Geol Survey

Guide to the Geology of the Casey-Martinsville Area

Clark and Cumberland Counties, Illinois

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Bryan G. Huff
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Field Trip Guidebook 1994D October 8, 1994

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Natural Resources Building
615 East Peabody Drive
Champaign, IL 61820-6964

Cover photos by W. T. Frankie

From upper right: An oil well pump jack south of Martinsville, a central engine house from which a number of shallow oil wells could be pumped, and a stone quarry southeast of Casey

Geological Science Field Trips The Educational Extension Unit of the Illinois State Geological Survey (ISGS) conducts four free tours each year to acquaint the public with the rocks, mineral resources, and landscapes of various regions of the state and the geological processes that have led to their origin. Each 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 who prepare earth science units. Grade school students are welcome, but each must be accompanied by a parent or guardian. High school science classes should be supervised by at least one adult for each ten students.

A list of guidebooks of earlier field trips 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. Telephone: (217) 244-2427.

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Printed by authority of the State of Illinois/1994/500

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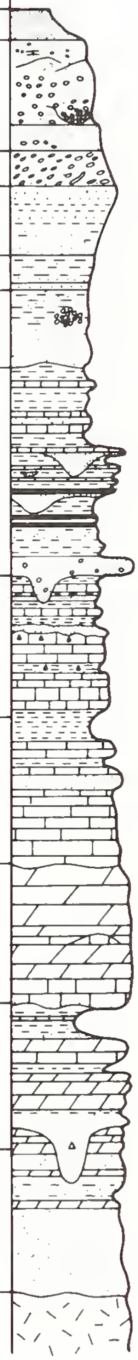
FIGURES

Era		Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks
CENOZOIC "Recent Life"	Age of Mammals		Holocene	10,000	Recent—alluvium in river valleys
		Quaternary 0-500'	Pleistocene Glacial Age	1.6 m.	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	5.3 m.	Chert gravel; present in northern, southern, and western Illinois
			Eocene	36.6 m. – 57.8 m.	Mostly micaceous sand with some silt and clay; present only in southern Illinois
			Paleocene	66.4 m.	Mostly clay, little sand; present only in southern Illinois
MESOZOIC "Middle Life"	Age of Reptiles	Cretaceous 0-300'		144 m. – 286 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")		320 m.	Largely shale and sandstone with beds of coal, limestone, and clay
		Mississippian 0-3,500'		360 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'		408 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'		438 m.	Principally dolomite and limestone
		Ordovician 500-2,000'		505 m.	Largely dolomite and limestone but contains sandstone, shale, and siltstone formations
		Cambrian 1,500-3,000'		570 m.	Chiefly sandstones with some dolomite and shale; exposed only in small areas in north-central Illinois
ARCHEOZOIC and PROTEROZOIC					Igneous and metamorphic rocks; known in Illinois only from deep wells



〰 major unconformity

Generalized geologic column showing succession of rocks in Illinois.

CASEY–MARTINSVILLE AREA

The Casey–Martinsville geological science field trip is intended to acquaint you with the *geology**, landscape, and mineral resources for parts of Clark and Cumberland Counties in east-central Illinois. This area is characterized by gently rolling uplands that developed on deposits left by two periods of continental glaciation during the last 300,000 years. The surface continuity of the area is broken where the two sheets of glacial deposits meet and where they both are eroded by the North Fork of the Embarras River and its tributaries. *Mineral* resources produced in these counties include petroleum, stone, and sand and gravel.

Casey lies approximately 180 miles south-southwest of Chicago's Loop, 95 miles east-southeast of Springfield, and 170 miles east-northeast of Cairo.

Structural and Depositional History

Precambrian Era The geology of the Clark–Cumberland Counties area, like the rest of Illinois, has undergone many changes through the several billion years of geologic time (see rock succession column, facing page). The oldest rocks beneath the field trip area belong to the ancient Precambrian (Archeozoic and Proterozoic) *basement complex*. We know relatively little about these rocks from direct observations because they are not exposed at the surface anywhere in Illinois. Only about 30 holes have been drilled deep enough in Illinois for geologists to collect samples from Precambrian rocks; depths range from some 8,200 to 8,600 feet in the Casey–Martinsville area to at least as much as 17,000 feet in southern Illinois. From these samples, however, we know that these ancient rocks consist mostly of granitic *igneous* and possibly *metamorphic*, crystalline rocks some 1.5 to 1.0 billion years old. These ancient rocks, which underwent deep weathering and erosion when they were part of Earth's surface about 0.6 billion years ago, formed a landscape that must have been quite similar to the present-day Missouri Ozarks. We have no rock record in Illinois for the long interval of weathering and erosion that lasted from the time Precambrian rocks were formed until Cambrian sediments were deposited across the older land surface; that interval, however, is longer than geologic time from the Cambrian to the present!

Geologists seldom see the Precambrian rocks, except as cuttings from drill holes. To determine some of the characteristics of the basement complex, they use various techniques, including surface mapping, measurements of Earth's gravitational and magnetic fields, and seismic tests. The evidence indicates that rift valleys similar to those in east Africa formed in what is now southernmost Illinois during the late Precambrian *Era*. These midcontinental rift structures, known as the Rough Creek *Graben* and the Reelfoot *Rift* (fig. 1), formed when plate *tectonic* movements (slow global deformation) began to rip apart an ancient Precambrian protocontinent that had formed earlier when various ancient landmasses came together. (Continental collision is going on today as the Indian subcontinent moves northward against Asia, folding and lifting the Himalayas). The slow fragmentation of the Precambrian protocontinent eventually isolated a new landmass, called *Laurasia*, which included much of what is now the North American continent.

Near the end of the Precambrian 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.

Paleozoic Era During the Paleozoic Era, what is now the southern Illinois area continued to sink slowly and to accumulate sediments deposited in shallow seas that repeatedly covered the area. At least 17,000 feet of sedimentary strata accumulated during the 325 million years of the Paleozoic Era. These sediments, when compacted and hardened (*indurated*), and the underlying

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*Words in italics are defined in the glossary at the back of the guidebook. Also please note: although all present localities have only recently appeared within the geologic time frame, we use the present names of places and geologic features because they provide clear reference points for describing the ancient landscape.

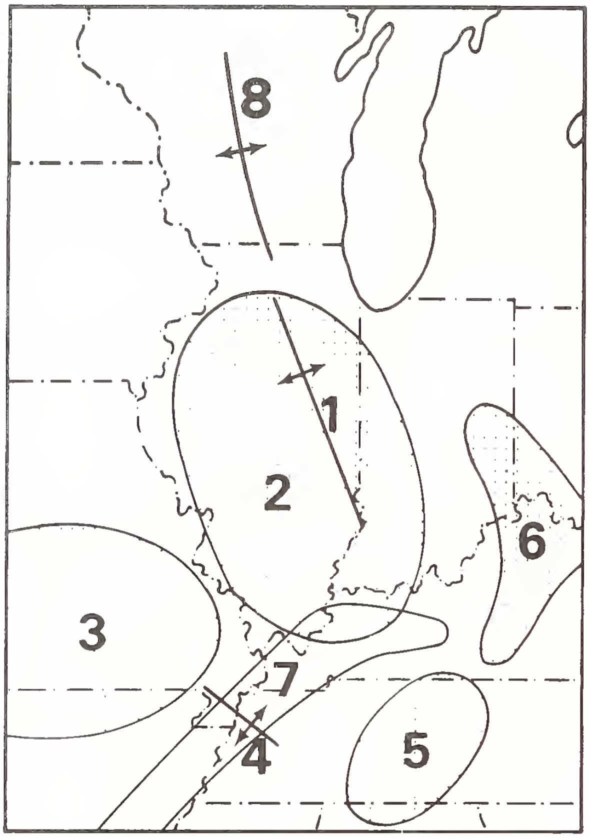


Figure 1 Location of some of the major structures in the Illinois region. (1) La Salle Anticlinal Belt, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Rough Creek Graben-Reelfoot Rift, and (8) Wisconsin Arch.

Precambrian rocks constitute the bedrock succession. The geologic column in figure 2 shows the succession of rock strata that a drill bit might encounter in this area if all the formations were present.

The field trip area is underlain by about 8,500 feet of Paleozoic sedimentary strata, ranging from deeply buried rocks of Cambrian age (about 523 million years old) to surface exposures of upper Pennsylvanian age (about 295 million years old). From middle Ordovician time about 460 million years ago, until the end of the Permian Period (and the Paleozoic Era) about 245 million years ago, the area that is now Illinois, Indiana, and western Kentucky, sank more slowly than it did earlier. Repeatedly, sediments poured into a broad trough or embayment covering the area and overflowed onto surrounding areas as well. Earth's thin crust has frequently been flexed and warped in various places. These recurrent movements over millions of years caused the seas to periodically drain from the region and slowly return. When the sea floors were uplifted and exposed to weathering and erosion by rain, streams, and wind, some of the previously deposited strata were eroded. Consequently, not all geologic intervals are represented in the rock record in Illinois (see the generalized geologic column opposite page 1).

Stratigraphic units and contacts Sedimentary rock, such as limestone, sandstone, shale, or combinations of these and other rock types, commonly occur in units called formations. A *formation* is a body of rock that has a distinctive lithology, or set of characteristics, and easily recognizable top and bottom boundaries. It is also thick enough to be readily traceable in the field and sufficiently widespread to be represented on a map. Most formations have formal names, such as Bond or Patoka, which are usually derived from geographic names and predominant rock types. In cases where no single rock type is characteristic, the word Formation becomes a part of the name (e.g., Bond Formation). A group, such as the McLeansboro Group, is a vertical lumping together of adjacent formations having many similarities. A member, or *bed*, is a subdivision of a formation that is too thin to be classified as a formation or that has minor characteristics setting it apart from the rest of the formation.

Many formations have *conformable* contacts where no significant interruptions took place in the deposition of the sediments that formed the rock units. In such instances, even though the composition and appearance of the rocks change 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 the presence of a significant gap between the time when the lower unit was deposited and the time when the overlying unit was

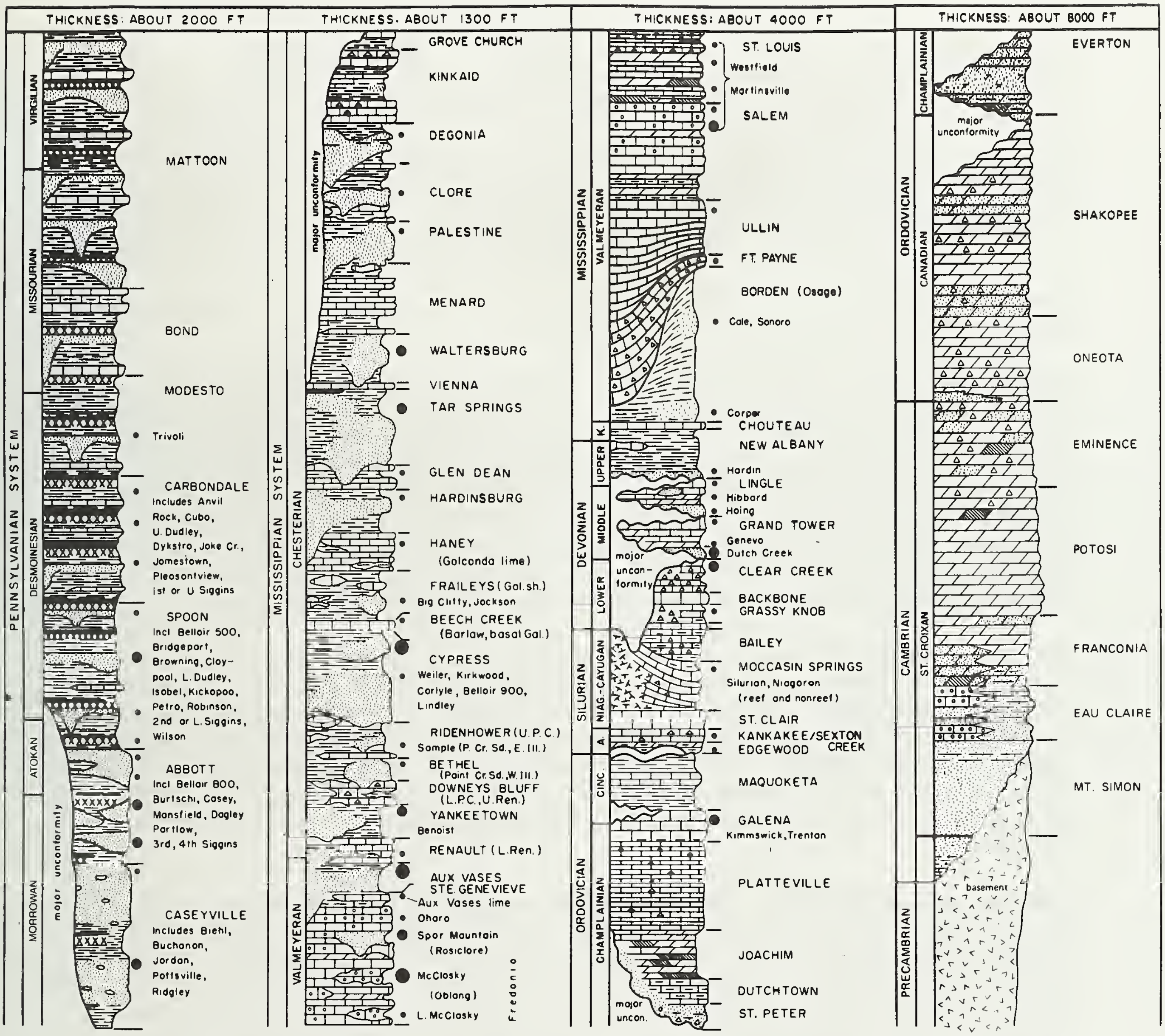


Figure 2 Generalized geologic column of southern Illinois. Black dots indicate oil and gas pay zones. Formation names are capitalized; other pay zones are not. About 4,000 feet lower Ordovician and upper Cambrian rocks under the St. Peter are not shown. Kinderhookian (K), Niagaran (Niag.), Alexandrian (A), and Cincinnatian (Cinc.) Series are abreviated. Variable vertical scale. Originally prepared by David H. Swann; modified from ISGS Illinois Petroleum 75.

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* (fig. 3a); where the lower beds were tilted and eroded before the overlying beds were deposited, the contact is called an angular unconformity (fig. 3b). Major unconformities are indicated on the generalized geologic column opposite page 1; each represents a long interval of time during which a considerable thickness of rock, present in nearby regions, was either eroded or never deposited in parts of this area. Several smaller unconformities are also present. They represent shorter time intervals and thus smaller gaps in the depositional record.

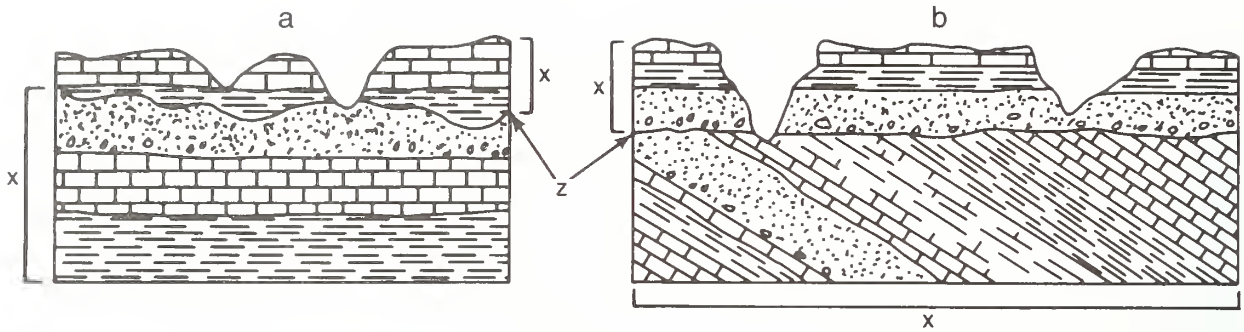


Figure 3 Schematic drawings of (a) a disconformity and (b) an angular unconformity (x represents the conformable rock sequence and z is the plane of unconformity).

Pennsylvanian Period Although bedrock strata of Pennsylvanian age, consisting of sandstone, siltstone, shale, limestone, coal, and underclay that were deposited as sediments in shallow seas and swamps between about 320 and 295 million years ago, occur immediately beneath a fairly thin cover of glacial deposits, they are not commonly exposed at the surface. The thickness of Pennsylvanian strata increases from less than 400 feet in western Clark County to about 700 feet in eastern Cumberland County. The degree of metamorphism (rank) of coal deposits and other indirect evidence indicate that perhaps as much as a mile of latest Pennsylvanian and younger rocks once covered northern Illinois. A description of these rocks and their occurrence may be found in Depositional History of the Pennsylvanian Rocks (at the back of the guidebook).

Near the close of the Mississippian Period (320 million years ago), gentle arching of the bedrock in eastern Illinois initiated the broad upwarp of the La Salle Anticlinal Belt (figs. 1 and 4), a complex structure with smaller structures such as domes, anticlines, and synclines superimposed on it. This gradual arching continued through the Pennsylvanian Period. Because the youngest Pennsylvanian strata are absent from the area of the anticlinal belt, due to nondeposition or erosion, we cannot know just when movement along the belt ceased. Perhaps, it was by the end of the Pennsylvanian or a little later during the Permian Period, the youngest rock system of the Paleozoic Era.

Mesozoic and Cenozoic Eras It is possible that rocks of Mesozoic and Cenozoic ages could also have been present over more of the state than the scattered occurrences present in western and extreme southern Illinois. The approximately 243 million years between the close of the Paleozoic Era and the onslaught of glaciation 1 to 2 million years ago is ample time for the erosion of perhaps several thousands of feet of strata. 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, 4, and 5). Development of the Pascola Arch, in conjunction with the earlier sinking of deeper parts of the area that would become the Illinois Basin, gave the basin its present asymmetrical, spoon-shaped configuration. The geologic map of Illinois (fig. 6) shows the distribution of the rock systems of the various geologic time periods as they occur at the bedrock surface; that is, as if all glacial, windblown, and surface materials were removed.

The Casey–Martinsville field trip area is located along the eastern central flank of the Illinois Basin. Bedrock strata here are tilted to the south and west toward the deeper part of the basin located in Hamilton and White Counties, about 90 miles away. 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.

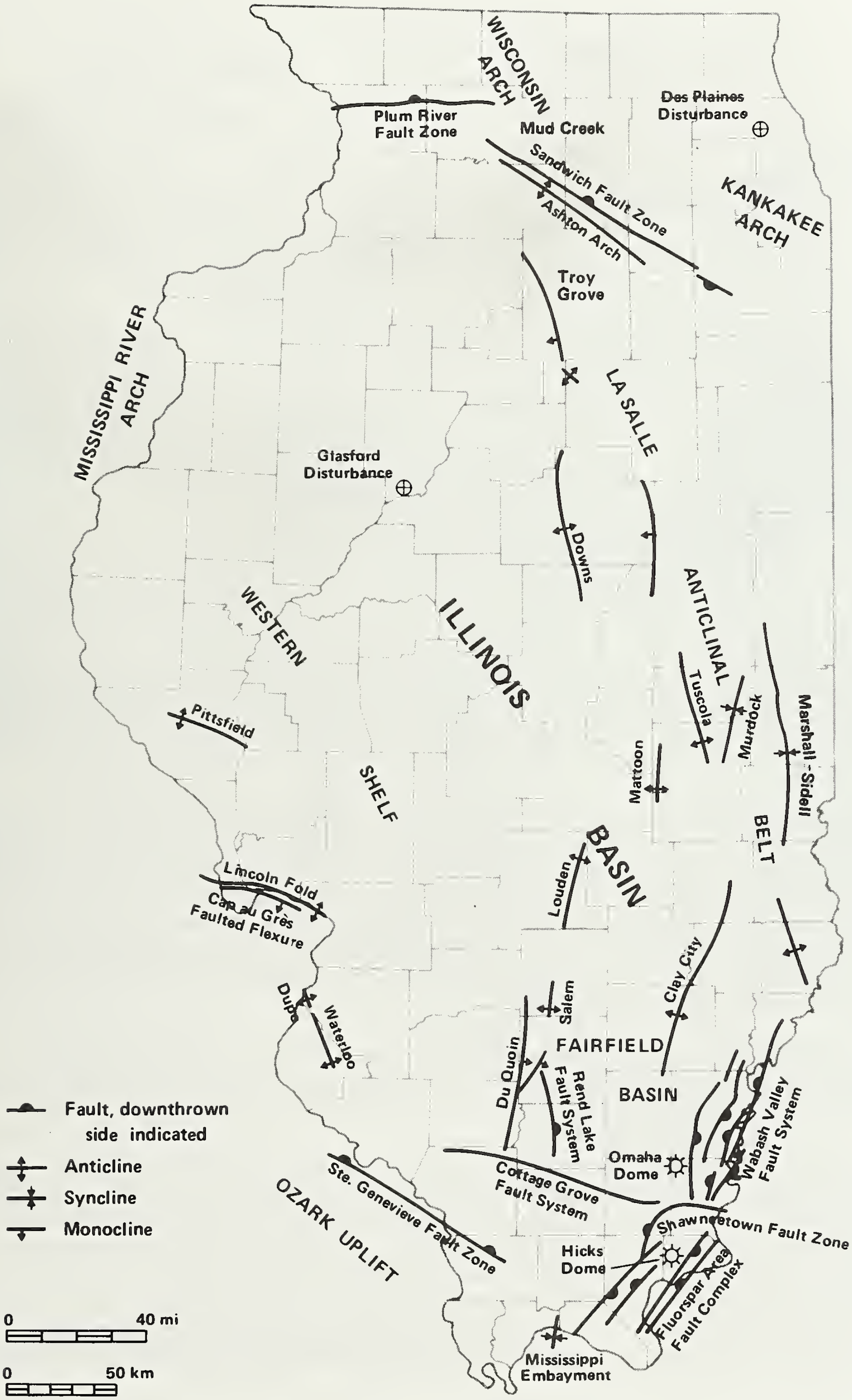


Figure 4 Structural features of Illinois

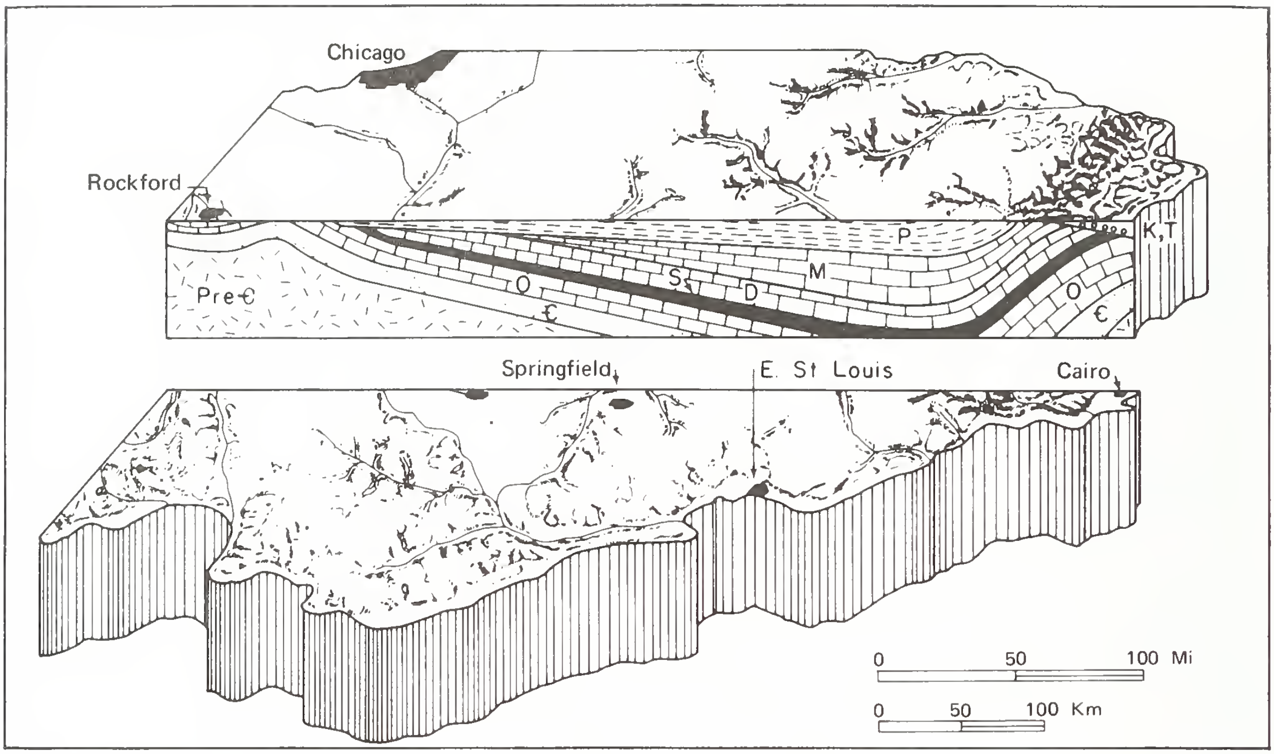


Figure 5 Stylized north-south cross section shows the structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks has been greatly exaggerated and younger, unconsolidated surface deposits have been eliminated. The oldest rocks are precambrian (pre-c) granites. They form a 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.

As noted previously, before the start of *glaciation* 1 to 2 millions years ago, the ancient Illinois land surface was exposed to long periods of intense weathering and erosion. This produced a series of deep valley systems carved into the gently tilted bedrock formations. In the area that is now Illinois, all rocks except those of Precambrian age were subjected to this erosion. 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 except the Precambrian rocks. When the glaciers finally melted away, nonindurated deposits were left behind. Our Modern Soil has developed in these deposits.

Glacial history A brief general 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 Guidebook).

Beginning about 1.6 million years ago, during the Pleistocene *Epoch*, massive sheets of ice, hundreds of feet thick—continental glaciers—flowed slowly southward from centers of snow and ice accumulation in the far north. The last of these glaciers melted from northeastern Illinois about 13,500 years before the present (B.P.). Although ice sheets covered parts of Illinois several times during the Pleistocene Epoch, pre-Illinoian drift deposits are known only from the deeper parts of the largest bedrock valleys. During the Illinoian glaciation, around 270,000 years B.P., North American continental glaciers reached their southernmost extent, advancing as far south as the northern part of Johnson County, about 130 miles south-southwest of the Casey–Martinsville area (fig. 7).

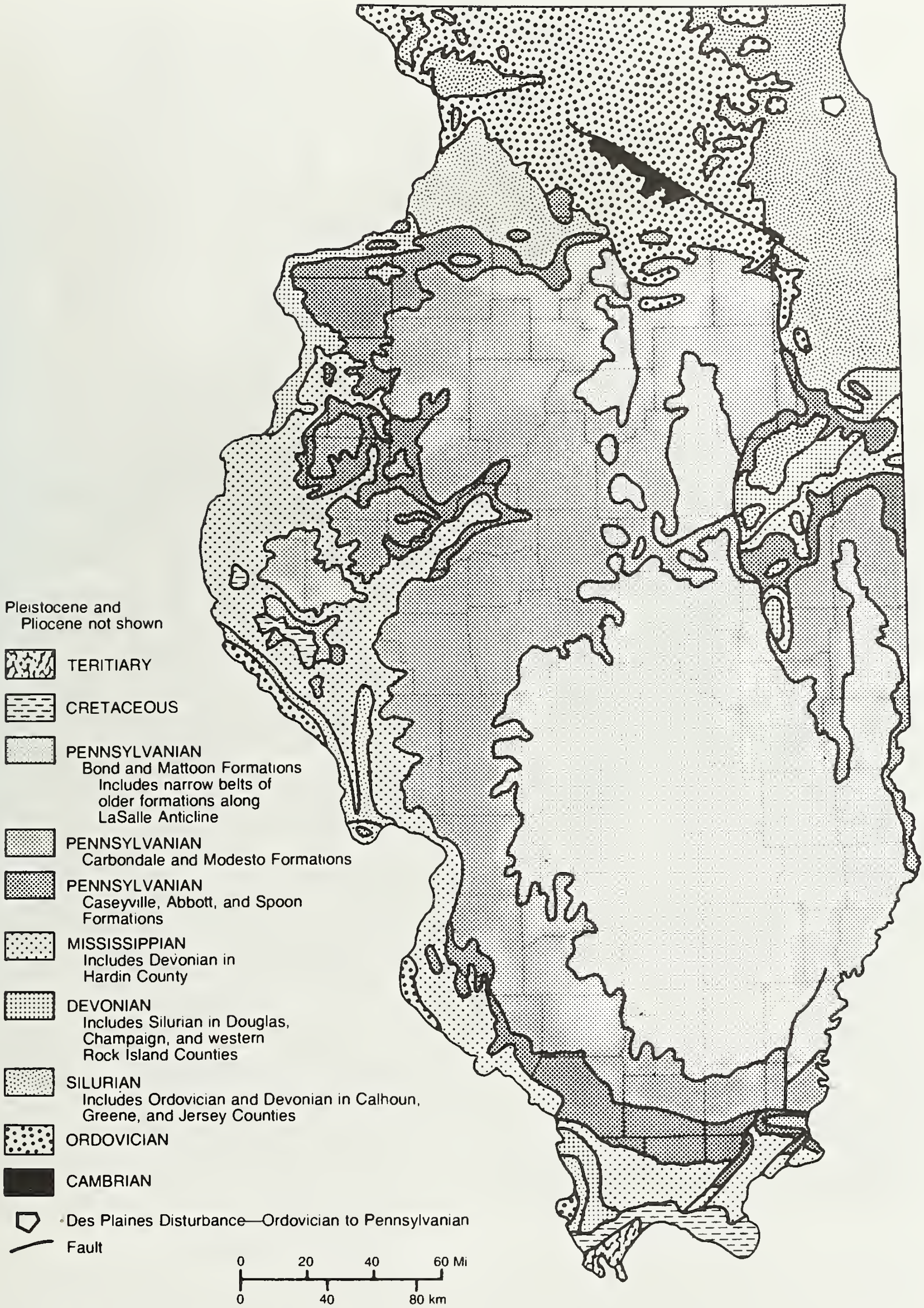


Figure 6 Bedrock geology beneath surficial deposits in Illinois.

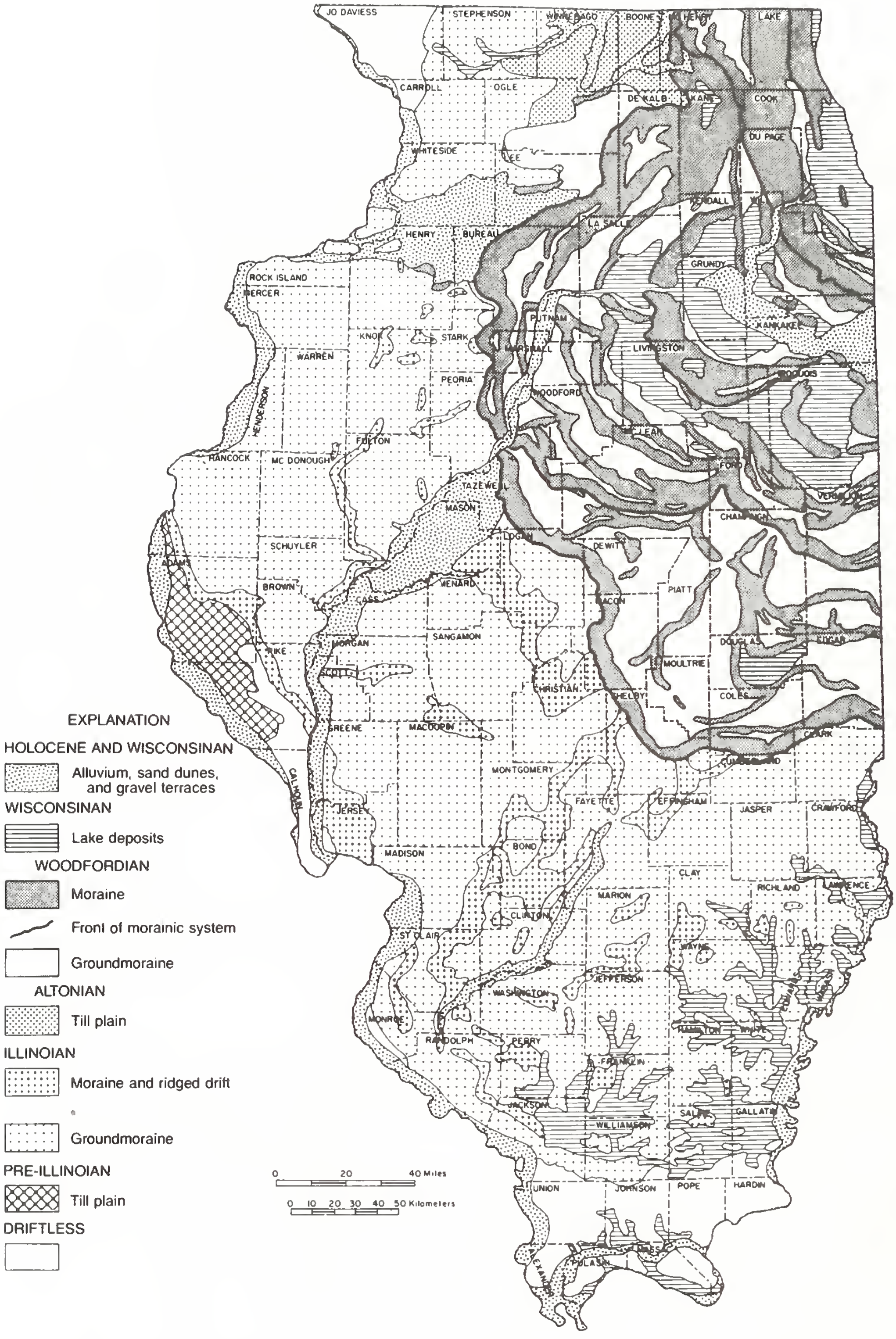


Figure 7 Generalized map of glacial deposits in Illinois (after Willman and Frye 1970).

Until recently, glaciologists had assumed that ice thicknesses of a mile or more were reasonable estimates for the thickenss of these glaciers. However, the ice may have had a maximum thickness of only about 2,000 feet in the Lake Michigan Basin; it was possibly only about 700 feet thick across most of the land surface (Clark et al. 1988). This conclusion was reached on the basis of 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.

Although Illinoian glaciers probably built morainic ridges similar to those of the later Wisconsinan glaciers, they are not nearly so prominent. Illinoian moraines apparently were not so numerous and those that were formed have been exposed to weathering and erosion for thousands of years longer than their younger Wisconsinan counterparts.

As mentioned previously, erosion had produced an extensive network of bedrock valleys that were deeply carved into the irregular bedrock surface by the time glaciation began about 1.6 million years ago. As glaciation began, streams changed from erosion to aggradation—that is, the streams began to build up and fill in their channels because the flow or volume of water was insufficient to carry the 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 any pre-Illinoian fills in the preglacial valleys were ever completely flushed out of their channels by succeeding deglaciation meltwater torrents.

The topography of the bedrock surface throughout much of Illinois is largely hidden from view by glacial deposits except along the major streams and in areas mantled by thin drift near the glacial margins. However, studies of mine shafts, water-well logs, and other drill-hole information show that the underlying bedrock surface is uneven, which is also true in many other parts of Illinois. In Clark and Cumberland Counties, glacial drift is unevenly distributed, partly because of the irregular bedrock surface and partly because of erosion.

A cover of Woodfordian *loess* (pronounced "luss"), or wind-blown silt, mantles the glacial drift in the field trip area and neighboring counties. These fine grained dust deposits of Wisconsinan age are about 5 feet thick in the northern part of the area but thin to less than 3 feet southward. The fertile soils in the field trip area have developed in the loess.

GEOMORPHOLOGY

Physiography

Physiography is the general term used for describing landforms. A *physiographic province* is a region in which the relief or landforms differs markedly from those in adjacent regions. The Casey–Martinsville field trip area is situated in the Till Plains Section of the Central Lowlands Province (fig. 8). The present gross features of the Till Plains Section are determined largely by its preglacial topography. The Till Plains Section has seven divisions in Illinois, two of which are encountered on this field trip: the Springfield Plain and the Bloomington Ridged Plain.

The Springfield Plain, which underlies the field trip area, includes the level area of the Illinoian glacial drift. Although it is generally flat with tabular uplands in this part of our state, its surface is gently undulating with modern shallowly entrenched drainage in some areas. Even though glacial deposits are somewhat thinner than in the area covered by younger glaciers, surface topography is essentially the result of glacial deposition and subsequent erosion by streams. The glacial drift is generally less than 25 feet thick beneath the tabular uplands, but it exceeds 100 feet in the buried

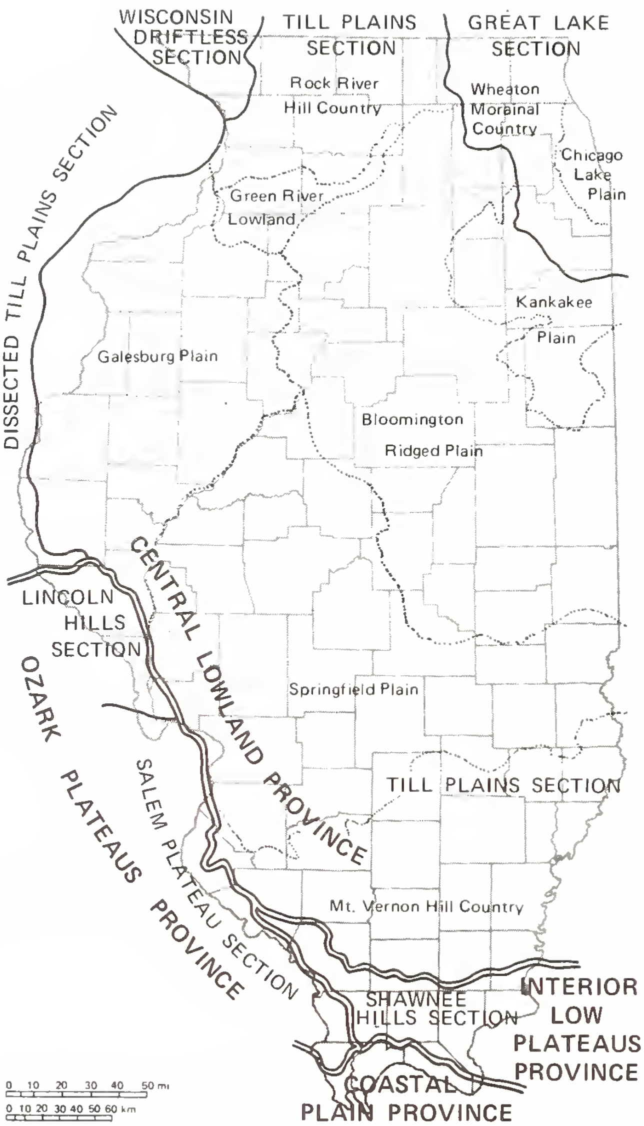


Figure 8 Physiographic divisions of Illinois.

bedrock valleys. The Springfield Plain is 100 to 120 feet lower in elevation than the Bloomington Ridged Plain to the north.

The northern part of the field trip area is only a couple of miles south of the younger Bloomington Ridged Plain, which is of Wisconsinan age. The south boundary of Bloomington Ridged Plain is marked by the Shelbyville Moraine. Although the larger Wisconsinan moraines are conspicuous from a distance, they generally are less obvious from close up because of their gentle outer slopes.

Drainage

As noted previously, the field trip area is drained by the North Fork of the Embarras (pronounced "Ambraw") River and its tributaries (Lindsay, Willis, Kettering, and Quarry Branches, and Turkey Run and Bluegrass Creek). North Fork joins the Embarras River about 25 miles south of the field trip area. The Embarras joins the Wabash River just southeast of Lawrenceville, about another 25 miles away. Range and Birch Creeks drain the western part of the area southwestward about 18 miles to the Embarras River. The tributary network is much more extensive on the Springfield Plain than it is on the Bloomington Ridged Plain to the north.

Relief

The highest (elevation) land surface on the field trip route, except for interstate cross-overs, is slightly more than 670 feet above mean sea level (msl). This location is adjacent to a crossroad about 3 miles north of I-70 on SR-49. The lowest elevation is slightly less than 540 feet msl in the North Fork of the Embarras River below the bridge near Stop 8. The surface *relief* of the field trip route, calculated as the difference between the highest and lowest elevations, is thus about 130 feet. Local relief generally ranges from 30 to 50 feet along the larger stream valleys.

MINERAL RESOURCES

Mineral Production

Of the 102 counties in Illinois, 97 reported mineral production during 1992, the last year for which complete records are available. During 1992, $2.894 billion worth of minerals were extracted, processed, and manufactured in Illinois, a decrease of 0.5% over the previous year. The value of the extracted minerals was $2.607 billion, a decrease of 4.4% from 1991. Mineral fuels (coal, crude oil, and natural gas) made up 78.2% of the total value. Industrial and construction materials such as clay, fluorspar, sand and gravel, stone, and tripoli accounted for 21.4%. The remaining 0.4% came from metals such as lead, zinc, and silver, and from other minerals, such as peat and gemstones (Samson, in preparation). Illinois ranked 16th among the 50 states in total production of nonfuel minerals and continued to lead all other states in the production of industrial sand, tripoli, and fluorspar.

Clark County ranked 46th among all counties on the basis of the total value of its mineral production of crude oil, stone, and sand and gravel. Cumberland County ranked 82nd on the basis of its mineral production of crude oil and sand and gravel.

During 1992, 46 counties in Illinois produced 19,137,000 barrels of crude oil valued at $368,586,000. Crude oil production is combined for Clark and Cumberland Counties and amounted to 299,000 barrels valued at $5,761,000. This is about 1.6% of the total Illinois oil production and ranks these two counties 16th in production. Cumulative total oil production for these counties since 1900, when oil first was produced here, amounts to approximately 95,277,000 barrels.

More than 68.5 million tons of stone valued at more than $295.3 million were produced from 177 operations in 53 Illinois counties during 1991, the last year for which totals are available. Clark County production is reported in U. S. Bureau of Mines District 3 in which 26 operations in 10 counties produced more than 10,184,000 tons of stone valued at more than $30.7 million.

Fifty-four counties produced nearly 35.7 million tons of sand and gravel valued at $123.7 million from 149 operations during 1992. The production for Clark and Cumberland Counties is reported in U. S. Bureau of Mines District 3 in which 52 operations in 19 counties produced more than 6.8 million tons of sand and gravel having a value of slightly more than $21.3 million.

Groundwater

Probably few of us think of groundwater as a mineral resource when we consider the natural resource potential of an area. Yet the availability of groundwater is essential for orderly economic and community development. More than 48% of the state's 11 million citizens and 97% of those who live in rural areas depend on groundwater for their water supply.

The source of groundwater in Illinois is precipitation that infiltrates the soil and percolates into the groundwater system lying 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. 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.

In this part of Illinois, deposits of sand and gravel occurring in the glacial drift and in the bedrock valleys are important aquifers. The glacial drift is generally less than 50 feet thick; however, the sand and gravel deposits are typically thinner and discontinuous in occurrence throughout most of the field trip area. Thicker glacial deposits occur in several south-trending valleys cut into the bedrock surface. These buried bedrock valleys pass through Cumberland County a few miles east of the Embarras River and about 6 miles east of the west boundary of Clark County, roughly coinciding with Mill Creek east of Martinsville. Water-yielding sand and gravel beds occur in parts of these valleys. Thin glacial *outwash* gravels in the northern parts of the counties lying in front (that is, to the south) of the Shelbyville Morainic System also locally provide an adequate source for small groundwater supplies. Where glacial deposits yield water too slowly to supply the pump in a drilled well, the construction of a bored well with a large diameter may be necessary to obtain an adequate water supply. This type of well has a reservoir below the water level in the well.

The uppermost bedrock in this area is part of the Pennsylvanian System of rocks and consists mostly of shale but does contain a few interbedded layers of limestone, fine grained sandstone, and coal. The shale yields little water. Small supplies of groundwater are sometimes obtained from wells where the limestone and coal beds are fractured or from sandstones.

In general, groundwater for domestic and farm supplies is available in the upper 150 to 200 feet of earth materials, from either sand and gravel in the glacial drift or sandstone, limestone, or coal in the bedrock of Pennsylvanian age. At greater depths, the groundwater is too highly mineralized for most uses.

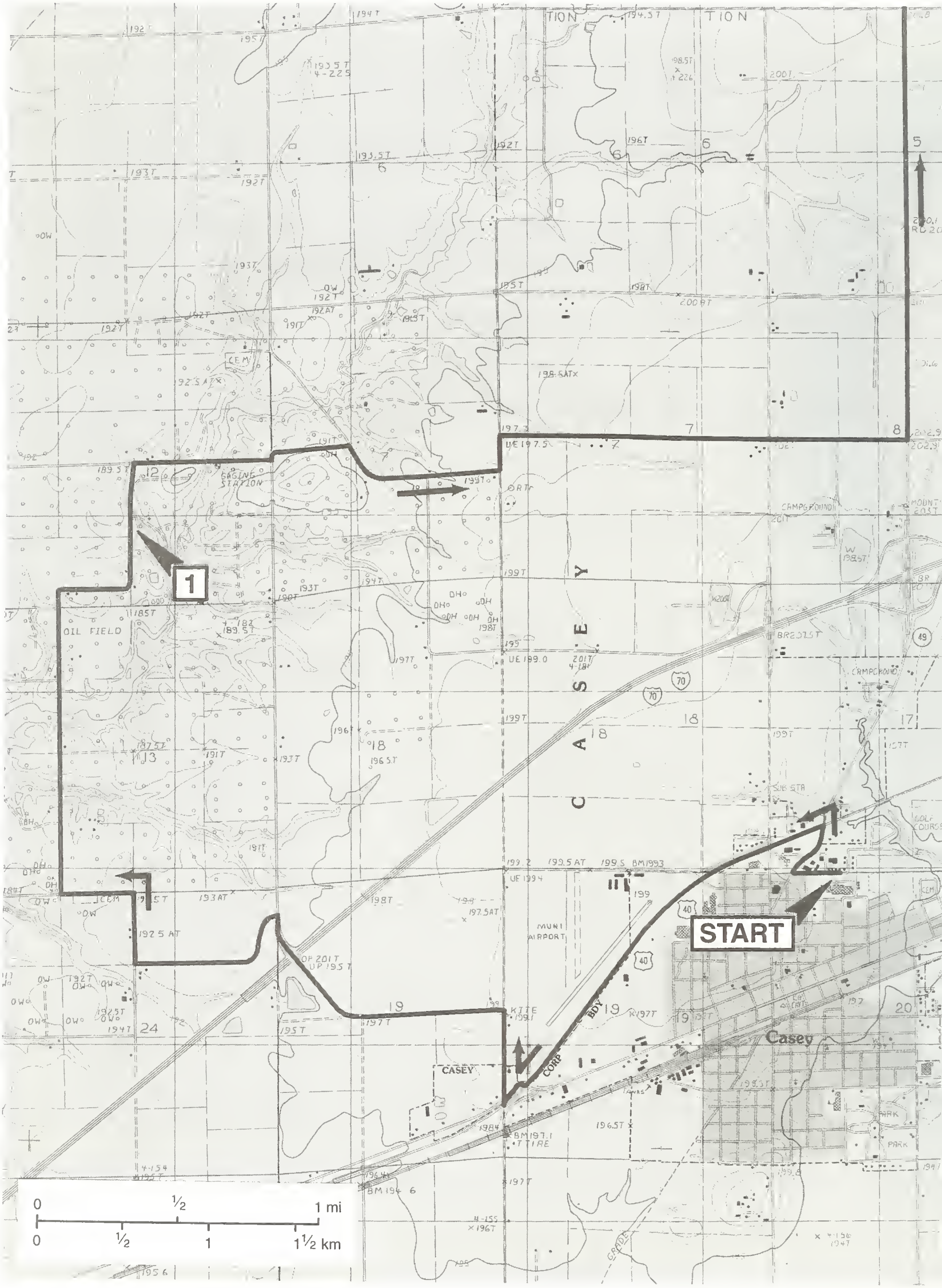
Future of Mineral Industries in Illinois

For many years, the mineral resources of the Midcontinent have been instrumental in the development of our nation's economy. The mineral resource extraction and processing industries continue to play a prime role in our economy and in our lives, and they will continue to do so in the future. The following paragraphs tell of recent initiatives involving the Illinois State Geological Survey (ISGS) and mapping, especially in southern Illinois.

The prime mission of the ISGS is to map the geology and mineral resources of the state, conduct field mapping, collect basic geologic data in the field and in the laboratory, and interpret and compile these data on maps and in reports for use by industry, the general public, and the scientific community. Over the years, maps of the geology of the state have been published at various scales. Recently, more detailed maps and reports covering particular regions have been completed. To meet growing demands for detailed geologic information to guide economic development and environmental decision-making, the ISGS began a program to geologically map the 1,071 7.5-minute quadrangles of Illinois.

Geologic mapping of southern Illinois at the 1:24,000 scale (1 inch on the map equals nearly 0.4 mile on the ground) began with the Cave in Rock area (Baxter et al. 1963). This detailed mapping program led to a new understanding of the mineral potential for this area. In 1981, the ISGS resumed detailed mapping in southern Illinois with funding from the Nuclear Regulatory Commission (NRC). In 1984, mapping was continued with matching federal funds from the Cooperative Geologic Mapping Program (COGEOMAP) of the U.S. Geological Survey (USGS).

Recently, the U.S. Congress passed the National Geologic Mapping Act of 1992. This Act authorizes a national program to map the geology of the United States in detail. Under the Act, the USGS will work with the 50 state geological surveys to coordinate and plan the program. Expenditures of up to $25 million annually will be matched by the states. In Illinois, legislation authorizing cooperation with the Federal Government has been passed. If fully funded at the state and federal levels, this program would result in completing the detailed geologic mapping of Illinois in about 20 years. Benefit-cost analyses of geologic mapping projects by the ISGS showed that the value of the benefits that flow from having detailed geologic maps available range from 12 to 27 times the cost of doing the mapping. Benefits include the value of mineral resources discovered through mapping and the reduced costs of environmental clean-up that come from using geologic maps to properly locate waste disposal facilities in geologically capable areas.


START
1
CASEY
Casey
OIL FIELD
GAGING STATION
MUNI AIRPORT
CAMPGROUND
GOLF COURSE
PARK
70
40
49
0
½
1 mi
0
½
1
1½ km

GUIDE TO THE ROUTE

Assemble in the parking area on the on the north side of Casey–Westfield High School (NW NE NW & NE NW NW, Sec. 20, T10N, R14W, 2nd P.M., Clark County; Casey 7.5-Minute Quadrangle [39087C8]*). We'll start calculating milage at the entrance to East Georgia Street. Park your vehicle in line so that the caravan can start out immediately after registration.

You must travel in the caravan. Please drive with 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. If the road crossing is protected by a vehicle with flashing lights and flags, then obey the signals of the ISGS staff directing traffic. When we stop, park as close as possible to the car in front of you and turn off your lights.

Note: Some stops on the field trip are on private property. The owners have graciously given us permission to visit on the day of the field trip only. Please conduct yourselves as guests and obey all instructions from the trip leaders. 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 use this booklet for a field trip with your students, youth group, or family, you must (because of trespass laws and liability constraints) get permission from property owners or their agents before entering private property.

Miles to next point	Miles from start	
0.0	0.0	STOP: TURN LEFT (west) onto East Georgia Street.
0.1	0.1	STOP: 2-way at the intersection. TURN RIGHT (northeast) onto State Route (SR) 49. BEWARE of fast moving traffic coming from the left.
0.2	0.3	STOP: 4-way, flashing red lights, at the intersection of Route (US) 40 and SR 49. TURN LEFT (southwest) onto US 40. Be extremely careful. Traffic from all directions moves very fast.
1.25	1.55	Slow down and prepare for right turn.
0.05	1.6	CAUTION: TURN RIGHT (northwest) onto (010E). Westside Church of Christ is on the right-hand side. Follow road around small S curve and prepare to TURN RIGHT (north) onto (000E). This road is on the Clark/Cumberland county line. Notice the flat topography on both sides of the road. This is part of the Illinois till plain, which we will discuss at Stop 2.
1.3	2.9	Bridge crossing I-70. PREPARE TO MAKE A LEFT TURN at the bottom of overpass.
0.2	3.1	TURN LEFT (east) at the T-intersection onto the unmarked road.

* The number in brackets [39087C8] 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 64 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.

0.5	3.6	PREPARE to make a RIGHT TURN at T- intersection.
0.1	3.7	STOP: 1-way at the T-intersection. TURN RIGHT (north) onto the unmarked road. CAUTION: traffic at times is obscured by tall corn at intersection.
0.3	4.0	Road curves to the LEFT, 90 degrees.
0.1	4.1	On the left, you can see the Long Point Cemetery and the former site of Long Point Chapel.
0.1	4.2	TURN RIGHT (north) onto the unmarked road at the T-intersection. You are now in the heart of Siggins Oil Field. Wells drilled in this field are normally on a 10-acre spacing. Many of the wells have been plugged and are abandoned. You can easily spot some of the wells by looking for power lines leading into the fields to the wells. Small service roads also branch off at different points along the road to allow access to the wells for servicing and picking up crude oil. On the next 2.5 miles of the route, you can view numerous oil well pump jacks, oil storage tanks, and other oil field equipment.
0.7	4.9	CAUTION: Narrow one-lane bridge crossing Ranger Creek.
0.35	5.25	CAUTION: Road CURVES TO THE RIGHT. There is a pump jack to the right, next to the farmhouse.
0.25	5.5	CAUTION: Road CURVES TO LEFT. NOTE: On the right side of the road, you can see numerous pieces of oil field equipment, including spare pump jacks, pipe, and other items spread out on the countryside. There is a large battery of oil tanks and some buildings. Notice the large structure that looks like a headframe for a coal mine that sticks up through the trees to the east.
0.2	5.7	Pull over and park vehicles on right edge of road.

STOP 1 We'll discuss the Siggins Oil Field, Siggins Oil Mine, and petroleum geology in general (SW SW NW SE, Sec. 12, T10N, R10E, 3rd P.M., Cumberland County; Union Center 7.5-Minute Quadrangle [39088C1]). There are numerous tank batteries and pump jacks in the woods to your right and pump jacks and separators in the field to your left.

Petroleum geology Four factors help geologists determine a particular location's potential for an accumulation of oil and gas. The first is the original source of the oil and gas. Source rocks must be rich in organic matter. They must also have been naturally heated so that the organic material can begin to be converted to hydrocarbons and expelled from the source rock. The hydrocarbons then migrate toward a layer of what is known as reservoir rock. The reservoir is the second factor to be considered—it can be thought of as a natural underground "container" of oil, gas, and water. A reservoir must have enough porosity (the amount of voids, pores, and other openings in the rock) to store the oil and gas. It must also have enough permeability (the amount of interconnected porosity) to deliver the oil and gas into a well bore drilled through the rock. In other words, the oil must be able to move from the rock to the well.

The third factor that must be considered is the nature of the reservoir's seal. A seal is a layer of rock that usually overlies the reservoir and that has poor porosity and/or permeability. It effectively seals the reservoir and prevents the vertical migration of oil and gas from the reservoir rock. The fourth factor is the trapping mechanism. A trap is the geometric arrangement of the reservoir

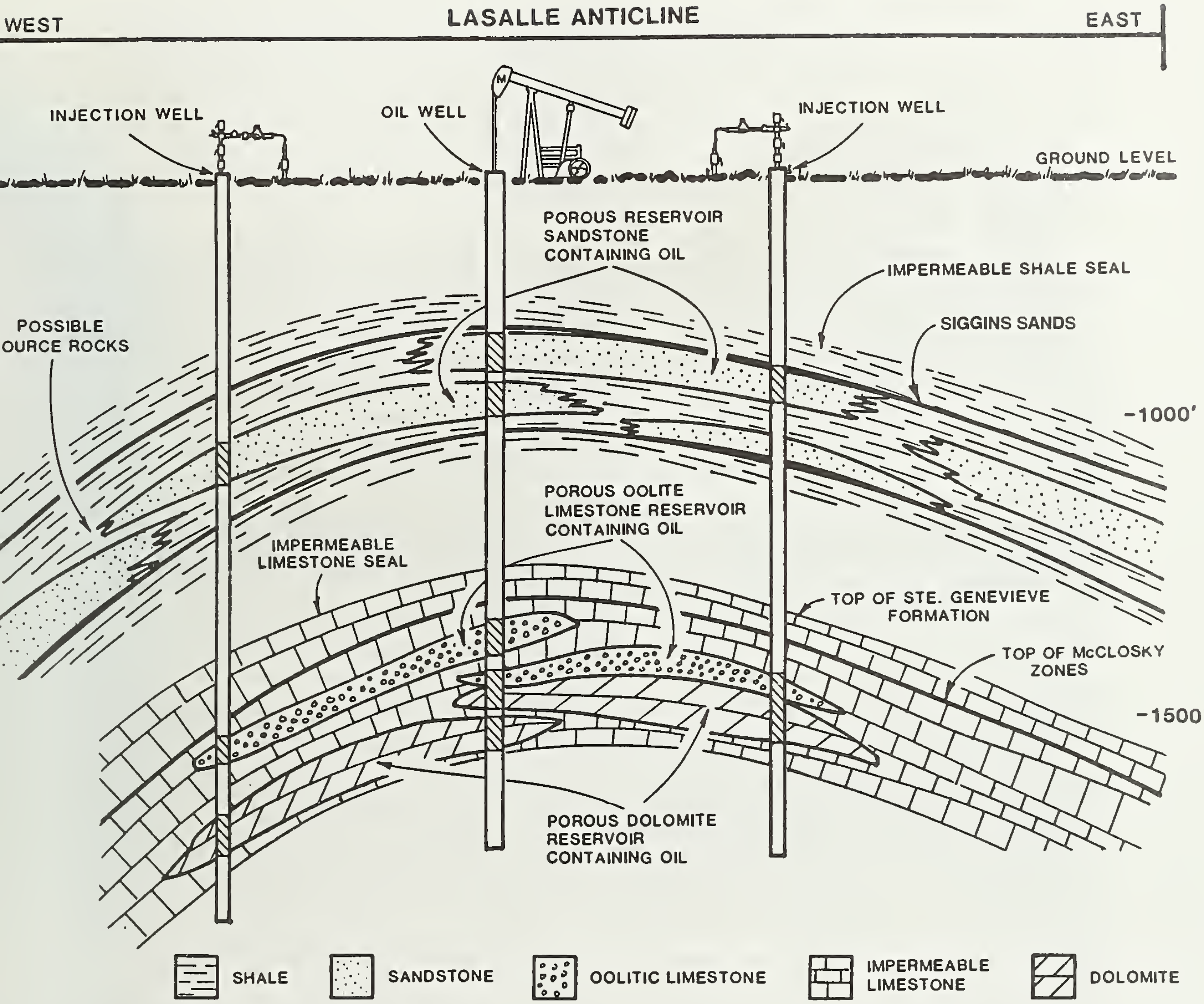


Figure 9 Diagrammatic sketch of Siggins Oil Field.

rocks and seals past which the petroleum cannot migrate. It can be thought of as the final resting place for a given accumulation of oil and gas. A trap must be of sufficient size for a reservoir to be developed economically.

Traps are generally either structural or stratigraphic in nature. Structural traps are more commonly identified because they are easier to find. They typically form when layers of rock are folded by natural forces into geometric shapes called anticlines (fig. 9). An anticline is a fold that is convex upward (an underground "hill"). Stratigraphic traps are typically formed when the physical properties of a reservoir rock change along its length or lateral extent. An example of a stratigraphic trap would be a sandstone bed that has good porosity and permeability but that laterally changes into a shale bed. The shale would have poor permeability and thus trap the oil and gas in the sandstone.

Siggins Oil Field The Siggins Oil Field was discovered in 1906. The field has produced about 4 million barrels of oil from one of the most densely drilled areas in Illinois. It is developed in a dome covering about 7 square miles and is near the crest of the La Salle Anticlinal Belt. Production has been from four Pennsylvanian sandstones (fig. 9): the Upper Siggins and Lower Siggins, which occur in the upper half of the Tradewater Formation (formerly Spoon Formation); and the 3rd and 4th Siggins, which occur in the lower part of the lower half of the Tradewater Formation (formerly Abbott Formation). These reservoirs range from about 16 to 40 feet thick and are 400 to more than 600 feet below the surface. In addition to the Pennsylvanian production, a small amount of oil is recovered from some 60 feet of Ordovician Trenton Limestone Group at a depth of 3,013 feet.

In 1942 Forest Oil installed the first planned secondary recovery waterflood project in Illinois on 40 acres in this field. During a waterflood project, water is pumped down into the producing horizons through input wells. These wells are located under the small steel boxes, which are located in straight lines throughout parts of the field. The water is forced through the reservoir rock and flushes the oil ahead of it toward recovery wells. The oil is then pumped from these wells to the surface. The predecessor of the Siggins flood operation was an accidental flood in the Main Consolidated Field (the Kraft Flood), in which water from above the producing zone broke through and traversed the oil sand, greatly increasing production. The operators recognized what had occurred and converted production wells to injection wells in order to augment the volume of accidental water getting into the producing formation. The first applied, commercially successful waterflood in Illinois was thus created. The first waterflood efforts at Siggins were not commercially successful, but other projects in the field were highly successful. Production increased from 100 barrels of oil per day in 1940 to 3,000 barrels per day in October of 1949. The field is still active because secondary oil recovery methods using waterflooding have been practiced here. Waterflooding has proven to be one of the most important conservation measures used in the oil industry. In Illinois alone, it accounted for about half of the 18 million barrels of oil produced last year.

Siggins Oil Mine Oil "mining" has been employed in a few projects in the United States, including here at Siggins Field. It is a technology that uses a central collection room into which lateral wells drain a petroleum reservoir. The idea is to drill horizontal wells in a spoke-like arrangement into the reservoir rock from a central location. This arrangement theoretically should drain a much larger area of oil-saturated reservoir rock when compared with conventional methods. A conventional well can only access the reservoir rock that is available by a vertical penetration. For example, if the reservoir is 4 feet thick, a conventional well can contact only 4 feet of rock. If you drill horizontally into the zone, however, a much greater area can be exposed and drained. To date, two oil-mining projects have been attempted in shallow oil reservoirs in Illinois. One is in the Colmar-Plymouth field in McDonnough County, and the other is located here at the Siggins Oil Field.

In 1987 Three Star Drilling and Production (of Sumner, Illinois) obtained a permit for the G.A.D. [Gravity Assisted Drainage] no.1 well in Sec. 12, T10N, R10E, Cumberland County, Illinois. The objective of the project was to construct an oil mine that consisted of a main shaft (the actual hole for which the permit was issued), a collection room, and horizontally drilled lateral collection wells in the Siggins sand (Pennsylvanian) of the Siggins Oil Field at a depth of approximately 450 feet (fig. 10). The project was designed to collect oil from 100 of the 2,100 acres that make up the field.

An 8-foot-square vertical shaft was blasted with dynamite and dug with jackhammers, picks, and shovels to a depth of 426 feet. At a depth of about 350 feet, a horizontal tunnel approximately 20 feet long was bored to the south of the main shaft into the oil reservoir rock. A circular work room 24 feet in diameter was excavated at the end of the tunnel. A cement floor was poured in the workroom and the tunnel to facilitate drainage and to direct fluid into the main shaft. Because the main shaft was deeper than the tunnel and workroom, it served as a collection area or oil sump. A fan (25 horse power) was installed to remove potentially explosive gas and provide fresh air.

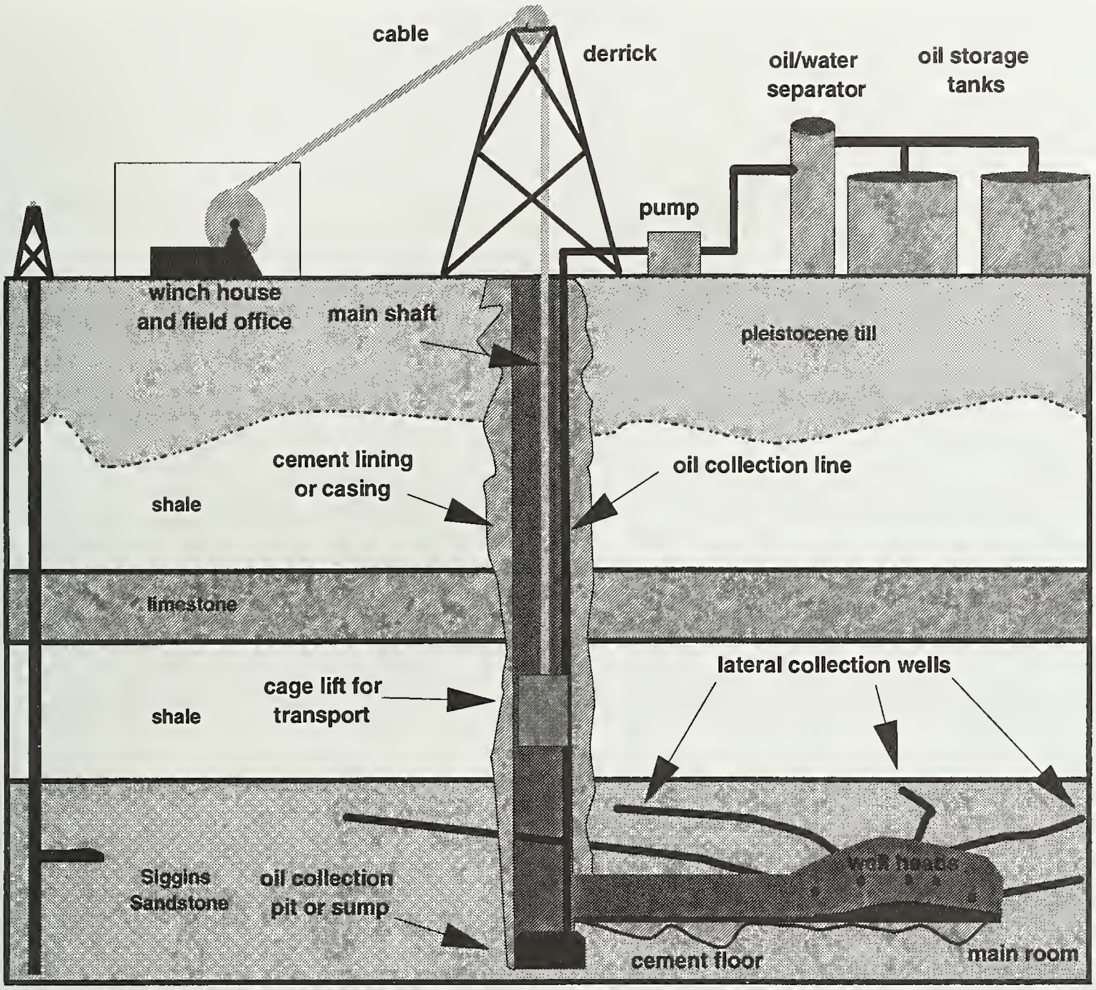


Figure 10 Diagram of the oil mine at Siggins Field. Small drawing of derrick at left is true to scale; main diagram and rock column are not to scale.

A total of 33 upward tilting lateral holes were drilled from the main room into the surrounding oil reservoir using a specialized electrohydrostatic drill (fig. 11). The cumulative horizontal penetration for the project was 34,780 feet of reservoir rock; individual holes ranged from 300 to 2,015 feet long. The holes were drilled using 10 foot sections (or joints) of drill pipe which screw together to make 1 long pipe (fig 12). The orientation and position of each hole was carefully monitored using surveys that showed compass orientation and elevation. A small attachment, called a bent sub, was used to control the angle of the drill bit to ensure that each hole was where it should be (that is, not too low in the reservoir where it would only produce water and not so high that it would not produce, fig. 13).

Once a hole was completed, an 8-foot-long section of pipe was cemented in place, and the rest of the hole was left open to drain the reservoir. Valves or spigots were attached to the pipe (fig. 14) to control the oil flow and direct fluids to a production line leading to the sump. From the sump, the oil was pumped to the surface where it was stored in tanks and later transported to the refinery. The project was completed early in 1991. Initial production from the wells was as much as 25 barrels of oil per day. Fluid that seeped through the walls and ceiling of the tunnel and work room produced a continuous, light rain of oil and water. These fluids collected on the floor and

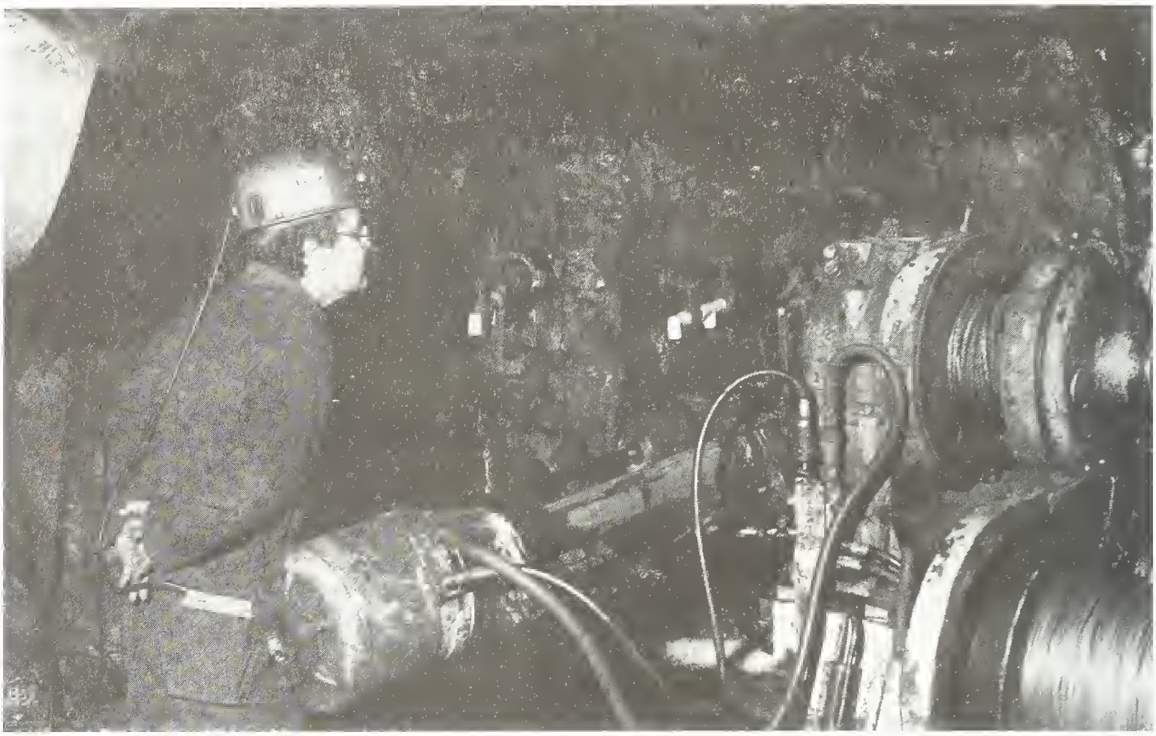


Figure 11 Electrohydrostatic drill was used to bore lateral collection wells and north wall of main room. Note spigots attatched to wall, air intake in upper corner, and oil and water seeping through walls. Photos by Joel Dexter

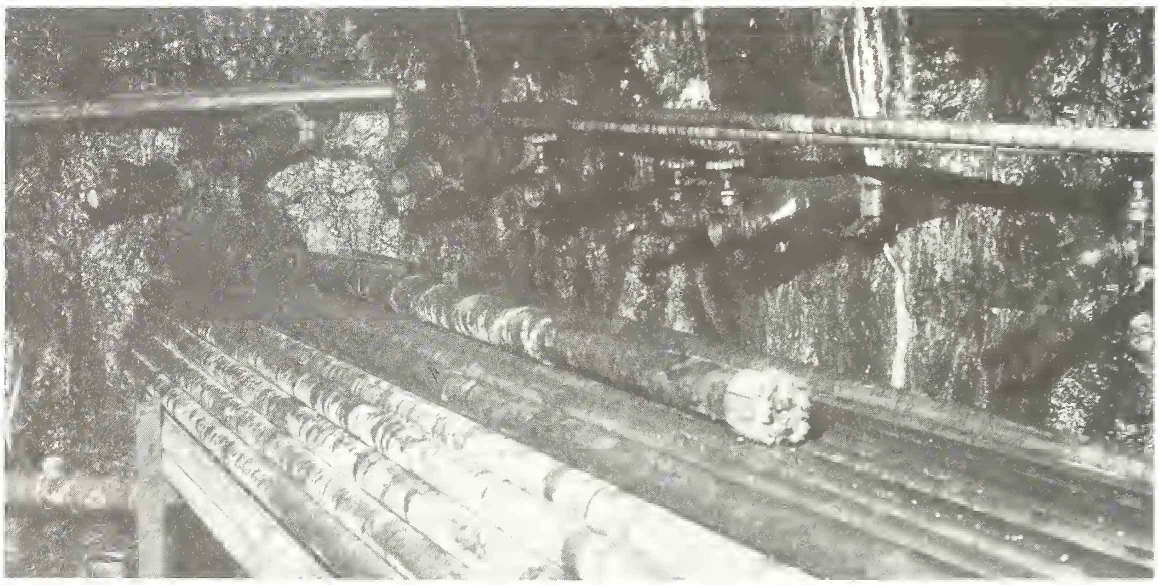


Figure 12 Drill pipe and bit stacked on pipe rack in front of north and east walls of main work room of the Siggins oil mine. Note fluid seepage and spigots on walls.

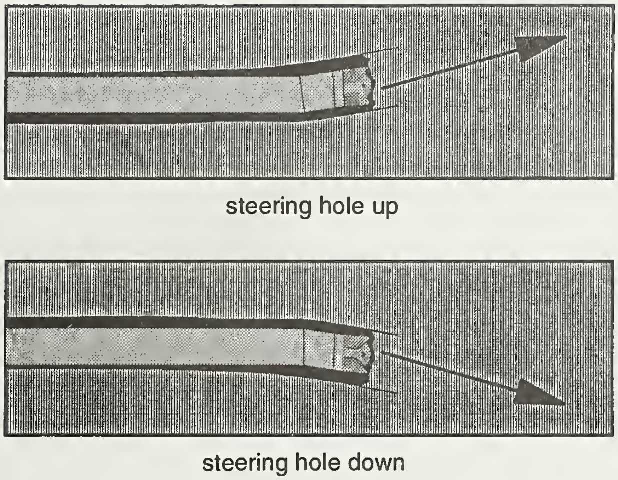
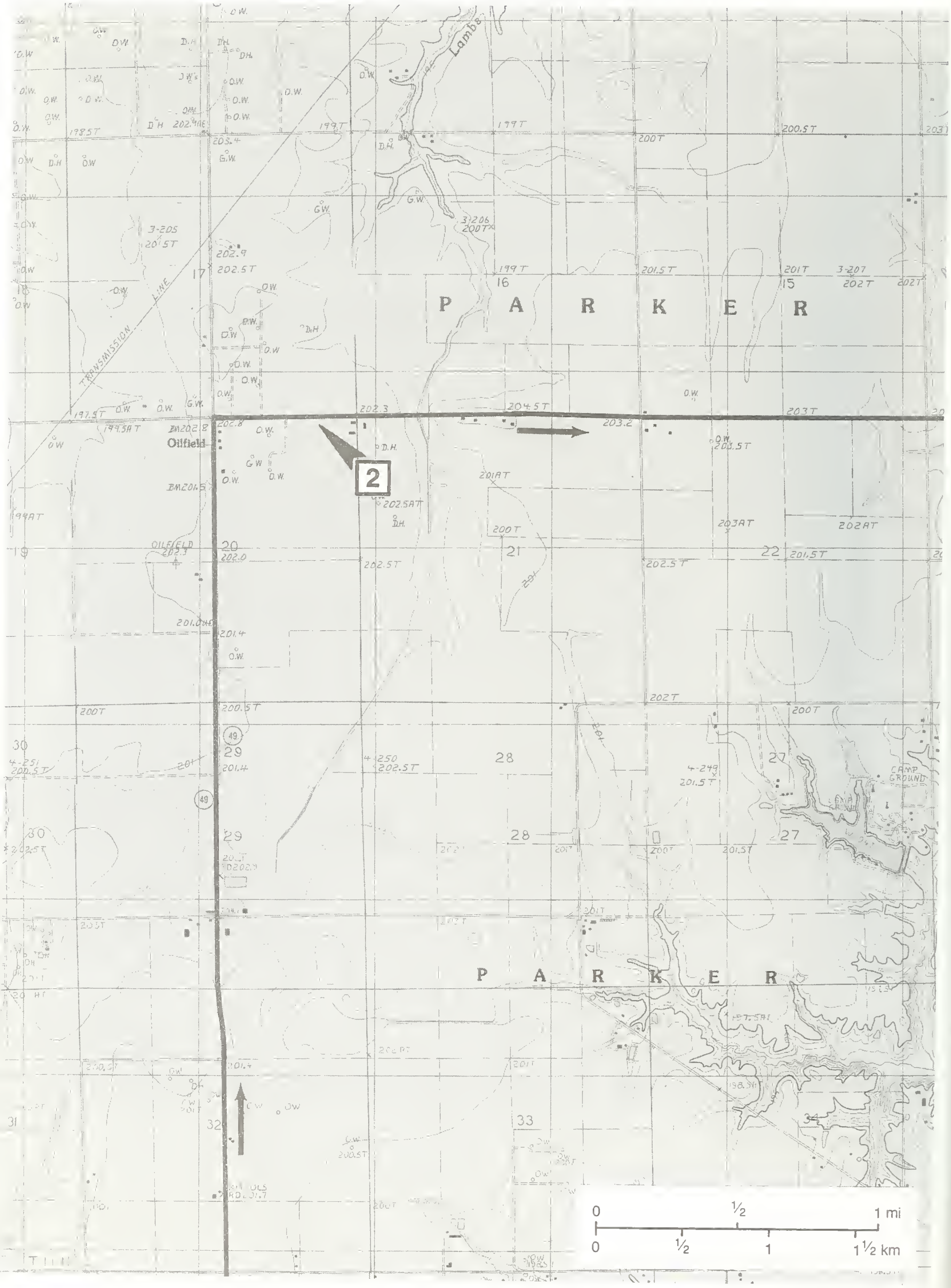


Figure 13 Diagram of directional drilling, which is controlled by a bent sub and turbine driven motor.

Figure 14 Close up of valves or spigots attached to lateral collection wells on east wall of main workroom of the Siggins oil mine. Note dripping oil and water on walls, beading on valves, and fresh rock surfaces (lighter color).

eventually drained into the sump, adding to the oil production. Total production from the project is unknown. The Department of Mines and Minerals currently lists the project as abandoned.


PARKER
PARKER
Oilfield
TRANSMISSION LINE
Lamb
2
CAMP GROUND
0 ½ 1 mi
0 ½ 1 1½ km

0.0	5.7	Leave STOP 1 and CONTINUE AHEAD (north).
0.2	5.9	STOP: 1-way at the T-intersection. TURN RIGHT (east) onto the unmarked road.
0.35	6.25	Crossing bridge on Ranger Creek.
0.15	6.4	STOP: 1-way at the T-intersection. TURN LEFT (north) onto the unmarked road. After making left turn, the road turns immediately to the right.
0.3	6.7	STOP: 1-way at the T-intersection. TURN RIGHT (southeast) onto the unmarked road.
0.15	6.85	Road CURVES TO THE LEFT.
0.2	7.05	CONTINUE AHEAD (east) at T-intersection from the right. .
0.25	7.3	STOP: 1-way at the T-intersection. TURN LEFT (north) from 1240N to 000E.

LAND SURVEY
Note: For a distance of approximately 0.1 mile the field trip route is along the boundary between lands surveyed from the Second Principal Meridian (2nd P.M) in Indiana and the Third Principal Meridian (3rd P.M.) in Illinois.

In 1804, initial surveying from the 2nd P.M (fig. 15) was carried west of Vincennes, Indiana. This survey became the basis for surveying about 10 percent of what is now eastern Illinois. Because the western boundary of this tract had not been established with certainty, it was decided in 1805 to designate the 3rd P.M. as beginning at the mouth of the Ohio river and extending northward, to facilitate surveying new land cessions. By late 1805 a base line had been run due east to the Wabash River and due west to the Mississippi River from the 3rd P.M. During March 1806, surveying commenced northward on both sides of the 3rd P.M. Sometime after the selection of an initial point from which to establish a base line and from which the surveys were to be laid out, the base line apparently was arbitrarily moved north 36 miles, where it roughly coincides with the base line of the 2nd P.M.

The township and range system permits the accurate identification of most parcels of land in Illinois to facilitate the sale and transfer of public and private lands. In the early 1800's, each normal township was divided to the best of the surveyor's ability into 36 sections, each of which was 1 mile square and contained 640 acres.

Township and range lines in figure 16 do not form a perfect rectangular grid over the state because of the use of different baselines and principal meridians and because minor offsets were necessary to compensate for the Earth's curvature. The surveying corrections producing the minor offsets were usually made at regular intervals of about 30 miles. Figure 16 shows what happened when surveying from the 2nd P.M. met surveying from the 3rd P.M. From Iroquois County south to White County, only narrow partial townships could be made where the two surveys met. These partial townships are all located in R. 11 E. and, in most places, are less than one section wide (see route map).

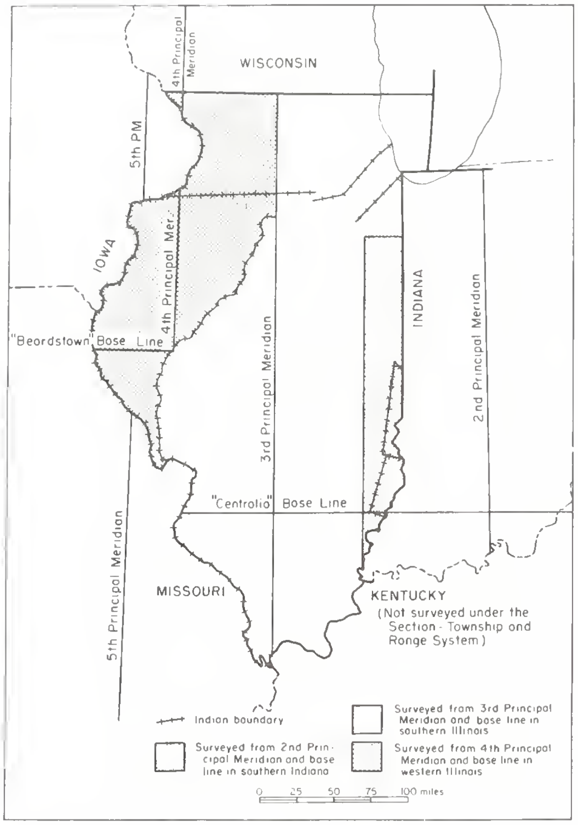


Figure 15 Principal meridians and base lines of Illinois and surrounding states (Cote 1978).

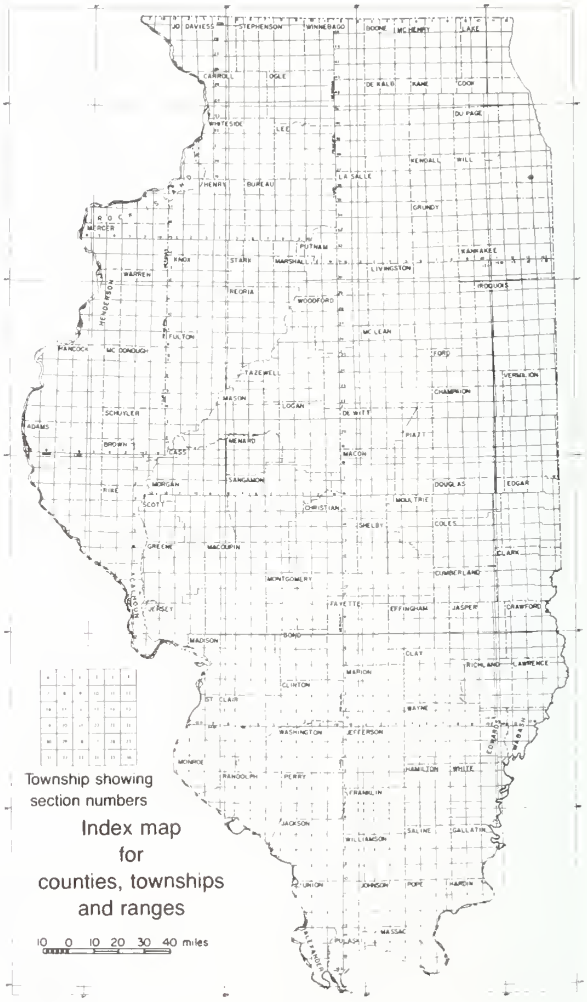


Figure 16 Index map (Cote 1978).

0.1	7.4	CAUTION: TURN RIGHT (east) at T-intersection (1250N and 000E). When you make the turn, you are leaving the geographic area designated as Siggins Oil Field.
1.0	8.4	CAUTION: CONTINUE AHEAD (east) at crossroad (1250N and 100E).
0.2	8.6	CONTINUE AHEAD (east) at T-intersection from the right.
0.25	8.85	STOP: 2-way stop at the intersection of 1250N and SR 49 (150E). TURN LEFT (north) onto SR 49. Notice that the topography along SR 49 north of Casey is very flat, you are travelling across the Illinoian till plain.
2.25	11.1	The road takes a slight CURVE TO THE LEFT and cuts between a large hill. This may be a dune feature developed on top of the Illinois plain.
1.05	12.15	To the northwest is a good view of the tree-covered ridge that represents the Shelbyville Moraine.

0.85	13.0	Approaching the hamlet of Oilfield. There is a nice view of the Shelbyville moraine to the northwest.
0.3	13.3	Entering Oilfield. To the left, there is a battery of oil tanks and at least five visible pump jacks in the field. This area was once very productive. We will discuss its history at Stop 2. PREPARE TO TURN RIGHT.
0.1	13.4	TURN RIGHT (east) at the intersection (1700N and 150E). When you make the right turn, you can see a large battery of tanks and numerous pump jacks in the fields on the north and south sides of the road. The Shelbyville Moraine trends from the southwest to the northeast. As you scan the horizon towards the north you can see a total picture of the length and extent of the moraine in this area.
0.35	13.75	Pull over and park on right side of road.

STOP 2 We'll view the Shelbyville Moraine and discuss the Illinois Till Plain and Westfield Oil Field (SE SE SE, Sec. 17, T11N, R14W, 2nd P.M., Clark County; Westfield East 7.5-Minute Quadrangle [39087D8]).

Shelbyville Moraine The prominent ridge 3 miles to the north and northwest is the Shelbyville Moraine. From this vantage point on the Illinoian Till Plain, the moraine looks more impressive than it does close up because outwash deposits in front of the moraine have reduced its steepness.

The Shelbyville Morainic System is several miles wide and consists of three broad ridges formed when Woodfordian glaciers reached their southernmost advance during Wisconsinan time nearly 20,000 years ago. The outermost ridge that is visible from here is the Westfield Moraine. About a mile to the north of the Westfield is the Nevins Moraine, which lies at about the same elevation as the Westfield. The Paris Moraine is about 1.5 miles north of the Nevins.

The Crest of the Westfield Moraine is from 720 to 760 feet above mean sea level. This moraine rises about 120 feet above where we are standing now. The Westfield Moraine was formed when the front of the Shelbyville glacier stood just to the north. The front of the ice mass melted about as fast as new ice advanced to the glacier's terminus where it dropped a load of rock debris as it melted. Thus, the glacier was acting as a huge natural conveyor belt, carrying rock materials into this area from the north. The formation of a prominent ridge, such as the Westfield Moraine, indicates that the ice front stood in this general area for a considerable time. Scattered along the crest of the moraine are small knobs of glacial debris known as kames.

Illinoian Till Plain We will be traveling across the older glacial deposits of the Illinoian Till Plain for the entire field trip. Although the general upland surface of the Illinoian Till Plain is relatively flat, it has been deeply dissected by streams that cut valleys during the 175,000 years since the Illinoian glacier melted. Scattered across this upland surface are low kames.

Early Petroleum Exploration We are currently near the southeast edge of the Westfield Oil Field. It is one of the oldest in Illinois and was discovered in 1904. A historical marker located to the northwest near Westfield, however, indicates that the first drilling in this area was during the 1860s. It was not successful at that time, and it wasn't until 1904 before the search for oil commenced again. A hole was drilled near the southwest corner of section 17, about a mile west of our current location. The well produced gas, but so little oil was found that the well was completed as a gas well. The first oil was produced in October 1904 from a well on the J. S. Phillips farm here in the NE, Sec. 18. By 1907, drilling in this area had nearly outlined the field, and the quest for deeper oil zones began in 1908. By 1909, several hundred wells had been completed above a depth of about 900 feet. Imagine the activity in this township during April 1909, when 39 wells were completed. All of the wells were producers, with a combined average production of 32.5 barrels of oil per day. Oil was found in 1910 on the K. and S. Young farm in Sec. 17 in the Ordovician between 2,300 and 2,400 feet deep. By that time, the production of the wells in this field ranged from about 5 to 700 barrels per day; the average was approximately 38 barrels per day. From 1904 through 1990, 2,150 wells were completed in this field. About 500 were active producers in 1990.

Westfield Oil Field The Westfield Oil Field is developed in a dome situated near the crest of the La Salle Anticlinal Belt and covers more than 15 square miles. Production has come from 25 feet of Pennsylvanian Sandstone at a depth of 280 feet, from Mississippian Westfield Limestone at a depth of 335 feet, from 18 feet of Mississippian Carper Sandstone at a depth of 875 feet, and from 40 feet of Ordovician Trenton Limestone at a depth of 2,300 feet (fig. 2).

0.0	13.75	Leave STOP 2 and CONTINUE AHEAD (east).
0.35	14.1	Crossing bridge over Lamb's Branch Creek.
0.15	14.25	The road cuts across a small hill. This topographic expression may be a dune-type feature of the Illinois till plain.
0.65	14.9	CAUTION: CONTINUE AHEAD (east) at crossroad (1700N and 300E). The unique structure on the northeast corner of the intersection is a local polling place. Notice the two doors, one for Republicans and one for Democrats. It is a one-room polling house.
1.01	5.9	CAUTION: CONTINUE AHEAD (east) at intersection (1700N and 400E). The road to the right leads to the Forest Campground.
0.3	16.2	Crossing bridge over Lindsey Branch. Notice that the road has descended into the valley cut by Lindsey Branch.
0.2	16.4	CONTINUE AHEAD (east) at T-intersection from the right (1700N and 450E).
0.1	16.5	Crossing tributary to Lindsey Branch. NOTE: The topography is gently undulating along this section of the road This is caused mainly by erosion from the various creeks that cut into the Illinoian till plain.
1.0	17.5	Road begins descent into valley of the North Fork of the Embarras River.
0.3	17.8	CONTINUE AHEAD (east) at T-intersection from the left 1700N and 590E). You will cross the bridge of the North Fork of the Embarras River. The bed of this creek is very sandy.
0.2	18.0	Road ascends hill. You are leaving the valley cut by the Embarras.
0.2	18.2	Road flattens out, once again you are traversing the Illinoian till plain.
0.65	18.85	STOP: 2-way at intersection (1700N and 700E). TURN RIGHT (south) onto 700E.


Lindsay
Branch
NORTH FORK
MARTINSVILLE
Bluegrass
Cr
3
NORTH FORK
EMBARRAS
RIVER
Branch
PIPELINE
CAMPGROUND
Br
Kettering
Martinsville
0
½
1 mi
0
½
1
1½ km

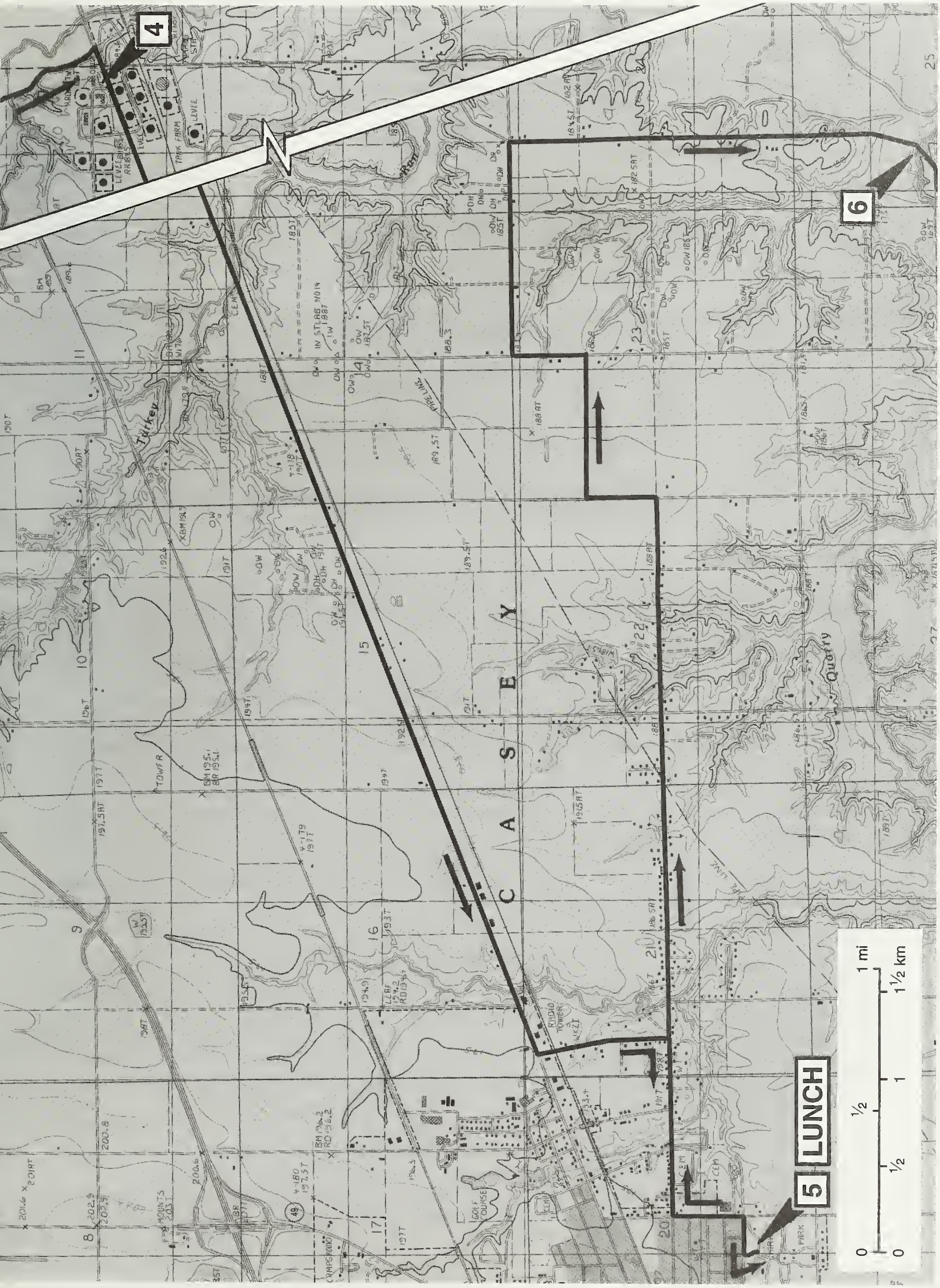
0.95	19.8	CONTINUE AHEAD (south) at crossroad (1600N and 700E) and PREPARE TO MAKE STOP.
0.2	20.0	Pull over and park along right side (west) of road.

STOP 3 We'll view and discuss an exposure of Vandalia Till along the south bank of Bluegrass Creek (NE NW SW NW, Sec. 29, T11N, R13W, 2nd P.M., Clark County; Westfield East 7.5-Minute Quadrangle [39087D8]).

Vandalia Till This exposure typifies the complexities in the glacial drift that underlies much of the field trip area. Here the upper part of the Vandalia Till is exposed, but it is less uniform than what we will be seeing later at stop 6. This exposure is characterized by abundant irregular sand lenses, silt inclusions and beds, and till fractures, some of which are filled with sand. The pebbly till is overlain by a sloping sand and gravel bed on the left end of the exposure. The sand and gravel extends downward to fill a vertical fracture in the till. Water percolates more readily through the sand and gravel than through the till, allowing the water to drain away and air to enter. This process promotes the precipitation of iron, manganese, and other minerals. The sand and gravel is overlain by brownish and yellowish silts and interbedded silt and till.

On the right end of the exposure, the pebbly Vandalia Till is characterized by several nearly vertical fractures, some of which are filled with sand and gravel from the overlying irregularly shaped bed of sand and gravel. Above the sand and gravel are interbedded gravels, silts, and till. The fractures are thought to have been formed by a combination of processes common to areas beneath and near the ice margin, as well as postglacial processes. These processes include loading and unloading by glacial ice, differential compaction of the underlying materials, desiccation (drying), weathering, and ice-wedge formation. In this last process, narrow cracks in the till result from thermal contraction at the ground surface. The cracks may then fill with ice or hoarfrost, widening the cracks and allowing sediment to fall into them. In addition glacial sub-ice (below) and near-ice (in front of) conditions can also account for the overlying interbedded gravels and silts. The gravels may have been deposited by meltwater streams carrying finer silts and clays farther away, whereas the silts settled out in quieter pools of meltwater. The thin beds of till probably resulted from flows of muddy, debris-laden ice off the front of the glacier. The distorted upper contacts of sand and gravel bodies such as the one seen here may have resulted from deformation of the soft, saturated sediment by overlying moving ice.

0.0	20.0	Leave STOP 3 and CONTINUE AHEAD (south) on 700E.
0.1	20.1	Crossing bridge over Bluegrass Creek.
0.7	20.8	CONTINUE AHEAD (south) at crossroad (1500N and 700E).
0.35	21.15	CONTINUE AHEAD. Intersection of entrance/exit ramps for I-70.
0.15	21.3	Crossing bridge over I-70. CONTINUE AHEAD.
0.15	21.45	Intersection of entrance/exit ramps for I-70. CONTINUE AHEAD.
0.35	21.8	CONTINUE AHEAD (south) at T-intersection from the right (1400N).
0.15	21.95	Road CURVES RIGHT. The USDA County Office for Clark County and the Soil and Conservation District is on the right side of the road.
0.15	22.1	CONTINUE AHEAD at T-intersection from the right, Mill Street.


4
5
LUNCH
6
C A S E Y
Turkey
Quarry
0 ½ 1 mi
0 ½ 1 1½ km

0.2	22.3	Prepare to STOP.
0.1	22.4	STOP: 2-way at the intersection of 1330N Route 40 (1330N and 680E). TURN RIGHT (west). CAUTION: Traffic moving extremely fast.
0.2	22.6	CONTINUE AHEAD (west) at crossroad (1320N and 660E).
0.55	23.15	Crossing bridge over North Fork of the Embarras River.
0.35	23.5	Prepare to turn LEFT.
0.1	23.6	TURN LEFT: (southeast) at the intersection with County Route 23.
0.4	24.0	CAUTION: Road curves left then immediately right in an "S" curve.
0.15	24.15	View of Marathon Tank Farm, to the right. PREPARE TO TURN RIGHT.
0.15	24.3	STOP: 1-way at intersection (1250N and 610E). TURN RIGHT (southwest) onto 1250N.
0.1	24.4	CAUTION: TURN RIGHT and enter parking lot of Marathon – park vehicles where leaders direct you to park.

STOP 4 We'll stop at the Marathon Pipe Line Company and discuss the history of tank farms, the pipeline system, and the products stored at and transported from this location (NE NE SE, Sec. 12, T10N, R14W, 2nd P.M., Clark County; Casey 7.5-Minute Quadrangle [39087C8]).

Marathon Pipe Line Company When crude oil was first recovered from the ground in the mid-1800s, it was transported by rail car, tank wagon, or frequently in wagon-loads of whiskey barrels. The 42-gallon-barrel measurement persists to this day in the oil industry. It wasn't long before pipelines were used for quicker, cheaper, and safer transport of crude oil and, later, the finished products. Early pipelines were constructed from threaded pipe, which was hauled by mule teams and screwed together by hand using large pipe tongs. In the 1920s, welded joints were introduced, which greatly improved both the speed and safety of construction, as well as the integrity of the pipeline. Tank farms were built along pipelines for temporary storage of oil products as they were shipped.

Beginning in 1905, the Ohio Oil Company (which would one day become Marathon) began to purchase and construct pipelines and tank farms in Illinois. They needed the lines to serve the booming oil industry in south-central Illinois. Ohio Oil quickly erected more than 1,000 oil tanks (many having a capacity of 35,000 bbl., or 1,470,000 gallons) at Martinsville, Casey, and Stoy. At Martinsville alone, there were more than 300 tanks, representing about 10 million bbl. (420 million gallons) of storage capacity, connected to an ever-growing complex of pipelines. By the 1920s, the Illinois Pipe Line Company (as it was then called) could move 70,000 bbl. (2.9 million gallons) of crude oil per day. Today, Marathon Pipe Line Company has more than 1,800 miles of active pipeline in Illinois—enough capacity to pump hundreds of thousands of barrels per day of crude and products. Marathon built many more miles of pipeline throughout the midwest, west, and gulf coast areas of the country.

As the Illinois oil boom gradually declined in the 1950s and 1960s, less storage space was needed. The size of the Martinsville Station decreased although most of the pipelines remained active. The tank dikes and depressions left from many of the old tanks can still be seen surrounding the station. The Martinsville Station today has the capacity to store more than 1 million bbl.

(43 million gallons) of crude oil and 923,000 bbl. (38 million gallons) of refined products. An average of 300,000 bbl. of crude and 55,000 bbl. of products is pumped through the station daily. The crude delivered to the Martinsville Station is not all Illinois crude; it comes from all over the world and is shipped to refineries in the north and east. The refined products originate from the Robinson (Illinois) refinery and the St. Louis area, and they are shipped to the north, south, and east. The Martinsville Station continues to be a vital link in the network of Marathon pipelines serving the United States.

0.0	24.4	STOP: Leave Stop 4 and TURN RIGHT (west) onto 1250N.
0.4	24.8	CONTINUE AHEAD (southwest) at crossroad of intersection (1220N and 550E).
0.6	25.4	Entering into a valley cut by Turkey Run Creek and crossing bridge.
0.45	25.85	CONTINUE AHEAD (southwest) at crossroad of intersection (1190N and 450E).
0.3	26.15	CONTINUE AHEAD (southwest) at T-intersection from the left (430E).
1.05	27.2	CONTINUE AHEAD (southwest) at T-intersection from the left (1140N and 330E).
0.3	27.5	CONTINUE AHEAD (southwest) at T-intersection from the right (1130N and 300E).
0.75	28.25	Crossing bridge over Quarry Branch.
0.05	28.30	CONTINUE AHEAD (southwest) at T-intersection from the right (1110N and 230E). PREPARE TO MAKE A LEFT TURN.
0.2	28.5	TURN LEFT (south) at T-intersection from the left (1100N and 210E).
0.05	28.55	CAUTION: Crossing single railroad tracks. Look both ways. Do not trust signal lights.
0.45	29.0	T-intersection (1050N and 210E). TURN RIGHT (west) onto 1050N.
0.1	29.1	City of Casey water tower and waste-water treatment facility on the left.
0.1	29.2	T-intersection from the right (1050N and 190E). CONTINUE straight ahead (west) on 1050N.
0.05	29.25	Crossing a tributary of Branch Creek.
0.05	29.3	Cemetery on the left.
0.05	29.35	CONTINUE AHEAD (west) at T-intersection from the right (1050N and 170E).
0.25	29.6	STOP: 4-way at the intersection (1050N and 150E). TURN LEFT (south). This is also Southeast 8th Street in Casey.
0.05	29.65	CONTINUE AHEAD (south) at East Adams Avenue intersection on the right.

0.05	29.7	CONTINUE AHEAD at East Jefferson Avenue intersection with East 8th street.
0.1	29.8	CONTINUE AHEAD at East Madison Avenue intersection on the right.
0.05	29.85	TURN RIGHT (west) on to East Monroe Avenue.
0.05	29.9	CONTINUE AHEAD (west) at intersection with Southeast 7th Street on the right.
0.05	29.95	TURN LEFT at the intersection of Southeast 6th Street and East Monroe Avenue. Enter Fairview Park and park vehicles in parking lot.

STOP 5 LUNCH, ARE YOU HUNGRY? We will be using the shelter to the immediate left next to the restroom facilities. NOTE: Shelters are on a first come, first serve basis. (Shelter: near NW NE SE SW, Sec. 20, T10N, R14W, 2nd P.M., Clark County; Casey 7.5-Minute Quadrangle [39087C8]).

0.0	29.95	Leave STOP 5 and proceed to park exit.
0.15	30.1	STOP: 2-way at park exit. TURN RIGHT (east) onto East Monroe Avenue.
0.05	30.15	CONTINUE AHEAD (east) at intersection with Southeast 7th Street. .
0.1	30.25	YIELD SIGN. Intersection with East Monroe Avenue and East 8th Street. TURN LEFT (north) onto East 8th Street.
0.15	30.4	CONTINUE AHEAD at intersection with East Jefferson Avenue.
0.05	30.45	CONTINUE AHEAD at intersection with East Adams Avenue.
0.05	30.5	STOP: 4-way intersection of East Washington Avenue and South 8th Street. (1050N and 150E). TURN RIGHT (east) onto 1050N.
0.1	30.6	Cemetery on the right.
0.1	30.7	CONTINUE AHEAD (east) at T-intersection from the left (1050N and170E).
0.15	30.85	CONTINUE AHEAD (east) at T-intersection from the left (1050N and 190E).
0.25	31.1	Crossing small ditch Culvert. CONTINUE AHEAD (east) at intersection from the left (1050N and 210E).
0.1	31.2	STOP: 4-way at intersection (1050N and 220E). CONTINUE AHEAD.
0.25	31.45	Crossing culvert with concrete abutments. CONTINUE AHEAD.
0.8	32.25	CAUTION: Crossroad (1050N and 330E). CONTINUE AHEAD on 1050N.
0.45	32.7	Road jogs slightly to the right.
0.3	33.0	STOP: 1-way at T-intersection (1050N and 400E). TURN LEFT (north).

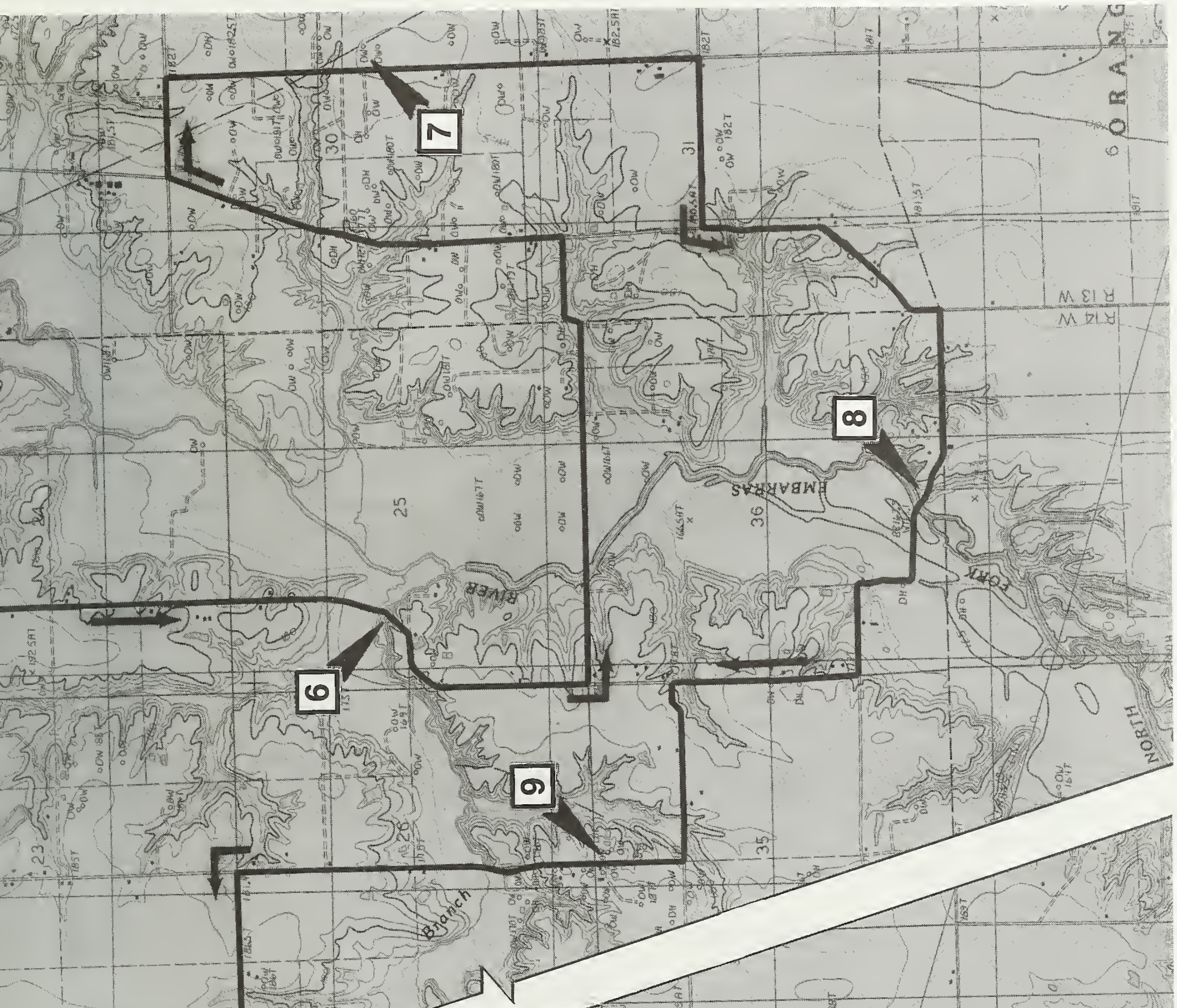
0.25	33.25	TURN RIGHT (east) at T-intersection from the right (1070N and 400E).
0.25	33.5	Pump jack to the right.
0.15	33.65	Pump jack to the right.
0.1	33.75	STOP: T-intersection with YIELD SIGN (1070N and 450E). TURN LEFT (north) onto 450E.
0.15	33.9	Oil tank battery on the left.
0.1	34.0	TURN RIGHT (east) at T-intersection from the right (1100N and 450E).
0.4	34.4	Pump jack on the left.
0.2	34.6	Oil tanks in field on the left.
0.15	34.75	STOP: Intersection (1100N and 530E). TURN RIGHT (south). Friendship United Methodist Church is on the northwest corner of the intersection. Numerous oil tanks are in this area.
0.65	35.4	Exposure of Vandalia till is in field on the left.
0.1	35.5	Tank batteries are on the left and right sides of road.
0.3	35.8	Tank batteries are on the left.
0.2	36.0	Road descends into the valley of Quarry Branch and curves slightly to the right.
0.15	36.15	Bridge crossing Quarry Branch. PREPARE TO MAKE STOP.
0.05	36.2	Pull over and park vehicles along right (west) side of road.

STOP 6 We'll view and discuss the exposure of Vandalia Till on right side of the road. It contains numerous glacial pebbles, many of which are striated (near center of SE SW NW, Sec. 25, T10N, R14W, 2nd P.M., Clark County; Casey 7.5-Minute Quadrangle [39087C8]).

This is an easily accessible exposure of the Vandalia Till Member of Illinoian age. The Vandalia is the uppermost till under the loess across much of south-central Illinois. It is a sandy, silty, stony till, and it is compact and hard.

Here the Modern Soil is developed in thin loess on top of the Vandalia Till. The Modern Soil is a term used for any soil profile that is developed immediately under the existing land surface. The Modern Soil profile developed here is divided into two layers, or horizons. The upper horizon consists of a dark gray-brown soil. The lower horizon is yellowish brown and has manganese streaks. It is thought to be partly a relic of the Sangamon Soil (see Pleistocene Glaciations in Illinois in the supplemental reading). The till becomes more pinkish gray downward, with irregular yellowish gray masses scattered throughout the upper 2 or more feet. Pebbles and cobbles of highly variable lithologies are abundant in the till; some of them exhibit signs of glaciation such as faceting (flattening on one or more sides) and striations (scratches) from being held frozen in the base of the ice and scraped across bedrock of other rocks. With a little searching, you can find good representative specimens of the three major rock groups: sedimentary, igneous, and metamorphic.

0.0	36.2	Leave Stop 6 and CONTINUE AHEAD (south).
0.05	36.25	Road takes SHARP TURN TO THE RIGHT.
0.05	36.3	Road turns back to the left.
0.1	36.4	Note the sign on right side of road: "No Dumping." This is one of the environmental problems we all face, the indiscriminate dumping of household garbage.
0.5	36.9	TURN LEFT (east) at T-intersection from left (900N and 500E).
0.1	37.0	Descending into the valley of the North Fork of the Embarras River.
0.1	37.1	Crossing bridge over the North Fork of Embarras River. There is an exposure of Vandalia till on right in the cutbank of the river.
0.25	37.35	Notice the oil field structure over what is probably an injection well. You can see pump jacks in the field and along the tree line to the right (south) and one pump jack to the left. We are in the Martinsville Oil Field.
0.25	37.6	Oil tank battery to the left. There is also an exposure of typical Vandalia Till in the cutbank of the road.
0.25	37.85	Road takes a bend to the left then to the right (S curve).
0.1	37.95	Deeply eroded gully containing exposure of Vandalia till is on the left side of road. There is approximately 1 to 4 feet of weathered till overlying 1 to 2 feet of exposed diamicton.
0.1	38.05	STOP: T-intersection (900N and 630E). TURN LEFT (north) on 630E. Note the oil tank battery straight ahead on the hill. There is a pipe coming down the hill so that a tanker truck can fill up with crude oil from the tank battery.
0.25	38.3	Several oil tank batteries and pump jacks are on the right.
0.15	38.45	Pump jacks to the left in the middle of the field.
0.15	38.6	CONTINUE AHEAD (north) at T-intersection from right (930N and 630E). You can see several tank batteries and pump jacks along the sides of the road.
0.7	39.3	STOP: Crossroad of intersection (1000N and 640E). TURN RIGHT (east) onto 1000N.
0.10	39.4	Crossing a buried pipeline that runs northwest to southeast.
0.10	39.5	TURN RIGHT (south) at the T-intersection onto 670E.
0.90	40.4	Pull over and park vehicles along right side (west) of road.


6
7
8
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EMBARRAS
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STOP 7 We'll discuss the Martinsville Oil Field (SW NW NE SE, Sec. 30, T10N, R13W, 2nd P.M., Clark County; Casey 7.5-Minute Quadrangle [39087C8]).

Martinsville Oil Field Prospecting for oil and gas in Clark County began in 1866 when the Clark County Petroleum and Mining Company was organized and established its headquarters in Marshall, Illinois. Natural gas seeps in Parker Township (T11N, R14W) led the company to believe that commercial quantities of oil and gas could be found in this area. They did not prosper, and the failure has been attributed to their inability to prevent water from getting into the well. Water is heavier than oil or gas, and it would fill the hole. This would cause drilling problems and prevent hydrocarbons with low pressures from entering the hole.

A second period of exploration began in 1904 and continued through 1910. Improved drilling and well completion methods were used, and numerous profitable oil and gas pools were discovered in the area. It was during this second period of drilling, in 1907, that the Martinsville Oil Field was discovered. Production was established from a well with a name and location lost in history. As the field was developed, production was established from the following strata: a shallow sandstone (Pennsylvanian) at 250 feet, the Casey Sandstone (Pennsylvanian), the St. Louis Limestone (Mississippian), the Carper Sandstone (Mississippian), Devonian limestones, and the Trenton Limestone (Ordovician). The deepest production in the field is from the Trenton Limestone at a depth of approximately 2,700 feet. Oil in the field is trapped in a dome that can be mapped on all of producing horizons. Since its discovery, about 450 oil wells have been drilled in the field. The field encompasses approximately 2,700 acres. The majority of these wells produce from the Pennsylvanian Casey Sandstone at a depth of approximately 500 feet. Although this field first produced oil almost 90 years ago, it still produces 2,000 to 3,000 barrels of oil per month. Production has historically been grouped with other Clark County fields that were discovered during the early 1900's so an exact cumulative production figure for the field is unavailable. Cumulative oil production for the Clark County Division, however, is about 90 million barrels, and production from the Martinsville field is probably on the order of several million barrels.

0.0	40.4	Leave STOP 7 and CONTINUE AHEAD (south).
0.65	41.05	TURN RIGHT (west) at intersection (850N and 670E).
0.5	41.55	TURN LEFT (south) at intersection (850N and 620E).
0.05	41.6	Good exposures of Vandalia till in ravine walls to the right in the pasture land.
0.3	41.9	Road curves to the right.
0.1	42.0	Notice the significant erosion in field to left and exposures of Vandalia till to the right.
0.3	42.3	TURN RIGHT (west) at intersection (800N and 600E).
0.4	42.7	Road curves to right and then immediately left.
0.05	42.75	Road descends into the valley of the North Fork of the Embarras River.
0.1	42.85	Crossing bridge over the Embarras. PREPARE TO STOP. Pull over and park vehicle along right side of road. DO NOT part on bridge.

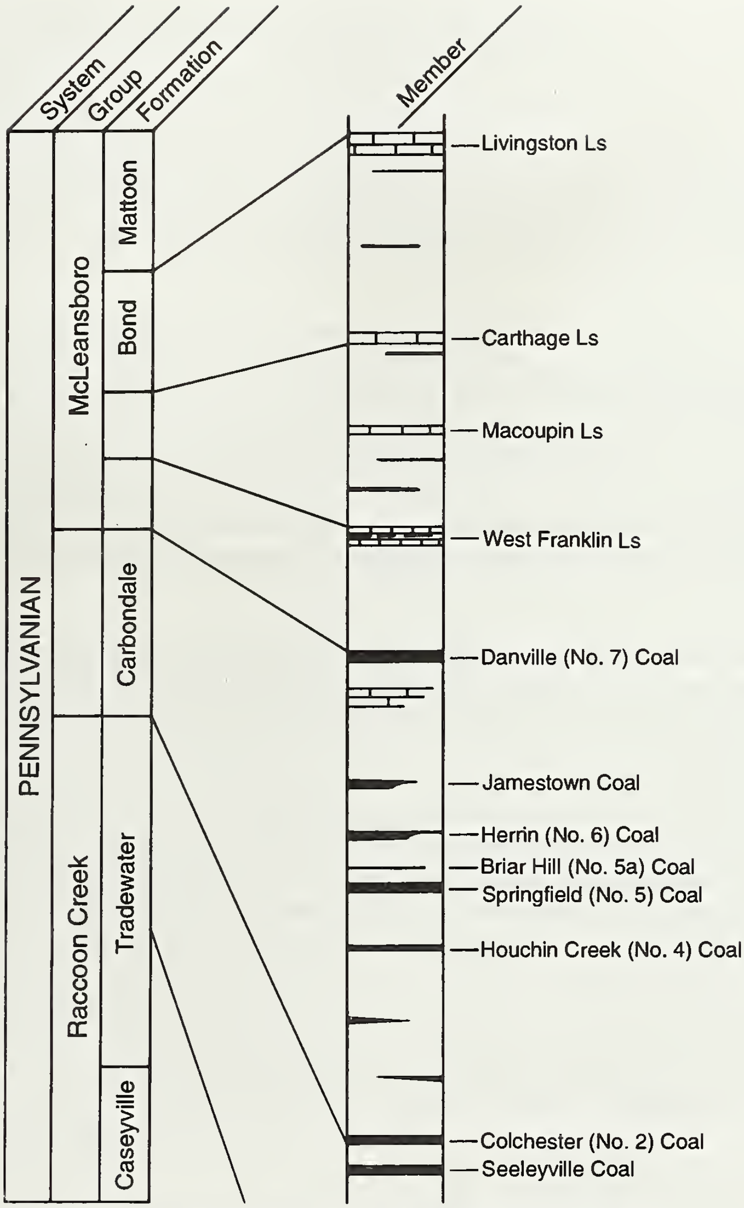

Figure 17 Simplified diagram of the stratigraphic section discussed, showing its relation to the Pennsylvanian System of Illinois (Not drawn to scale).

STOP 8 We'll discuss the exposure of Pennsylvanian strata of the Patoka Formation along the east bank of the Embarras and collect fossils (NW SW SW SE, Sec. 36, T10N, R14W, 2nd P.M., Clark County; Casey 7.5-Minute Quadrangle [39087C8]).

The section exposed at this stop lies somewhere in the Patoka Formation below the Shoal Creek Limestone Member of the Bond Formation. Stratigraphic information from nearby wells and ISGS Circular 380 (Clegg 1965) indicates the exposed section is about 120 feet above the Danville Coal and is at or near the base of the Macoupin Limestone Member of the Patoka Formation (fig. 17). The Macoupin Limestone is not as well developed here as it is in other parts of Clark County.

At this stop, we will be examining strata that is typical of most of the Pennsylvanian strata in the trip area. Unlike the thicker Livingston Limestone we will see at stop 10, most of the Pennsylvanian is made up of shales, claystones, and sandstone such as is found in this outcrop we will be examining. In addition, the Pennsylvanian is characterized by a repetitive sequence of strata called cyclothems (see figure in supplemental reading on the Pennsylvanian). Here we can see at least one cyclothem and parts of another. Although no one cyclothem always contains the exact sequence illustrated in the figure of an ideal cyclothem (in the supplemental reading), we can see some of the typical units: a claystone overlain by limestone, black shale, more limestone, gray shale, and finally a sandstone.

The cyclothem described in the supplementary reading on the Pennsylvanian resulted from the ongoing retreat and advance of shallow seas across the area. In particular, the advance of the sea is marked by the limestone and black shale parts of the cyclothem. The black shale represents the maximum transgression (coverage) of the sea waters. The limestones represent the periods of shallower and more oxygenated waters in the marine portion of this cycle. Here, as is the case in a number of the upper Pennsylvanian cyclothems, the initial transgression is represented by the thin limestone below the black shale, the maximum transgression by the black shale, and the retreat of the sea by the overlying limestone that grades into the lower fossiliferous shale. The retreat is marked by the influx of muds into the area.

We will also be collecting various marine invertebrates found here, especially those in the black shale and associated limestones and limy shale. We should be able to find crinoid stems, brachiopods, bivalves, gastropods, bryozoans, and cephalopods among the abundant fossil fauna in these marine rocks.

Because of the erodibility of the shales and mudstones, we will not see many exposures of Pennsylvanian strata in the trip area. Most outcrops are slumped and covered with colluvium from the overlying Illinoian till and vegetation. Active erosion along the river provides a fresh exposure at this stop, and you will have the opportunity to see these units. Because of slumping at even this exposure, we will not see the entirety of what is present.

A general description of the exposed section is given below (taken from ISGS field notes).

Sandstone, medium bedded, micaceous, clayey, brownish tan to red, abundant plant remains, approximately 2 feet plus under roots of trees

Shale, medium to light gray, fissile, very weathered, contains iron siderite concretions, grades into greenish gray shale below, 8 feet

Shale, greenish gray, calcareous, fossiliferous, with abundant crinoid stems near the base, 1 foot 6 inches

Limestone, bluish gray, very shaly (argillaceous), quite fossiliferous, weathers a reddish gray, 4 inches

Shale, greenish gray, very limy, fossiliferous, 1.5 inches

Shale, Black, well laminated, very fossiliferous with brachiopods, gastropods, bivalves, cephalopods and other marine fossils, roughly 1 foot

Limestone, very argillaceous, mottled, quite fossiliferous, few inches.

Claystone, greenish gray, poorly exposed, mostly covered, 3 to 4 feet

Shale, dark brown, sandy, micaceous, 1 to 2 feet grades to thin-bedded, dirty micaceous sandstone

0.0	42.85	Leave STOP 8 and CONTINUE AHEAD (west).
0.25	43.1	Road makes a 90 degree turn to the right.
0.1	43.2	Road makes a 90 degree turn to the left.
0.3	43.5	TURN RIGHT (north) at T-intersection from the right (830N and 500E).
0.5	44.0	TURN LEFT (west) at T-Intersection from the left (880N and 500E).
0.05	44.05	Road makes an S curve.
0.45	44.5	TURN RIGHT (north) at T-intersection from the right (870N and 450E).
0.20	44.7	Pull over and park vehicles on right side (east) of road.

STOP 9 We'll view and discuss the abandoned central power plant, R.E. Stratton Lease (NW NW NW NE, Sec. 35, T10N, R14W, 2nd P.M., Clark County; Casey 7.5-Minute Quadrangle [39087C8]).

Although this central power plant is no longer operating, you can still learn from it about some of the early equipment used to recover oil. There is at least one central power plant similar to this one still operating in Illinois. It is operated by Tohill Oil Operators and is located in Crawford County, north of Flat Rock (near the SE corner of Sec. 30, T6N, R11W). A detailed description of the Tohill facility is described in the "Guide to the Geology of the Lawrenceville Area" (ISGS Field Trip Guidebook 1993D).

During the first decade of this century, there were few legal limitations on spacing and drilling procedures for oil wells. Because there was no electricity to power individual pump jacks, holes were drilled close together so that a number of wells could be operated from a single power source. Although as many as 40 wells might use one power house through a connecting system of shackle-rods, the usual number was from 10 to 25. Shackle-rods are solid steel rods with a loop or shackle attached to one end; the loops allow for easier connections to the bandwheel. The power house for many of the central production units generally contained an engine powered by natural gas. The gas for the engine came from the wells on the lease or was purchased from a neighboring lease or a nearby pipeline.

A central power plant, such as this one, consists of an engine that powers a large-diameter, horizontal bandwheel having shackle-rod lines attached to its circumference. The bandwheel is eccentric. As the wheel revolves on a vertical axle, a reciprocating motion (push-pull) is imparted to the shackle-rods. The engine is connected to the bandwheel by a long, very large, flat belt. The shackle-rods radiate from the bandwheel in various directions and are connected to pump jacks at various well sites. The shackle-rods are generally about 25 feet long and 3/4 to 1 inch in diameter. The shackle-rod lines are supported on metal posts (usually made of old 2-inch line pipe) topped with wooden guide blocks that are lubricated with a heavy grease. These older central power plants could operate wells from a distance of at least 1 mile. The Tohill central power plant is operating one of the wells at a distance of 0.75 mile. The rods are pulled toward the power house by the pull-wheel, but the return movement of the rods is at least partially a result of gravitational pull on the weight of the sucker rod that extends down into the well.

0.0	44.7	Leave Stop 9 and CONTINUE AHEAD (north) on 450E.
0.25	44.95	In the gully to left is what appears to be another old engine pump house.

0.1	45.05	Crossing bridge over the Quarry Branch Creek.
0.7	45.75	TURN LEFT (west) at T-intersection from the left (1000N and 450E). CAUTION: The intersection is at the bottom of a low in an old drainage feature and the traffic from the left may not be able to see you.
0.35	46.1	Crossing creek. To your left is a good exposure of Vandalia till, on the east side of the creek.
0.05	46.15	Oil tank battery on the left side of road.
1.1	47.25	CAUTION: CONTINUE AHEAD (west) at crossroad (1000N and 400E).
0.2	47.45	Crossing bridge over a tributary to Quarry Branch Creek.
0.15	47.6	Good exposure of Vandalia Till along the ditch on the right side of the road. Numerous pebbles are present.
0.1	47.7	Crossing bridge over tributary of Quarry Branch.
0.3	48.0	STOP: T-intersection (1000N and 330E). TURN LEFT (south) onto 330N.
0.2	48.2	Crossing bridge over Quarry Branch Creek.
0.45	48.65	TURN RIGHT (west) at T-Intersection (930N and 330E).
0.65	49.3	Crossing Quarry Branch Creek. Notice the old metal guardrails on the bridge.
0.2	49.5	Road makes a large S curve to the right 45 degrees and then back to the left 90 degrees.
0.25	49.75	STOP: Crossroad (950N and 230E). TURN LEFT (south).
0.3	50.05	Crossing bridge over Quarry Branch Creek.
0.05	50.1	Vulcan Materials, Inc., Casey Quarry office building. On both sides of the road are old abandoned quarries.Some are now full of water. On the left side of the road is the rock crushing plant. You must have permission to enter these premises. PARK out of the way near the office to secure this permission. Do not climb on any fence. CAUTION: loose rocks on the face. Look above you when getting a specimen.

STOP 10 We'll view and discuss exposures of the Pennsylvanian Livingston Limestone Member at the Casey Quarry of Vulcan Materials Inc. (office: SW NW SE SW, Sec. 28, T10N, R14W, 2nd P.M., Clark County; Casey 7.5-Minute Quadrangle [39087C8]).

You must have permission to enter this quarry! To have a safe visit while you are here, please

- Do not climb on any exposed rock faces.
- Do not pull rocks from the quarry faces.
- Do not throw any rocks regardless of how small they are.
- Stay away from the edge of the pit.
- Stay off all equipment.

Twenty to thirty feet of Pleistocene glacial deposits, mainly the Illinoian Vandalia Till, must be removed from the top of the limestone before it can be quarried. Bulldozers remove this overburden, which thickens on the east end of the quarry.

Once the overburden is removed, the operators drill 3.5-inch holes in a 8 foot by 11 foot pattern and blast the limestone, thus shattering it for easy removal by the end loader we see today in the quarry bottom. Roughly 50 pounds of explosive are loaded in each hole, and the shots are made sequentially with the first row at 25 milliseconds and the second row at 45 milliseconds.

The quarry operates only one shift per day and is not open on weekends unless a special need arises. It provides limestone products for many of uses. Roughly 17% of the limestone is used for agricultural uses, and a larger percentage is used for road materials. The limestone is of fairly good quality and has an average 91% calcium carbonate content. About 170,000 to 200,000 tons of limestone were quarried in 1993. You can see limestone processing equipment east of the office. There are several crushers used to prepare limestone aggregate of various sizes. The primary crusher is a 5432 impact crusher, and the secondary crusher is a Hewlit Robins hammer mill type crusher.

The upper surface of the limestone frequently shows long scratches, called "glacial striae," that were caused by hard rocks being dragged slowly across the softer surface by the glaciers. The north-south orientation of the striae shows that the glacier moved in that direction.

Here we will be able to examine the Livingston Limestone Member of the Bond Formation, one of the better developed limestones found in the upper part of the Pennsylvanian succession in Illinois (fig. 17). We were able to see a more complete cyclothem in the Patoka Formation at stop 8, but here we can see the extensive and relatively thick (for Pennsylvanian limestones) Livingston Limestone. This limestone was deposited in a shallow sea that covered the Midcontinent region some 285 million years ago.

The two limestone benches are separated by a shale or claystone, but the shale here is not black nor is it fossiliferous. Beneath the lower limestone bench is a mudstone or claystone (not exposed). Although the portion of the cyclothem above the Limestone is eroded at this stop, it (like at stop 8) is generally a gray shale. Here, the stone is light to medium gray, fine grained, hard, compact, somewhat brecciated, locally fossiliferous (brachiopods and crinoid stem fragments) and medium to thick bedded.

A description of the section exposed in the quarry from ISGS field notes follows

Limestone, grayish white to yellowish tan, mottled with medium blue gray spots, massive, more argillaceous (shaly) than lower bench of limestone, fossiliferous, somewhat nodular, sub-crystalline, 5 to 6 feet

Shale or claystone, light gray, stained yellowish brown, poorly bedded, soft, plastic, no fossils noted, some gypsum crystals, 10 to 12 feet

Limestone, light bluish gray, hard, massive, crystalline, fossiliferous, possessed a structure resembling wheat grains, grades down into mottled limestone, 12 feet

Limestone, light bluish gray, similar to the overlying bench but more massive, crystalline, near the middle there is a zone within the limestone that becomes nodular locally and thin-bedded but grades laterally to more massive beds, 16 to 18 feet exposed.

0.0 50.1 Leave Stop 10. **End of Field Trip. Have a safe journey home! Join us at Salem on April 22, 1995.**

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GLOSSARY

The following definitions are from several sources in total or in part, but the main reference is: Bates, R.L., and J.A. Jackson, eds., 1987, Glossary of Geology: American Geological Institute, Alexandria, VA, 3rd Ed., 788 p.

Age—An interval of geologic time; a division of an epoch.
Aggrading stream—One that is actively building up its channel or floodplain by being supplied with more load than it can transport.
Alluviated valley—One that has been at least partially filled with sand, silt, and mud by flowing water.
Alluvium—A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material deposited during comparatively recent time by a stream or other body of running water as a sorted or semisorted sediment in the bed of a stream or on its floodplain or delta, etc.
Anticline—A convex upward rock fold in which strata have been bent into an arch; the strata on each side of the core of the arch are inclined in opposite directions away from the axis or crest; the core contains older rocks than does the perimeter of the structure.
Aquifer—A geologic formation that is water-bearing and which transmits water from one point to another
Argillaceous—largely composed of clay-sized particles or clay minerals.
Base level—Lowest limit of subaerial erosion by running water, controlled locally and temporarily by water level at stream mouths into lakes or more generally and semipermanently into the ocean (mean sea level).
Basement complex—Largely crystalline igneous and/or metamorphic rocks of complex structure and distribution that underlie a sedimentary sequence.
Basin—A topographic or structural low area that generally receives thicker deposits of sediments than adjacent areas; the low areas tend to sink more readily, partly because of the weight of the thicker sediments; this also denotes an area of deeper water than found in adjacent shelf areas.
Bed—A naturally occurring layer of Earth material of relatively greater horizontal than vertical extent that is characterized by a change in physical properties from those overlying and underlying materials. It also is the ground upon which any body of water rests or has rested, or the land covered by the waters of a stream, lake, or ocean; the bottom of a watercourse or of a stream channel.
Bedrock—The solid rock underlying the unconsolidated (non-indurated) surface materials, such as, soil, sand, gravel, glacial till, etc.
Columnar section—A graphic representation in a vertical column of the sequence and stratigraphic relations of the rock units in a region.
Conformable—Layers of strata deposited one upon another without interruption in accumulation of sediment; beds parallel.
Disconformity—An *unconformity* marked by a distinct erosion-produced irregular, uneven surface of appreciable relief between parallel strata below and above the break; sometimes represents a considerable interval of nondeposition.
Drift—All rock material transported by a glacier and deposited either directly by the ice or reworked and deposited by meltwater streams and/or the wind.
End moraine—A ridge-like or series of ridge-like accumulations of drift built along the margin of an actively flowing glacier at any given time; a moraine that has been deposited at the lower or outer end of a glacier.
Epoch—An interval of geologic time; a division of a period.
Era—A unit of geologic time that is next in magnitude beneath an eon; consists of two or more periods.
Fault—A fracture surface or zone in Earth materials along which there has been vertical and/or horizontal displacement or movement of the strata on both sides relative to one another.
Flood plain—The surface or strip of relatively smooth land adjacent to a stream channel that has been produced by the stream's erosion and deposition actions; the area covered with water when

the stream overflows its banks at times of high water; it is built of alluvium carried by the stream during floods and deposited in the sluggish water beyond the influence of the swiftest current.
Formation—The basic rock unit distinctive enough to be readily recognizable in the field and widespread and thick enough to be plotted on a map. It describes the strata, such as limestone, sandstone, shale, or combinations of these and other rock types; formations have formal names, such as Joliet Formation or St. Louis Limestone (Formation), usually derived from geographic localities.
Fossil—Any remains or traces of an once living plant or animal specimens that are preserved in rocks (arbitrarily excludes Recent remains).
Geology—The study of the planet Earth. It is concerned with the origin of the planet, the material and morphology of the Earth, and its history and the processes that acted (and act) upon it to affect its historic and present forms.
Geophysics—Study of the Earth by quantitative physical methods.
Glaciation—A collective term for the geologic processes of glacial activity, including erosion and deposition, and the resulting effects of such action on the Earth's surface.
Glacier—A large, slow-moving mass of ice at least in part on land.
Gradient—A part of a surface feature of the Earth that slopes upward or downward; a slope, as of a stream channel or of a land surface.
Igneous—Said of a rock or mineral that solidified from molten or partly molten material, i.e., from magma.
Indurated—A compact rock or soil hardened by the action of pressure, cementation, and especially heat.
Joint—A fracture or crack in rocks along which there has been no movement of the opposing sides.
Laurasia—A combination of Laurentia, a paleogeographic term for the Canadian Shield and its surroundings, and Eurasia. It is the protocontinent of the Northern Hemisphere, corresponding to Gondwana in the Southern Hemisphere, from which the present continents of the Northern Hemisphere have been derived by separation and continental displacement. The hypothetical supercontinent from which both were derived is Pangea. The protocontinent included most of North America, Greenland, and most of Eurasia, excluding India. The main zone of separation was in the North Atlantic, with a branch in Hudson Bay, and geologic features on opposite sides of these zones are very similar.
Limestone—A sedimentary rock consisting primarily of calcium carbonate (the mineral, calcite).
Lithify—To change to stone, or to petrify; esp. to consolidate from a loose sediment to a solid rock.
Lithology—The description of rocks on the basis of color, structures, mineral composition, and grain size; the physical character of a rock.
Local relief—The vertical difference in elevation between the highest and lowest points of a land surface within a specified horizontal distance or in a limited area.
Loess—A homogeneous, unstratified deposit of silt deposited by the wind.
Magma—Naturally occurring mobile rock material or fluid, generated within Earth and capable of intrusion and extrusion, from which igneous rocks are thought to have been derived through solidification and related processes.
Meander—One of a series of somewhat regular, sharp, sinuous curves, bends, loops, or turns produced by a stream, particularly in its lower course where it swings from side to side across its valley bottom.
Meander scars—Crescent-shaped, concave marks along a river's floodplain that are abandoned meanders, frequently filled in with sediments and vegetation.
Metamorphic rock—Any rock derived from pre-existing rocks by mineralogical, chemical, and structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment at depth in Earth's crust. (gneisses, schists, marbles, quartzites, etc.)
Mineral—A naturally formed chemical element or compound having a definite chemical composition and, usually, a characteristic crystal form.

Moraine—A mound, ridge, or other distinct accumulation of...glacial drift, predominantly till, deposited...in a variety of topographic landforms that are independent of control by the surface on which the drift lies.
Nonconformity—An unconformity resulting from deposition of sedimentary strata on massive crystalline rock.
Outwash—Stratified drift (clay, silt, sand, gravel) that was deposited by meltwater streams in channels, deltas, outwash plains, on floodplains, and in glacial lakes.
Outwash plain—The surface of a broad body of outwash formed in front of a glacier.
Pangea—A hypothetical supercontinent; supposed by many geologists to have existed at an early time in the geologic past, and to have combined all the continental crust of the Earth, from which the present continents were derived by fragmentation and movement away from each other by means of some form of continental displacement. During an intermediate stage of the fragmentation, between the existence of Pangea and that of the present widely separated continents, Pangea was supposed to have split into two large fragments, *Laurasia* on the north and *Gondwana* on the south. The proto-ocean around Pangea has been termed *Panthalassa*. Other geologists, while believing in the former existence of Laurasia and Gondwana, are reluctant to concede the existence of an original Pangea; in fact, the early (Paleozoic or older) history of continental displacement remains largely undeciphered.
Period—An interval of geologic time; a division of an era.
Physiography—The study and classification of the surface features of Earth on the basis of similarities in geologic strucure and the history of geologic changes.
Physiographic province (or division)—(1) A region, all parts of which are similar in geologic structure and climate and which has consequently had a unified geologic history; (2) a region whose pattern of relief features or landforms differs significantly from that of adjacent regions.
Relief—(a) A term used loosely for the actual physical shape, configuration, or general uneveness of a part of Earth's surface, considered with reference to variations of height and slope or to irregularities of the land surface; the elevations or differences in elevation, considered collectively, of a land surface (frequently confused with topography). (b) The vertical difference in elevation between the hilltops or mountain summits and the lowlands or valleys of a given region; "high relief" has great variation; "low relief" has little variation.
Sediment—Solid fragmental material, either inorganic or organic, that originates from weathering of rocks and is transported by, suspended in, or deposited by air, water, or ice, or that is accumulated by other natural agents, such as chemical precipitation from solution or secretion from organisms, and that forms in layers on Earth's surface at ordinary temperatures in a loose, unconsolidated form; e.g, sand, gravel, silt, mud, till, loess, alluvium.
Sedimentary rock—A rock resulting from the consolidation of loose sediment that has accumulated in layers (e.g., sandstone, siltstone,limestone).
Stage, substage—Geologic time-rock units; the strata formed during an age or subage, respectively.
Stratigraphy—the study, definition, and description of major and minor natural divisions of rocks, especially the study of the form, arrangement, geographic distribution, chronologic succession, classification, correlation, and mutual relationships of rock strata.
Stratigraphic unit—A stratum or body of strata recognized as a unit in the classification of the rocks of Earth's crust with respect to any specific rock character, property, or attribute or for any purpose such as description, mapping, and correlation.
Stratum—A tabular or sheet-like mass, or a single and distinct layer, of homogeneous or gradational sedimentary material of any thickness, visually separable from other layers above and below by a discrete change in character of the material deposited or by a sharp physical break in deposition, or by both; a sedimentary *bed.*
Subage—An interval of geologic time; a division of an age.
Syncline—A downfold of strata which dip inward from the sides toward the axis; youngest rocks along the axis; the opposite of anticline.

System—The largest and fundamental geologic time-rock unit; the strata of a system were deposited during a period of geologic time.
Tectonic—Pertaining to the global forces involved in, or the resulting structures or features of Earth's movements.
Tectonics—The branch of geology dealing with the broad architecture of the upper (outer) part of Earth's crust; a regional assembling of structural or deformational features, their origins, historical evolution, and mutual relations.
Till—Unconsolidated, nonsorted, unstratified drift deposited by and underneath a glacier and consisting of a heterogenous mixture of different sizes and kinds of rock fragments.
Till plain—The undulating surface of low relief in the area underlain by ground moraine.
Topography—The natural or physical surface features of a region, considered collectively as to form; the features revealed by the contour lines of a map.
Unconformable—Having the relation of an unconformity to underlying rocks and separated from them by an interruption in sedimentation, with or without any accompanying erosion of older rocks.
Unconformity—A surface of erosion or nondeposition that separates younger strata from older strata; most unconformities indicate intervals of time when former areas of the sea bottom were temporarily raised above sea level.
Valley trains—The accumulations of outwash deposited by rivers in their valleys downstream from a glacier.
Water table—The upper surface of a zone of saturation.
Weathering—The group of processes, chemical and physical, whereby rocks on exposure to the weather change in character, decay, and finally crumble into soil.

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.

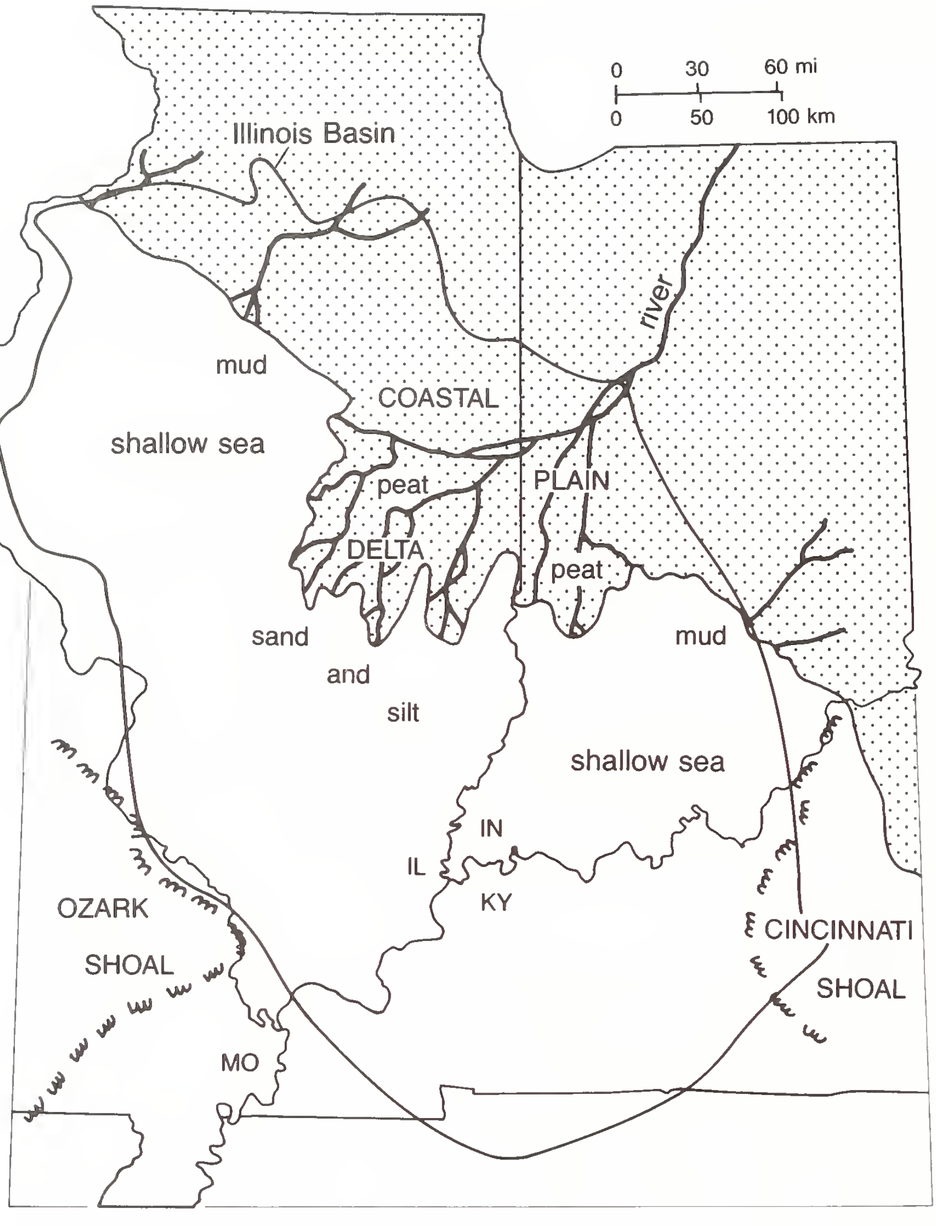
Depositional conditions in the Illinois Basin during the Pennsylvanian Period were somewhat similar to those of the preceding Chesterian (late Mississippian) time. A river system flowed southwestward across a swampy lowland, carrying mud and sand from highlands to the northeast. This river system formed 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.

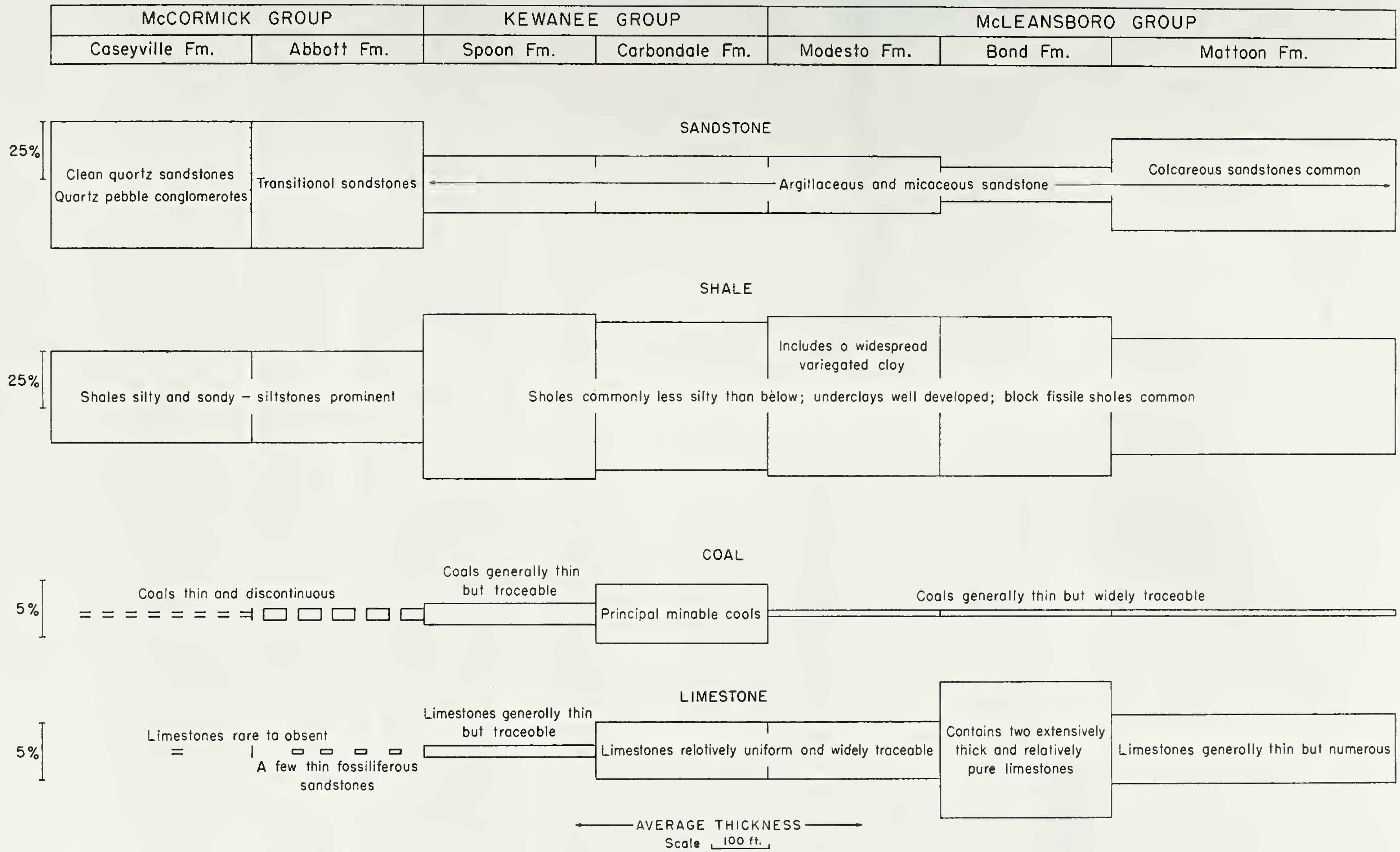
Beneath the quiet water of extensive swamps that prevailed for long intervals on the emergent coastal lowland, peat was formed by accumulation of plant material. Lush forest vegetation covered the region; it thrived in the warm, moist Pennsylvanian-age climate. Although the origin of the underclays beneath 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.



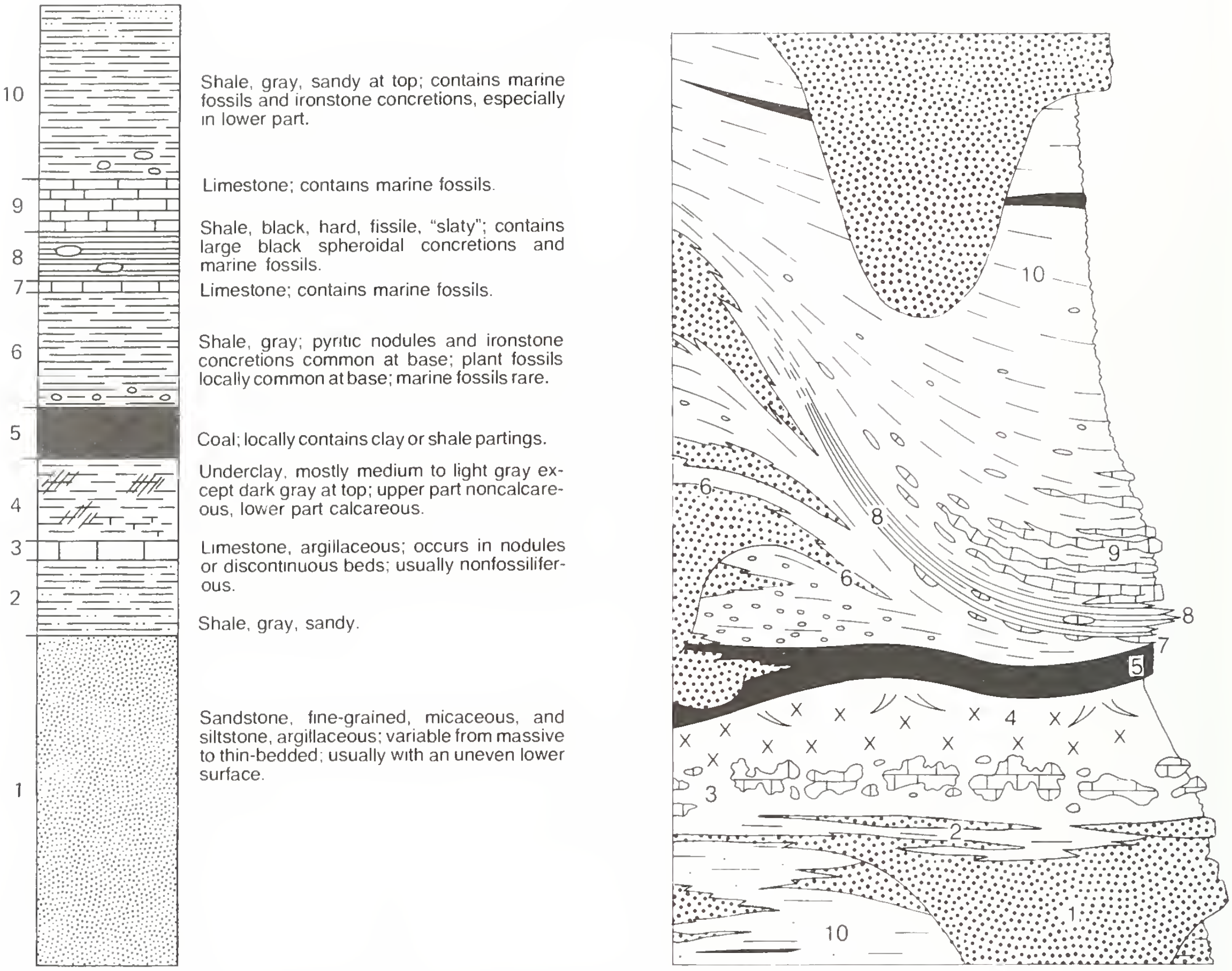
Paleogeography of Illinois-Indiana region during Pennsylvanian time. The diagram shows a Pennsylvanian river delta and the position of the shoreline and the sea at an instant of time during the Pennsylvanian Period.

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.

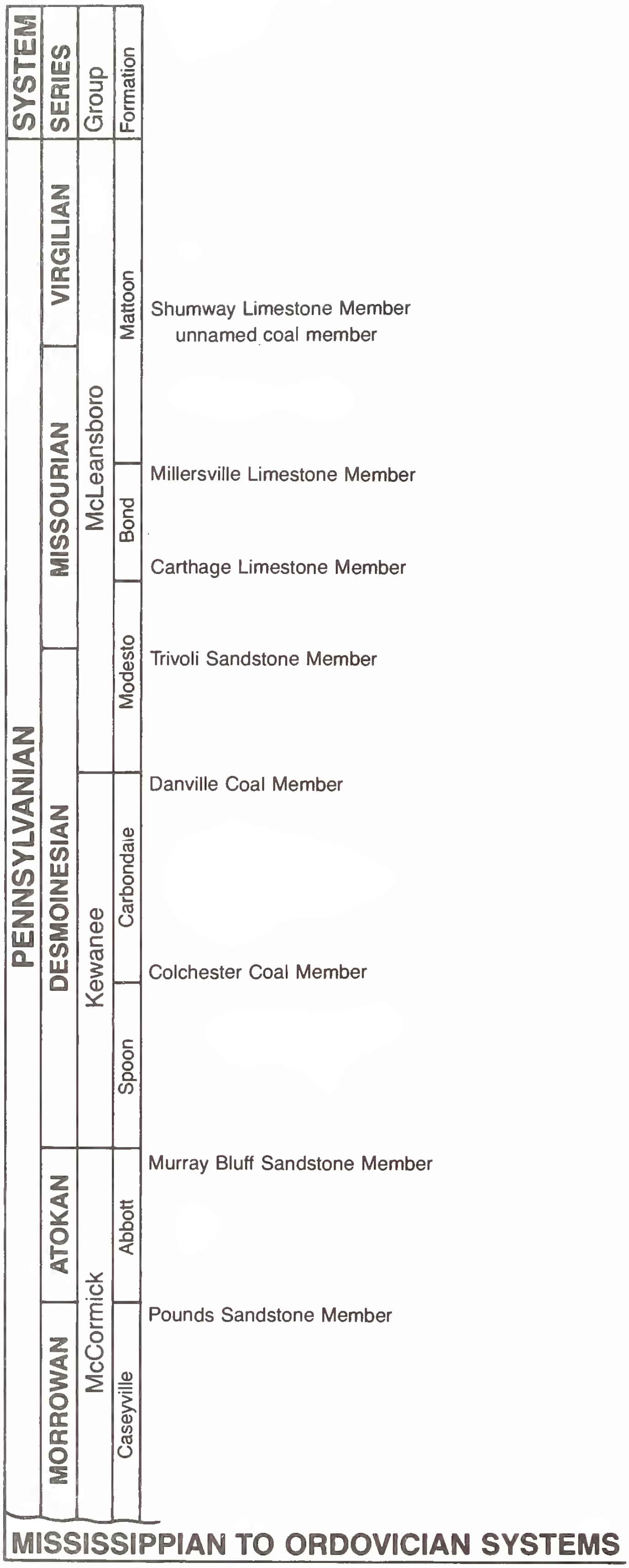
The periodic invasions of the Pennsylvanian sea across the coastal swamps killed the Pennsylvanian forests, and the peat deposits were often buried by marine sediments. After the marine transgressions, peat usually became saturated with sea water containing sulfates and other dissolved minerals. Even 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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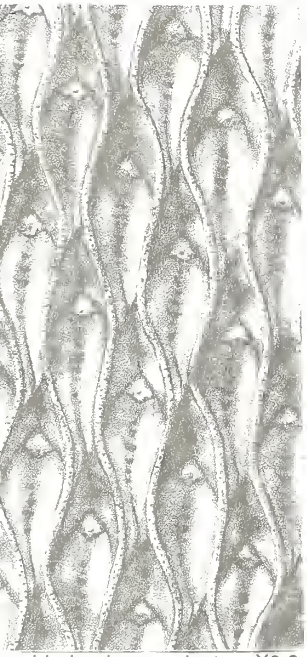
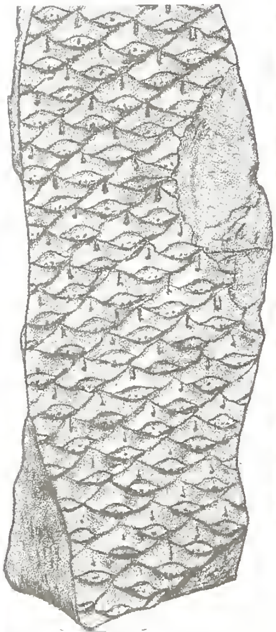
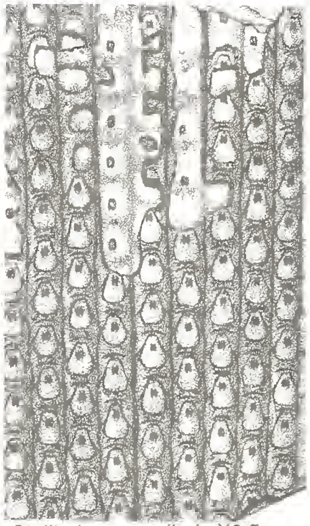
Common Pennsylvanian plants: lycopods, sphenophytes, and ferns



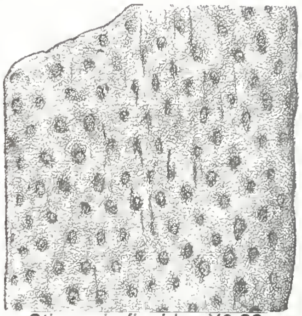
Lepidodendron aculeatum X0.8



Lepidophloios laricinus X0.63



Sigillaria mammilaris X0.5

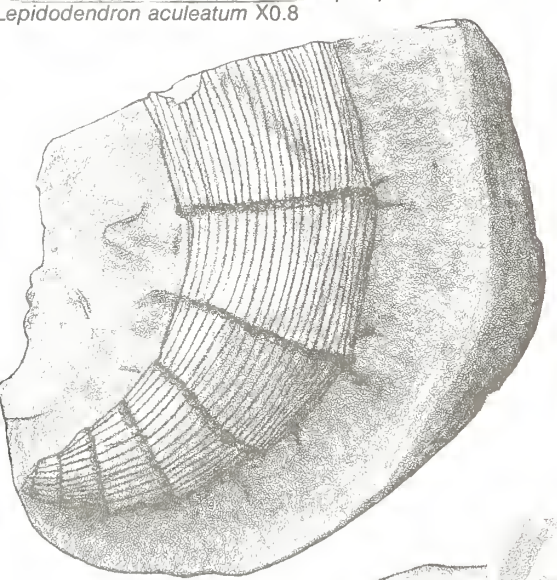


Stigmaria ficoides X0.32

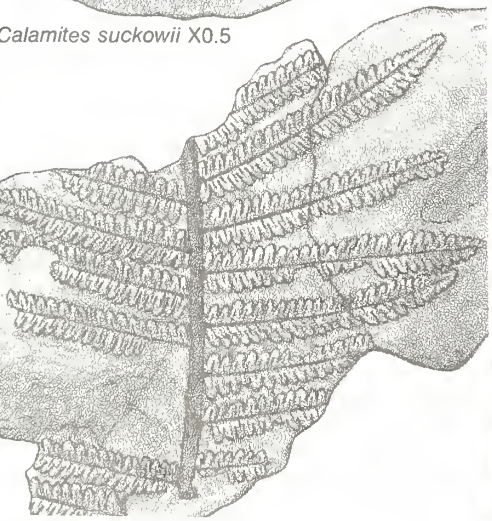
Lepidostrobus ovatifolius X0.8

Annularia stellata X0.63

Sphenophyllum cuneifolium X0.4

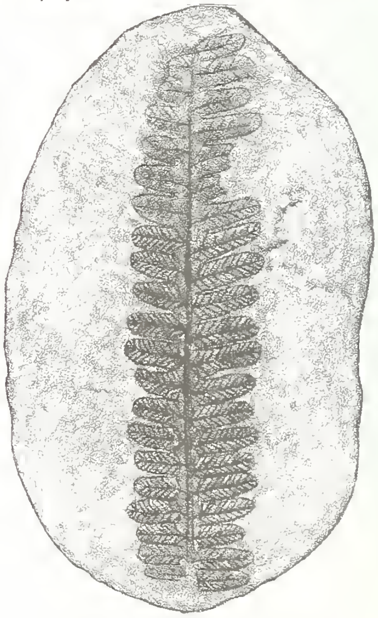


Calamites suckowii X0.5



Pecopteris sp. X0.32

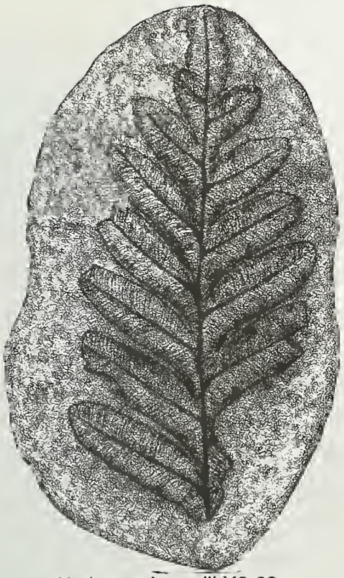
Pecopteris miltonii X2.0



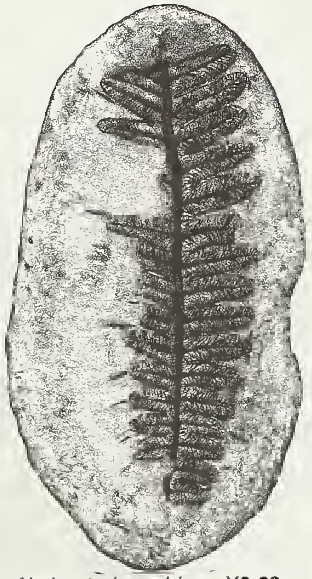
Pecopteris hemitelioides X1.0

J. R. Jennings, ISGS

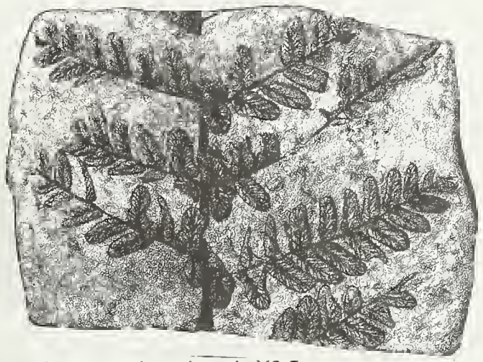
Common Pennsylvanian plants: seed ferns and cordaiteans



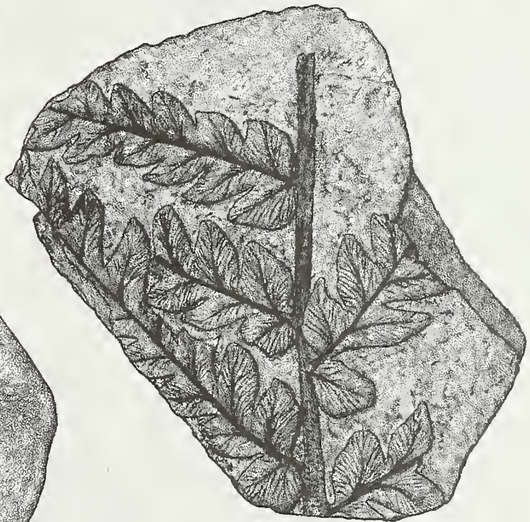
Alethopteris serlii X0.63



Alethopteris ambigua X0.63



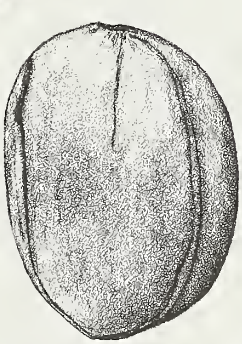
Neuropteris rarinervis X0.5



Mariopteris nervosa X0.8

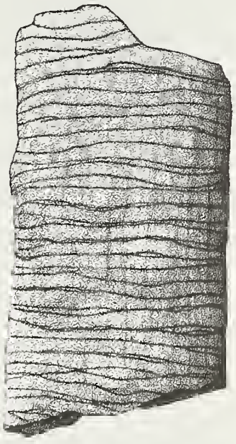
Neuropteris scheuchzeri X0.63

Sphenopteris rotundiloba X0.8



Trigonocarpus parkinsonii X1.25

Cordaicladus sp. X1.0

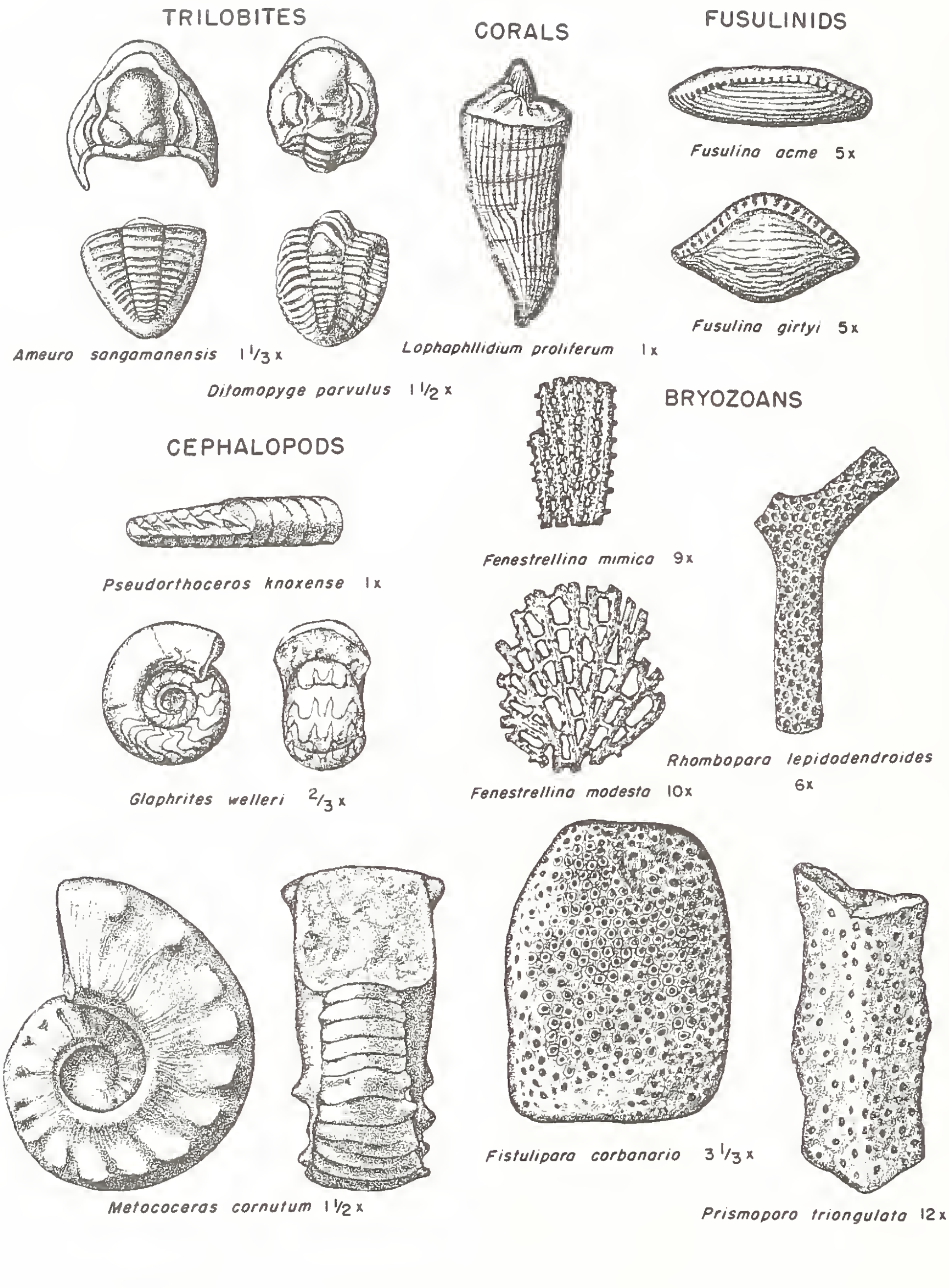


Artisia transversa X0.63

Cordaicarpon major X2.0

Cordaites principalis X0.63

J. R. Jennings, ISGS


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

PELECYPODS

Nucula (Nuculopsis) girtyi 1x

Edmonia ovata 2x

Astartella concentrica 1x

Dunbarella knighti 1½x

Cardiomorpha missouriensis "Type A" 1x

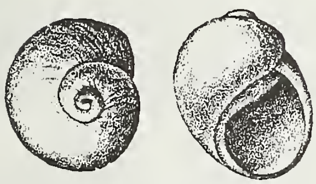
Cardiomorpha missouriensis "Type B" 1½x

GASTROPODS

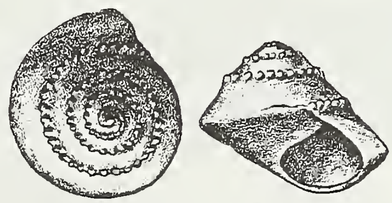
Euphemites carbonarius 1½x

Trepospira illinoisensis 1½x

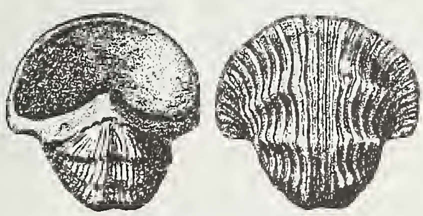
Donaldina robusta 8x



Naticopsis (Jedria) ventricosa 1½x



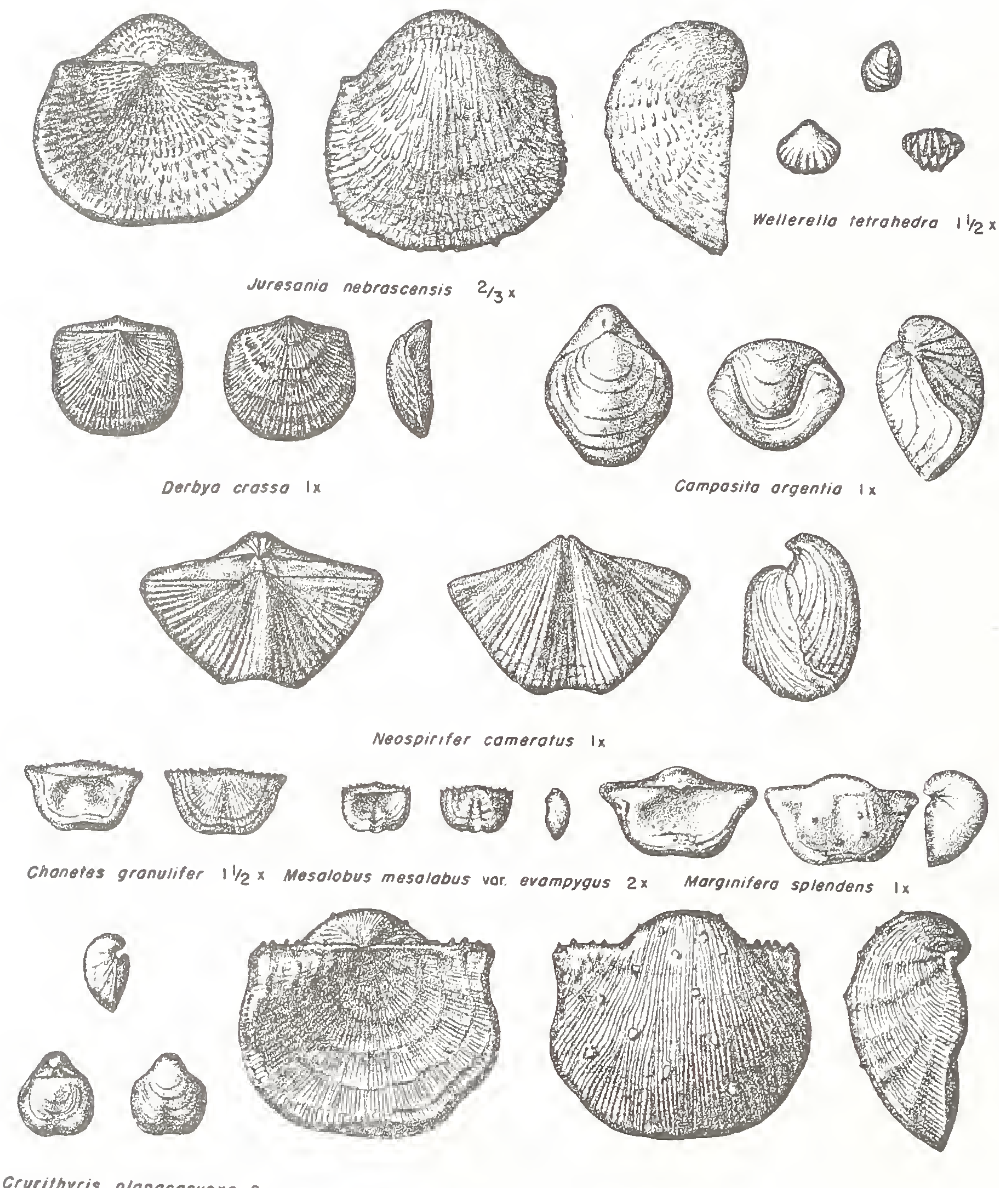
Trepospira sphaerulata 1x



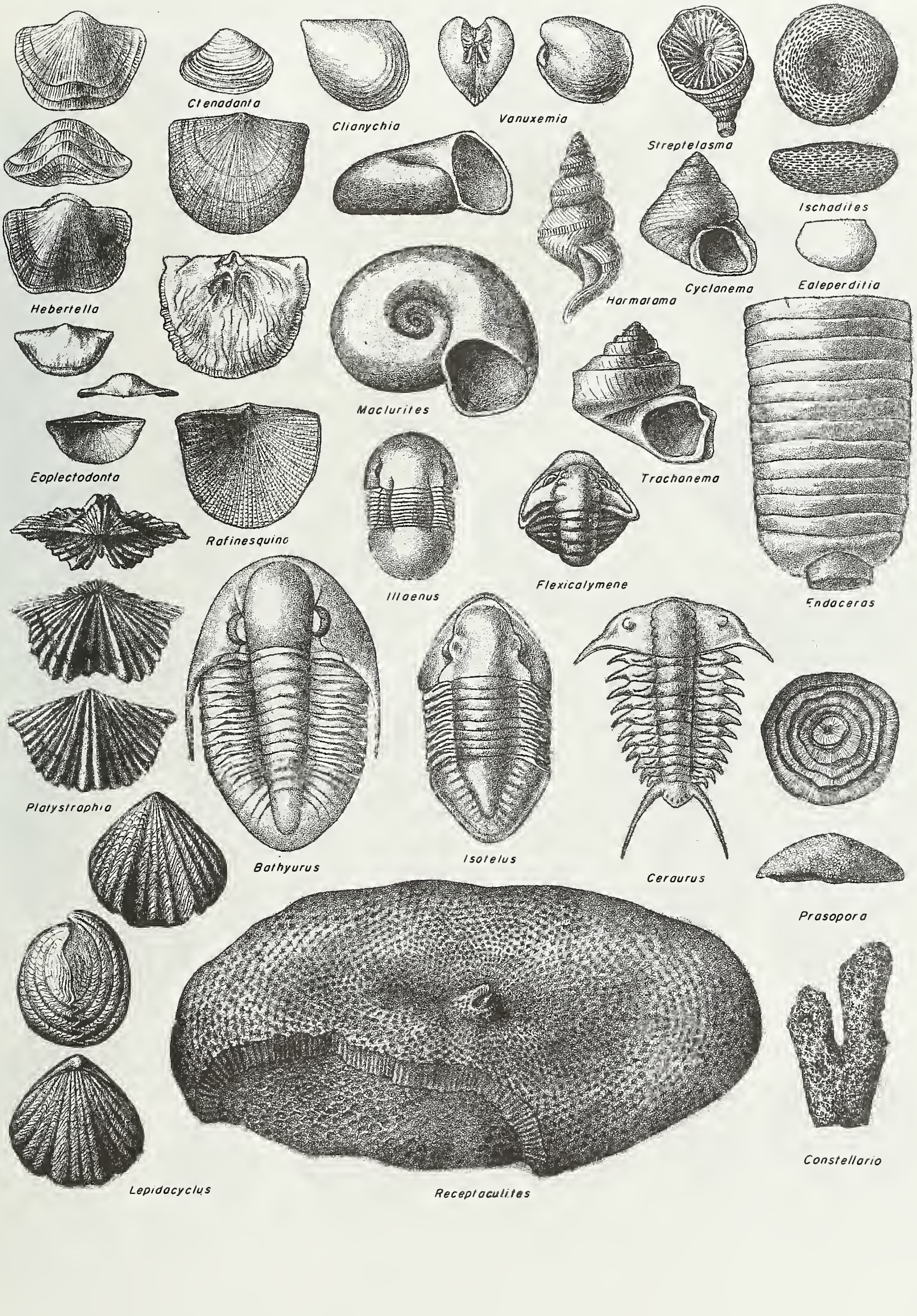
Knightites montfortianus 2x

Glabrocingulum (Glabrocingulum) grayvillense 3x

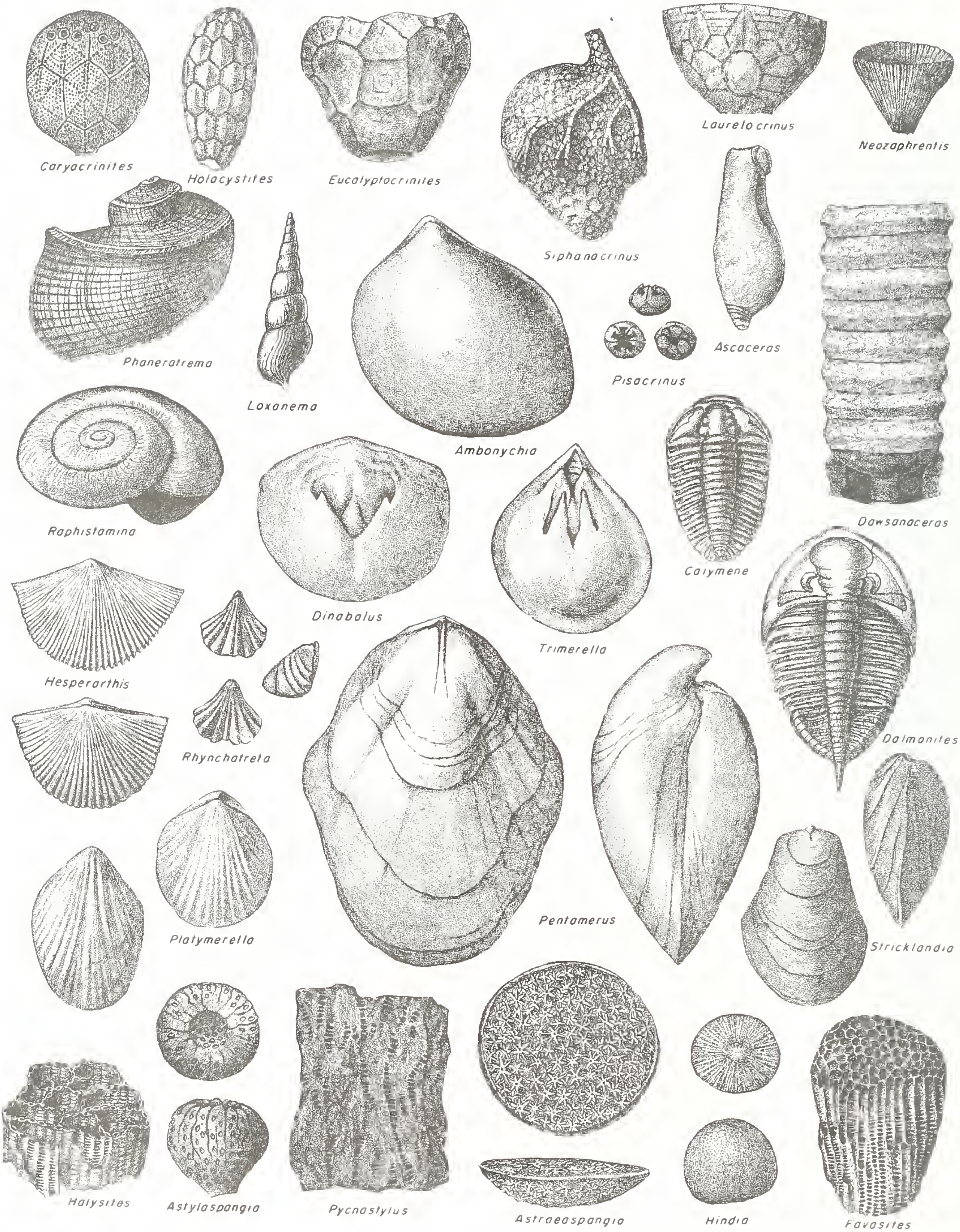
BRACHIOPODS



ORDOVICIAN FOSSILS



REPRESENTATIVE SILURIAN FOSSILS FROM NORTHWESTERN ILLINOIS



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 Mississiippi, 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.

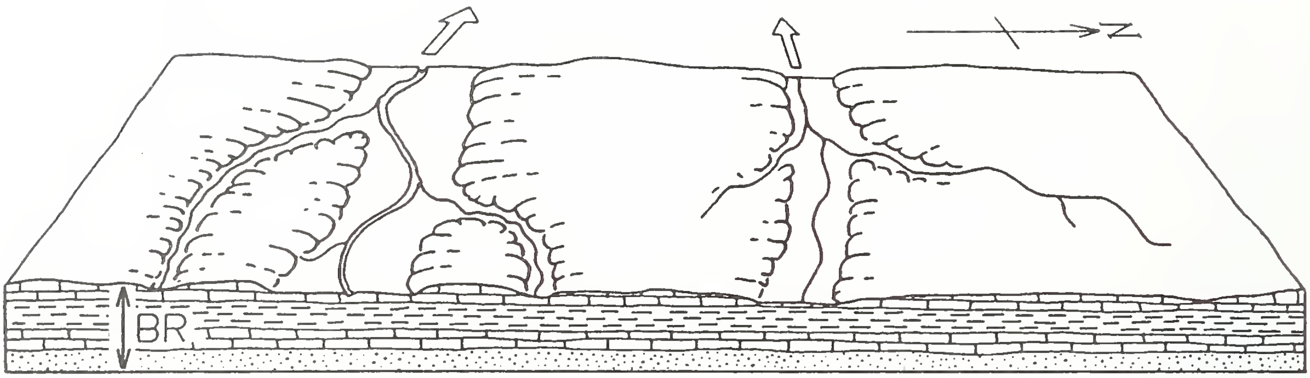
Eolian deposition occurred when certain climatic conditions were met, probably in a seasonal pattern. Deposition could have occurred in the fall, winter or spring season when low precipitation rates and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and 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.

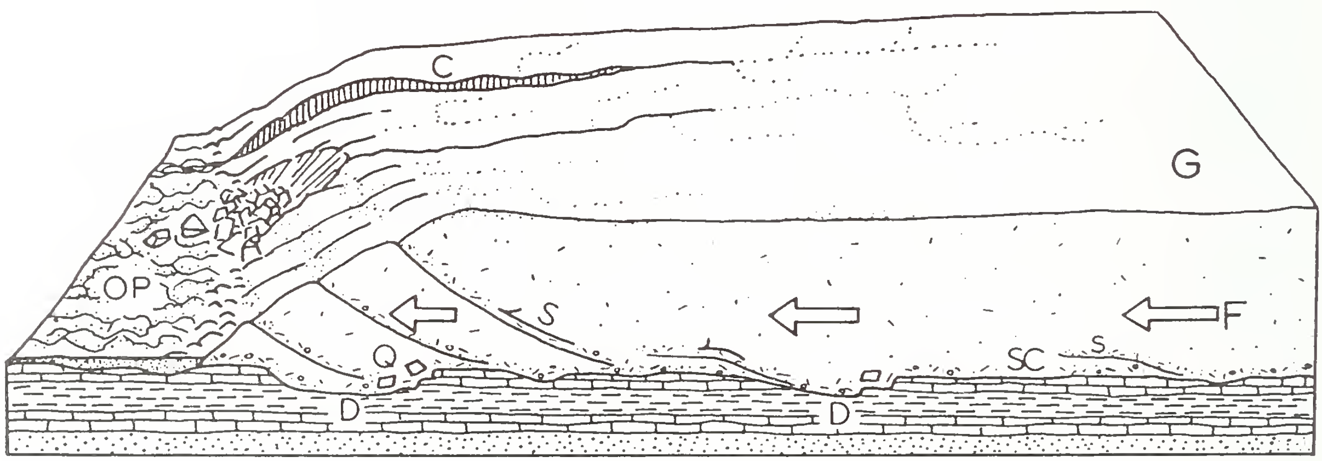
Glaciation in a Small Illinois Region

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.

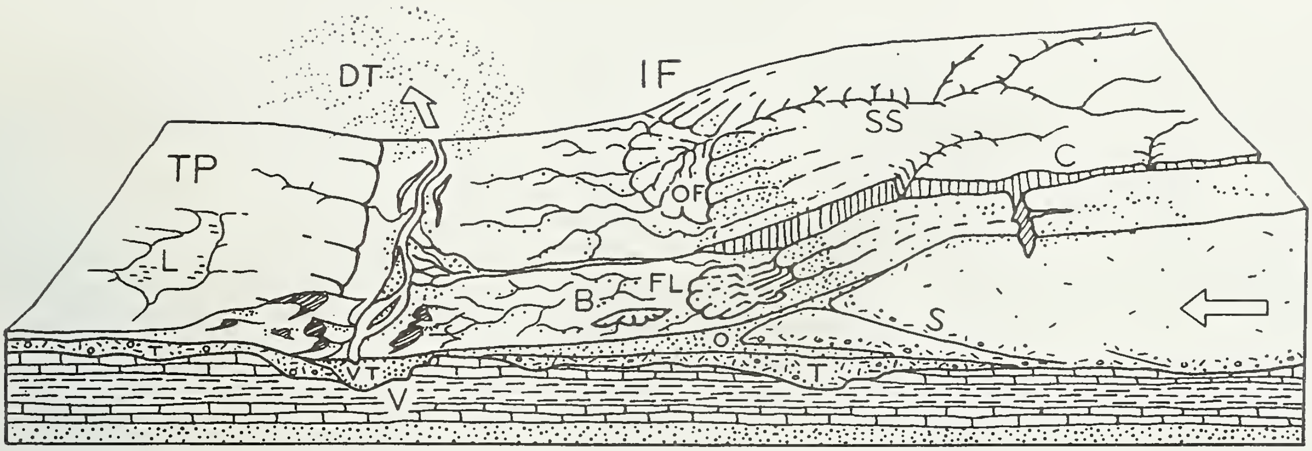
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated—layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



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.



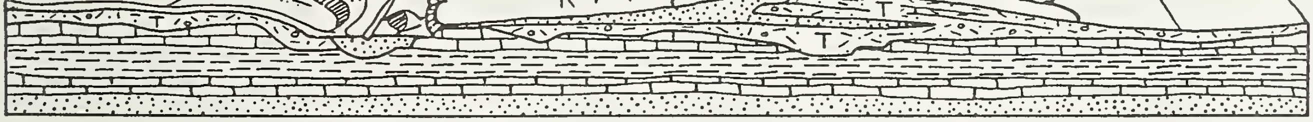
2. **The Glacier Advances Southward** — As the Glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughnesses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

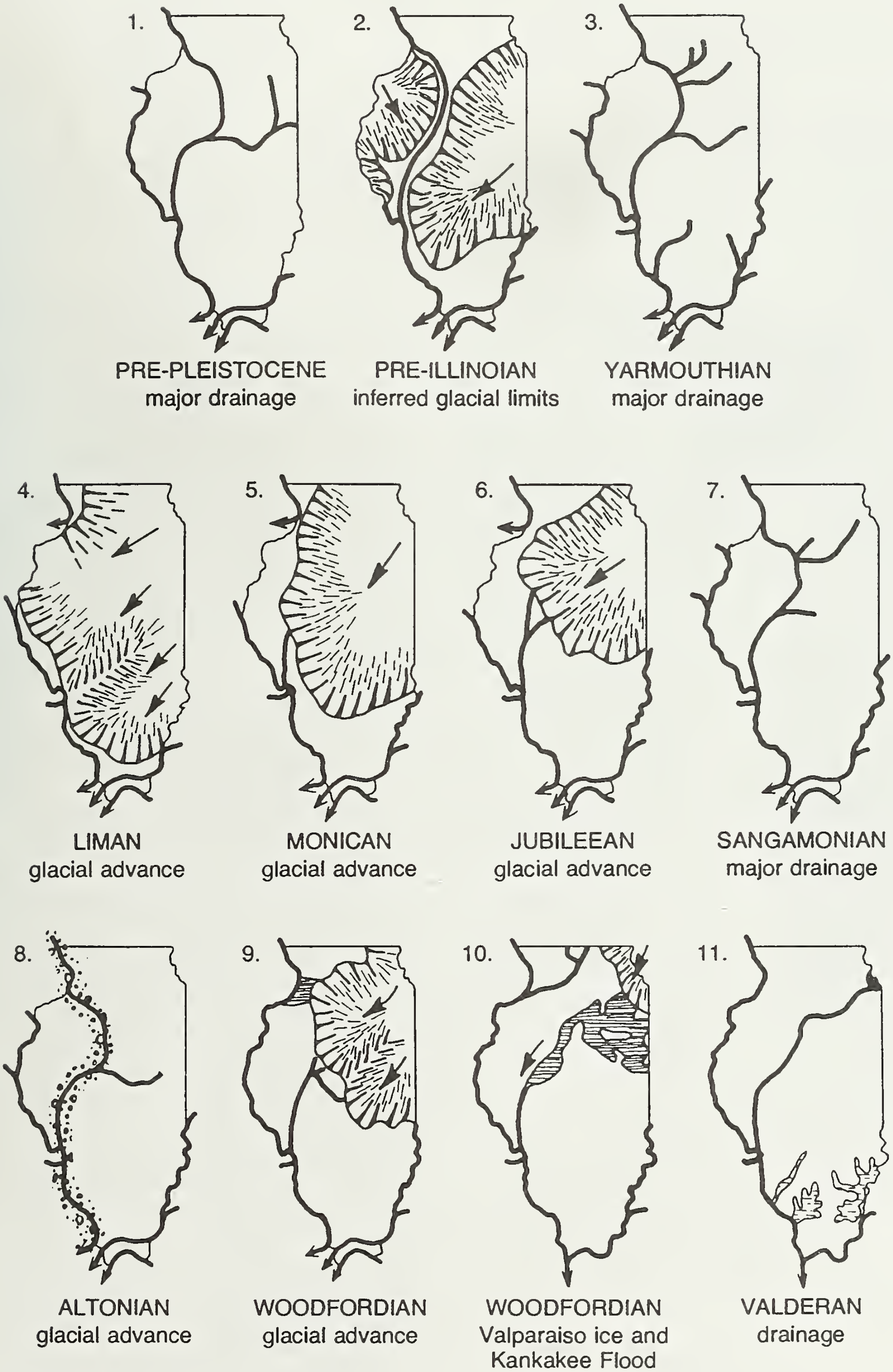
TIME TABLE OF PLEISTOCENE GLACIATION

		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		

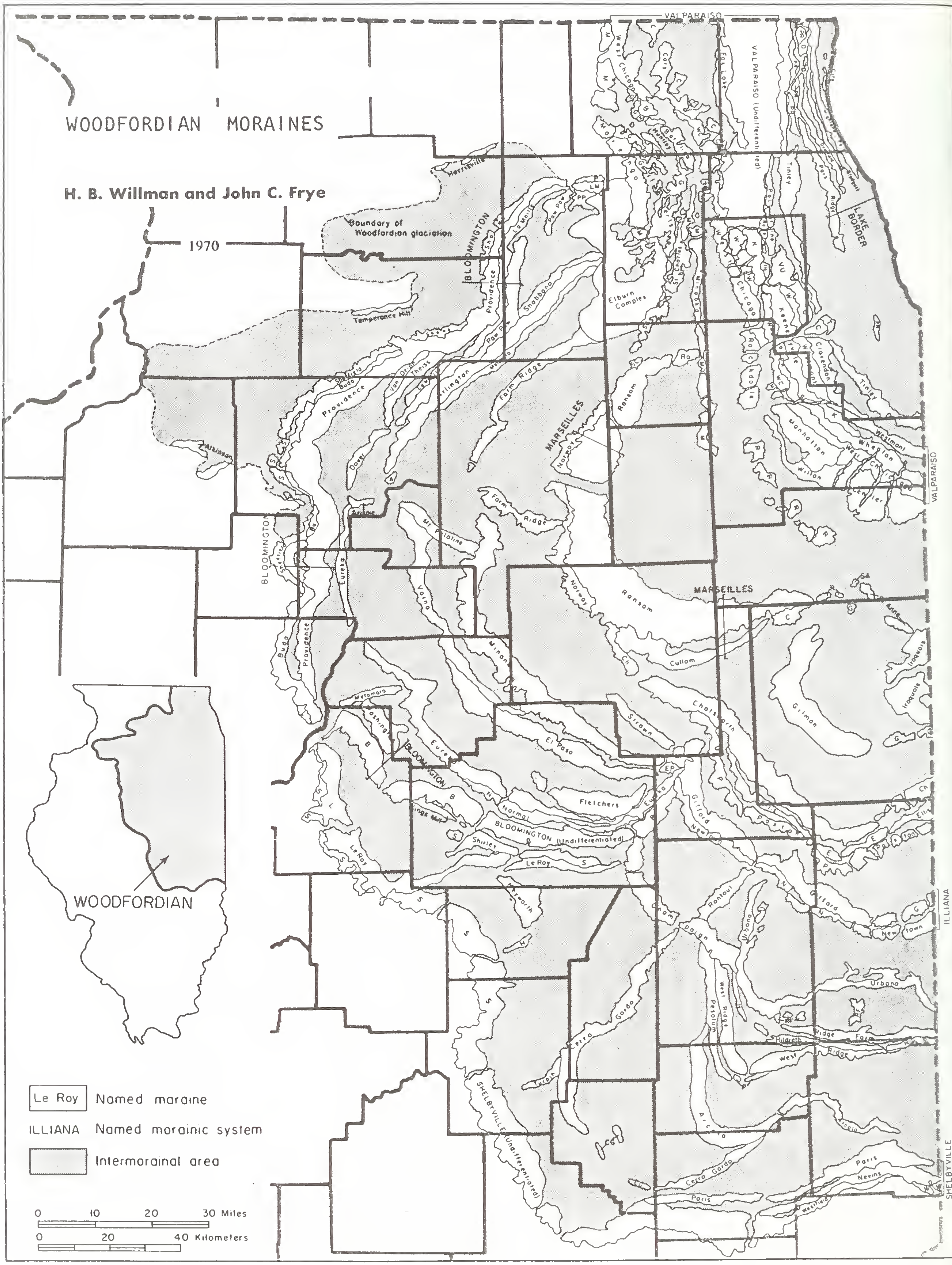
*Old oversimplified concepts, now known to represent a series of glacial cycles.

(Illinois State Geological Survey, 1973)

SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



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



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

ILLINOIS STATE GEOLOGICAL SURVEY

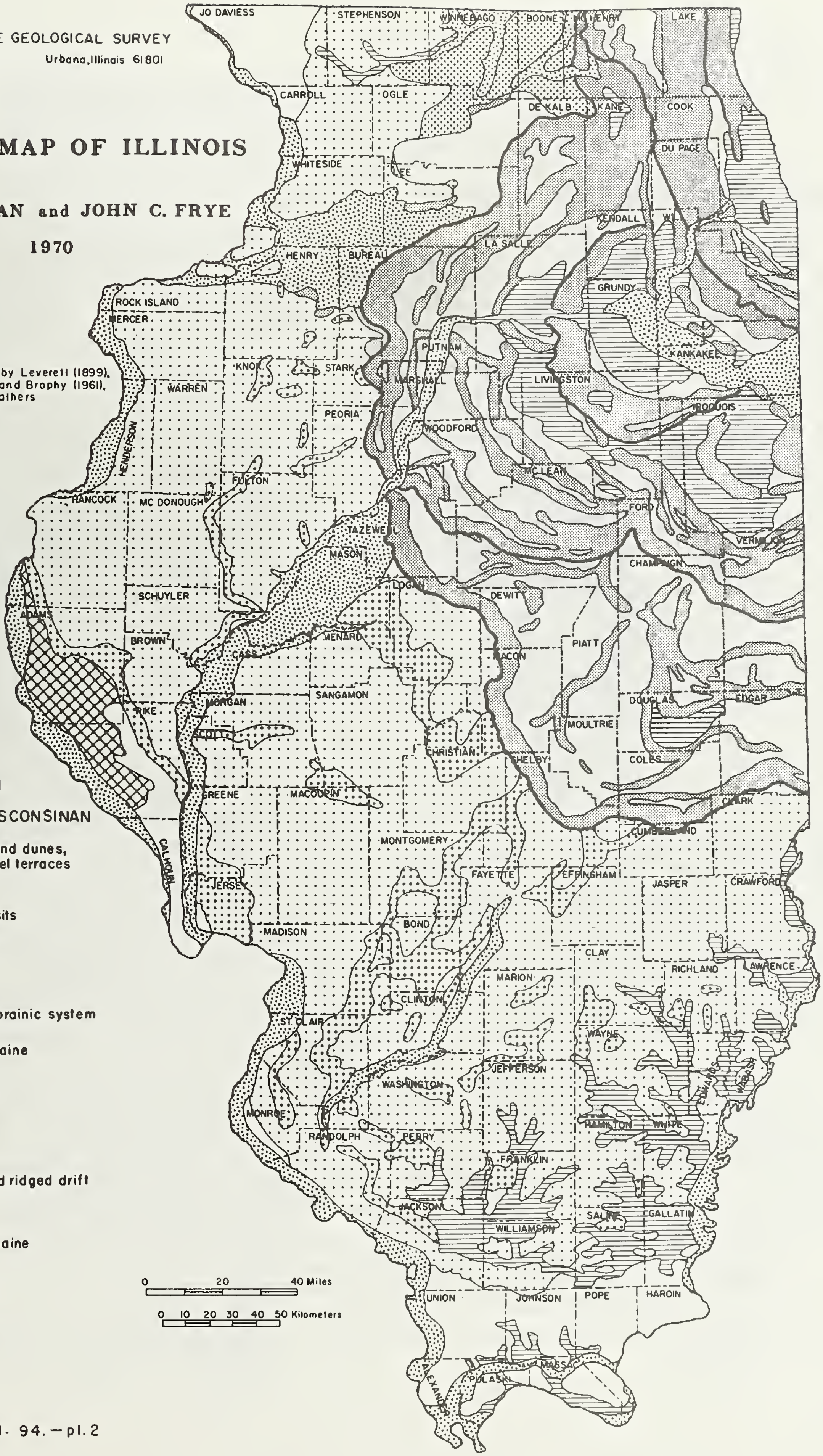
John C. Frye, Chief   Urbana, Illinois 61801

GLACIAL MAP OF ILLINOIS

H.B. WILLMAN and JOHN C. FRYE

1970

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



EXPLANATION

HOLOCENE AND WISCONSINAN

Alluvium, sand dunes, and gravel terraces

WISCONSINAN

Lake deposits

WOODFORDIAN

Moraine

Front of morainic system

Groundmoraine

ALTONIAN

Till plain

ILLINOIAN

Moraine and ridged drift

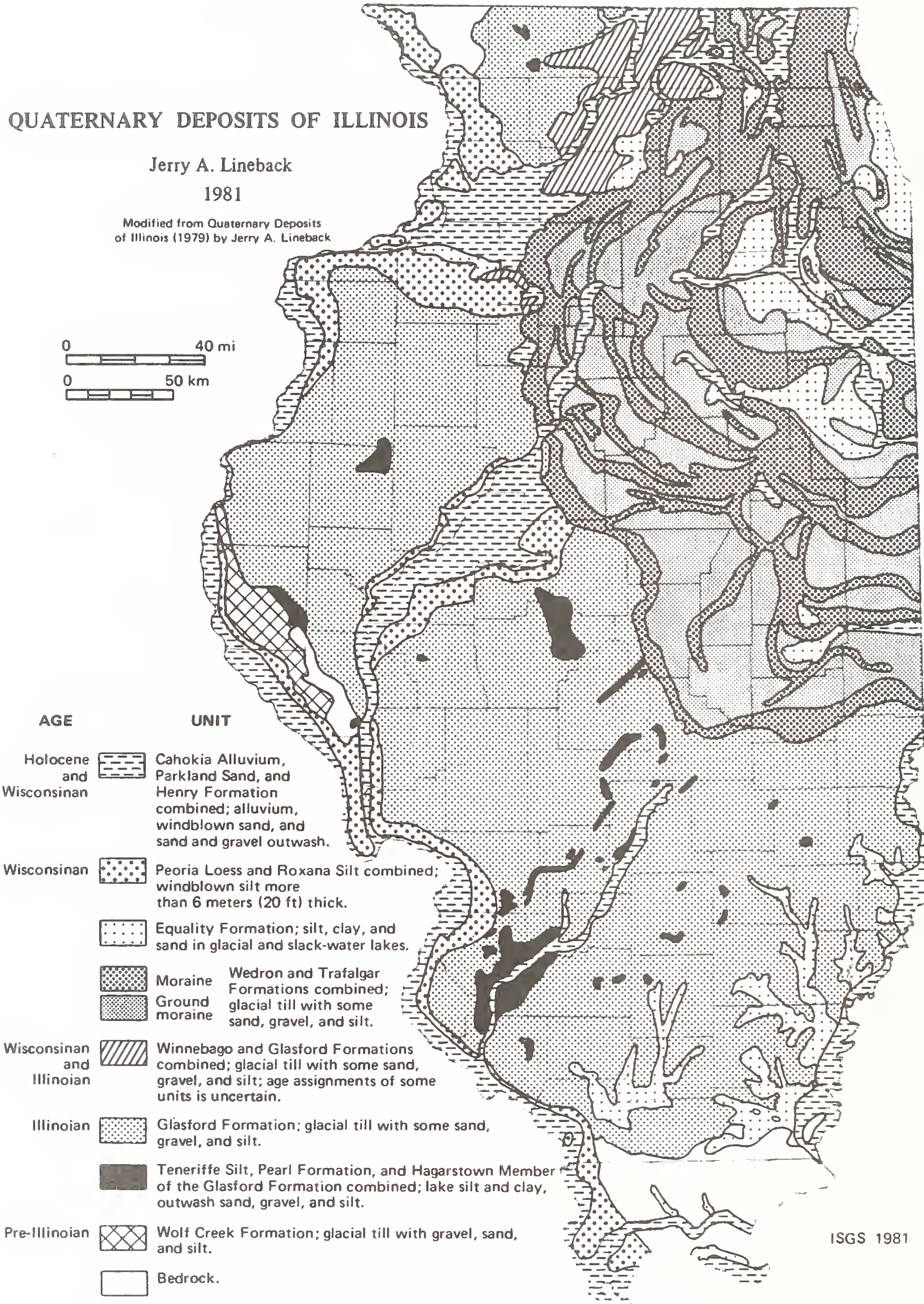
Groundmoraine

KANSAN

Till plain

DRIFTLESS

Modified from Bull. 94.—pl. 2



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 Wisconsinan
Cahokia Alluvium, Parkland Sand, and Henry Formation combined; alluvium, windblown sand, and sand and gravel outwash.
Wisconsinan
Peoria Loess and Roxana Silt combined; windblown silt more than 6 meters (20 ft) thick.
Equality Formation; silt, clay, and sand in glacial and slack-water lakes.
Moraine
Ground moraine
Wedron and Trafalgar Formations combined; glacial till with some sand, gravel, and silt.
Wisconsinan and Illinoian
Winnebago and Glasford Formations combined; glacial till with some sand, gravel, and silt; age assignments of some units is uncertain.
Illinoian
Glasford Formation; glacial till with some sand, gravel, and silt.
Teneriffe Silt, Pearl Formation, and Hagarstown Member of the Glasford Formation combined; lake silt and clay, outwash sand, gravel, and silt.
Pre-Illinoian
Wolf Creek Formation; glacial till with gravel, sand, and silt.
Bedrock.
ISGS 1981

ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, Illinois 61801

GEOGRAM 6
October 1975

DO YOU LIVE ABOVE AN UNDERGROUND RIVER?

Myrna M. Killey

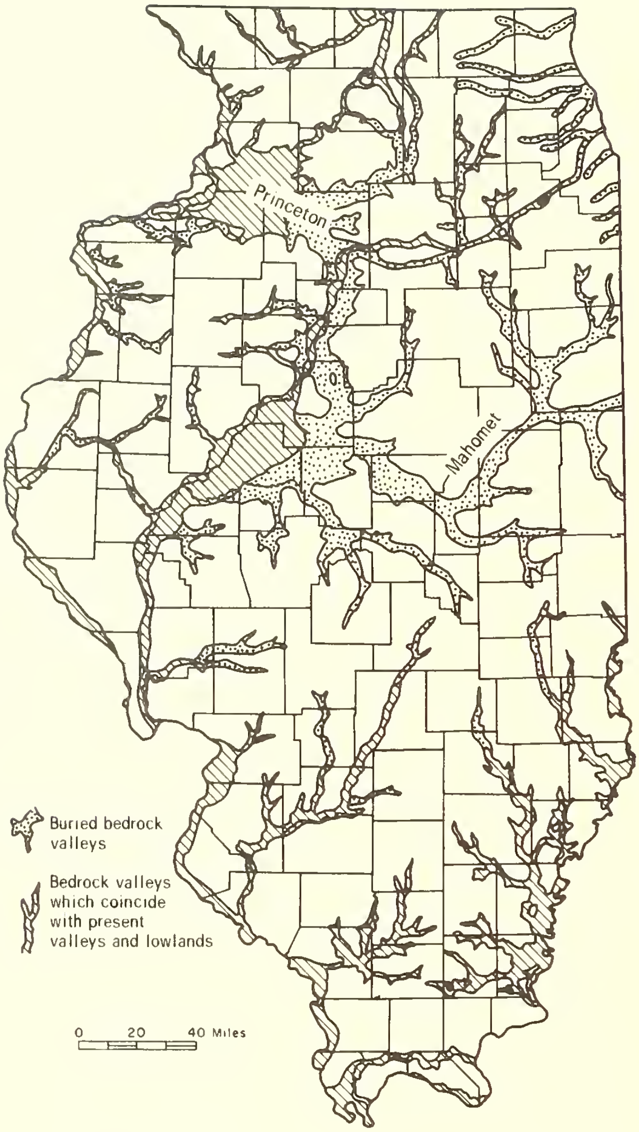
Do you think of an underground river as a hidden stream rushing through a tunnel in solid rock? Such subterranean rivers do exist in some states—in Alabama and Missouri, for example. In Illinois, however, except in a few areas where water flows through cracks and channels it has created by dissolving the limestone bedrock, underground "rivers" are not really rivers at all. The Mahomet "river" that underlies part of east-central Illinois is a good example. So is the eastern part of this "river," which is called the Teays (rhymes with "days"). Such rivers are vital to many towns, for they are a reliable source of water.

The Mahomet-Teays river system was discovered more than 25 years ago when numerous water wells were drilled in the eastern and midwestern United States. The story of this vast river system has been pieced together largely from information obtained from records made during the drilling of the wells.

More than a million years ago, before the glaciers of the Great Ice Age crept down over the Midwest, a river as large as the present Mississippi flowed generally westward from its probable source in the mountains of West Virginia, crossed Ohio and Indiana, and traversed east-central Illinois from Hoopeston to Havana. At Havana it joined another ancient river system that occupied what is now the Illinois River Valley (see map). All along its course it cut a deep valley in the bedrock.

When the successive glaciers invaded Illinois from Canada, the fringes of the ice melted during the warmer periods, and the water (meltwater) carried with it great quantities of sand and gravel that had been embedded in the ice. This material, called *outwash*, was deposited in thick layers in the Mahomet Valley. As the later glaciers advanced southward, both the valley and its outwash were buried by ice. When the ice finally melted, tremendous amounts of unsorted rock debris (pebbly, sandy clay called *till*) that had been held in the ice blanketed the land surface, including the former river valley, to depths of 50 to more than 100 feet. (The outwash and till deposits are collectively called *drift*.) The great Mahomet River Valley was obliterated from the landscape and the river no longer existed. Instead, on the new land surface the river patterns we know today developed.

The buried Mahomet Valley is invaluable to east-central Illinois because its porous sand and gravel deposits act as vast underground sponges, storing the rainwater that seeps downward from the land surface. Water flows easily through the sand and gravel into wells drilled in the porous materials. In contrast, glacial till is too fine-grained to allow the water it holds to flow easily and, therefore, cannot supply large amounts of water to wells. Towns such as Hoopeston, Champaign-Urbana, Mahomet, Monticello, and Clinton that are situated above the buried Mahomet Valley have large ground-water supplies available to them, but towns away from the valley have more difficulty obtaining their water. Perhaps the term "underground river" is still applied to the Mahomet Valley because it is easier to imagine great volumes of well water coming from a river than from beds of sand and gravel in a buried valley.



The Mahomet Valley has been traced for about 150 miles across Illinois, it lies at an average depth of more than 200 feet below land surface, and its bottom is at an average elevation of 350 feet above sea level. In some places the ancient valley varies in width from 5 miles at the Indiana line to almost 10 miles near Clinton in De Witt County.

Another major "underground river" is the Princeton Bedrock Valley in the north-central part of Illinois. Many smaller bedrock valleys in the state contain sand and gravel deposited by glacial meltwater. The Mississippi, Illinois, Kaskaskia, and Wabash Rivers also contain beds of outwash deposited by glacial meltwaters, but their courses were not obliterated by the glaciers, and their valleys have remained open as drainageways.

The water supplies in these deposits in the ancient river valleys of Illinois are one of many resources contributing to the state's natural wealth. Of the 3.3 billion gallons of water a day used by Illinois, about 450 million gallons are pumped from sand and gravel deposits, mainly of glacial origin. The value of ground water from these deposits is over $115 million per year.

Do you live above an underground "river"? Look at the map and see. Locate the source of the water you use in your town. If you should see a well being drilled, stop and ask if you can look at the earth materials brought up from the well. These are the kinds of material used to interpret the geologic history of Illinois.

GEOGRAM 5
October 1975

ANCIENT DUST STORMS IN ILLINOIS

Myrna M. Killey

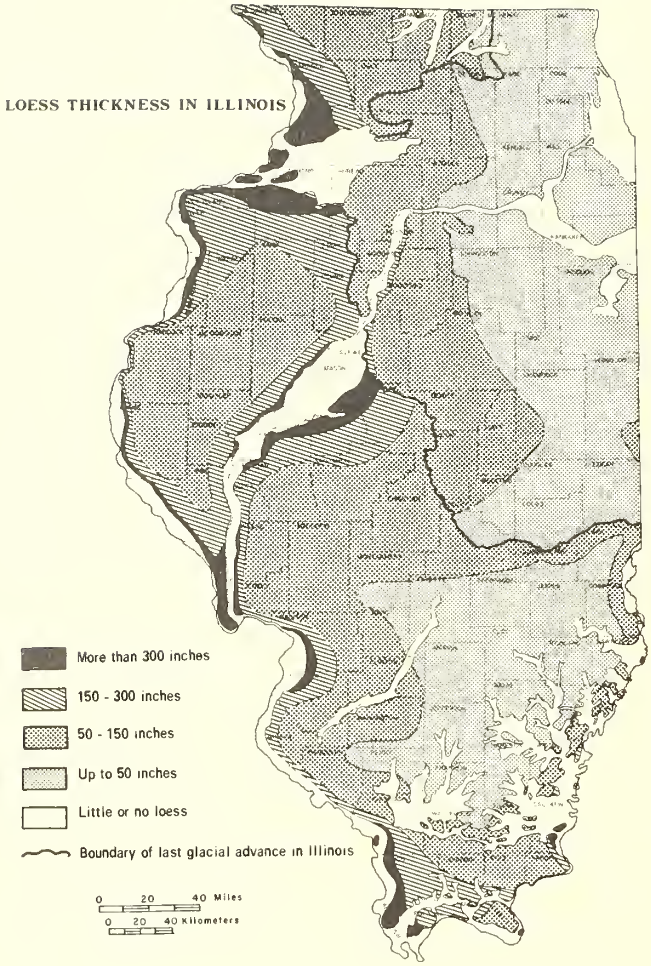
Fierce dust storms whirled across Illinois long before human beings were here to record them. Where did all the dust come from? Geologists have carefully put together clues from the earth itself to get the story. As the glaciers of the Great Ice Age scraped and scoured their way southward across the 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.

ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, Illinois 61801

GEOGRAM 2
October 1974

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.

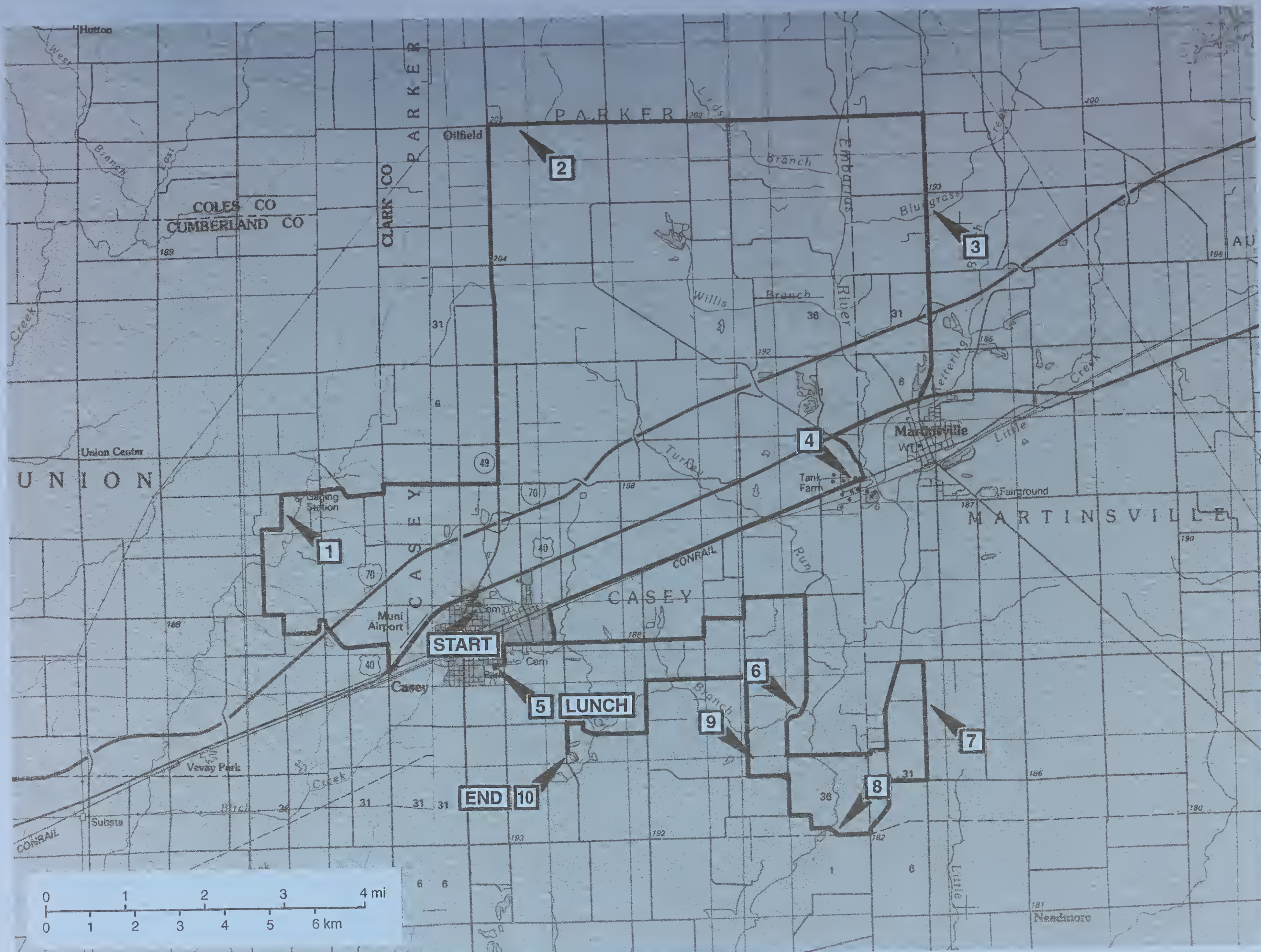
The continental glaciers of the Great Ice Age scoured and scraped the land surface as they advanced, pushing up chunks of bedrock and grinding them against each other or along the ground surface as the rock-laden ice sheets pushed southward. Hundreds of miles of such grinding, even on such hard rocks 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.



Hutton
COLES CO
CUMBERLAND CO
CLARK CO
PARKER
PARKER
Oilfield
UNION
Union Center
CASEY
CASEY
Gaging Station
Muni Airport
Casey
START
LUNCH
END
MARTINSVILLE
Martinsville
Tank Farm
Fairground
Vevay Park
Substa
Neadmore
CONRAIL
CONRAIL
Embarras River
Willis Branch
Bluegrass
Turkey
Run
Branch
Creek
Little
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0 1 2 3 4 mi
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