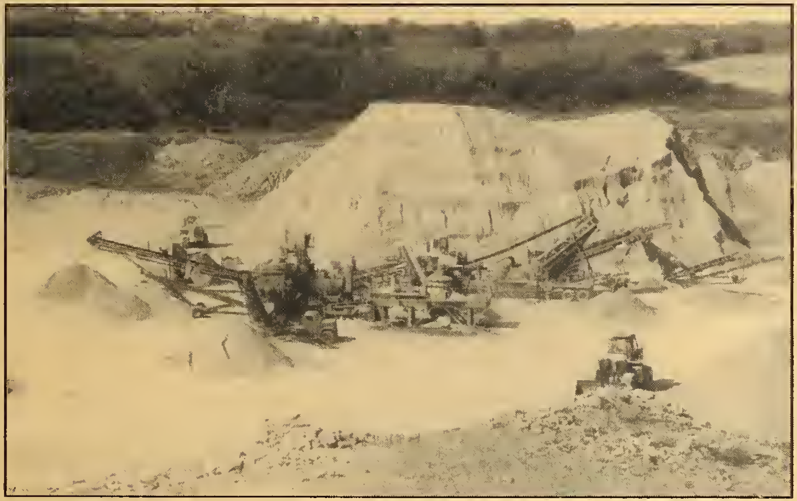
Guide to the Geology of the Elizabeth Area

Jo Daviess County, Illinois

David L. Reinertsen
Wayne T. Frankie



Field Trip Guidebook 1994C September 17, 1994

Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

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Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
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Champaign, IL 61820-6964

Cover photos by W.T. Frankie

Clockwise from upper left: View of Galena Stone Products Quarry, Longhollow Observation Tower, and meanders along Furnace Creek

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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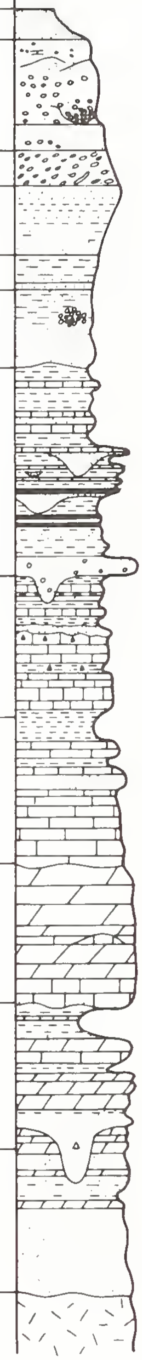
Era	Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks
CENOZOIC "Recent Life" — Age of Mammals	Quaternary 0–500'	Holocene	10,000	Recent—alluvium in river valleys
		Pleistocene Glacial Age	1.6 m.	Glacial till, glacial outwash, gravel, sand, silt, lake deposits of clay and silt, 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.	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")		286 m. – 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.

ELIZABETH AREA

The *mineral**, galena (lead sulfide, PbS), for which the largest city in Jo Daviess County is named, was the focus of much prospecting and mining in extreme northwestern Illinois during the first half of the 1800s. Lead ore played a large role in the economic development, not only of the Galena–Elizabeth area, but also of Illinois. Considerable wealth, amassed by many of the early settlers and developers, gave rise to Jo Daviess County's impressive homes and businesses. The amalgamation of architectural styles, natural setting, people, and mineral resources created the distinctive charm of this part of Illinois.

In 1800, 95% of our nation's population lived east of the Appalachian Mountains. During the early part of the last century, thousands of people had moved west and north seeking cheap, abundant land, and the Illinois Territory and what later became Jo Daviess County experienced a boom in population growth. The population of the Illinois Territory in 1810 was 12,282. In 1820, 2 years after statehood, our population had increased to 55,162. By 1830, it had rapidly grown to 157,445, and by 1840, it had swelled to 476,183. During this period, Jo Daviess County experienced a sort of "lead rush," similar to later gold rushes.

The landscape, *geology*, and mineral resources surrounding the city of Elizabeth are the subjects of this field trip. The area's rugged surface, containing some of the most scenic landscapes in the state, was formed mainly by differential erosion of Ordovician and Silurian *sedimentary strata* (see rock succession column on facing page) consisting primarily of *dolomite* and shale, as well as some *limestone*. Ridges are upheld by resistant dolomite caps, and slopes are developed on soft shale. Steep-walled valleys are incised into lower, older, resistant dolomite strata.

The town of Elizabeth lies approximately 140 miles west-northwest of Chicago, 180 miles north-northwest of Springfield, and 255 miles north of East St. Louis.

Structural and Depositional History

Precambrian Era The Jo Daviess County area, like the rest of present-day Illinois, has undergone many changes through several billion years of geologic time. 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 our state for geologists to collect samples from Precambrian rocks; depths range from some 2,000 to 2,500 feet in the Elizabeth area to at least as much as 17,000 feet in southern Illinois. From these samples, however, we know that the ancient rocks consist mostly of granitic and possibly *metamorphic*, crystalline rocks that formed about 1.5 to 1.0 billion years ago when molten *igneous* materials slowly solidified within the earth. By about 0.6 billion years ago, deep weathering and erosion had exposed the ancient rocks at the surface, forming a landscape probably quite similar to part of 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 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

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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.

Creek *Graben* and the Reelfoot Rift (fig. 1), formed when plate *tectonic* movements (slow global deformation) began to rip apart an ancient Precambrian supercontinent 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 supercontinent eventually isolated a new landmass, called *Laurasia*, which included much of what is now the North American continent.

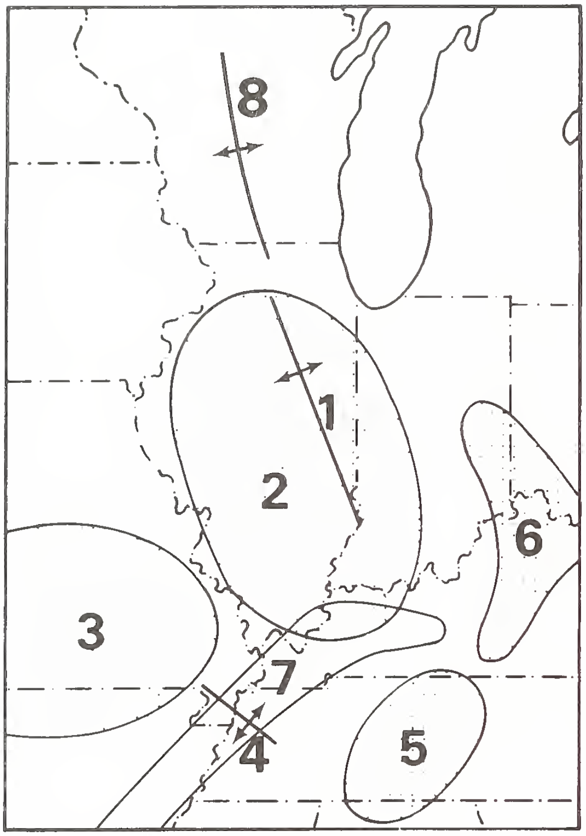


Figure 1 Location of some of the major structures in the Illinois region. (1) La Salle Anticlinal Belt, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Rough Creek Graben-Reelfoot Rift, and (8) Wisconsin Arch.

Near the end of the Precambrian Era and continuing until late Cambrian time, about 570 million to 505 million years ago, tensional forces within the earth apparently caused block *faulting* and relatively rapid subsidence of the hilly landscape on a regional scale. This permitted the invasion of a shallow sea from the south and southwest.

Paleozoic Era During the Paleozoic Era, what is now southern Illinois continued to sink slowly and to accumulate sediments deposited in shallow seas that repeatedly covered the area. At least 15,000 feet of sedimentary strata accumulated during the 325 million years of the Paleozoic Era. These sediments, when compacted and hardened (*indurated*), and the underlying Precambrian rocks constitute the bedrock succession. Bedrock refers to the indurated or lithified rock units that underlie the soils or other relatively loose, crumbly, materials near Earth's surface.

The field trip area appears to be underlain by as much as 2,500 feet of Paleozoic sedimentary strata, ranging from deeply buried rocks of late Cambrian age (about 523 million years old) to surface exposures of lower Silurian age (about 423 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 into surrounding areas as well. Because of compressive and stretching forces that developed at various times, 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, wind, and streams, 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

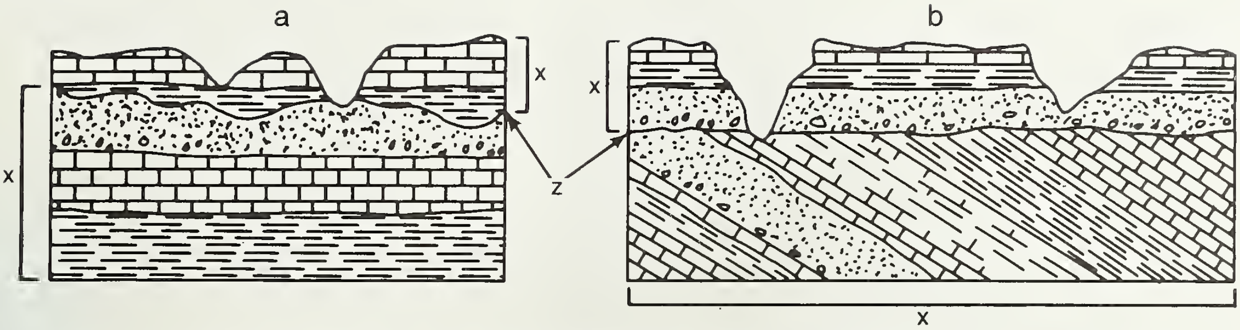


Figure 2 Schematic drawings of (a) a disconformity and (b) an angular unconformity (x represents the conformable rock sequence and z is the plane of unconformity).

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 St. Peter Sandstone or Scales Shale, 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., Dubuque Formation). A group, such as the Galena Group or the Maquoketa Shale 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 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. 2a); where the lower beds were tilted and eroded before the overlying beds were deposited, the contact is called an angular unconformity (fig. 2b). Major unconformities are indicated on the 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.

Ordovician Period The oldest rock exposed on the field trip is the middle Ordovician dolomite of the Wise Lake Formation in the upper part of the Galena Group (fig. 3), which formed from sediments deposited in the embayment that encompassed present-day Illinois about 468 million years ago. Most of the remaining Galena Group strata are dolomite (calcium magnesium carbonate, $CaMg(CO_3)_2$) that was originally deposited as limestone ($CaCO_3$) in the shallow seas of the embayment that covered what is now Illinois and adjoining states. The limestone was later altered to dolomite. The total thickness of the Galena Group is about 245 feet. The upper Ordovician Maquoketa Shale Group unconformably overlies the Galena Group. The mud that produced the shale was flushed into shallow areas from nearby low-lying land areas. These shales are the youngest Ordovician rocks and are about 200 feet thick.

Silurian Period The youngest Ordovician strata were partially eroded before early Silurian sediments accumulated in shallow seas covering what is now northwesternmost Illinois. Nearby low-

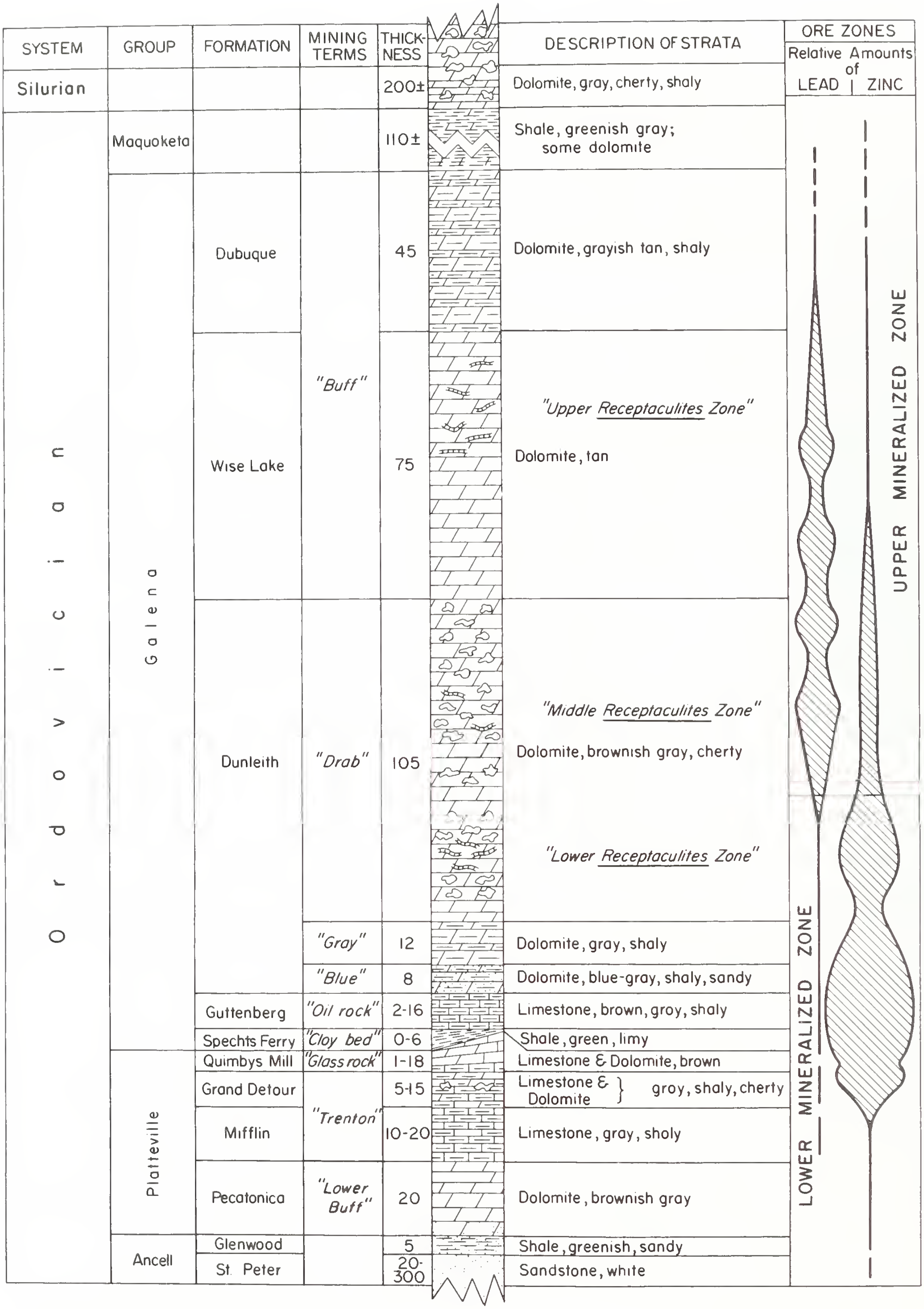


Figure 3 Generalized sequence of strata in the Elizabeth area.

lying lands generally did not contribute much sediment to the seas covering the region from 438 to about 420 million years ago. Most of the sediment deposited during this period consisted of limestone formed primarily from the shells of living organisms, both animals and plants. Early Silurian dolomite, which is the resistant caprock (top layer of rock) of the high ridges in the field trip area, reaches a thickness of about 140 feet. A greater thickness of Silurian strata may have been present across the area, but subsequent erosion removed it. Furthermore, still younger rocks may also have been present, but long periods of erosion may have removed them as well.

Regionally, the bedrock strata essentially are flat-lying, although there is a slight tilt of about 16 feet per mile to the south-southwest away from the Wisconsin Arch (figs. 1 and 4). The area's major structural features consist of low-amplitude northeast-trending synclines (downward arches) formed by a northwest–southeast compressive force. An east–west, preexisting joint system seems to have dissipated the shearing component of the northwest–southeast compressive force by yielding along fracture zones that were later favorable for ore deposition. Bradbury (1960) postulated that the staggered (en echelon) arrangement of north–northwest-trending smaller synclines and ore bodies may have formed as a result of a set of localized forces, such as might be created by a strike-slip (horizontal displacement) fault in the basement rocks.

Mesozoic and Cenozoic Eras After the Paleozoic Era (approximately 245 million years ago), during the Mesozoic Era, the rise of the Pascola Arch (fig. 1) in what is now 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 encompassing 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 gave the basin its present asymmetrical, spoon shape. The geologic map of Illinois (fig. 6) shows the distribution of various rock systems as they occur at the bedrock surface; that is, as if all glacial, windblown, and other surface materials were removed.

During the Mesozoic and part of the Cenozoic Eras, a span of some 243 million years, and before the start of *glaciation* about 2 million years ago, the ancient Illinois land surface apparently was exposed to essentially continuous weathering and erosion. This erosion carved a series of deep valley systems into the gently tilted bedrock formations. All rocks except those of Precambrian age were subjected to erosion somewhere in Illinois in these valleys. As much as several thousand feet of post-Pennsylvanian bedrock strata may have been removed during this episode.

Glacial history Beginning nearly 2 million years ago, during the Pleistocene *Epoch*, massive sheets of ice—continental glaciers—several hundred feet thick flowed southward from centers of snow and ice accumulation in the far north and covered parts of present-day Illinois several times (fig. 7). The surface topography was considerably subdued by the repeated advance and melting of the glaciers, which scoured and scraped the old preglacial erosion surface. Exposed bedrock that was not directly eroded by the ice was indirectly affected by a drape or mantle of fine, windblown silt called *loess* (rhymes with bus).

North American continental glaciers reached their southernmost extent during Illinoian glaciation, from perhaps 300,000 to 175,000 years before the present. Advancing from centers of snow and ice accumulation in what is now Canada, the glaciers reached as far as the northern part of Johnson County in southern Illinois, about 340 miles south-southeast of Elizabeth.

Figure 7 shows the extent of the various major glaciations that covered Illinois. We are located in the area marked by stippling in figure 7, in the unglaciated area known as the Wisconsin Driftless Section, or the "*Driftless Area*" as it is commonly called (fig. 8).

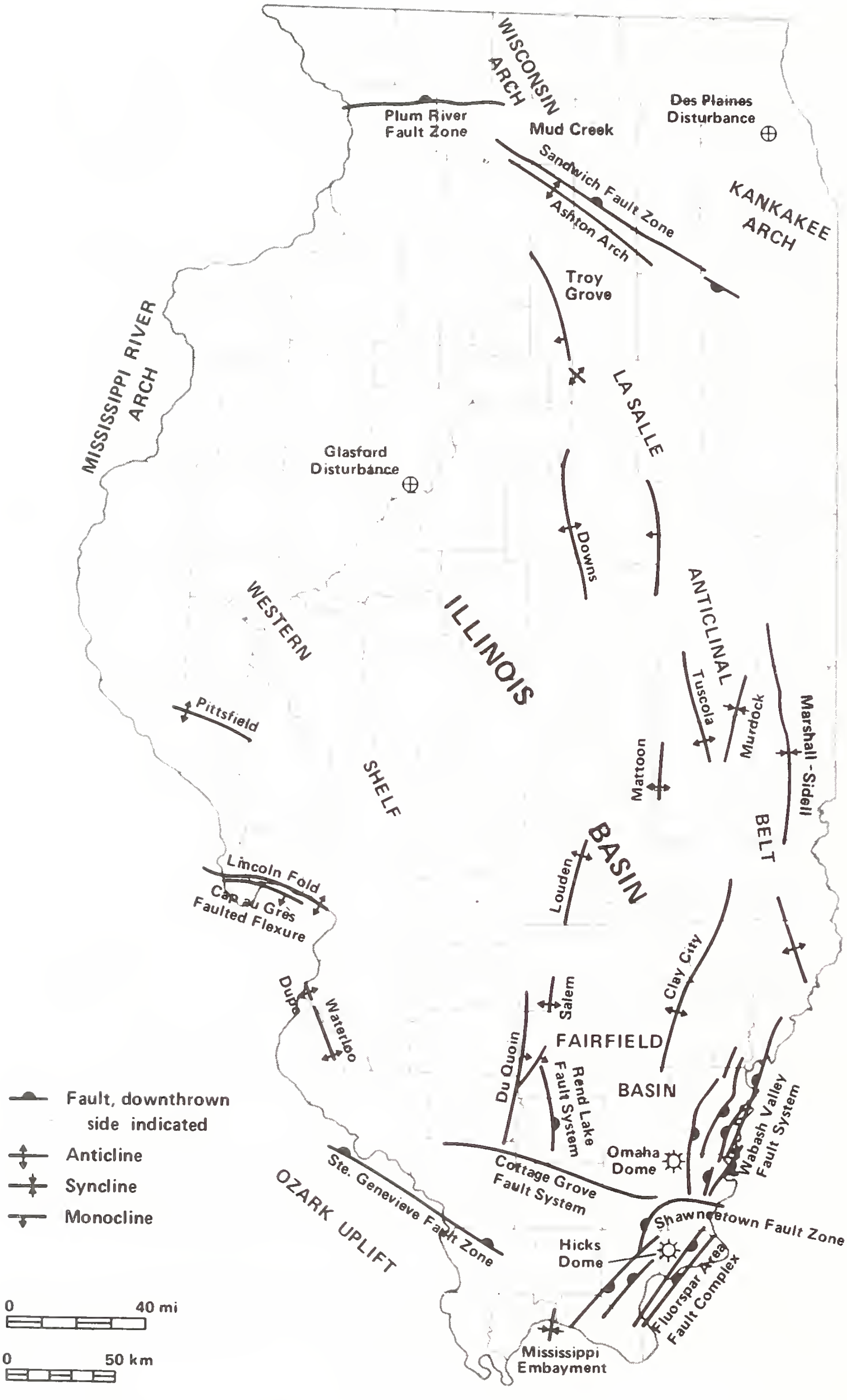


Figure 4 Structural features of Illinois.

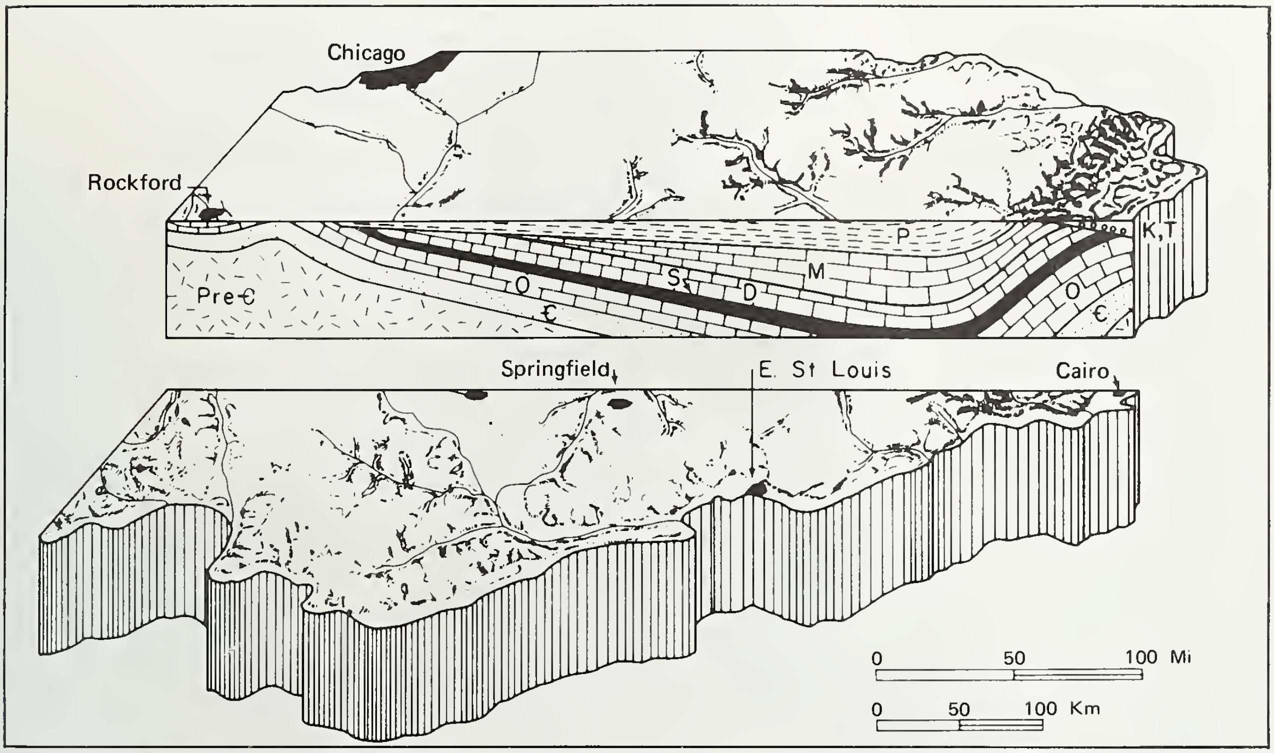


Figure 5 Stylized north–south cross section shows the structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks has been greatly exaggerated and younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-C) granites. They form a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

The closest point of the Illinoian glacial boundary is about 5 miles northeast of the confluence of Mill Creek and Apple River (Stop 3), the easternmost extent of the Elizabeth field trip. Although glaciers did not cover this area, nor completely surround it at any one time during the major ice advances (fig. 7), *outwash* deposits of silt, sand, and gravel were dumped along the Mississippi Valley. When these deposits dried out during the winters, strong prevailing winds from the northwest winnowed out the finer materials, such as fine sand and silt, and carried them eastward across the unglaciated terrain. Loess up to 35 feet thick has been found in a narrow band along the uplands adjacent to the Mississippi River, but it thins away from the river to less than 12 feet thick in northeastern Jo Daviess County.

GEOMORPHOLOGY

Physiography

A *physiographic province* is a region in which the relief and landforms differ markedly from those in adjacent regions. The Wisconsin Driftless Section has some of the most rugged topography in Illinois. The area is a submaturely dissected, low plateau bounded by the outwash-filled valley of the Mississippi to the west and the Illinoian glacial margin on the east and southeast. Only loess, in which the modern soils are developed, mantles the deeply dissected bedrock surface. Remnants of the upland surface remain, but most of the area is in slopes. Except for the major streams, most drainage is via a system of V-shaped, steep-walled, relatively short tributaries with steep *gradients* (longitudinal bottom slope). Some of the minor tributaries have incised *meanders*. *Sinkholes* (depressions caused by dissolution of underlying dolomite) and other karst features, although present, are not conspicuous.

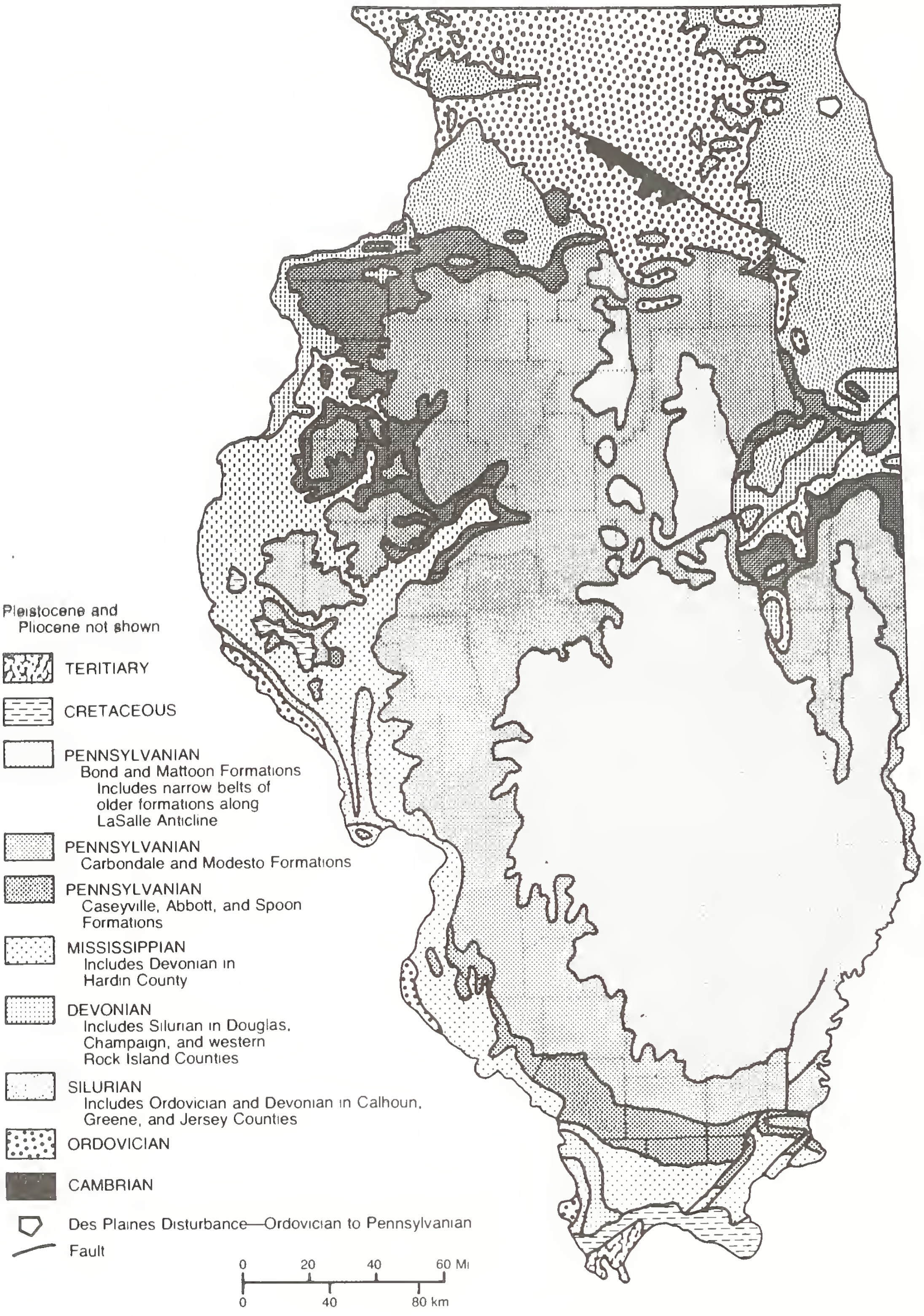


Figure 6 Bedrock geology beneath surficial deposits in Illinois.

Figure 7 Maximum extent of (a) early Pre-Illinoian (about 1 million years ago), (b) late Pre-Illinoian glaciation (about 600,000 years ago), (c) Illinois glaciation (about 250,000 years ago), and (d) late Wisconsinan glaciation (22,000 years ago). Driftless area is shown by stippled pattern, and arrows indicate direction of ice movement.

Drainage

The Mississippi River is the major drainageway, or master stream, in northwestern Illinois. The main tributary in the Elizabeth area is the Apple River, which flows southwest to the master stream. The larger tributaries that we encounter include Hells Branch, and Mill and Furnace Creeks. As noted previously, a well-developed network of smaller, V-shaped, steep-gradient tributaries has grown headward into the upland remnants. Considerable subsurface drainage occurs through small caves and solution channels that have developed in the dolomite bedrock.

Relief

Relief is defined as the vertical difference in elevation between the hilltops or mountain summits and the lowlands or valley bottoms of a particular area. The highest point along the field trip route is roughly 1,015 feet above mean sea level (msl) in the northern part of the area at Stop 1; the hill several hundred feet east of the stop is slightly more than 1,060 feet msl. The lowest elevation on the route is 632 feet msl at the bridge crossing Furnace Creek about 0.2 mile southwest of Stop 6.

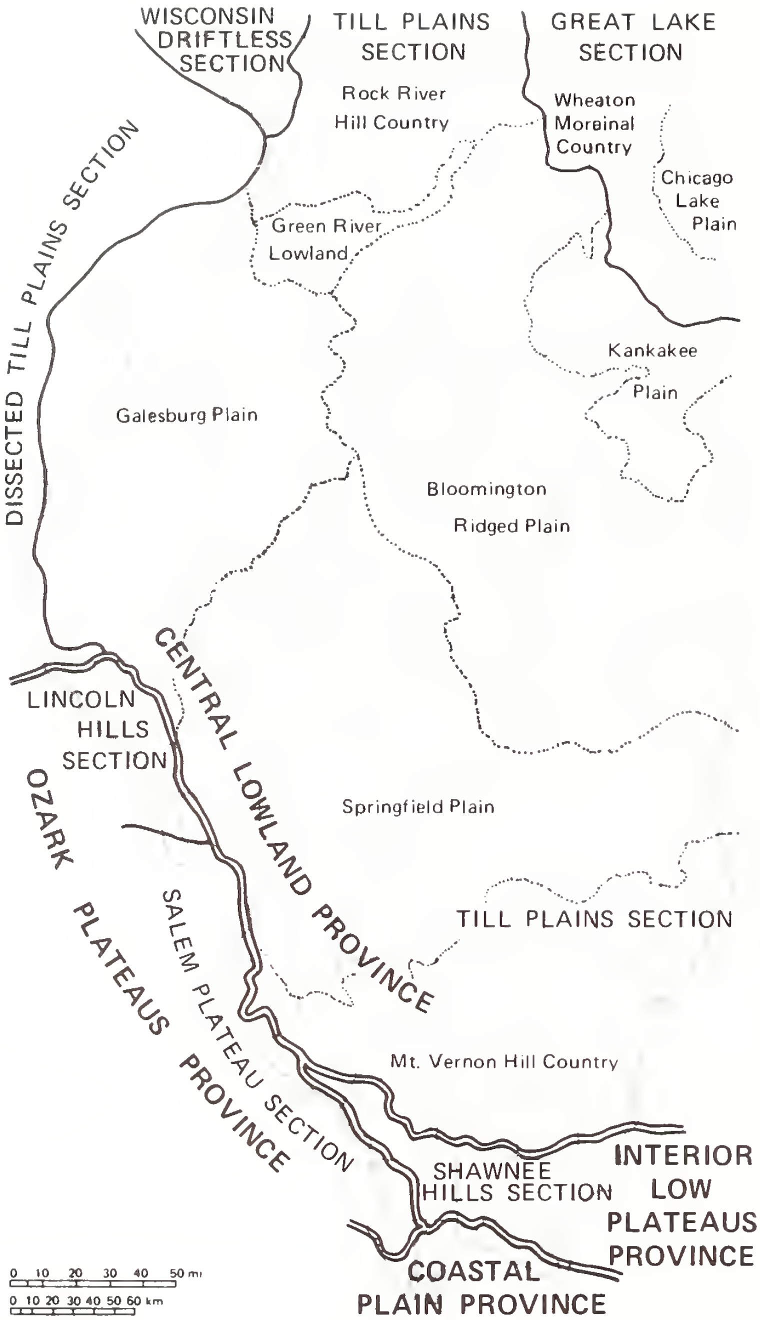


Figure 8 Physiographic division of Illinois.

The relief along the route is therefore slightly more than 380 feet. Local relief of 150 to 200 feet in 0.25 to 0.5 mile is fairly common in this area, and it approaches 300 feet in a few places.

The highest point in Illinois is Charles Mound with an elevation of 1,235 feet msl. It is about 9 miles north-northwest of Stop 2 and 0.25 mile south of the Wisconsin state line. The lowest elevation in the region is the Mississippi River surface, which has a normal pool elevation of 592 feet msl upstream from Lock and Dam No. 12 at Bellevue, Iowa. Regional relief is thus about 643 feet.

MINERAL RESOURCES

Mineral Production

The field trip route lies within the heart of the Zinc and Lead District of Northwestern Illinois. Areas of mineralization in Illinois, Iowa, and Wisconsin make up the Upper Mississippi Valley District. The Illinois portion of the district has a history of lead mining that dates from Indian mines from the late 1700s. The last commercial zinc and lead operation was closed in 1973.

Among all counties in Illinois, Jo Daviess County ranked 90th in 1992 in total value of minerals extracted—only stone and sand and gravel were mined. The stone produced here is used as agricultural lime, roadstone, and riprap. Of the 102 counties in Illinois, 97 reported mineral production during 1992, the last year for which complete records are available.

Jo Daviess and 15 other northern Illinois counties make up the U.S. Bureau of Mines District 1. During 1992, 51 companies with 59 operations produced more than 22 million tons of sand and gravel, with a value of slightly more than $83 million. Current data for stone production are not available because they are available only for odd-numbered years.

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 just 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) 1991. Illinois ranked 16th among the 50 states in total production of nonfuel minerals and continued to lead all other states in production of industrial sand, tripoli, and fluorspar.

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.

Thick permeable sand and gravel deposits occur locally in the Mississippi Valley, and some may be found in the major tributaries, especially in the lower parts of their valleys. Electrical earth resistivity surveys (a geophysical method for characterizing buried sand and gravel deposits) can be useful in locating groundwater supplies in these valleys.

Silurian and Ordovician dolomite units are creviced and water-bearing. Most domestic water wells in the area get their water from these formations at depths of less than 250 feet. Wells into these creviced formations are susceptible to bacterial pollution, particularly where the formation is overlain by less than 35 feet of overburden (soil and/or unconsolidated materials above the formation). Open crevices provide little filtering action and polluted water may travel long distances through these openings with little loss of pollutants.

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.

GUIDE TO THE ROUTE

Assemble in the parking area on the southwest side of River Ridge Community High School (SW NW SE, Sec. 24, T27N, R2E, 4th P.M., Jo Daviess County; Elizabeth 7.5-Minute Quadrangle [42090C2]*). We'll start calculating mileage at the intersection of West Street and Madison Street (US 20) just outside of the parking lot exit and to the right.

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.

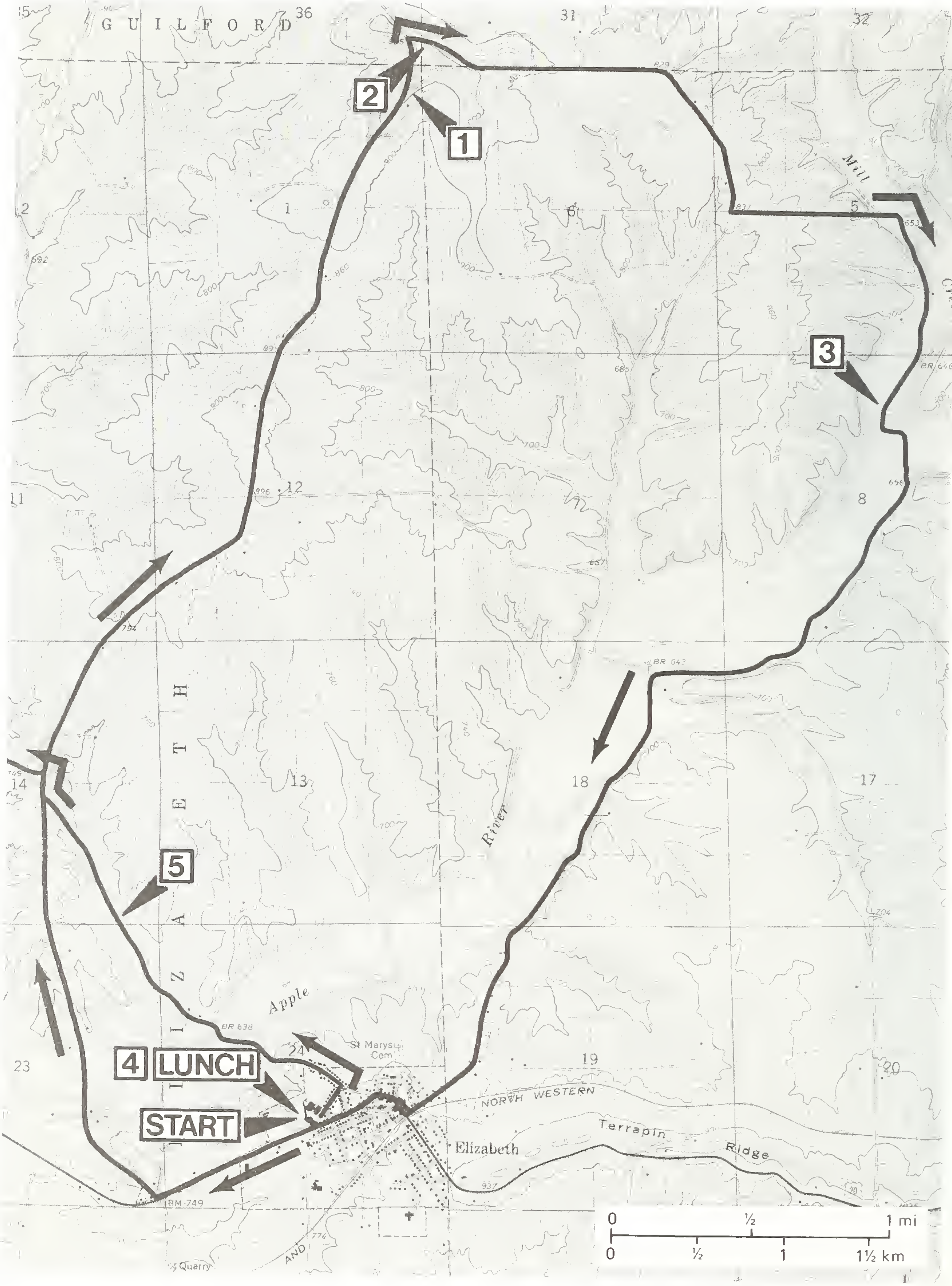
Note: Some stops on the field trip are on private property. The owners have graciously given us permission to visit on the day of the field trip only. Please conduct yourselves as guests and obey all instructions from the trip leaders. So that we may be welcome to return on future field trips:

- 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: 1-way stop at the intersection of West and Madison Streets. TURN RIGHT (southwest) on US 20.
0.5	0.5	Prepare to TURN RIGHT.
0.1	0.6	TURN RIGHT (northwest) onto the Elizabeth-Scales Mound blacktop.
0.45	1.05	Cross Apple River bridge.
0.45+	1.5+	View to the left at about 10 o'clock is of a large roadcut on US 20 that we will pass later this afternoon; we will also visit an observation tower farther up on top of the ridge.
0.6+	2.15	South Georgetown Road intersection to the right. CONTINUE AHEAD (north) on the Scales Mound blacktop. The view to the right (northeast) is of a farm with three silos. Up the hill to the left of the silos are a couple of small spoil piles; up the hill to the right on the other side of the valley is a larger spoil pile beneath a tree. These spoil piles are from old diggings along a crevice filling of lead. The abandoned Wishon Mine shaft was located near the larger pile.

* The number in brackets [42090C2] 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.


GUILFORD
ELIZABETH
1
2
3
4 LUNCH
5
START
Mill
Apple
River
St Marys Cem
NORTH WESTERN
Terrapin
Ridge
Elizabeth
Quarry
BR 638
BR 642
BM 749
0 ½ 1 mi
0 ½ 1 1½ km

0.25	2.4	The upland slopes here are underlain by the OrdovicianMaquoketa shale. The ridge tops in the distance, to the right and left, are capped by Silurian dolomite, which is quite resistant to erosion and therefore protects the underlying Maquoketa shale.
0.65	3.05	This roadcut is in Maquoketa siltstones and silty shales. The west side (left) shows considerable evidence of slumping because of the weak bedrock and overlying surface materials here.
0.45+	3.5+	T-Road, Shaw Road, from the right. CONTINUE AHEAD (north) on Scales Mound Road.
0.2+	3.7+	To the left are large blocks of Silurian dolomite that are remnants of an earlier thicker and more extensive bedrock surface in this area.
0.25+	3.95+	Good scenic views to both the right and left.
0.2	4.15+	This roadcut also shows the thin bedded siltstones and shales in the Maquoketa Group.
0.3	4.45+	Just behind the house to the left is an exposure of the Silurian dolomite that caps and protects this hill. The roadcut on either side has the upper part of the Maquoketa present and some of the lower Silurian rocks, but they are difficult to see because of surface slumping and vegetation. CONTINUE AHEAD (north).
0.1+	4.6+	In the roadcut to the left is a piece of Silurian dolomite partly covered by crown vetch. Considerable digging would be necessary to ascertain whether it is in place or is a slump block from higher up on the hillside.
0.2+	4.8+	To the left is the route of the old road around this knob. The roadcut exposes Silurian dolomite.
0.2+	5.05+	PARK along the roadside as far off the road as you safely can. CAUTION: • Limited visibility and fast traffic. • Stay on the right side of the roadcut unless instructed otherwise. • Do NOT pull or push down large slabs or blocks from the roadcut face. • If you pick up a rock or a slab, put it down when you are finished with it. Please do NOT drop or throw it down! • Do NOT climb to the top of the face! It is unstable. If you are compelled to get to the top, please approach it from either end where the rocks are more stable.

STOP 1 On both sides of the roadcut we will observe Silurian dolomite of the Mosalem and Tete des Morts Formations and geest, a deep red residual clay containing much chert (NE NE NE, Sec. 1, T27N, R2E, 4th P.M., Jo Daviess County; Elizabeth 7.5-Minute Quadrangle [42090C2]). Silurian formations make up the upper part of the bedrock in the field trip area (fig. 9).

Throughout the area where it only caps the knobs and ridges, the Silurian dolomite seldom is more than 75 feet thick and generally is much thinner. Because of a regional southward dip, the Silurian strata thicken to as much as 300 feet in the southern part of the Driftless Area, particularly in the synclinal belt along the north side of the Plum River Fault Zone (Kolata and Buschbach 1976).

SERIES	FORMATION	COLUMN	THICK.* (ft)	GENERAL CHARACTER
NIAGARAN	Racine		300	Dolomite, pure, gray, thin-bedded to massive; local reef structures; local areas of brownish gray, argillaceous dolomite
	Marcus		35–45	Dolomite, very pure, buff, vesicular, massive; contains *Pentamerus* in great abundance in lower 5'-15'
ALEXANDRIAN	Sweeney		45–55	Dolomite, pure, pinkish gray; in thin wavy beds with green clay partings; corals abundant; 3'-5' cherty zone near middle contains *Microcardinalia* and *Pentamerus*
	Blanding		35–50	Dolomite, pure, brownish gray; lower 3'-8' slightly argillaceous; contains many layers of white chert; silicified corals abundant
	Tete des Morts	gl	0–24	Dolomite, pure, gray, glauconitic, massive, cliff-forming; persistent chert band in upper part; silicified corals abundant; pitted surface on top
	Mosalem		0–100	Dolomite; upper 20'-30' is argillaceous, gray, cherty, medium bedded; lower part is very argillaceous dolomite grading to dolomitic shale at base

*Where overlain by next younger unit.

Figure 9 Silurian strata in northwestern Illinois (Willman 1973).

The Mosalem Formation at the base is largely argillaceous, medium to dark gray, partly cherty dolomite that ranges from only a few feet to as much as 100 feet thick. It is thickest where it fills channels in the underlying Maquoketa Group. It weathers to yellow to brown. The Mosalem is the thinner bedded, slabby, more broken dolomite in the bottom of the cut; it is some 15 feet thick. Although the formation is largely nonfossiliferous, fossils are present in some places.

The overlying Tete des Morts Formation is a relatively pure, fine- to medium-grained, massive, slightly cherty, light gray dolomite that is 15 to 20 feet thick. It forms conspicuous cliffs at or near the top of the Silurian exposures in the ridges and knobs north of Hanover, which is about 8 miles south-southwest from here. South of Hanover it thins rapidly and disappears. The Tete des Morts dolomite is generally thicker bedded with many pits or vesicles in it, and it looks different from the underlying Mosalem dolomite. Except for corals, particularly *Favosites*, fossils are scarce.

The uppermost unit exposed in the roadcut is "geest" (also called "residuum" or "terra rossa"). This red clay layer underlies thick deposits of loess where present and overlies dolomite and limestone formations in northwestern Illinois. No glacial materials have been found in the geest deposits. The presence of geest directly overlying erosional surfaces indicates that at least a major part of the geest deposits are Tertiary. The abundance of white chert in the geest and the presence of white chert in the underlying Silurian dolomite indicate that the geest on the highest erosional surfaces is largely residuum from solution of the underlying dolomite.

0.0	5.05+	Leave STOP 1; CONTINUE AHEAD (north) and prepare to turn right.
0.15+	5.25+	TURN RIGHT (east) at the T-intersection onto East Hoffman Road.
0.05+	5.3+	PARK on the shoulder as far off of the blacktop as you safely can. CAUTION: • Narrow road • Limited visibility to the east • Do NOT block the drive.

STOP 2 We'll discuss the *peneplains* and erosional surfaces from this viewpont ($NW_{extended}$ SW SW SW, Sec. 31, T28N, R3E, 4th P.M., Jo Daviess County; Elizabeth 7.5-Minute Quadrangle [42090C2]).

Topography of the field trip area Since the last Paleozoic sea withdrew from the Midcontinent at the end of the Pennsylvanian Period some 286 million years ago, or possibly as late as the end of the Permian Period nearly 245 million years ago, the Upper Mississippi Valley region has remained a land area. During this long interval of erosion, many hundreds of feet of Paleozoic strata have been stripped away. During the Pliocene Epoch between 5.3 and 1.6 million years ago, near the end of the Tertiary Period, the topography or relief of the region was reduced to a very low plain, the Dodgeville Peneplain.

A peneplain is a land surface worn down by stream erosion and mass wasting to a low, nearly featureless plain that gradually slopes upward from the sea. Such an erosion surface would take a very long time to develop, and it would be characterized by sluggish streams flowing in broad valleys. Bedrock structures, such as *anticlines* (strata arched upward), would have no influence on the topography but would be uniformly beveled.

Within the field trip area, the slope of the Dodgeville Peneplain and the dip of the Silurian dolomite are the same. The erosion surface corresponds to the dip slope—a fact cited by some geologists who argue that the upland surface is not a peneplain at all but a structurally controlled feature that formed when strata less resistant than the Silurian dolomite were stripped away. Northward in Wisconsin and Minnesota, however, the surface bevels Ordovician strata that dip more steeply. Other arguments against the peneplain idea include the absence of a thick residual soil and the apparent control of present-day streams by bedrock joints, factors that should not exist if the region had been peneplained.

In the Driftless Area (unglaciated terrain) of Wisconsin, the Dodgeville surface is well preserved. In Jo Daviess County, Illinois, only remnants of the Dodgeville Peneplain are preserved as isolated, flat-topped ridges and knobs of Silurian dolomite (fig. 10). We can only imagine the tops of these Silurian flats joined by a plane surface representing the former peneplain, sloping gently southwestward from about 1,235 to 1,000 feet msl.

After the Dodgeville Peneplain was formed, the region was uplifted and another partial peneplain called the Lancaster Peneplain was eroded down to resistant strata about 200 feet lower. The Lancaster Peneplain is extensively preserved on the bedrock surface of northern Illinois. It is well

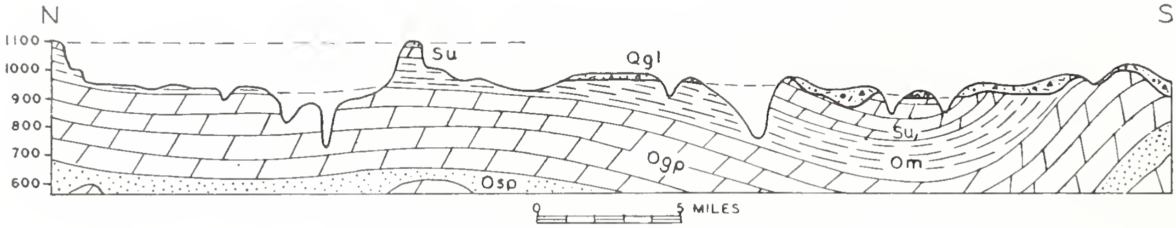


Figure 10 Cross section shows Dodgeville (upper) and Lancaster (lower) surfaces in northwestern Illinois from Apple River to northwestern Carroll County. Qgl, glacial drift; Su, Silurian dolomite; Ogp, Galena-Platteville dolomite; Osp, St. Peter Sandstone (Horberg 1950).

developed in the Driftless Area. East of the Driftless Area, it is a gently undulating surface covered by glacial deposits. It closely coincides with the top of the Galena Dolomite and slopes southwestward from an elevation of about 985 to 800 feet msl. The field trip area is near the south edge of the Lancaster Peneplain. The Lancaster surface, which slopes southwestward, is evident by the even horizon toward the east, north, and west. The skyline appears even because the nearly common summit levels merge when viewed from a distance.

The present topography of the Elizabeth area is the result of stream dissection of the Lancaster Peneplain during the Pleistocene glaciations and modification of the dissected surface by glacial deposits. The Driftless Area is more rugged than adjacent areas because it was never glaciated; however, its mature topography is not a preglacial, erosion surface as was formerly thought. It was also eroded during the Pleistocene.

The relief of the bedrock surface is closely related to the establishment of the Mississippi Valley through the region during the earliest pre-Illinoian glaciation. Maximum relief was probably developed during the latter stages of pre-Illinoian glaciation when the valley was eroded to its maximum depth by meltwater. After that, the valley was alternately aggraded (built up) by outwash and reexcavated during subsequent glacial and interglacial intervals. In the glaciated area to the east and south, till and outwash were deposited on the bedrock surface during the Illinoian glaciation. Loess was deposited on the uplands throughout the Upper Mississippi Valley region during the Illinoian and Wisconsinan glaciations. Deposition of a thick *valley train* in the Mississippi Valley during the late Wisconsinan Woodfordian and Valderan glaciations aggraded the valley to a level approximately 30 feet above its present *floodplain*. This *aggradation* also resulted in *alluviation* of the tributary valleys. Since the last glacier melted away, the Mississippi River and its tributaries have been deepening their valleys in the Wisconsinan *alluvial* deposits.

From this vantage point you can see some farming practices that are not so common elsewhere in Illinois. Crops, planted in strips following the contour around the hills and along slopes, appear like a patchwork quilt. This practice minimizes erosion on the steep slopes in the region. In some cases, ridges have been constructed following the contour around the hills, and the crops are planted in the flatter areas behind the ridge crest. This practice helps conserve moisture by reducing run-off from the field. In some locations you see grass strips from high up on the slopes heading downslope—these are grass-waterways. Thick, coarse grass is established to minimize downcutting of surface run-off. As a result, you see very few gullies here compared with the number you see elsewhere in the state, even though you would expect to see more gullying here because of the steepness of the slopes and the fact that easily eroded shale underlies the loessal soils.

0.0	5.3+	Leave STOP 2 and CONTINUE AHEAD (east).
0.1	5.4+	Blocks of Silurian Tete de Morts dolomite have slumped down the slope here.
0.1	5.5+	Part way around the curve note the small flat areas on both sides of the road. These are probably developed on the lower part of the Mosalem dolomite. The gentle slopes below the flat areas are underlain by the Maquoketa Group.
0.65+	6.2	Y-intersection. BEAR RIGHT (south) on Hoffman Road, a gravel road.
0.35	6.55+	The high ground in the distance to the south is Terrapin Ridge, which is just east of Elizabeth. Terrapin Ridge is also capped by Silurian dolomite and is slightly more than 1040 feet (msl) in elevation.
0.2+	6.75+	TURN LEFT (east) on East Hoffman Road at the T-intersection with Goose Hollow Road.
0.1	6.85+	To the right, the vertical fenceline suddenly becomes nearly horizontal for a short distance. The surface materials in the north-facing bank do not dry out quickly and are, therefore, susceptible to slumping. The field beyond the fence shows evidence of slope wash.
0.25	7.1+	The slope of the road steepens as you come down across the edge of the resistant Galena Group dolomite.
0.05-	7.15+	The Galena Group (Wise Lake Formation) strata become thicker bedded as we go down the slope into the valley of Mill Creek.
0.2	7.35+	TURN RIGHT (south) at the Y-intersection onto South Grebner Road. Apple Canyon Lake lies about 4 miles north-northeast of here.
0.2+	7.55+	The valley to the left widens from 0.15 to 0.3 mile as the valley of Hells Branch intersects Mill Creek.
0.2+	7.8+	The confluence of Mill Creek and Hells Branch is some 330 feet to the left.
0.05+	7.85+	T-road from left, South Salem Road. CONTINUE AHEAD south on South Grebner Road.
0.2	8.05+	PARK along the shoulder as far off the road as you safely can. CAUTION: • The road is narrow and visibility is somewhat restricted. • View the river from the narrow iron bridge just ahead. • Note that there is a 3-ton load limit on the bridge—that's 60 kids each weighing 100 pounds. • Do NOT throw rocks into the river!

STOP 3 We'll discuss the history of Apple River (SW NW SE, Sec. 24, T27N, R3E, 4th P.M., Jo Daviess County; Elizabeth 7.5-Minute Quadrangle [42090C2]).

The confluence of Apple River (on the right) and Mill Creek (on the left) is just east of the bridge. The valley of Apple River is just about the same width as that of Mill Creek. Downstream toward the Mississippi, about 13 miles south-southwest from here, the valley of Apple River widens and the river meanders across this wider mature valley.

Trowbridge and Shaw (1916) studied this region in considerable detail and surmised that some peculiar characteristics of the valley of Apple River northeast of this locality strongly indicated that a major change in the area's drainage occurred as a result of Illinoian glaciation. Their studies showed that a northwest–southeast oriented drainage system flowed through what is now Apple River Canyon State Park during Pre-Illinoian time. A number of tributaries drained into it, and the valley bottom widened toward the southeast. A drainage divide lying a short distance southwest of this stream separated it from the larger Apple River system that drained southwest. Tributaries from each system eroded their own valleys headward into the divide. As chance would have it, two of these tributaries were aligned so that as their valleys were extended headward toward each other and deepened by erosion, a sag developed across the divide.

The southeastern part of the northern drainage system was blocked later by the Illinoian glacier. Water flowing southeast from the headwaters and meltwater flowing northwestward from the glacier formed a lake where the surface rose high enough to discharge across the sag in the divide noted previously. As the water flow increased across this sag, its downcutting action accelerated and cut the canyon southwestward some 3.5 miles to Lilly Branch, about 6 miles northeast of here. This nearly straight, deep, narrow, steep-walled canyon is as much as 200 feet deep, 250 to 400 feet wide at the bottom and usually full of water, and 1,500 to 1,700 feet wide at the upper rim. Only a few small, short, steep tributaries enter the river in this stretch, all of which are characteristic of a youthful stream. The main canyon, therefore, is younger than the valley upstream from it.

The southeastern part of the northern drainage system remained buried by glacial deposits when the glacier melted. The flow of the South Fork, the stream that occupied the remainder of the old valley southeast of the canyon junction, was reversed to flow northwest toward the canyon. The lake was drained as the bottom of the canyon was eroded to a depth slightly lower than the lake bottom. Several tributaries join the South Fork with "v"s opening toward the northwest, as they did before stream reversal took place. Tributaries northwest of the canyon also have this feature.

Later melting of the Wisconsinan ice sheet in regions outside of this area provided vast quantities of water to the Mississippi River, depositing sand and gravel and ponding back its tributaries. As we continue on the route, there will be places where you will be high enough above the Apple River floodplain to see some of the large meanders mentioned previously.

0.0	8.05+	Leave STOP 3 and CONTINUE AHEAD across the bridge. NOTE: Do NOT follow the car ahead too closely because there is a weight limit of 3 tons on the bridge!
0.3+	8.4+	CAUTION: Unguarded intersection of South Grebner Road and South Apple River Road. Visibility is restricted to the left. TURN RIGHT (southwest) on Apple River Road.
0.45	8.85	From this little rise along the south valley wall you can get a better idea of the size of the Apple River floodplain and view the river's meanders.
0.6	9.45	Cross a rock-supported ledge of Wise Lake dolomite, part of which is exposed along the left side of the road. You are just above the river here.
0.2+	9.65+	CAUTION: lopsided intersection of South Apple River, Goose Hollow, and South Becker Roads. Do NOT cross the bridge. CONTINUE AHEAD and TO THE RIGHT on South Apple River Road.

0.3+	10.0	CAUTION: climb the hill; there is a precipitous drop on the right to Apple River! To the left for the next 0.6 mile, slumping has affected earth materials to some degree, although vegetation masks much of what has slumped. You can view meanders of Apple River through openings in the trees on the right.
0.6+	10.6+	CAUTION: precipitous slope on the right to Apple River.
0.7	11.3+	CAUTION: enter the northeastern part of Elizabeth.
0.15+	11.5	STOP: 2-way stop at the intersection. TURN RIGHT (northwest) on US 20 and enter the business district. Stay on US 20 for the next 0.35+ mile to the high school turn-off.
0.35+	11.85+	TURN HARD RIGHT (northeast) and then LEFT (west) to enter River Ridge Community High School's parking lot. NOTE: please keep the caravan intact as much as possible to facilitate departing for the afternoon part of the field trip. Mileage figures will resume from the parking lot entrance/exit.

STOP 4 LUNCH. We will break for lunch here.

0.0	11.85+	Leave STOP 4 and TURN LEFT (northeast) on West Street.
0.15+	12.05+	STOP: 1-way stop at the T-intersection with West Main Street. TURN LEFT (northwest) and proceed downhill.
0.15	12.2+	The slope of the road steepens as we come down over the Ordovician Galena Group Wise Lake Formation.
0.15	12.35+	CAUTION: gravel road ahead.
0.15+	12.55	CAUTION: enter old, 1-lane, wood-floored, iron bridge. Do NOT follow the car in front of you too closely because of weight considerations.
0.05	12.6	CAUTION: road steepens markedly as it comes up across the outcrop of Wise Lake strata.
0.5+	13.15	PARK along the shoulder as far off the road as you safely can. NOTE: • Enter this property ONLY through the gate. • Do NOT go through OR over any fences. • You MUST HAVE PERMISSION! • The actual stop locality is north of the gate by about 0.2 mile.

STOP 5 We'll discuss early lead mining in the Elizabeth area at the abandoned site of the Haggerty Mining and Development Company (Gate: SE SW SE SE, Sec. 14, T27N, R2E, 4th P.M., Jo Daviess County; Elizabeth 7.5-Minute Quadrangle [42090C2]).

The rocks exposed in this vicinity belong to the Galena Group, which is approximately 250 feet thick in the area of the field trip. This group contains practically all of the region's lead and zinc ore. Its name is derived primarily from this fact, the lead ore being primarily in the form of the mineral galena. The Galena Group is exposed in the quarry we will visit at Stop 7, and it forms the valley walls of the Apple River and its tributaries.

With the exception of a small amount of limestone, oil-rock, and shale at the base, as well as a few limestone layers and shaley partings near the top, the Galena Group consists of dolomite. It is crystalline, coarse grained, porous, and weathers into exceedingly rough, irregular forms. Hand sized specimens show small cavities, many of which are lined with dolomite or calcite crystals. It weathers into a coarse yellow dolomite sand. The Galena is crisscrossed with numerous joints and crevices. At nearly all places where these rocks are exposed, they are broken by cracks that cross the strata at all possible angles and trend in various directions.

There are four abandoned lead mines within the immediate area of Elizabeth: the Wishon Mine, the Haggerty Mine, the Kansas Mine, and the Illinois Mine (fig. 11). During the early 1900s, the landscape was covered with numerous old workings and test pits (fig. 11). Today, the majority of these disturbances are hard to find most likely because of continued erosion of the landscape and possible back-filling of the old workings. The first mining within the Elizabeth District was done near the former town of Weston in about 1833. From 1833 to 1875, during the height of mining activity within the Elizabeth District, an estimated 75 million pounds of lead ore was produced (Cox 1910).

Information on most of the small scale mines like the Haggerty Mine is limited and sometimes very sketchy. The following is the only historical data found on the Haggerty Mine (from Cox 1910, 1914).

"Haggerty Mining and Development Company - The mine is located in the SE/4, SE/4 Sec. 14, on the old Log Chain range, and is owned and operated on a small scale by Geo. R. McLean. It is equipped with a boiler, hoist and pump, and has one shaft down 47 feet."

This mine was known to have been in operation between 1909 and 1914, but no production figures are known to exist. The mine was classified as a crevice mine. The majority of the crevices north of Elizabeth strike generally east to west, with minor crevices north to south and quartering directions (Cox 1910). The crevices striking nearly east to west are locally known as "east and wests," and those striking nearly north to south are known as "north and souths." The quartering crevices are known as "10-o'clocks," "2-o'clocks," "4-o'clocks," etc., depending on the time of the day at which the sun shines into them or is in their lines of strike (Cox 1914). The term "range" is applied to a single ore-bearing crevice or to a series of parallel ore-bearing crevices (Cox 1914). Total production figures reported by Cox (1910) listed 900 thousand pounds of ore from the "Log Chain Range."

0.0	13.15	Leave STOP 5, CONTINUE AHEAD (northwest).
0.15+	13.3+	DANGER: there is a deep ditch and an unmarked concrete box culvert on the right. Do NOT crowd the right road shoulder here.
0.3	13.6+	STOP: 1-way stop at the T-intersection with South Scales Mound Road. TURN RIGHT (north) and prepare to turn left immediately.
0.05-	13.65+	TURN LEFT (northwest) onto Georgetown Road.
0.3	13.95+	Road steepens down across the top of the Galena dolomite.
0.05+	14.05+	CAUTION: the culvert under the road has been washed out on the right side and the blacktop is broken off. A marker may or may not be present.
0.05+	14.1+	TURN LEFT (south) at the T-intersection with West Longhollow Road. CAUTION: you are crossing a large culvert under the roadway as you make your turn. The sides are not well marked!

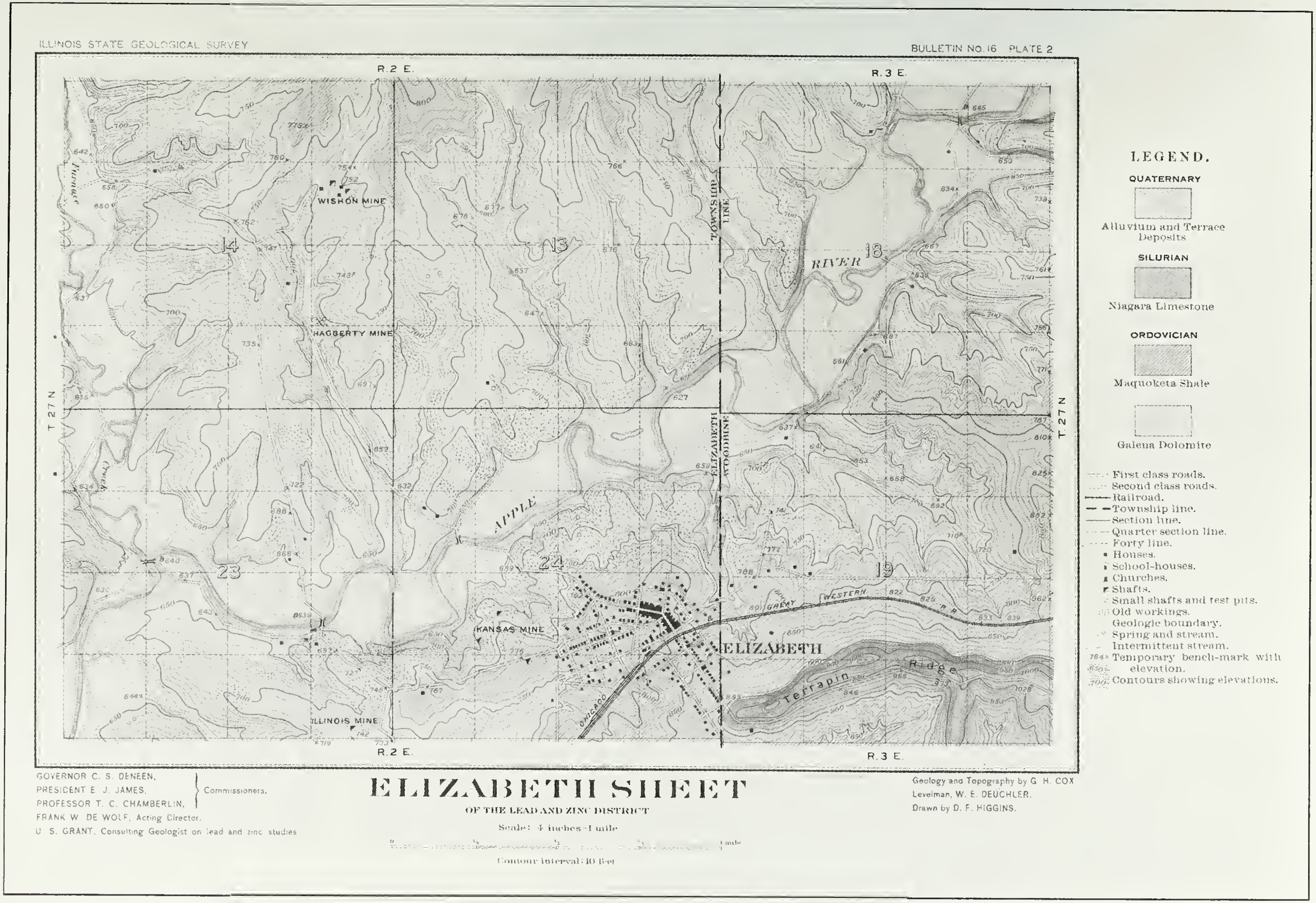
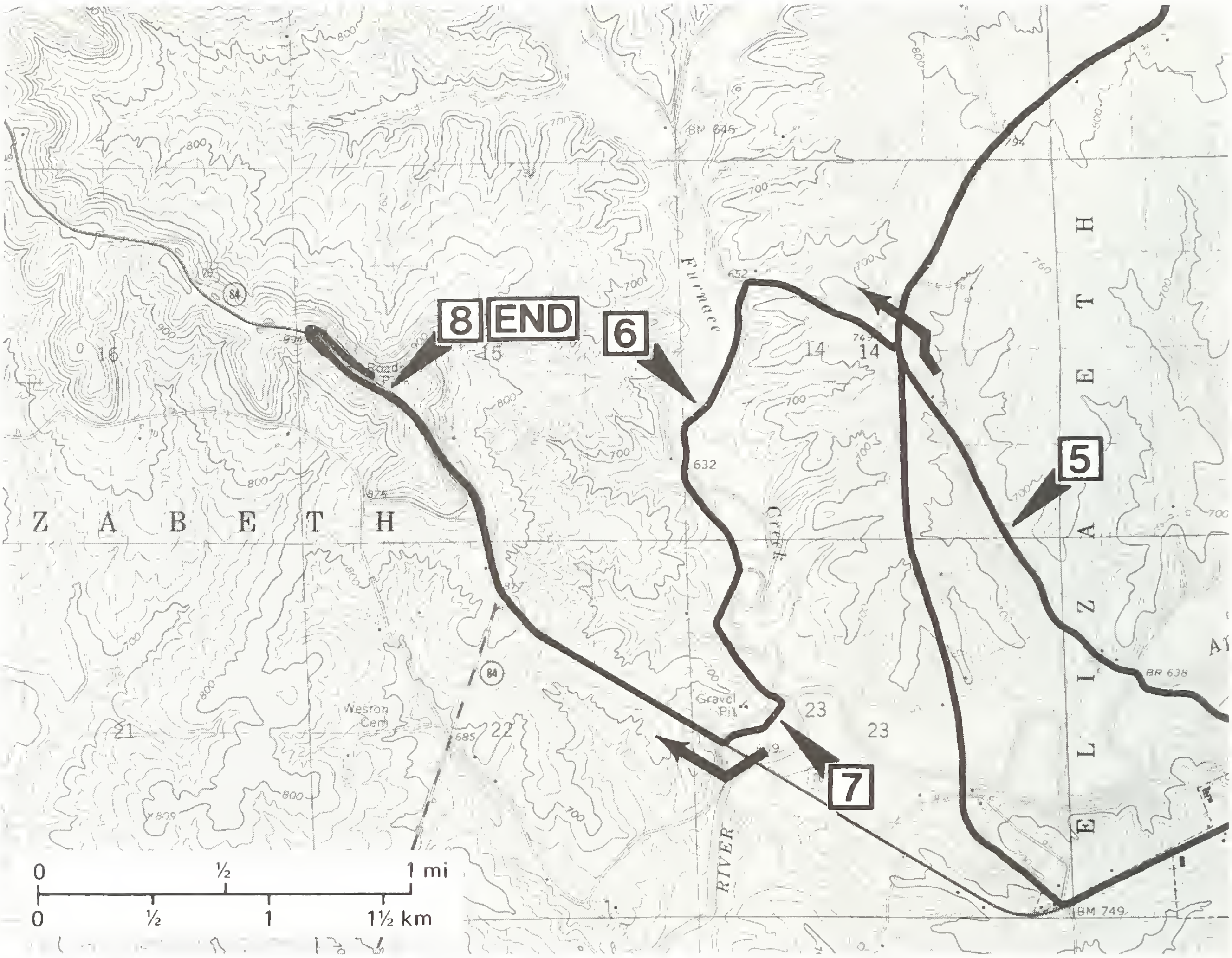


Figure 11 Elizabeth sheet (map) of the Lead and Zinc District showing mine shaft locations and old workings (Cox 1914).



0.15+ 14.25+ To the left are large blocks of thick-bedded, vesicular Galena sticking out from the hillside above the fence. One looks almost like an animal head.

0.2+ 14.5 PARK along shoulder as far off the road as you safely can.

STOP 6 We'll discuss the meanders of Furnace Creek (Near Ctr N½ SW NW SW, Sec. 14, T27N, R2E, 4th P.M., Jo Daviess County; Hanover 7.5-Minute Quadrangle [42090C3]).

The relief of the bedrock surface in northwestern Illinois is closely related to the establishment of the Mississippi Valley through the region during early Pre-Illinoian glaciation. Maximum surface relief probably was developed during Pre-Illinoian glaciation when the Mississippi Valley was eroded to its greatest depth by glacial meltwater. After that, the valley was alternately *aggraded* by outwash and reexcavated during subsequent glacial and interglacial intervals. Later, during Wisconsinan Woodfordian and Valderan glaciations, thick valley train sands and gravels aggraded the Mississippi Valley and its tributaries. Terrace remnants of these deposits along the Mississippi Valley and lower parts of the tributary valleys indicate that the valley filling in the Mississippi Valley was approximately 30 feet higher than its present floodplain. During Holocene time, after the last glacier melted away, the Mississippi River and its tributaries have been cutting deeper valleys by eroding Wisconsinan outwash deposits and bedrock. Nearly 100 feet of the outwash deposits underlie the present channel in the Mississippi Valley.

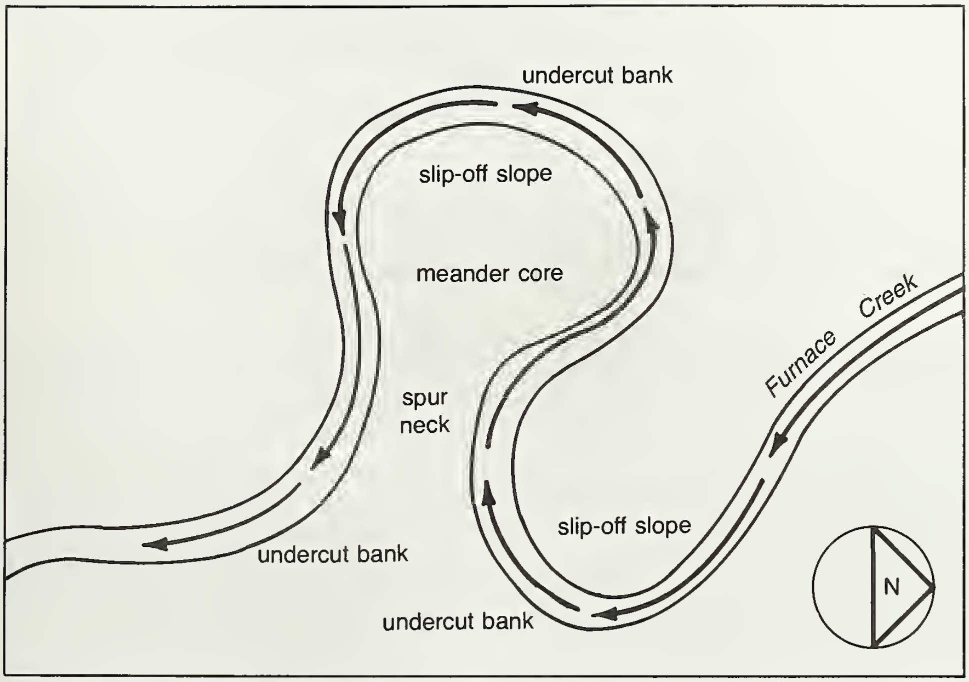


Figure 12 Diagram of meanders along Furnace Creek.

We are stopped along the east side of Furnace Creek Valley. The valley flat here has a surface elevation of 635 feet msl and is underlain by fine grained lake silts that were deposited in the quiet backwaters of the tributaries to the Mississippi River during glacial times. Several episodes of silt deposition occurred. Each one was followed by stream downcutting that left remnants of the old flat lake beds as terraces close to the Mississippi. We are currently too far upstream to recognize terraces with any certainty. Initially, Furnace Creek was established as it meandered from one low sag to another across the draining lake bottom. Downcutting ensued periodically, resulting in partial removal of older, somewhat higher floodplain features. Parts of meander scars were eroded and left perched slightly above the present creek level. *Base level* for Furnace Creek is Apple River with an elevation of about 627 feet msl at their confluence. As a stream approaches its base level, downcutting is minimal, and its energies are expended in lateral meandering, which slowly erodes its channel and valley. Figure 12 shows the development of meanders and their progression downstream. Your route map shows larger meanders just a short distance downstream, but they are not as easily observed as the smaller ones here.

0.0	14.5	Leave STOP 6 and CONTINUE AHEAD (west).
0.15+	14.65+	CAUTION: narrow concrete bridge across Furnace Creek.
0.5	15.15+	Galena dolomite crops out along the right side of the road.
0.25+	15.45+	PARK along shoulder as far off the road as you safely can. CAUTION:

- Narrow road
- Limited visibility
- Heavy truck traffic
- You MUST HAVE PERMISSION from the company office in Galena to enter this property
- Do NOT CLIMB on any exposed rock faces
- Do NOT pull rocks from the quarry faces

- Do NOT CARRY ROCKS from one pile to another
- Do NOT THROW any rocks regardless of how small they are
- Stay away from all pit edges
- STAY OFF ALL EQUIPMENT
- LIVE to have a good time!

STOP 7 We'll view and discuss strata of the Ordovician Wise Lake Formation exposed in the Galena Stone Products, Inc., Eustice Quarry (Gate: S½ SE SW NW, Sec. 23, T27N, R2E, 4th P.M., Jo Daviess County; Hanover 7.5-Minute Quadrangle [42090C3]).

Strata exposed in this quarry belong to the Ordovician (Galena Group) Wise Lake Formation. The thickness of rock exposed in this quarry is approximately 70 feet. Currently, they are quarrying two different levels of dolomite. The upper level is approximately 45 to 50 feet thick, and the lower level is 21 feet thick. The dolomite beds in the upper level are generally thicker than the lower beds. In addition, the beds in the upper bench contain a number of crevices or vertical fractures filled with weathered debris that most likely originated from the overlying Maquoketa Shale. The stone produced from the upper bench, therefore, is not as clean as that produced from the lower bench. The contact or division between the upper thick beds and the lower thin beds is arbitrarily placed at the base of the lowest thick bed of dolomite, upon which the stockpiles of the different sizes of aggregate are located and upon which the crusher is currently operating.

This quarry has been in operation for more than 30 years. Current production is between 125,000 and 150,000 tons of aggregate annually. The products and current costs are listed below.

PRODUCT	USE	SIZE	COST/TON
Wall rock	decorative and retention	4′ × 4′ × 3′	$10.00
Septic stone	use in septic fields	1″ to 1.5″	$ 4.50
Crushed rock	county gravel roads	3/4″ to (-)	$ 3.44
Chips	seal coat for oiled roads	3/8″ × 1/2″	$ 5.50
Agricultural stone	fine crushed for fields	3/8″ to (-)	$ 3.44

Aggregate produced from this quarry is also used in concrete highway construction. A large amount of the aggregate is being used in the concrete for US 20.

0.0	15.45+	Leave Stop 7. CONTINUE AHEAD (south).
0.15	15.6+	STOP: 2-way stop at the crossroad. TURN RIGHT (northwest) on Route 20 and ascend hill. CAUTION: fast traffic! To the right you will see some of the quarry operations.
0.7+	16.3+	Intersection with IL 84 from the LEFT. CONTINUE AHEAD uphill on US 20.

0.25+	16.6	Across the road on the left is the contact between the Ordovician Maquoketa Group and the overlying Silurian Mosalem Formation.
0.5	17.1	Prepare to TURN RIGHT.
0.1+	17.2+	TURN RIGHT (east) at the entrance to the scenic tower.
0.25	17.45+	PARK as close as you can but do not block the 1-way drive. Others may want to visit the tower and/or visit the rest rooms.

STOP 8 We'll see a bird's-eye-view of the field trip area from the Longhollow Observation Tower and discuss pollution problems at this site (SW NW NE SW, Sec. 15, T27N, R2E, 4th P.M., Jo Daviess County; Hanover 7.5-Minute Quadrangle [42090C3]).

The view from the top of the Longhollow Observation Tower is across a very scenic part of Illinois. Here, you are able to see the general "lay of the land" of many of the field trip stops and how the major stratigraphic groups affect the topography of the area. The same stratigraphic groups were encountered in the water supply well drilled here. Notice how the land slopes toward you from the Terrapin Ridge just east of Elizabeth. Lighting conditions caused by time of day and perhaps air density may influence your perception of this slope and others in the area.

Elizabeth is about 2.5 miles east-southeast; Stockton is about 14 miles east-northeast; Apple Canyon Lake is almost 8 miles northeast; the ridge tops to the north are 2 to 4 miles away; Galena is about 9.5 miles northwest; the Mississippi River is about 7.5 miles southwest; Hanover is just more than 5 miles south-southwest; and Savanna is about 18 miles south-southeast. Vegetation on the ridge top is just high enough to block views of some of these places.

The Longhollow Observation Tower was built in late 1982 at a cost of approximately $130,000; 75% of the funds came from the Federal Great River Road Project and the remainder came from the State. The long logs came from the southeastern United States. Two sides were built on the ground and then hoisted into place by tall cranes for final assembly.

Longhollow Observation Tower data		**Elevation (ft) above msl**
Total tower height	75.5′	1069.5
Top viewing level height	60.0′	1054.0
Middle viewing level height	40.0′	1034.0
Lower viewing level height	20.0′	1014.0
Basal concrete platform		994.0
Number of landings	12	
Number of steps	96	

The knob on which the Overlook site is located is characterized by thin soils developed in loess that is 0 to 16 feet thick. The loess mantles Silurian dolomite and Ordovician shale and dolomite. The Silurian dolomite is rather highly jointed and fractured. In addition, a few small sinkholes are known to be present. When US 20 was widened down the hill toward Elizabeth, blasting opened additional joints and fractures in the dolomite. These characters plus the small area and shape of this ridge top have contributed to environmental problems. In addition, this is a high-use site. A deep water-supply well was constructed in 1984 to service the restrooms. Later, the Illinois Department of Public Health (IDPH) determined the well was contaminated.

According to P. C. Reed, Geologist in the Hydrogeology Section, C. E. Simonson and R. Ruden of the IDPH requested ISGS assistance. Because the water supply here is not potable (drinkable), the IDPH and the Illinois Department of Transportation (IDOT) wanted help in defining the character of the casing and earth materials in and around the 450-foot-deep supply well. A thin loess covering above a carbonate rock generally is not adequate to attenuate much pollution before it enters the open joints and fractures in the underlying strata. Surface and shallow groundwater thus enter into the bedrock system with little or no filtration.

Reed reported that a number of tests and geophysical logs were conducted in this immediate area:
(1) *Natural gamma log* - gamma radiation indicates that three rock units are present in the wellbore.
(2) *Temperature-resistance log* - records earth temperature and quality of the water in the wellbore.
(3) *Caliper log* - furnishes data about the size and shape of the wellbore.
(4) *Acoustic-velocity log* - determines the lithology and porosity of the strata penetrated in the wellbore.
Additional geochemical and x-ray analyses were also conducted on some of the materials collected.

Although this ISGS study was not designed to pin-point the source of the coliform bacteria in the Overlook well, results indicated that sewage in the Silurian dolomite internal drainageways could communicate with the underlying Galena dolomite (the bottom of the well) either because of a lack of or faulty seals above the top of the Galena Group dolomite. At this site, additional studies would be needed to determine the extent of the pollution in this vicinity and to ascertain whether construction of another well would be feasible. Reed said that water samples from streams and wells from a larger area would also need to be analyzed for chemical or bacterial contamination.

End of the field trip. Have a safe journey home!

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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, editors, 1987, Glossary of Geology: American Geological Institute, Alexandria, VA, 3rd Edition, 788 p.

Acoustic-velocity log —This log records an acoustic wave pattern through the fluid in an uncased borehole into the surrounding rock, which provides information on the lithology and porosity of these earth materials.
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 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 generally 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 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, or glacial till.
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; it sometimes represents a considerable interval of nondeposition.
Dolomite—A mineral, calcium-magnesium carbonate ($Ca,Mg[CO_3]_2$); sedimentary rocks that are composed largely of the mineral dolomite; it also is precipitated directly from seawater. It is white, colorless, or tinged yellow, brown, pink, or gray; has perfect rhombohedral cleavage; appears pearly to vitreous; and effervesces feebly in cold dilute hydrochloric acid.
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.
Driftless Area—A 10,000-square-mile area in northeastern Iowa, southwestern Wisconsin, and northwestern Illinois where the absence of glacial drift indicates that the area may not have been glaciated.

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.
Floodplain—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.
Fluvial—Of or pertaining to a river or rivers.
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 plant or animal specimens 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 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 surface.
Glacier—A large, slow-moving mass of ice that occurs 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.
Karst—Area underlain by limestone having many sinkholes separated by steep ridges or irregular hills. Tunnels and caves resulting from solution by groundwater honeycomb the subsurface.
Lacustrine—Produced by or belonging to a lake.
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 preexisting 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. (e.g., gneisses, schists, marbles, quartzites).
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.
Morphology—The scientific study of form, and of the structures and development that influence form; term used in most sciences.
Natural gamma log—These logs are run in cased, uncased, air, or water-filled boreholes. Natural gamma radiation increases from the left to the right side of the log. In marine sediments, low radiation levels indicate non-argillaceous limestone, dolomite, and sandstone.
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.
Oxbow lake—A crescent-shaped lake in an abandoned bend of a river channel.
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 agreeing with 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.
Peneplain—A land surface of regional proportions worn down by erosion to a nearly flat or broadly undulating plain.
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.
Radioactivity logs—Logs of bore holes obtained through the use of gamma logging, neutron logging, or combinations of the several radioactivity logging methods.
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 be-

tween 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, and alluvium).
Sedimentary rock—A rock resulting from the consolidation of loose sediment that has accumulated in layers (e.g., sandstone, siltstone, and limestone).
Sinkholes—Small circular depressions that have formed by solution in areas underlain by soluble rocks, most commonly limestone and dolomite.
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 that dip inward from the sides toward the axis; the youngest rocks occur 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.
Temperature-resistance log—This log, run only in water, portrays the earth's temperature and the quality of groundwater in the well.
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.

ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, Illinois 61801

GEOGRAM 2
October 1974

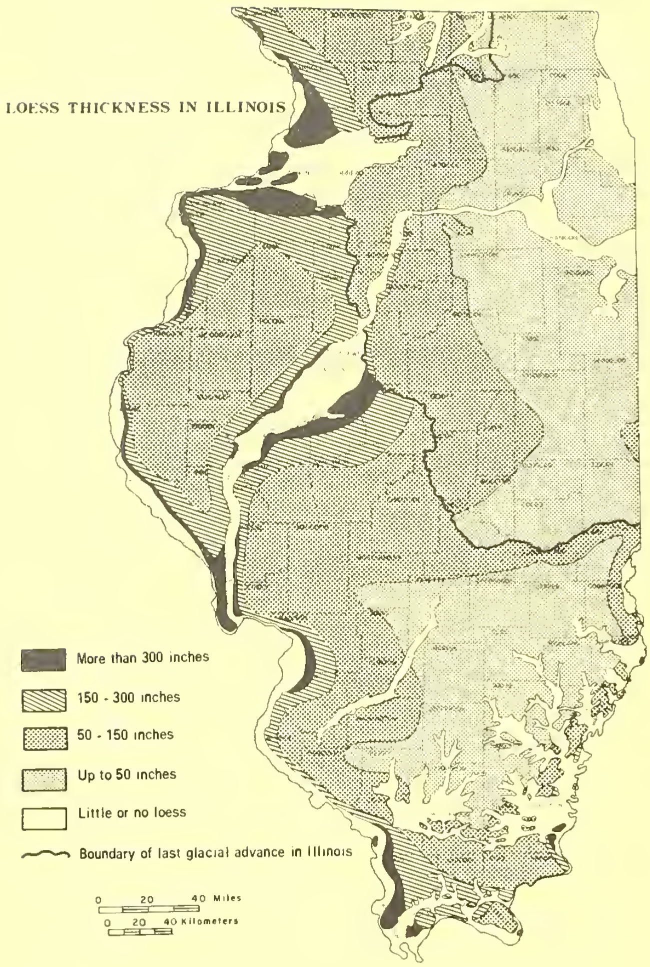
ERRATICS ARE ERRATIC

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.)

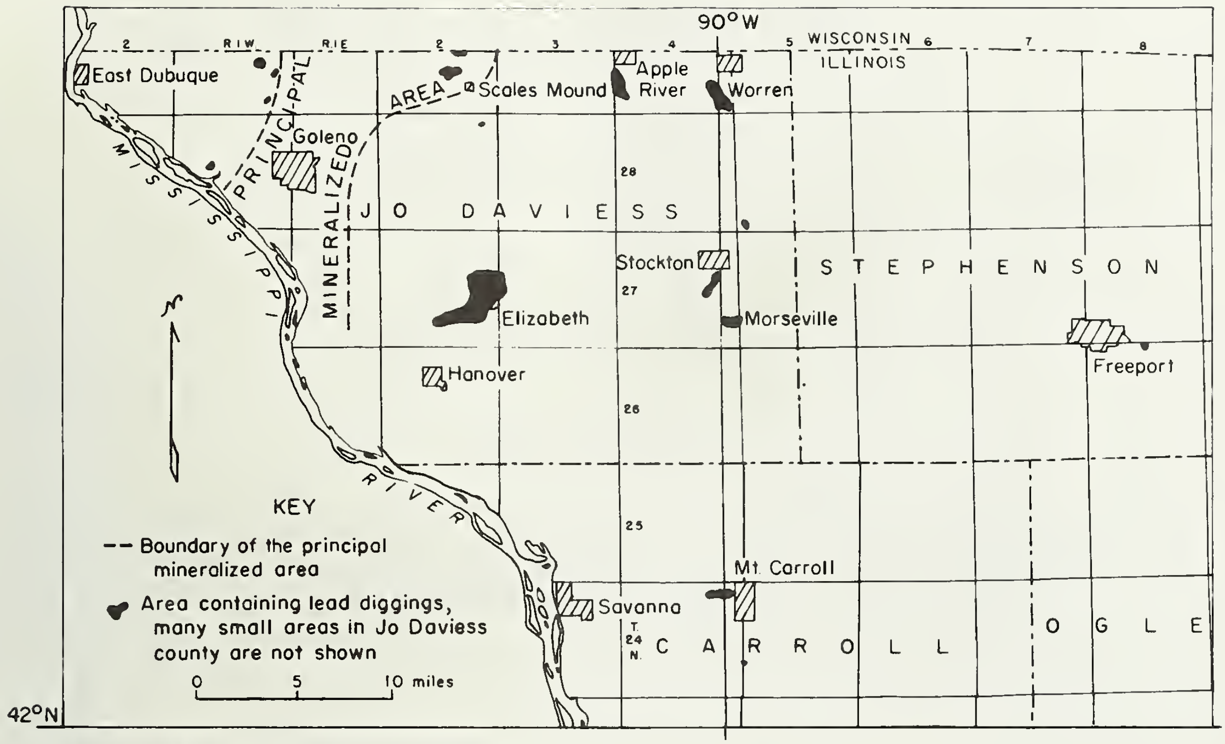


limestone grains. Some of the dissolved minerals later became solid again, gathering around a tiny nucleus or along roots to form the lumpy masses. A few such concretions are shaped roughly like small dolls and, from this resemblance, are called "loess kindchen," a German term meaning "loess children." 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.



Zinc-lead district in northwestern Illinois.

ZINC-LEAD DEPOSITS OF NORTHWESTERN ILLINOIS

Principal Mineralized Area

The principal mineralized area in which the zinc-lead deposits in northwestern Illinois have been found occurs in Jo Daviess County in a belt from 5 to 10 miles wide and 15 miles long. The belt extends approximately northeast through Galena, from the Mississippi River to the Wisconsin stateline. Lead ore has also been mined near Elizabeth, Apple River, Warren, and at other places in Jo Daviess County. These occurrences increase the known mineralized district to include most of the county. Small amounts of lead ore are also reported to have been mined outside of this area near Freeport in Stephenson County and near Mount Carroll in Carroll County.

Stratigraphic Position of Ore Deposits

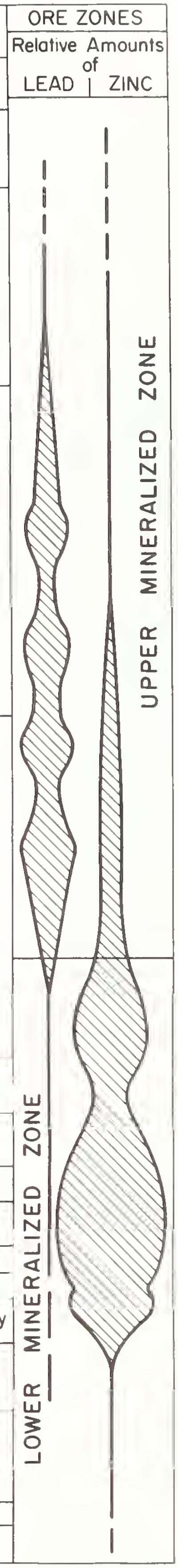
The zinc-lead ore deposits occur in the middle Ordovician carbonate formations of the Galena and Platteville Groups (Champlainian Series) of the Ordovician System. The major deposits of zinc ore (sphalerite, ZnS) are found in the lower part of the Galena Group, which includes the "Drab," "Gray," and "Blue" zones of the Dunleith Formation; the "oilrock," or Guttenberg Formation; and the "Clay bed," or Spechts Ferry Formation. Some deposits are found in the "Glassrock," or Quimby's Mill Formation, which is in the top of the Platteville Group. These deposits are mainly of the flat-and-pitch type described below.

The major deposits of lead ore (galena, PbS) containing little associated sphalerite are found principally in the upper part of the Galena Group. This includes the top half of the Dunleith ("Drab") and the overlying Wise Lake Formation ("Buff"). These deposits are of the crevice type. Locally, the lead ore may grade into the mixed lead-zinc ore, especially in the lower part of the Wise Lake Formation.

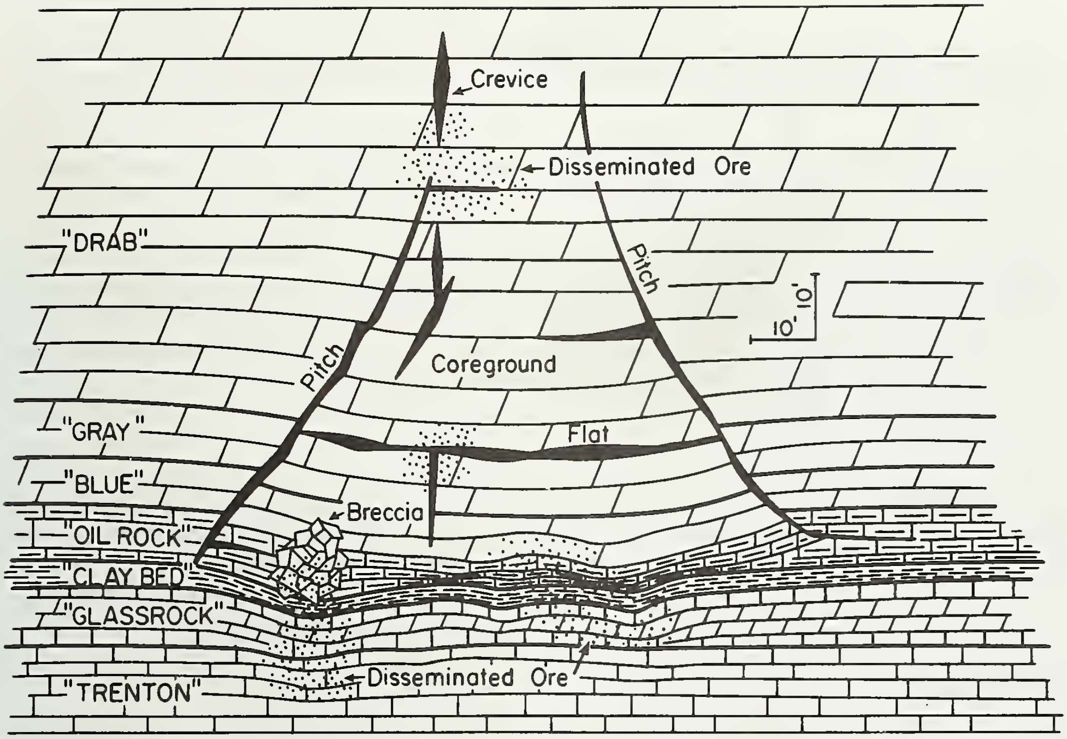
Flat-and-Pitch Deposits

The flat-and-pitch deposits in the lower ore-bearing zone consist of flats, which are nearly horizontal, sheet-like bodies of ore between or parallel to the bedding planes of the strata, and pitches, which are similar to flats except they cut across the bedding planes. Pitches usually slope more than 45 degrees, and many become more steep upward and grade into vertical

SYSTEM	GROUP	FORMATION	MINING TERMS	THICKNESS	DESCRIPTION OF STRATA
Silurian				200±	Dolomite, gray, cherty, shaly
Ordovician	Maquoketo			110±	Shale, greenish gray; some dolomite
	Galena	Dubuque	"Buff"	45	Dolomite, grayish tan, sholy
		Wise Lake		75	*"Upper Receptaculites Zone"* Dolomite, tan
		Dunleith	"Drab"	105	*"Middle Receptaculites Zone"* Dolomite, brownish groy, cherty *"Lower Receptaculites Zone"*
			"Gray"	12	Dolomite, gray, shaly
			"Blue"	8	Dolomite, blue-groy, sholy, sandy
		Guttenberg	"Oil rock"	2-16	Limestone, brown, gray, shaly
		Spechts Ferry	"Cloy bed"	0-6	Shale, green, limy
	Platteville	Quimbys Mill	"Glass rock"	1-18	Limestone & Dolomite, brown
		Grand Detour	"Trenton"	5-15	Limestone & Dolomite } gray, sholy, cherty
		Mifflin		10-20	Limestone, gray, shaly
		Pecotonica	"Lower Buff"	20	Dolomite, brownish gray
	Ancell	Glenwood		5	Shale, greenish, sandy
		St. Peter		20-300	Sandstone, white



Generalized sequence of strata in the Galena area.



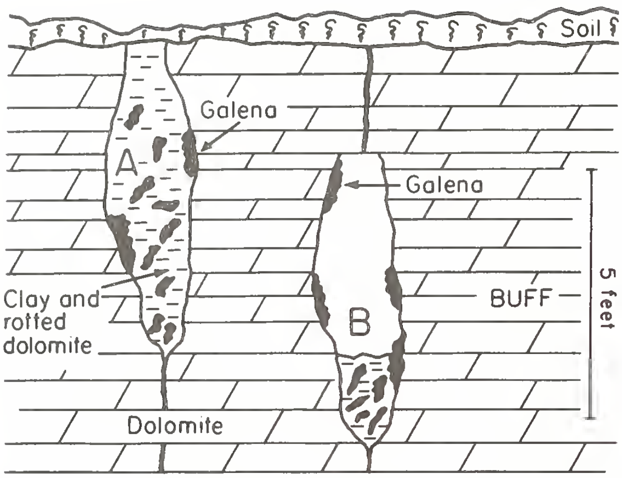
Flat-and-pitch ore bodies.

crevices; some flatten downward. The mineralized rock between pitches bounding an ore body is called the coreground.

Flat-and-pitch deposits are associated with small synclinal structures, which trend northwest, northeast, or east. Between pitches bounding an ore body, the oilrock and Glassrock are thinner than usual, apparently because of dissolution, and the overlying strata have sagged to form the synclinal structure. This sagging opened up the fractures, which became mineralized. The mineralized sags are usually 50 to 200 feet wide, but they may be as wide as 300 feet and extend longitudinally for thousands of feet in a straight line or in an arcuate manner. Usually, the minable thickness is about 40 feet, but sometimes it is thicker. There are many variations in the shape or character of these deposits. The ore generally occurs as fissure-filled deposits, but in the oilrock and Glassrock there are also disseminated-type deposits. Rarely, the ore will assay as high as 20% zinc, but 10% zinc is considered rich ore and 3% to 4% ore is considered minable. In some deposits, minable ground is confined entirely to the pitches, but parts of the coreground are also minable. Minerals, other than galena, associated with zinc ore include pyrite (FeS_2), marcasite (FeS_2), and calcite ($CaCO_3$). Above the water table, where oxidation has occurred, secondary minerals occur, including cerussite (lead carbonate, $PbCO_3$), anglesite (lead sulfate, $PbSO_4$), smithsonite (zinc carbonate, $ZnCO_3$), and limonite (iron oxide, $2Fe_2O_3 \cdot 3H_2O$).

Crevice Deposits

The crevice deposits of the upper mineralized zone occur as fissure fillings along joints that are oriented mainly in an east-west direction. The crevices are actually vertical fissures, or cavities, that were opened up along the joints by solution of the dolomite. Along a typical crevice, the minable ore occurs as pods or lenses, which range from a few feet to a few hundred feet long, scattered along the strike of the joints. The ore bodies are generally only a few inches to a few feet wide, but where there are two or more closely spaced crevices, they extend over widths of 30 feet or more. The ore is usually pure galena, but locally it may grade to mixtures of galena and sphalerite.



Crevice ore bodies. Crevice A reaches the ground surface and is filled with clay; B is only partly clay-filled.

Shallow crevice deposits were the principal source of lead ore in the United States between 1820 and 1865. These deposits were easily discovered in partial exposures along stream valleys. They were also discovered by the presence of residual accumulations of ore where erosion had intersected mineralized joints. In some cases, the topographic expression of crevices as shallow depressions led to the discovery of ore bodies. When these easily exploited deposits were depleted, lead ore production declined sharply. During the later years of production, zinc ore was the chief mineral commodity of the area, and it was obtained almost exclusively from the larger, deeper flat-and-pitch deposits. The last operating mine in northwestern Illinois, which was located south of Galena, was closed in 1973.

Origin of Ore Deposits

The origin of the ore bodies is still in question. An early theory that was widely accepted is the "cold water theory." In this theory, lead and zinc minerals were assumed to be present in trace quantities disseminated throughout the Galena Dolomite or higher rock units. The lead and zinc were originally supposed to have been deposited with the carbonate rocks when they were precipitated from the ancient Ordovician sea more than 400 million years ago. Percolating groundwater then dissolved the lead and zinc minerals from these rocks and carried them downward to be reprecipitated in openings in the strata where the ore is now found.

The theory now generally favored by geologists is emplacement by warm solutions emanating from strata buried deep in the Illinois Basin. The warm, mineralized solutions ascended until they encountered the cavernous, jointed Champlainian (middle Ordovician) rocks that had the proper temperature-pressure conditions to allow the precipitation of the lead and zinc sulfides. The neutralizing effect of carbonate-rich groundwater on the acid-sulfide bearing solutions could also have been partly responsible. These ideas may explain why the ore bodies are restricted to such a narrow vertical interval of Ordovician strata. However, the absence of deep downward extensions of ore and major faults that could have provided access to the rising solutions has not yet been resolved.

The open fissures in which the crevice ores were deposited and the synclinal structures associated with the flat-and-pitch ore bodies are solutional in origin and were formed before ore emplacement. Whether solution was by meteoric groundwater or by warm solutions from depth has not been definitely determined. If the latter is true, the openings may have been formed contemporaneously with ore deposition.

Prospecting for Ore Deposits

The long, fairly narrow ore bodies in the Upper Mississippi Valley zinc-lead district, especially the deeper ore bodies, are difficult to find. To extend the life of the mining district, new reserves must be found. Geophysical and geochemical methods have been used in the exploration for ore deposits, but with limited success. Drilling is the most commonly used means of prospecting for lead and zinc ores and is currently the most effective method of searching for the deep ore bodies. Drilling is used to explore the trends of known ore deposits and to search for new ore bodies in previously untested areas.

Most prospecting for lead and zinc ores in northwestern Illinois has consisted largely of drilling in areas of old shallow lead diggings, along the trends of known deeper ore bodies, and in the vicinities of occasional water wells that happen to penetrate ore. Wildcat holes drilled in unproven ground outside areas of known ore deposits have been relatively few. Many interrelated geologic factors must be evaluated by the geologist before deciding where to drill such exploratory holes.

There are two principal methods of drilling deep holes: churn drilling and rotary drilling with a diamond bit.

Churn drilling Churn drilling, also known as cable-tool drilling, is much less expensive than diamond drilling and has been widely used in the zinc-lead district for deep prospecting. Vertical holes 6 inches in diameter are drilled by a heavy steel rock bit suspended from a steel cable that is attached to the controlling machinery at the surface. The heavy bit is alternately lifted and dropped, and the rock is penetrated by the repeated blows of the bit. The broken rock is periodically bailed from the hole, and samples of the rock chips are saved for examining or assaying.

Diamond drilling Diamond drilling provides better rock samples than those obtained by churn drilling, if core recovery is good. The cores obtained are continuous samples, or a column, of the rock interval penetrated by the bit. In soft or fractured rock, often in critical zones of mineralization where samples are most desired, no sample may be recovered in some intervals because of poor core recovery. A definite advantage of diamond drilling is the ability to drill inclined holes. Drilling is accomplished by means of a small-diameter diamond bit attached to a column of pipe called the drill stem. The bit cuts through the rock when the drill stem is rotated by the power machinery at the surface. Water or a water-oil mixture is pumped down the inside of the drill stem under pressure to cool and lubricate the diamond bit. The water also flushes out crushed rock from the bottom of the hole and carries it up the drill hole to the surface. The rock core enters the hollow drill stem, where it is surrounded by the coolant as the bit cuts downward, and the core remains there until it is retrieved when the drill stem is pulled out of the hole. The diameter of the drill stem and bit are usually decreased periodically as the hole deepens, depending upon the depth to be drilled.

ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, Illinois 61801

GEOGRAM 8
November 1976

AN EARLY INHABITANT OF ILLINOIS—THE TRILOBITE

Dennis R. Kolata

Many strange creatures have inhabited Illinois in the past and have left their fossil remains entombed in the rocks that underlie our prairie lands. One such animal is the trilobite (figs. 1 and 2), an extinct marine arthropod that is distantly related to the living crabs, lobsters, and crayfish.

Trilobites were among the earliest inhabitants of Illinois. The oldest specimens have been found in Cambrian age rocks formed approximately 500 million years ago (fig. 3). After the Ordovician Period the trilobites slowly declined in abundance and diversity, finally becoming extinct at the close of the Permian Period, about 200 million years ago. They swam in the warm, shallow seas that covered all of Illinois and most of North America and crawled on and burrowed in the muddy sea bottoms. As the seas advanced and retreated over a span of about 350 million years (Paleozoic Era, fig. 3), the trilobites slowly evolved—that is, changed structurally and functionally through time—into a great variety of forms. They were variously adapted as scavengers, predators, and filter feeders that occupied niches in the level sea bottom and in reef communities. Trilobites lived with sponges, corals, clams, snails, brachiopods, crinoids, and other marine animals.

Trilobites are so named because the segments on their upper (dorsal) surface usually possess longitudinal furrows that form a three (tri-) lobed division of the body (fig. 4). The central lobe is called the axial lobe, and the two lateral counterparts are called pleural lobes. The cephalon (head) is located at the anterior (front) end of the body, a segmented thorax in the middle, and a pygidium (tail) at the posterior end. The dorsal surface consisted of a hard, mineralized protective shield (carapace); it is this part of the shell, or exoskeleton, that is most commonly preserved in the fossil record. The lower (ventral) surface bore a pair of antennae and numerous pairs of jointed appendages that served as walking, swimming, feeding, and respiratory organs. The ventral surface, however, consisted

Fig. 1 (left) - *Ceraurus* cf. *pleurexanthemus* Green (×1). Found in Ordovician age rocks of the Grand Detour Formation, Platteville Group, near Rockford, Winnebago County, Illinois.

Fig. 2 (right) - *Calymene celebra* Raymond (×1). Dorsal (upper picture) and side (lower picture) views of a specimen found in the Silurian age Racine Formation near Grafton, Jersey County, Illinois.

of relatively soft tissue and rarely is preserved. A typical trilobite is about 2 inches long, but some are less than half an inch in length and giants of the group measure fully 2 feet.

Like the living crustaceans (crabs, lobsters, crayfish, etc.), trilobites shed their shells periodically in order to grow. In some species a single trilobite produced 27 shells or more. In fact, it is very likely that most trilobite fossils are the discarded shells. Although trilobite fragments are rather abundant in some rocks, complete specimens are rare. It was only under the most exceptional conditions, such as burial by sediment before or immediately after death, that complete trilobites were preserved relatively unchanged.

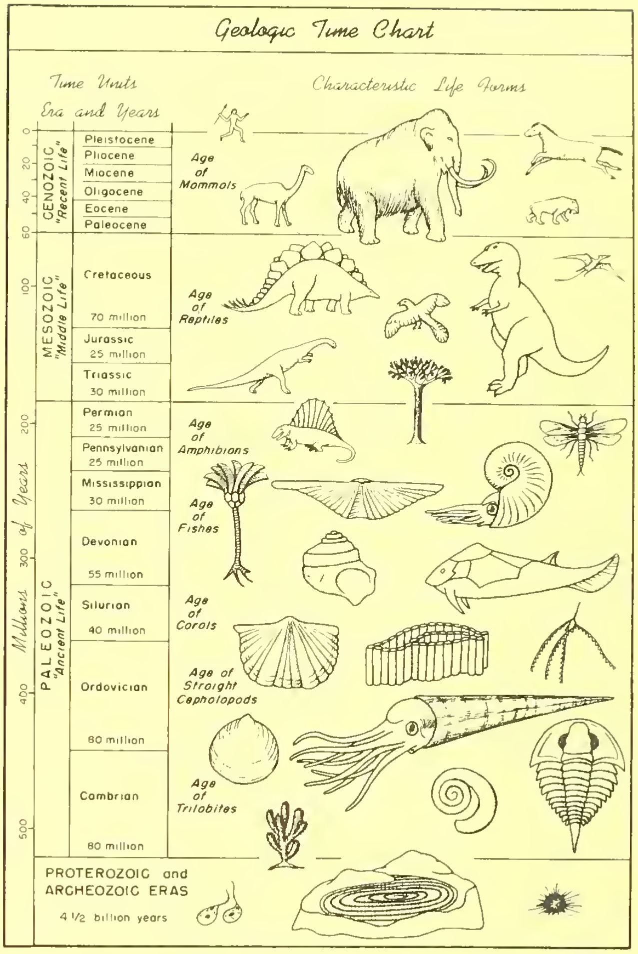


Fig. 3 - Geologic time chart.

Because of their unusual and interesting appearance, trilobites are among the fossils most sought after for collection and study. Avid collectors continually comb the countryside searching for new trilobite localities. The most productive efforts are made at outcrops of shale, limestone, and dolomite in quarries, roadcuts, and natural exposures. The Paleozoic rocks of Illinois have long been known for their abundant and well-preserved trilobite fossils. Cambrian age trilobites have been found in a few small outcrops in north-central Illinois and in several cores drilled from deeply buried Cambrian rocks at various localities throughout the state. Some of the better trilobite collections have been made from the more accessible Ordovician and Silurian rocks that are exposed in the northern and southwestern parts of the state. Trilobites have been found in some post-Silurian Paleozoic rocks in Illinois, but they are much less abundant and diverse than those in the older rocks.

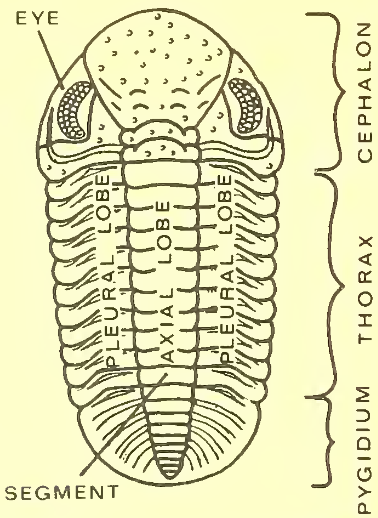
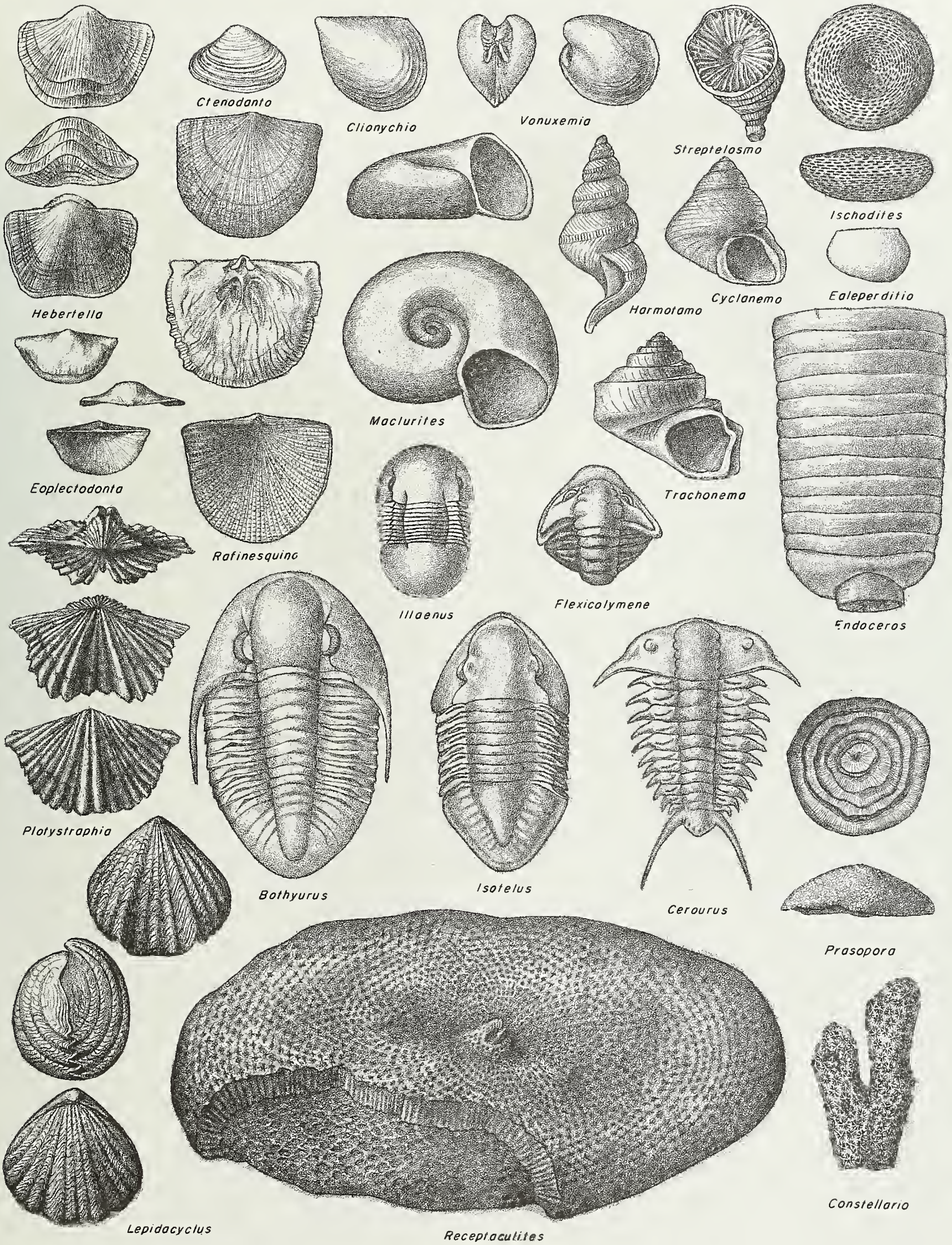


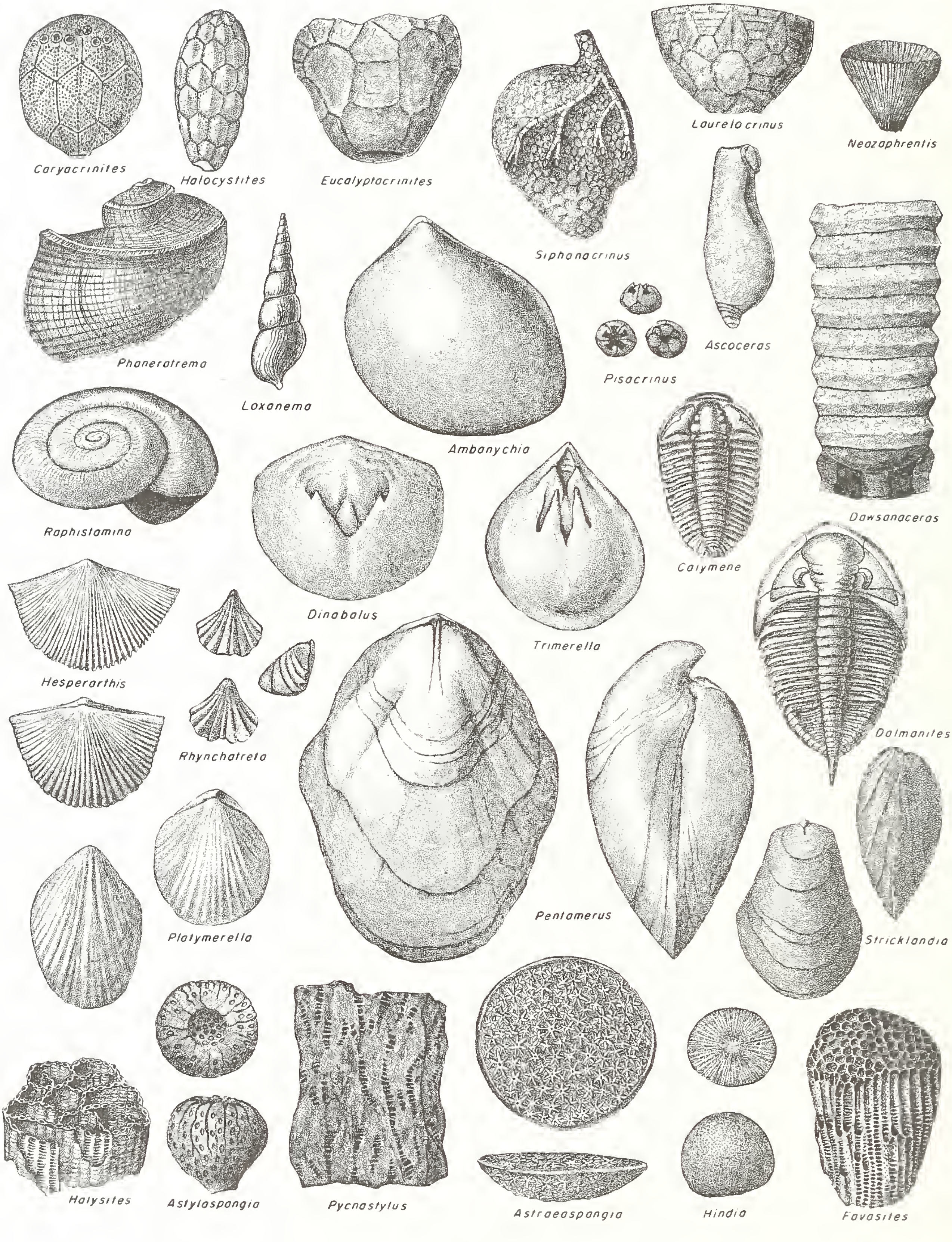
Fig. 4 - Dorsal view of *Phacops*, a common Devonian trilobite, showing various structures (×1).

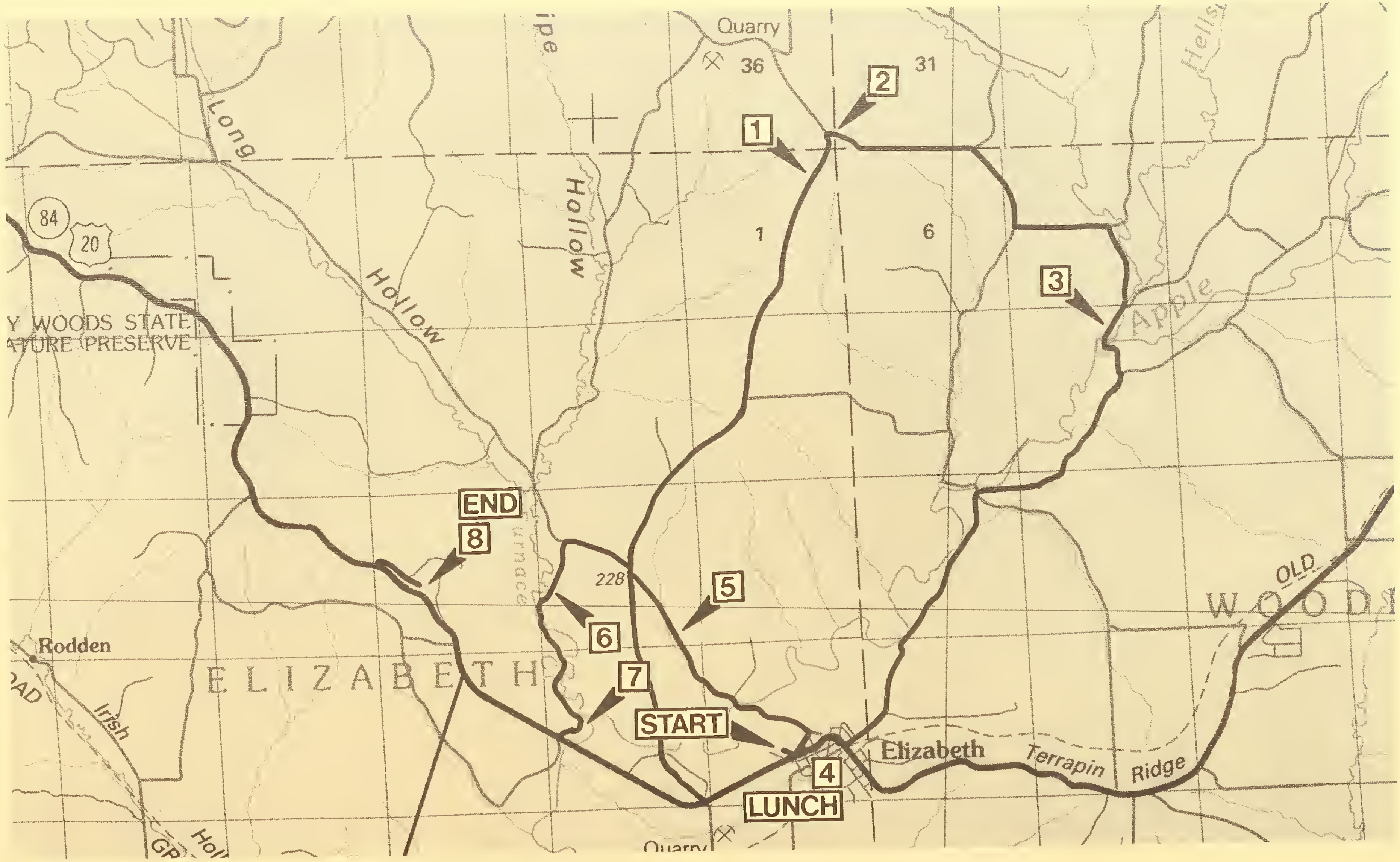
The study of trilobites is not just an academic exercise, because these fossils are useful in determining the relative age of some sedimentary rocks. Knowing the relative age is important for economic reasons, particularly where it is necessary to locate and identify strata containing oil, natural gas, coal, and ore deposits. The study of such index fossils and their relationship to the strata in which they are found is called biostratigraphy.

ORDOVICIAN FOSSILS



REPRESENTATIVE SILURIAN FOSSILS FROM NORTHWESTERN ILLINOIS

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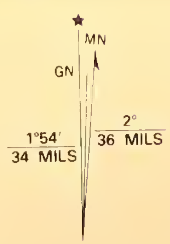
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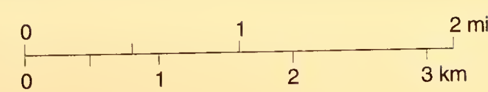
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