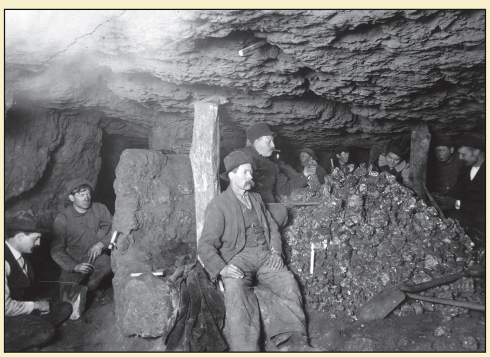
# Guide to the Geology, Hydrogeology, Botany, History, and Archaeology of the Driftless Area of Northwestern Illinois, Jo Daviess County

Samuel V. Panno,[1] Philip G. Millhouse,[2] Randy W. Nyboer,[3] Daryl Watson,[4] Walton R. Kelly,[5] Lisa M. Anderson,[1] Curtis C. Abert,[1] and Donald E. Luman[1]

[1]Illinois State Geological Survey, [2]Illinois State Archaeological Survey, [3]Illinois Natural History Survey, [4]Highland Community College, and [5]Illinois State Water Survey



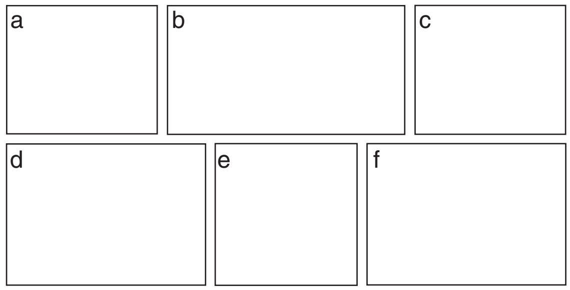

**Geological Science**
**Field Trip Guidebook 2014A**

**May 31, 2014**

ILLINOIS STATE
GEOLOGICAL SURVEY
PRAIRIE RESEARCH INSTITUTE

ILLINOIS STATE GEOLOGICAL SURVEY
Prairie Research Institute
University of Illinois at Urbana-Champaign

***Cover photograph:*** *(a) Pentamerus, a genus of brachiopod, lived during Silurian to Middle Devonian time attached to the sea floor. (b) Spear points left by past Native American cultures. (c) Fragile prickly pear cactus. (d) Photograph of the Kipp property near the Black Jack Mine in the late 1800s showing visitors examining a pile of ore. (e) Karst springs in Jo Daviess County are typically circular, with bedrock exposed near the center and drainage off to a nearby stream. (f) The steamboat Nominee docked in Galena, with two men and a stack of pigs of lead (ingots) in the foreground, circa 1852.*




**Geological Science Field Trips** The Illinois State Geological Survey (ISGS) conducts 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 every 10 students.

The inside back cover shows a list of guidebooks of earlier field trips. Guidebooks may be obtained by contacting the Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820-6918 (telephone: 217-244-2414 or 217-333-4747). Many are available through downloadable pdf: http://www.isgs.illinois.edu/?q=content/field-trip-guidebooks. Guidebooks may also be ordered from the Shop ISGS link at the top of the ISGS home page: http://www.isgs.illinois.edu.

Six U.S. Geological Survey 7.5-minute quadrangle maps (Warren, Rush, Elizabeth NE, Hanover, Rice, and East Galena Quadrangles) provide coverage for this field trip area.

# Guide to the Geology, Hydrogeology, Botany, History, and Archaeology of the Driftless Area of Northwestern Illinois, Jo Daviess County

Samuel V. Panno,[1] Philip G. Millhouse,[2] Randy W. Nyboer,[3] Daryl Watson,[4] Walton R. Kelly,[5] Lisa M. Anderson,[1] Curtis C. Abert,[1] and Donald E. Luman[1]

[1]Illinois State Geological Survey, [2]Illinois State Archaeological Survey, [3]Illinois Natural History Survey, [4]Highland Community College, and [5]Illinois State Water Survey

**Geological Science**
**Field Trip Guidebook 2014A**

**May 31, 2014**

ILLINOIS STATE GEOLOGICAL SURVEY
Prairie Research Institute
University of Illinois at Urbana-Champaign
615 E. Peabody Drive
Champaign, Illinois 61820-6918
http://www.isgs.illinois.edu

## Acknowledgments

The authors acknowledge the following for their contribution to the field trip: the Galena-Jo Daviess County Historical Society, the River Ridge High School A.V. Club, the City of Galena, the Jo Daviess Conservation Foundation, the Galena/Jo Daviess County Convention & Visitors Bureau, the Galena Center for the Arts, the Illinois Department of Natural Resources, Conmat, Inc., Chestnut Mountain Resort, private landowners who granted access to their property, Tom Golden of Eastern Shore Soil Services, an anonymous donor who sponsored the band at lunch, and Nancy and Adlai Stevenson. We are also grateful to Steve Repp, curator of the Alfred W. Mueller Collection, for providing the historic photos of Galena, Illinois. Thanks also go to the ISGS public field trip logistical team: Lisa M. Anderson, Curtis C. Abert, Daniel J. Adomaitis, Michael W. Knapp, Cynthia A. Briedis, Kathleen M. Henry, Ronald Klass, and Derek Sompong. Their time and expertise are critical; without this team, the field trips would not be a success. Finally, we thank Susan Krusemark and Michael W. Knapp of the ISGS for their invaluable assistance to the authors by editing, compiling, and taking care of the details in finalizing this guidebook. This field trip and guidebook were also supported through the assistance and generosity of the League of Women Voters of Jo Daviess County and the Galena Foundation.

LWV®

THE GALENA FOUNDATION

# CONTENTS

**Figures**

# INTRODUCTION

This field trip takes place in the *Driftless Area*[1] of northwestern Illinois (Figure 1), where participants will learn how the geology and natural resources (*mineral*, and fauna and flora) are inseparably intertwined with human history and habitation in this area. This guidebook is intended to present to participants the geology, hydrogeology, archaeology, history, and botany of Jo Daviess County and how those entities relate to the county's unique place in the history of the United States.

## Geologic Framework

This section describes the geologic history of Illinois and Jo Daviess County from 1.5 billion years ago to prior to the Pleistocene *Epoch* (Figure 2). This section has been modified from *Guide to the Geology of the Apple River Canyon State Park and Surrounding Area of Northeastern Jo Daviess County, Illinois*, by Frankie and Nelson (2002).

### Precambrian Era

The oldest rocks in the field trip area lie about 2,500 feet below the surface and belong to the ancient Precambrian *basement complex*. We know relatively little about these rocks from direct observations because of their depth and the fact that they are not exposed at the surface in Illinois. Only about 35 drill holes have reached deep enough for geologists to collect samples from Precambrian rocks of the state. From these few samples, as well as from measurements of the Earth's gravitational and magnetic fields and from seismic studies, we know that these ancient rocks consist mostly of granitic and rhyolitic *igneous*, and possibly *metamorphic*, crystalline rocks formed about 1.5 to 1.0 billion years ago. From about 1.0 billion to about 600 million years ago, these Precambrian rocks were exposed at the surface. During this long *period*, the rocks were deeply weathered and eroded, and the area was probably similar to the *topography* of the present Missouri Ozarks. During this time, *rift* valleys in southern Illinois (similar to those in eastern Africa) formed as the movement of crustal plates (known as plate *tectonics*) began to rip apart the Precambrian North American continent.

### Paleozoic Era

After the beginning of the Paleozoic *Era*, about 520 million years ago in the late Cambrian Period, the rifting stopped and the North American continent was spared being split apart. The hilly Precambrian landscape began to sink slowly on a broad regional scale, allowing the invasion of shallow seas from the south and southwest into what would be Illinois. During the next 280 million years of the Paleozoic Era, the area that is now called the Illinois *Basin* (Figure 3) continued to accumulate sediments that were deposited in the shallow seas that repeatedly covered this subsiding basin. The region continued to sink until at least 20,000 feet of *sedimentary* strata was deposited in the deepest part of the basin, located in the Rough Creek Graben area of southeastern Illinois and western Kentucky. At various times during this era, the seas withdrew and deposits were weathered and eroded. As a result, there are some gaps in the Paleozoic sedimentary record in Illinois.

From the Late Cambrian to the end of the Paleozoic Era, sediments continued to accumulate in the shallow seas that repeatedly covered Illinois and adjacent states. These inland seas were connected with the open ocean to the south during much of the Paleozoic, and the area that is now southern Illinois was similar to an embayment. The southern part of Illinois and adjacent parts of Indiana and Kentucky sank more rapidly than the areas to the north, allowing a greater thickness of *sediment* to accumulate. During the Paleozoic and Mesozoic, the Earth's thin crust was periodically flexed and warped in places as stresses built up in response to the *tectonic* forces associated with the collision of continental and oceanic plates and mountain building. These movements caused repeated invasions and withdrawals of the seas across the region; consequently, the former sea floors were periodically exposed to erosion, which removed some sediment from the rock record.

Many of the sedimentary units, called *formations*, have *conformable* contacts—that is, no significant interruption in deposition occurred as one formation was succeeded by another. In some 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 virtually continuous. In contrast, however, in other places the top of the lower formation was at least partially eroded before deposition of the next formation began. In these instances, fossils or other evidence within or at the boundary between the two formations indicate a significant age difference between the lower unit and the overlying unit. This type of contact is called an *unconformity*. Unconformities occur throughout the

[1]Terms in italics (except for Latin names) are defined in the glossary at the back of the guidebook. Also, please note that although all present localities have only recently appeared within the geologic time frame, the present names of places and geologic features are used because they provide clear reference points for describing the ancient landscape.

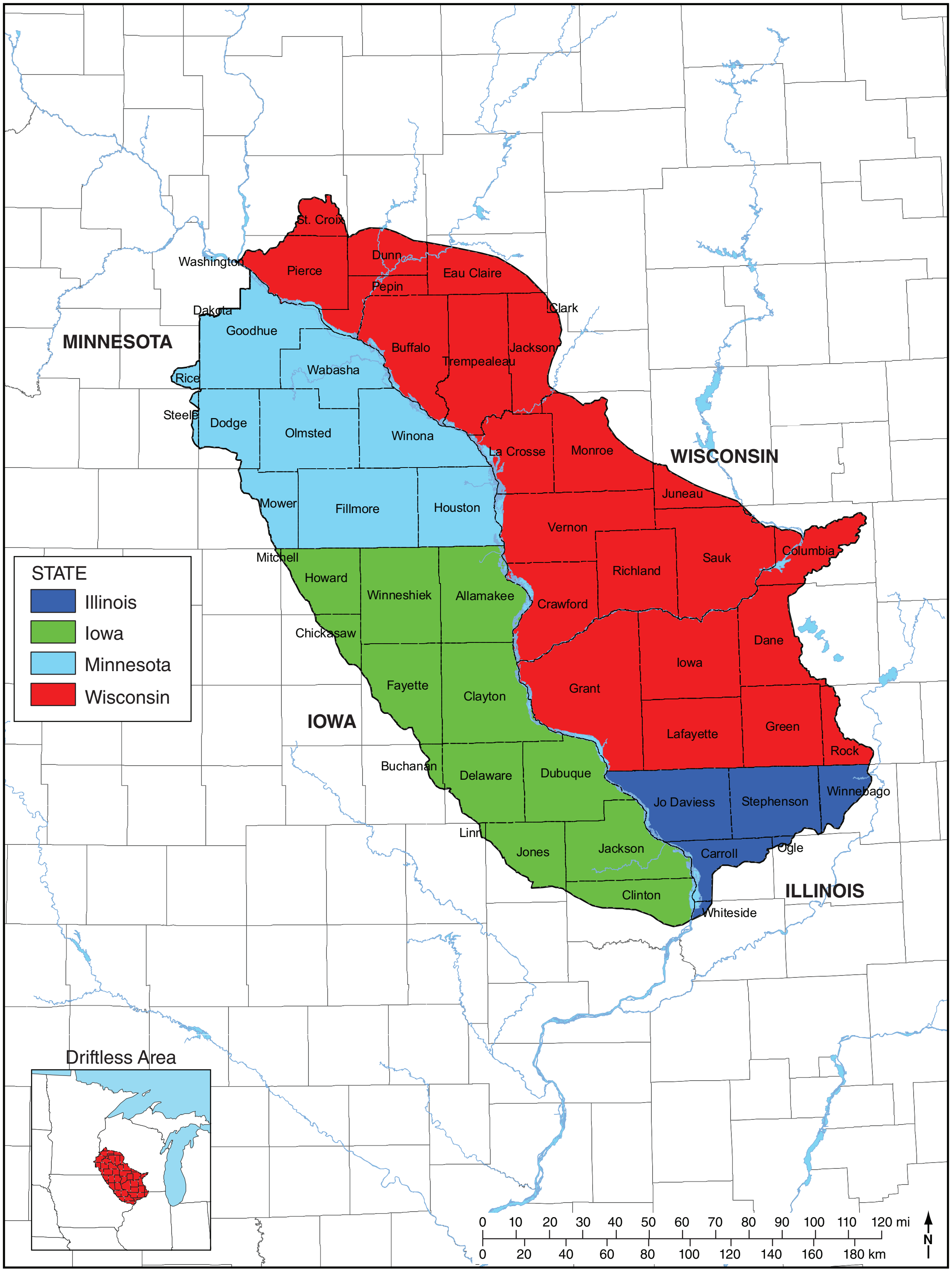



**Figure 1** Jo Daviess County is part of the Driftless Area that encompasses four states and more than 16,000 square miles. It represents an area that was not directly affected by glaciation during the Illinois and Wisconsin glacial epochs (figure modified from the Driftless Area Initiative's Major Land Resource Areas map, http://www.driftlessareainitiative.org/maps.cfm). Used with permission of The Driftless Area Initiative, with special thanks to David C. Wilson (cartographer).

| 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 | 10,000 – 1.8 m | Glacial till, glacial outwash, gravel, sand, silt, lake deposits of clay and silt; wind deposits of loess and sand dunes. Deposits cover nearly all of state except northwest corner and southern tip |
| | | Tertiary 0–500' | Pliocene | 1.8 m – 5.3 m | Chert gravel, present in northern, southern, and western Illinois |
| | | | Eocene | 33.7 m – 54.8 m | Mostly micaceous sand with some silt and clay; present only in southern Illinois |
| | | | Paleocene | 54.8 m – 65 m | Mostly clay, little sand; present only in southern Illinois |
| MESOZOIC "Middle Life" | Age of Reptiles | Cretaceous 0–300' | | 65 m – 144 m | Mostly sand, some thin beds of clay, and, locally, gravel; present only in southern and western Illinois |
| PALEOZOIC "Ancient Life" | Age of Amphibians and Early Plants | Pennsylvanian 0–3,000' ("Coal Measures") | | 290 m – 323 m | Largely shale and sandstone with beds of coal, limestone, and clay |
| | | Mississippian 0–3,500' | | 323 m – 354 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' | | 354 m – 417 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' | | 417 m – 443 m | Principally dolomite and limestone |
| | | Ordovician 500–2,000' | | 443 m – 490 m | Largely dolomite and limestone but contains sandstone, shale, and siltstone formations |
| | | Cambrian 1,500–3,000' | | 490 m – 543 m | Chiefly sandstones with some dolomite and shale; exposed only in small areas in north-central Illinois |
| | | Precambrian | | 543 m | Igneous and metamorphic rocks; known in Illinois only from deep wells |

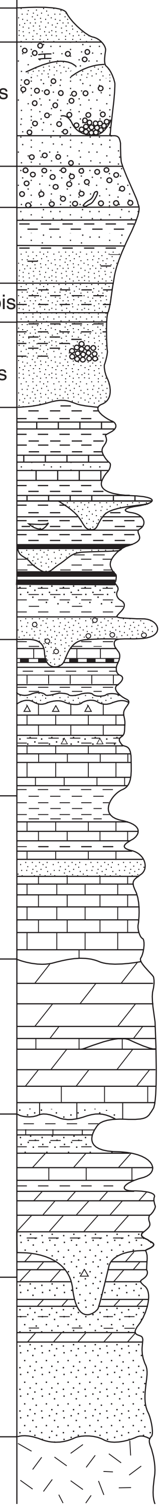


**Figure 2** Generalized geologic column of Illinois showing all eras and periods throughout Illinois' geologic history (from Frankie and Nelson 2002, p. iv).

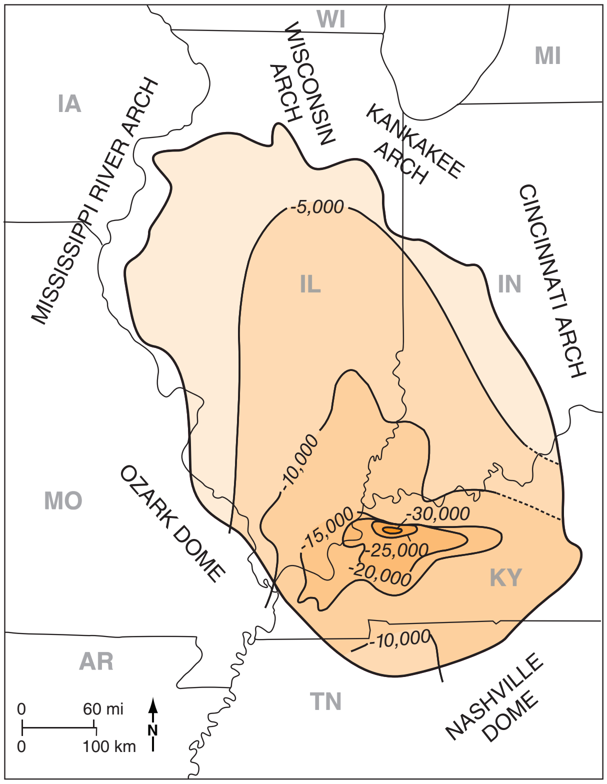



**Figure 3** The Illinois Basin (shaded) and all the surrounding structures (arches and domes) that bound the basin margins showing the depth of the basin. Contour interval is 5,000 feet (Figure 3-3 from Kolata and Nimz 2010, p. 78).

Paleozoic rock record and are shown in the generalized stratigraphic column as wavy lines. Each unconformity represents an extended time interval for which no rock record exists; this is similar to periodically removing several pages or even a chapter from a history book.

Near the close of the Mississippian Period, gentle arching of the rocks in eastern Illinois initiated the development of the LaSalle *Anticlinorium*, a complex structure having smaller structures such as domes, *anticlines*, and *synclines* superimposed on the broad upwarp of the anticlinorium. Further gradual arching continued through the Pennsylvanian Period. Because the youngest Pennsylvanian strata are absent from the area of the anticlinorium (either because they were not deposited or because they were eroded), we cannot determine just when folding ceased—perhaps by the end of the Pennsylvanian or during the Permian Period a little later, near the close of the Paleozoic Era.

### Mesozoic Era

During the Mesozoic Era, the rise of the Pascola Arch in southeastern Missouri and western Tennessee produced a structural barrier that helped form the current shape of the Illinois Basin by closing off the embayment and separating it from the open sea to the south. The Illinois Basin is a broad, subsided region covering much of Illinois, southwestern Indiana, and western Kentucky. Development of the Pascola Arch, in conjunction with the earlier sinking of the deeper portion of the basin north of the Pascola Arch in southern Illinois, gave the basin its present asymmetrical, spoon-shaped configuration. The geologic map shows the distribution of the rock *systems* of the various geologic time periods as they would appear if all the glacial, windblown, and surface materials were removed (Figure 4).

Younger rocks of the latest Pennsylvanian and perhaps the Permian (the youngest rock systems of the Paleozoic) may at one time have covered the southern and northern portions of Illinois. It is possible that Mesozoic and Cenozoic rocks (see Figure 2) could also have been present here. Indirect evidence, based on the *stage* of development (rank) of coal deposits and the generation and maturation of petroleum from source rocks (Damberger 1971), indicates that perhaps as much as 1.5 miles of Late Pennsylvanian and younger rocks once covered southern Illinois. During the more than 240 million years since the end of the Paleozoic Era (and before the onset of *glaciation* 1 to 2 million years ago), however, several thousands of feet of strata may have been eroded. Nearly all traces of any post-Pennsylvanian *bedrock* that may have been present in Illinois were removed. During this extended period of erosion, deep valleys were carved into the gently tilted bedrock formations. Later, the topographic *relief* was reduced by repeated advances and melting back of continental *glaciers* that scoured and scraped the bedrock surface. These glacial processes affected all the formations exposed at the bedrock surface in Illinois. The final melting of the glaciers left behind the *nonlithified* deposits from which our modern soil has developed.

## Structural Setting

Jo Daviess County is located northwest of the Illinois Basin on the southwestern flank of the regional, broad, and gently sloping Wisconsin Arch (Figure 5). Paleozoic bedrock strata in the field trip area have a regional dip of 20 to 30 feet per mile to the southwest, except where the strata are affected by local structure (e.g., folds and faults). The Wisconsin Arch is a broad, positive area that separates the Michigan Basin on the east from the Forest City Basin on the west. The northern end of the Wisconsin Arch—termed the Wisconsin Dome—is a region of Precambrian outcrops in northern Wisconsin. The rest of the arch is overlapped by Cambrian, Ordovician, and Silurian sedimentary rocks. The southeast end of the Wisconsin Arch connects with the Kankakee Arch, which separates the Michigan and

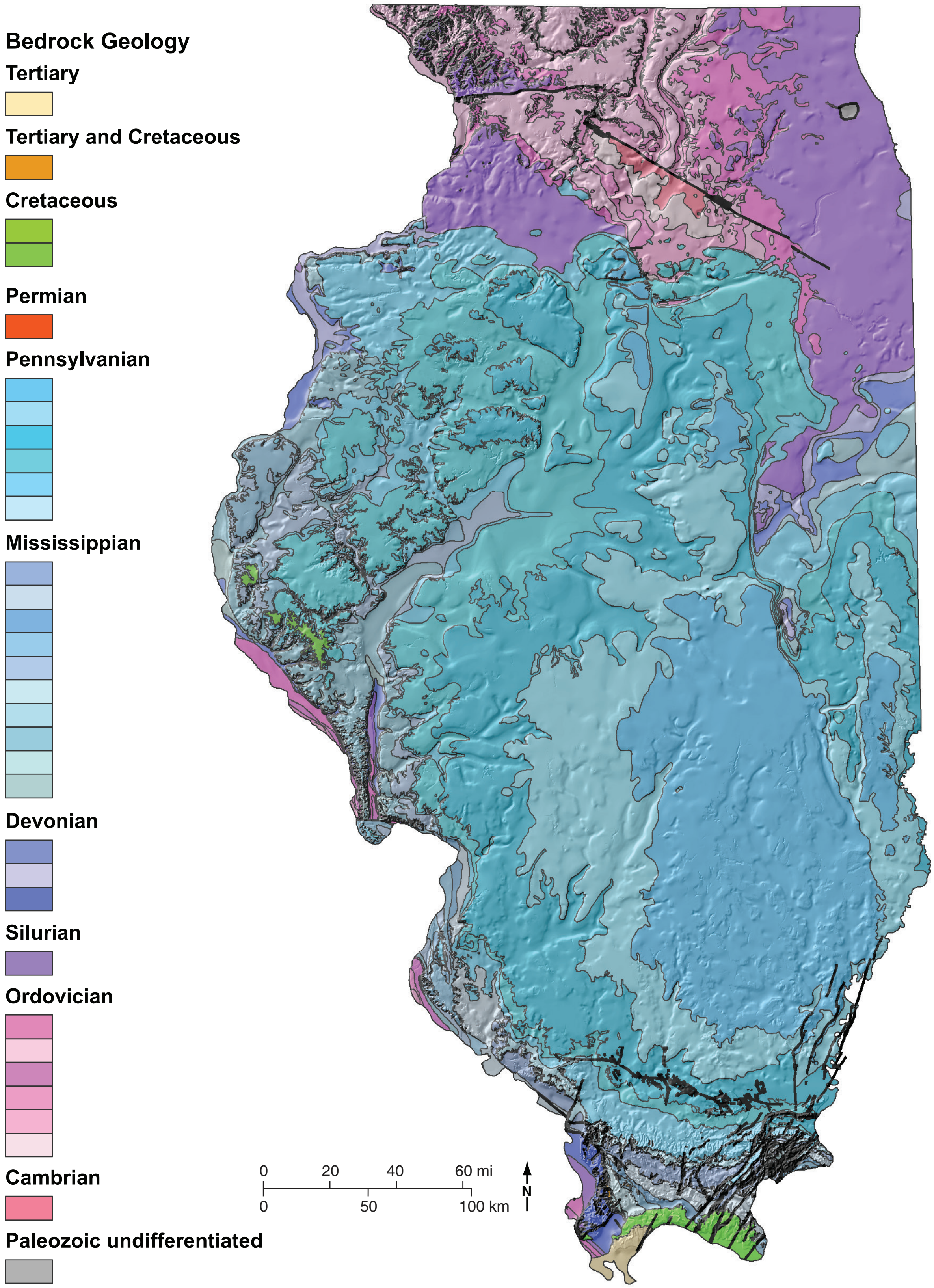



**Figure 4** Generalized bedrock geology map of Illinois. The black lines in the north-central and southern parts of the map are faults and fault zones (Figure 2-12 from Kolata and Nimz 2010, p. 68).

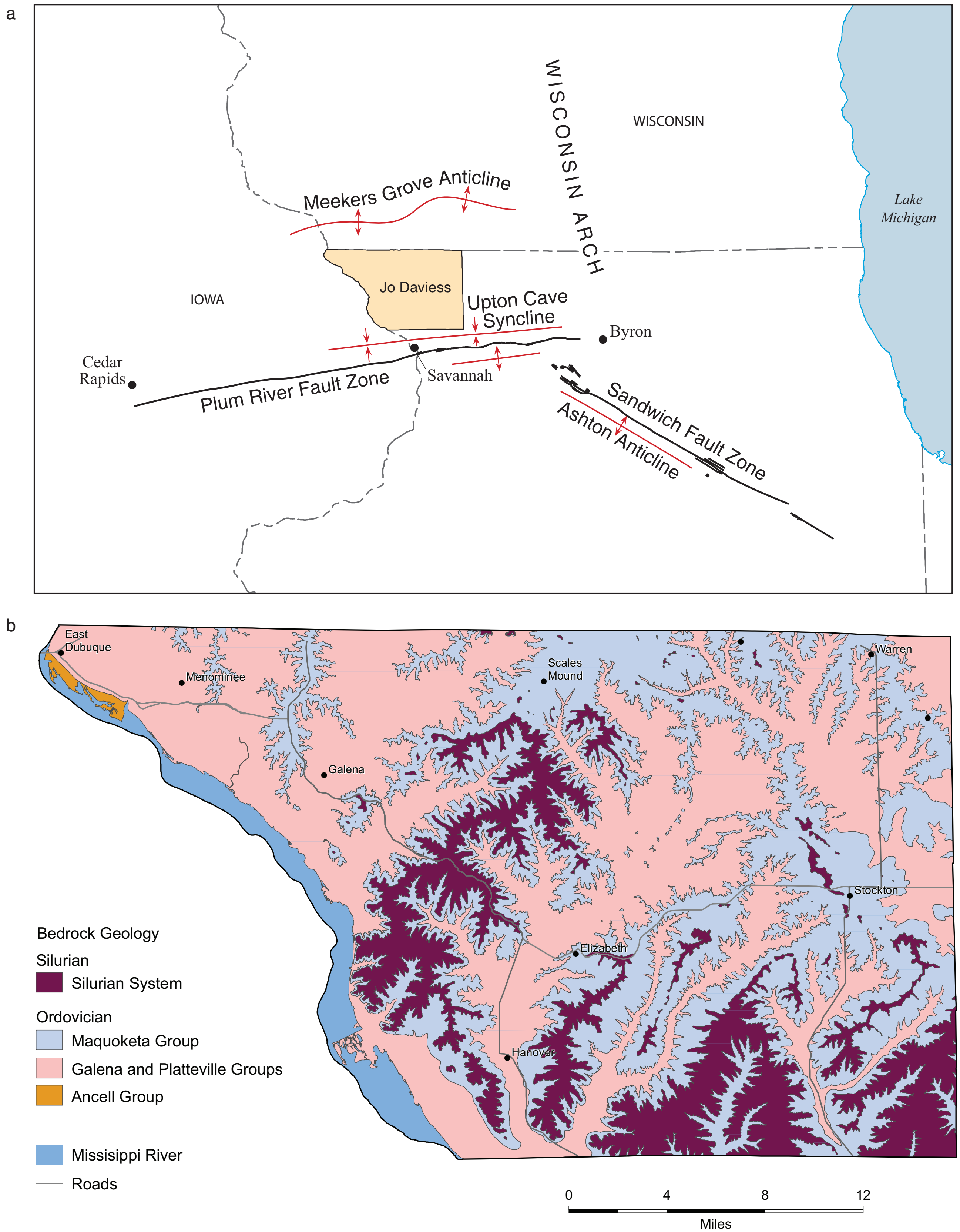



**Figure 5** (a) Major structural features in northern Illinois, southern Wisconsin, and eastern Iowa that bound Jo Daviess County (from Panno et al. in preparation b). (b) Generalized geologic map of Jo Daviess County (modified from McGarry 2000).

Illinois Basins (Nelson 1995). The Illinois Basin is the major structural depression between the Ozark Dome to the west, the Cincinnati Arch to the east, and the Kankakee Arch to the north.

The Wisconsin Arch began to emerge late in the Cambrian Period and was well established by the middle of the Ordovician Period. The Wisconsin Arch may have been covered by seas in the late Ordovician through middle Silurian time, but rose again in late Silurian or Devonian time (Nelson 1995).

## Preglacial History of Northwestern Illinois

After 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 was uplifted and 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 erosional plain, referred to as 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 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 because they would be uniformly beveled.

In northern Jo Daviess County, 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 that were less resistant than the Silurian dolomite were stripped away by erosion. In the unglaciated Driftless Area of Wisconsin, the Dodgeville surface is well preserved. However, in Jo Daviess County, Illinois, only remnants of the Dodgeville surface are preserved as isolated, flat-topped ridges and knobs of Silurian dolomite. We can imagine the tops of these Silurian flats joined by a plane surface representing the former peneplain, sloping gently southwestward from about 1,200 to 1,000 feet above mean sea level (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 and is well developed in the Driftless Area. The Lancaster surface closely coincides with the top of the Ordovician Galena Dolomite to the north near Galena and slopes southwestward from an elevation of about 985 to 800 feet above msl.

## The Driftless Area

The Driftless Area of northwestern Illinois, southwestern Wisconsin, southeastern Minnesota, and northeastern Iowa is unlike other parts of these states because it escaped the direct effects of Pleistocene-*age* glaciation (Figure 6). The higher elevation of the area resulted in the diversion of continental glaciers around the Driftless Area. Today, the area has relatively thin, fragile soils and is well known for its former mining activities, present-day agriculture, unique ecology, and steep and rugged knobs, hills, and valleys. It lays claim to the highest elevations in Illinois. Jo Daviess County has a long history of geological processes that sculpted the present landscape; conflict between Native Americans and early settlers; prehistoric, historic, and recent mining activities; agriculture; and, more recently, natural area preservation and tourism.

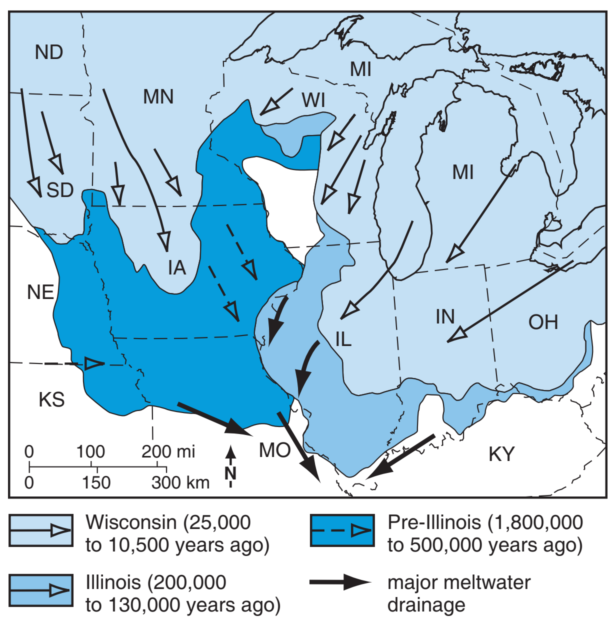



**Figure 6** Glaciation of North America in the vicinity of Jo Daviess County showing the extent of Pre-Illinois (1,800,000 to 500,000 years ago), the extent of the Illinois glacial episode (200,000 to 130,000 years ago), and the extent of the Wisconsin glacial episode (25,000 to 10,500 years ago; Figure 3 from Killey 2007, p. 3).

## Glacial Geology

Most of Illinois and all the neighboring states to the north, east, and west were inundated by continental glaciers from the north during the Pleistocene Epoch [1,600,000 to 12,000 years before present (BP); Hansel and McKay 2010]. Often referred to as the "Ice Age," the glaciers of this epoch did not enter into Jo Daviess County or a contiguous portion of land in southwestern Wisconsin, southeastern Minnesota, and northeastern Iowa. Glaciation had a profound effect on most of Illinois from extensive physical erosion by advancing glaciers, the effects of flooding by glacial meltwaters, and the deposition of fine-grained (clay, *silt*, sand) and course-grained (gravel) materials. Much of Illinois is now covered with a blanket of materials hundreds of feet thick in many places that mask the underlying terrain. The Driftless Area provides a window into the appearance of northern Illinois and southern Wisconsin topography prior to glaciation. Some changes to the topography, however, are due to changes in climate, including the effects of the erosive nature of glacial meltwaters (deep valleys), the *weathering* effect associated with the climate (e.g., frost wedging), and the accumulation of windblown *loess* (excellent agricultural soils). The following is a brief summary of the glacial history of Illinois that was derived, to a large extent, from Frankie and Nelson (2002).

During the Pleistocene Epoch, the climate cooled and continental glaciers began forming in eastern and central Canada as snow and ice accumulated in these areas. The glaciers began spreading in all directions from these centers. Their advances into the central lowlands of the United States dramatically changed the landscape of the midwestern United States. As the glaciers entered Illinois about 800,000 years ago (Hansel and McKay 2010), they carried with them rock debris. This debris was incorporated into the ice as the glaciers advanced and was deposited as the glaciers retreated or melted. Numerous advances and retreats of glaciers occurred during the Pleistocene Epoch, but geologic records have been destroyed for all but the last 425,000 years. The older episodes are collectively referred to as Pre-Illinois, and each glacial episode is punctuated by interglacial episodes when the climate was similar to what it is today.

The first of the last two glacial episodes began about 300,000 years ago and is referred to as the Illinois Glacial Episode. The Illinois Episode continued for 175,000 years and, based on sediment consolidation [B.B. Curry, Illinois State Geological Survey (ISGS), personal communication], saw up to 1,000 feet of ice in northern Illinois that almost reached the southernmost tip of Illinois (Figure 6). However, the glacier went around the Driftless Area and much of Jo Daviess County, stopping a mere 3 miles east of Apple River Canyon State Park. This episode was followed by another interglacial episode that lasted for about 50,000 years until the beginning of the Wisconsin Glacial Episode (about 75,000 years ago). The glaciers from this episode were only about 700 feet thick and extended into northeastern Illinois only about 25,000 years ago; the Wisconsin glacier finally retreated from Illinois about 13,500 years ago (Figures 7 and 8).

During the late stages of the Wisconsin Glacial Episode, fine silt deposited in what is now the Mississippi River valley was blown up onto most of Illinois by strong westerly winds. This material, known as loess, reached thicknesses of up to 25 feet. The loess later developed into the present soil zone; because of erosion, the loess thickness now ranges from 0 to 25 feet.

## Geology and Hydrogeology

**Samuel V. Panno, Illinois State Geological Survey, and Walton R. Kelly, Illinois State Water Survey**

### Geology

Bedrock in Jo Daviess County consists of Middle Ordovician (444–490 million years ago) carbonate rocks of the Galena-Platteville Group, thin remnants of the Ordovician Maquoketa Shale, and Silurian (412–443 million years ago) dolomite.

The well-known knobs of Jo Daviess County (e.g., Scales Mound) are erosional remnants of an older terrain (Figure 9). The resistant Silurian dolomite cap rock protects the knobs from erosion, but undercutting of the softer and more easily erodible Maquoketa Shale on which the dolomite rests results in highlands with intact dolomite caps in some areas and scattered and tilted house-size blocks of dolomite that slide around on the shale in other areas (Figure 10). The Maquoketa Shale and underlying Galena Dolomite make up the subdued hills and valleys of Jo Daviess County.

Tectonic compression and extension occurred in Illinois and the surrounding states during and after the formation of the Wisconsin Arch, which began in Cambrian time (490–543 million years ago) and continued to be active in late Silurian or Devonian time (354–417 million years ago; Nelson 1995). The Wisconsin Arch, in part, separates the Illinois Basin to the south from the Michigan Basin to the east. Jo Daviess County lies on the southwestern flank of the Wisconsin Arch (Frankie and Nelson 2002). As a result of compression and extension, bedrock along the Wisconsin Arch has a well-developed vertical *joint* system. Heyl et al. (1959) stated,

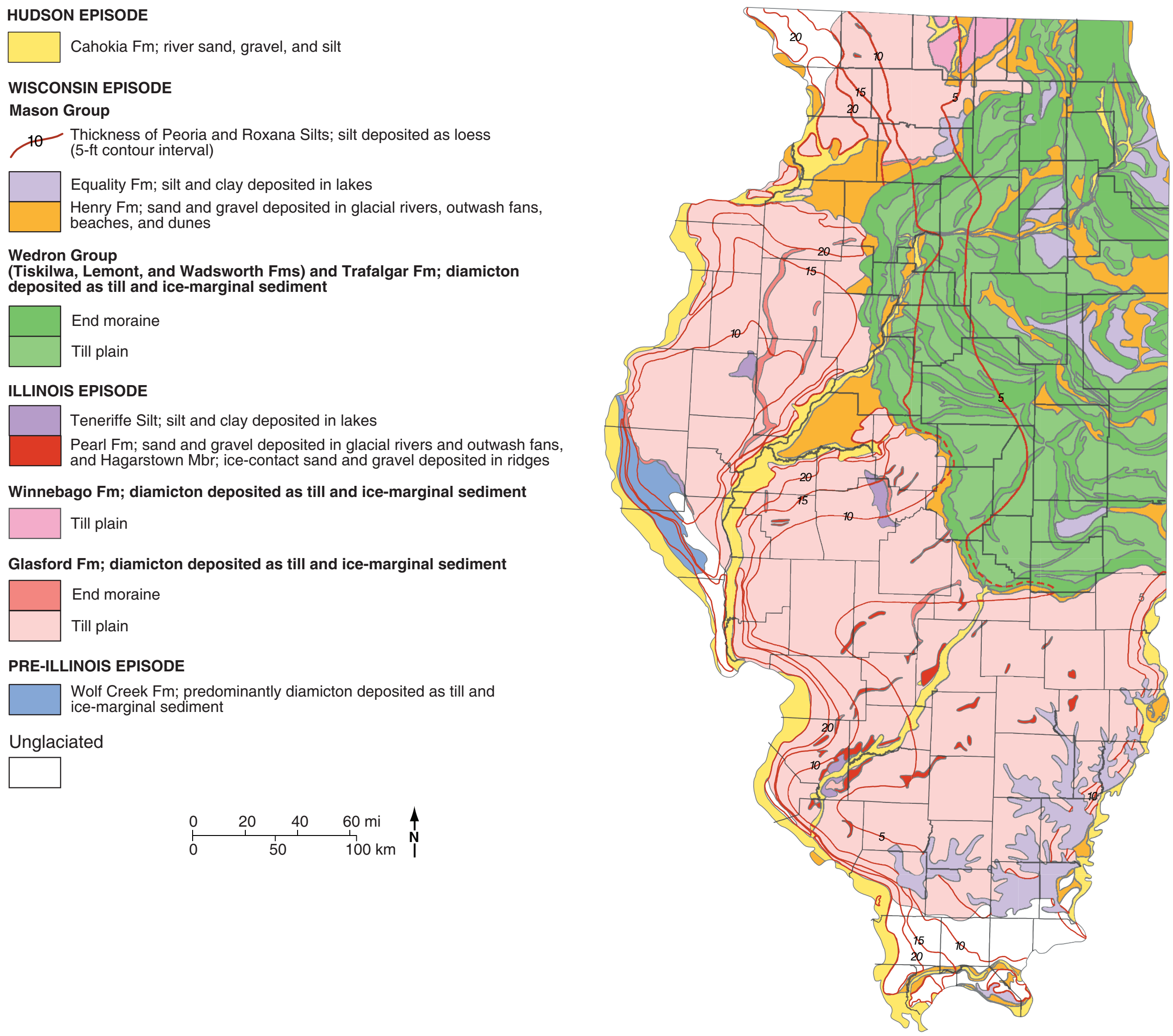



**Figure 7** Generalized map of the glacial deposits of Illinois (Figure 12-12 from Kolata and Nimz 2010, p. 229).

> All the rock formations in the district [most of Jo Daviess County] contain well-developed vertical and inclined joints. The vertical joints are traceable for as much as 2 miles horizontally, and for as much as 300 feet vertically. Joints are especially well developed in the Galena dolomite. (p. 1)

Both Heyl et al. (1959) and Bradbury (1959) found that most of the fractures and *crevices* in the area were oriented predominantly in east–west and north–south directions. Recent work by Panno et al. (in preparation a) examined 18,000 crop lines, aligned sinkholes, and historic mining trends (following vein-filling *ores*) throughout Jo Daviess and into adjacent counties and found similar fracture and crevice trends. Panno et al. (in preparation b) suggested, based on this work, that the east- to west-trending fractures were formed during the Appalachian fold and thrust belt during the late Paleozoic Alleghanian Orogeny. These fractures were enlarged and mineralized by *ore*-forming solutions around early Permian time. Most of the north- to south-trending fractures and crevices of the carbonate bedrock in the county formed sometime later.

## Galena Dolomite

In the mid-1990s, the ISGS identified Jo Daviess County as *karst* (Panno et al. 1997; Weibel and Panno 1997; Figure 11). Subsequent work by McGarry and Riggs (2000) identified most of Jo Daviess County as having "a very high aquifer sensitivity because

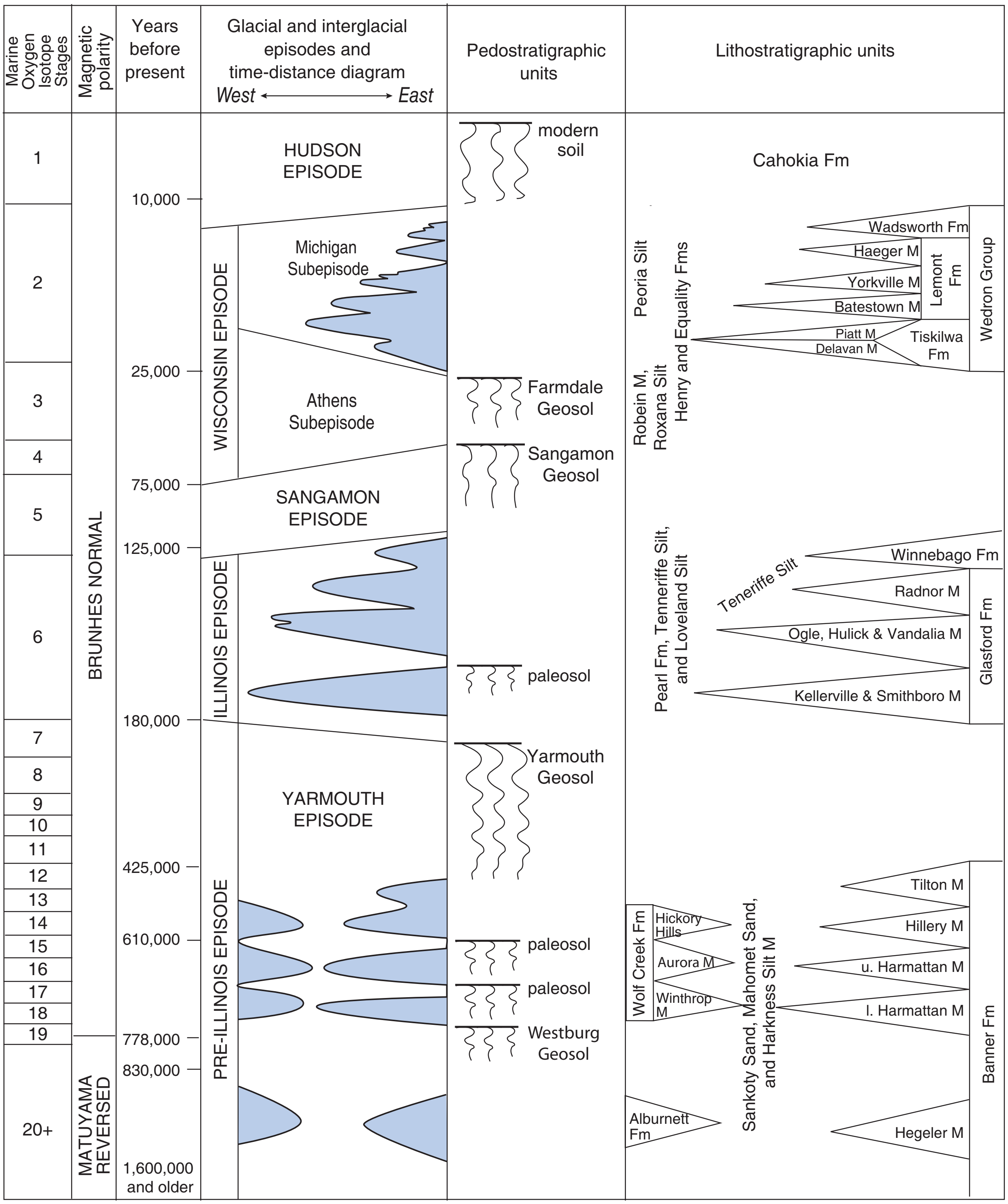



**Figure 8** Simplified timeline of glacial and interglacial events in Illinois during Pleistocene glaciation (Figure 12-6 from Kolata and Nimz 2010, p. 223).

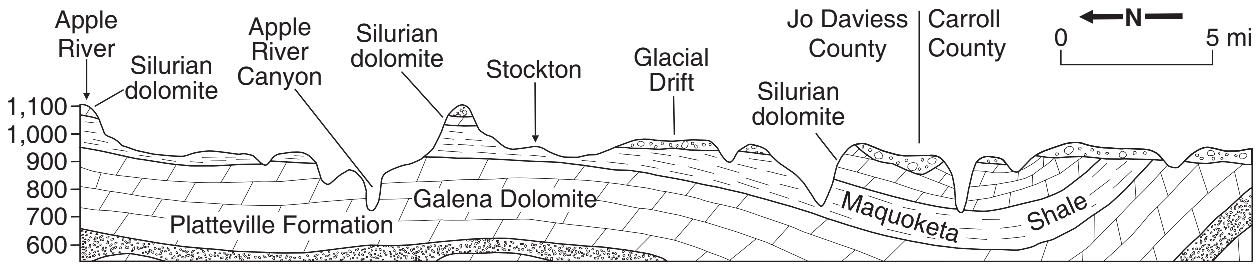



**Figure 9** Cross section across Jo Daviess County showing isolated Silurian dolomite-capped mounds of the Dodgeville surface (modified from Figure 10 from Frankie and Nelson 2002, p. 15).

**Figure 10** Tilted blocks of Silurian dolomite atop Maquoketa Shale showing movement of the blocks as they erode and collapse from the top of a knob in Jo Daviess County. Photograph by Elizabeth L. Baranski; used with permission.

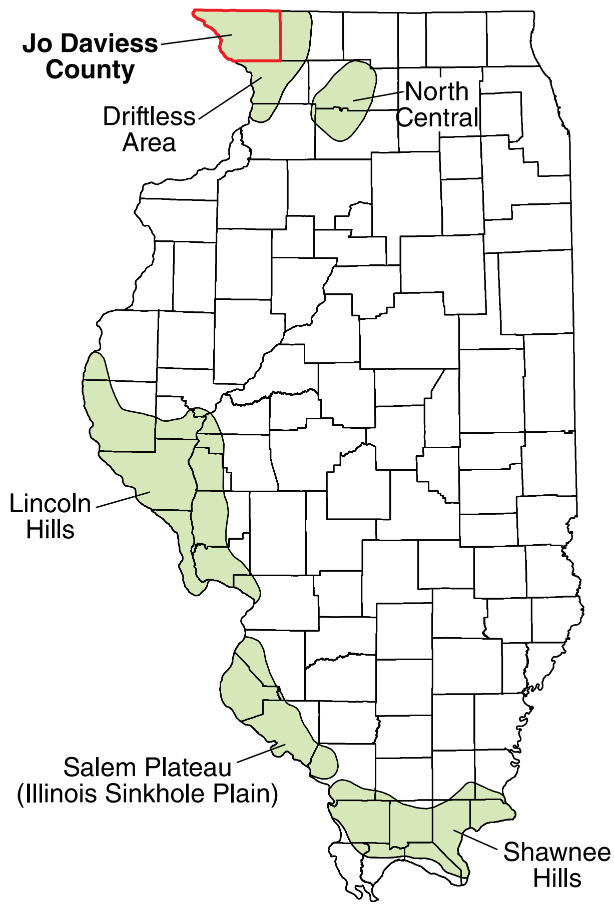



**Figure 11** Map of the karst areas of Illinois showing the extent of karst terrain in Illinois, including northwestern Illinois (from Weibel and Panno 1997).

fractured dolomite bedrock aquifers lie beneath the glacial *drift* or loess. Areas where dolomite bedrock is exposed are most sensitive." The karst water-bearing formations include the Galena-Platteville Group and the Silurian dolomite. Panno and Luman (2008) examined sinkholes and the abundant secondary porosity (crevices) exposed along road cuts and in quarries in eastern Jo Daviess County and concluded that the area overlies a karst *aquifer* within the Galena Dolomite. They also showed that sinkholes in the county were sparse and difficult to locate because of its thin soils, although the county did fall into the "medium" to "high" category of aquifer vulnerability per Lindsey et al. (2010). Ekberg (2008) subdivided the secondary porosity of the Galena-Platteville into matrix, fracture, and conduit porosity. These subdivisions are supported by spring hydrographs and drawdown curves from aquifer tests that support a triple-porosity aquifer. The fracture porosity through which groundwater flows consists of northeast- and northwest-trending vertical fractures (consistent with Heyl et al. 1959) and of bedding planes (Ekberg 2008). Domestic wells in Jo Daviess County get their water from the Galena Dolomite at depths of less than 250 feet (Frankie and Nelson 2002). Frankie and Nelson (2002) suggested that these aquifers are susceptible to bacterial pollution because the "open crevices provide little filtering action, and polluted water may travel


**Figure 12** En echelon cover-collapse sinkholes in loess overlying crevices in Silurian dolomite, as shown on a LiDAR (light detection and ranging) shaded relief elevation model. Map by Donald E. Luman.

long distances through these openings with little loss of pollutants" (p. 25). In addition, McGarry and Riggs (2000) characterized eastern Jo Daviess County as having a combination of low (because of the presence of Maquoketa Shale) and very high sensitivities (because of exposed fractured dolomite bedrock) to groundwater contamination. These findings are consistent with regional water quality results reported in Panno and Luman (2008).

## Silurian Dolomite

Examination of the LiDAR elevation data revealed numerous *cover-collapse sinkholes* in western Jo Daviess County overlying Silurian dolomite. Examination of the area on the ground revealed numerous sinkholes, solution-enlarged crevices, and small caves. Crevices in the Silurian dolomite are relatively wide (up to 6 feet or more). Sinkholes in this area are roughly circular features, 6 to 21 feet deep and 60 to 100 feet in diameter, based on measurements of LiDAR elevation data. Several of these sinkholes, initially seen in aerial photographs, were documented by Weibel and Panno (1997) and Panno et al. (1997). Many more sinkholes were found using LiDAR elevation data, and most of the sinkholes lay *en echelon* along nearly east- to west-trending (N 80° W) lineaments in sediment overlying Silurian-age dolomite (Figure 12). Weibel and Panno (1997) and Panno et al. (1997) reported that they were collapse features with no evidence of waste piles or ejecta that would suggest excavations. Consequently, we interpreted them as sinkholes and not small-scale mining operations (known as *sucker holes*) following veins of ore minerals. Only about 10 of these Silurian dolomite sinkholes have been examined in the field, and it is possible that a few could be related to adjacent large-scale mining operations (e.g., Touseull and Rich 1980). Although a large *sinkhole* area is located in the vicinity of the New California Diggings (Figure 12) in the far southern edge of the Galena subdistrict (Heyl et al. 1959), the ore deposits in this area were primarily within the deeper Galena Group dolomite underlying the Silurian dolomite and Maquoketa Shale. Therefore, features identified as cover-collapse sinkholes in sediment overlying the Silurian dolomite are not related to mining operations. Road cuts in the area (between 3 and 4 miles to the east) reveal that these aligned sinkholes probably formed along nearly east- to west-trending crevices that range from 1.5 to 6 feet in width (Figure 13). The depth of the crevices at this site is at least 20 feet from land surface, as seen in road cuts. Collapse of sediment into these large crevices probably created the sinkholes and associated lineaments observed in the imagery. In addition, it is possible that large blocks of Silurian-age dolomite on ridges could separate along crevices and migrate downhill on the underlying shale. This would dilate existing crevices even more, thereby creating additional linear collapse features (D. Mikulic, ISGS, personal communication).

Because the Silurian dolomite is of limited areal extent and forms the highlands of Jo Daviess County, based on water-well data from the Illinois State Water Survey, it is rarely used as a groundwater source in this area. However, it is a prolific aquifer in other counties of northern Illinois (e.g., Will County to the southeast).

### Ore Deposits

Solution-enlarged crevices also acted as foci for ore mineralization in this area. The Upper Mississippi Valley Zinc–Lead District, which includes Jo Daviess County and extends into Iowa and Wisconsin, is referred to as the Upper Mississippi Valley District. The geology of this area has been summarized by Heyl et al. (1959) and Bradbury (1959). Lead- and zinc-bearing ore minerals were mined from the Jo Daviess County area from the late 1700s until 1976 (Figure 14). Primary ore mineralization was found in solution-enlarged crevices or in solution cavities in carbonate rocks of the Galena Group, called "gash-vein deposits." *Galena* ($PbS_2$) was the main ore mineral in these deposits (Figure 15), and *sphalerite* ($ZnS_2$) was the most abundant ore mineral associated with bedding planes and reverse faults (Heyl et al. 1959). Geochemical and isotopic indicators within the ore and associated minerals indicate that hydrothermal ore-forming fluids (hot brines) carrying lead and zinc in solution were the source of the mineralization. Ore-forming solutions originating from evaporative brines associated with the Reelfoot Rift System (late Paleozoic time) is one of the more recent hypotheses proposed to explain the origin of these deposits (Rowan and de Marsily 2001). Ore mineralization and dolomitization (the conversion of *limestone* to dolomite by hot brines) of the Ordovician-age carbonate rocks of this district have been dated as Early Permian in age (270 and 280 million years ago; Brannon et al. 1992; Pannalal et al. 2004). The hot, acidic, metal-bearing brines (the more acidic the water, the more dissolved metals it can hold) migrated through fractures and crevices within carbonate rock and dissolved some of the carbonate rock. This buffered the brine and made it much less acidic and unable to carry as much dissolved metal; thus, the metals were deposited as sulfides on the walls of the now wider crevices.

Ore deposits were located throughout Jo Daviess County, and evidence of the *mines* and workings are visible as old crevice mine openings, trenches, and sucker holes. Heyl et al. (1978) described early mining in the area as follows:

> Production was largely from "float" deposits formed by weathering of sulfide veins that left concentrations of residual galena on hillside bedrock overlain by varying thicknesses of residual soil. The miners would dig a pit to bedrock and then reach out in all directions, dragging the galena to the center. The mining limit of each pit was soon reached, and then the miners simply moved a short distance away and dug another pit. This system of "suckering" produced the pock-marked hillsides so common in the district. (p. 4; see Figure 16)

The sucker holes are visible throughout the county and are the most visible on LiDAR shaded relief elevation models (Figure 17).

## Hydrogeology

The Galena-Platteville Formation constitutes the major aquifer of Jo Daviess County. Ekberg (2008) subdivided the secondary porosity of the Galena-Platteville into matrix, fracture, and conduit porosity (a triple-porosity aquifer). The fracture porosity through which groundwater flows consists of northeast- and northwest-trending vertical fractures (consistent with Heyl et al. 1959) and bedding planes (Ekberg 2008). These northeast- and northwest-trending fractures are oriented more north–south and east–west in Jo Daviess County (Panno et al. in preparation b). Ekberg (2008) found that the fractures, crevices, and bedding planes of the Galena Dolomite aquifer constitute the greatest porosity. The Galena and underlying Platteville Formations, collectively referred to as the Galena-Platteville Dolomite, constitute an important and reliable groundwater resource for residents of Jo Daviess County (Hackett and Bergstrom 1956; Csallany and Walton 1963). Csallany and Walton (1963) found that "most water-yielding openings occur in the upper one-third of the shallow dolomite aquifers" (p. 1). They stated that some shallow dolomite wells have yields in excess of 1,000 gallons per minute. They also found that where the Galena-Plat-

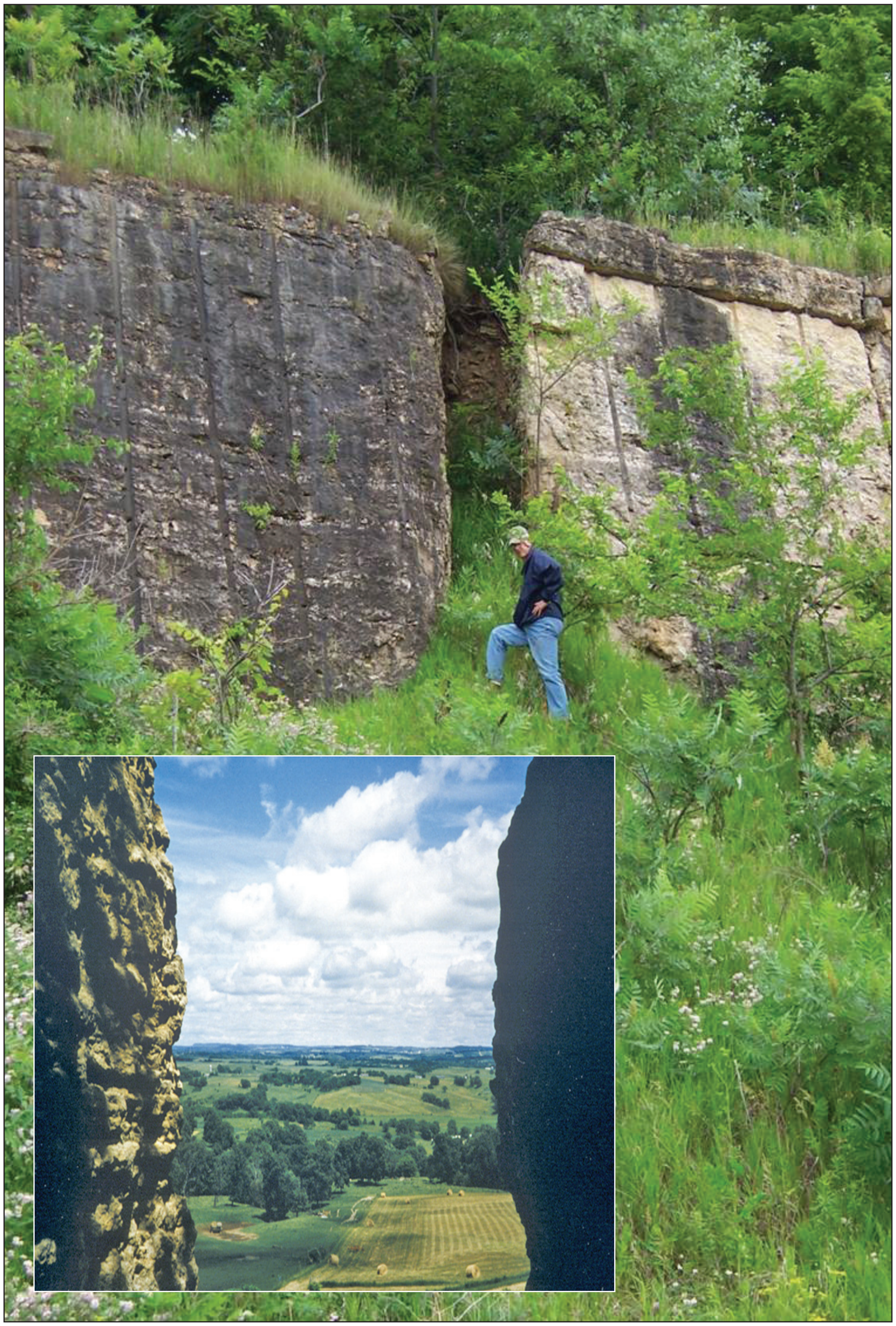


**Figure 13** Solution-enlarged crevice in a road cut that is typical of crevices in Silurian dolomite. (inset). The crevice shown in the photograph is 3 feet wide. Photograph by Samuel V. Panno; used with permission.

teville Dolomite is overlain by unconsolidated deposits in northern Illinois,

> solution activity has enlarged openings, and the unit yields moderate quantities of water to wells. Where the unit is overlain by the Maquoketa Shale, the Galena-Platteville Dolomite is a less favorable source of ground water and yields little water from joints, fissures, and solution cavities. (p. 6)

Panno et al. (in preparation a,b) found that the widths of fractures and solution-enlarged crevices in the Galena Dolomite ranged from less than 0.4 inches to 3 feet or more. In general, the crevices provide a network of pathways through which infiltrating surface water and groundwater can flow rapidly (Figure 18). Bedding planes may also provide pathways for groundwater movement. The effect of depth on the porosity and permeability associated with shear zones is currently under investigation. However, elevated concentrations of nitrate as nitrogen ($NO_3$-N) and choride ($Cl^-$) in groundwater from private wells suggest the system is open to surface-borne contamination to depths of at least 100 feet (Panno and Luman 2008).

There are 16 public water supplies in Jo Daviess County having between one and nine production wells, for a total of more than 50 in the county. Three of these public supply wells are screened in shallow sand and gravel aquifers (two in East Dubuque and one in Galena). The others are drilled into bedrock, and many of them are open to multiple aquifers. Almost two-thirds of the wells are open to the Galena-Platteville Aquifer. About one-third of the wells are open to deeper aquifers, including the Jordan Sandstone, Ironton-Galesville Sand-


**Figure 14** The first map of the Upper Mississippi River lead mines, prepared by R.W. Chandler (1829). Wisconsin Historical Society, WHi-39775; used with permission.

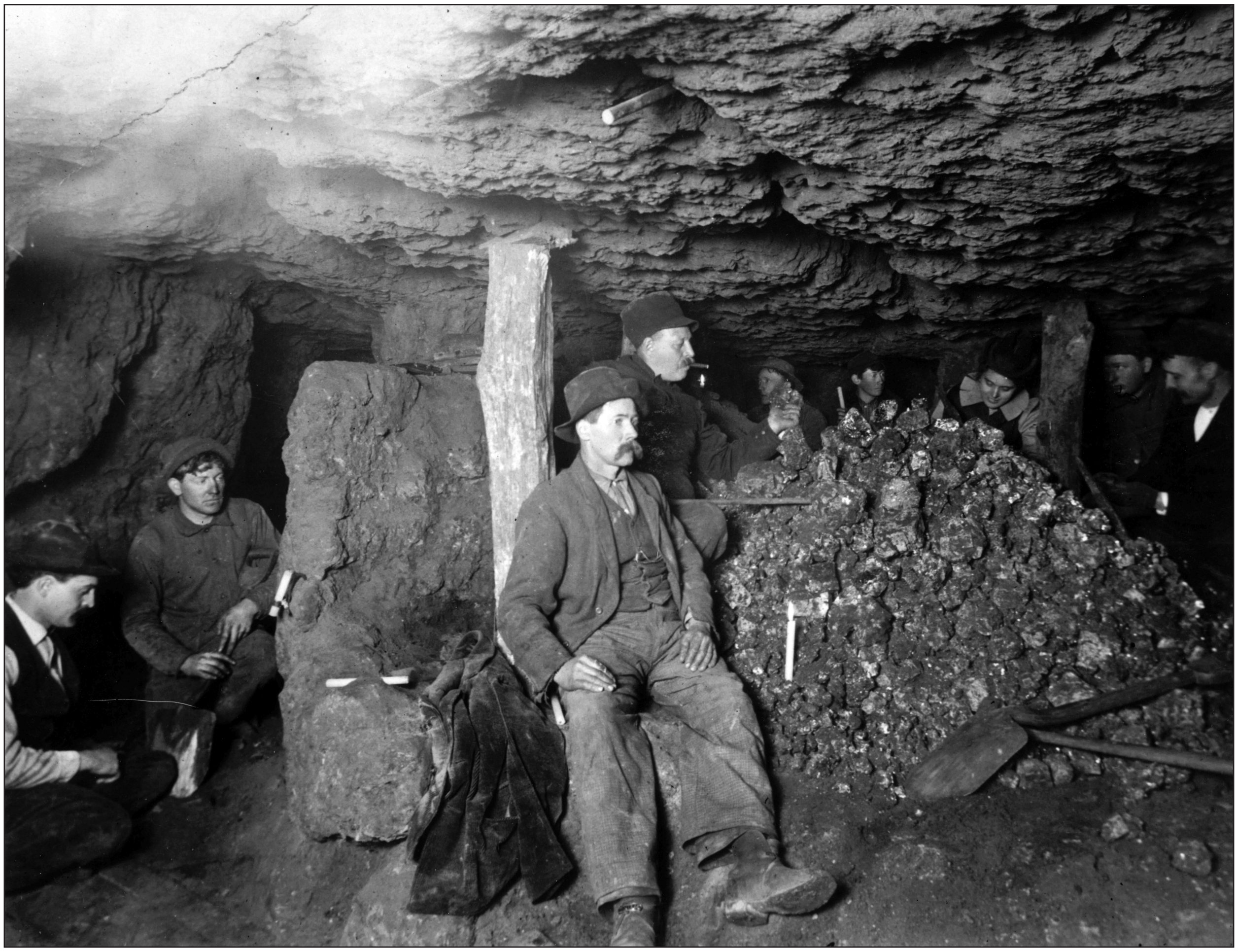


**Figure 15** Photograph of the Kipp property near the Black Jack Mine in the late 1800s showing visitors examining a pile of ore estimated to be worth $15,000 at that time ($383,000 today). Notice the candles used by the miners and visitors as their only source of light. Oil lamps were introduced in the early 1900s. From the collection of the Illinois State Geological Survey.

stone, Eau Claire Formation, and Mt. Simon Sandstone; about half of these wells are open to shallower bedrock aquifers (Galena-Platteville and Ancell) as well. Bedrock well depths range from 200 to 1,825 feet. Seven of Galena's eight wells are more than 1,500 feet deep.

Water quality data are available for about two-thirds of the public supply wells. The water in the bedrock wells is a calcium-magnesium-bicarbonate (Ca-Mg-$HCO_3$) type and is generally of good quality. Chloride concentrations are typically less than 20 mg/L, and $NO_3$-N concentrations are generally below detection. The only water quality concerns for the bedrock wells are two nuisance problems—high hardness and iron concentrations—and both of these problems are corrected in the treatment plants. The water quality in the sand and gravel wells in East Dubuque is inferior to that found in the bedrock wells. Concentrations of total dissolved solids are significantly higher, greater than the secondary standard of 500 mg/L. Chloride and $NO_3$-N concentrations are also much higher than in the bedrock wells, although below drinking water standards.

It is reasonable to assume that relatively rapid recharge to the karst aquifer occurs throughout the county, but probably less so where Maquoketa Shale is present. Those areas where Maquoketa Shale constitutes the bedrock surface, and where drain tiles are used to lower the *water table*, a much greater amount of recharge may discharge to streams before entering the karst aquifer. Sinkholes and macropores (e.g., desiccation cracks in soil) are present in the county and are locations of focused recharge. Sinkholes in the area are not commonly seen either because of the degree of cultivation, which tends to obscure all but the very largest of sinkholes, or perhaps because of their natural scarcity. During dry periods, macropores (desiccation cracks) are ubiquitous and form easily because of the thinness of the soil and the depth of the water table (below the soil–rock interface).

**Figure 16** Sucker hole at the Blewett Mine near Galena. Note the mounding around the edges and the size of the tree within the hole. The tree is about 2.5 to 3 feet in diameter and probably close to 100 years old. Photograph by Samuel V. Panno; used with permission.

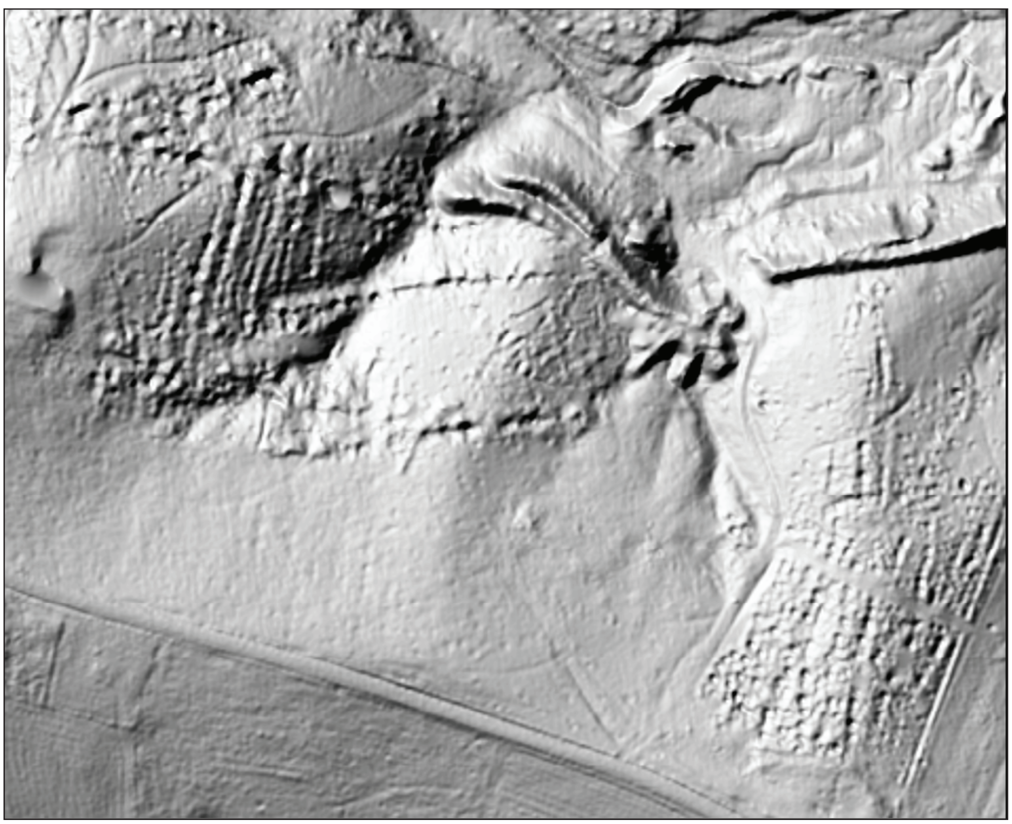


**Figure 17** Vinegar Hill Mine showing sucker holes on a LiDAR shaded relief elevation model (from Panno et al. in preparation b). Map by Donald E. Luman.

**Figure 18** Vegetative crop lines showing fracture and crevice patterns in underlying Galena Dolomite (from Panno et al. in preparation b).

## Springs

Springs are a common feature throughout Jo Daviess County, and the locations of some have been mapped by Reed (2008) and Maas (2010). The only available data on the chemical composition of springs in the county are from Maas (2010) for six springs in northeastern Jo Daviess County within the Warren Quadrangle. The springs lay along prominent lineaments identified by Panno et al. (in preparation b) and are consistent with the discharge of groundwater along bedrock crevices where the overburden thins near stream valleys. Groundwater, under hydrostatic pressure, would be able to breach land surface in low-lying areas with relatively thin overburden (usually near stream valleys). Bedrock springs typically appear to be large circular to elliptical depressions (Figure 19). A small section of the circular depressions is breached, providing openings through which the spring water discharges to a nearby stream.

## Chemical Composition of Groundwater

Groundwater in Jo Daviess County is a Ca-Mg-$HCO_3^-$-type groundwater (very hard) with elevated concentrations of $Cl^-$ and $NO_3$-N in some areas (Panno and Luman 2008). The background or natural concentration range for $Cl^-$ in shallow groundwater in northern and central Illinois is between 1 and 15 mg/L (Panno et al.

**Figure 19** Karst springs in Jo Daviess County are typically circular, with bedrock exposed near the center and drainage off to a nearby stream. Photograph by Samuel V. Panno; used with permission.

2006a). The range for background concentration of $NO_3$-N in Illinois is between 0 and 2.5 mg/L (Panno et al. 2006b; Hwang et al. in preparation). On the basis of chemical compositions of groundwater from wells and springs, the distribution of these ions and relatively high dissolved oxygen concentrations (4.7 to 8.7 mg/L) in the underlying aquifer is indicative of an open, oxygenated, unconfined karst system. Surface streams typically have dissolved oxygen concentrations between 8 and 12 mg/L. Potential sources of $Cl^-$ and $NO_3$-N include road salt, human and animal waste, and fertilizers (e.g., potash). Water resources in an open aquifer system such as this are especially vulnerable to surface-borne contaminants. There is little or no attenuation of contaminants discharged into sinkholes, macropores, and fissures; consequently, areas *downgradient* of contamination sources (wells, springs, and streams) can show effects within a few days or even hours (Green et al. 2006). The convergent nature of flow in karst aquifers may result in contaminants becoming concentrated in conduits (Field 1993).

When discussing background concentrations, one must be aware that, for example, concentrations of sodium ($Na^+$), $Cl^-$, and $NO_3$-N that are somewhat elevated above background levels do not constitute water that is harmful to humans or to natural flora and fauna of an area. They do, however, indicate that surface-borne contaminants from land-use activities have entered groundwater and will ultimately discharge to surface waters. Further, it has been shown that elevated concentrations of $Na^+$ and $Cl^-$ can be deleterious to vegetation (e.g., Panno et al. 1999) and aquatic organisms (e.g., Kelly et al. 2012). These can impart a salty taste to drinking water when $Cl^-$ concentrations exceed 250 mg/L, and elevated $Na^+$ concentrations in drinking water may be a problem for people with high blood pressure (U.S. Environmental Protection Agency 2014). Nitrate-N concentrations greater than 10 mg/L in drinking water have been shown to cause methemoglobinemia (blue baby syndrome) and may be linked to stomach cancer (O'Riordan and Bentham 1993). For the purposes of this investigation (Panno et al. 2006b), we considered concentrations exceeding the upper end of background levels as anthropogenic tracers that may be used to investigate aquifer recharge areas, recharge rates, and groundwater movement through the underlying karst aquifer.

Chloride and $NO_3$-N concentrations in private and public wells [most cased more than 100 feet (30 meters) below the surface] in the county were as high as 55 and 31 mg/L, respectively. These concentrations are well above the upper background threshold concentrations (i.e., levels that would be expected for pristine groundwater in this area). Potential sources of these contaminants include road salt ($Cl^-$), nitrogen fertilizer ($NO_3$-N), livestock waste, and effluent from private septic systems (both $Cl^-$ and $NO_3$-N). Contaminant concentrations in relation to sample depth were consistent with those of an open karst system (Panno and Luman 2008), where little or no stratification of concentrations is observed such that the migration of contaminants is subject to the vagaries of an anisotropic aquifer.

Work by Maas and Peterson (2010) in the eastern part of Jo Daviess County indicated that water from five of six springs sampled discharged from open, oxygenated systems and typically contained $Cl^-$ (5.44 to 26.7 mg/L) and $NO_3$-N (2.92 to 30.1 mg/L) concentrations above background. Spring water from all six springs was undersaturated with respect to *calcite* and dolomite. Because spring water is typically an amalgam of deep and shallow groundwater, the data suggest that shallow groundwater (not in equilibrium with the carbonate rock) is mixing with deeper groundwater before discharging from the springs. The lack of saturation with respect to calcite and dolomite indicates that karstification of the Galena Dolomite is an ongoing process in this area. The elevated concentrations of $NO_3$-N found in all but one of the springs are similar to those of tile drain waters in Illinois. This suggests that these springs may be affected by recharge water containing relatively high concentrations of surface-borne contaminants.

Because of the nature of groundwater flow in karst aquifers, groundwater pathways may be discrete conduits or crevices, bedding planes, or both and may be fed by numerous and smaller crevices within carbonate bedrock. Because springs are discharge points for groundwater, they may be fed by numerous flow paths of various ages. Some of the inputs may have a shallow component containing surface-borne contaminants from a variety of land uses, whereas other inputs may originate from deeper, usually less contaminated, sources. The percentages of each component source can vary depending on the groundwater flow paths to the springs and can vary with the time and season.

Nitrate-N concentrations for most of the springs were greater than those of shallow groundwater in Illinois (based on data from Panno et al. 2005). This is not surprising given that row crop agriculture is the dominant land use in the area and that N-fertilizer and manure are commonly applied to the fields. This indicates that N-based fertilizers, manure and human wastes, or both are likely entering the groundwater systems. The high dissolved oxygen concentrations in the spring samples (Maas 2010) suggest rapid movement of water into the subsurface, which would limit attenuation within the soil zone. In situations where water recharges more slowly through the soil zone, oxygen is consumed as organic matter is reduced, resulting in anoxic conditions that promote denitrification, which would decrease $NO_3$-N concentrations. The thin soils and the presence of macropores and sinkholes in this area appear to promote rapid recharge to bedrock aquifers, a common feature of karst regions.

## References


Bradbury, J.C., 1959, Crevice lead–zinc deposits of northwestern Illinois: Illinois State Geological Survey, Report of Investigations 210, 49 p.

Brannon, J.C., F.A. Podosek, and R.K. McLimans, 1992, Alleghenian age of the Upper Mississippi Valley zinc–lead deposit determined by Rb–Sr dating of sphalerite: Nature, v. 356, p. 509–511.

Chandler, R.W., 1829, Lead mines on the upper Mississippi River: Madison, Wisconsin Historical Society.

Csallany, S., and W.C. Walton, 1963, Yields of shallow dolomite wells in northern Illinois: Illinois State Water Survey, Report of Investigations 46, 43 p.

Damberger, H.H., 1971, Coalification pattern of the Illinois Basin: Illinois State Geological Survey, RPR1971-D.

Ekberg, D.W., 2008, Secondary porosity development in the karstic Galena/Platteville (Trenton/Black River) dolomite on the Wisconsin Arch: Implications for triple porosity ground water flow [Abstract]: National Ground Water Association Ground Water Summit, Memphis, Tennessee, March 30–April 3.

Field, M.S., 1993, Karst hydrology and chemical contamination: Journal of Environmental Systems, v. 22, no. 1, p. 1–26.

Frankie, W.T., and R.S. Nelson, 2002, Guide to the geology of the Apple River Canyon State Park and surrounding area of northeastern Jo Daviess County, Illinois: Illinois State Geological Survey, Field Trip Guidebook 2002B, 88 p.

Green, R.T., S.L. Painter, A. Sun, and S. Worthington, 2006, Groundwater contamination in karst terrains: Water, Air, and Soil Pollution, v. 6, no. 1–2, p. 157–170.

Hackett, J.E., and R.E. Bergstrom, 1956, Groundwater in northwestern Illinois: Illinois State Geological Survey, Circular 207, 25 p.

Hansel, A.K., and E.D. McKay, 2010, Quaternary Period, *in* Geology of Illinois: Illinois State Geological Survey, p. 216–247.

Heyl, A.V., Jr., A.F. Agnew, E.J. Lyons, C.H. Behre Jr., and A.E. Flint, 1959, The geology of the Upper Mississippi Valley zinc–lead district: U.S. Geological Survey, Professional Paper 309, 310 p.

Heyl, A.V., Jr., W.A. Broughton, and W.S. West, 1978, Geology of the Upper Mississippi Valley base-metal district: University of Wisconsin-Extension, Geological and Natural History Survey, Information Circular No. 16, revised.

Hwang, H.H., S.V. Panno, and K.C. Hackley, In preparation, Effects of land use change on groundwater quality of northeastern Illinois, USA: A historic perspective: Environmental and Engineering Geoscience.

Illinois Association for Advancement of Archaeology, 2009, Cultural sequence and peopling of North America, *in* A. Berkson and M.D. Wiant, editors, Discover Illinois Archaeology: Illinois Association for Advancement of Archaeology/Illinois Archaeology Survey.

Kelly, W.R., S.V. Panno, and K.C. Hackley, 2012, Concentrations and trends of chloride and other major ions in waters of the Chicago, Illinois region: Journal of Environmental and Engineering Geoscience, v. 17, no. 1, p. 65–81; special issue on the hydrogeological effects of urbanization.

Killey, M.M., 2007, Illinois' Ice Age legacy: Illinois State Geological Survey, p. 3.

Kolata, D.R., and C.K. Nimz, editors, Geology of Illinois: Illinois State Geological Survey, p. 68, 78, 92, 150, 162–163, 223, 229.

Lindsey, B.D., B.G. Katz, M.P. Berndt, A.F. Ardis, and K.A. Skach, 2010, Relations between sinkhole density and anthropogenic contaminations in selected carbonate aquifers in the eastern United States: Environmental Earth Science, v. 60, p. 1073–1090.

Maas, B.J., 2010, Investigation of spatial and temporal variations in water quality around Nora, IL: Bloomington, Illinois State University, master's thesis, 128 p.

Maas, B.J., and E.W. Peterson, 2010, Investigation of spatial and temporal variations in water quality around Nora, IL: North-Central Geological Society of America, Abstracts with Programs, paper no. 47-2.

McGarry, C.S., 2000, Bedrock Geology map of Jo Daviess County, Illinois: Illinois State Geological Survey, Open File Series OFS 2000-8h, 1:62,500.

McGarry, C.S., and M.H. Riggs, 2000, Aquifer sensitivity map, Jo Daviess County, Illinois: Illinois State Geological Survey, Open File Series OFS 2000-8i, 1:62,500.

Nelson, J.W., 1995, Structural features in Illinois: Illinois State Geological Survey, Bulletin 100, 144 p.

O'Riordan, T., and G. Bentham, 1993, The politics of nitrate in the UK, *in* T.P. Burt, A.L. Heathwaite, and S.T. Trudgill, editors, Nitrate—Processes, patterns, and management: New York, John Wiley and Sons, p. 403–416.

Pannalal, S.J., D.T.A. Symons, and D.F. Sangster, 2004, Paleomagnetic dating of Upper Mississippi Valley lead–zinc mineralization, WI, USA: Journal of Applied Geophysics, v. 56, p. 135–153.

Panno, S.V., K.C. Hackley, H.H. Hwang, S. Greenberg, I.G. Krapac, S. Landsberger, and D.J. O'Kelly, 2006a, Characterization and identification of the sources of Na-Cl in ground water: Ground Water, v. 44, no. 2, p. 176–187.

Panno, S.V., W. R. Kelly, A.T. Martinsek, and K.C. Hackley, 2006b, Estimating background and threshold nitrate concentrations using probability graphs: Ground Water, v. 44, no. 5, p. 697–709.

Panno, S.V., and D.E. Luman, 2008, Assessment of the geology and hydrogeology of two sites for a proposed large dairy facility in Jo Daviess County near Nora, IL: Illinois State Geological Survey, Open File Series 2008-2, 32 p.

Panno, S.V., D.E. Luman, W.R. Kelly, T.H. Larson, and S.J. Taylor, In preparation a, Karst terrains of northwestern Illinois' Driftless Area, Jo Daviess County: Illinois State Geological Survey, Circular.

Panno, S.V., D.E. Luman, and D.R. Kolata, In preparation b, Characterization of karst terrain using remotely-sensed data in Jo Daviess County, Illinois: Illinois State Geological Survey, ICGM Jo Daviess-kt, 1:62,500.

Panno, S.V., C.P. Weibel, and W.B. Li, 1997, Karst regions of Illinois: Illinois State Geological Survey, Open File Series 1997-2, 42 p.

Panno, S.V., C.P. Weibel, C.M. Wicks, and J.E. Vandike, 1999, Geology, hydrology, and water quality of the karst regions of southwestern Illinois and southeastern Missouri: Illinois State Geological Survey, Guidebook 27, 38 p.

Reed, P.C., 2008, Spring place names and historic data on springs, licks and selected water wells in Illinois: Springfield, Illinois, Capitol Blueprint, 177 p.

Rowan, E.L., and G. de Marsily, 2001, Infiltration of Late Paleozoic evaporative brines in the Reelfoot Rift: A possible salt source for Illinois Basin formation waters and MVT mineralizing fluids: Petroleum Geoscience, v. 7, p. 267–279.

Touseull, J., and C. Rich Jr., 1980, Documentation and analysis of a massive rock failure at the Bautsch Mine, Galena, IL: U.S. Bureau of Mines, Report of Investigations 8453, 49 p.

U.S. Environmental Protection Agency, 2014, Sodium in drinking water: U.S. Environmental Protection Agency, Contaminant Candidate List, http://water.epa.gov/scitech/drinkingwater/dws/ccl/sodium.cfm.

Weibel, C.P., and S.V. Panno, 1997, Karst terrains and carbonate bedrock of Illinois: Illinois State Geological Survey, I-Map 8, 1:500,000.

# NATIVE AMERICAN HISTORY IN JO DAVIESS COUNTY

**Philip G. Millhouse, Illinois State Archaeological Survey**

## Introduction

The Native American history in Jo Daviess County spans nearly 12 millennia from the end of the Pleistocene to the present day (Figure 20). The great story of these people is visible across our landscape in the form of ancient village sites, winter rock shelters, and ancestral burial mounds on prominent bluff tops (Millhouse 1993). Additional insights into how these people lived can be seen in the oral traditions and ceremonies of contemporary Native American people. This rich historical record is a palimpsest that allows us to examine and learn from cultures that occupied the area for thousands of years prior to the arrival of the first Europeans. Within this saga are stories of cultures that lived in relative peace and successfully managed their environment meticulously well for centuries, countered by other examples of groups failing under the stress of population pressure, resource depletion, and warfare. The challenges and issues faced by these cultures would be very familiar to us today. We can understand and learn from their experience or ignore it at our peril. If we choose the former, it is important for us to preserve, understand, and respect these places of past endeavor because by doing so, we may well create a foundation for solving some of our contemporary global difficulties.

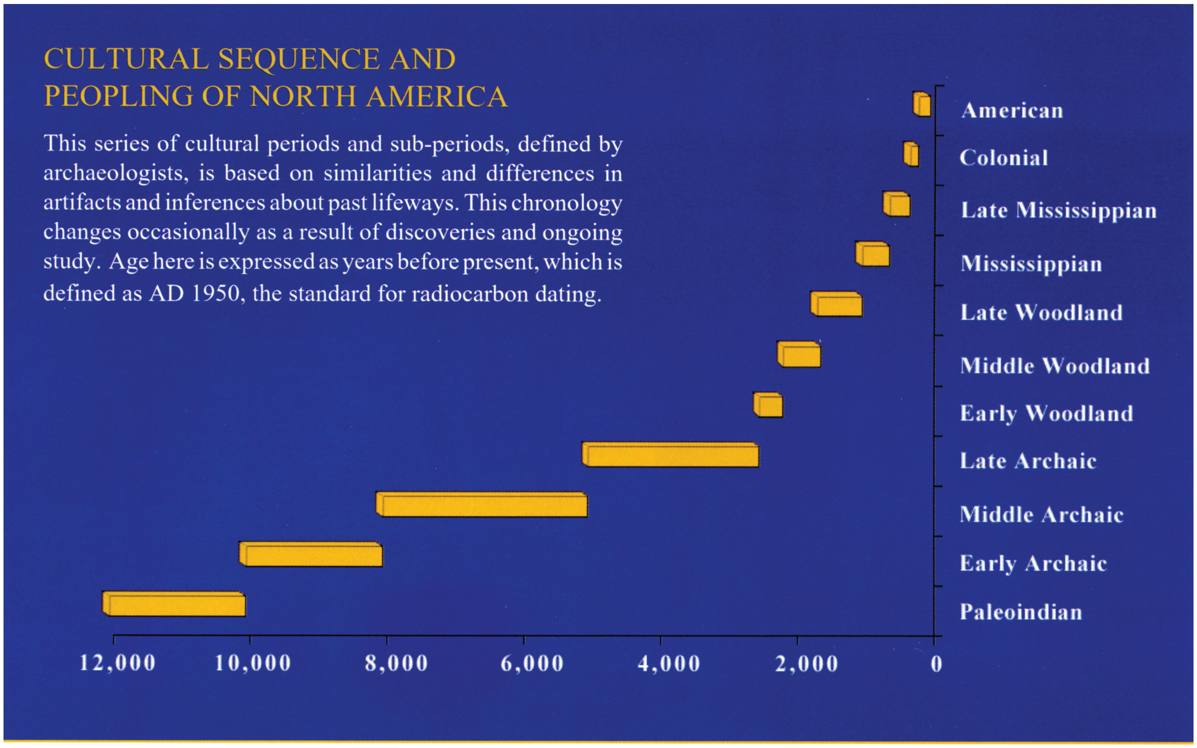
## Paleo-Indian Tradition: 11,000–9000 B.C.

After the retreat of the last glaciers, small bands of highly mobile hunters entered Jo Daviess County, likely from the south and east. The area these people encountered was much cooler and dominated by spruce forest. These groups moved over large territories (279.6–403.9 miles; 450–650 kilometers) in pursuit of megafauna such as mammoth and mastodon. The nature of this colonization means that Paleo-Indian sites are very rare and often ephemeral. The great time depth of these sites has left little preserved, with the exception of stone tools and the debris from their production and repair. The importance of stone tools to these mobile people is indicated by their preference for very high-quality raw materials from distant sources. These materials were obtained through social exchange or visits to the sources during their migrations. The tools most diagnostic of the inhabitants being Paleo-Indian were the long, well-flaked Clovis or Folsom points with distinctive channel flakes driven up from the base to facilitate hafting (Figure 21). These tools were hafted onto long shafts used to bring down megafauna with the aid of a spear thrower, or atlatl.

Although, to date, no single-component Paleo-Indian sites have been found in Jo Daviess County, the presence of fluted points in local collections indicates that these people were definitely moving through the area. Undoubtedly, Paleo-Indian people were exploiting a variety of rich resources and had a dynamic social life and complex belief systems; we simply have little preserved material to interpret these aspects of their lives. By the end of the Paleo-Indian tradition, the forest regime had evolved to a more diverse mixture of fir, pine, elm, ash, and oak. The megafauna had become extinct by this time, although it is unclear whether habitat loss, human hunting pressure, or both were responsible. The megafauna were replaced by a variety of smaller mammals we would recognize today. The following resources provide more detailed information on our current knowledge of Paleo-Indian occupation in the region: Birmingham et al. (1997), Loebel (2005, 2007, 2009), Overstreet et al. (2005), Stoltman (1998), and Theler and Boszhardt (2003).

## Archaic Tradition: 9000–1000 B.C.

The broad time of Archaic occupation in Jo Daviess County is characterized by slow population growth, adaption to changing environments, and an increased settling in to more localized areas, with a corresponding intensification of resource exploitation. Initially, Archaic people lived within a cool, moist climate dominated by a relatively closed mesic forest with very limited openings of oak–hickory or prairie. This environment was home to abundant white-tailed deer, squirrel, and other game. These conditions changed from approximately 8,000 to 4,000 BP, when an extended dry period known as the Hypsithermal Interval saw an expansion of prairie grasslands and oak–savanna across the region. Although the impact of the Hypsithermal varied locally, in some areas the drying was significant enough to cause a restriction in settlement location as groups clustered around the larger wetlands and river systems that remained intact. Around 4,000 BP, the climate had become moister and the floral communities assumed a state that remained relatively stable until the dramatic alterations brought on by American settlement. The resource-rich patchwork consisted of forested valleys and upland prairies with a game-rich edge area of mixed grass and copses of oak–hickory.



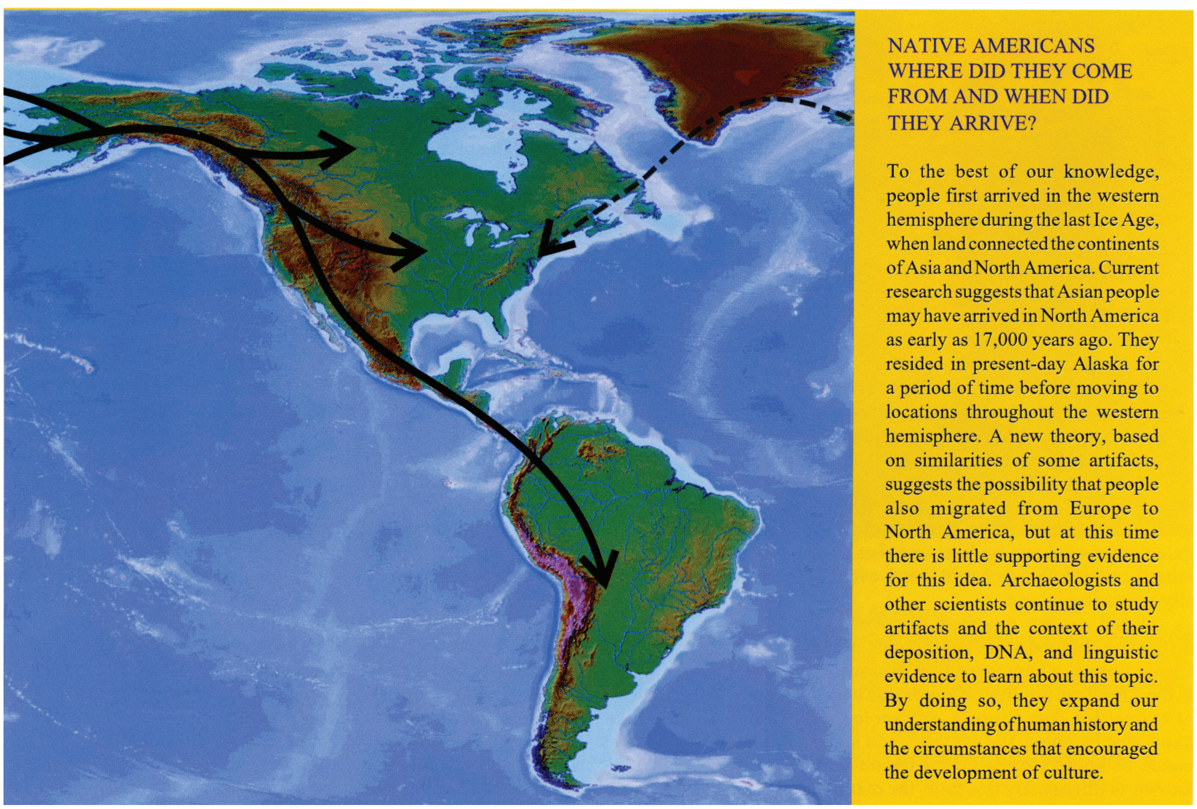




**Figure 20** Colonization of the Americas by Native Americans began as early as 17,000 years before present near the end of the Ice Age, when ice connected Asia and North America. There is some evidence that people may have migrated from Europe to North America around the same time, but there is little supporting evidence for this theory (Berkson and Wiant 2009). Used with permission of the Illinois Association for Advancement of Archaeology and Illinois Archaeology Survey.

**Figure 21** Spear points left by past Native American cultures are commonly found in Jo Daviess County and are an important clue to the culture of the time. Photograph by Philip G. Millhouse; used with permission.

Later, Archaic people developed a settlement system and seasonal round during this time that would be utilized in varying forms for the next several millennia. This land use entailed bands gathering at base camps near large wetland complexes in warm months and then dispersing to smaller camps over the year to exploit specific resources. During the winter months, a band would split up into even smaller kin groups to ride out the winter within protected inland rock shelters. As Archaic populations grew and settled into local landscapes, resource exploitation intensified and people began to manage their environment with fire and other tools to maintain or expand prairie edge zones and encourage nut-producing mast trees. This conscious alteration of the environment would continue in many forms until postcontact time. The so-called virgin timber and prairie that Europeans encountered was actually the result of centuries of extensive manipulation by Native American cultures through time.

Archaic people in the area also developed a number of additional innovations that included the use of regional projectile point styles, manufacture of ground-stone tools such as grooved axes, the use of subterranean pit features to store food, the long-term use of stable community cemeteries, and the beginning of experiments with domesticating plants. The end of the Archaic period saw the establishment of exchange systems that moved exotic materials across the midcontinent, much of which ended up as burial goods for the esteemed deceased. Although these advancements are often overshadowed by professional studies focusing on earlier or later time periods, it is the many innovations of the Archaic Tradition that established a solid foundation for later cultural developments across the Midcontinent. The following resources provide more detailed information on our current knowledge of Archaic occupation in the region: Birmingham et al. (1997), Emerson et al. (2009), Plegar and Stoltman (2009), and Theler and Boszhardt (2003).

## Woodland Tradition: 1000 B.C.–A.D. 1000

The Woodland Tradition is often considered to begin when the first ceramics were produced, initially in the Southeast and later in the Midwest (Figure 20). The first ceramic vessels were large, thick conoidal pots that were low fired and meant to sit permanently in the ground. During the middle of the Woodland Tradition, from approximately 200 B.C. to 200 A.D., some groups actively participated in long-distance exchange networks and a set of corresponding ritual and burial traditions, with alterations at the local level. The abundant availability of galena may have given local Middle Woodland groups access to a much-desired commodity in this exchange system. Much of the exotic trade material was fashioned into elaborate ornaments and pieces of ceremonial art that were ultimately deposited as grave goods in large burial mounds (Figure 22). These cultures also continued experimenting with horticulture by cultivating gardens of squash, gourds, sunflower, goosefoot, knotweed, marshelder, and a little barley. These Middle Woodland groups are often referred to as Hopewell, a generic term covering people across the Midcontinent who shared some of these similarities. Hopewell people lived in *terrace* or *floodplain* villages spaced approximately 11.2 miles (18 kilometers) apart along major rivers. Most of these villages were overlooked by impressive groups of burial mounds

**Figure 22** Burial mounds constructed by the Woodland Indians are common along the Mississippi River bluffs. Photograph by Philip G. Millhouse; used with permission.

containing the remains of their ancestors, accompanied by substantial materials to take into the afterlife. Jo Daviess County has several large Middle Woodland mound groups, such as those visible in East Dubuque's Gramercy Park.

By 300 A.D, the shared Hopewell beliefs, exchange systems, and elaborate burial practices that were overlain on local traditions had faded. Although long thought to be a cultural decline, this was actually a period of dynamic change across the region. This time witnessed a dramatic population increase and filling of the landscape, the adoption of the bow and arrow (which revolutionized hunting and warfare), competition for resources and the congregation of people into fortified villages, and the introduction of maize as an extensively cultivated crop. In Jo Daviess County, Late Woodland people were participating in another widely shared ideology centered on the construction of earthen effigy mounds across the landscape. The construction of these enigmatic mounds likely drew dispersed communities together, and they probably carried multiple meanings pertaining to clan structure, territories, and burial of the dead. Excellent examples of these mounds can be seen at the Keough Effigy and Casper Bluff Land and Water Reserves, owned and managed by the Jo Daviess Conservation Foundation (JDCF). Sometime around 900 A.D., effigy mound construction largely ceased in many places and there appeared to be a substantial concentration of the population, increased warfare, and the construction of fortified villages. The following resources provide more detailed information on our current knowledge of Woodland occupation in the region: Benn (2009), Birmingham (2010), Birmingham and Eisenberg (2000), Birmingham et al. (1997), Emerson and Titlebaum (2000), Emerson et al. (2000), Farnsworth and Emerson (1986), Rosebrough (2010), Stoltman (1986, 2006), Stoltman and Christianson (2000), and Theler and Boszhardt (2003).

## Mississippian and Oneota Traditions: A.D. 1000–1400

The stresses on local people at the end of the Woodland Tradition were being felt by many cultural groups across the Midcontinent at this time, and their solutions varied widely by locale. In southwest Illinois near present-day East St. Louis, a culture arose referred to as Mississippian. This culture and way of living were a radical departure from the way people had lived during the Archaic and Woodland Traditions. Mississippian people lived in large, fortified towns, were reliant on substantial maize cultivation, and had a rigid social system in which rank was inherited. These towns were often constructed around a public plaza flanked by large platform mounds topped by the residences and temples associated with elite priests and authorities. In the immediate vicinity of the East St. Louis area was the enormous city of Cahokia with more than 10,000 inhabitants, surrounded by a number of large satellite towns and villages. It is now becoming clear that many of the new participants in these changes were migrants from afar, possibly drawn to the perceived spiritual power, authority, and prosperity of Cahokia's leaders. The sheer size of Mississippian developments in this area ensured that their ideas and actions would have a powerful influence throughout the Midwest.

As Cahokia grew, its sphere of influence expanded northward in the form of local people emulating portions of Mississippian cultural practices or actual migrations of small numbers of Mississippian people from the south. In Jo Daviess County, a small group of Mississippian people apparently settled into the Lower Apple River Valley between Hanover and where the river joins the Mississippi. This settlement consisted of two towns with platform mounds and a number of smaller satellite communities. A substantial indigenous population was present at the time of the Mississippian arrival. The lack of defensive posture in the settlement pattern and evidence of strong Woodland influences in some of the material culture indicate that the two groups lived together for several generations. The JDCF's Wapello Land and Water Reserve south of Hanover contains the John Chapman site, one of the two large Mississippian towns in the area.

Although there was a Mississippian presence on the Apple River and replication or emulation of certain southern elements, it was not long before the local Mississippian–Woodland amalgamation began traveling in its own trajectory. True Mississippian social structure with powerful leaders, rigid hierarchy, and inherited leadership did not take hold. The populations in the north were much smaller, the geography vast, and the resources plentiful. All these factors were not conducive to replicating the social structure of southern Mississippians. It is a possibility that some of the small Mississippian groups who came north did so purposely to remove themselves from this kind of structure.

In many places across the north after A.D. 1300, a new culture developed that is referred to as Oneota. These people lived in substantial villages and grew large amounts of maize, but also had a very diverse subsistence system and more decentralized leadership than did Mississippian groups. Some of these Oneota manifestations were likely the distant Siouan ancestors of groups such as the Ho-Chunk, Ioway, and Oto. Several archaeological sites located at the mouth of the Apple

River and across the Mississippi have Oneota components. These people may simply be the descendants of the earlier Woodland–Mississippian communities in the area. At present, there does not seem to be any evidence of Native American occupation after the mid-14th century. What ultimately became of the small Oneota communities in the area is not known. The following resources provide more detailed information on our current knowledge of Mississippian and Oneota occupation in the region: Birmingham and Goldstein (2005), Birmingham et al. (1997), Emerson (1991), Emerson and Lewis (1991), Emerson et al. (2007), Finney (2013), Millhouse (2012), Pauketat (2004), Stoltman (1991), and Theler and Boszhardt (2003).

## Postcontact Native American People: A.D. 1690–2014

Although several early French expeditions recorded Siouan groups in the vicinity of Dubuque, we do not have good European records of a Native American group in Jo Daviess County until around 1690. At this time, a series of Algonquin-speaking Miami villages were located near present-day Galena. Leaders from these villages brought samples of galena to Nicolas Perrot and convinced him to establish a short-lived fortification and trading post somewhere in the vicinity of present-day East Dubuque. Early French maps from this time clearly show the Galena River, lead mines, and Miami villages. The Miami were recent arrivals who temporarily fled west to the security of the Driftless Area during the Iroquoian expansion during the Beaver Wars. When the Iroquois threat diminished, the Miami returned to their eastern homeland.

This vacuum was filled by the Meskwaki, another Algonquin refugee group from the Great Lakes, who fled to northeastern Wisconsin to escape the Iroquois. After a series of disastrous wars with the French, the Meskwaki migrated southwest to establish villages along the Mississippi River between the present-day Quad Cities and Prairie du Chien. One of the most critical centers of Meskwaki activity was the portion of the lead (galena) district centered around present-day Dubuque and Galena. It was here that the Meskwaki engaged in large-scale mining, smelting, and trading of the finished lead bars referred to as pigs. This activity was conducted on an industrial scale and represented a critical source of reliable income for the tribe, and much of the actual mining was done by women (Figure 23). In the Galena area proper, Meskwaki from the Bucks band operated a number of mines north of town along Hughlett's Branch and the North Fork of the Galena River. By the early 1820s, a small community of Americans had established a cluster of trading houses

**Figure 23** Native Americans worked the Buck Mine Trench for galena, which they used for paint, decorations, and ceremonial and trading purposes. Photograph by Philip G. Millhouse; used with permission.

in and around the present site of Galena. Many of these traders had learned from their French and British predecessors and married Meskwaki women. These marriages were not only economically beneficial, but, in the minds of the Meskwaki, would ensure fair treatment from the traders because they were now kin relations. This profitable economic activity brought other Native Americans to the area.

This nascent Creole community was truncated by the arrival of Colonel James Johnson from Kentucky in 1822 with a large party of miners, including enslaved African Americans. Johnson arrived with a government lease, American Indian agents, and a large military contingent as backup. After a few days of very tense meetings, the American Indian agents convinced the Meskwaki to back down and allow Johnson to work the mines as legalized (a loose use of the term) under the hated Treaty of 1804. This was the beginning of a massive rush of lead miners, smelters, and adventurers who quickly displaced the resident Meskwaki. The tensions created by the aforementioned treaty, displacement of the Meskwaki in the Galena River Valley, and trespassing onto Ho-Chunk mining lands to the northeast sparked the Winnebago War of 1827 and finally culminated in the disastrous Black Hawk War of 1832. This debacle was followed by a series of treaties that further codified the legal justification for removal of the remaining Native American groups along the east side of the Mississippi between the Rock and Wisconsin Rivers. In many histories, this marks the end of a Native American presence on the local landscape, but the reality is much different.

When combing through old records and talking to farm families who have been in the area for many generations, a very different picture emerges. Although not resident on the land, it appears that Native American groups returned to Jo Daviess County on a regular basis until the 1920s. These visits were likely tied to wanting to exploit certain resources, visit the graves of ancestors, or perform ceremonies at special places with spiritual or historical significance. Two examples of this were the construction of a small burial mound over a deceased infant along Smallpox Creek in the 1870s and the annual visit of Native Americans to perform ceremonies at a mound group above the Apple River north of Elizabeth. In more recent times, Native Americans from the Meskwaki and Ho-Chunk communities have attended the opening of JDCF preserves to speak and perform blessing ceremonies (Figure 24). Although forcibly removed en masse over a century and a half ago, there still is and will always be a Native American connection and presence in Jo Daviess County. The following resources provide more detailed information on our current knowledge of postcontact Native American occupation in the region: Birmingham et al. (1997), Broihahn (2008), Collins (2008), Millhouse (2010), Murphy (2000), and Schermer (2008).

## William Baker Nickerson (1865–1926) and American Archaeology

There is no way to discuss the history of Native Americans in Jo Daviess County or the history of trying to decipher that past without mentioning William Baker Nickerson. Nickerson worked as a signal operator for a number of railroads throughout the east and Midwest. Wherever Nickerson went, he conducted archaeology at local sites, from the East to Ohio, Michigan, northwestern Illinois, southern Minnesota, and even Manitoba. For a good part of his career, Nickerson was stationed at Portage Tower near the mouth of the Galena River and embarked on a decade of archaeological explorations throughout Jo Daviess County. Nickerson was self-educated in the sciences, read widely, and corresponded regularly with archaeologists and antiquarians of his day, including receiving advice, instructions, and limited monetary support from Fredrick Ward Putnam of Harvard's Peabody Museum. The result of this was an exacting excavator whose skills, methods, and interpretations were decades ahead of much of the professional work being done at the time (Figure 25). Nickerson was also far ahead in his archaeological thinking, realizing that investigators needed to move beyond mounds and excavate the domestic debris of village sites to truly begin reconstructing past histories. In a prophetic 1910 publication, Nickerson pleaded for the need to preserve the burial mounds that were rapidly disappearing to the

**Figure 24** Sage smoke ceremony at the Casper Bluff Land and Water Reserve. Photograph by Philip G. Millhouse; used with permission.

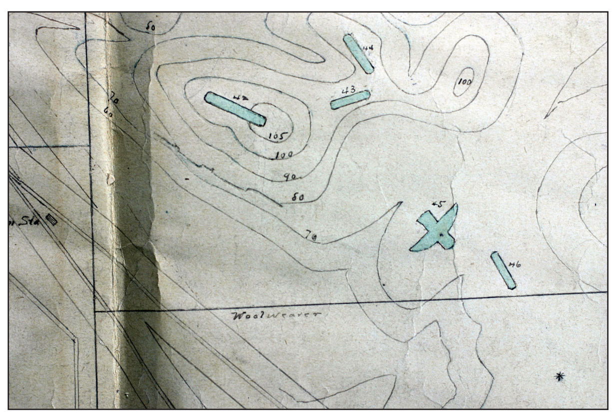


**Figure 25** *Aiken Group of Ancient Earthworks*, the first map of the Aiken bird effigy and mounds at the Casper Bluff Land and Water Reserve, by W.B. Nickerson (1898). Courtesy of the Illinois State Museum and the Illinois State Archaeological Survey, University of Illinois.

plow and urban expansion. Some of the sites Nickerson mentioned were finally preserved a century later through the work of the JDCF and others.

Although many institutions Nickerson worked for hinted at a future position, none followed through. Nickerson was working at a time when the field was beginning to professionalize and individuals like him, no matter what their talents, were frozen out of positions because of their lack of formal training and degrees. When Nickerson died in 1926 in Kidder, Iowa (just west of Dubuque), he quietly left a remarkable, if unheralded, archaeological legacy. Several months after his death, the University of Chicago began some of its first archaeological work, and Nickerson's widow kindly gave the field party Nickerson's detailed maps and field notes to use. The inexperienced University of Chicago students quickly realized their good fortune and began mimicking Nickerson's methods and techniques, although not necessarily his more forward-thinking ideas. This manner of excavation was soon humbly coined the "Chicago Method" and became the standard in the Midwest for many decades. In the intervening years, knowledge of Nickerson's contributions faded, awaiting rediscovery a century after he conducted his pioneering work. Nickerson's work in Jo Daviess County can be read through these sources: Nickerson (1908a,b, 1911, 1913). The following resources provide more detailed information on the career of William Baker Nickerson: Bennett (1942, 1945) and Browman and Williams (2002).

## References


Benn, D.W., 2009, Continuity in the Woodland mound building tradition of northeast Iowa: Journal of the Iowa Archaeological Society, v. 56, p. 1–32.

Bennett, J.W., 1942, W.B. Nickerson—Pioneer in scientific archaeology: American Antiquity, v. 8, no. 1, p. 122–124.

Bennett, J.W., 1945, Archaeological explorations in Jo Daviess County, Illinois: University of Chicago Press.

Berkson, A., and M.D. Wiant, editors, 2009, Discover Illinois archaeology: Illinois Association for Advancement of Archaeology and Illinois Archaeological Survey, p. 3.

Birmingham, R.A., 2010, Spirits of Earth: The effigy mound landscape of Madison and the Four Lakes: Madison, The University of Wisconsin Press.

Birmingham, R.A., and L.E. Eisenberg, 2000, Indian mounds of Wisconsin: Madison, The University of Wisconsin Press.

Birmingham, R.A., and L. Goldstein, 2005, Aztalan: Mysteries of an ancient Indian town: Madison, Wisconsin Historical Society Press.

Birmingham, R.A., C.I. Mason, and J.B. Stoltman, editors, 1997, Wisconsin archaeology: The Wisconsin Archaeologist, v. 78, no. 1/2 [special issue].

Broihahn, J., 2008, Meskwaki mining metamorphosis: Mining archival and archaeological resources for insights on Meskwaki mining and smelting in the Upper Mississippi Valley lead fields: The Wisconsin Archaeologist, v. 89, no. 1/2, p. 98–118.

Browman, D.L., and S. Williams, editors, 2002, Origins of stratigraphic excavation in North America, The Peabody Museum Method and the Chicago Method, *in* New perspectives on the origins of Americanist archaeology: Tuscaloosa, The University of Alabama Press, p. 242–345.

Collins, J.M., 2008, Meskwaki mining in the Upper Mississippi River lead district during the era of Julien Dubuque: The Wisconsin Archaeologist, v. 89, no. 1/2, p. 150–161.

Emerson, T.E., 1991, The Apple River Mississippian culture of northwestern Illinois, *in* T. Emerson and B. Lewis, editors, Cahokia and the hinterlands: Middle Mississippian cultures of the Midwest: Urbana, University of Illinois Press, p. 164–182.

Emerson, T.E., and R.B. Lewis, editors, 1991, Cahokia and the hinterlands: Middle Mississippian cultures of the Midwest: Urbana, University of Illinois Press.

Emerson, T.E., D.L. McElrath, and A.C. Fortier, editors, 2000, Late Woodland societies: Tradition and transformation across the Midcontinent: Lincoln, University of Nebraska Press.

Emerson, T.E., D.L. McElrath, and A.C. Fortier, editors, 2009, Archaic societies: Diversity and complexity across the Midcontinent: Albany, State University of New York Press.

Emerson, T.E., P.G. Millhouse, and M.B. Schroeder, 2007, The Lundy Site and the Mississippian presence in the Apple River Valley: The Wisconsin Archaeologist, v. 88, no. 2, p. 1–23.

Emerson, T.E., and A.R. Titlebaum, 2000, The Des Plaines complex and the Late Woodland stage of northern Illinois, *in* T.E. Emerson, D.L. McElrath and A.C. Fortier, editors, Late Woodland societies: Tradition and transformation across the Midcontinent: Lincoln, University of Nebraska Press, p. 413–428.

Farnsworth, K.B., and T.E. Emerson, editors, 1986, Early Woodland archaeology: Kampsville, Illinois Center for American Archaeology, Kampsville Seminars in Archaeology, Volume 2.

Finney, F.A., 2013, Intrasite and regional perspectives on the Fred Edwards Site and the Stirling Horizon in the Upper Mississippi Valley: The Wisconsin Archaeologist, v. 94, no. 1/2, p. 3–248.

Loebel, T.J., 2005, The organization of Early Paleoindian economies in the western Great Lakes: University of Illinois at Chicago, Department of Anthropology, unpublished Ph.D. dissertation.

Loebel, T.J., 2007, A survey of Wisconsin fluted points: Current research in the Pleistocene, v. 24, p. 118–119.

Loebel, T.J., 2009, Withington 947GT158: A Clovis/Gainy campsite in Grant County, Wisconsin: The Wisconsin Archaeologist, v. 34, no. 2, p. 223–248.

Millhouse, P.G., 1993, Preliminary results of an archaeological survey being conducted in Jo Daviess County, Illinois: Beloit, Wisconsin, Beloit College, anthropology honors thesis.

Millhouse, P.G., 2010, Native American lead mining in the Galena River Valley and the potential for archaeological research: Illinois Archaeology, v. 22, no. 1, p. 318–357.

Millhouse, P.G., 2012, The John Chapman Site and creolization on the northern frontier of the Mississippian World: University of Illinois at Urbana-Champaign, Department of Anthropology, Ph.D. dissertation; available from University Microfilms International, Ann Arbor, Michigan.

Murphy, L.E., 2000, A gathering of rivers: Indians, Metis and mining in the western Great Lakes, 1737–1832: Lincoln, University of Nebraska Press.

Nickerson, W.B., 1898, Aiken group of ancient earthworks: Aiken, Jo Daviess Co., Illinois: Springfield, Illinois State Museum library, Nickerson Collection, manuscript [map]; and Champaign, Illinois Transportation Archaeological Research Program, digital image, Nov. 16, 2005.

Nickerson, W.B., 1908a, Mounds of Northwestern Illinois: Records of the Past, v. 7, no. 2, p. 85–95.

Nickerson, W.B., 1908b, Stone graves of northwestern Illinois: Records of the Past, v. 7, no. 1, 52–58.

Nickerson, W.B., 1911, The mound builders—A plea for the conservation of the antiquities of the central and southern states: Records of the Past, v. 10, no. 6, p. 334–338.

Nickerson, W.B., 1913, Archaeology of Jo Daviess County, Illinois, 1895–1901: Explorations of W.B. Nickerson [Report to the Peabody Museum of American Archaeology, Harvard University]: Springfield, Illinois State Museum, typescript in the manuscript collection.

Overstreet, D.F., J.A. Clark, R.W. Yerkes, M.F. Kolb, and J.F. Petewicz, 2005, The Dalles Site (47IA374), A Plainview-like component in southwestern Wisconsin. The Wisconsin Archaeologist, v. 86, no. 1, p. 1–16.

Pauketat, T.R., 2004, Ancient Cahokia and the Mississippians: Cambridge, United Kingdom, Cambridge University Press.

Plegar, T.C., and J.B. Stoltman, 2009, The Archaic Tradition in Wisconsin, *in* T.E. Emerson, A.C. Fortier, and D. McElrath, editors, Archaic societies: Diversity and complexity across the Midcontinent: Albany, State University of New York Press, p. 697–724.

Rosebrough, A.L., 2010, Every family a nation: A deconstruction and reconstruction of the effigy mound ‘culture’ of the western Great Lakes of North America: Madison, University of Wisconsin, Department of Anthropology, Ph.D. dissertation; available through University Microfilms International, Ann Arbor, Michigan.

Schermer, S.J., 2008, The archaeology of the mines of Spain: The Meskwaki and Julien Dubuque: The Wisconsin Archaeologist, v. 89, no. 1/2, p. 132–149.

Stoltman, J.B., 1986, The Prairie phase: An Early Woodland manifestation in the Upper Mississippi Valley, in K.B. Farnsworth and T.E. Emerson, editors, Early Woodland archaeology: Kampsville, Illinois, Center for American Archeology, p. 121–136.

Stoltman, J.B., editor, 1991, New perspectives on Cahokia: Views from the periphery: Madison, Wisconsin, Prehistory Press, Monographs in World Archaeology No. 2.

Stoltman, J.B., 1998, Paleoindian adaptive strategies in Wisconsin during Late Pleistocene times: The Wisconsin Archaeologist, v. 79, p. 53–67.

Stoltman, J.B., 2006, Reconsidering the context of Hopewell interaction in southwestern Wisconsin, *in* D.K. Charles and J.E. Buikstra, editors, Recreating Hopewell: Gainesville, University Press of Florida, p. 310–327.

Stoltman, J.B., and G. Christiansen, 2000, The Late Woodland Stage in the Driftless Area of the Upper Mississippi Valley, *in* T.E. Emerson, D.L. McElrath, and A.C. Fortier, editors, Late Woodland societies: Tradition and transformation across the Midcontinent: Lincoln, University of Nebraska Press, p. 497–524.

Theler, J.L., and R.F. Boszhardt, 2003, Twelve millennia: Archaeology of the Upper Mississippi Valley: Iowa City, University of Iowa Press.

# GALENA AND JO DAVIESS COUNTY SETTLEMENT HISTORY

**Daryl Watson, Highland Community College (Freeport, Illinois)**

## The Settlement of Jo Daviess County

The first European Americans to penetrate the Upper Mississippi River Region were the French. Although they were initially hoping to find gold and silver, they found a region rich with furs, fish, and forest products. Trade with the native peoples quickly became a profitable enterprise, but the desire for precious metals ran deep, and rumors of Native American mining were periodically confirmed by the appearance of lead and copper as trade goods. Although the French sporadically pursued attempts to find and engage in this trade, the first real evidence of discovery came with Nicolas Perrot about 1690 (Schockel 1916, p. 179–182). It was reported that by 1741, French and Native American miners on the Fever (now Galena) River had sold to French Canadian traders 2,500 bars of lead, each weighing roughly 70 pounds.

The Native Americans had mined lead sporadically for thousands of years for use as paint, charms, and ceremonial powder (Walthall 1981). The Europeans, however, wanted it for musket balls, roof flashing, water pipes, pewter, leaded glass, waterproofing, and as a paint additive. French trader Julian Dubuque moved to the Iowa side of the river in 1788 and engaged in the lead trade on a large scale ("Galena and its lead mines" 1866). He obtained permission from the Fox (Meskwaki) and Sauk (Sac) as well as from the Spanish government, which had acquired the western side of the river when the French lost the French and Indian War to the British (1754–1763).

A little-known fact is that Thomas Jefferson arranged for two exploration parties with the Louisiana Purchase in 1803. The Lewis and Clark Expedition left St. Louis in 1804 and the Lieutenant Zebulon Pike Expedition left the following year. The directive of the latter was to explore the Upper Mississippi and learn all there was to know about the land, animals, minerals, and people. Included was a visit to Dubuque's lead mines, which were being worked primarily by Meskwaki with French help. Dubuque greatly distrusted the Americans and was not forthcoming with much information; he avoided a face-to-face meeting with Pike. The year before (1804), territorial governor William Henry Harrison had forced two chiefs of the Sauk tribe to sign a treaty giving up their lead mining lands, with the stipulation that they could remain until the U.S. Government sold the land to white settlers and miners. The chiefs were reportedly given copious amounts of alcohol and signed the treaty without any real understanding of what it contained (Channick 1988, p. 6–10).

The period between French, then British, and finally American control of the region created serious conflict among the various parties involved, including the various tribes of the region. The French traditionally had good relations with most tribes; their traders offered liberal terms, learned the language, and often took Native American wives. They traveled with the trade and did not take over complete control of the land. The British were less generous and did not hesitate to stir up trouble between the American traders and the Native Americans. The War of 1812 saw the American forces finally gain the upper hand in the region, but the animosity among the various parties continued to increase. It would culminate in the Black Hawk War of 1832.

A number of American traders came into the Galena area after the War of 1812 ended. They were generally not welcome, but by 1821, the little settlement of Galena featured at least five American-based traders. The largest mine in the immediate vicinity was the old Buck Lead Mine, located about one-half mile north of the settlement. This was mined by the elderly Fox Indian, Buck, and by other elderly men and women of the band. The younger men rarely engaged in this kind of work (Kett 1878, p. 233). Tools were originally deer antlers and crude stone instruments. The easily accessible mineral and shallow crevices were the extent of their operations (Figure 26), but trade goods at a very early date had brought in iron picks, shovels, and related tools of the trade.

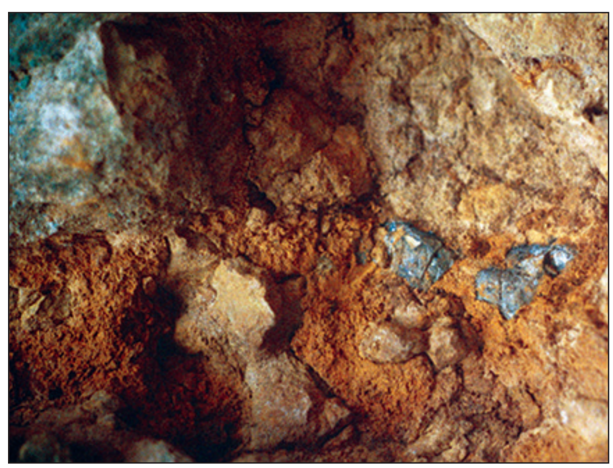


**Figure 26** Lead ore (galena) is found within crevices in the Galena-Platteville Formation. The cubic crystal structure of the mineral can be seen here. Photograph by Philip G. Millhouse; used with permission.

The first official leases were issued in 1822—four in total (Johnson 1977, p. 4–5; Mansberger et al. 1997, p. 22). Nine were issued the following year. These first "miners" were in name only, with the exception of some from the Missouri lead mines of southeastern Missouri. Colonel James Johnson of Kentucky brought a number of slaves with his group of 100 "miners," but slaves were never a significant factor in the Galena lead mines. Moses Meeker of Cincinnati came with a very well-equipped and well-funded group in 1823 (Johnson 1977, p. 4–5). He was a producer of white lead, used in the production of paint. It was also during this year that the first steamboat was able to ascend the Mississippi River above the Rock Island rapids. Suddenly, the Upper Mississippi River Lead Mining District was doing well. Leases issued for mining jumped to 350 in 1826 and to 2,384 in 1827 (Mansberger et al. 1997, p. 24). Twenty-one smelters were also operating by 1828. By 1827, the name of the fledgling settlement officially became Galena (Latin for lead sulfide), as opposed to the Fever River Settlement or January's Point.

Finding and raising the mineral is only half the story of Galena and the lead region. The other part is how that mineral acted as a catalyst for the development of Galena and the entire region. Transportation was a critical part of the economic development of the region because the mineral had to be transported to markets farther south and east: St. Louis, Cincinnati, New Orleans, and New York. Given the incredible weight of lead (only gold is heavier), most was shipped by keelboat, barge, and flatboat down the Mississippi. The steamboat changed all that. These vessels could quickly and efficiently carry huge loads downstream and return with tons of necessary supplies to keep the early miners and residents stocked up. Ice prevented trade during the winter months, so many miners and teamsters went back south during the cold months. The teamsters hauled the ore from the mines to the smelters and then hauled the pigs of lead from the smelters to the Galena levee.

During the earliest years of mining, northwestern Illinois and southwestern Wisconsin were noted for their southern character. The early miners were usually farmers from southern Illinois and the Upland South—Kentucky, Tennessee, and adjacent parts of southern Indiana and Missouri (Figure 27). As time moved on, more and more settlers came from New England, New York, Pennsylvania, and the British Isles. Kett, in his 1878 book *The History of Jo Daviess County*, reported that the streets of Galena swarmed with rough miners: "all sorts of moving vehicles were seen in her thoroughfares, and every language was spoken, every costume worn" (p. 828).

The city leaders of Galena realized at a very early date that they had to develop a consistent and effective means of transportation for all the freight and people moving into and out of the region. Thus began the buildup of the largest steamboat line north of St. Louis (Figure 28). At first, Galena's entrepreneurs competed with each other, but over time, they shrewdly joined forces and created a near monopoly of the Upper Mississippi trade (Toole 1964, p. 229–248). Bigger and better boats were ordered from huge boat works in Cincinnati and Pittsburgh (Peterson 1937, p. 204–226). No longer was Galena simply servicing the mining trade. The American frontier was on the move, and the Upper Mississippi was the gateway to new lands and new opportunities. Soon the main street of Galena was lined with huge mercantile houses—wholesale and retail—to serve the exploding trade of the region. Large banks supplied ample financing, with lead sometimes serving in the same capacity as gold and silver. The 1830s and 1840s saw Galena become the hub of the Upper Mississippi River Lead District and of every other kind of trade. Not even the nationwide depression of 1837 slowed its growth (unlike Chicago, which suffered heavily).

Tin miners from Cornwall in the southwest of England and the lead mining Dalesmen of northeastern England (Yorkshire) brought advanced mining and smelting techniques (Figure 29). The lead mining peaked in 1845, with the Illinois, Wisconsin, and Dubuque, Iowa, mines (Upper Mississippi Valley Lead District) producing 55 million pounds of mineral, more than 85% of the nation's output (Figure 30). The Missouri mines in southeastern Missouri supplied most of the remainder, but in a twist of fate, the production of the latter mines would overtake the Upper Mississippi mines by the time the Civil War broke out in 1861 (Schockel 1916, p. 194).

The leasing system, whereby miners could stake a claim and pay the government one-tenth of the mineral produced, was neither effective nor efficient. By 1836, the government agreed to sell all the leased lots in Galena (and a number of other communities), and in 1846, all lands within the lead-mining district were opened up for sale. The former date marks the beginning of the first permanent improvements to Galena's fabric because now businessmen were willing to look farther down the road. When all lands went up for sale, agriculture expanded rapidly and the character of the entire region changed from one of a raw mining camp to one dominated by farms and livestock. Most of the early miners were farmers, and many engaged in mining to acquire cash with which to improve or add to their farm holdings.

**Figure 27** Early mining operation in Jo Daviess County. This photograph is one of a pair of photographs from a stereoscopic card for viewing with a stereoscope, popular in the mid to late 1800s. Photograph courtesy of the Alfred Mueller Collection (Galena Illinois).


**Figure 28** Detail of a lithograph titled *View of Galena Ill.*, drawn and published by E. Whitefield (1856). Notice the width of the Galena River compared with what it is today. Image courtesy of the Galena Public Library.

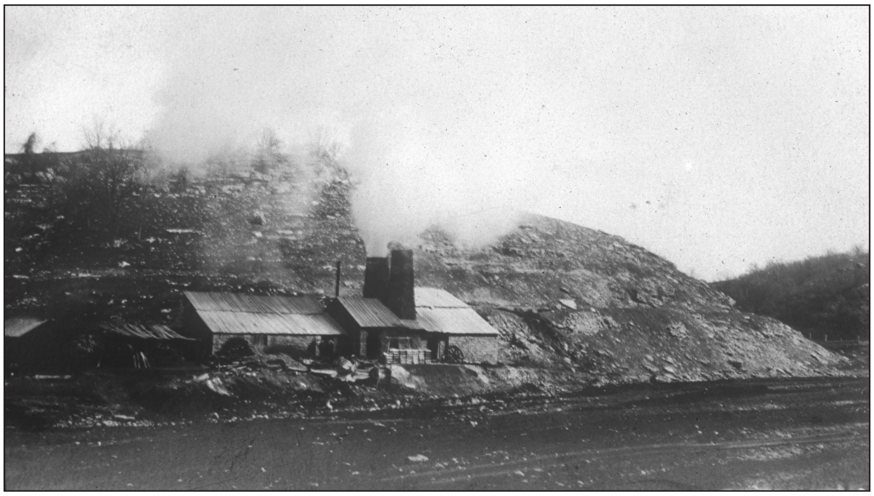


**Figure 29** Hughlett Furnace, located one-fourth mile north of Galena, was a major smelting operation fueled by wood. Notice the barren landscape where trees had been cut for fuel (Plate 1 from Cox 1914).

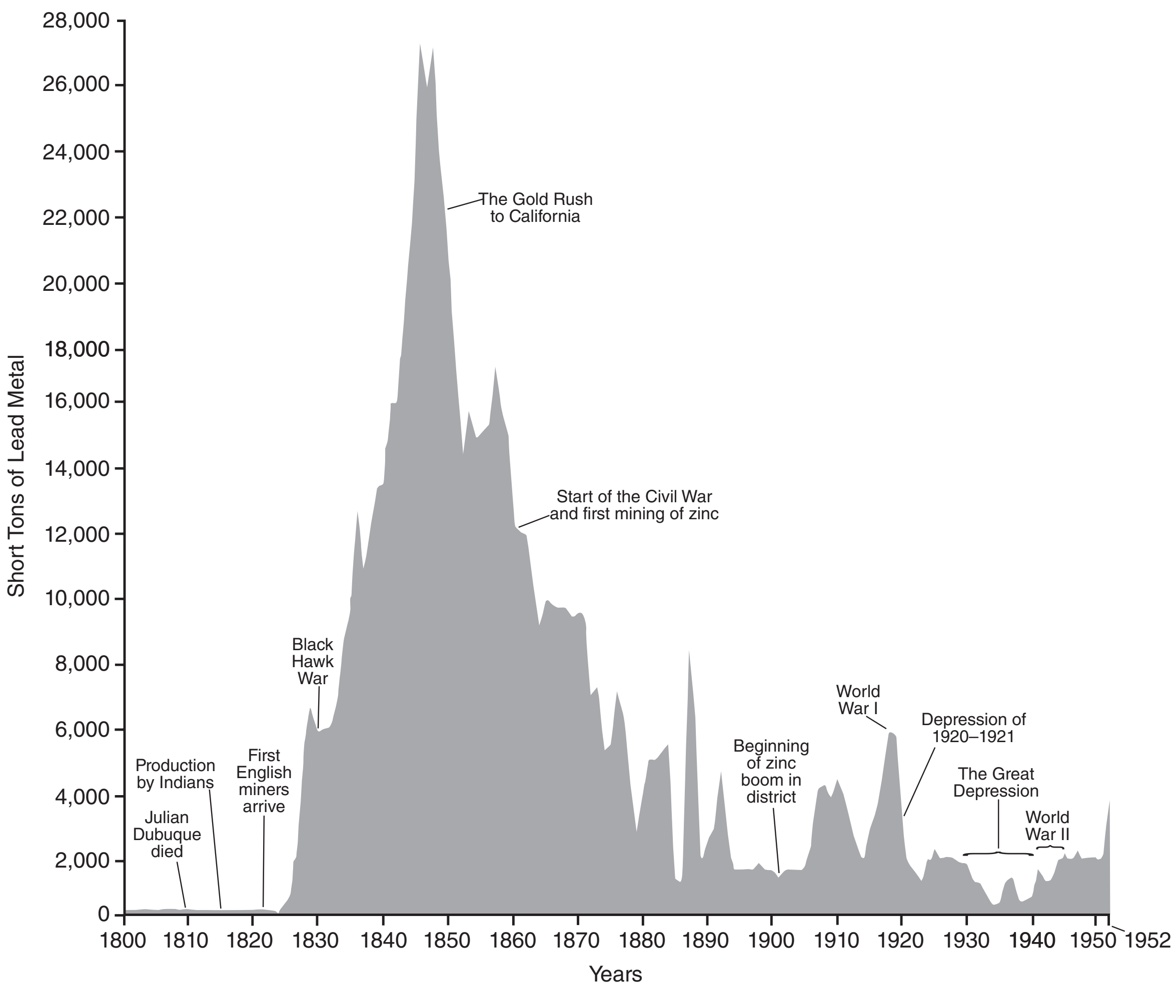



**Figure 30** Metallic lead production from 1800 to 1952 in the Upper Mississippi Valley District (Driftless Area) showing major historical events. The greatest production was between 1845 and 1850 (Figure 48 modified from Heyl et al. 1959, p. 73). Figure courtesy of the U.S. Geological Survey.

Mining changed further in the late 1840s. Formerly the domain of small groups of individuals, the best mineral deposits had been taken up—the easily available lead was nearly gone. As miners went deeper, larger and more expensive pumps were needed to keep the groundwater out of their mines. Increased capitalization and more systematic techniques were needed, at the very time the California Gold Rush came. News of California gold swept the lead mining districts like a fever. Huge numbers of miners—and everyone else, it seemed—flocked to the West. It is interesting that the mines of the Upper Mississippi and those of southeastern Missouri were the first to send experienced miners to California; they did much to open up the gold fields for the masses that followed. Many returned, but many did not. The loss of life, talent, and money from the area was, as one early settler said, "a great detriment to the township and county in general" (Kett 1878, p. 581).

Galena, however, continued to grow. It outfitted many of the prospectors heading west and continued as the largest steamboat port north of St. Louis, even though it was more than 3 miles from the Mississippi River. Boats, however, were having an increasingly hard time making it up the muddy little Mississippi tributary. It was silting in badly owing to massive erosion from mining and farming activities upstream (Figure 31). The rate of fall above Galena is substantial, but from Galena to the Mississippi, it is negligible. The result was heavy siltation in Galena's harbor and all the way to the Mississippi. A traveler voiced the obvious as early as 1841 in the local *Northwestern Gazette and Galena Advertiser* (Johnson 1977, p. 23, 25):

**Figure 31** Extensive mining in this area (e.g., the Blewett Mine just north of Galena) has created a rugged, excavated landscape with the remains of a disintegrating infrastructure and steep, cone-shaped gob piles. Photograph by Samuel V. Panno; used with permission.

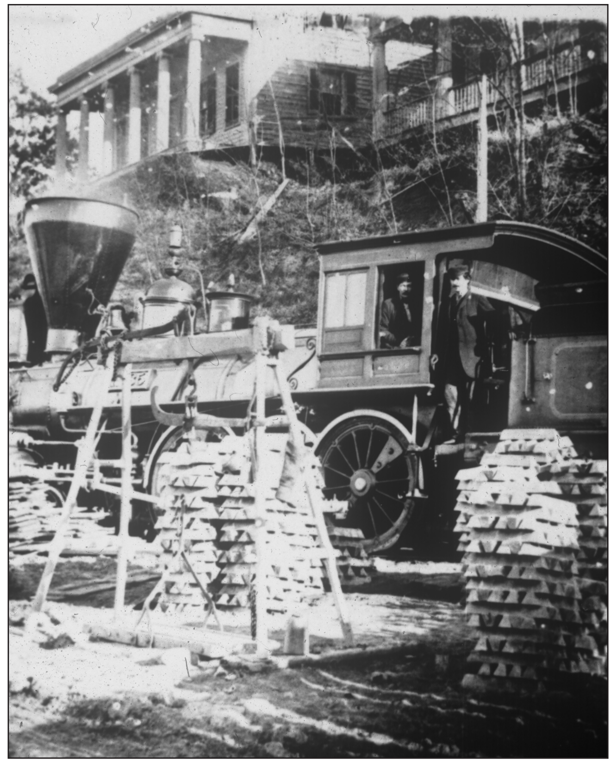


**Figure 32** The railroad replaced river travel and was used to shuttle pigs of lead (ingots) to Chicago. This 1865 photograph of the Illinois Central Railroad shows pigs of lead being weighed before being loaded aboard the train. Photograph courtesy of the Alfred W. Mueller Collection (Galena, Illinois).

> Within a few rods of the usual steamboat landing, our boat struck the bottom of the river. She then threw off her tow-boats, drew back a few rods, and with a full head of steam, dashed forward, and after many struggles which made the very engine sweat, plowed her way to the landing. This Fever River, as it is with singularly bad taste named, has all the appearance of a large canal. What can prevent its ultimately being filled with mud?

The town fathers persuaded the Illinois state legislature to change the name from Fever to Galena River in 1854, but the state of Wisconsin did not follow suit; thus, the river retains its original name where it flows in that state. Dredging efforts at Galena were too little and too late—this at a time when railroads were becoming the transportation vehicle of choice (Figure 32).

The Galena and Chicago Union Railroad had reached Freeport in 1852, but the task of extending a line to Galena and the Mississippi was undertaken by the Illinois Central. The latter wished to make Galena its western

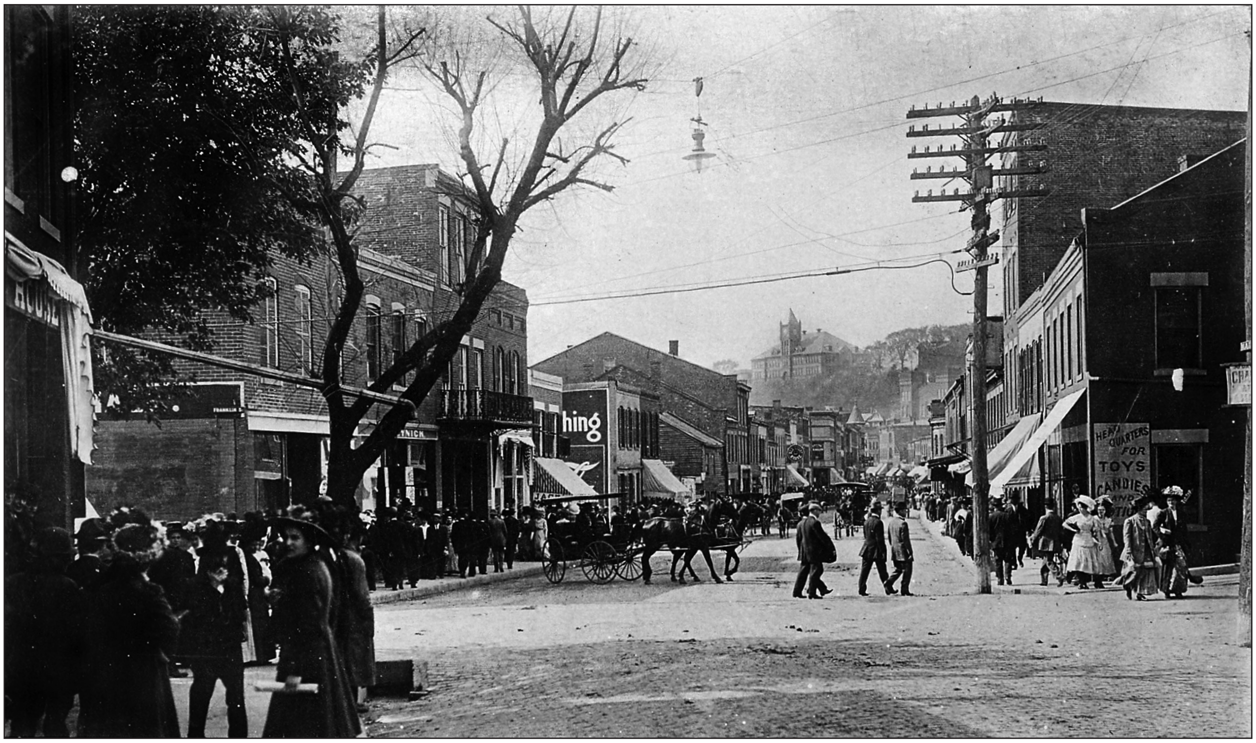



**Figure 33** Corner of Hill and Main Streets in Galena, Illinois, around the turn of the century. Photograph courtesy of the Alfred W. Mueller Collection (Galena, Illinois).

terminus, but the town leaders refused to give up their valuable waterfront. A compromise was finally reached, but the next year (1855), the rail line was extended to Dunleith (now East Dubuque) on the Mississippi. The Illinois Central and the Galena and Chicago Union were controlled by eastern investors, many tied to Chicago interests; Galena and its boats were competition. It was not long before trade of all kinds was siphoned from Galena eastward to Chicago.

Another blow to Galena's economy came from a nationwide depression (the Panic of 1857) that devastated the nation's economy. A severe drought in 1859 closed the river to navigation for a time, and then the Civil War came in April of 1861 and the north–south river trade that had so dominated Galena trade since the beginning collapsed.

The politics of war was the final straw. Galena split between two defiant camps: the new Republican party, led locally by U.S. Congressman Elihu B. Washburne of Galena (whose home is now a State Historic Site), and the Douglas Democrats, led by local attorney John Rawlins and others (Owens 1963, p. 23–51). The Democrats split further over the "War" faction that wanted no treasonous secession and a more peace-oriented faction that wanted to end the war and bloodshed through negotiation with the South. Leadership in Galena waned, and the problems facing the town went unresolved. Many prominent businessmen had already left for Chicago or points farther west. Trade was now firmly entrenched in an east–west direction, and the geography that had built Galena was now destroying it. Chicago was the beneficiary.

The town had peaked in population in the 1850s with roughly 14,000 people (Figure 33). (So many migrants were moving through the town to points farther north and west that it was almost impossible to get an accurate count.) Wealth generated by the town's huge trade had been translated into stately mansions, oftentimes built next to lowly miners' cottages. Ulysses S. Grant moved to Galena in 1860 to work in a leather goods shop run by his two younger brothers. He was here only one year before the Civil War broke out. Although not well known by his fellow townsmen at the time, he returned 4 years later as the victorious general of the Union armies. The grateful community (a small group of wealthy Republicans) awarded him a fine home—now a State Historic Site (Figure 34). But Galena would never be the same after the war; it gradually became a small agricultural trade center.

**Figure 34** General Ulysses S. Grant and his son Jesse in 1865 standing on the porch of their home at 500 Bouthillier Street in Galena, Illinois. Photograph courtesy of the U.S. Grant State Historic Sites.

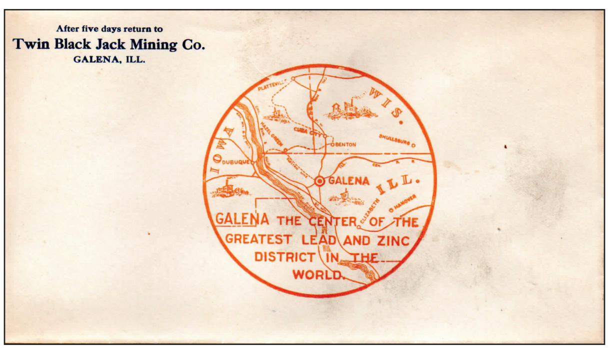



**Figure 35** Stamp on an envelope from the Twin Black Jack Mining Company referring to "Galena the center of the greatest lead and zinc district in the world." Image courtesy of the Tom Golden Collection.

Zinc mining gave some hope to the mining interests with the development of an economical way to process the mineral in the late 1850s (Heyl et al. 1959, p. 74–75). Zinc was found to provide protection for anything made of iron or steel, through either galvanizing or applying zinc oxide primer, which is still true today. However, before these discoveries and the development of economically feasible methods of processing, the ore was simply discarded. Zinc was normally found at lower levels in the Galena Dolomite, and large amounts of capital were needed to pursue a more difficult form of mining. Large companies were created to handle the challenge (Figure 35). The era of the small miner was largely gone. The last large Illinois mine, the Grey/Bautsch Mine located off Blackjack Road 4 miles south of Galena, closed in 1975. Today, it is a Superfund cleanup site because of the presence of heavy metals in the tailings. For many years, these were mixed with road salt and applied extensively to roads and streets throughout the lead and zinc region during wintertime. Production of zinc expanded rapidly after 1900 (see Figure 49 in Heyl et al. 1959, p. 76), but prices and demand fluctuated. A second wind came with World War II, but production declined thereafter until the last mine closed on the Wisconsin side (south of Shullsburg) in 1979 (Figure 30).

## The Agricultural Economy

Despite a rebirth of mining with the demand for zinc ore after the Civil War, the mining district had become, and remained, an overwhelmingly agricultural district (Figure 36). During the earliest years, most miners went back south for the winter. The rivers were frozen, the boats were holed up in St. Louis, and overland travel remained difficult at best. The first boat of the spring season to arrive at Galena was, by all accounts, a joyful and wondrous event.

This early mining district, whose population was in the vicinity of 10,000 by 1829 (Figure 14), proved to be a huge market for agricultural produce, no matter what time of the year. Droves of cattle and hogs were driven up from southern Illinois in the fall of the year. It was a journey fraught with danger for both men and animals. The following account is from the Funk family (famous in the 20th century for their hybrid seed corn) of McLean County (Bloomington, Illinois). They drove many herds of cattle and hogs to Galena and later to Chicago, but the December 1830 drive was memorable because of heavy snow and cold:

> When they crossed the Illinois River, some of the pigs . . . broke through the ice and were drowned . . . many . . . were frozen to death. . . . At the commencement of the journey they weighed from two hundred and fifty to three hundred pounds, but on their arrival at Galena, after a journey of forty-five days, they weighed from one hundred and fifty to one hundred and eighty pounds each. (Duis 1968, p. 592–593)

The conclusion of the Black Hawk War in 1832 opened up the entire lead region to settlement. Increasingly, immigrants were coming from the East, not the South, and more and more were coming for agricultural and business opportunities, not mining. The opening of the Erie Canal (from Albany to Buffalo) in 1825 and the explosion of lake steamers greatly increased the flow

**Figure 36** Today, farmland dominates the landscape of Jo Daviess County. Photograph by Richard Mattas; used with permission.

of immigrants, giving the county a much more northern attitude in institutions and outlook. Many were farmers looking for permanent homes. Even by 1840, Jo Daviess County had more farmers than miners (Schockel 1916, p. 208).

Corn, oats, and wheat were the main crops, although potatoes, rye, and barley were also important. With the railroads in place, the northern tier of Illinois counties and southern tier of Wisconsin counties made this corridor the largest wheat-producing region in the nation during the 1850s. Cattle and hogs were also common, mostly roaming at will. During this time, the crops were fenced in, not the livestock. Because Galena had a number of slaughterhouses, it became an important meat-shipping point, especially with the coming of the railroad. Those same railroads also encouraged commercial agriculture on a large scale; wheat, for example, could be transported cheaply to the huge grain elevators being built in Chicago. By the 1880s, the county was noted for its purebred Hereford cattle, and by 1900 for its dairy cows. Today, it is the largest county in Illinois for all types of cattle grazed.

The lumber trade also became huge. The Wisconsin pineries supplied white pine logs and lumber to Galena, Chicago, and elsewhere in the Upper Mississippi Valley and beyond. In 1857, Galena had three sawmills (Schockel 1916, p. 209). Steamboats supplied them with huge rafts of logs, but until the white pine lumbering to the north was developed, good timberland was not overly abundant in the lead region. This made the local limestone and dolomite a convenient and common building material. Immigrants from the British Isles knew well how to build in stone and gladly used the native stone in place of wood. It was used for house and barn foundations up until concrete replaced it shortly after 1900. The ubiquitous stone retaining walls of Galena were often made of stone quarried in place or that had been dug out of nearby mines.

After the Civil War, Galena failed to regain regional importance. It slowly but surely lost population but did retain a respectable amount of business activity (Figure 37), most of it now agriculturally related. The Ryan Packing House was thought to be one of the largest outside Chicago (“A list of buildings being erected this year” 1880). The town also became a small but important railroad center, with the Illinois Central, Burlington, Chicago Great Western, and North Western all providing service to the town by 1888.

However, no new residents were coming into the county. The population of Jo Daviess County peaked in the mid-1870s at about 27,500. Today, it is about 22,000 and the population of Galena is about 3,500. All the land had been taken up by the Civil War, and people were moving farther west. As a result, the ethnic make-up of the county changed little. Those with English, Irish, Scots-Irish, and German roots predominated, and still do. Place names such as Irish Hollow (Scots-Irish) or Cabbage Town (German) reflect the early settlement patterns.

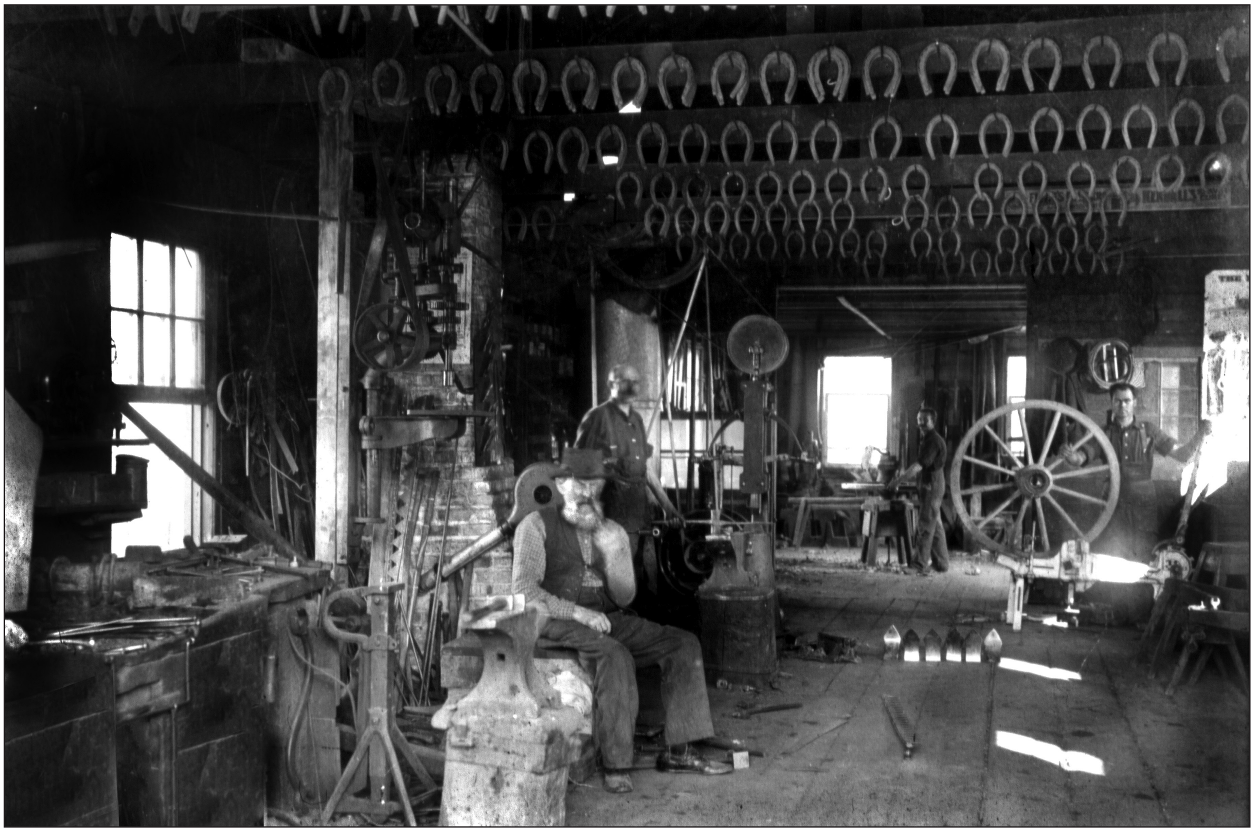


**Figure 37** Richardson Blacksmith Shop on Commerce Street in Galena, circa 1910, now part of the U.S. Grant Museum. Photograph courtesy of the Alfred W. Mueller Collection (Galena, Illinois).

## Jo Daviess County Today

The physical environment of Galena and Jo Daviess County has had a huge impact on the nature of their development. The presence of lead ore began the European American rush into the region (Figure 38). The isolation and rugged topography made water transport incredibly important. Steamboats reigned supreme before the Civil War and the coming of the railroads. However, the loess-covered hills also proved valuable for grazing livestock. The flatter and more fertile lands on the northeastern side of the county proved equally valuable for grain farming. Today, large farms growing corn and beans are the rule, with the number of farms declining as the acreage of each has increased. The more rugged western and southern sections of the county now support a rich and flourishing tourism and recreational industry. Second homes and small rural acreages are common. Galena sees more than one million visitors annually (Figure 39). They have found the Driftless Area to be unique—a place where land and people have shaped each other. It is a process that continues.

**Figure 38** Abandoned mines such as this are located all across Jo Daviess County and, for safety reasons, most have been sealed.

**Figure 39** Recent aerial photograph of the City of Galena taken from a hot-air balloon. Photograph courtesy of George Bookless Studio (Galena, Illinois).

## References


Channick, H.S., 1988, William Henry Harrison steals western Illinois from the Sauk and Fox: Illinois State Historical Society, The Illinois Heritage, v. 1, p. 6–10.

Cox, G.H., 1914, Lead and zinc deposits of northwestern Illinois: State of Illinois, State Geological Survey, Bulletin 21, Plate 1, p. 12.

Duis, E., 1968, The good old times in McLean County, Illinois, 2nd edition: Bloomington, Illinois, McKnight and McKnight Publishing Co.

Galena and its lead mines, 1866, Harper's New Monthly Magazine, v. 32, May, p. 681–696.

Heyl, A.V., Jr., A.F. Agnew, E.J. Lyons, C.H. Behre Jr., and A.E. Flint, 1959, The geology of the Upper Mississippi Valley Zinc–Lead District: U.S. Geological Survey, Professional Paper 309, 310 p.

Johnson, C.H., Jr., 1977, The building of Galena: An architectural legacy: Stevens Point, Wisconsin: Worzalla Publishing Co.

Kett, H.F., 1878, The history of Jo Daviess County, Illinois: Chicago, Illinois, H.F. Kett & Co.

A list of buildings being erected this year: J.M. Ryan's Pork House, 1871, Galena Daily Gazette, August 20, p. 3.

Mansberger, F., T. Townsend, and C. Stratton, 1997, "The people were literally crazy": The lead and zinc mining resources of Jo Daviess County, Illinois: Springfield, Illinois, Fever River Research.

Owens, K.N., 1963, Galena, Grant, and the fortunes of war: DeKalb, Northern Illinois University Press.

Peterson, W.J., 1937, Steamboating on the Upper Mississippi: Iowa City, University of Iowa.

Schockel, B.H., 1916, History of development of Jo Daviess County: Illinois State Geological Survey, Bulletin 26, 173–228.

Toole, R.C., 1964, Competition and consolidation: The Galena Packet Co., 1847–63: Journal of the Illinois State Historical Society, v. 57, no. 3, p. 229–248.

Walthall, J.A., 1981, Galena and aboriginal trade in eastern North America: Springfield, Illinois State Museum.

# THE ECOLOGY AND BIOTIC RESOURCES OF THE DRIFTLESS AREA OF NORTHWESTERN ILLINOIS

**Randy W. Nyboer, Illinois Natural History Survey**

A unique set of geologic conditions and processes, the timing of historic settlement of the county, and the area's biogeographic position in North America have been instrumental in shaping the biotic ecology of Jo Daviess County. The Illinois portion of the four-state, 15,000-square-mile Driftless Area covers only about 6.5%, or 990 square miles, of this unglaciated landform (Hartley 1966; Ruesink et al. 1994). All occur within Jo Daviess and Carroll Counties. The following narrative of the development of the biotic resources found here today is just a brief overview of a complex set of ecological processes that have taken place over the past 10,000 to 13,000 years since the retreat of Wisconsinan glaciers. Over the past 1.6 million years of the Pleistocene Epoch, several periods of glaciation covered the Midwest, with each failing to override the Driftless Area (Willman and Frey 1970; King 1981; Figures 12-1 and 12-6 in Kolata and Nimz 2010).

## Early Vegetation of Jo Daviess County

Being the highest landform in the upper Midwest, the Driftless Area has escaped devastation by the glaciers that covered all the surrounding areas. Ecologists believe that this fact, coupled with the shorter duration and extent of Wisconsinan glaciation, made the Driftless Area a refugium for many northern plants and animals (Gleason 1923; Hartley 1966). A number of the plants now commonly found in the Rocky Mountains, Canada, or the Great Plains still occur here, disjunct from the species' current range (Figures 40 and 41). Pollen records taken from bogs indicate that the forests of Jo Daviess County were like spruce woodlands by the close of Wisconsinan glaciation (King 1981). By about 11,000 BP, forests of pine, fir, and birch replaced the spruce, a forest type that occurs today in northern Wisconsin. The gradual warming of the climate changed these forests to a pine–oak composition and eventually to an oak–hickory forest type by 9,000 BP (King 1981). White pines, being the most tolerant to these climatic changes, persisted in cooler ravines of the Driftless Area and other northern areas of Illinois (Cawley 1965; Nyboer 1982). The greatest change in the vegetation came between 8,000 and 5,000 BP during the Hypsithermal Period. This period, having a much drier and warmer climate, influenced the migration of the Prairie Peninsula from the Great Plains into Illinois, replacing many of the oak–hickory forests with tallgrass prairie. The remaining forests of northern Illinois lost much of the oak component during this time, leaving a hickory-dominated forest type

**Figure 40** Canada Violet (*Viola canadensis*) IL-E. Photograph by Randy W. Nyboer; used with permission.

**Figure 41** The Jeweled Shooting-Star (*Dodecatheon amethystinum*) is rare in Illinois and is found primarily in the Driftless Area on rich, rocky slopes in open mesic woodlands. Photograph by Randy W. Nyboer; used with permission.

**Figure 42** Photograph of Apple River Canyon State Park showing the Apple River and Canada yew shrub that is a remnant population of the Pleistocene glacial episode. Photograph by Randy W. Nyboer; used with permission.

(King 1981). Sweeping landscape fires increased as the prairie replaced the forests and influenced the changing vegetation. The cooler climate species, such as the white pine and Canada yew, retreated to those areas of Jo Daviess County where shaded cliff faces or other specialized habitats created the conditions for them to persist, mostly as we see them today (Figure 42). It was not until late in the Hypsithermal that an increase in moisture allowed the deciduous forests to increase and compete with the prairies. About 1,000 BP (the Little Ice Age), a cooler, moister climate prevailed, and fossil pollen records indicated a slight increase in conifer tree species expanding again in the northern parts of Illinois. At the time of European settlement, the landscape was still covered by vegetation similar to that found in 1,000 BP (King 1981).

## Modern-Day Vegetation of Jo Daviess County

By 1820, any climatic influence on the vegetation of Jo Daviess County by the Little Ice Age was ending and a new change was beginning to assert itself on the landscape—European settlement. Although Native Americans had made minor changes to the vegetation of the county for the past several thousand years, it was not until the arrival of European settlers that the historic clearing of prairies, forests, and wetlands occurred, completely altering the vegetation of the county and the Midwest in general.

Prior to settlement of the Illinois Driftless Area in 1820, forests (including savanna and woodlands) covered about 74% of the area. Prairies made up about 22% of the land cover, and wetlands of all types occupied about 3.5% of the area. Today, only about 20% of the forests, about 3.5% of the prairie, and about 2.7% of the wetlands remain (Pepoon 1909a,b, 1910; Gleason 1910, 1923; Hartley 1966; White 1978; Rachuy 1994; Ruesink et al. 1998).

In Jo Daviess County, the deciduous forests were heavily affected by early settlement. The extent of lead mining made wood, used for firing the smelting furnaces, too valuable to be used simply as a building material; thus, the Wisconsin pineries supplied most of the lumber needed. With limestone and dolomite being so common, many structures were built of native stone (Schockel 1916; Figure 43). The prairies fared much better up until the mining boom played out and agriculture replaced mining as the leading economic resource for the county. The 1860 land survey maps still showed large areas of prairie in the uplands away from Galena, with small farm fields interspersed. However, not long after this, these prairies were converted to either row crops or pastures. Where soils were either too dry or rocky to allow their conversion or too steep to allow access for grazing, a few

**Figure 43** The George N. Townsend house located just south of Apple River Canyon State Park was built of local stone in 1856. This is a good example of the use of local stone, which can be seen throughout Jo Daviess County. Photograph by Daryl Watson; used with permission.

**Figure 44** Sand prairie and pale coneflowers in a burned unit near an abandoned Army warehouse on the Savanna Army Depot. Photograph by Randy W. Nyboer; used with permission.

large remnants of prairie persisted into the next century. Upland wetlands associated with springs and artesian upwellings, often used for human consumption or cooling perishable food stores, were extensively grazed by livestock.

In 1975, Illinois conducted the first inventory in the United States for natural areas on both public and private lands. Forests, prairies, and wetlands that exhibited minor degradation from past grazing, logging, or other human-induced disturbances were surveyed by a team of ecologists from the University of Illinois. They also looked for rare habitats and populations of rare species. At the end of the inventory, Jo Daviess County had only 2.1 acres of sand hill prairie to add as a statewide significant natural area (White 1978; Figures 44 and 45). This is a testimony to the devastating influence early European settlers had on this landscape. The ecologists identified a number of other potential natural area types besides high-quality natural communities that were in need of conservation because so few were found in the Driftless Area. Finally, 14 of these sites were recognized because of the rare species occurring there or because of the presence of small, rare habitats. It was within these two latter categories that most of the Ice Age relicts occurred (White 1978).

**Figure 45** Fragile prickly pear cactus (*Opuntia fragilis*) IL-E is found only in the sand prairies at the Savanna Army Depot in Illinois. Photograph by Randy W. Nyboer; used with permission.

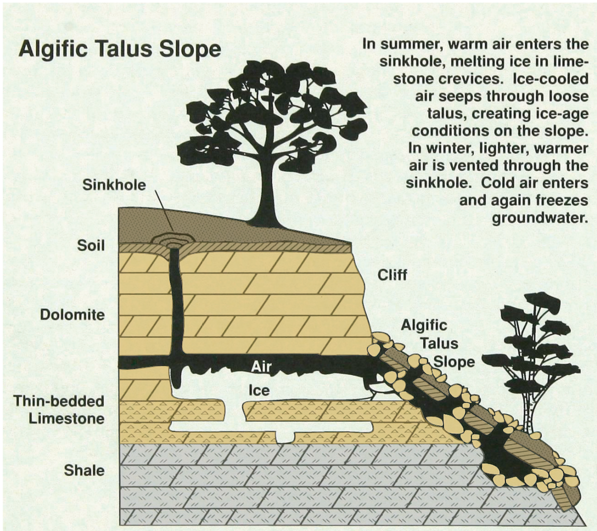



**Figure 46** Conceptual model of an algific talus slope (modified from Anderson and Danielson 1999). Used with permission.

**Figure 47** Reaching into an algific talus slope cold air vent during the summer, one can feel very cold air discharging from underground. This is not unlike placing your hand in a refrigerator on a hot summer day. Photograph by Richard Mattas; used with permission.

In 1981, an entirely new type of habitat, called an *algific talus slope*, was discovered and described by an Iowa ecologist (Post 1998). This complex, cold air-producing talus slope was eventually found in Illinois, but only a few were of an undisturbed nature (Figures 46 and 47). Growing on these slopes were several species of Ice Age plants that had not been seen in Illinois before! Even better, two species of snails thought to have become extinct after the Ice Age were found living within the mossy cover of the algific talus slopes (Figure 48).

In 2008, the Illinois Natural Areas Inventory Update began, using updated survey techniques and modern technology the 1978 inventory did not have. Among the more than 30 years of natural ecological healing, new land stewardship techniques that did not exist in 1978, a number of refined databases, and aerial photography, the ecologists for the Illinois Natural Areas Inventory Update located and surveyed several new high-quality forests, prairies, and wetlands (Nyboer, unpublished 2012 data).

**Figure 48** The Iowa Pleistocene snail (*Discus macclintocki*) IL-E Fed-E is found only within algific talus slopes of the Driftless Area. Photograph by Randy W. Nyboer; used with permission.

Even with the past disturbances, the Illinois Driftless Area still has an extremely rich diversity of plants and animals. Considering it constitutes only 1.7% of the state's total land area, it provides habitat for 42% (915 species) of our native flora. More than 270 species of birds occur here, about 90% of the 300 species of birds that regularly occur in the state. Forty-five species of mammals occur here, representing 78% of the state's mammal species. Eleven amphibian and 26 reptile species occur here, representing 28% of the amphibian and 44% of the reptile species found in Illinois. Finally, the 1,632 miles of rivers, streams, and wetlands of the Driftless Area support 89 species of fish and 39 species of mussels (Post 1998).

## Endangered and Threatened Species of Jo Daviess County

Although the Illinois Endangered Species Protection Act was signed in 1972 (one year before the Federal Endangered Species Act of 1973), the first official listing of Illinois species did not occur until 1981 (Natural Land Institute 1981). At that time, four mammals, one bird, and 33 plants were listed as either endangered or threatened for Jo Daviess County. As of 2004 (the most

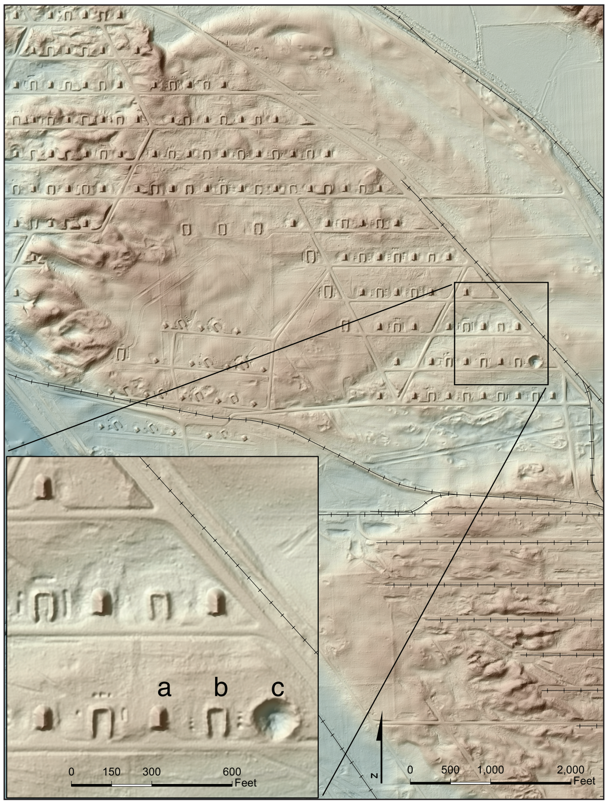



**Figure 49** The Savanna Army Depot is shown here in a LiDAR shaded relief elevation model with the mounds or igloos that once stored military ordnance on the site. The Savanna Army Depot is located to the west along the floodplain of the Mississippi River and is visible from the quarry. From 1918 to 2000, the focus of this depot was bomb manufacturing, testing, and storage. Three features are visible in the figure: (a) an igloo or bunker that housed ordnance; (b) a y-site that consisted of sand berms about 6 feet high for temporary storage of munitions (overflow); and (c) a crater formed by the 1948 explosion of ordnance housed within an igloo. The crater, based on LiDAR data, is 170 feet in diameter and 30 feet deep. Sand dunes may be seen in the upper left and lower right quadrants of the figure. Map by Donald E. Luman.

recent list revision), one mammal, six birds, five herptiles, 10 mussels or snails, four fish, one butterfly, and 51 plants were listed for the county (Nyboer and Ebinger 2004; Nyboer et al. 2006). From the first listing in 1981, two of the mammals have recovered significantly statewide to be delisted and one became extirpated. The only bird listed at that time, the American Bald Eagle, is now also delisted because of its recovery.

The recovery success story of the American Bald Eagle is one in which Jo Daviess County has played an extremely large role. When first listed in Illinois in 1981, the state had two active nests: one at the Savanna Army Depot in Jo Daviess County (Figure 49) and the other at the Crab Orchard Natural Wildlife Refuge in southern

**Figure 50** Bald Eagles are now returning to Jo Daviess County, thanks, in large part, to the efforts of Terrance Ingram and the Eagle Nature Foundation. Photograph by Richard Mattas; used with permission.

Illinois. The eagle was delisted on both the federal and state levels in 2007 and 2009, respectively, and now more than 100 nesting pairs occur statewide. Jo Daviess County alone has nearly 20 nesting pairs (Nyboer et al. 2006; Figure 50)!

Going back to those relict Iced Age plants, Jo Daviess County has the only locations for 11 of those species. Another seven species may be found only in both Driftless Area counties. State-listed plants and animals that migrated from the Great Plains prairies during the Hypsithermal Period include 14 plants, three reptiles, and one butterfly. Others that migrated here after glaciation are from the Atlantic coastal plain and the Appalachian Mountains.

Overall, the Illinois Driftless Area is a one-of-a-kind landscape that displays a rich diversity of our biological heritage. This unique natural heritage will persist only with the proper stewardship and with the cooperation of local citizens and conservation organizations working together to create successful partnerships so that future generations may enjoy these biological treasures.

# References


Anderson, T.R., and Danielson, B.J., 1999, Managing Iowa habitats: Rare species of northeast Iowa's air-conditioned slopes: Ames, Iowa State University Extension, PM 1351n, p. 1.

Bowles, M.L., V.E. Diersing, J.E. Ebinger, and H.C. Schultz, editors, 1981, Endangered and threatened species of Illinois: Status and distribution: Rockford, IL: Natural Land Institute, p. 1–213.

Cawley, E.T., 1965, Tree succession in Pine Hollow State Forest and its implications: Proceedings of the Iowa Academy of Science, v. 72, p. 180–187.

Gleason, H.A., 1910, The vegetation history of the inland sand deposits of Illinois: Illinois State Laboratory of Natural History, Bulletin 9, p. 23–174.

Gleason, H.A., 1923, The vegetational history of the Middle West: Annals of the Association of American Geographers, v. 12, p. 39–85.

Hansel, A.K., and E.D. McKay III, 2010, Quaternary Period, in D.R. Kolata and C.K. Nimz, editors, Geology of Illinois: Illinois State Geological Survey, p. 216–247.

Hartley, T.G., 1966, The flora of the "Driftless Area": State University of Iowa Studies in Natural History, v. 21, no. 1, p. 1–174.

King, J.E., 1981, Late Quaternary vegetational history of Illinois: Ecological Monographs, v. 51, p. 43–62.

Nyboer, R.W., 1982, Technical forest resource management plan for White Pines Forest State Park: Unpublished Department of Conservation management plan for the release and regeneration of native white pines, p. 1–37.

Nyboer, R.W., and J.E. Ebinger, editors, 2004, Endangered and threatened species of Illinois: Status and distribution, Volume 3: Changes to the Illinois list of endangered and threatened plant species: Springfield, Illinois Endangered Species Protection Board, 34 p.

Nyboer, R.W., J.R. Herkert, and J.E. Ebinger, editors, 2006, Endangered and threatened species of Illinois: Status and distribution, Volume 2: Animals: Springfield, Illinois Endangered Species Protection Board, 181 p.

Pepoon, H.S., 1909a, An ecological survey of the Driftless Area—Part 1: School Science and Mathematics, v. 9, no. 5, p. 441–446.

Pepoon, H.S., 1909b, An ecological survey of the Driftless Area—Part 2: School Science and Mathematics, v. 9, no. 6, p. 522–527.

Pepoon, H.S., 1910, The forest associations of northwest Illinois: Transactions of the Illinois State Academy of Science, v. 3, p. 143–156.

Post, S.L., 1998, The Driftless Area: An inventory of the region's resources: Springfield, Illinois Department of Natural Resources, Critical Trends Assessment Program, 22 p.

Rachuy, J., 1994, Prairie survey of Jo Daviess County: Springfield, Illinois Wildlife Preservation Fund, Report to the Illinois Department of Natural Resources, 52 p.

Ruesink, W.G., D.K. Niven, D.S.K. Chien, L.B. Suloway, K.J. Hunter, W.C. Handel, S.D. Bailey, S.K. Robinson, E.J. Heske, J.E. Hofmann, C.A. Phillips, J.K. Bouseman, L.M. Page, K.S. Cummings, C.A. Mayer, M.J. Wetzel, and D.W. Webb, 1998, Driftless Area assessment: Springfield, Illinois Department of Natural Resources, Critical Trends Assessment Program, 220 p.

Schockel, B.H., 1916, History of the development of Jo Daviess County: Illinois State Geological Survey, Bulletin 26, 173–228 p.

White, J., 1978, Illinois natural areas inventory technical report, Volume 1: Survey methods and results: Urbana, Illinois Natural Areas Inventory, 426 p.

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

# GUIDE TO THE ROUTE AND STOP DESCRIPTIONS

We will be traveling in a caravan. Please drive with your headlights on while in the caravan. Follow the vehicle in front of you closely but safely. Please obey all traffic signs and signals along the route. You will see ISGS staff members along the route to help flag and direct you. When we come to a stop, please park as close as possible to the car in front of you and turn off your lights.

Some of the stops today will be on private property. The owners have been kind enough to grant us access on the day of the field trip. Please treat their property with respect and do not litter or climb fences. Treat public property with the same respect. Parents, please closely supervise your children. If using a rock pick, please wear eye protection. Stay away from highwalls in the quarry.

**Please note:** ISGS staff have a first aid kit and a portable AED (automated external defibrillator) with us today. Please notify a staff member (orange vests) if you need help. Many staff members are certified in CPR/first aid.

If you are using the field trip guidebook at a later date, remember that proper permission to enter private property is required. You must obtain permission—no trespassing, please. Permission is also recommended should you want to enter the Hanover Bluff Quarry at a later date—contact the Department of Natural Resources at Apple River Canyon State Park to do so.

Now—sunscreen on? Let's enjoy the day! We have a great field trip planned for you!

**START of field trip:** Arrive at Apple River Canyon State Park, concessions picnic shelter. Park in caravan formation in parking lot, register, and enjoy STOP 1 of the field trip. The maps to the route and stops start on page 58.

---

## STOP 1: APPLE RIVER CANYON STATE PARK *Coordinates N 42° 26.952′, W 90° 3.126′*

---

Apple River Canyon State Park is located in northeastern Jo Daviess County and is a unique geologic feature of Illinois (Figure 42). The canyon was formed during the Illinois Glacial Episode when a glacial lobe blocked the drainage of a watershed flowing to the southeast (delineated by the glacial *till* boundary). A lake formed within the watershed and began discharging across a drainage boundary into the adjacent Apple River watershed. Continued discharge of glacial meltwaters across the boundary caused downcutting of the landscape until the divide was breached and eventually drained the lake. The rushing waters escaping the lake rapidly carved their way through Silurian dolomite and Maquoketa Shale, and finally into Galena Dolomite. A narrow canyon, as deep as 200 feet and as wide as 250 to 400 feet at the bottom, formed what is now Apple River Canyon (Frankie and Nelson 2002; Figure 51).

Apple River Canyon State Park is also the site of the former town of Millville (Figures 52 and 53), which was built around a stagecoach stop between Chicago and Galena and was the site of a sawmill in 1836. Construction of the railroad several miles north of the town in 1854 reduced the significance of Millville as a civic and commercial center; finally, a massive flood in 1892 destroyed any semblance of the town.

Apple River Canyon State Park will be a registration and assembly point. At this first site of interest, we will discuss bedrock geology, glacial geology, hydrology, hydrogeology, botany, and history of the area. A hike along the Primrose Trail and across the river will give field trip participants a view of the canyon and will introduce them to the unique flora of the area (Figure 54). Parking and bathrooms are available.

TURN RIGHT (north) out of parking lot onto North Canyon Park Road.

Travel approximately 250 feet, follow curve of the road to the right (east) and TURN RIGHT onto East Canyon Road.

Continue about 3 miles to stop sign. TURN RIGHT (south) on IL-78.

Travel 3 miles and TURN RIGHT (west) on East Greenvale Road.

Travel 1 mile and obey stop sign at North Stockton Road. Proceed on East Greenvale Road for about 2.5 miles further and park in caravan formation along road. Arrive at STOP 2—Benton Mound.

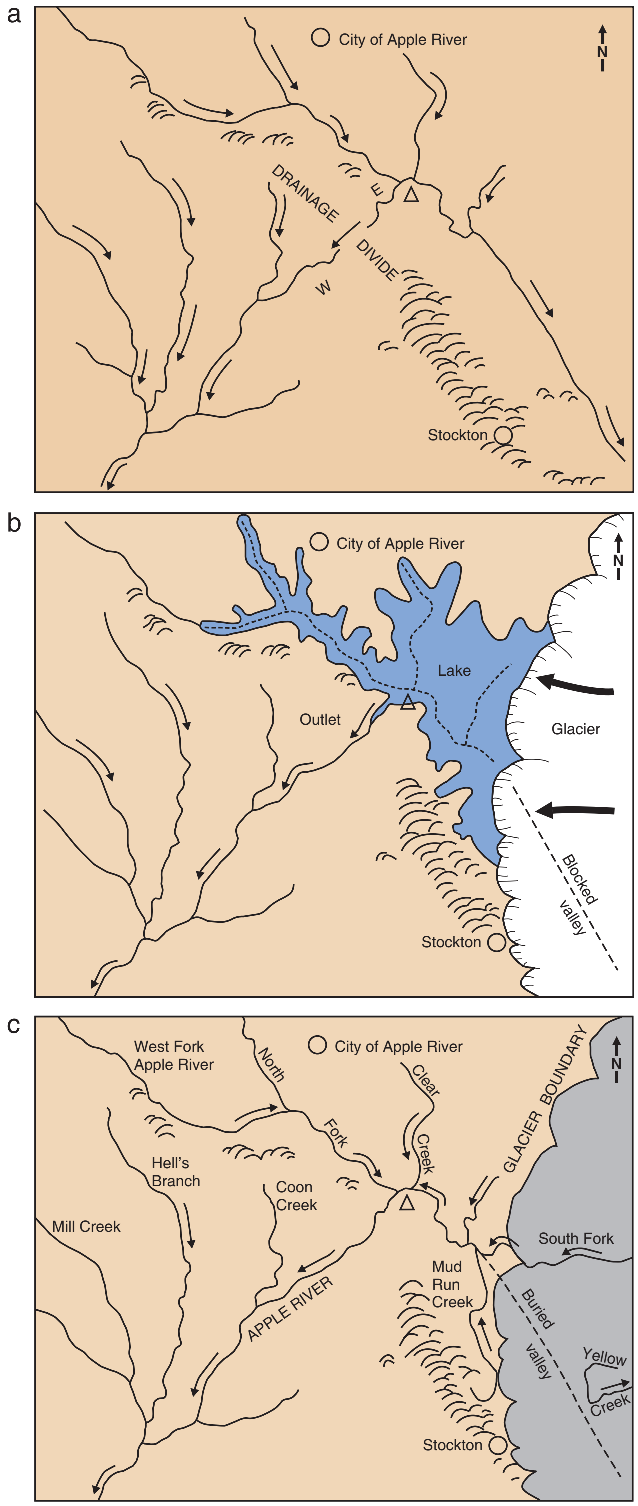



**Figure 51** Formation of Apple River Canyon: (a) Preglacial drainage. (b) Formation of a lake during the Illinois glacial episode. (c) Postglacial drainage today (Figure 18 from Frankie and Nelson 2002, p. 51).

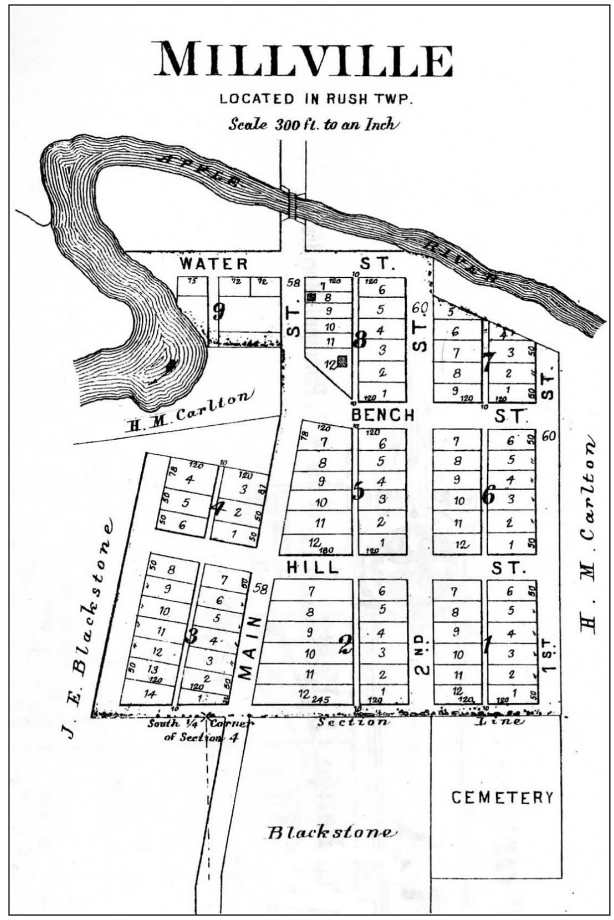



**Figure 52** An 1893 plat book of the village of Millville. The bluff immediately north of the Apple River is the Primrose Trail. Image from the Daryl Watson Collection (Apple River, Illinois); used with permission.


**Figure 53** Photograph from 1925 of a hand-painted sign describing the features in and around Millville. Photograph from the Daryl Watson Collection (Apple River, Illinois); used with permission.

**Figure 54** The "poster wildflower" of the Driftless Area in Illinois, and specifically Apple River Canyon, is the Bird's-Eye Primrose (*Primula mistassinica*), a State Endangered Plant. This is the only place it grows in Illinois. Photograph by Michael R. Jeffords (Illinois State Natural History Survey); used with permission.

## STOP 2: GREENVALE ROAD/BENTON MOUND *Coordinates N 42° 23.911′, W 90° 2.975′*

Benton Mound is the second highest point in Jo Daviess County and provides a panoramic view of multiple knobs and the rugged topography of the county. Here, participants will learn more of the geology and how the *stratigraphy* is responsible for the formation of the knobs and highlands.

The following is summarized from Frankie and Nelson (2002): The stop is on the northern flank of Benton Mound about 130 feet below its crest of 1,226 feet above msl. The mound is an erosional remnant protected by its 100-foot-thick cap of Silurian dolomite. From this point, it is possible to view several similar mounds to the north and northwest. Six miles away lie three knobs: Mt. Sumner (1,160 feet above msl), Squirrel Grove and Hudson Mounds (slightly higher than Mt. Sumner), and Charles Mound (1,241 feet above msl; Figure 55). These mounds represent what is left of the Dodgeville erosional surface (Figure 9). In addition, more information on the history responsible for the development of this area will be presented. Just south of Benton Mound, we will pass an old stone house built in 1856 by George N. Townsend, Millville's postmaster; it is on the historic register (Figure 43). Within the house, holes are still found in the eaves for honeybees to enter their hives, which were located in the attic. This provided easy access for the owners to collect honey.


**Figure 55** Numerous Silurian dolomite-capped knobs may be seen in the distance, as viewed from Benton Mound. Photograph by Samuel V. Panno; used with permission.

Leave STOP 2 and proceed to stop sign on North Canyon Park Road.

TURN LEFT (south) onto North Canyon Park Road (County 10). Use caution—hill limits visibility.

Travel 2.5 miles south to US 20.

TURN RIGHT (west) onto US 20.

Travel approximately 12.5 miles—through Woodbine, through Elizabeth (use caution in downtown Elizabeth; US 20 makes a sharp curve to the west), to IL-84. Make sure you enjoy the views along the way!

TURN LEFT (south) onto IL-84.

Travel to Hanover—about 4.25 miles. Please note that owing to bridge construction on Apple River, a stoplight will be in place to control one-lane traffic.

Observe the stoplight and TURN RIGHT (west) onto Fulton Road. Do not cross bridge.

Continue on Fulton Road about .5 miles; keep to the left as the road becomes Hanover Hill Road.

Travel 2 miles to Whitton Road and TURN LEFT (southeast).

Travel about 1.5 miles and park caravan along road. Arrive at STOP 3—Hanover Bluff Quarry.

## STOP 3: HANOVER BLUFF NATURE PRESERVE *Coordinates N 42° 12.609′, W 90° 17.365′*

The Hanover Bluff Nature Preserve includes a sizeable abandoned *quarry* that was mined for aggregate up to the *palisades* facing the Mississippi River. The result is an area surrounded by high cliffs of Silurian dolomite (Figure 56) that are reminiscent of vistas of the southwestern United States (Figure 57). The following summary is from Frankie and Nelson (2002): The quarry and adjacent property, known as the Lang Property, is made up of 88.4 acres. The stratigraphy is dramatically exposed in the quarry and, at the top, consists of the Sweeney Formation, which is characterized by a pinkish gray dolomite with wavy beds and green shale partings. Coral and brachiopod fossils (*Microcardinalia* and *Pentamerus oblongus*) are abundant in this section. Below that is the Blanding Formation, which is a brownish gray dolomite with numerous layers of white *chert* and abundant silicified corals. Below that is the Mosalem Formation, the upper 20 to 30 feet of which is gray and *argillaceous* with bands of chert nodules. The lower part of the formation is argillaceous dolomite that grades into dolomitic shale; fossils are rarely found in this lower formation.

The nature preserve overlooks the former Savanna Army Depot, an ordnance-manufacturing, testing, and storage facility located along the Mississippi River that operated from 1918 to 2000 (Figure 49). Activity and construction at the Depot peaked during World War II, raising base employment above 7,000 (Figure 58). Today the 13,062-acre property is being managed to meet area economic development and wildlife habitat conservation goals (Figures 44 and 45).

**Figure 56** Entrance to the abandoned quarry on the Hanover Bluff Nature Preserve showing a spire of Silurian dolomite that rises about 50 feet above the quarry floor. Photograph by Samuel V. Panno; used with permission.

The infrastructure and buildings associated with the base administration are located in Carroll County to the south and are being managed by the Jo-Carroll Depot Local Redevelopment Authority. More than 11,000 acres of the facility is located in Jo Daviess County. The majority of this acreage is now being jointly managed by the U.S. Fish & Wildlife Service and the Illinois Department of Natural Resources to preserve and restore the high-quality wildlife habitat areas as the Lost Mound Unit of the Upper Mississippi River National Wildlife and Fish Refuge. Before becoming the Savanna Army Depot, this area was known to locals as "The Prairie." In 1910, Illinois Natural History Survey Ecologist Henry Allan Gleason published his findings after studying the extensive sand prairies he found here. Besides finding many rare plants not previously known in Illinois at The Prairie, he also stated that the sand prairies he found here were the best examples remaining in Illinois at the time. The creation of the Savanna Army Depot probably saved the largest remaining sand prairie in the state from being converted to row crop production, with the advent of irrigation systems. Along with the bottomland forest, the sand prairie and sand savanna areas of the Lost Mound Unit support a host of endangered, threatened, and rare species.

**Figure 57** The western wall of the quarry is a remnant of the Silurian dolomite palisades along the Mississippi River bluff. Photograph by Samuel V. Panno; used with permission.

**Figure 58** This photograph from the *Clinton Herald* on October 4, 1947, shows an experiment of burying 1,000-pound bombs beneath the soil at the Savanna Army Depot "in order to preserve them." Photograph used with permission of the *Clinton Herald*.

Reminders of the property's history as a proving ground remain. On a January night in 1948, 150 tons of antitank mines exploded in one of the storage igloos, which were designed to direct any explosions up and down. No one was injured, but the blast shattered windows in nearby communities, was felt throughout a 30,000-square-mile area, and left a 100-foot-diameter, 50-foot-deep crater (Figure 58). The Depot is a Superfund site; several hundred locations were identified by the U.S. Environmental Protection Agency as potentially posing environmental concern or requiring environmental investigation. Access to many areas is restricted because of the possibility of unexploded ordnance. As funds are made available, site cleanup is being undertaken by the U.S. Department of the Army so that the property can be transferred from its property inventory.

Leave STOP 3 by following caravan and completing a U-TURN on Whitton Road. Do not leave caravan formation—follow Whitton Road southeast until U-turn point. Do not worry—we will help you. This is necessary to avoid construction in Hanover.

Continue northwest about 1.5 miles to Hanover Hill Road and TURN RIGHT (northeast).

Travel 1.5 miles and TURN LEFT onto West Blanding Road (west).

Follow West Blanding Road 7 miles to Blanding Landing—LUNCH STOP on the Mississippi River. West Blanding Road becomes South River Road the last mile of our route. At the entrance to the park, make a LEFT TURN and use caution as you cross the railroad tracks.

**LUNCH:** *Coordinates N 42° 17.160′, W 90° 24.180′*

Leave lunch stop by crossing railroad tracks and TURNING RIGHT (southeast) onto South River Road.

Continue 1 mile and TURN LEFT (northeast) onto South Blanding Road.

Travel approximately 3.5 miles to West Chestnut Road and TURN LEFT (west).

Enter Chestnut Mountain Resort and park caravan in parking lot.

Arrive at STOP 4—short walk to view sinkholes.

## STOP 4: CHESTNUT MOUNTAIN COVER-COLLAPSE SINKHOLES OVERLYING SILURIAN DOLOMITE *Coordinates N 42° 19.174′, W 90° 23.482′*

Numerous cover-collapse sinkholes are found throughout the highlands of western Jo Daviess County in fine-grained sediments overlying crevices in Silurian dolomite (Figure 59). Along the road to Chestnut Mountain Ski Resort, we will stop at several sinkholes just off the road. The sinkholes formed as a result of the collapse of sediment into solution-enlarged crevices. These sinkholes are usually circular and range from 30 to 70 feet in diameter and from 10 to 20 feet deep. The sinkholes are similar to the sucker holes in size, shape, and depth, but they lack the ejecta that forms elevated rings around the sucker holes. The sinkholes form in sediments overlying large crevices (about 3 feet wide) within the underlying Silurian dolomite. Because of the linear nature of crevices, the sinkholes often form en echelon (sometimes more than six in a row) along the trend of the crevices (Figure 12).

**Figure 59** This cover-collapse sinkhole overlying a Silurian dolomite crevice is about 20 feet in diameter and about 10 feet deep. The lack of ejecta around the rim of the sinkhole and the fact that ore minerals did not occur in Silurian dolomite are evidence that this is not a sucker hole. Photograph by Samuel V. Panno; used with permission.

Leave STOP 4 by driving east on West Chestnut Road.

Obey stop sign and then TURN LEFT (north) onto South Blanding Road.

Continue 400 feet, obey stop sign, and TURN LEFT (northwest) onto West Blackjack Road (County 8).

Travel about 3.5 miles and TURN LEFT (southwest) onto West Hart John Road.

Continue 1 mile to stop sign at South Pilot Knob Road and TURN RIGHT (north).

In 600 feet, TURN LEFT (west) into Casper Bluff Land and Water Reserve and follow drive to parking lot. Arrive at STOP 5.

## STOP 5: CASPER BLUFF LAND AND WATER RESERVE: THE AIKEN MOUND SITE

*Coordinates N 42° 21.656′, W 90° 25.628′*

**Figure 60** Bird effigy at the Casper Bluff Land and Water Reserve. Photograph by Digital Dubuque Photography of the Jo Daviess Conservation Foundation; used with permission.

**Figure 61** View of the Mississippi River from the Casper Bluff Land and Water Reserve. Photograph by Richard Mattas; used with permission.

The Casper Bluff Land and Water Reserve is located on the sloping bluff top along the east side of the Mississippi overlooking the mouths of the Galena River and Smallpox Creek. The 80-acre preserve is named for Dave and Pat Casper, the former owners, who worked with the JDCF to allow them to purchase the property. The bluff top is home to stands of oak trees, restored prairie, walking trails, and striking vistas across the Mississippi River to the Iowa bluffs.

The preserve is also significant because it contains a large portion of the Aiken Mound Group (11JD5). This mile-long Native American burial mound group was constructed by Late Woodland (A.D. 600–1000) people and consists of conical and linear mounds as well as a ritual enclosure and a large bird effigy (Figure 60). At one time, the group contained more than 50 mounds (Figure 61), but today, approximately 20 remain intact. The bluff spurs adjacent to and around the mounds also contain abundant evidence of habitation by a long sequence of Native American cultures over many millennia. These mounds are part of a larger sacred landscape that includes an almost continuous chain of mound groups extending from the Keough Effigy Mounds Land and Water Reserve southeast to the Casper Bluff Land and Water Reserve.

The Aiken Mounds (11JD5) are also important because local pioneer archaeologist William Baker Nickerson created a detailed map of the mounds and conducted limited excavations at the ritual enclosure and bird effigy at the end of the 19th century. Nickerson was so impressed with the mound group that he used it as an example in his prescient 1911 publication, *The Mound Builders—A Plea for the Conservation of the Antiquities of the Central and Southern States*. Nickerson penned this article more than a century ago, and his plea has at last been answered.

Leave STOP 5 by exiting the reserve driveway and TURNING LEFT (north) onto South Pilot Knob Road.

Continue about 2 miles to stop sign at North Blackjack Road.

Obey stop sign and TURN LEFT (north) onto North Blackjack Road.

Follow route into Galena, approximately 2 miles.

Slow down as you enter Galena and follow curve to the RIGHT (north) onto Fourth St.

Travel 300 feet to US 20 (Decatur/Spring Street) and obey stop sign.

TURN LEFT (west) onto US 20 and continue 2 blocks (400 feet).

TURN RIGHT (north) onto Park Avenue.

Continue 400 feet to Bouthillier Street and TURN LEFT.

Cross railroad tracks and enter Depot Park—arrive at STOPS 6 and 7 (a two-part stop!).

Please park in available parking spaces. The trip will end here.

Thank you for joining us. We hope you enjoyed the trip. Please travel home safely.

## STOP 6: NATURAL "SPRING" *Coordinates N 42° 24.624′, W 90° 25.806′*

**Figure 62** Natural "spring" along the Galena River Trail. The spring may be an abandoned flowing artesian well. The photograph was taken in February of this year, when most of the county was covered with snow. The warmth and movement of the upwelling groundwater warmed the surrounding ground and melted the snow. Photograph by Samuel V. Panno; used with permission.

A natural "spring" is located along the Galena River Trail in Galena, Illinois (Figure 62). The history of the spring is uncertain, and it is possible that it is an abandoned flowing artesian well. A building could be seen in close proximity to the spring in 1893, based on a plat book of the area. Locals stated that the spring was used to clean cement trucks at one point, and chunks of concrete may be found within the spring pool and surrounding area. The specific conductance of the spring water changes very little throughout the year, indicating a constant chemical composition. Its chemical composition is similar to that of the city's wells, which are approximately 1,600 feet deep and tap sandstone of the Cambrian-age Mount Simon Formation that were under flowing artesian conditions when they were drilled.

The $Cl^-$ concentration of water from the unnamed Galena Trail spring is 1.1 mg/L. The very low $Cl^-$ concentration of the spring, the constant temperature, and the specific conductance data for the spring might suggest a relatively deep source (150 feet or greater based on unpublished data by S. Panno, ISGS) that is not mixing with shallow groundwater. The terms "deep" and "shallow," in this case, may be thought of in terms of water quality and not depth. Deep may be used to refer to pristine groundwater unaffected by human-related contaminants, whereas shallow may be used to refer to groundwater affected by human-related contaminants. Groundwater affected by recent recharge from rainfall and snowmelt would reflect the effects of seasonal temperature changes and would reveal the presence of surface-borne contaminants such as road salt. Little or no local or near-surface influence on the spring water is apparent even after significant rainfall or snowmelt events, based on data provided by E.L. Baranski. Specific conductance and temperature for the spring are a stable 460 µS/cm and 13.3°C all year long. Data for the stable isotopes of deuterium (−53 parts per thousand) and oxygen-18 (−8.0 parts per thousand) from a shallow private well in Galena and the Galena Trail spring are essentially identical and fall close to what would be expected at the latitude of Jo Daviess County. (Isotopes of precipitation change with changes in latitude, becoming lighter to the north and heavier to the south because of temperature and humidity effects.) It is apparent that groundwater for shallow private wells in the area (about 100 feet deep) and the Galena Trail spring are from the same aquifer (Galena-Platteville); however, the chemical composition of groundwater from shallow wells in the area is affected by surface-borne contaminants, as discussed above, whereas the Galena Trail spring is not. This suggests a relatively deep source of groundwater for the unnamed spring that is unmixed with shallow, typically chemically influenced groundwater. Consequently, the unnamed spring behaves more like a flowing artesian well than a spring.

## STOP 7: GALENA, ILLINOIS *Coordinates N 42° 24.624′, W 90° 25.806′*

Galena lies across the Galena River from our vantage point in the Depot parking lot (Figure 39). The City of Galena is an incredibly well-preserved example of a 19th-century boomtown that became the largest river port north of St. Louis prior to the Civil War (Figures 63 and 64). It was the product of geography and geology. Rich veins of lead ore were found here and across the Illinois border into Wisconsin. Galena, which is Latin for lead sulfide, was the head of navigation for the boats of the time (Figure 65). Main and Bench Streets represent old river terraces, formed as the Galena River channel adjusted to changing Mississippi River levels because of glacial meltwater. The stream's channel was scoured and then buried in sediment. The pilings for the walk bridge you see had to be sunk 90 feet before hitting bedrock.

Despite periods of Pleistocene sedimentation, the first miners found a clear and deep stream more than 200 feet wide, but mining and farming choked it with new sediment, ruining the river trade that had fueled Galena's growth. The railroad, arriving in 1854, carried away what trade remained, mostly to Chicago. The U.S. Army Corps of Engineers instituted a massive flood control project in 1948 as flooding became more frequent (Figure 66). The levee and floodgates (the latter still used) saved the downtown commercial district—along with the town's future as a major tourist destination. Yet the river you see now is but a remnant of its former self (Figure 67)—a reminder of 150 years of environmental degradation.

Many local citizen activists have taken actions to remediate the environmental damage to the area and its wildlife in Jo Daviess County. For example, no group has done more to further the success of the Eastern Bluebird in Jo Daviess County, Illinois, than the Conservation Guardians of Northwest Illinois (formerly the Natural Area Guardians). Established in 1990, the organization has held bluebird workshops for years, teaching newcomers the basics of bluebird care and nest monitoring. The County typically fledges between 800 and 1,500 nestlings per year (Figure 68), depending on predation, disease, weather, and number of reports from monitors. The Conservation Guardians of Northwest Illinois now carry on their work as part of the Jo Daviess Conservation Foundation.

**Figure 63** Galena, Illinois, around the turn of the century. Photograph courtesy of the Alfred W. Mueller Collection (Galena, Illinois).


**Figure 64** Main Street in Galena, Illinois, in 1905 (left) and in 2014 (right) showing little change over more than 100 years. The most noticeable change is that the brick streets have been replaced by asphalt. 1905 photograph courtesy of the Alfred W. Mueller Collection (Galena, Illinois). 2014 photograph by Elizabeth L. Baranski; used with permission.

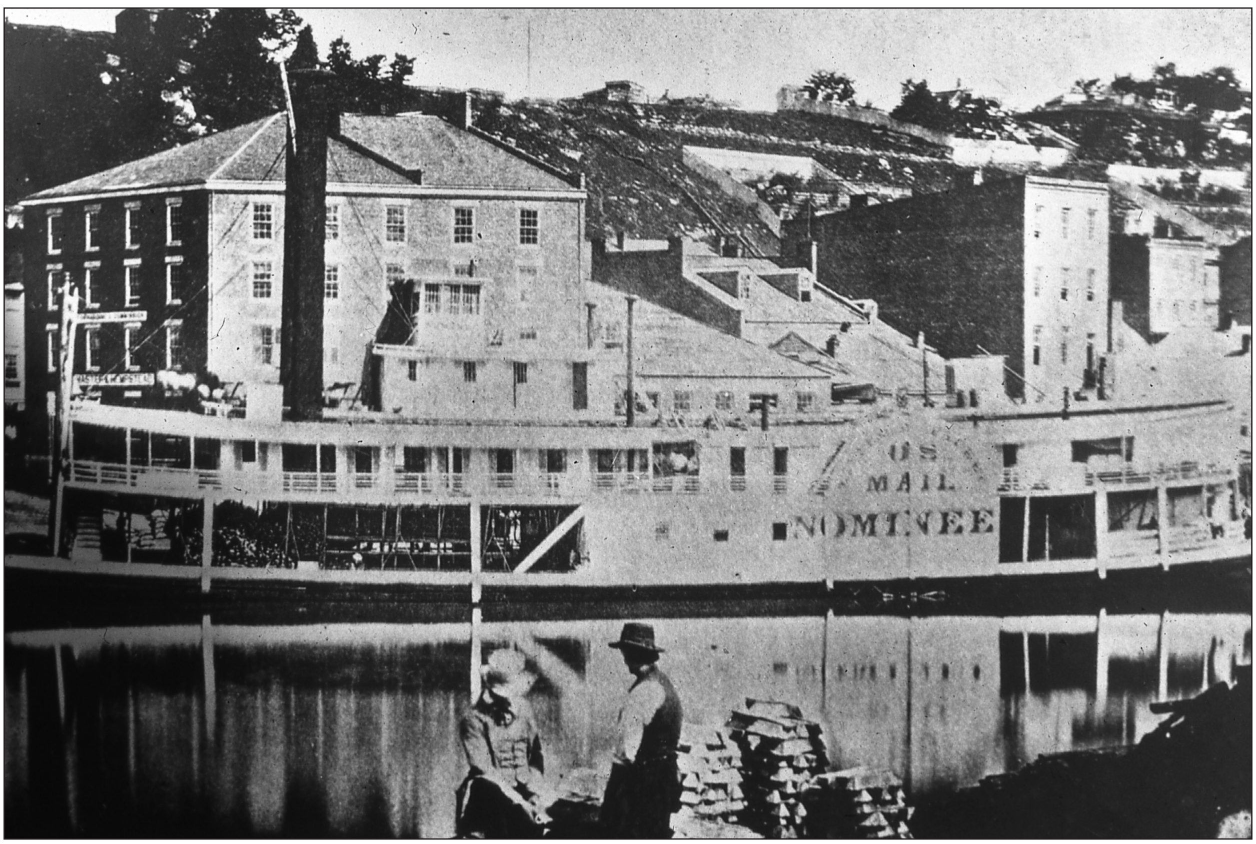



**Figure 65** The steamboat *Nominee* docked in Galena, with two men and a stack of pigs of lead (ingots) in the foreground, circa 1852. Most of the buildings seen in this photograph are still standing. Photograph courtesy of the Alfred W. Mueller Collection (Galena, Illinois).


**Figure 66** During the early half of the 20th century, Galena experienced repeated flooding that threatened its downtown. Photograph courtesy of the Alfred W. Mueller Collection (Galena, Illinois).

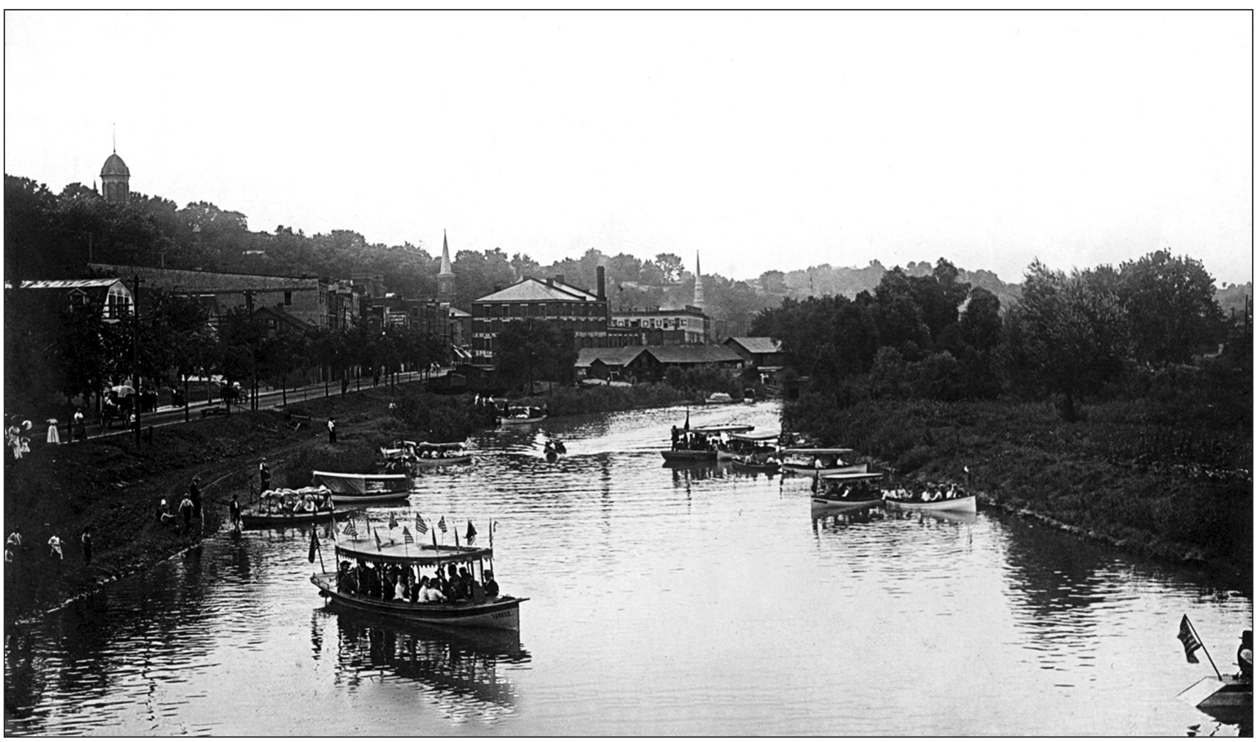


**Figure 67** Pleasure boats on the Galena River around the turn of the century. Photograph courtesy of the Alfred W. Mueller Collection (Galena, Illinois).

**Figure 68** Bluebirds are now returning to Galena, thanks to the efforts of the Jo Daviess Conservation Foundation's Conservation Guardians of Northwest Illinois (formerly the Natural Area Guardians). Photograph by Barbara Baird; used with permission.

# References


Anderson, A.G., and G.E. Muehlenhardt, 2002, Lost Mound National Wildlife Refuge, Savanna, Illinois: Interim comprehensive conservation plan: Savannah, IL, U.S. Department of the Interior, Fish & Wildlife Service, Branch of Ascertainment and Planning, http://www.fws.gov/midwest/planning/LostMound/interimCCP_nov03.pdf (accessed March 25, 2014).

Frankie, W.T., and R.S. Nelson, 2002, Guide to the geology of the Apple River Canyon State Park and surrounding area of northeastern Jo Daviess County, Illinois: Illinois State Geological Survey, Field Trip Guidebook 2002B, 88 p.

Illinois Natural History Survey, 2014, Endangered, threatened, & rare species of Lost Mound Unit: Illinois Natural History Survey, Prairie Research Institute, University of Illinois at Urbana-Champaign, http://wwx.inhs.illinois.edu/fieldstations/lostmound/species/ (accessed March 25, 2014).

Illinois Natural History Survey, 2014, Lost Mound Field Station: Illinois Natural History Survey, Prairie Research Institute, University of Illinois at Urbana-Champaign, http://wwx.inhs.illinois.edu/fieldstations/lostmound/ (accessed March 25, 2014).

Jo-Carroll Depot Local Redevelopment Authority, 2014, Savanna Depot Park: Business, industry, technology: Savanna, IL, Jo-Carroll Depot Local Redevelopment Authority, http://www.lrasavannail.us/ (accessed March 25, 2014).

Rowell, S., 2013, Savanna Army Depot site, IL, USA—Story about the 50 foot crater at Savanna Depot (April 12, 2013): Internet Archive, audio archive, radio aporee: maps collection, https://archive.org/details/aporee_17431_20286 (accessed March 25, 2014).

RRAVCLUB, 2013, Savanna Army Depot: Throughout the years: Hanover, IL, River Ridge High School, http://www.youtube.com/watch?v=SYxAfy80KYk (accessed March 25, 2014).

Shank, W., J. Mecum, D. Wolfe, and R.S. Lange, 1982, Written historical and descriptive data: Savanna Army Depot: U.S. Department of the Interior, National Park Service, Historic American Engineering Record, HAER No. IL-19, http://lcweb2.loc.gov/pnp/habshaer/il/il0400/il0464/data/il0464data.pdf (accessed March 25, 2014).

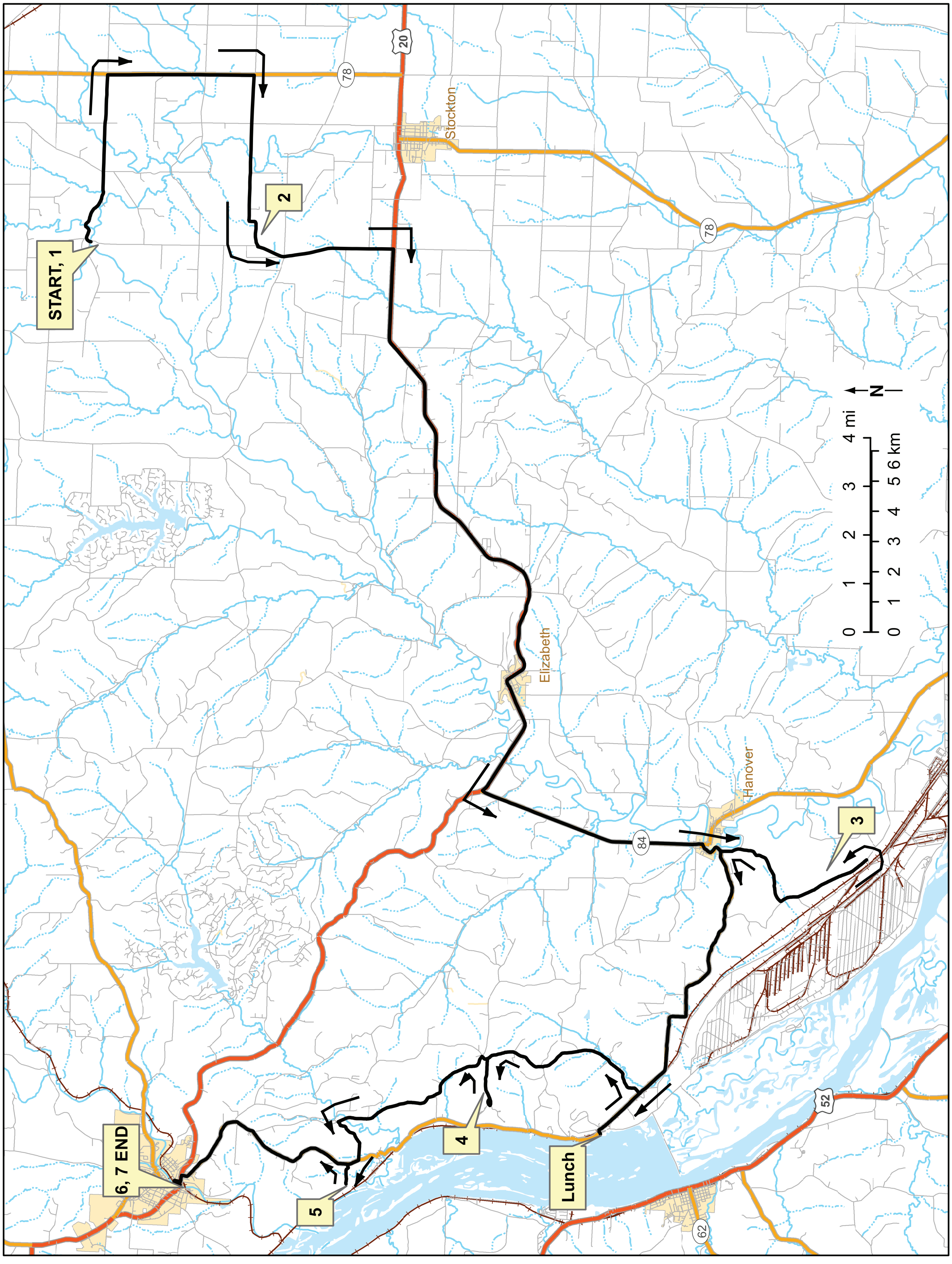
U.S. Environmental Protection Agency, Region 5 Superfund, 2013, Savanna Army Depot activity: U.S. Environmental Protection Agency, EPA ID# IL3210020803, http://www.epa.gov/region5/superfund/npl/illinois/IL3210020803.html (accessed March 25, 2014).

U.S. Environmental Protection Agency, Superfund Information Systems, 2013, Superfund Site Progress Profile: Savanna Army Depot activity: U.S. Environmental Protection Agency, EPA ID# IL3210020803, http://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0501174 (accessed March 26, 2014).

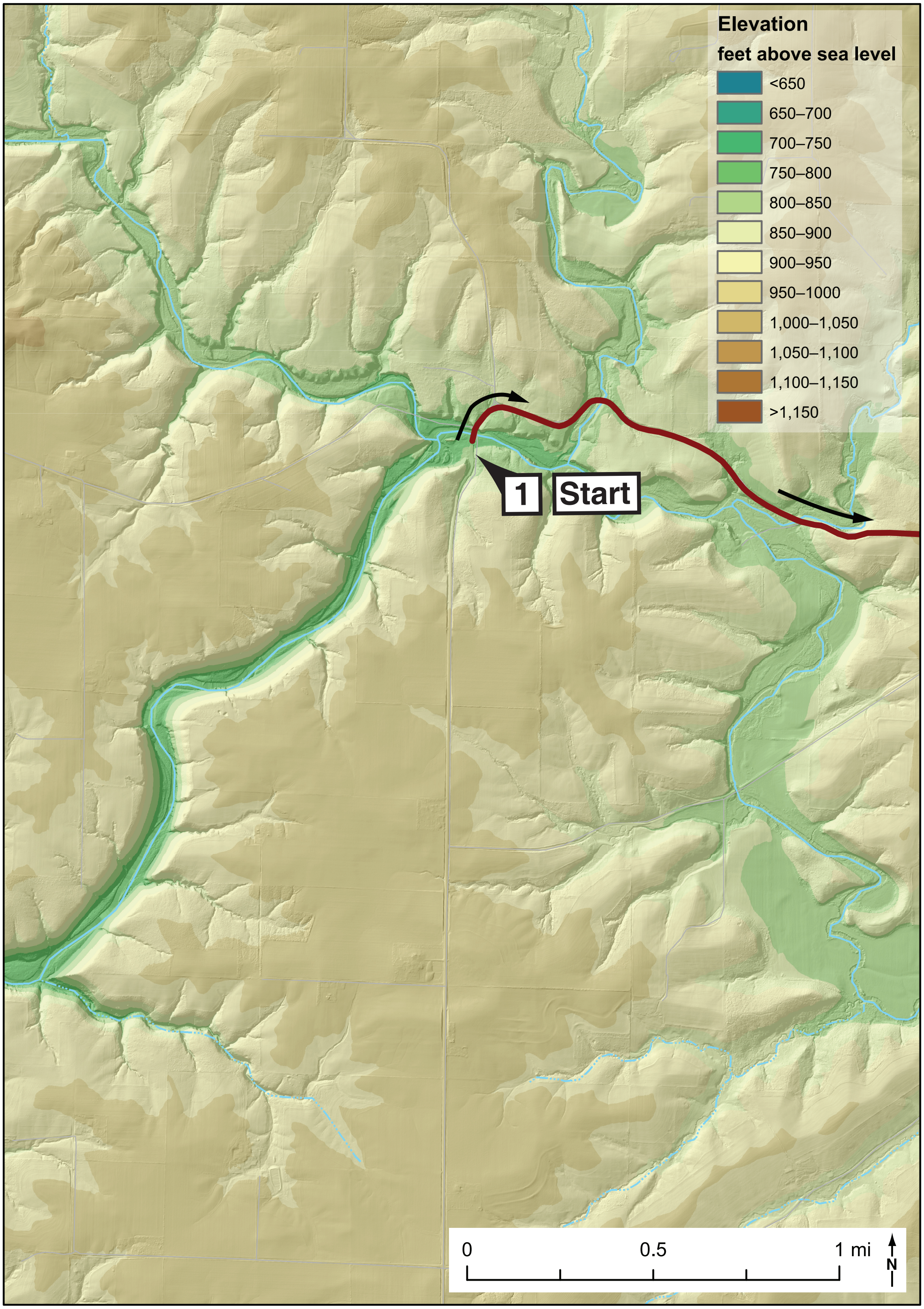
U.S. Fish & Wildlife Service, 2002, Lost Mound National Wildlife Refuge: Environmental assessment and interim comprehensive conservation plan: U.S. Department of the Interior Fish & Wildlife Service, http://www.fws.gov/midwest/planning/LostMound/EA_november03.pdf (accessed March 25, 2014).

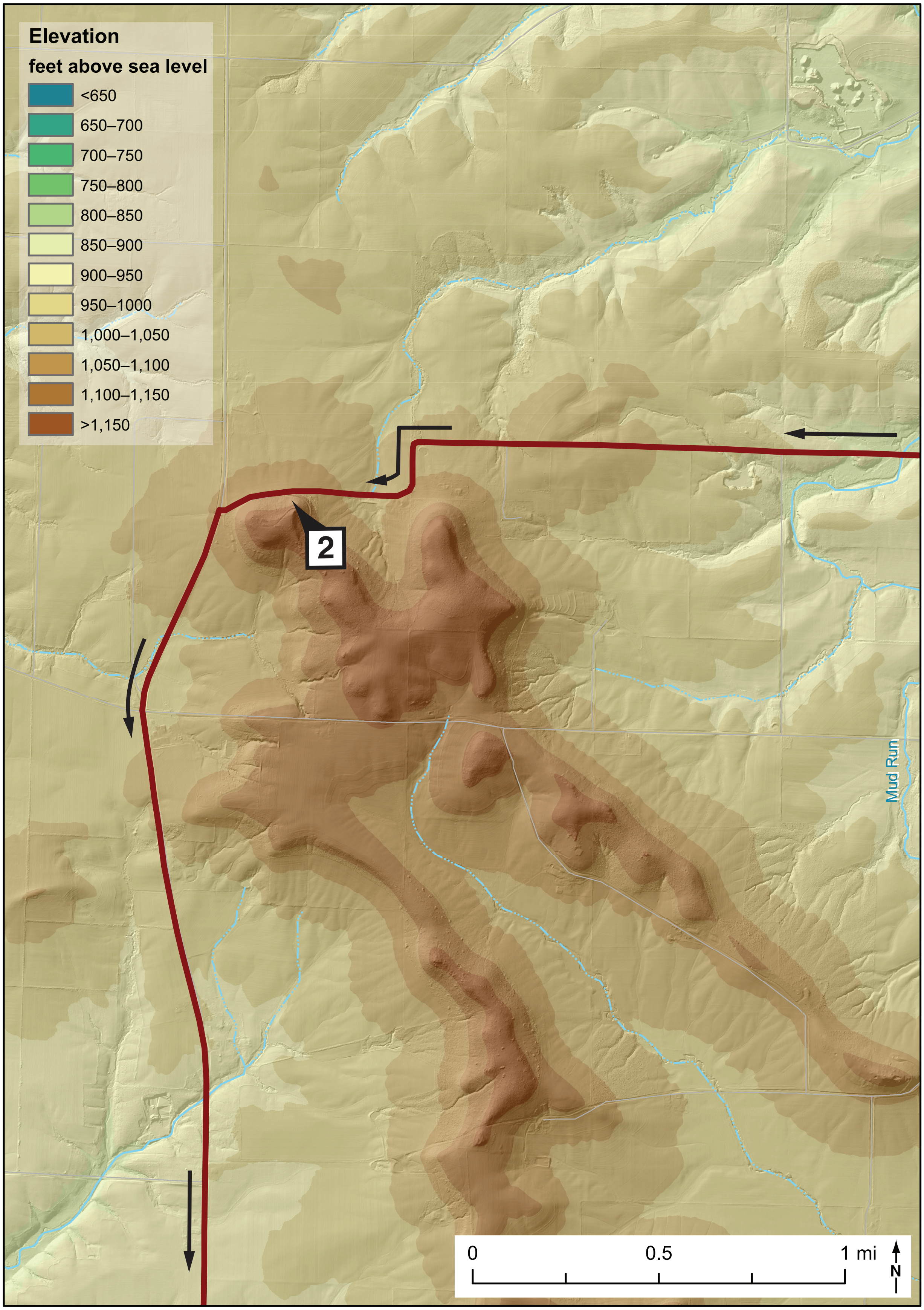
Utica Observer-Dispatch, January 22, 1948, Mines explode, break windows 50 miles away: Associated Press, p. 12, http://fultonhistory.com/newspaper%202/Utica%20NY%20Daily%20Observer/Utica%20NY%20Observer%201948.pdf/Utica%20NY%20Observer%201948%20-%200065.PDF (accessed March 25, 2014).

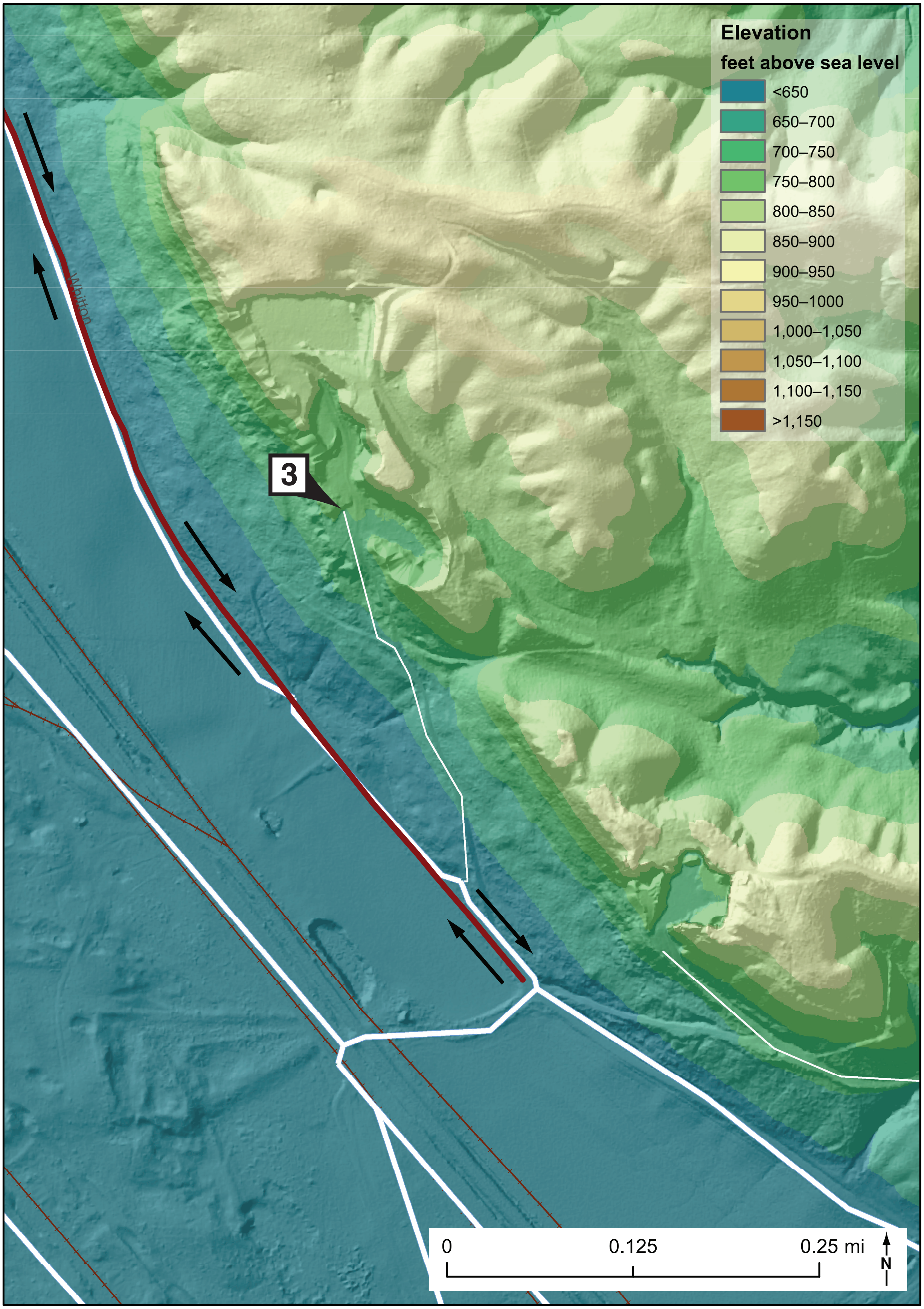
# MAP OF THE FIELD TRIP ROUTE

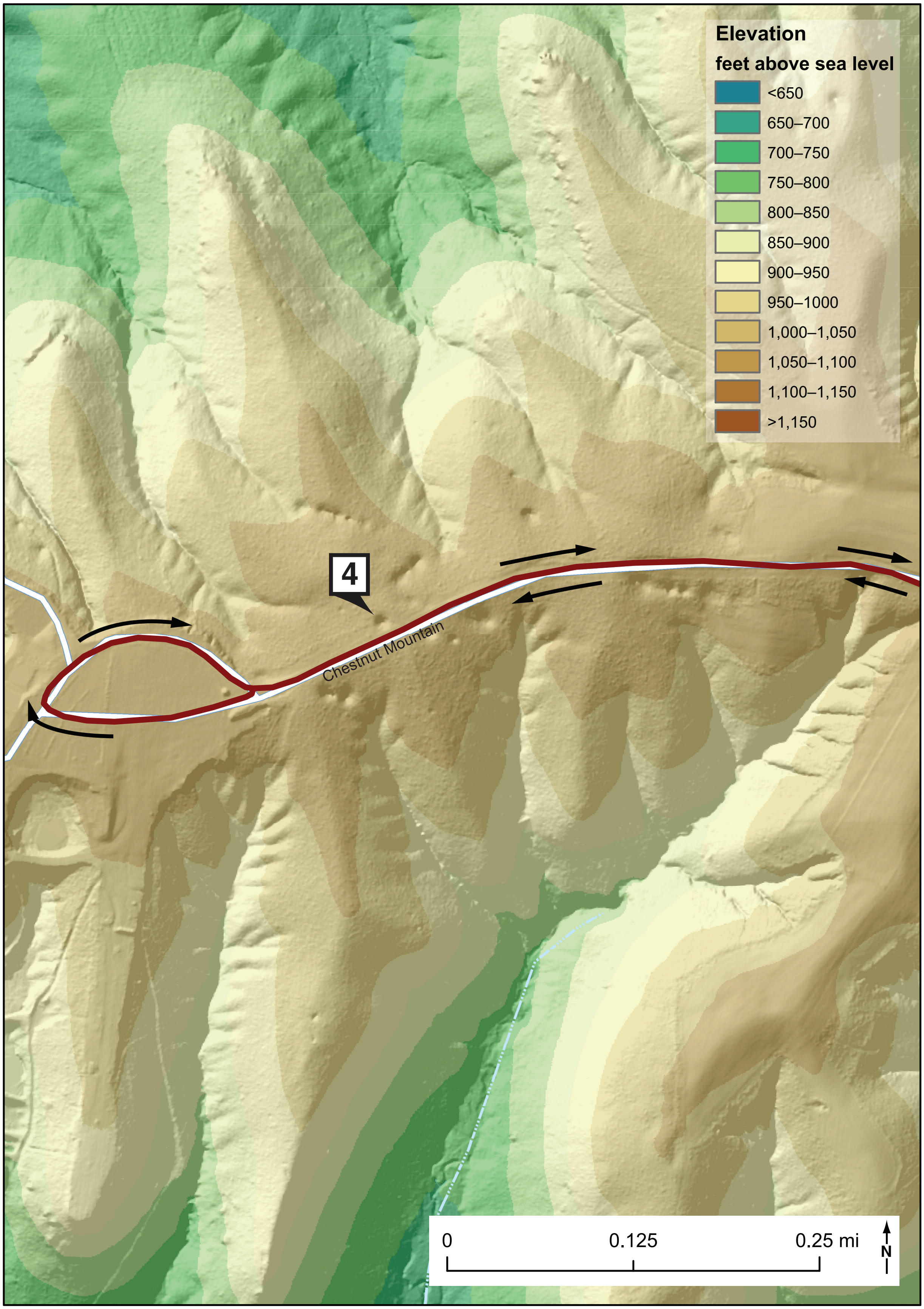


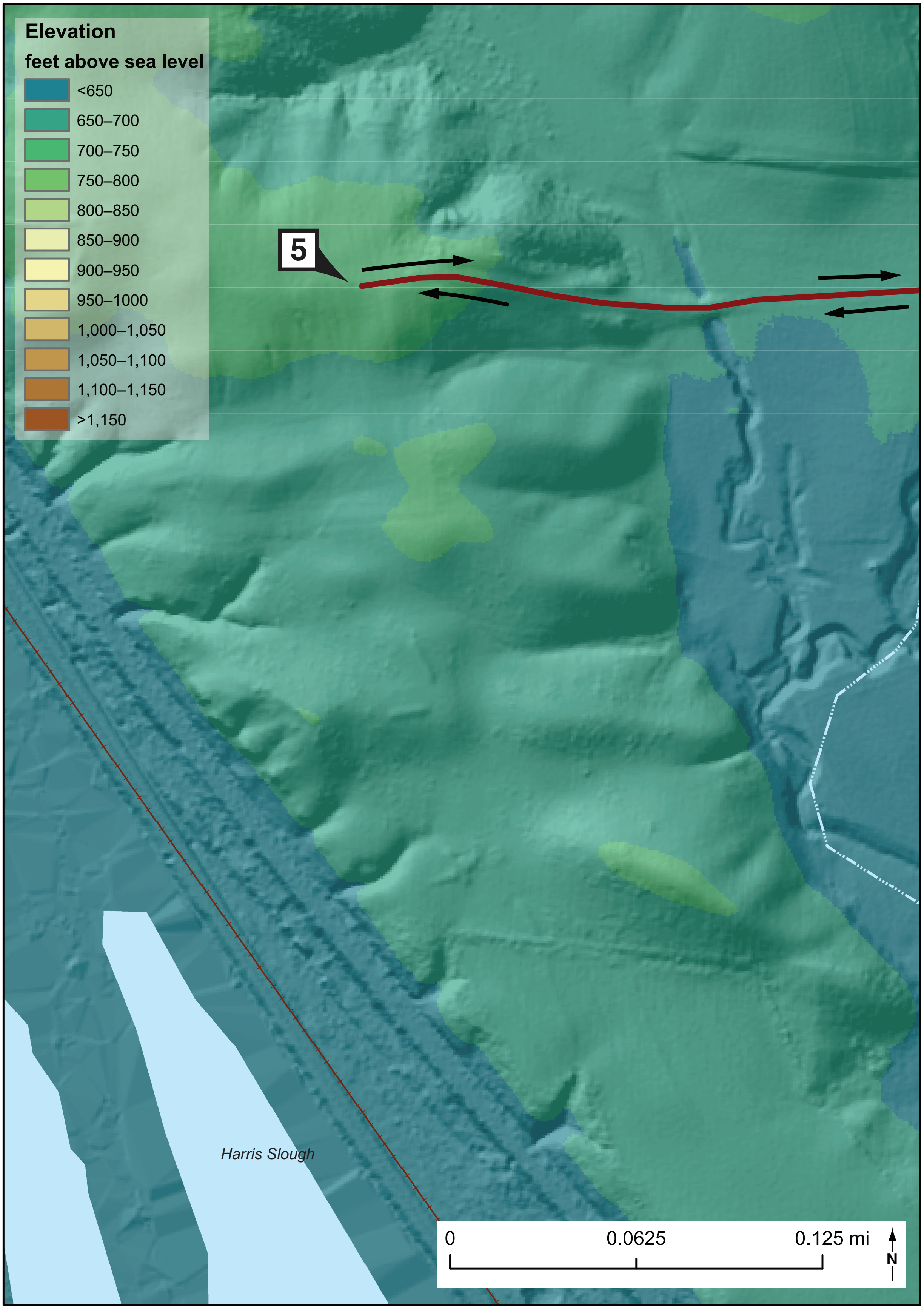
# DETAIL OF FIELD TRIP STOPS

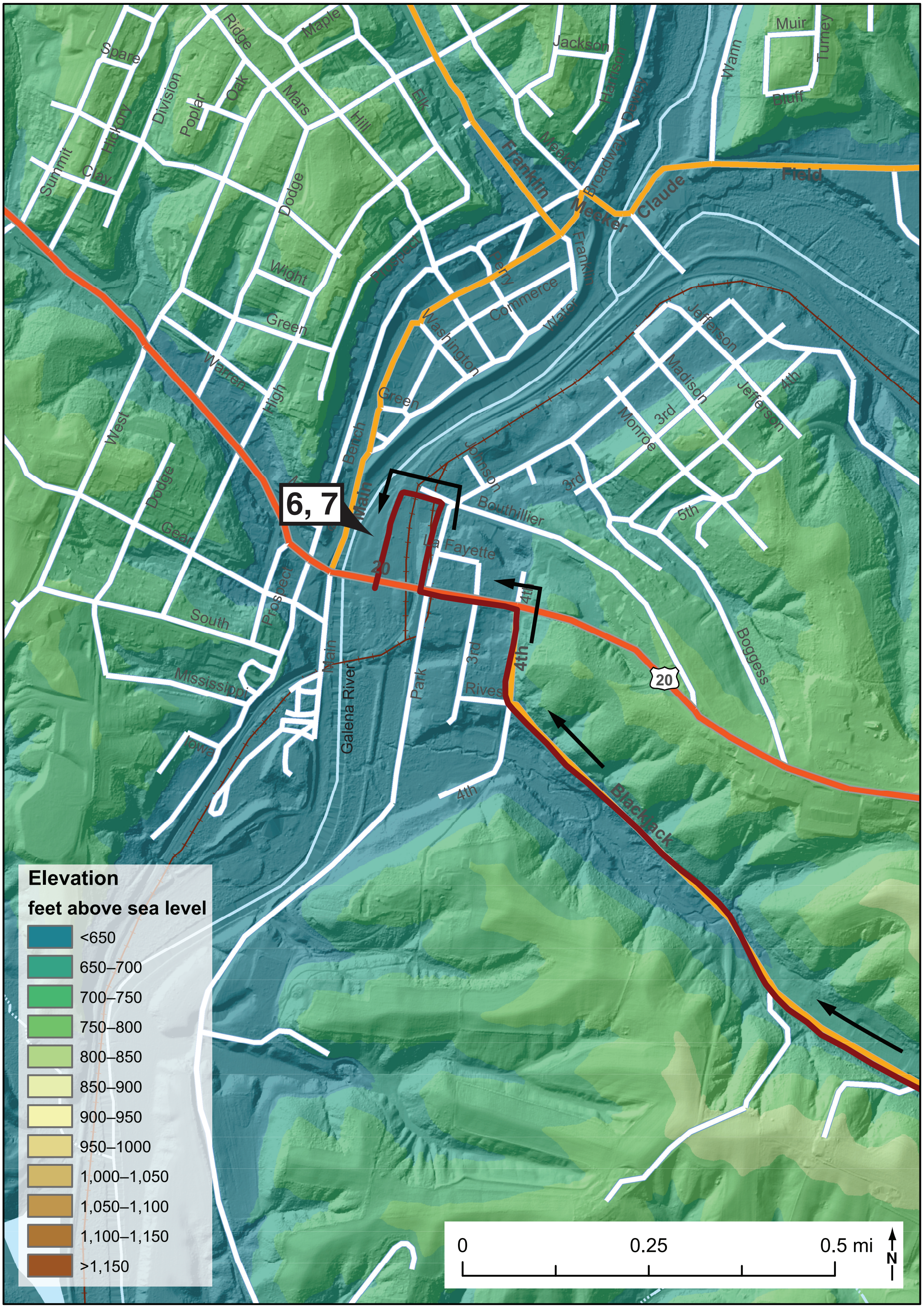



Elevation
feet above sea level
<650
650–700
700–750
750–800
800–850
850–900
900–950
950–1000
1,000–1,050
1,050–1,100
1,100–1,150
>1,150
2
Mud Run
0
0.5
1 mi
N


Elevation
feet above sea level
<650
650–700
700–750
750–800
800–850
850–900
900–950
950–1000
1,000–1,050
1,050–1,100
1,100–1,150
>1,150
3
Whitton
0
0.125
0.25 mi
N

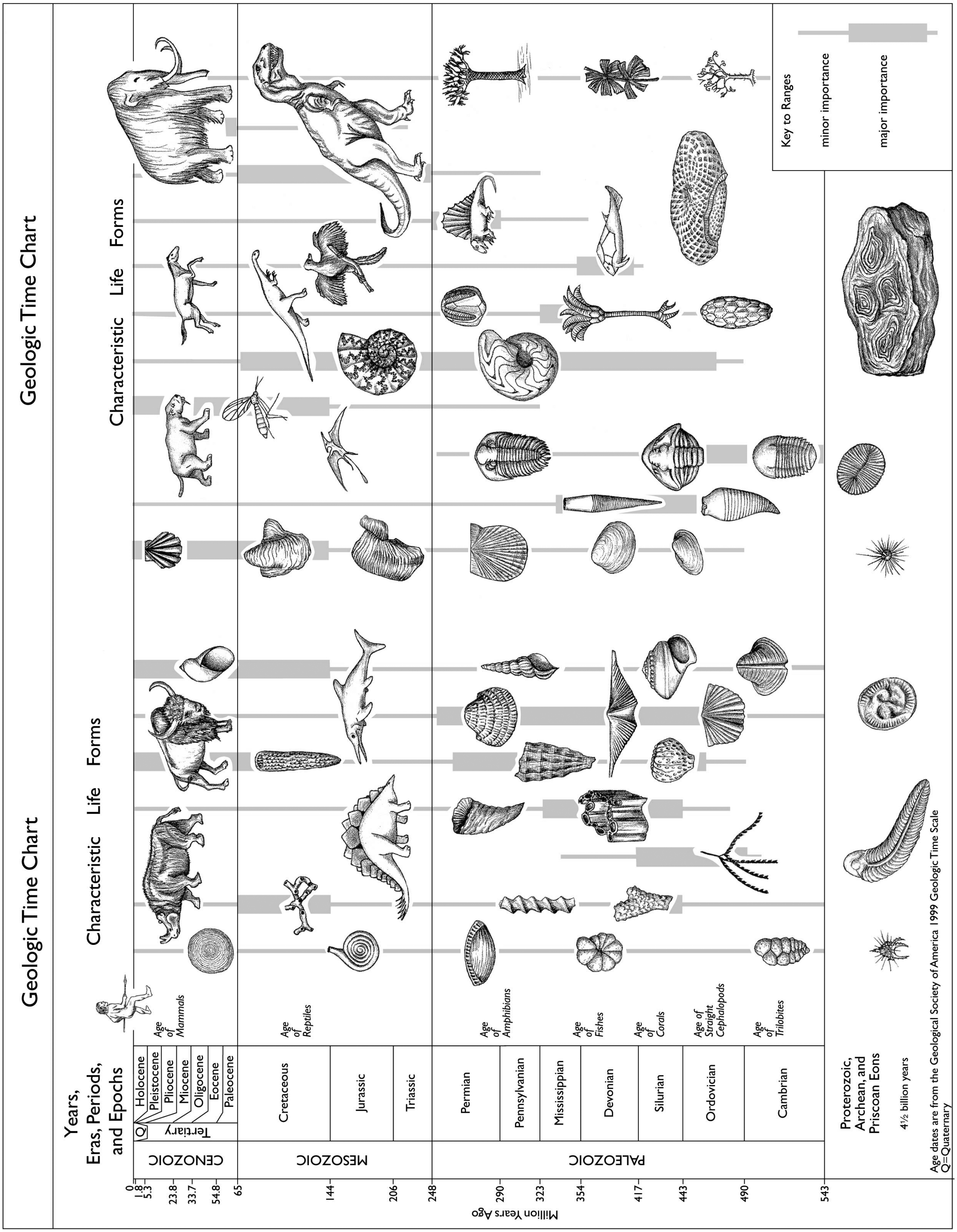

Elevation
feet above sea level
<650
650–700
700–750
750–800
800–850
850–900
900–950
950–1000
1,000–1,050
1,050–1,100
1,100–1,150
>1,150
4
Chestnut Mountain
0
0.125
0.25 mi
N


Elevation
feet above sea level
<650
650–700
700–750
750–800
800–850
850–900
900–950
950–1000
1,000–1,050
1,050–1,100
1,100–1,150
>1,150
5
Harris Slough
0
0.0625
0.125 mi
N

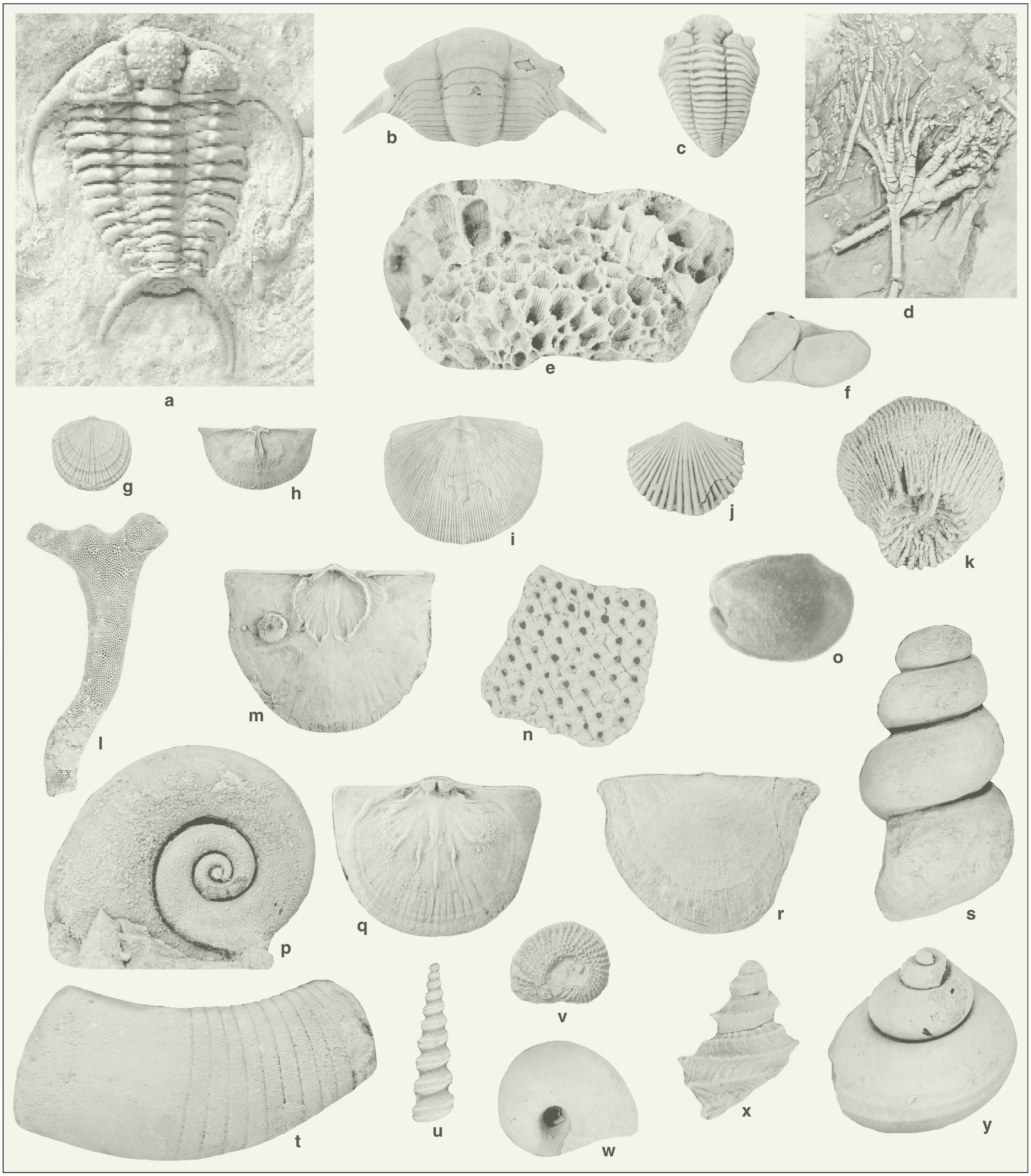


Elevation
feet above sea level
<650
650–700
700–750
750–800
800–850
850–900
900–950
950–1000
1,000–1,050
1,050–1,100
1,100–1,150
>1,150
0
0.25
0.5 mi
N
6, 7
20
Field
Claude
Meeker
Franklin
Blackjack
Galena River
Main
Park
4th
3rd
South
Mississippi
Bouthillier
La Fayette
Jefferson
Madison
Monroe
Boggess
Washington
Commerce
Water
Green
High
Warren
West
Dodge
Prospect
Summit
Hickory
Division
Poplar
Oak
Ridge
Maple
Mars
Hill
Elk
Jackson
Wann
Muir
Bluff
Spare
Clay
Wight
Johnson
Rives
5th
4th

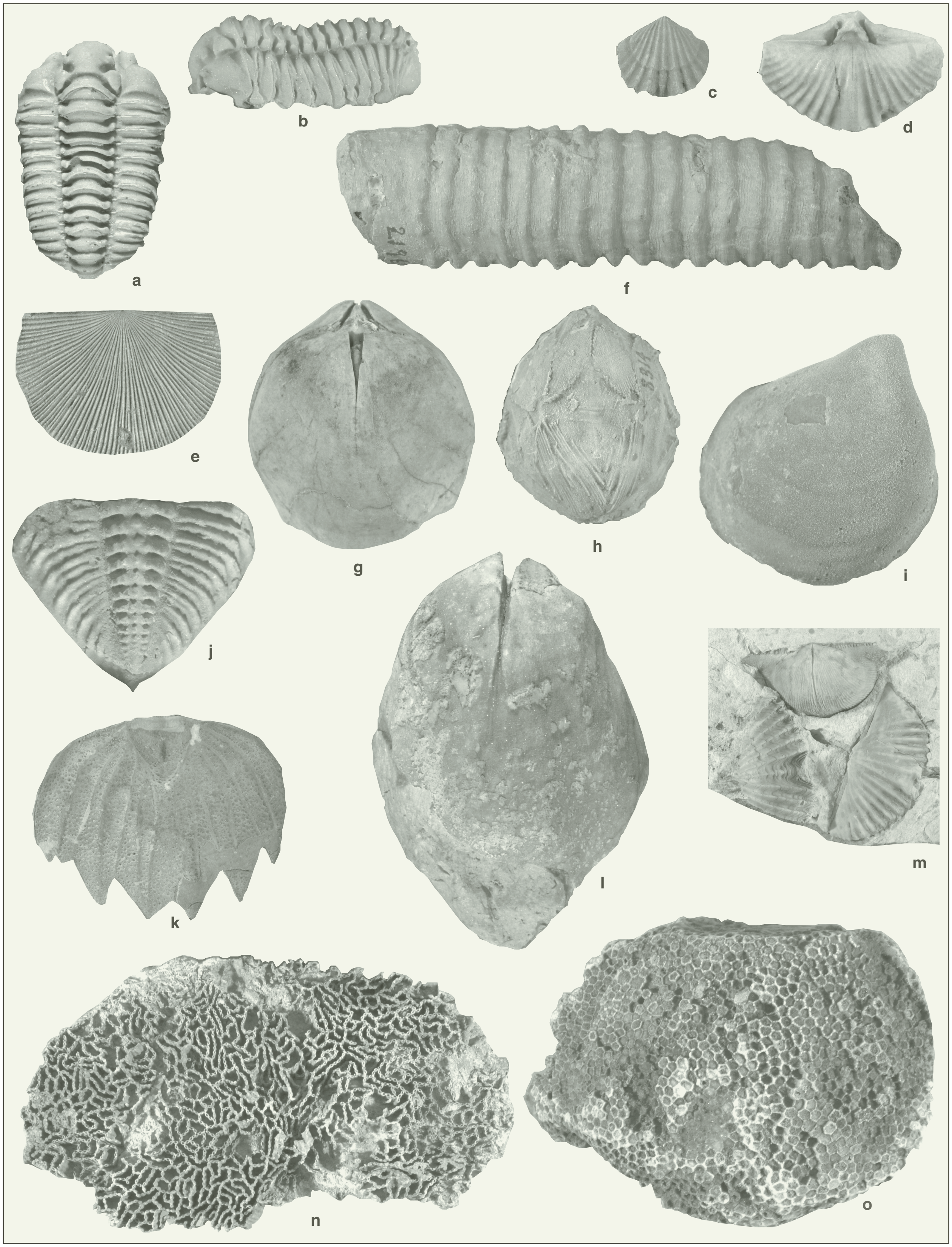
# FOSSIL GUIDE




Geologic time chart showing the succession of life forms through time (from C. Collinson, 2002, Guide for beginning fossil hunters: Illinois State Geological Survey, p. 2–3).




Characteristic fossils of the Ordovician Platteville and Galena Groups: a, trilobite *Gabriceraurus* sp.; b, trilobite *Thaleops ovata*; c, trilobite *Encrinurus* sp.; d, crinoid *Cupulocrinus gracilis*; e, colonial coral *Foerstephyllum* sp.; f, ostracod *Eoleperditia fabulites*; g, brachiopod *Dalmanella* sp.; h, brachiopod *Sowerbyella punctostriata*; i, brachiopod *Campylorthis deflecta*; j, brachiopod *Hesperorthis concava*; k, horn coral *Streptelasma* sp.; l, trepostome bryozoan; m, brachiopod *Strophomena plattinensis*; n, blue-green algae *Receptaculites oweni*; o, clam *Vanuxemia* sp.; p, snail *Maclurites* sp.; q, r, brachiopod *Opikina minnesotensis*; s, snail *Hormotoma major*; t, cephalopod *Richardsondoceras* sp.; u, snail *Ectomaria* sp.; v, snail *Phragmolites* sp.; w, snail *Tetranota* sp.; x, snail *Lophospira* sp.; y, snail *Clathrospira* sp. Fossils are from the Platteville Group, except g, h, k, n, and s, which are from the Galena Group. All specimens shown approximately life size (from Kolata and Nimz 2010). Photographs by Dennis R. Kolata.




Characteristic fossils of the Silurian Period and the Early Devonian Epoch. (a, b) Trilobite *Gravicalymene celebra*, ×1.25, Joliet Dolomite; (c, d) spiriferid brachiopods, ×1.5; (e) brachiopod *Schuchertera* sp., ×1.8; (f) cephalopod *Dawsonoceras annulatum*, ×0.7, Racine Dolomite; (g) brachiopod *Amphigenia curta*, ×1.4; (h) cystoid *Caryocrinites* sp., ×1.2, Racine Dolomite; (i) bivalve *Amphicoelia neglecta*, ×1.0, Racine Dolomite; (j) trilobite pygidium *Glyptambon gassi*, ×2.0, Racine Dolomite; (k) trilobite pygidium *Arctinurus occidentalis*, ×0.9, Racine Dolomite; (l) brachiopod *Pentamerus* sp., ×0.9, Marcus Dolomite; (m) brachiopod *Eodevonaria arcuata* (upper) and spiriferid brachiopods (lower), ×1.1; (n) colonial coral *Halysites* sp., ×0.6; (o) colonial coral *Favosites* sp., ×0.6, Louisville Limestone. Fossils c, d, e, g, and m are from the Lower Devonian Clear Creek Formation (from Kolata and Nimz 2010).

# GLOSSARY

The following definitions are adapted in total or in part from several sources. The principal source is R.L. Bates and J.A Jackson, eds., 1987, *Glossary of Geology*, 3rd ed.: Alexandria, Virginia, American Geological Institute, 788 p.

**age** An interval of geologic time; a division of an epoch.

**algific talus slope** A rare combination of geologic conditions that sustain an ecosystem that exists in the Driftless Area (algific = cold producing). These features occur only in karst areas and sustain flora and fauna from the Pleistocene epoch.

**anticline** A convex-upward rock fold in which strata have been bent into an arch; the strata on either 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.

**anticlinorium** A complex structure having smaller structures, such as domes, anticlines, and synclines, superimposed on its broad upwarp.

**aquifer** A geologic formation that is water bearing and that transmits water from one point to another.

**argillaceous** Said of rock or sediment that contains, or is composed of, clay-sized particles or clay minerals.

**basement complex** The suite of mostly crystalline igneous and/or metamorphic rocks that generally underlies the sedimentary rock sequence.

**basin** A topographic or structural low area that generally receives thicker deposits of sediments than adjacent areas; the low areas tend to sink more readily, partly because of the weight of the thicker sediments; the term also denotes an area of relatively deep water adjacent to shallow-water shelf areas.

**bedrock** The solid rock (sedimentary, igneous, or metamorphic) that underlies the unconsolidated (nonindurated) surface materials (for example, soil, sand, gravel, glacial till, etc.).

**calcite** A common rock-forming mineral consisting of $CaCO_3$; it may be white, colorless, or pale shades of gray, yellow, and blue; it has perfect rhombohedral cleavage, appears vitreous, and has a hardness of 3 on the Mohs scale; it effervesces (fizzes) readily in cold dilute hydrochloric acid. It is the principal constituent of limestone.

**chert** Silicon dioxide ($SiO_2$); a compact, massive rock composed of minute particles of quartz and/or chalcedony; it is similar to flint, but lighter in color.

**conformable** Said of strata deposited one upon another without interruption in accumulation of sediment; beds parallel.

**cover-collapse sinkholes** Sinkholes formed in sediment overlying creviced bedrock. These features form when soil falls into the crevice and is repeatedly washed away by groundwater. A silo-shaped cavity forms in the soil from the bedrock–soil interface and works its way to the surface. Erosion causes the collapse feature to develop into a bowl-shaped depression.

**crevice** A narrow opening in rock that is wider than a fracture. If present in a bedrock aquifer, crevices can provide pathways for rapid groundwater flow.

**dolomite** A mineral, calcium magnesium carbonate [$CaMg(CO_3)_2$]; also the name applied to sedimentary rocks composed largely of the mineral. 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.

**downgradient** Refers to the direction of flow of groundwater within an aquifer, similar to the term “downstream” for surface water.

**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 suggests that the area may not have been glaciated.

**en echelon** A diagonal line of equally spaced items.

**epoch** An interval of geologic time; a division of a period (for example, Pleistocene Epoch).

**era** The unit of geologic time that is next in magnitude beneath an eon; it consists of two or more periods (for example, Paleozoic Era).

**floodplain** The surface or strip of relatively smooth land adjacent to a stream channel produced by the stream’s erosion and deposition actions; the area covered with water when the stream overflows its banks at times of high water; it is built of alluvium carried by the stream during floods and deposited in the sluggish water beyond the influence of the swiftest current.

**formation** The basic rock unit, one 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), generally derived from the geographic localities where the unit was first recognized and described.

**fossil** Any remains or traces of a once-living plant or animal preserved in rocks (arbitrarily excludes recent remains); any evidence of ancient life. Also used to refer to any object that existed in the geologic past and for which evidence remains (for example, a fossil waterfall)

**galena** A mineral made up of lead sulfide that is the major ore of lead. Galena is gray and silvery in color, is very dense, and forms crystals in the shape of a cube or octahedron (eight-sided). Galena is often associated with sphalerite.

**geology** The study of the planet Earth that is concerned with its origin, composition, and form; its evolution and history; and the processes that acted (and act) upon the Earth to control its historic and present forms.

**glaciation** A collective term for the geologic processes of glacial activity, including erosion and deposition, and the resulting effects of such action on the Earth's surface.

**glacier** A large, slow-moving mass of ice formed on land by the compaction and recrystallization of snow.

**igneous** Said of a rock or mineral that solidified from molten or partly molten material (that is, from magma).

**joint** A fracture or crack in rocks along which there has been no movement of the opposing sides (*see also* fault).

**karst** Collective term for the landforms and subterranean features found in areas with relatively thin soils underlain by limestone or other soluble rocks; characterized by many sinkholes separated by steep ridges or irregular hills. Tunnels and caves formed by dissolution of the bedrock by groundwater honeycomb the subsurface. Named for the region around Karst in the Dinaric Alps of Croatia, where such features were first recognized and described.

**limestone** A sedimentary rock consisting primarily of calcium carbonate (the mineral, calcite). Limestone is generally formed by accumulation, mostly in place or with only short transport, of the shells of marine animals, but it may also form by direct chemical precipitation from solution in hot springs or caves and, in some instances, in the ocean.

**loess** A homogeneous, unstratified accumulation of silt-sized material deposited by the wind.

**metamorphic** Any rock derived from pre-existing rocks by mineralogical, chemical, and structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment at depth in the Earth's crust (for example, gneisses, schists, marbles, and quartzites).

**mine** A place where economically valuable minerals are extracted from the earth either as underground mines or as open pit mines. Minerals or valuable materials can include aggregate, metals, and coal.

**mineral** A naturally formed chemical element or compound having a definite chemical composition, an ordered internal arrangement of its atoms, and a characteristic crystal form and physical properties.

**nonlithified** Loose sediment that has not been converted to rock by natural geologic processes.

**ore** A mineral of economic value that can be commercially mined at a profit. Ore minerals include galena and sphalerite.

**palisades** A picturesque extended rock cliff or line of bold cliffs rising precipitously from the margin of a stream or lake.

**peneplain** A land surface of regional scope worn down by erosion to a nearly flat or broadly undulating plain.

**period** An interval of geologic time; a division of an era (for example, Cambrian, Jurassic, and Tertiary).

**quarry** A mine that is usually open (not underground) and the source of aggregate, rock, and sand and gravel. Quarries often appear as large holes in the earth with steep cliffs on all sides.

**relief** (a) A term used loosely for the actual physical shape, configuration, or general unevenness of a part of Earth's surface, considered with reference to variations of height and slope or to irregularities of the land surface; the elevations or differences in elevation, considered collectively, of a land surface (frequently confused with topography). (b) The vertical difference in elevation between the hilltops or mountain summits and the lowlands or valleys of a given regional extent. Formed in places where the forces of plate tectonics are beginning to split a continent (for example, East African Rift Valley).

**rift** (a) A narrow cleft, fissure, or other opening in rock made by cracking or splitting; (b) a long, narrow continental trough that is bounded by normal faults—a graben of regional extent.

**sediment** Solid fragmental matter, either inorganic or organic, that originates from weathering of rocks and is transported and deposited by air, water, or ice or that is accumulated by other natural agents, such as chemical precipitation from solution or secretion from organisms. When deposited, sediment generally forms layers of loose, unconsolidated material (for example, sand, gravel, silt, mud, till, loess, and alluvium).

**sedimentary** A rock resulting from the consolidation of loose sediment that has accumulated in layers (for example, sandstone, siltstone, mudstone, and limestone).

**silt** A rock fragment or detrital particle smaller than a very fine sand grain and larger than coarse clay, having a diameter in the range of 4 to 62 microns; the upper size limit is approximately the smallest size that can be distinguished with the unaided eye.

**sinkhole** Any closed depression in the land surface formed as a result of the collapse of the underlying soil or bedrock into a cavity. Sinkholes are common in areas where bedrock is near the surface and susceptible to dissolution by infiltrating surface water. Sinkhole is synonymous with "doline," a term used extensively in Europe. The essential component of a hydrologically active sinkhole is a drain that allows any water that flows into the sinkhole to flow out the bottom into an underground conduit.

**sphalerite** A mineral made up of zinc sulfide that is a major source of zinc. Sphalerite can be black, brown, red, green, or yellow and is often referred to by miners as black jack.

**stage, substage** Geologic time-rock units; the strata formed during an age or subage, respectively. Generally applied to glacial episodes (for example, Woodfordian Substage of the Wisconsinan Stage.

**stratigraphy** The study, definition, and description of major and minor natural divisions of rocks, particularly the study of their form, arrangement, geographic distribution, chronologic succession, naming or classification, correlation, and mutual relationships of rock strata.

**sucker holes** Holes found in mining areas of northwestern Illinois that were dug by early miners (Illinois settlers were referred to as suckers in the 19th century, and Illinois was referred to as The Sucker State) as a means of accessing shallow ore minerals along crevice-filling ore deposits in areas with shallow soils.

**syncline** A convex-downward fold in which the strata have been bent to form a trough; the strata on either side of the core of the trough are inclined in opposite directions toward the axis of the fold; the core area of the fold contains the youngest rocks (*see also* anticline).

**system** A fundamental geologic time–rock unit of worldwide significance; the strata of a system are those deposited during a period of geologic time (for example, rocks formed during the Pennsylvanian Period are included in the Pennsylvanian System).

**tectonic** Pertaining to the global forces that cause folding and faulting of the Earth's crust; also used to classify or describe features or structures formed by the action of those forces.

**tectonics** The branch of geology dealing with the broad architecture of the upper (outer) part of Earth; that is, the major structural or deformational features, their origins, historical evolution, and relations to each other. It is similar to structural geology but generally deals with larger features, such as whole mountain ranges or continents.

**terrace** An abandoned floodplain formed when a stream flowed at a level above the level of its present channel and floodplain.

**till** Nonlithified, nonsorted, unstratified drift deposited by and underneath a glacier and consisting of a heterogeneous mixture of different sizes and kinds of rock fragments.

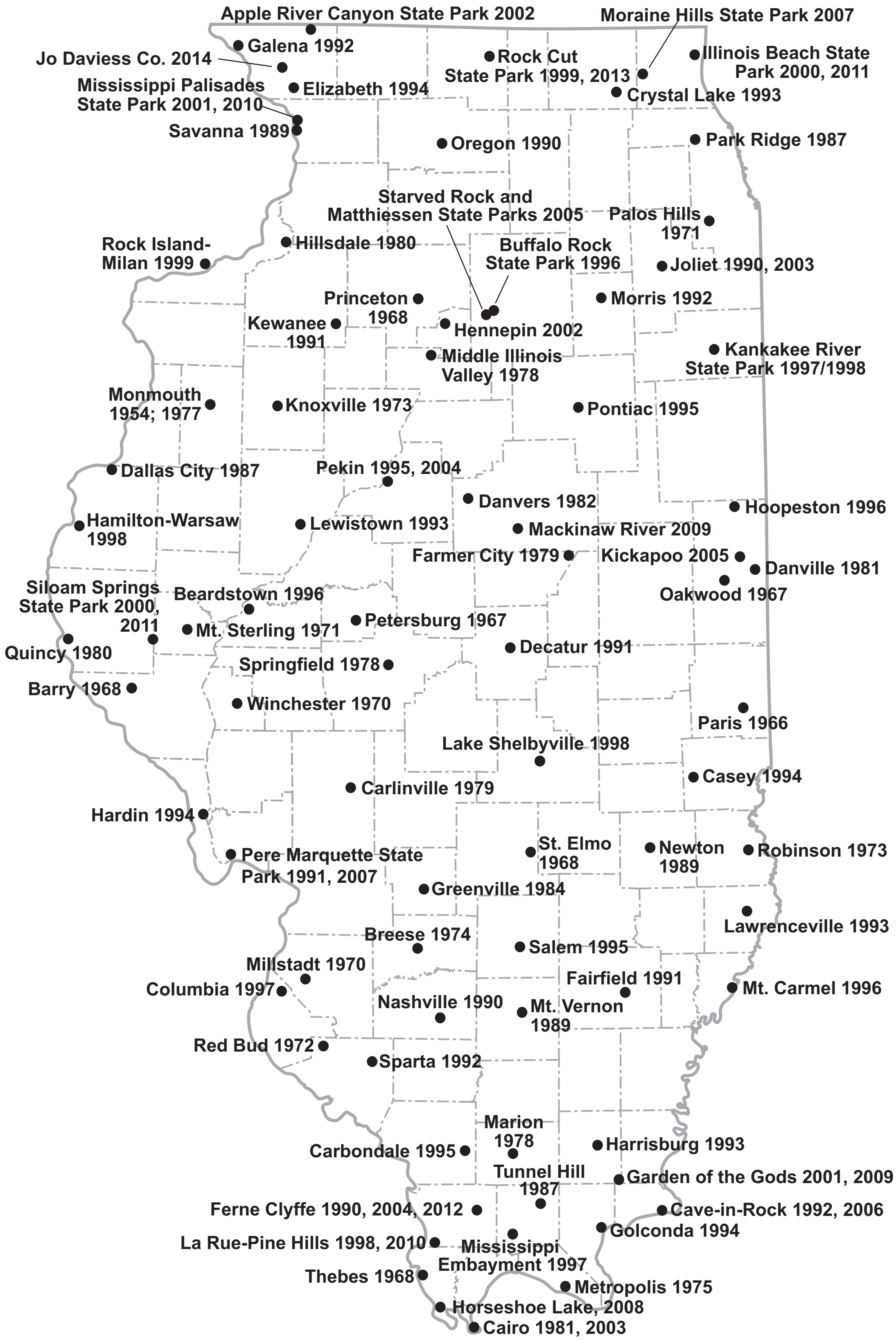
**topography** The natural or physical surface features of a region, considered collectively as to form; the features revealed by the contour lines of a map.

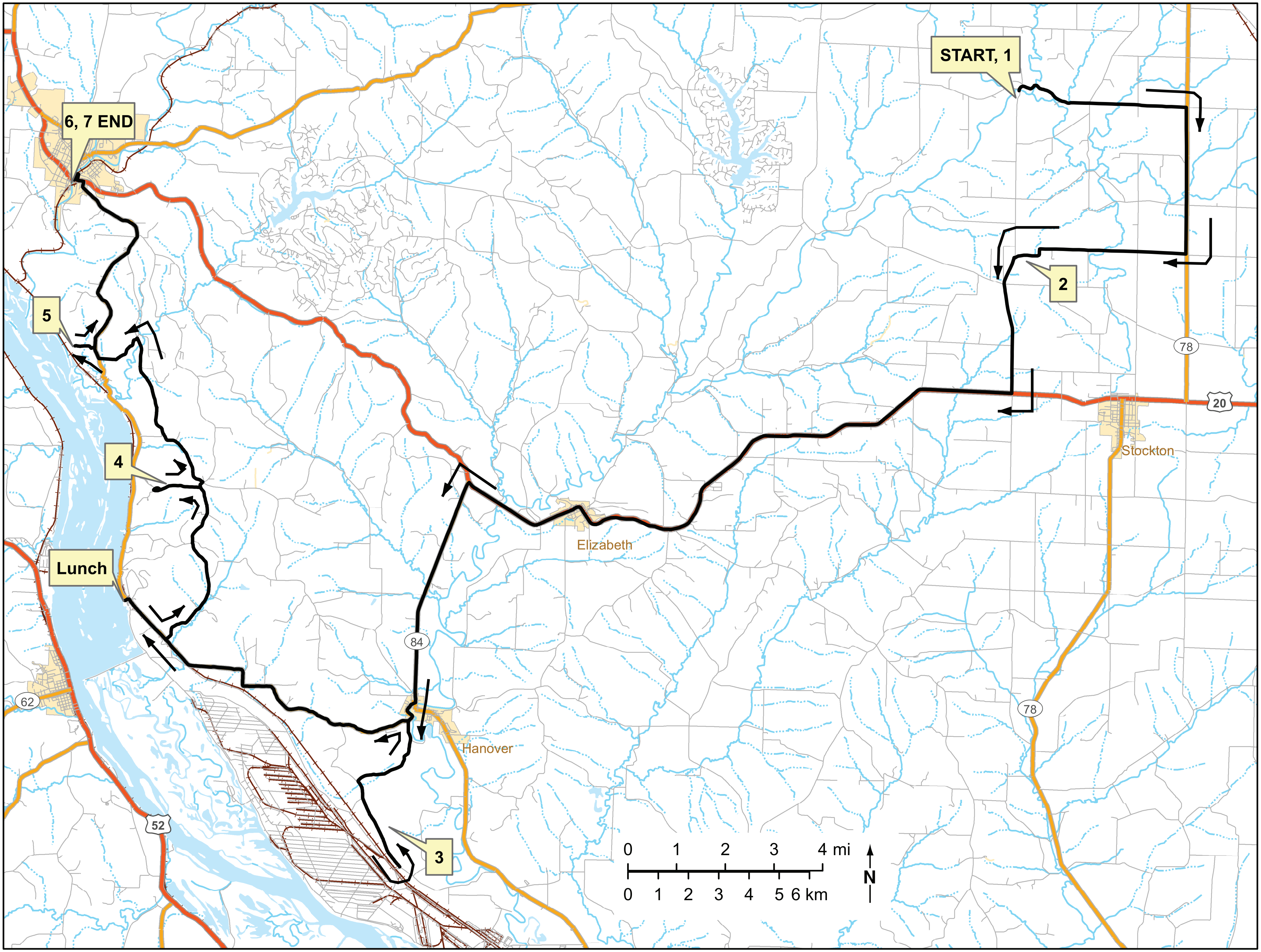
**unconformity** A substantial break or gap in the geologic record where a rock unit is overlain by another that is not next in stratigraphic succession.

**water table** The point in a well or opening in the Earth where groundwater begins. It generally marks the top of the zone where the pores in the surrounding rocks are fully saturated with water.

**weathering** The group of processes, both chemical and physical, whereby rocks on exposure to the weather change in character and decay and finally crumble to soil.

# ISGS Field Trip Guidebooks




START, 1
2
3
4
5
6, 7 END
Lunch
Stockton
Elizabeth
Hanover
78
20
84
62
52
0 1 2 3 4 mi
0 1 2 3 4 5 6 km
N