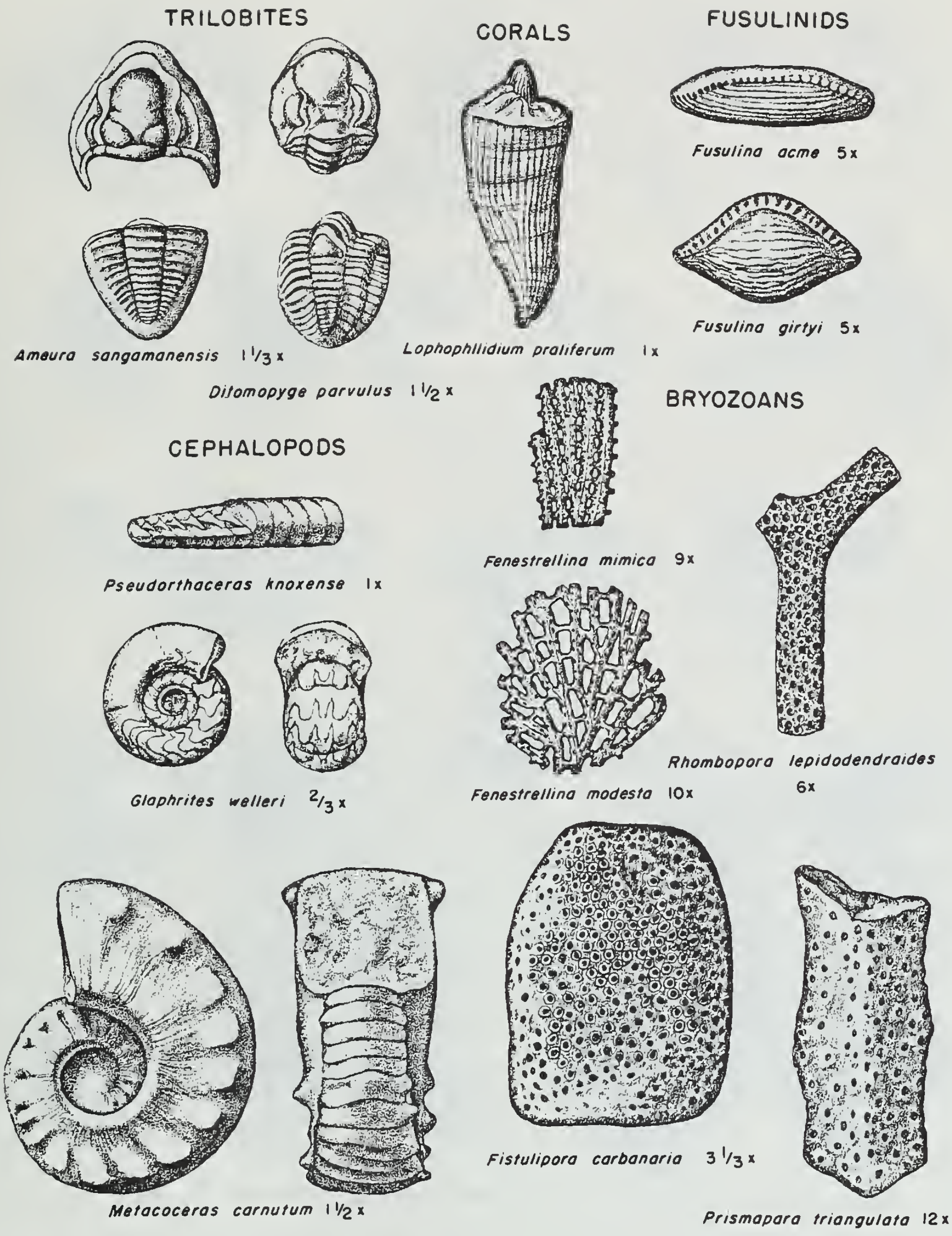
Artisia transversa X0.63



Cordaicarpon major X2.0

Cordaites principalis X0.63

J. R. Jennings, ISGS


TRILOBITES
CORALS
FUSULINIDS
Fusulina acme 5x
Fusulina girtyi 5x
Ameura sangamanensis 1 1/3 x
Lophophlidium praliferum 1x
Ditomopyge parvulus 1 1/2 x
BRYOZOANS
CEPHALOPODS
Pseudorthaceras knoxense 1x
Fenestrellina mimica 9x
Rhombopora lepidodendraides 6x
Glaphrites welleri 2/3 x
Fenestrellina modesta 10x
Fistulipora carbanaria 3 1/3 x
Metacoceras carnutum 1 1/2 x
Prismapara triangulata 12x

PELECYPODS

Nucula (Nuculopsis) girtyi 1x

Edmonia ovata 2x

Astartella concentrica 1x

Dunbarella knighti 1½x

Cardiomorpha missouriensis "Type A" 1x

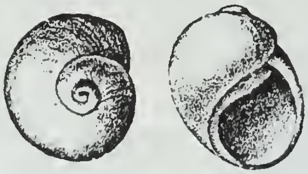
Cardiomorpha missouriensis "Type B" 1½x

GASTROPODS

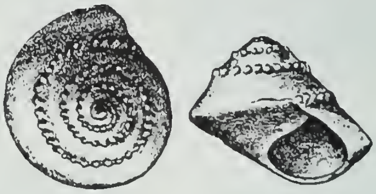
Euphemites carbonarius 1½x

Trepaspira illinoisensis 1½x

Donaldina robusta 8x



Naticopsis (Jedria) ventricosa 1½x



Trepaspira sphaerulata 1x

Knightites montfortianus 2x

Glabrocingulum (Glabrocingulum) grayvillense 3x

BRACHIOPODS

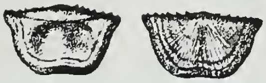
Wellerella tetrahedra 1½ x

Juresania nebrascensis ⅔ x

Derbya crassa 1x

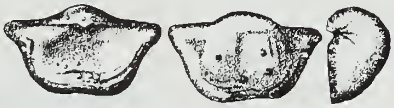
Composita argentia 1x

Neospirifer cameratus 1x



Chonetes granulifer 1½ x

Mesolobus mesolobus var. *euampygus* 2 x



Marginifera splendens 1x

Crurithyris planoconvexa 2 x

Linoproductus "cora" 1x

ERRATICS ARE ERRATIC

Myrna M. Killey

You may have seen them scattered here and there in Illinois—boulders, some large, some small, lying alone or with a few companions in the corner of a field, at the edge of a road, in someone's yard, or perhaps on a courthouse lawn or schoolyard. Many of them seem out of place, like rough, alien monuments in the stoneless, grassy knolls and prairies of our state. Some—the colorful and glittering granites, banded gneisses, and other intricately veined and streaked igneous and metamorphic rocks—are indeed foreign rocks, for they came from Canada and the states north of us. Others—gray and tan sedimentary rocks—are native rocks and may be no more than a few miles from their place of origin. All of these rocks are glacial boulders that were moved to their present sites by massive ice sheets that flowed across our state. If these boulders are unlike the rocks in the quarries and outcrops in the region where they are found, they are called erratics.

The continental glaciers of the Great Ice Age scoured and scraped the land surface as they advanced, pushing up chunks of bedrock and grinding them against each other or along the ground surface as the rock-laden ice sheets pushed southward. Hundreds of miles of such grinding, even on such hard rocks as granite, eventually rounded off the sharp edges of these passengers in the ice until they became the rounded, irregular boulders we see today. Although we do not know the precise manner in which erratics reached their present isolated sites, many were probably dropped directly from the melting front of a glacier. Others may have been rafted to their present resting places by icebergs on ancient lakes or on the floodwaters of some long-vanished stream as it poured from a glacier. Still others, buried in the glacial deposits, could have worked their way up to the land surface as the surrounding loose soil repeatedly froze and thawed. When the freezing ground expands, pieces of rock tend to be pushed upward, where they are more easily reached by the farmer's plow and also more likely to be exposed by erosion.


An eight-foot boulder of pink granite left by a glacier in the bed of a creek about 5 miles southwest of Alexis, Warren County, Illinois. (From ISGS Bulletin 57, 1929.)

Generally speaking, erratics found northeast of a line drawn from Freeport in Stephenson County, southward through Peoria, and then southeastward through Shelbyville to Marshall at the east edge of the state were brought in by the last glacier to enter Illinois. This glaciation, called the Wisconsinan, spread southwestward into Illinois from a center in eastern Canada, reaching our state about 75,000 years ago and (after repeated advances and retreats of the ice margin) melting from the state about 12,500 years ago. Erratics to the west or south of the great arc outlined above were brought in by a much older glacier, the Illinoian, which spread over most of the state about 300,000 to 175,000 years ago. Some erratics were brought in by even older glaciers that came from the northwest.

You may be able to locate some erratics in your neighborhood. Sometimes it is possible to tell where the rock originally came from by determining the kind of rock it is. A large boulder of granite, gneiss, or other igneous or metamorphic rock may have come from the Canadian Shield, a vast area in central and eastern Canada where rocks of Precambrian age (more than 600 million years old) are exposed at the surface. Some erratics containing flecks of copper were probably transported here from the "Copper Range" of the upper peninsula of Michigan. Large pieces of copper have been found in glacial deposits of central and northern Illinois. Light gray to white quartzite boulders with beautiful, rounded pebbles of red jasper came from a very small outcrop area near Bruce Mines, Ontario, Canada. Purplish pieces of quartzite, some of them banded, probably originated in the Baraboo Range of central Wisconsin. Most interesting of all are the few large boulders of Canadian tillite. Tillite is lithified (hardened into rock) glacial till deposited by a Precambrian glacier many millions of years older than the ones that invaded our state a mere few thousand years ago. Glacial till is an unsorted and unlayered mixture of clay, sand, gravel, and boulders that vary widely in size and shape. Tillite is a gray to greenish gray rock containing a mixture of grains of different sizes and scattered pebbles of various types and sizes.

Many erratics are of notable size and beauty, and in parts of Illinois they are commonly used in landscaping. Some are used as monuments in courthouse squares, in parks, or along highways. Many are marked with metal plaques to indicate an interesting historical spot or event. Keep an eye out for erratics. There may be some of these glacial strangers in your neighborhood that would be interesting to know.

ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, Illinois 61801

GEOGRAM 5
October 1975

ANCIENT DUST STORMS IN ILLINOIS

Myrna M. Killey

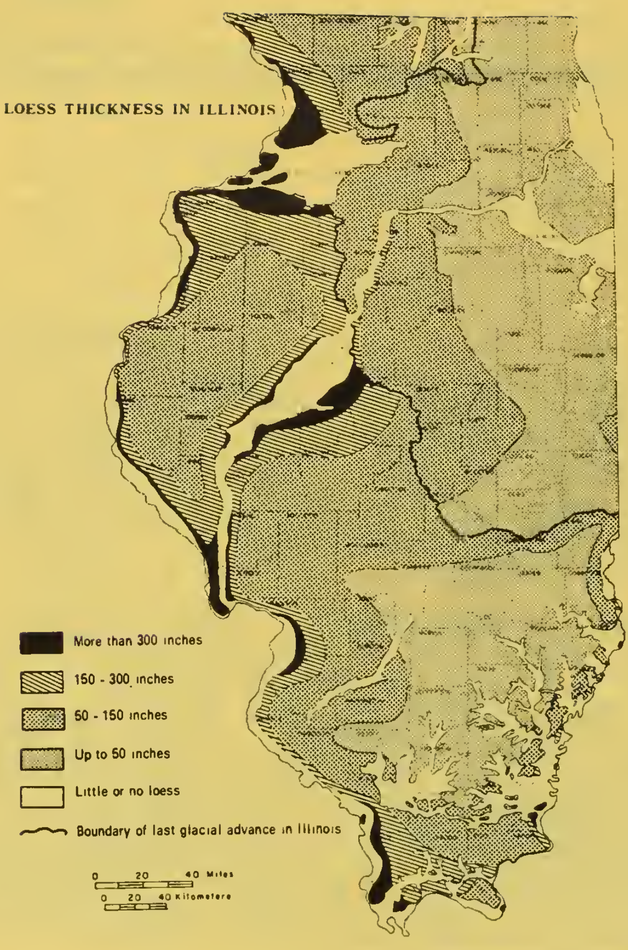
Fierce dust storms whirled across Illinois long before human beings were here to record them. Where did all the dust come from? Geologists have carefully put together clues from the earth itself to get the story. As the glaciers of the Great Ice Age scraped and scoured their way southward across the landscape from Canada, they moved colossal amounts of rock and earth. Much of the rock ground from the surface was kneaded into the ice and carried along, often for hundreds of miles. The glaciers acted as giant grist mills, grinding much of the rock and earth to "flour"—very fine dust-sized particles.

During the warm seasons, water from the melting ice poured from the glacier front, laden with this rock flour, called silt. In the cold months the meltwater stopped flowing and the silt was left along the channels the water had followed, where it dried out and became dust. Strong winds picked up the dust, swept it from the floodplains, and carried it to adjacent uplands. There the forests along the river valleys trapped the dust, which became part of the moist forest soil. With each storm more material accumulated until the high bluffs adjacent to major rivers were formed. The dust deposits are thicker along the eastern sides of the valleys than they are on the western sides, a fact from which geologists deduce that the prevailing winds of that time blew from west to east, the same direction as those of today. From such clues geologists conclude that the geologic processes of the past were much like those of today.

The deposits of windblown silt are called loess (rhymes with "bus"). Loess is found not only in the areas once covered by the glaciers but has been blown into the nonglaciated areas. The glaciers, therefore, influenced the present land surface well beyond the line of their farthest advance.

Loess has several interesting characteristics. Its texture is so fine and uniform that it can easily be identified in roadcuts—and because it blankets such a vast area many roads are cut through it. Even more noticeable is its tendency to stand in vertical walls. These steep walls develop as the loess drains and becomes tough, compact, and massive, much like a rock. Sometimes cracks develop in the loess, just as they do in massive limestones and sandstones. Loess makes good highway banks if it is cut vertically. A vertical cut permits maximum drainage because little surface is exposed to rain, and rainwater tends to drain straight down through it to the rock underneath. If the bank is cut at an angle more water soaks in, which causes the loess to slump down. Along Illinois roads the difference between a loess roadcut and one in ordinary glacial till is obvious. The loess has a very uniform texture, while the till is composed of a random mixture of rock debris, from clay and silt through cobbles and boulders.

Many loess deposits are worth a close look. Through a 10-power hand lens separate grains can be seen, among them many clear, glassy, quartz grains. Some loess deposits contain numerous rounded, lumpy stones called concretions. Their formation began when water percolating through the loess dissolved tiny



limestone grains. Some of the dissolved minerals later became solid again, gathering around a tiny nucleus or along roots to form the lumpy masses. A few such concretions are shaped roughly like small dolls and, from this resemblance, are called "loess kindchen," a German term meaning "loess children." They may be partly hollow and contain smaller lumps that make them rattle when shaken.

Fossil snails can be found in some loess deposits. The snails lived on the river bluffs while the loess was being deposited and were buried by the dust. When they are abundant, they are used to determine how old the loess is. The age is found by measuring the amount of radioactive carbon in the calcium carbonate of their shells.

Some of the early loess deposits were covered by new layers of loess following later glacial invasions. Many thousands of years passed between the major glacial periods, during which time the climate was as warm as that of today. During the warm intervals, the surface of the loess and other glacial deposits was exposed to weather. Soils developed on most of the terrain, altering the composition, color, and texture of the glacial material. During later advances of the ice, some of these soils were destroyed, but in many places they are preserved under the younger sediments. Such ancient buried soils can be used to determine when the materials above and below them were laid down by the ice and what changes in climate took place.

The blanket of loess deposited by the ancient dust storms forms the parent material of the rich, deep soils that today are basic to the state's agriculture. A soil made of loess crumbles easily and has great moisture-holding capacity. It also is free from rocks that might complicate cultivation. Those great dust storms that swirled over the land many thousands of years ago thus endowed Illinois with one of its greatest resources, its highly productive soil.

PLEISTOCENE GLACIATIONS IN ILLINOIS

Origin of the Glaciers

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

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

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

Effects of Glaciation

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

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

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

Glacial Deposits

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

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

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

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

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

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

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

Loess, Eolian Sand and Soils

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

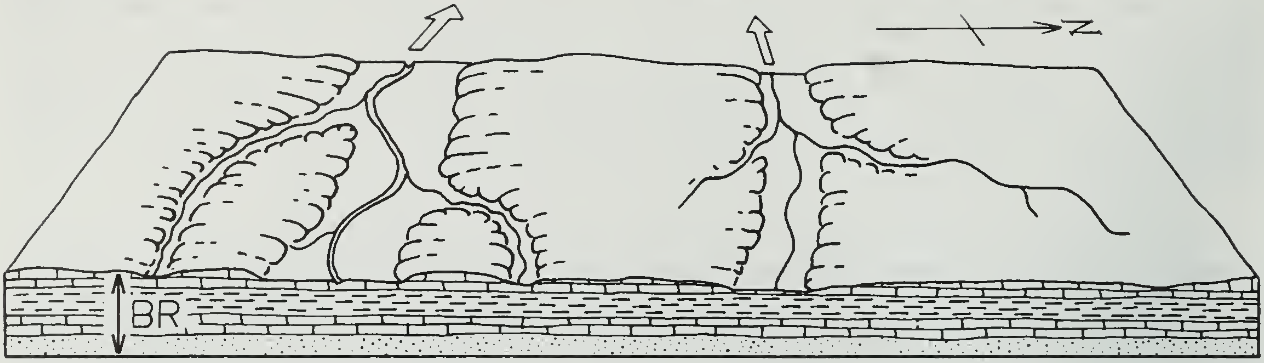
Eolian deposition occurred when certain climatic conditions were met, probably in a seasonal pattern. Deposition could have occurred in the fall, winter or spring season when low precipitation rates and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and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

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

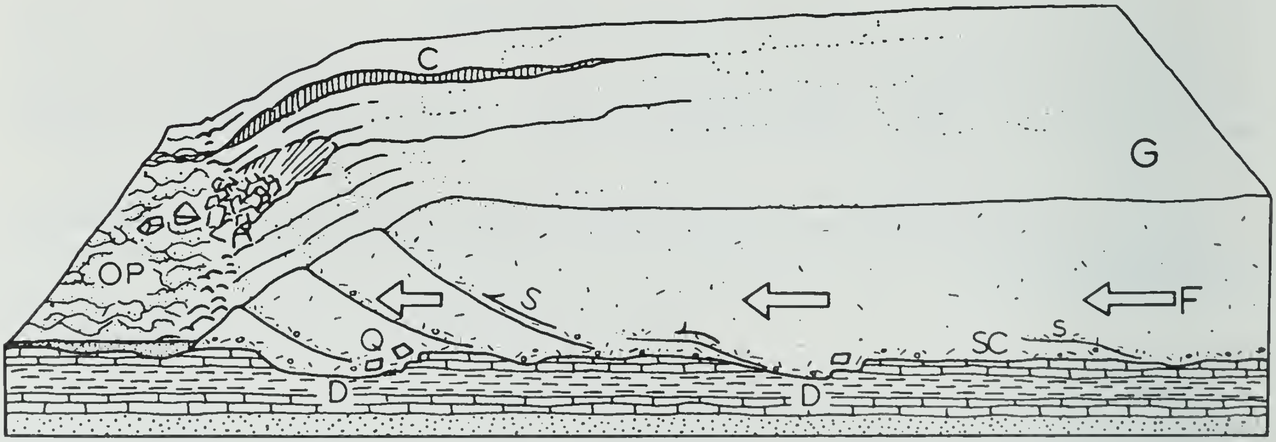
Glaciation in a Small Illinois Region

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

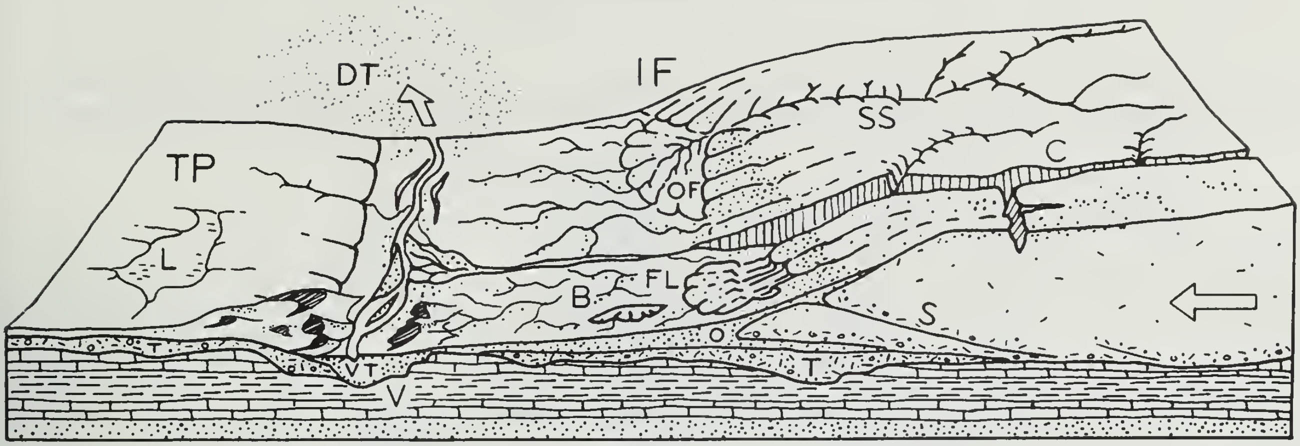
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated—layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



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



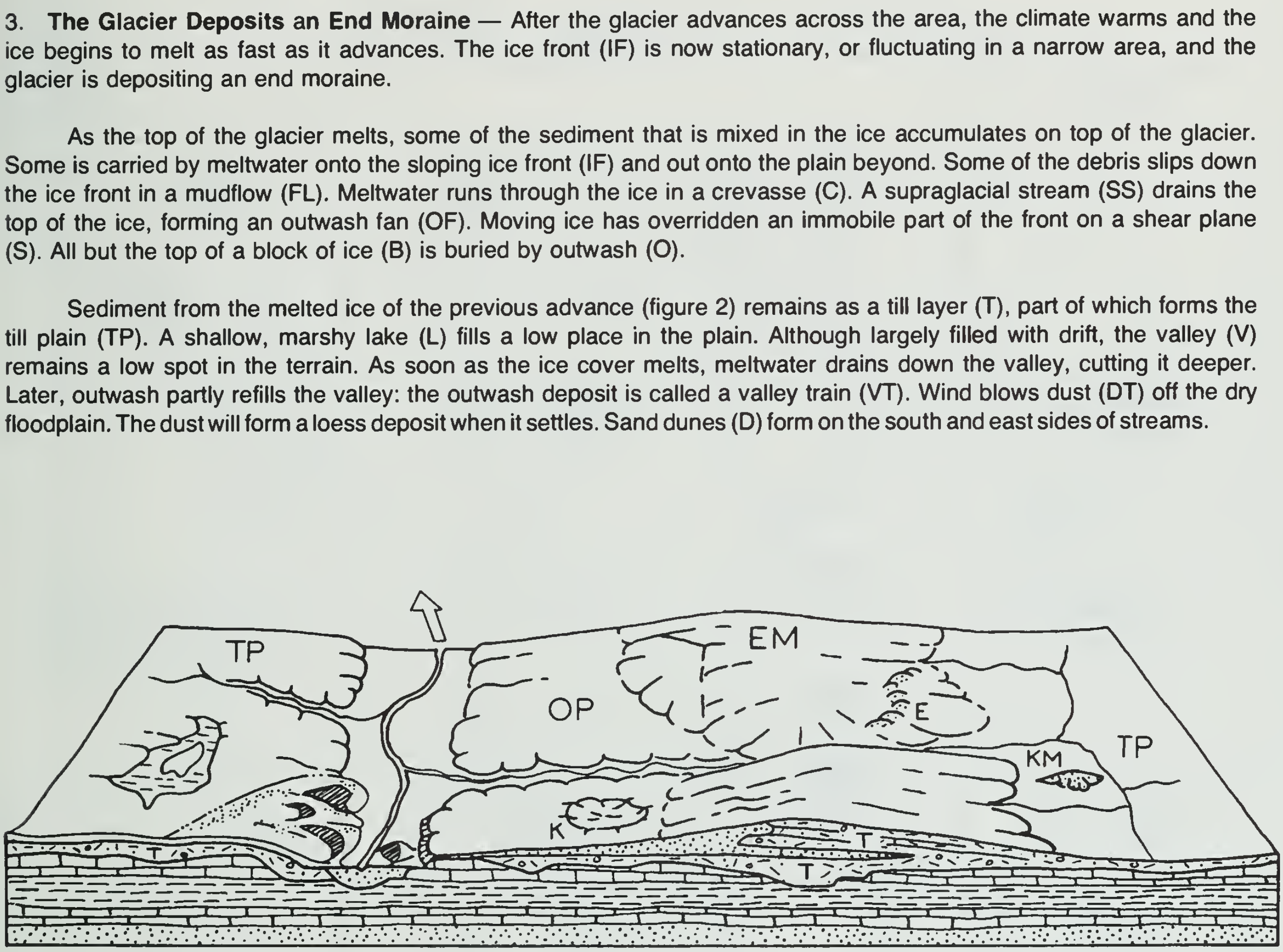
2. **The Glacier Advances Southward** — As the Glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughnesses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



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

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

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



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

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

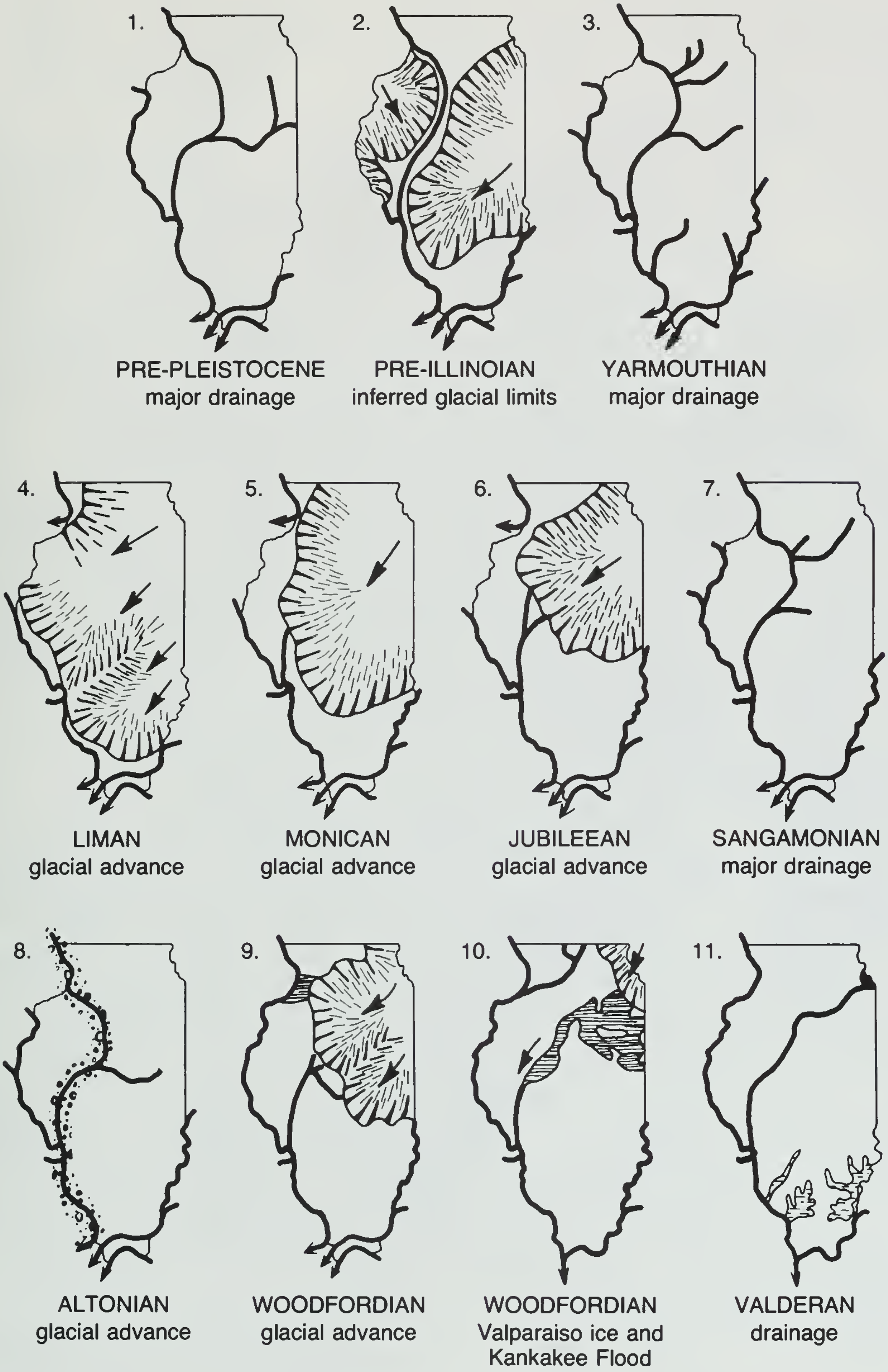
TIME TABLE OF PLEISTOCENE GLACIATION

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

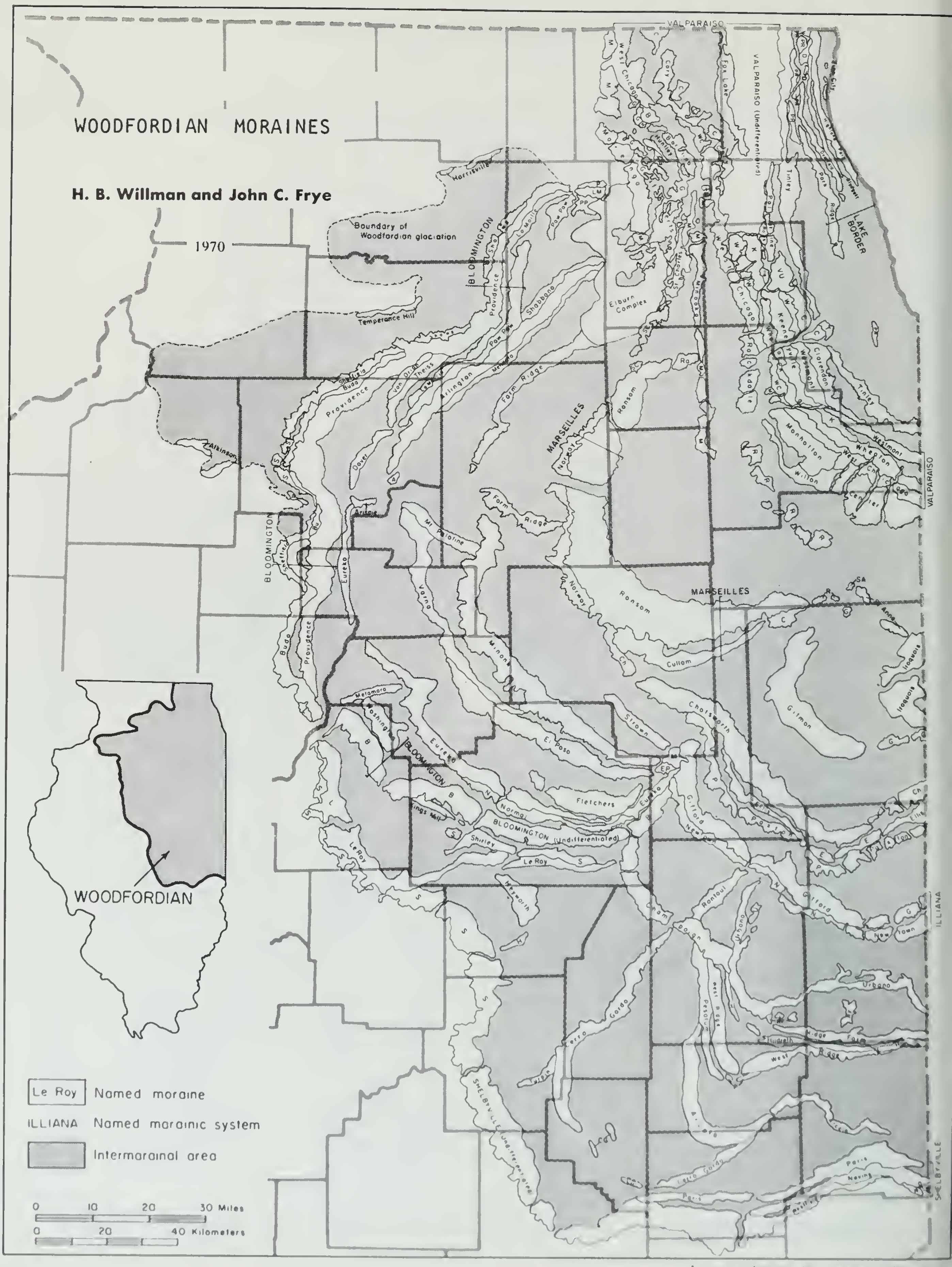
*Old oversimplified concepts, now known to represent a series of glacial cycles.

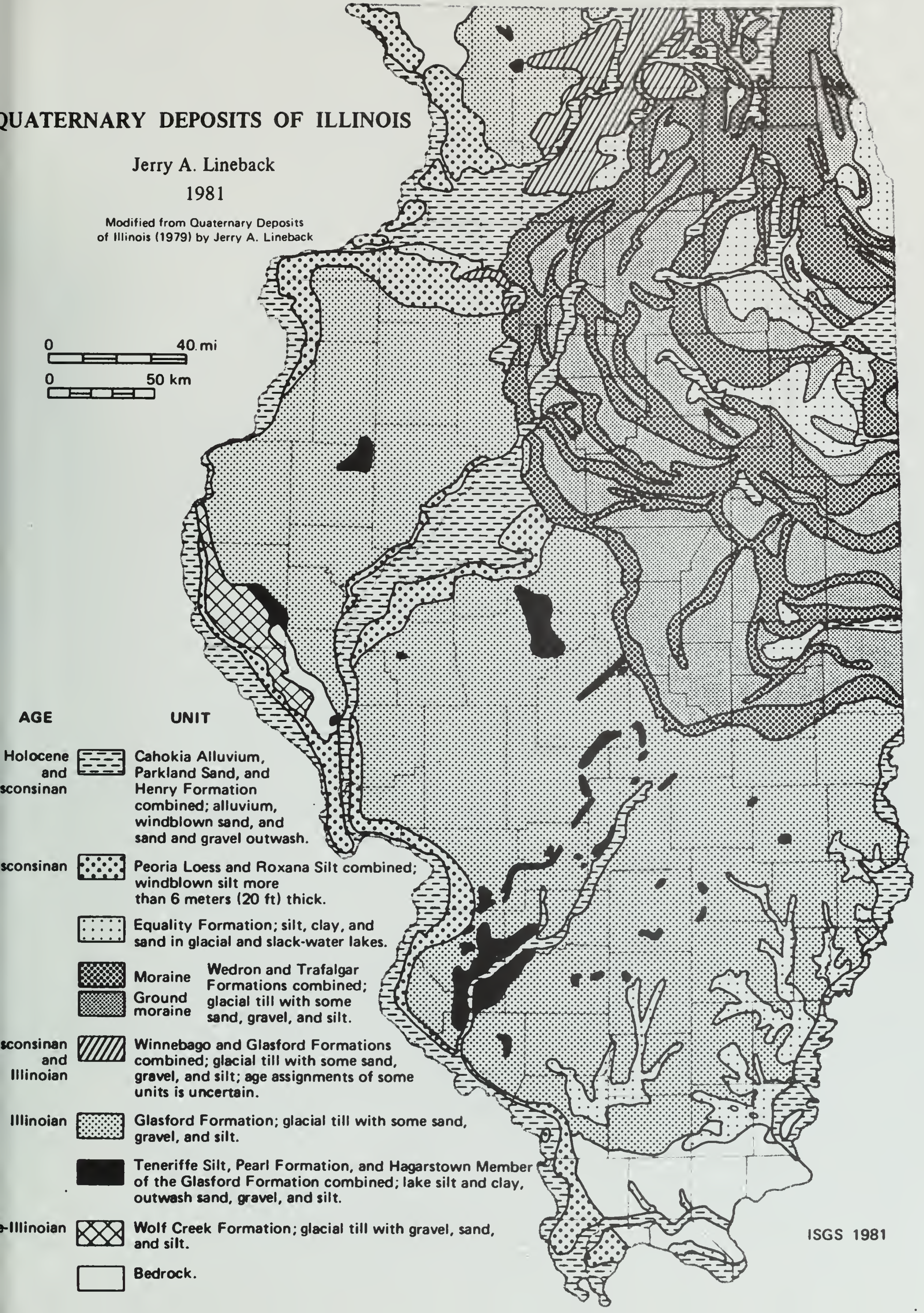
(Illinois State Geological Survey, 197

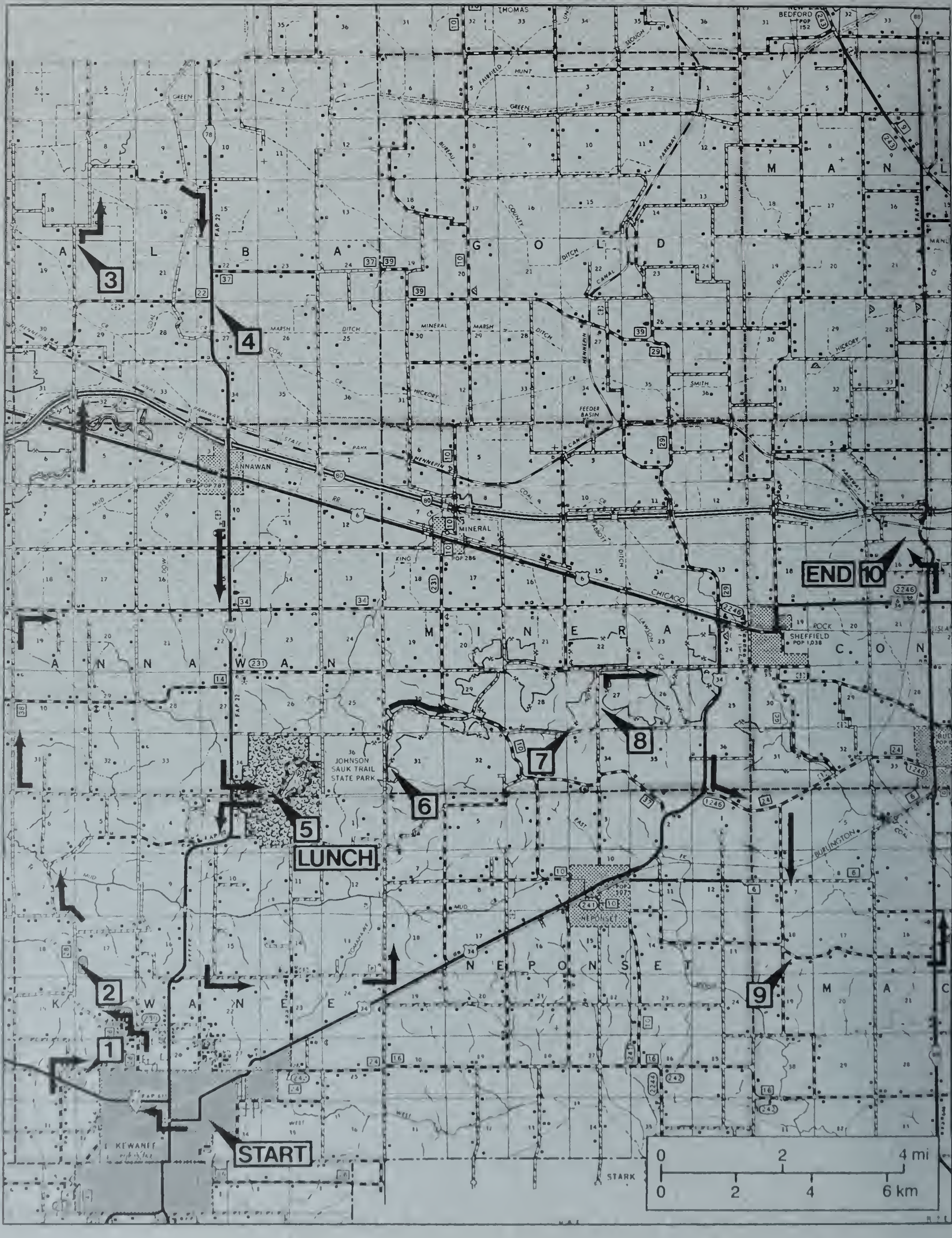
SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



(Modified from Willlman 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
ILLIANA
SHELBYVILLE
BLOOMINGTON (Undifferentiated)
SHELBYVILLE (Undifferentiated)
Harrisville
Temperance Hill
Atkinson
Providence
Shabbona
Farm Ridge
Elburn Complex
Ransom
Norway
Mt Palatine
Eureka
Varna
Minonk
Cullom
Chatsworth
Gilman
Iroquois
El Paso
Strawn
Fletchers
Normal
Metamora
Shirley
Le Roy
Heyworth
Rantoul
Urbana
Cerro Gordo
West Ridge
Paris
Nevins
Manhattan
Wilton
Wheaton
Tinley
Park Ridge
Clarendon
Newtown
WOODFORDIAN
Le Roy Named moraine
ILLIANA Named morainic system
Intermorainal area
0 10 20 30 Miles
0 20 40 Kilometers


QUATERNARY DEPOSITS OF ILLINOIS
Jerry A. Lineback
1981
Modified from Quaternary Deposits of Illinois (1979) by Jerry A. Lineback
0
40 mi
0
50 km
AGE
UNIT
Holocene and sconsinan
Cahokia Alluvium, Parkland Sand, and Henry Formation combined; alluvium, windblown sand, and sand and gravel outwash.
sconsinan
Peoria Loess and Roxana Silt combined; windblown silt more than 6 meters (20 ft) thick.
Equality Formation; silt, clay, and sand in glacial and slack-water lakes.
Moraine
Ground moraine
Wedron and Trafalgar Formations combined; glacial till with some sand, gravel, and silt.
sconsinan and Illinoian
Winnebago and Glasford Formations combined; glacial till with some sand, gravel, and silt; age assignments of some units is uncertain.
Illinoian
Glasford Formation; glacial till with some sand, gravel, and silt.
Teneriffe Silt, Pearl Formation, and Hagarstown Member of the Glasford Formation combined; lake silt and clay, outwash sand, gravel, and silt.
e-Illinoian
Wolf Creek Formation; glacial till with gravel, sand, and silt.
Bedrock.
ISGS 1981


START
1
2
3
4
5
LUNCH
6
7
8
9
END 10
THOMAS
NEW BEDFORD POP 152
ANNAWAN POP 787
MINERAL POP 286
SHEFFIELD POP 1,038
NEPONSET
JOHNSON SAUK TRAIL STATE PARK
FEEDER BASIN
HENNEPIN
CANAL
PARKWAY
STATE PARK
CHICAGO
ROCK
ISLAND
BURLINGTON
KEWANEE
STARK
A L B A
G O L D
M A N L
A N N A W A N
M I N E R A L
C O N
K E W A N E E
N E P O N S E T
M A C
0 2 4 mi
0 2 4 6 km