# GEOLOGY OF THE BLOOMFIELD QUADRANGLE Johnson County, Illinois

W. John Nelson

Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

BULLETIN 99 1993

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Morris W. Leighton, Chief
Natural Resources Building
615 East Peabody Drive
Champaign, Illinois 61820-6964

***Cover photo*** *Lower part of the Hardinsburg Sandstone shows coarsening upward interval of silty shale and thin bedded sandstone. Cave Creek, NE SE SW, Section 14, T13S, R3E.*

*Graphic Artist — M. Knapp*
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# CONTENTS

## Figures



## Table



## Plate



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Thanks are owed to numerous landowners who granted me permission to map on their property in the Bloomfield Quadrangle. Special appreciation is owed to Warden Larry Mizell and Lt. Carlos Kerley, who accompanied me while I was mapping on the grounds of the Vienna Correctional Center. ISGS reviewers Istvan Barany, Heinz H. Damberger, Joseph A. Devera, and C. Pius Weibel, and USGS reviewer Charles L. Rice offered helpful comments on the manuscript and map of the quadrangle. This project was supported, in part, by the U.S. Geological Survey through the Cooperative Geologic Mapping Program.

## ABSTRACT

The Bloomfield Quadrangle in extreme southern Illinois is underlain by bedrock of Chesterian (late Mississippian) and Morrowan (early Pennsylvanian) age. Chesterian strata are assigned to the Pope Group, an interval of limestone and shale alternating with sandstone and shale formations. Pennsylvanian strata belong to the Caseyville and Tradewater Formations and consist mainly of sandstone and lesser amounts of siltstone, shale, and thin coal beds.

Major structures in the quadrangle are the McCormick Anticline and associated faults, and the Little Cache and Wartrace Fault Zones. The anticline is a thrust-fold structure detached within the Paleozoic sedimentary section. Thrusting and folding were induced by compressive block uplift along the Lusk Creek Fault Zone southeast of the study area. A later episode of extension induced normal faulting along the McCormick Anticline and Little Cache and Wartrace Fault Zones. Ten sharp-crested, outcrop-scale anticlines in the southern part of the quadrangle may be recent pop-up features. More likely, they developed during the episode of compression responsible for the McCormick Anticline.

No oil, gas, coal, or other minerals have been produced in the study area. Prospects for future development appear slight. Limestone from the Kinkaid, Menard, Glen Dean, and Golconda Formations may be suitable for aggregate, agricultural lime, road rock, and other uses.

# INTRODUCTION

## Location and Accessibility

The Bloomfield Quadrangle is located in southernmost Illinois, approximately 20 miles south of Marion and 110 miles southeast of St. Louis, Missouri (fig. 1). Other nearby cities are Paducah, Kentucky, 25 miles to the southeast; Cape Girardeau, Missouri, 40 miles to the west; and Evansville, Indiana, 80 miles to the northeast.

Paved highways provide ready access to the study area. Interstate highway 24 (I-24) crosses the southwest quarter of the quadrangle and U.S. highway 45 (US 45) crosses the northwest quarter (fig. 2). Illinois route 146 runs east-west across the southern part of the area and Illinois route 147 extends northeast-southwest through the central portion. The Ganntown road south of Wartrace (a village named for an Indian war path [Sneed 1977]), and the Tunnel Hill road west of Simpson also have hard surfaces. Other roads in the quadrangle have gravel surfaces. Few points in the study area are farther than 1 mile from an all-

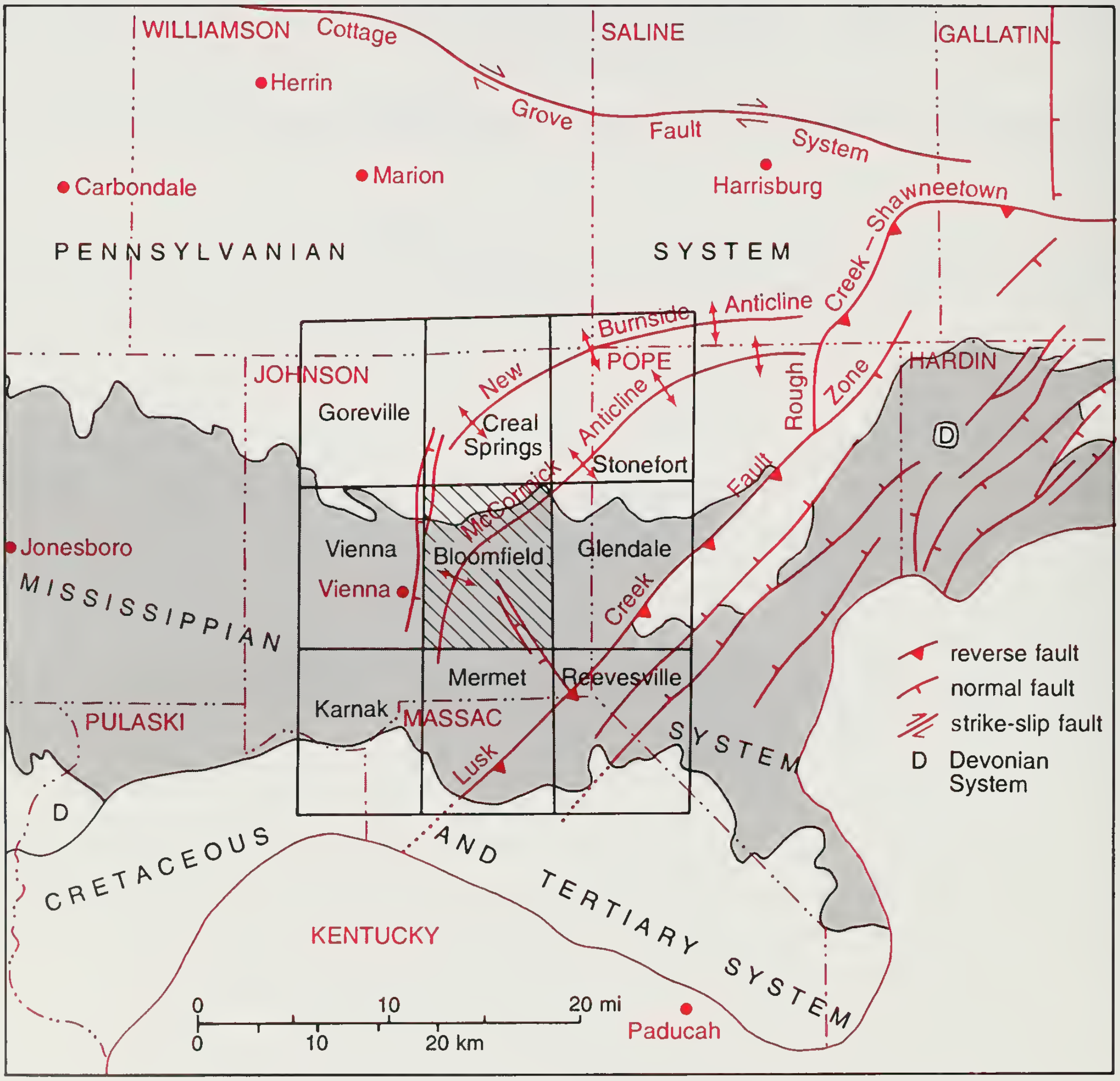


**Figure 1** Geologic setting of the Bloomfield Quadrangle. Surrounding 7.5-minute quadrangles and most recent geologic maps are as follows: Goreville (Jacobson 1991), Creal Springs (Trask and Jacobson 1989), Stonefort (Nelson and Lumm 1990; report by Nelson et al. 1991), Vienna (Dial 1963), Glendale (Devera 1991), Karnak (Weller and Krey 1939), Mermet (Weller and Krey 1939), Reevesville (Gause 1966). Geology was generalized and modified from Willman and others (1967).

weather road. The relatively remote northern portion of the area, located in the Shawnee National Forest, is served by well maintained foot trails.

Most land in the Bloomfield Quadrangle is privately owned. Several tracts in the northern part of the area belong to the U.S. Forest Service, which publishes maps showing its landholdings and trails. A prison farm operated by the Illinois Department of Corrections occupies several square miles in the east-central part of the quadrangle. The boundaries of the prison farm are indicated on the topographic map. These boundaries are neither fenced nor routinely patrolled; however, permission should be obtained from the warden before entering prison grounds.

## Climate, Topography, and Land Use

The climate of southern Illinois is warm and temperate. Average temperatures at New Burnside, Johnson County, are 35°F in January to 79°F in July. Average rainfall is 45 inches per year. The driest time of the year is late summer to early fall, and the wettest period is spring. Snowfall averages 14 inches per year (Fehrenbacker and Walker 1964).

The map area lies within the Shawnee Hills section of the Interior Low Plateaus physiographic province (Horberg 1950). Bedrock structure is the primary determinant of landforms. The northern one-quarter of the quadrangle is underlain by rock of Pennsylvanian age (Nelson 1992), which includes thick and well indurated sandstones that produce rugged topography. Local relief is more than 250 feet in several places. The Battery Rock Sandstone, near the base of the Pennsylvanian, forms vertical cliffs as high as 70 or 80 feet at Taylor Bluff and along Max Creek. The area of Pennsylvanian bedrock is largely wooded, although gently sloping uplands have been cleared for pasture. South of the Battery Rock escarpment is a gently to moderately rolling region underlain by less resistant shale, shaley sandstone, and limestone of Mississippian age. Elevations here are lower and local relief is generally 100 to 150 feet. The larger streams have aggraded and form broad, commonly swampy alluvial flats. Mississippian sandstones cap subtle plateaus and cuestas. Most upland surfaces and large areas of the bottomlands have

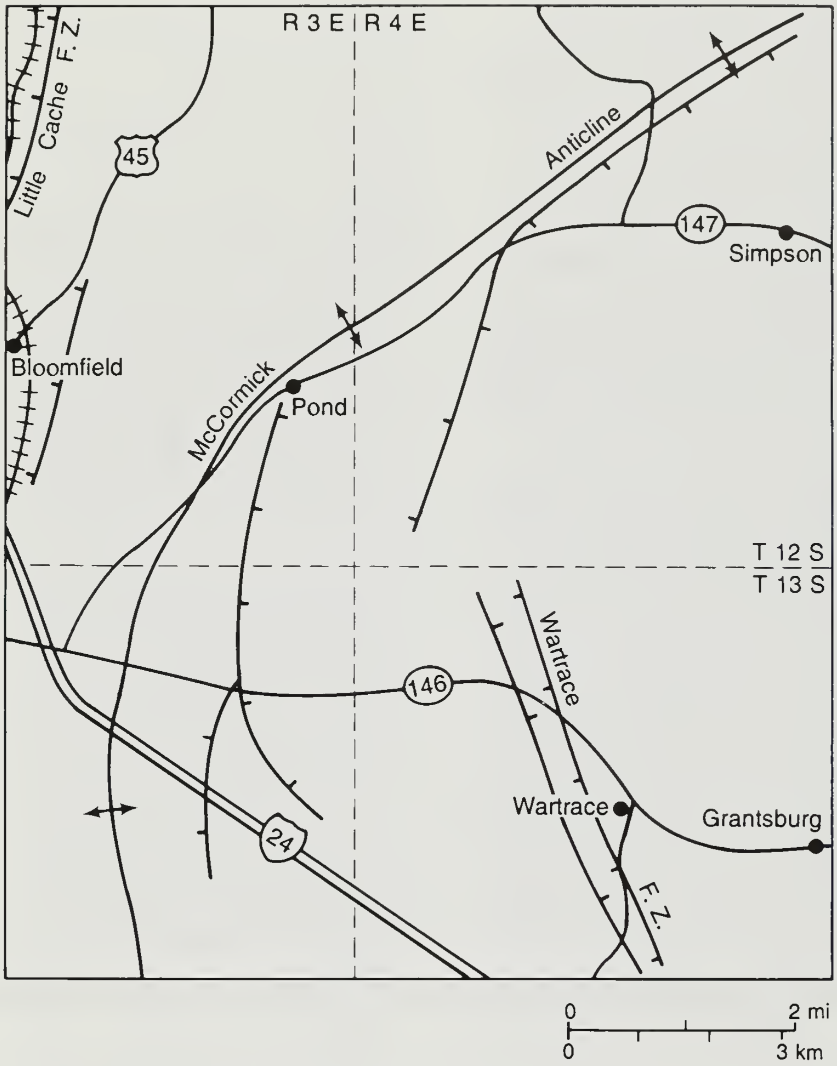


**Figure 2** Major highways and structural features of the Bloomfield Quadrangle.

been cleared for agriculture, thus only the hillsides and ravines remain wooded.

The Bloomfield Quadrangle is entirely rural. Cattle raising is the primary agricultural activity; some corn and other crops are grown. Oak, hickory, and other hardwoods are logged extensively. The villages of Bloomfield, Simpson, Grantsburg, Wartrace, and Pond all contain fewer than 100 people. The Johnson county seat is at Vienna (population 1,420) about 1 mile west of the study area.

## Geologic Setting

The Bloomfield Quadrangle lies on the southern margin of the Illinois Basin, east of the Ozark Dome (fig. 1). Bedrock strata in the quadrangle dip regionally northward at a little more than 1°. The regional dip reflects post-Pennsylvanian tectonic uplift centered southwest of the study area.

East of the quadrangle lies the complexly faulted Illinois-Kentucky fluorspar district with its dominantly high angle, normal, reverse, and oblique-slip faults that strike northeast. Northwest of the fluorspar district, the McCormick and New Burnside Anticlnes also strike northeast (figs. 1 and 2). The southwestern part of the McCormick Anticline crosses the Bloomfield Quadrangle.

Weakly lithified Cretaceous and early Tertiary sedimentary rocks overlap Paleozoic strata in the Mississippi Embayment south of the study area.

## Method of Study

The Bloomfield Quadrangle was mapped from October 1986 through March 1988. The area northwest of

US 45 was mapped by C. Pius Weibel, and the eastern edge of the study area was mapped in company with Joseph A. Devera, who concurrently mapped the adjacent Glendale Quadrangle (Devera 1991). We mapped the Bloomfield primarily to trace the continuation of the McCormick Anticline from adjacent quadrangles mapped under the Cooperative Geologic Mapping Program (COGEOMAP) of the Illinois State Geological Survey (ISGS) and the U.S. Geological Survey (USGS).

Bedrock exposures in southern Illinois are largely confined to stream beds, ravines, and artificial exposures such as roadcuts. Sandstones, and in some places, limestones form ledges and cliffs on steep slopes. Vegetation can be a serious hindrance to mapping; some ravines are so densely overgrown with brambles and vines as to be nearly impassable. This is particularly true for the recently logged areas that were frequently encountered in the Bloomfield Quadrangle. Mapping took place during late fall, winter, and early spring to minimize interference from vegetation. Aerial photos have proven to be of little use in geologic mapping of this region. Photos were mainly taken in the summer to study agricultural patterns, and they reveal little information about bedrock.

Mapping consisted of exploring all likely areas of outcrops and plotting information on USGS topographic base maps. Field notes are available for examination in the ISGS library. The notes are keyed to locations on a topographic base map also available for examination.

All well logs from the public records of the ISGS for the area were also examined. Wells in the Bloomfield Quadrangle are largely water wells and shallow engineering borings, and their logs are poor in quality. Better quality well records, including geophysical logs and sample studies performed by geologists, exist for wells in neighboring quadrangles. About 30 rock specimens were collected during mapping, and 30 thin sections were prepared for petrographic study. Palynological study of coal samples for correlation was conducted by Russel A. Peppers (unpublished ISGS data, 1988). Some invertebrate fossils from the Bloomfield Quadrangle were identified by Devera. William A. DiMichele of the U.S. National Museum collected and identified plant fossils at two localities.

## Previous Studies

S. Weller and Krey (1939) made a "preliminary" geologic map of a portion of southern Illinois including the Bloomfield Quadrangle. Their map was published on a planimetric (rather than a topographic) base at a scale of 1:62,500. Weller and Krey distinguished Mississippian formations but did not subdivide Pennsylvanian strata. J. Weller (1940) made a structure-contour map (scale 1:125,000) of extreme southern Illinois. Both reports describe stratigraphy and structural features of the region.

A master's thesis by Knight (1968) includes a geologic map of the Bloomfield Quadrangle at a scale of 1:24,000 on topographic base. The accompanying text describes stratigraphy, paleontology, and structure. Knight presented exhaustive faunal lists, including all species identified by himself and previous workers.

Maps and reports that pertain to quadrangles surrounding the Bloomfield Quadrangle are designated in figure 1.

# STRATIGRAPHY

## DEVONIAN SYSTEM

Devonian strata in the Bloomfield Quadrangle are known only from the log of the Comanche Oil Corporation 1-C Branham Community well, drilled in 1975 to a total depth of 3,175 feet in the NE NW NW, Section 21, T13S, R4E, near the south edge of the quadrangle. The Branham well is the deepest test hole to date in the quadrangle and the only well that reached strata below the Pope Group (Mississippian). A gamma ray-neutron log and lithologic description of cuttings from selected intervals are available for this dry oil-test hole (ISGS Geologic Records Unit). I examined the well cuttings for the interval from 100 to 905 feet (ISGS Geologic Samples Library).

The deepest strata penetrated in the Branham well were about 95 feet of white to light gray limestone containing abundant chert, tentatively assigned to the Lower Devonian Clear Creek Formation. Overlying the Clear Creek(?) is a 90-foot interval of white to brown, medium to coarse grained limestone that contains clean, well rounded sand at the base. These strata probably represent the Middle Devonian Grand Tower Limestone with its basal Dutch Creek Sandstone Member.

Overlying the Grand Tower is 250 feet of shale referable to the New Albany Shale. The New Albany is characteristically composed of olive gray to black fissile shale; regionally it ranges in age from late Middle Devonian through early Kinderhookian (Mississippian) (Cluff et al. 1981).

## MISSISSIPPIAN SYSTEM

The oldest stratum of definite Mississippian age in the Branham well is the Chouteau Limestone, which is approximately 5 feet thick. Overlying the Chouteau is the Springville Shale, which is about 55 feet thick. The Springville in turn is overlain by a succession of carbonate rock 1,915 feet thick. This interval cannot be subdivided on the basis of the log of the Branham well, but logs of wells in adjacent quadrangles indicate that the Fort Payne (oldest), Ullin, Salem, St. Louis, and Ste. Genevieve Formations are present.

### Pope Group

The name Pope Group is applied here to the succession of carbonate and siliclastic formations that occur in the upper part of the Mississippian System in the study area. The Pope Group contrasts lithologically with underlying Mississippian carbonate rocks and overlying Pennsylvanian siliciclastic rocks.

The name Pope originated as Pope Megagroup in Swann and Willman (1961) and has been revised to Pope Group by Nelson (in preparation). The Pope Group corresponds with rocks previously called Chester Group or Chester Series. The name Pope was introduced to distinguish the lithostratigraphic unit from the chronostratigraphic unit, Chesterian Series.

### Lower part of Pope Group

The portion of the Pope Group below the Golconda Formation does not crop out in the Bloomfield Quadrangle, but it was penetrated in the Branham well. In this well, the oldest unit is the Aux Vases Sandstone, a 20-foot interval of light greenish gray, calcareous, glauconitic siltstone to very fine sandstone interbedded with sandy limestone. Above the Aux Vases is a 130-foot interval of limestone (fossiliferous lime mudstone to skeletal grainstone) with interbeds of variegated claystone and siltstone. This interval represents the Renault and Downeys Bluff Limestones. Next above is 255 feet of dominantly sandstone strata assigned to the West Baden Sandstone (undifferentiated Bethel and Cypress Sandstones); the sandstone is white to light gray, very fine to medium grained quartz arenite containing thin interbeds or laminae of silty shale and siltstone. Fragments of coal and shale containing plant fossils were logged near the top of the West Baden interval.

**Golconda Formation** The oldest rocks exposed in the Bloomfield Quadrangle are interbedded limestones and shales assigned to the Golconda Formation (plate 1). The formation was named by Ulrich (in Butts 1917) for the town of Golconda in Pope County, Illinois. The Golconda has retained the rank of formation in western Kentucky. In Illinois, it was elevated to a group containing the Haney Limestone, Fraileys Shale, and Beech Creek Limestone as formations (McFarlan et al. 1955, Swann 1963). The Haney, Fraileys, and Beech Creek have not met the test of mappability anywhere in southern Illinois; therefore, the revision of the Golconda back to a formation has been proposed (Nelson, in prep.) for Illinois. In the Bloomfield Quadrangle, lithologies typical of the Haney and Fraileys Member are present, but the two units cannot be delineated separately. The Golconda has thus been mapped as a single unit at the rank of formation.

The Golconda crops out along Cave Creek in Sections 14 and 23, T13S, R3E, and is projected to occur beneath colluvium in a small area along the ravine at the southwest corner of the quadrangle. Along Cave Creek, the Golconda is 150 to 160 feet thick, although the lower 30 to 40 feet is not exposed within the Bloomfield Quadrangle. The contact of the Golconda with the underlying Cypress Formation was observed along Cave Creek a short distance south of the quadrangle boundary. The log of the Branham well indicates the Golconda to be about 180 feet thick. Records of wells a few miles north of the Bloomfield Quadrangle show an average thickness of 175 feet.

Outcrops and well records show the Golconda to be composed of interbedded limestone and shale in this area. The proportion of shale is greatest in the lower part of the formation and decreases upward. The Beech Creek, Fraileys, and Haney Members can be identified with difficulty, if at all. A limestone bed 5 to 10 feet thick at the base of the Golconda is commonly identified on well logs as the "Barlow lime." Although it is commonly asserted that the "Barlow" in the Bloomfield area is correlative with the type Beech Creek Limestone of Greene County, Indiana, the correlation has not been demonstrated. This limestone does not crop out, and it is not present in the Branham well.

The lower part of the Golconda is poorly exposed and commonly erodes to deeply gullied slopes. This lower unit is probably the Fraileys Shale Member. Small outcrops and float of dark gray and greenish gray clay-shale containing siderite nodules were observed west of Cave Creek at the south edge of the quadrangle. Well logs indicate similar shale containing thin interbeds of limestone in the lower Golconda elsewhere in the Bloomfield Quadrangle. Cuttings from this interval in the Branham well are dark olive gray, fissile clay shale that is calcareous near the top and contains siderite nodules.

The upper part of the Golconda, the Haney Member, is composed of limestone that contains interbeds of shale. Good exposures of these strata are present along the bed of Cave Creek and on adjacent hillsides. The limestone is mostly light to medium gray and brownish gray, coarse grained, crinoidal grainstone and packstone. Darker gray wackestone and fossiliferous lime mudstone are less common. Fossils are abundant, including brachiopods, *Archimedes sp.* and other fenestrate bryozoans, the blastoid *Pentremites sp.*, horn corals, algal structures, and echinoderm fragments. Limestone beds are typically a few inches thick and separated by wavy shale partings. Some limestone beds are partly silicified, and chert nodules are present. Intervals of limestone 5 to 15 feet thick are separated by intervals of shale a few inches to several feet thick. The shale is greenish gray to olive gray, soft, and slightly fissile, partly silty, and commonly calcareous.

According to J. Weller and Sutton (1940), the following fossils are confined to the Golconda: the bryozoan *Archimedes lativolvis*, the blastoid *Pentremites obesus*, the brachiopod *Rhyncopora perryensis*, and the crinoid *Pterotocrinus capitalis*. Knight (1968), however, identified *P. capitalis* in the younger Glen Dean as well as in the Golconda in the Bloomfield Quadrangle.

The contact of the Golconda with the underlying Cypress Formation, as exposed south of the Bloomfield Quadrangle and indicated on well logs, is sharp or gradational and appears to be conformable.

## Hardinsburg Sandstone

Named for a locality in Breckinridge County, Kentucky (Butts 1917), the Hardinsburg Sandstone crops out along Cave Creek and adjacent drainages along the southern border of the study area. It is a moderately resistant unit that forms a cuesta with a north-facing dip slope. It is well exposed along ravines and forms discontinuous ledges on hillsides.

The Hardinsburg appears to be about 100 feet thick on the outcrop, although the upper contact cannot be accurately located. In the Branham well, the Hardinsburg is 92 feet thick. Regionally the Hardinsburg thickens eastward and thins northward and westward. It is 40 to 80 feet thick in the Vienna Quadrangle to the west (Dial 1963), 95 to 120 feet in the Glendale Quadrangle to the east (Devera 1991), and 120 to 150 feet in the Reevesville Quadrangle to the southeast (Gause 1966). Several records from wells in the Creal Springs Quadrangle, north of the Bloomfield Quadrangle, show the Hardinsburg to be only about 40 feet thick and largely composed of shale.

In the Bloomfield Quadrangle, the Hardinsburg is principally composed of sandstone with interbeds of siltstone and silty shale. The sandstone is light gray to light brown, weathering to yellowish gray. It is very fine to fine grained, well sorted, and well indurated quartz arenite. In thin sections, it is composed of 95% or more of clear, mostly subrounded quartz grains. Beds vary from less than 1 inch to about 2 feet thick, but most are less than 6 inches. Interference ripples are prevalent. Current ripples are less common, and their indicated paleocurrents differ from one bed to the next. In some cases, paleocurrent trends differ by 180° in adjacent beds. A few horizontal burrows were noted. Siltstone and silty shale occur as wavy partings in sandstone and as discrete beds up to several feet thick. These rocks are medium to dark gray and greenish gray, and they display horizontal and ripple laminations. Laminae and lenses of sandstone and ball-and-pillow structures are common in shaley intervals of the Hardinsburg.

In general, the lower part of the Hardinsburg consists of shale and siltstone that grades upward to an interval of irregular thin to thick bedded sandstone containing shale and siltstone interbeds (fig. 3). The upper Hardinsburg is dominantly thin bedded sandstone that grades upward to shale of the overlying Glen Dean.

The only fossil that I observed in the Hardinsburg was a stigmarian root cast in a piece of sandstone float along a hillside just south of the quadrangle boundary in the NE SW NE, Section 22, T13S, R3E. Knight (1968) reported impressions of *Lepidodendron* trunks in the Hardinsburg. Fragmentary plant fossils and coal particles were logged in cuttings from the upper Hardinsburg in the Branham well.

The Hardinsburg-Golconda contact occurs within a covered interval a few feet thick. Knight (1968), who evidently observed exposures now covered, stated that this contact is sharp and disconformable.

**Glen Dean Limestone** The Glen Dean is a unit of interbedded limestone and shale that takes its name from a locality in Breckinridge County, Kentucky (Butts 1917). The main outcrop belt of this formation runs eastward from the southwest corner of the Bloomfield Quadrangle to the valleys of Mill Creek and Johnson Creek. Inliers of the Glen Dean occur in ravines east of the fault in Sections 10 and 15, T13S, R3E. Three small inliers of Glen Dean were mapped along the fault that runs southward from Pond toward Cave Creek.

The Glen Dean underlies the lower slopes of hills capped by the resistant Tar Springs Sandstone. Exposures of the lower part of the Glen Dean are few and fragmentary. Limestone of the upper Glen Dean

**Figure 3** Lower part of the Hardinsburg Sandstone shows coarsening upward interval of silty shale and thin bedded sandstone. Cave Creek, NE SE SW, Section 14, T13S, R3E. Staff is 5 feet in length.

forms ledges in some places, especially near Mill Creek and Johnson Creek. The best exposures are at the north end of the isolated hill in the south-central part of Section 16, T13S, R4E.

The thickness of the Glen Dean is estimated to be 60 to 80 feet in the Bloomfield Quadrangle. In the Branham well, the Glen Dean is 66 feet thick; the upper part of the formation was not logged. Similar thicknesses were reported in the Vienna Quadrangle to the west (Dial 1963) and the Glendale Quadrangle on the east (Devera 1991).

The lower two-thirds of the Glen Dean is dominantly shale with some limestone interbeds. The exposed shale is medium gray to dark greenish gray, soft, silt-free, and slightly to highly fissile. Some of it is calcareous and contains faint impressions of fenestrate bryozoans. Shale of the lower Glen Dean is exposed in a gully in the SE SW NW, Section 22, T13S, R4E. Other outcrops are along a north-flowing stream just outside the study area near the center of the E1/2, Section 16, T13S, R3E. At this site, lenses and thin beds of highly fossiliferous limestone occur within greenish gray shale.

The upper 18 to 25 feet of the Glen Dean appears to be largely, if not entirely limestone. Fresh limestone is light to dark gray or brown; weathered limestone is dark gray with orange mottling. Weathered limestone tends to be rough textured and crumbles easily. The limestone is fine to very coarse (typically coarse), crinoidal grainstone. Locally, it is crossbedded. Some oolitic limestone occurs near the top of the Glen Dean. Beds are generally lenticular and 4 to 24 inches thick. In thin section, bioclasts are generally well rounded and coated with micrite; the cement is clear crystalline calcite.

The Glen Dean is highly fossiliferous. Echinoderm columnals and plates, whole *Pentremites* calices, and fenestrate and ramose bryozoans are abundant. Rugose corals and brachiopods are common. Thin sections reveal scattered ostracods and foraminifera. Guide fossils of the Glen Dean include *Archimedes laxus* and *Prismopora serratula* (bryozoans) and *Pentremites spicatus, Pterotocrinus acutus*, and *P. bifurcatus* (echinoderms) (J. Weller and Sutton 1940, Swann 1963, Gause 1966). Knight (1968) also identified *Agassizocrinus conicus, Pharocrinus sp.* and *Pterotocrinus capitalis*. The last-named species was previously thought to be confined to the Golconda Formation (J. Weller and Sutton 1940).

The contact of the Glen Dean with the Hardinsburg Sandstone is gradational through an interval of interbedded sandstone and shale several feet thick. The contact was mapped at the highest occurrence of sandstone, but it is approximately located because of poor exposures.

## Tar Springs Sandstone

Originally named by Owen in 1856, the Tar Springs Sandstone was described in greater detail by Butts in 1917. The type locality is in Breckinridge County, Kentucky.

In the Bloomfield Quadrangle, the Tar Springs caps a cuesta north of the outcrop belt of the Glen Dean. A triangular block of Tar Springs tilts westward between two faults in the western part of the study area, south of Pond. The Tar Springs is a moderately resistant unit, but it does not form ledges extensively. The best exposures are on hillsides and in deep ravines along Mill Creek and Johnson Creek. Unfortunately, much of this area is nearly inaccessible because of recent logging activities. Many small outcrops were studied in gullies east of McCorkle Creek.

Thickness of the Tar Springs, estimated from surface exposures and well logs, ranges from about 80 to 130 feet. Measurements in adjacent quadrangles are similar (Dial 1963, Devera 1991).

The composition of the Tar Springs is roughly one-half sandstone and one-half siltstone and shale. The rock types are interbedded in variable proportions and succession. Thin layers of coal are also present.

Sandstone of the Tar Springs varies from light gray to greenish gray and brown, and it weathers medium to dark gray and brown. It is dominantly very fine grained, well indurated, and quartzose. Fine grained mica is present in some beds. The Tar Springs has tabular to moderately lenticular bedding that ranges from less than 1 inch to about 4 feet thick. Most of the sandstone is thin to medium bedded and displays current ripples, interference ripples, small load casts, tool marks, and horizontal burrows. Along Mill Creek, calcareous sandstone occurs in the lower Tar Springs. In weathered exposures, most of the calcite cement has been leached, and the bedding surfaces are knobby, resembling limestone outcrops. The calcareous sandstone is ripple laminated and displays abundant horizontal burrows and trails.

**Figure 4** Tar Springs–Vienna contact along McCorkle Creek, NE NW SE, Section 3, T13S, R3E. Thin weathered coal and underclay directly underlie a basal limestone ledge of Vienna.

In thin section, sandstone of the Tar Springs is composed dominantly of subrounded to angular clear quartz sand with an argillaceous matrix and cemented by iron oxide. Pressure-welding of the quartz grains is common.

Siltstone in the Tar Springs is light to dark gray and greenish gray, and it has horizontal laminations and ripple laminations. Silty shale and clay shale are medium to dark gray and generally fissile. Shale and siltstone are commonly interlaminated with one another and with sandstone.

A thin coal bed occurs in several places at the top of the Tar Springs. The best exposure of the coal is in the northwest bank of McCorkle Creek near the center of the E1/2, Section 3, T13S, R3E (fig. 4). A thin coal in the middle of the Tar Springs is exposed in a roadcut along I-24 near the center of the NE, Section 10, of the same township. The coal is near the top of the roadcut and poorly exposed because of vegetation and slope wash.

The Tar Springs appears to contain several sequences that are upward-coarsening and several that are upward-fining; each sequence ranges from 15 to 30 feet thick. Upward-coarsening sequences are more common. They commence with basal shale or siltstone that grades upward to thin bedded shaley sandstone and then medium bedded sandstone. In upward-fining sequences, the rock types appear in reverse order. The coal in the roadcut on I-24 caps an upward-fining sequence. I was unable to trace any individual sequence from one area to another.

The only fossils that Knight (1968) and I have found in the Tar Springs are plant remains, mostly fragments, and trace fossils of unknown affinity.

The Tar Springs-Glen Dean contact is generally sharp and probably disconformable where the basal beds of the Tar Springs are sandstone. Where the basal Tar Springs is shale, the contact is gradational and mapped at the top of the highest limestone bed. An intertonguing contact was observed in the SE SW NE, Section 18, T13S, R4E. At this locality, gray to reddish gray, crinoidal grainstone is interbedded with greenish gray, bioturbated calcareous sandstone.

**Vienna Limestone** The Vienna Limestone was named by S. Weller (1920) for a town just west of the Bloomfield Quadrangle. The type section was described in a small quarry on the west side of Vienna, but the quarry has been backfilled. As originally defined by Weller, the Vienna Limestone comprised a lower member of siliceous limestone and an upper member of black, siliceous, noncalcareous shale. Swann (1963) subsequently restricted the Vienna to "a single massive unit [of limestone] or to two or three limestone beds with thin calcareous shales between them," and reassigned the overlying noncalcareous shale to the Waltersburg Formation. Swann's definition is used here because it maintains the identity of the Vienna as a calcareous interval separated from adjacent siliceous, noncalcareous formations. Some difficulty was experienced in mapping the upper contact in areas where the upper part of the Vienna consists of poorly exposed, intercalated shale and limestone. The contact is drawn with a dashed line in such areas.

The Vienna was mapped in a narrow strip on the north side of Mill Creek and also northeast of Johnson Creek near the southeast corner of the study area. It also crops out adjacent to McCorkle Creek in the west-central part of the quadrangle.

Along McCorkle Creek, both the Vienna and the overlying Waltersburg Formation are thin and poorly exposed. The two formations are combined into a single map unit in that area.

Along Mill and Johnson Creeks, the Vienna forms slopes beneath ridge-capping sandstone of the Waltersburg. The limestone crops out extensively along the ravines and locally produces small ledges. Westward, where the Waltersburg is mostly shale, the Vienna produces low, rolling topography with few outcrops. Some of the best exposures of the Vienna are the hillside directly west of Wartrace cemetery, the ravine that trends northeast from the center of Section 17, T13S, R4E, and the northwest bank of McCorkle Creek in the center of the E1/2, Section 3, T13S, R3E (figs. 4 and 5).

The thickness of the Vienna ranges from 14 to 20 feet in the western part of the quadrangle to as much as 50 feet in the southeastern part. To the west, the Vienna consists of a single limestone unit overlain by noncalcareous shale and siltstone of the Waltersburg. Eastward the lower limestone thickens and is overlain by an interval of interbedded limestone and shale included in the Vienna. The contact with the Waltersburg was drawn at the highest occurrence of limestone.

The lower part of the Vienna is composed of siliceous, cherty limestone with some partings of shale. The limestone is mostly medium dark to dark gray and bluish gray; and it weathers to mottled yellowish, brownish, and olive gray. In hand specimen, it appears to be micritic or finely granular. Bedding is hummocky and ranges from a few inches to about 1 foot thick. Echinoderm fragments, *Archimedes* and ramose bryozoans, spiriferid brachiopods, and horn corals are present. The typical Vienna Limestone is tough, dense, and difficult to break with a hammer. It is highly siliceous; the silica and carbonate material are intimately intermixed, as seen in thin section. The uppermost portion, however, tends to be lighter in color, more coarsely crystalline, and less siliceous.

The Vienna contains a greater proportion of chert than any other limestone of the Pope Group. The chert is dark bluish gray, brown, and black when fresh, but as it weathers it bleaches to nearly white, stained with orange. Chert occurs as lenses and bands commonly 4 to 6 inches thick and, in some places, up to 12 inches thick. Molds of brachiopods, crinoid columnals, and other fossils are abundant in the chert.

The distinctive residuum of the Vienna consists of orange to red clay containing angular blocks and fragments of semivitreous, porous chert. Also common is a red, yellow, orange, or brown, porous, punky, tripolitic chert. As float, the tripolitic chert is easily mistaken for sandstone, except for its lower density and the presence of molds of fossil fragments. A dark brown, tripolitic chert rind commonly forms on weathered outcrops of the limestone.

Thin sections of the Vienna limestone show that the rock is mostly fossiliferous lime mudstone or wackestone, and in some places, packstone. Bioclasts include echinoderms, bryozoans, brachiopods (including spines from productids), ostracods, and endothyrid foraminifera. Detrital quartz silt is common. Matrix and grains are partially silicified. Some slides contain abundant silt-sized rhombic, zoned crystals of dolomite. The upper, light colored limestone is slightly glauconitic, medium to very coarse grained, crinoid-bryozoan grainstone.

Exposures of the upper shaley portion of the Vienna occur in gullies in Section 17 and in the NW SW, Section 10, T13S, R4E. The interval includes dark gray, fissile, calcareous clay-shale, greenish gray, soft clay-shale and claystone, and thin beds of micritic, abundantly fossiliferous limestone. This material grades upward to noncalcareous clay-shale and silty shale assigned to the Waltersburg.

According to J. Weller and Sutton (1940), the Vienna is the oldest formation that contains the razor clam *Sulcatopinna missouriensis* (now called *Pinna missouriensis*), and the bryozoan *Batostomella nitidula* (now called *Nikiforopora nitidula*), which may not occur in younger rocks.

The contact of the Vienna with the Tar Springs is sharp, but does not appear to be erosional. Siliceous limestone of the Vienna overlies dark gray noncalcareous shale or coal of the Tar Springs.

**Waltersburg Formation** The Waltersburg Sandstone was named by S. Weller (1920), who said that it is prominently exposed along Bay Creek between the towns of Simpson and Grantsburg (eastern Bloomfield Quadrangle). The name Waltersburg was taken from a small village about 9 miles east of this quadrangle. Subsequent workers such as Swann (1963) expanded the definition of the Waltersburg to include all the noncalcareous strata between the Vienna and Menard

**Figure 5** Vienna Limestone along McCorkle Creek, SE NE, Section 3, T13S, R3E. Large chert lenses are abundant in the upper part of the exposure.

Limestones. This interval contains substantial amounts of shale and siltstone in addition to sandstone; therefore, in this study, the unit is called the Waltersburg Formation rather than the Waltersburg Sandstone.

The Waltersburg underlies a large area that surrounds the state prison buildings and extends westward between Mill and Johnson Creeks. It also occurs in a narrow strip along McCorkle Creek, where it was combined with the Vienna on the map. Near the prison the Waltersburg is 80 to 120 feet thick and contains prominent bluff-forming sandstone units. Westward the Waltersburg gradually becomes thinner, shalier, and more thinly bedded. Near McCorkle Creek, the formation is reduced to 30 or 40 feet of shale and siltstone, which is very poorly exposed. Dial (1963) reported the Waltersburg to be 30 to 40 feet thick and composed largely of shale in the Vienna Quadrangle.

The Waltersburg here contains three distinct lithofacies that intertongue laterally: (1) bluff-forming, crossbedded sandstone (shown on the geologic map), (2) thin bedded, ripple marked sandstone, and (3) shale and siltstone.

The crossbedded sandstone occurs along a west-southwest-trending belt that is approximately 1 mile wide and extends through Sections 7, 8, 9, and 10 and part of adjacent sections, T13S, R4E. The sandstone is thickest—about 50 feet—in the NW, Section 10. The sandstone is light gray when fresh and weathers to brownish gray. It is mostly very fine to fine grained but contains a little medium sand. In thin section, it is quartz arenite; 95% or more of the grains are subrounded to subangular quartz that has undergone strong pressure-solution. Other detrital grains include chert, zircon, and mica. Some of the sandstone is porous where silica overgrowths and pressure-solution features are not strongly developed.

Most beds in the crossbedded sandstone are 1 to 3 feet thick. Tabular planar, wedge planar, and trough crossbedding are conspicuous on nearly all exposures. The foreset beds consistently dip to the west, southwest, and south (fig. 6). Current ripples are fairly common and more diversely oriented. Horizontally laminated sandstone crops out along Bay Creek in the S1/2, Section 3, T13S, R4E. Contorted or slumped bedding is present at a few sites.

The thin-bedded sandstone lithofacies of the Waltersburg is light brownish gray and very fine to fine grained. A thin section showed about 85% quartz, 15% weathered orthoclase grains, and less than 1% dark opaque minerals. Bedding is regular and fairly tabular; most beds are less than 1 to 3 inches thick, but a few thick beds occur. Interference ripple marks are ubiquitous. Also common are trace fossils, mostly indistinct and unidentified trails and small horizontal and vertical burrows. Thin interbeds of gray, silty shale and siltstone occur.

Figure 6 Crossbedded Waltersburg Sandstone on the south side of a lake at Vienna State Prison, SE SW, Section 4, T13S, R4E. View looks southeast at southwest-dipping foresets.

Thin bedded sandstone is the dominant lithology of the Waltersburg in the W1/2, Section 7, T13S, R4E, and in Section 12, T13S, R3E. Eastward, it interfingers laterally with crossbedded sandstone, which it also overlaps. Thin bedded sandstone drapes across the top of a lens or tongue of crossbedded sandstone along the bluff north of Johnson Creek in the NE, Section 7.

The shale and siltstone lithofacies occurs in the lower part of the Waltersburg in the central and eastern part of the study area. In this area, dark gray, fissile clay-shale 20 to 40 feet thick underlies crossbedded sandstone. Westward along McCorkle Creek, the entire Waltersburg is shale and siltstone. The dark gray and siliceous shale weathers to silvery gray. The siltstone is olive gray, weathers to orange brown, and contains horizontal laminations and ripple marks.

Coal and carbonaceous shale, near the top of the Waltersburg, overlie the thin bedded sandstone facies. Coal crops out at two places: the north bank of Johnson Creek, SE NE NW, Section 12, T13S, R3E; and the stream junction in the NE SE NW, Section 5, T13S, R4E. The coal is less than 12 inches thick and composed of alternating vitreous and dull coal laminae and black, carbonaceous shale. Shale containing plant fossils crops out above the coal at both sites and also elsewhere, especially in a cutbank north of the stream in the SE SW NE, Section 5, T13S, R4E. Jennings (1977) described specimens of *Senftenbergia sp.*, a coenopterid fern collected from the site along Johnson Creek. He had also (Jennings 1976) described and illustrated well preserved foliage, stems, and fructifications of a lyginopterid (?) plant from the same locality. Carbonaceous shales grade upward to olive gray, soft, fissile clay-shale at all these sites. The olive gray shale in turn grades upward to interbedded greenish gray shale and thin bedded limestone of the Menard Formation.

The contact of the Waltersburg with the underlying Vienna Limestone is sharp but apparently conformable in the western part of the study area. Eastward, the downward change from noncalcareous shale and siltstone of the Waltersburg to limestone and calcareous shale of the Vienna is gradational. Whether or not the calcareous beds are a lateral facies of the noncalcareous beds was not ascertained. The Waltersburg–Vienna contact was mapped at the top of the highest limestone bed.

**Menard Limestone** The formation was named for a locality in Randolph County, Illinois, approximately 60 miles northwest of the study area (S. Weller 1913). The Menard, an interval of limestone and lesser amounts of shale, is readily traceable both in outcrop and the subsurface throughout southern Illinois.

In the Bloomfield Quadrangle, the outcrop belt of the Menard is broken up by faulting. Narrow strips of Menard are mapped northwest of McCorkle Creek and along the fault that runs southward from Pond. Broader areas of exposure occur north of Johnson Creek and adjacent to Bay Creek in the east-central part of the map area.

The Menard typically forms moderately steep slopes below ridges capped by the Palestine Sandstone. In some places the Menard itself caps hills. The thicker limestone beds form discontinuous ledges. Sinkholes and springs are common in areas underlain by the Menard.

Thickness of the Menard, as estimated from outcrops and well records, is 125 to 140 feet. Little variation in thickness was noted in adjacent quadrangles (Dial 1963, Gause 1966, Nelson et al. 1991, Devera 1991).

Swann (1963) named three limestone members in the Menard: the Walche (oldest), Scottsburg, and Allard Limestone Members. The limestone members are separated and overlain by unnamed intervals of fossiliferous shale. I was unable to identify and trace out these members in outcrops. In the Bloomfield Quadrangle, the Menard contains a thick, middle interval of dominantly limestone, and thin intervals of shale at base and top.

The lower shale, which is poorly exposed, is about 10 to 15 feet thick. Most of it is greenish gray, soft, poorly laminated, and partly calcareous. Lenses and slabby beds of limestone a few inches thick occur within the shale. The limestone is gray and weathers to yellow and orange brown; it is highly fossiliferous. Much of the limestone is a coquina of whole and broken brachiopods, echinoderms, bryozoans, corals, and other invertebrates. Among the most common fossils (which are most abundant in the Menard, although not diagnostic for that formation) are the brachiopods *Composita subquadrata* and *Spirifer increbescens.* Good localities for collecting these fossils occur along the east-flowing stream in the SE SE NE, Section 6, and the SE SW NW, Section 5, T13S, R4E.

Basal beds of the Menard, transitional to the Waltersburg Formation, are exposed in the north bank of Johnson Creek in the SE NE NW, Section 12, T13S, R3E. Thin beds of sandy limestone, calcareous siltstone, and sandstone occur within soft dark shale here. The sandstone beds are burrowed and contain molds of brachiopods and bryozoans.

The main or middle part of the Menard is mostly medium to dark gray and brownish gray limestone that weathers to mottled light gray. A few beds are slightly dolomitic and weather to yellowish gray or yellowish orange. The texture varies from dense lime mudstone to coarse grainstone, but most of the limestone is relatively fine grained, skeletal wackestone and packstone that have patches of coarse fossil fragments. Beds are irregular, knobby, and 4 to 24 inches thick. Fossils are common but generally broken and difficult to separate from the matrix. Interbedded with the limestone are partings and beds of greenish gray and olive gray, soft, calcareous shale and also dark gray, fissile shale. Shale layers range from less than 1 inch to about 6 feet thick. Chert nodules are present mainly in the upper part of the Menard.

Some of the best exposures of the middle Menard are the roadcut along entrance ramp to I-24 in the NE SW, Section 3 (fig. 7), T13S, R3E; the ravines in the SW NE, Section 32, T12S, R4E; and the southeast-facing hillside in the NE SW, Section 33 in the same township.

Most of the dense, micritic limestone occurs in the lower middle part of the Menard. It probably corresponds to the Scottsburg Member of Swann (1963), although the member is not entirely this type of limestone. In thin section, it is lime mudstone containing pellets and scattered bioclasts. In the streambed in the SE SW NW, Section 5, T13S, R4E, the unit is micritic limestone containing polygonal structures that resemble mud cracks (fig. 8). The rock is faintly laminated and the laminae probably represent diurnal tidal cycles (Joseph Devera, personal communication 1990). Another exposure of laminated lime mudstone was found upstream in the SW SE NE, Section 6. This rock has a brecciated texture; the chips of micrite are surrounded by sparry calcite.The upper part of the middle limestone interval of the Menard is mostly wackestone or packstone and some grainstone. Occasional oolites were noted. Bioclasts include echinoderms, bryozoans, brachiopods, ostracods, and foraminifera. Grains are commonly rounded, and some are thinly coated with micrite.

The upper shaley part of the Menard is 15 to 20 feet thick and consists of dark gray, soft and fissile, sideritic clay-shale with thin interbeds of coquinoid limestone (fig. 8). Overall, the lithologies and fossils resemble those of the basal Menard. Some olive gray and greenish gray claystone and soft shale are present. Near the top is calcareous siltstone that grades to the overlying Palestine Sandstone. Good places to observe and collect fossils from the upper Menard include the streambed in the NW SE NW, Section 6, T13S, R4E; the roadcuts along I-24 in the NW NW and the NW NE SW, Section 3, T13S, R3E; and the ravine southeast of the crossroad near the center of N1/2, Section 32, T12S, R4E.

*Pentremites fohsi* and *Pterotocrinus menardensis* are index fossils of the Menard Limestone (J. Weller and Sutton 1940). Other characteristic fossils, not entirely restricted to the Menard, are the brachiopods *Composita subquadrata, Spirifer increbescens, Eumetria costata,* and the razor clam *Pinna missouriensis* (J. Weller and Sutton 1940, Knight 1968).

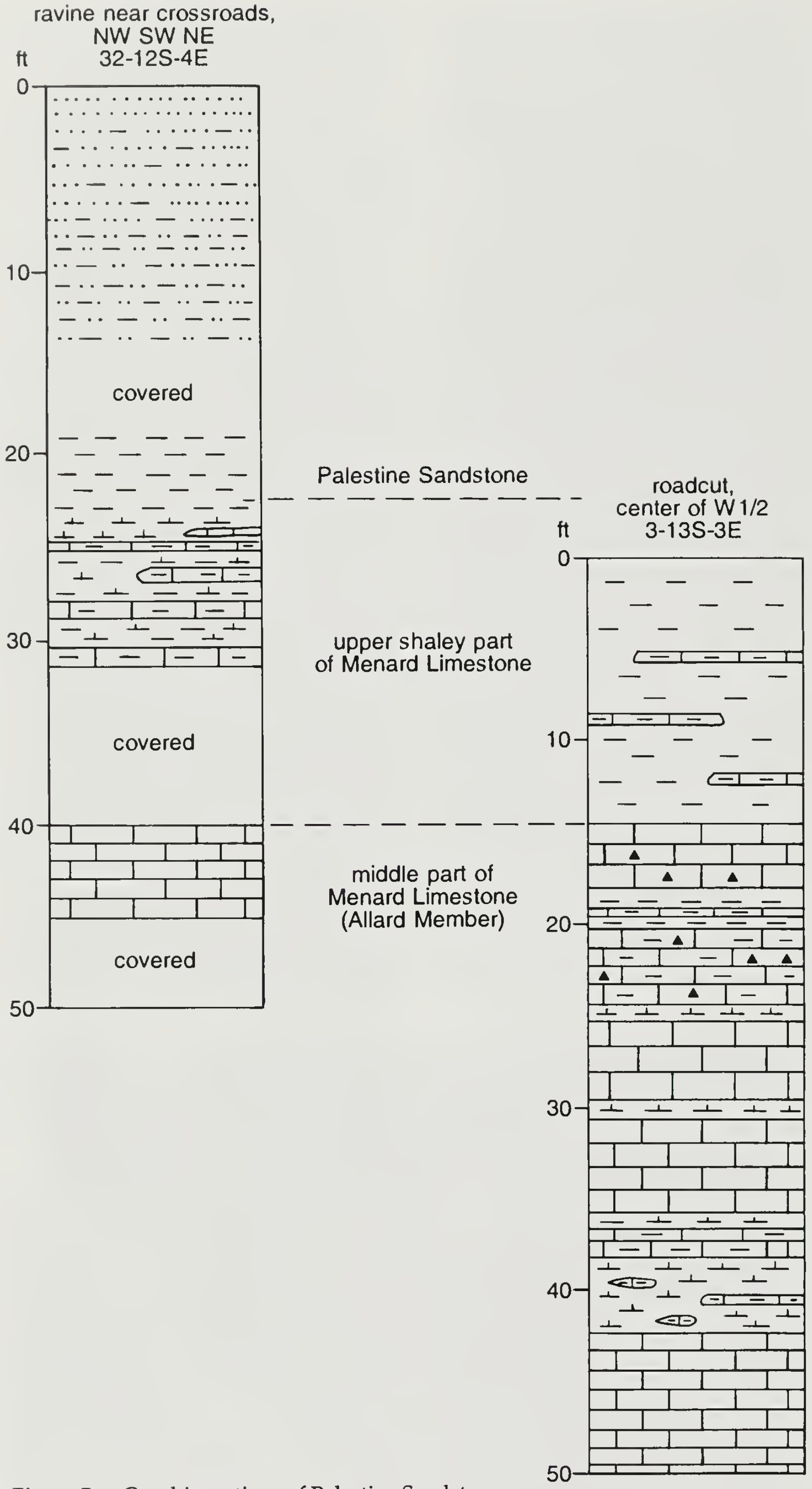


**Figure 7** Graphic sections of Palestine Sandstone and upper part of Menard Limestone.

The Menard-Waltersburg contact is poorly exposed. In the few places where it is exposed, the change from sandy beds of the Waltersburg to calcareous beds of the Menard is gradational. The contact was mapped at the base of the lowest limestone bed.

**Palestine Sandstone** Stuart Weller (1913) named the Palestine Sandstone for Palestine Township in Randolph County, Illinois. The type locality of the Palestine, located close to that of the Menard, is about 60 miles northwest of the Bloomfield Quadrangle. The Palestine is mapped as an interval of dominantly noncalcareous sandstone, siltstone, and shale between the limestones of the Menard below it and the Clore above it.

The Palestine crops out through an irregular, faulted belt that runs through the central part of the study area. Small inliers of the Palestine occur north of the main outcrop belt near Max Creek in Sections 19 and 20, T12S, R4E, and in a narrow strip along the fault in Sections 16 and 17 in the same township. The Palestine is a moderately resistant unit that forms small cuestas. Although the sandstone forms ledges near the east edge of the study area, generally the Palestine is exposed only in gullies, ravines, and locally on steep slopes.

The formation is estimated to be 40 to 60 feet thick in outcrops; it is thickest in the eastern part of the quadrangle. The log of a water well near Simpson (fig. 9) indicates nearly 100 feet of Palestine, which may have filled a channel eroded into the Menard Limestone.

In general, the Palestine in the Bloomfield Quadrangle is an upward-coarsening sequence in which silty shale or siltstone at the base grades upward to sandstone. Above the sandstone at the top of the Palestine is a thin, poorly exposed interval of shale and siltstone.

Shale of the basal Palestine is medium to dark gray, and it contains laminae, lenses, and interbeds of light gray siltstone to very fine sandstone. The sandstone is light gray and weathers brown; it is very fine grained and tends to be more micaceous than other sandstones of the Pope Group. Most beds are 1 to 6 inches thick; they are tabular to slightly lenticular and bear interference ripples, current ripples, small load casts, and tool marks. Trace fossils, consisting of sinuous trails and small horizontal burrows, are fairly common in the Palestine.

Molds of poorly preserved brachiopods (*Spirifer increbescens*, according to Knight [1968]) were observed in sandstone of the upper Palestine in a streambed in the SW NW NW, Section 6, T13S, R4E. Knight also reported calcareous shale and calcareous sandstone or sandy limestone within the upper part of the Palestine.

East of Cedar Creek in Sections 27 and 34, T12S, R4E, the Palestine

**Figure 8** Mud cracks in Menard Limestone in a stream bed, SE SW NW, Section 5, T13S, R4E.

contains thick bedded sandstone that forms cliffs up to 20 feet high. The sandstone is very fine grained, well sorted quartz arenite with no mica. Some of it is crossbedded; the foreset beds are diversely oriented. Slumped bedding also is prevalent. The lower contact is erosional in this area. On the south-facing bluff in the NW SE NE, Section 34, the Palestine rests directly on the main limestone of the Menard because the upper shaley portion of the Menard has been eroded.

A sample study of the Camp Simpson well (fig. 9) indicates nearly 50 feet of sandstone in the lower Palestine, overlain by a 50-foot interval that coarsens upward from dark gray, sideritic shale to carbonaceous sandstone. The upper shaley portion of the Menard, which is missing in this well, may have been eroded prior to deposition of the Palestine.

Knight (1968) reported that stigmarian root impressions are common near the top of the sandstone in the eastern part of the quadrangle.

Above the sandstone of the Palestine is an interval of dark gray, poorly laminated clay-shale, silty shale, and siltstone. A distinctive hard, brittle, olive gray to greenish brown siltstone occurs within this interval at several sites. Weathered surfaces of the siltstone are commonly bright red, yellow, and orange. The siltstone has very fine horizontal laminations, and it breaks into large rectangular sheets. Black carbonized plant remains, some appearing to be rootlets, are abundant in this rock. Two places to see this siltstone are the south bank of a stream in the center of the E1/2, Section 30, T12S, R4E, and along the small stream in the NE SW SE, Section 27, T12S, R3E.

In most of the study area, the Palestine–Menard contact is gradational through an interval of a few feet. Calcareous shale containing lenses and thin beds of limestone grades upward to noncalcareous shale and siltstone. The contact was mapped at the highest occurrence of calcareous shale or limestone. In the eastern part of the study area, both at the surface and in the subsurface, a sharp, disconformable contact occurs between sandstone of the Palestine above and limestone of the middle Menard.

**Clore Formation** A heterogeneous unit, the Clore Formation is composed largely of shale that contains numerous thin limestone beds and variable amounts of sandstone. The formation was named by S. Weller (1913) for Clore School in Randolph County, about 60 miles northwest of Bloomfield. Swann (1963) divided the formation into three members: Cora (oldest), Tygett Sandstone, and Ford Station Members (plate 1). All three members have been identified in the study area.

The Cora and Tygett Members were combined into a single unit when the Bloomfield Quadrangle was mapped. The top of the Tygett Sandstone is topographically prominent and easy to map; however, the Ford Station Member is poorly exposed, as is the contact to the overlying Degonia Formation. The Ford Station and Degonia were combined into a separate mapping unit.

S. Weller and Krey (1939), Dial (1963), and Knight (1968) mistook the Tygett Sandstone for the Degonia. Thus the Clore Formation, as mapped by these researchers, includes only the Cora Member. In some areas, the Ford Station Member was mapped as part of the Kinkaid Limestone, and so the Degonia Formation, which is thin and shaley here, also became part of the Kinkaid. These authors, and also J. Weller (1940), were aware of inconsistencies in their placement of the Clore, Degonia, and Kinkaid Formations.

The Clore thickens eastward from about 100 to 180 feet. These figures are uncertain because of the lack of information on placement of the upper contact. Most of the variation in thickness is attributed to changes in thickness of the Tygett Member.

*Cora Member* The Cora Member was named by Swann (1963) for the village of Cora in Jackson County, Illinois, about 50 miles west of the study area. As noted above, many previous researchers did not recognize the Tygett and Ford Station Members as belonging to the Clore. Thus, many early descriptions of lithology and paleontology of the Clore refer to the Cora Member only.

The Cora is a nonresistant unit that forms slopes below ridges capped by the Tygett Sandstone. It appears to be fairly uniform in thickness—45 to 60 feet throughout the study area, although it is as thin as 20 feet in adjacent portions of the Glendale Quadrangle (Devera 1991). The Cora consists dominantly of shale with thin interbeds of limestone. The sequence of beds appears consistent among a few complete sections (fig. 10) and numerous partial sections.

At the base of the Cora is an interval of interbedded shale and limestone. Most of the shale is dark gray, fissile, and soft. Some shale is greenish to olive gray, poorly laminated,

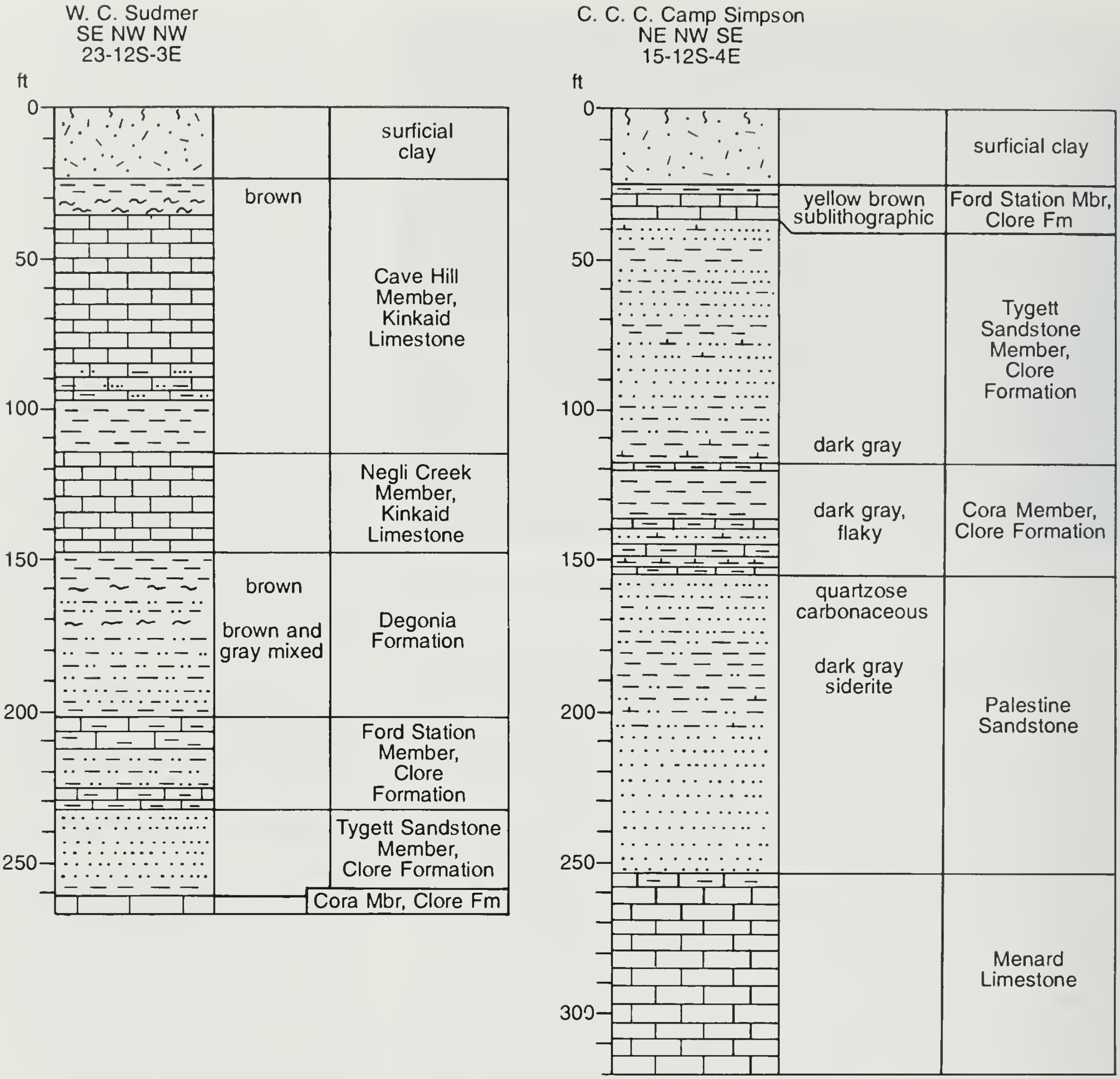


**Figure 9** Graphic logs of two water wells in the northern part of the Bloomfield Quadrangle.

soft and calcareous. The limestone is dark gray and weathers to yellowish gray, light gray, and orange; it is micritic and very argillaceous; and it occurs as nodules, lenses, and slabby beds a few inches thick. Much of it is highly fossiliferous or coquinoid, like the thin limestones of the basal and topmost portions of the Menard. Echinoderm fragments, fenestrate and ramose bryozoans, and whole and broken compositid, spiriferid, and productid brachiopods are the most common bioclasts.

Sandstone and siltstone are locally interbedded with Cora lithologies. In the ravine north of Concord Cemetery (Section 30, T12S, R4E), a 20-foot upward-coarsening interval is exposed on the hanging wall of a fault. The interval grades upward from dark gray, fissile shale at the base to thin bedded sandstone at the top. The sandstone is rooted at the top and overlain by thin, black, carbonaceous shale. Fossiliferous, nodular limestone, typical of the lower Cora, overlies and underlies the clastic interval. Placement of the Cora-Palestine contact is uncertain in the ravine in the SE SW, Section 19, T12S, R4E (fig. 10, left column). If the calcareous sandstone at the base of the section is Palestine (as it was mapped), then the Cora Member is only half its normal thickness. The sandstone may be a lentil within the lower Cora or a tongue of the Palestine.

Throughout the quadrangle, the middle portion of the Cora is almost entirely olive gray, dark gray and black, soft to moderately firm, fissile shale. A few thin coquinoid limestone beds are present.

The upper Cora is approximately half shale, like that below, and half limestone. The limestone is dark gray on fresh surfaces and weathers to light olive or yellowish gray. It is argillaceous, moderately fossiliferous, lime mudstone and wackestone that contain mainly spiriferid and

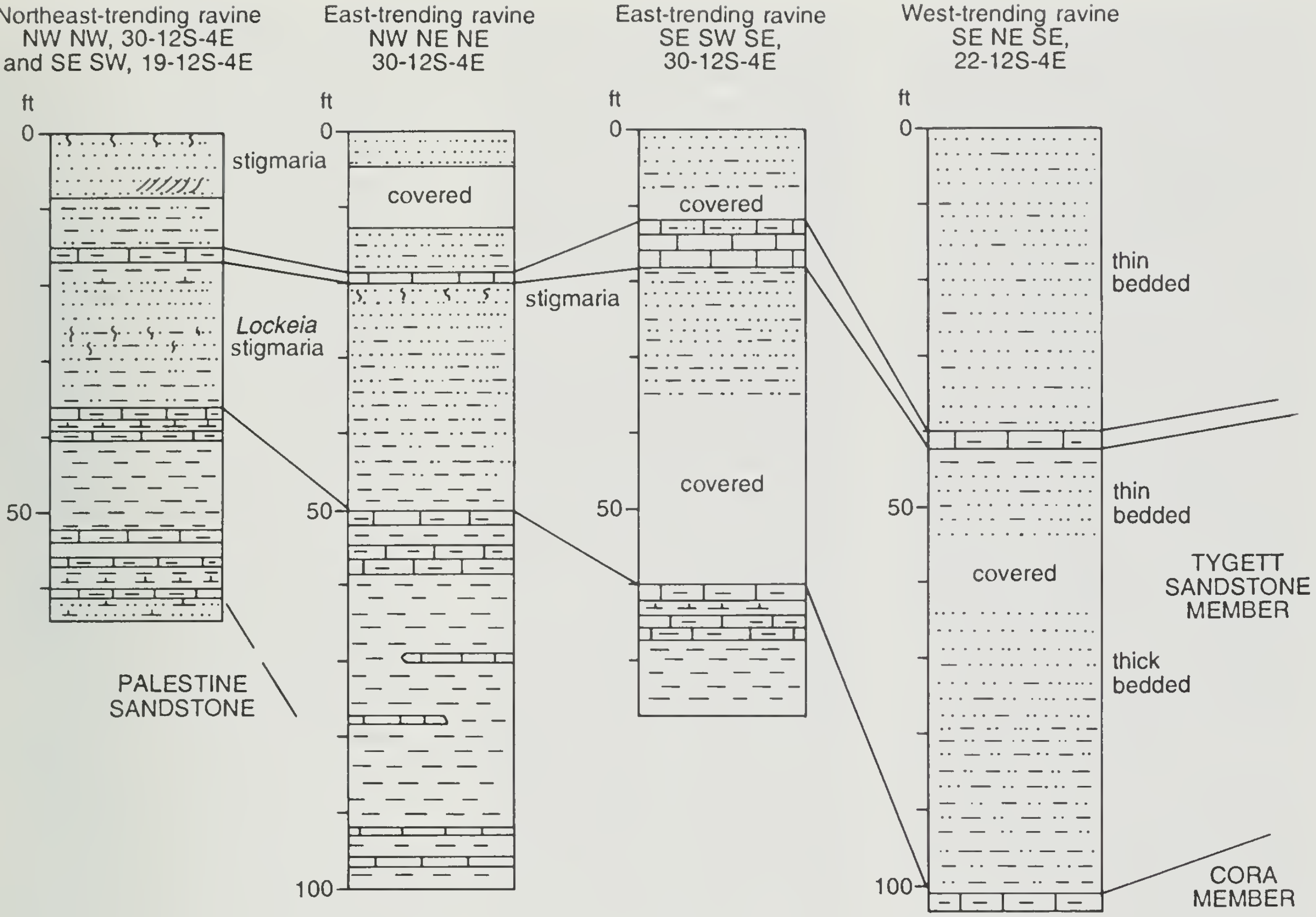


**Figure 10** Measured sections of Clore Formation.

productid brachiopods and fenestrate bryozoans. Weathering of these limestone beds produces the "hourglass" profile often cited as typical of Clore limestones. The rock tends to splinter into thin chips when struck, so that collecting large, intact specimens is rather difficult. Limestone beds of the upper Cora range up to about 5 feet thick, but they are more commonly 1 to 3 feet thick.

The bryozoan *Nikiforopora nitidula* (formerly *Batostomella*) is most typical of the Cora Member, although not confined to that unit (J. Weller and Sutton 1940). Other common fossils are *Composita subquadrata, Spirifer increbescens, Orthotetes kaskaskiensis*, and *Diaphragmus elegans* (brachiopods) as well as *Pinna missouriensis* and *Edmondia* (formerly *Allorisma*) *clavata* (pelecypods) (Knight 1968). Devera (personal communication 1989) identified *Derbyia sp., Neospirifer sp., Polypora sp., Fistulipora sp.*, and *Agassizocrinus sp.* in the Cora in the Bloomfield Quadrangle. Most of the above-named forms are common in the Menard as well as in the Clore. The Clore can be distinguished from adjacent limestones more readily by its lithology than by its fossil content.

The Cora–Palestine contact, generally gradational through an interval of a few inches, is mapped at the base of the lowest limestone bed. As noted above, limestone and shale of the lower Cora may intertongue locally with sandstone of the Palestine.

### *Tygett Sandstone Member*

Sandstone in the middle portion of the Clore Formation is assigned to the Tygett Member. The type locality of the Tygett Member is in northern Union County, Illinois, about 18 miles northwest of the Bloomfield Quadrangle (Swann 1963). The Tygett is widespread in southern Illinois, but it is variable in thickness and locally absent. It reaches its maximum thickness of up to 100 feet in the eastern Bloomfield and adjacent Glendale Quadrangles (Devera 1991), where it forms a prominent cuesta and stands in cliffs 20 to 30 feet high in some places. It rapidly thins westward in the Bloomfield Quadrangle and is as thin as 15 feet near Little Cache Creek.

In the central and eastern parts of the study area, the Tygett contains two intervals of sandstone separated by a thin unit of limestone. The Tygett also contains a thin middle limestone in parts of these quadrangles: Glendale (Devera 1991), Waltersburg (Weibel et al. 1991), Lick Creek (Weibel and Nelson, in preparation), and Makanda (Jacobson and Weibel, in preparation). Well logs from boreholes north of the Bloomfield Quadrangle also show the middle unit.

In his description of the type section, Swann (1963) identified the Tygett as an interval of sandstone 21 feet 3 inches thick. Overlying the sandstone is 3 feet of argillaceous limestone, succeeded by an 11-foot interval that coarsens upward from shale to very fine calcareous siltstone. Swann assigned the 3-foot limestone and overlying rocks to the Ford Station Member. It is likely that these rocks are equivalent to the upper part of the Tygett, as I mapped it. Mapping in progress (Jacobson and Weibel, in preparation) should resolve the correlation from the Bloomfield Quadrangle to the Tygett type section. In this report, the name Tygett is applied to the portion of the Clore Formation that is dominantly siliciclastic rock with limestone a minor constituent.

The lithologic sequence of the Tygett is illustrated by a series of measured sections (fig. 10). Both the upper and lower siliciclastic units typically coarsen upward from shale at the base to sandstone at the top. Stigmarian root casts are common at the top of the lower sandstone. Devera (1991) reported coal above the lower sandstone in the Glendale Quadrangle. On the east side of the Cedar Creek in Section 22, T12S, R4E, the lower sandstone becomes thick bedded and forms ledges and small cliffs. Crossbedding indicates a southward to southeastward paleocurrent. The upper sandstone is dominantly thin bedded east of Cedar Creek. To the west, the upper sandstone becomes a thick bedded cliff-former, as shown in exposures north of Max Creek in Sections 20 and 21, T12S, R4E. The middle Tygett limestone was not observed in this area. The upper sandstone north of Max Creek displays massive bedding, slumped bedding, and planar crossbedding. The dip of foreset beds indicates a dominantly southward to southeastward paleocurrent.

Several excellent exposures of Tygett occur in ravines west of Max Creek in Sections 19 and 30, T12S, R4E. In this area, both upper and lower siliciclastic units are about equally thick; the sandstones are largely thin bedded (fig. 10). Both sandstones are commonly burrowed. The trace fossil *Lockeia*, a bivalve resting trace, and *Rhizocorallium*, a U-shaped tube, have been found within the rooted portion of the lower Tygett sandstone (Joseph A. Devera, personal communication 1989). Farther west, only one siliciclastic unit occurs in the Tygett. Whether it is the upper or lower unit of the eastern area could not be determined.

Separating the two sandstones of the Tygett is an interval of limestone and shale 1 to 10 feet thick (fig. 10). The interval consists of either a single bed of limestone or two limestone beds separated by shale. Limestone beds are as thick as 6 feet and lithologically resemble limestone of the upper part of the Cora Member. Shale in this interval is dark gray, soft, and fissile clay-shale. Generally, there is either one bed of limestone, or two beds separated by shale.

The Tygett-Cora contact, where exposed, is sharp but conformable. Dark gray, noncalcareous shale of the Tygett overlies the uppermost limestone bed of the Cora.

***Ford Station Member*** Swann (1963) named the Ford Station Member of the Clore Formation for a locality in Randolph County, Illinois, about 60 miles northwest of the study area. The Ford Station is a poorly exposed succession of limestone and shale. Its thickness is estimated to be about 30 feet in the Bloomfield Quadrangle.

At or near the base of the Ford Station Member is a bed of limestone that thickens westward from about 2 to 10 feet. It is light to dark gray (mostly dark gray) when fresh and weathers to a yellowish gray or olive gray mottled with orange. The rock is dense lime mudstone and skeletal wackestone. This limestone is less argillaceous than limestone of the Cora and does not exhibit "hourglass" weathering. Whole and broken specimens of *Archimedes*, *Prismopora*, *Pentremites*, horn corals, and various brachiopods as well as echinoderm fragments are present. The limestone is sandy near the base and grades downward into calcareous sandstone at the top of the Tygett Member. Good exposures of the limestone are found along the abandoned railroad grade 1/4 mile north of Simpson, in several ravines near Casey Spring (Section 26, T12S, R3E), and in a railroad cut along the Conrail tracks 1/2 mile south of Bloomfield.

A similar limestone bed occurs at the base of the Ford Station Member in northern Union and southern Jackson Counties as far as 35 miles west of the Bloomfield Quadrangle. A limestone bed at this position also is indicated on geophysical logs of oil test wells north of the outcrop in the same area. This is probably the continuous marker bed informally called the "orange bed" because of the orange mottling it exhibits on weathered surfaces. Swann (1963) described a 4-foot-thick, light gray, massive limestone bed above the second of two sandstone intervals at the type locality of the Tygett Member. If this is the orange bed, as appears probable, then the sandstone below, which Swann assigned to the Ford Station Member, corresponds with the upper Tygett sandstone.

The Ford Station above the orange limestone bed in the Bloomfield Quadrangle is largely composed of dark gray, greenish gray, and olive gray clay-shale and silty shale. Thin interbeds of dark gray, micritic, argillaceous limestone occur within the shales. One of the few places to observe these strata lies north of Simpson in a railroad cut that is badly slumped and overgrown. A much fresher and nearly complete exposure of the Ford Station is in a railroad cut at Robbs, about 3 miles east of the study area.

The only area where the Ford Station-Tygett contact is well exposed is along north-trending ravines near Casey Spring in the E1/2, Section 26, T12S, R3E. Here the contact grades through an interval of several feet of sandy limestone and calcareous sandstone. Elsewhere, the contact is mapped at the highest occurrence of sandstone in the Tygett. The top of the sandstone generally marks a break in slope from gently rolling topography above to moderately steep slopes below.

**Degonia Formation** The Degonia Sandstone was named by S. Weller (1920) for Degonia Township in northwestern Jackson County, about 50 miles northwest of Bloomfield. In the type area, the Degonia is largely sandstone, but here it is mainly shale and called the Degonia Formation.

The formation in the study area is a nonresistant unit that forms low rolling topography. Exposures are mostly fragmentary and confined to streambanks and a few gullies, ditches, and one railroad cut at Bloomfield. The Degonia was combined with the Ford Station Member of the Clore in mapping. S. Weller and Krey (1939) and Knight (1968) largely misidentified the Tygett Sandstone as the Degonia; they mapped the true Degonia as part of the Kinkaid Limestone in some areas.

Because the Degonia is not separately mappable in the Bloomfield Quadrangle, an argument can be made for reducing its rank to member. Such a revision would entail redefining the Kinkaid or Clore Formation to include the Degonia as a member, or establishing a new formation containing the Degonia along with part or all of the Kinkaid and/or Clore Formations. Such far-reaching changes should not be made merely to accommodate problems confined to one or a few 7.5-minute quadrangles. The Degonia has been mapped as a formation in many geologic quadrangles of western Kentucky where its thickness, lithology, and quality of exposure are much the same as they are in the Bloomfield Quadrangle. The Degonia retains its lithologic identity in the Bloomfield Quadrangle; and it is readily distinguishable from adjacent units. The mapping problem is mainly due to surficial deposits that cover the lower contact.

The thickness of the Degonia here is difficult to determine; it may range from 20 to 50 feet. The Ford Station and Degonia together are roughly 50 to 80 feet thick.

The Degonia is composed of claystone, shale, siltstone, and very fine sandstone. The claystone is dark greenish gray, olive gray, and dull red. Variegated red and green claystone is characteristic of the upper Degonia here, as in much of southern Illinois (Swann 1963). A good exposure is located in a stream bank south of Illinois route 146 in the NW NE NE, Section 20, T12S, R4E. Shale in the Degonia is partly dark gray, fissile, clay-shale and partly gray and greenish gray, silty shale that is thinly laminated. Siltstone and very fine sandstone are dark greenish, bluish, and olive gray, brittle, and horizontally laminated. These rocks tend to break into large rectangular slabs bounded by joint planes. Some of the siltstone is burrowed. Degonia siltstone resembles siltstone of the upper Palestine, except for absence of plant fossils in the Degonia.

Sandstone in the railroad cut at Bloomfield is brown to olive gray, very fine, and micaceous; and it displays horizontal and ripple laminations.

No fossils, other than poorly defined trace fossils, were observed in the Degonia in the study area. The Degonia-Clore contact is concealed throughout the study area.

**Kinkaid Limestone** S. Weller (1920) named the Kinkaid Limestone for a creek in northwestern Jackson County, Illinois, near the type locality of the Degonia. Three members of the Kinkaid have been recognized in the Bloomfield Quadrangle; they are the Negli Creek Limestone (oldest), Cave Hill, and Goreville Limestone Member.

The Kinkaid crops out in a belt about 1 mile wide, extending from Bloomfield to Max Creek. East of Max Creek, a narrow, tilted strip of Kinkaid extends to the northeast corner of the study area. Several small outliers occur southeast of the main outcrop belt, and small inliers occur along the fault near Little Cache Creek. My mapping of the Kinkaid does not differ greatly from that of S. Weller and Krey (1939) and Knight (1968). The chief difference is that in the area near Casey Spring, previous researchers included the Ford Station Member of the Clore and all the Degonia Formation in the Kinkaid.

The Kinkaid generally erodes to a rolling topography with many sinkholes. Limestone units commonly form small ledges. Adjacent to cliffs of the overlying Caseyville Formation, much of the Kinkaid is covered with talus.

In this quadrangle, the Kinkaid ranges from about 90 to 150 feet thick; the variation in thickness is due to erosion of the upper part of the Kinkaid beneath the sub-Pennsylvanian unconformity.

*Negli Creek Limestone Member* Named for a locality in Indiana (Swann 1963), the Negli Creek Member is a unit of limestone consistently about 30 feet thick throughout the Bloomfield Quadrangle. It exhibits similar thickness in quadrangles north, east, and west of the study area.

Lithologically, the Negli Creek Limestone resembles the Menard Limestone except that the Negli Creek lacks shale interbeds. Fresh rock is medium to dark gray and brownish gray; it weathers to mottled light to medium gray. Most of it is lime mudstone, wackestone, or packstone containing fine to coarse bioclasts and small patches of sparry calcite. The upper beds of the Negli Creek tend to be lighter in color and include coarse grained skeletal packstone and grainstone. Limestone beds are irregular or hummocky and mostly 6 to 24 inches thick. Scattered chert lenses are present. Echinoderm fragments, bryozoans, brachiopods, and horn corals can be found, but the most diagnostic fossils are large gastropods of *Bellerophon sp.* and *Girvanella* (algal) oncoids. Both fossils occur in other limestones, but in Illinois they seem to be associated together only in the lower part of the Negli Creek (Swann 1963, Buchanan 1985).

One place to see both fossils is along the bank of the large pond in the SE SE, Section 23, T12S, R3E. Other good outcrops of Negli Creek are located in a bluff north of Max Creek in the SE NW SE, Section 18, T12S, R4E; a bluff near the northeast corner of Section 19 in the same township; and the northwest-facing hillside near Shoemaker Spring in the SE SW SW, Section 14, T12S, R3E.

The contact of the Negli Creek to claystone of the underlying Degonia is sharp and conformable.

*Cave Hill Member* The Cave Hill Member is a unit of interbedded limestone, claystone, and shale. The type section of the Cave Hill is in southeastern Saline County, Illinois, about 25 miles northeast of the present study area (Swann 1963).

The Cave Hill is 60 to 100 feet thick in the Bloomfield Quadrangle. Where the overlying Goreville Member is present, the Cave Hill is 85 to 100 feet thick; but the Goreville and upper Cave Hill were locally eroded at the sub-Pennsylvanian unconformity. The Cave Hill can be subdivided into a lower shale about 30 feet thick, a middle limestone-shale unit 50 to 60 feet thick, and an upper unit of shale, claystone, and limestone 10 to 20 feet thick where fully preserved.

The lower shale is dark greenish to bluish gray, soft, and moderately laminated. It tends to become silty and calcareous toward the top, and contains delicately preserved brachiopods and fenestrate bryozoans. Outcrops occur in gullies near the center of the SW, Section 17, T12S, R4E, and along the east-trending ravine in the center of the E1/2, Section 24, T12S, R3E.

Limestone of the middle part of the Cave Hill is medium to dark gray and generally weathers to smooth, rounded, light gray surfaces. It is largely lime mudstone that is dense and partly argillaceous. Brachiopods, bryozoans, and echinoderms are numerous. Most limestone beds are less than 12 inches thick. Interbedded with the limestone is gray, greenish gray and olive gray, calcareous, fossiliferous shale. Chert bands and lenses as thick as 12 inches occur in limestone in the lower part of the interval. The chert is nearly black on fresh exposures and weathers to yellow, orange, and white. The best outcrops of cherty limestone are in the SE, Section 24, T12S, R3E.

Some uncharacteristic lithologies occur within what is thought to be the Cave Hill Member in a gully east of Max Creek in the NW NE NE, Section 18, T12S, R4E. About 40 to 60 feet below the highest occurrence of limestone in this gully are exposures of dark gray to black, fissile clay-shale and soft, greenish gray shale or claystone. The black shale contains well preserved plant fossils, and the claystone contains what appear to be fossil roots. Directly below the claystone is a thin bed of yellow brown, shaley limestone containing abundant marine fossils and underlain in turn by soft, mottled red and gray claystone. The stratigraphic position of these rocks is uncertain because of poor exposure. They are tentatively assigned to the lower part of the Cave Hill.

The upper part of the Cave Hill comprises claystone, shale, and thin limestone beds. The shale and claystone are greenish gray, bluish gray, and reddish gray or maroon, variegated, and mottled. The limestone is yellowish gray, argillaceous to silty, nodular, and fossiliferous, and it occurs as lenses and thin beds. Variegated claystone can be seen alongside US 45 in the S1/2 SE, Section 15, T12S, R3E, and in a gully east of the road at the boundary of Sections 3 and 10, T12S, R4E.

The Cave Hill–Negli Creek contact is not exposed in the Bloomfield Quadrangle. In neighboring quadrangles, the contact is sharp and conformable (Devera 1991, Nelson et al. 1991, Weibel et al. 1991).

*Goreville Limestone Member*
The type locality of the Goreville Member is in a quarry about 6 miles west of the study area in the Vienna Quadrangle (Swann 1963), where it is about 40 feet thick. In the Bloomfield Quadrangle the Goreville is less than 20 feet thick; it is missing in places because of pre-Pennsylvanian erosion.

Scattered float and small outcrops of the Goreville Limestone were found along ravines and on the west-facing hillside in the S1/2 of Sections 13 and 14 and the NW, Section 23, T12S, R3E. Outcrops of Goreville also were noted just west of the study area along an east-flowing stream in the SE SW SE, Section 9, T12S, R3E. The Goreville consists of light to medium gray, medium to very coarse grained, crinoidal grainstone in beds 4 to 24 inches thick. This lithology is the same as that found at the type locality.

The Goreville–Cave Hill contact is not exposed in the study area; this contact is sharp and conformable in adjacent quadrangles (Devera 1991, Nelson et al. 1991, Weibel et al. 1991).

### Mississippian–Pennsylvanian Contact
The Mississippian–Pennsylvanian contact in the Bloomfield Quadrangle is unconformable, as it is elsewhere in southern Illinois (Siever 1951, Bristol and Howard 1971, Weibel and Norby 1992). Unconformity in the study area is demonstrated by the fact that basal Pennsylvanian strata variably overlie the Goreville and Cave Hill Members of the Kinkaid Limestone. Local relief on the contact is 50 to 60 feet. The Grove Church Shale Member of the Kinkaid, which locally overlies the Goreville Member in adjacent quadrangles, is absent in the Bloomfield Quadrangle. Well records for the Creal Springs Quadrangle, immediately north of the Bloomfield Quadrangle, indicate as much as 70 feet of Grove Church Member overlying about 40 feet of Goreville Member (Nelson et al. 1991). Hence, as much as 90 feet of uppermost Mississippian strata present in the Creal Springs Quadrangle is missing in the Bloomfield Quadrangle.

No cleanly exposed outcrops of the contact were found in the study area, although in several places, sandstone of the Caseyville Formation crops out within a few feet above calcareous shale and limestone of the Kinkaid. Paleokarst was observed just below the contact in a ravine located less than 1/8 mile south of the center of Section 17, T12S, R4E. The upper surface of limestone that crops out in the streambed is knobby and has about 2 feet of vertical relief. The limestone appears to have undergone dissolution. Draped over the limestone is gray sticky clay that contains fragments of Pennsylvanian sandstone and concretionary masses of dark brown ironstone.

## PENNSYLVANIAN SYSTEM

**Caseyville Formation** The Caseyville Formation takes its name from the village of Caseyville on the Ohio River in Union County, Kentucky (Owen 1856). The type section of the Caseyville, which was described by Lee (1916), lies on the Illinois side of the river opposite Caseyville and about 40 miles east of the study area. In the Bloomfield Quadrangle, the Caseyville is composed of quartz-arenitic sandstone, some of which contains quartz pebbles; it is interbedded with siltstone, shale, and thin coal. Sandstone is the predominant lithology. The unit is resistant to erosion and forms a rugged topography of deep ravines and scenic bluffs in the northern quarter of the study area.

Thickness of the Caseyville in the Bloomfield Quadrangle varies from about 150 to 280 feet. It is thinnest on the east side of Max Creek in the SE, Section 7 and the NE, Section 18, T12S, R4E, and thickest near the northwest corner of the study area. Near the northeast corner of the map area, the Caseyville is 220 to 250 feet thick.

As in neighboring quadrangles, the Caseyville here is divisible into four members. In ascending order, these are the Wayside, Battery Rock, "Drury," and Pounds Sandstone Members (plate 1). The Battery Rock and Pounds are crossbedded, massive, locally conglomeratic sandstones that form cliffs, ledges, and steep slopes. The Wayside and "Drury" Members are composed of thin bedded sandstone, siltstone, shale, and local coal that underlie valleys and gentle slopes.

*Wayside Member* The basal Wayside Member (Lamar 1925) of the Caseyville has also been called the Lusk Shale Member (J. Weller 1940, Knight 1968). The name Wayside has priority, and it is used here. In the Bloomfield Quadrangle, the Wayside is generally poorly exposed; it forms slopes that are largely concealed by talus from the cliffs of Battery Rock Sandstone above it. Exposures of the Wayside occur along Max Creek, in ravines near Little Cache Creek, and in gullies, ditches, and roadcuts elsewhere.

The Wayside Member ranges from about 30 to 100 feet thick. East of Max Creek in Sections 7 and 18, T12S, R4E, the Wayside is only 30 to 40 feet thick. The member probably is thinner than 50 feet thick along the flank of the McCormick Anticline between Max Creek and the northeast corner of the study area. Between Max Creek and US 45, the Wayside is 50 to 75 feet thick; west of US 45, it is 75 to 100 feet thick.

The Wayside consists largely of white to light gray, very fine to fine grained, thin bedded sandstone. The sandstone is very well indurated and typically a quartz arenite containing little or no mica, feldspar, or interstitial clay. Beds are flaggy and bear current ripples, interference ripples, load casts, and small-scale crossbedding. Intervals of thick bedded sandstone also are present, mainly near the base of the Wayside. The thick bedded sandstone is fine to coarse grained and contains scattered rounded granules and small pebbles of white quartz, along with fossil wood fragments.

The Wayside also includes light to dark gray massive to ripple laminated siltstone, and medium to dark gray clay-shale and silty shale. Dark gray shale is exposed in several gullies near Max Creek. Knight (1968) and James R. Jennings (personal communication 1989) reported finding plant fossils in this shale along the bank of the creek in the southern part of Section 7.

Lenses or beds of ferruginous conglomerate occur locally at or near the base of the Wayside Member. The clasts consist of ironstone fragments that are up to several inches across and intermixed with quartz pebbles. The matrix in some cases is sand cemented by limonite. In other cases, the clasts are held together by what appears to be a mixture of clay and concretionary ironstone. The true nature of this rock is problematic because most exposures are severely weathered. This type of conglomerate has not been observed in any unit other than the Wayside.

The sequence of beds in the Wayside Member is quite variable from place to place in the study area. Thick bedded, slightly pebbly sandstone occurs at or near the base of the Wayside in gullies west of Max Creek and also on the hillside west of US 45. Near Max Creek, the basal sandstone is overlain by shale, which grades upward to siltstone, then to thin bedded sandstone. In other areas, however, the Wayside grades from sandstone at the base to shale at the top. In still other areas, sandstone and shale are interbedded throughout the Wayside.

No fossils other than plant remains have been found in the Wayside in the Bloomfield Quadrangle. Indistinct trace fossils (mainly burrows) were observed in a few places, but they could not be identified. Marine fossils have been collected from this member in nearby areas (Jennings and Fraunfelter 1986, Devera 1991).

*Battery Rock Sandstone Member*
The Battery Rock Sandstone was named by Cox (1875), and its type locality is the same as that of the Caseyville Formation (Lee 1916). The Battery Rock forms a nearly continuous escarpment in the Bloomfield Quadrangle. Excellent exposures occur along the Cedar Creek, Max Creek, Taylor Bluff, and the drainages east of the fault in Section 10, T12S, R3E.

Like the Wayside Member, the Battery Rock is thinnest to the east near the McCormick Anticline, where it is 30 to 60 feet thick. Westward, it thickens to about 100 feet.

The Battery Rock is white to light gray when fresh, and it weathers to yellowish gray, or to light or medium gray. It is fine to coarse grained and contains numerous quartz pebbles up to 1 inch in diameter. These occur as lenses, and as horizontal and foreset laminae; and they are scattered throughout the rock. In general, the Battery Rock Sandstone becomes finer grained upward. Lenses of quartz pebble conglomerate and fossil logs are common near the erosional lower contact. A good exposure of a basal lag-conglomerate, containing large fossil logs and in contact with the Wayside member, is at the junction of Max Creek and a large tributary just east of the center of Section 7. In other exposures, as along Taylor Bluff, conglomerates occur at the bases of scour surfaces within the Battery Rock Sandstone.

Like other sandstones of the Caseyville Formation, the Battery Rock is a clean quartz arenite. The sand grains are subangular to rounded; the granules and pebbles are well rounded. Thin sections indicate silica overgrowths on the grains and well developed pressure-welding. Little or no argillaceous matrix is present. The weathered sandstone is commonly impregnated with iron oxide.

The dominant sedimentary structures of the Battery Rock are wedge-planar and tabular-planar crossbeds in sets as thick as 8 feet. Trough crossbedding and ripple marks are uncommon. In many exposures, the crossbedding is unidirectional; the foresets dip northwest, west, and southwest. Some bidirectional or multidirectional crossbedding was observed in a roadcut on US 45 and in bluffs along Cedar Creek (Section 3, T12S, R3E). Bidirectional crossbeds dip north and south. Foreset laminae are commonly contorted or overturned near the tops of crossbed sets. Along Cedar Creek, a few sets of foreset laminae exhibit coupling: the regular alternation of thin and thick laminae.

No animal or trace fossils were found in the Battery Rock. Plant fossils comprise logs, stems, and bark fragments.

The contact of the Battery Rock to the Wayside Member is sharp, and in places, clearly disconformable. A good exposure of the contact is at the junction of Max Creek and a large tributary east of the center of Section 7, T12S, R4E.

*"Drury" Member* The Drury Member of the Pottsville (now Caseyville) Formation was named by Lamar (1925) for Drury Creek in Jackson County, about 20 miles west of the study area. Nearly all subsequent researchers have applied the name Drury to an interval of slope-forming shale, siltstone, and sandstone lying between the younger, bluff-forming Pounds and the older, Battery Rock Sandstone Members of the Caseyville Formation. However, the relationship of the type Drury to the interval commonly called "Drury" is unclear. Mapping in progress (Jacobson and Weibel, in preparation) could resolve the matter. The "Drury" is

described as a member of the Caseyville lying below the Pounds Sandstone in this report; this usage is intended to maintain continuity with the mapping of adjacent quadrangles. Quotation marks around the name "Drury" reflect the questionable status of the unit.

The "Drury" is weakly resistant to erosion; therefore, long, continuous exposures are rare. Many small exposures of the "Drury" can be viewed along ravines tributary to Cedar, Max, and Little Cache Creeks. Several excellent exposures were found in railroad cuts and an abandoned sandstone quarry just west of the study area.

The thickness of the "Drury" is estimated to be 70 to 120 feet. No trends in thickness were discerned.

Lithology of the "Drury" Member resembles that of the Wayside Member: fine grained, quartzose, thin bedded sandstone, and gray to black siltstone and shale, mostly well laminated. Other constituents of the "Drury" include coal and lenticular, crossbedded sandstone.

Coal in the "Drury" is lenticular and occurs at several stratigraphic positions. An 18-inch coal bed crops out about 40 feet above the base of the "Drury" in the small east-trending ravine in the N1/2 NE NE, Section 9, T12S, R4E. The coal is shaley and overlies a sandstone that contains stigmarian root casts. A second rooted sandstone occurs higher in the "Drury" along the same ravine. About 1/2 mile southwest (SE SE NW, Section 9), coaly shale containing plant fossils overlies rooted claystone within 10 feet of the base of the "Drury." Knight (1968) reported a 3-inch coal, probably in the lower "Drury" Member in the NW SE NE, Section 7, in the same township. An 8-inch, shaley coal occurs near the top of the "Drury" beside the spillway of a pond in the NE NW SW, Section 10, T12S, R3E.

In adjacent quadrangles, the Gentry Coal Bed near the base of the "Drury" Member is widespread but lenticular. Local coal also occurs in the middle to upper part of the "Drury" (Nelson et al. 1991; Baxter, Potter, and Doyle 1963; and Baxter, Desborough, and Shaw 1967).

Shale containing plant fossils overlies the 18-inch coal in Section 9. The flora is dominated by *Lepidodendron*, including *L. aculeatum* and *L. mannabachense*. Pteridospem axes and *Neuralethopteris* also were identified (William A. DiMichele, personal communication 1987). The coaly shale near the center of Section 9 contains fossils of large *Calamites* stems, and the foliage, stems, and seeds of *Neuropteris*, *Sphenophyllum*, *Eusphenopteris*, and *Cordaites* (DiMichele, personal communication 1987).

The "Drury" is well exposed in railroad cuts and an abandoned sandstone quarry beside the railroad in Section 16, T12S, R3E. The upper 20 to 25 feet of the exposures consists of sandstone in beds mostly 1 to 4 inches thick, alternating with thinly laminated siltstone. Interference ripples occur throughout. Small lenses of crossbedded sandstone, the foreset beds dipping southward, occur in the rippled unit (fig. 11), which overlies a 20- to 25-foot interval of sandstone in flaggy, tabular beds 1 to 10 inches thick. The contact is erosional. This sandstone coarsens downward and grades into the Battery Rock Member.

The vertical succession of beds in the "Drury" Member is variable. Thin bedded sandstone and shale, and thick bedded sandstone seem to alternate in irregular fashion. Thin intervals of rock are separated by sharp, evidently erosional contacts. Paleocurrent directions indicated by ripple mark orientations are highly diverse within individual sandstone units. Crossbedding most commonly tends to indicate southward paleocurrents.

The contact with the Battery Rock Sandstone is typically gradational. Locally, it is sharp, but no evidence of disconformity was observed. The contact was mapped at the top of the highest ledge of thick bedded sandstone.

***Pounds Sandstone Member*** The Pounds Sandstone takes its name from Pounds Hollow in southern Gallatin County, Illinois, about 35 miles northeast of the study area (J. Weller 1940). The Pounds forms steep slopes and cliffs that are lower and more rounded than cliffs of the Battery Rock Sandstone. The subtle topographic expression of the Pounds reflects its weaker induration.

The Pounds is a quartzose, friable sandstone that is white to light gray, and weathers to yellowish gray. Although it is commonly fine grained, in some places it is coarse grained. Quartz pebbles are smaller and less numerous in the Pounds than in the Battery Rock. Some outcrops of Pounds contain no pebbles. Where pebbles are present, they tend to increase in abundance toward the base of the unit. The Pounds tends to be massive or to display irregular, thick bedding. Slumped bedding, possibly due to dewatering of sediment, is common. Crossbedding is less

**Figure 11** Sandstone in Drury Member of Caseyville Formation. Upper portion is shaley, ripple laminated sandstone; lower portion contains thicker, crossbedded sandstone. View looks west; foreset beds dip south. Locality is a railroad cut in SE SE NE, Section 16, T12S, R3E (Vienna Quadrangle).

prevalent in the Pounds than in the Battery Rock. The orientation of foreset beds is inconsistent. Near the east edge of Section 6, T12S, R4E, most of the foreset beds dip southwest. About 1/2 mile west of this point, the crossbedding indicates a southeastward paleocurrent.

The thickness of the Pounds varies from less than 10 to about 80 feet. It is very thin or absent in most of Section 8, T12S, R4E. Eastward and westward, it thickens to about 50 feet. The Pounds is thickest just east of US 45 along the north edge of the study area. The Pounds–"Drury" contact is poorly exposed. In some places, it is sharp; elsewhere it is gradational through an interval less than 10 feet thick.

**Tradewater Formation** The Tradewater Formation was named by Glenn (1912) and described in greater detail by Lee (1916). The type area of this unit is along the Tradewater River in Kentucky about 40 miles east of the Bloomfield Quadrangle. The Tradewater was recognized by many researchers in southern Illinois (including J. Weller in 1940) and by nearly all researchers in western Kentucky. Division of the Tradewater into Abbott (lower) and Spoon Formations was proposed by Kosanke et al. (1960); however, the Abbott and Spoon have proven to be impractical as mapping units outside of a small area. The usage of the Tradewater Formation as a map stratigraphic unit has thus been reinstated in southern Illinois (Jacobson 1991, Weibel et al. 1991).

The Tradewater has been mapped on north-facing dip-slopes and outlying hills along the north edge of the quadrangle. These uplands are covered with loess, so outcrops are scarce. Exposures are mainly in north-trending gullies in the eastern part of the area, and in an artificial cut and adjacent hillsides west of Little Cache Creek.

The remaining thickness of the Tradewater in the Bloomfield Quadrangle is probably less than 70 feet. In the neighboring Creal Springs Quadrangle, strata equivalent to the Tradewater are 500 feet or thicker (Trask and Jacobson 1989).

The Tradewater contains sandstone, shale, and thin coal. It is distinguished from the Caseyville primarily by the presence of substantial amounts of mica, feldspar, lithic fragments, and interstitial clay in the sandstones, and the general absence of quartz pebbles. Tradewater sandstones are more friable and less resistant to erosion. Because they contain impurities, they are generally brown rather than light gray. The best place to observe the difference between the Pounds Sandstone and an overlying basal Tradewater sandstone is along the spillway of an artificial lake in the center of the SW SW, Section 10, T12S, R3E. Here the two sandstones are separated by a 20-foot upward-fining interval of flaggy bedded sandstone, gray silty shale, gray claystone, and thin coal. The Tradewater sandstone has an erosional lower contact.

The coal in the spillway exposure is correlated with the Reynoldsburg Coal Bed on the basis of stratigraphic position and a palynological study by Russel A. Peppers (written communication 1988). Another exposure of the Reynoldsburg Coal was found along a stream bed in the SE SW SW, Section 4, T12S, R4E. About 1 1/2 miles northwest of this site is the type locality of the Reynoldsburg Coal in the Creal Springs Quadrangle (J. Weller 1940, Trask and Jacobson 1989). The Reynoldsburg in Section 4 is overlain by about 10 feet of medium to dark gray clay-shale, above which is sandstone.

The Tradewater–Caseyville contact is commonly gradational through an interval of 10 to 20 feet, from thick bedded Pounds Sandstone at the base, through thin bedded sandstone, to shale or claystone above. The contact was mapped at the top of the highest ledge of thick bedded sandstone, which corresponds with a break in slope.

# STRUCTURAL GEOLOGY

The Bloomfield Quadrangle is situated along the southern margin of the Illinois Basin and north of the head of the Mississippi Embayment (fig. 1). Near-surface strata dip regionally northward into the basin at an average rate of about 140 feet per mile (equivalent to a dip of a little more than 1°). This regional dip is interrupted by the McCormick Anticline and related faults, and by two zones of normal faulting, the Little Cache and Wartrace Fault Zones.

## McCormick Anticline and Related Faults

The McCormick Anticline extends westward from northeastern Pope County, Illinois, into Johnson County, where its axis gradually curves toward the southwest (figs. 1 and 2). From the northeast corner of the Bloomfield Quadrangle, the anticline extends southwestward to Pond, where it bends toward the south-southwest. It gradually loses expression but continues as a faulted anticlinal nose southward into the Mermet Quadrangle. Total length of the McCormick Anticline is about 28 miles.

Brokaw (1916) first used the name McCormick Anticline, but the structure is more appropriately described as a faulted anticlinorium. Along its entire length the McCormick consists of narrow, steeply plunging, en echelon anticlines and faults. Both the faults and the folds have left-stepping orientation (that is, they extend toward the left of an observer looking along the trend of the structure).

Northeast of Max Creek, the anticline is highly asymmetrical and faulted at its crest (fig. 12, section A-A′). The northwest limb is 1,500 to 2,000 feet wide, strikes N50°E and dips as steeply as 65°. Near the northeast corner of the map area, the transition from horizontal strata northwest of the anticline to dips of 45° and steeper on its flank takes place within a few yards. Toward the southwest, the change in dip becomes more gradual; dips generally increase toward the crest of the fold. Near Max Creek, the fold abruptly widens and dips diminish. The maximum structural relief is about 300 feet along Cedar Creek, 250 feet at Gilead Church, and less than 250

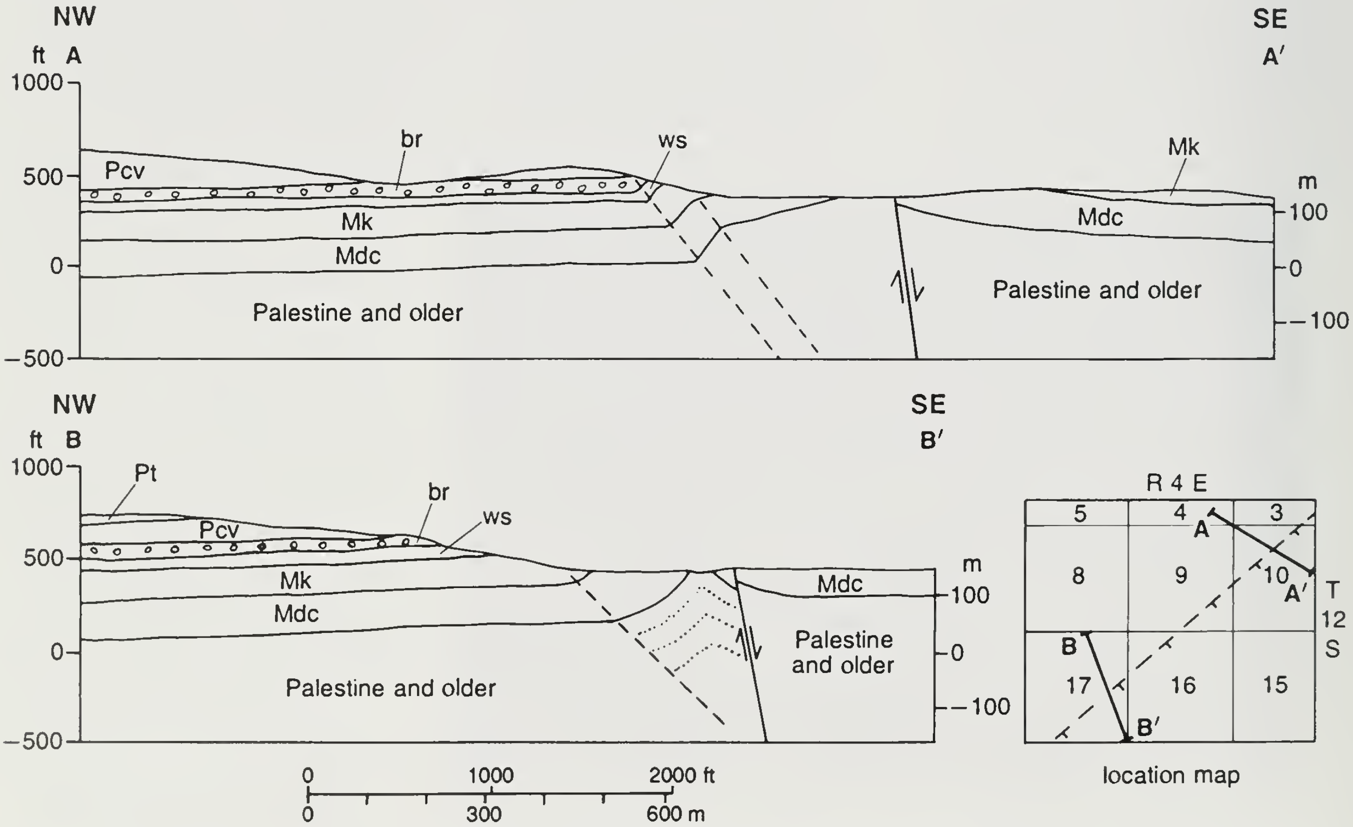


Figure 12 Cross sections of McCormick Anticline in the northeastern portion of quadrangle. Pt = Pennsylvanian, Tradewater Formation, Pcv = Caseyville Formation, br = Battery Rock Sandstone Member, ws = Wayside Member, Mk = Mississippian Kinkaid Limestone, Mdc = Degonia and Clore Formations.

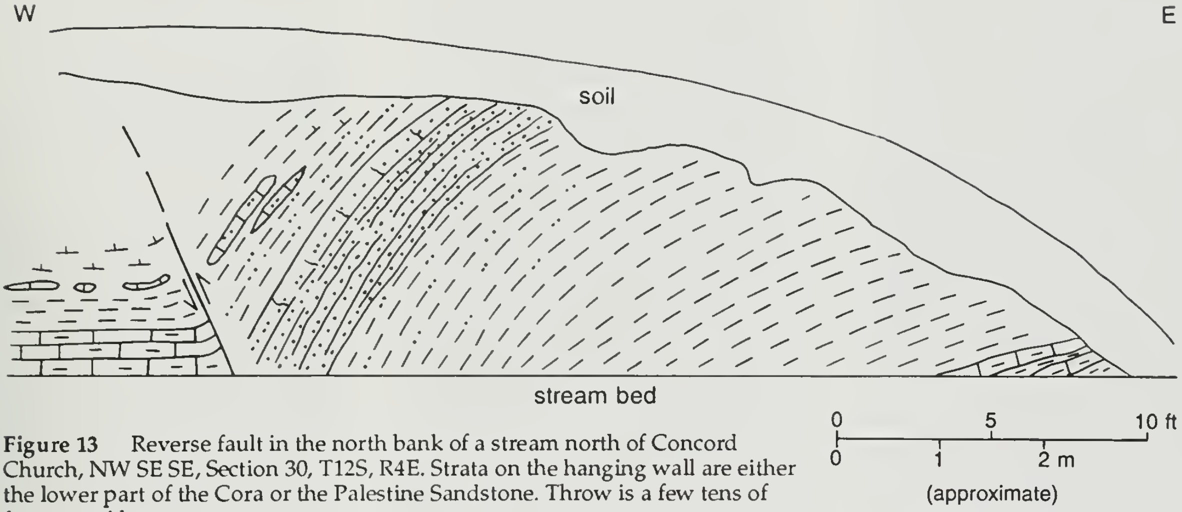


**Figure 13** Reverse fault in the north bank of a stream north of Concord Church, NW SE SE, Section 30, T12S, R4E. Strata on the hanging wall are either the lower part of the Cora or the Palestine Sandstone. Throw is a few tens of feet, east side up.

feet farther to the southwest. The fold has practically no southeast limb. Rather, the strata southeast of the fold crest have been downfaulted and tilted northward at less than 1°. Locally, moderate east or southeast dips were measured close to the fault. The fault is concealed but was inferred from stratigraphic offset. Along most of its length, it brings the Palestine Sandstone or the lower part of the Clore Formation on the northwest against the Degonia Formation on the southeast —a displacement of 100 to 150 feet down to the southeast.

The best exposure of the structure was found along a small south-flowing stream in the NE SE, Section 17, T12S, R4E. Here a nearly continuous section of Degonia, Clore, and Palestine Formations on the northwest limb dips about 45° northwest (fig. 12, section B-B′). The fold crest, in Palestine Sandstone, is a sharp hinge. The dip abruptly reverses to 40° to 45° southeast, and the sandstone is greatly fractured. The southeast limb is apparently truncated by the fault a few yards southeast of the fold axis.

As the fault crosses Illinois route 147, its trend changes from S40°W to S15°W. North of Max Creek, the southeast side is downthrown and strata near the fault are only slightly folded, which suggests high angle, normal faulting. South of Max Creek, the throw of the fault reverses; the southeast side is upthrown. The fault is exposed in the bank of the east-trending stream north of Concord Cemetery (SE SE, Section 30, T12S, R4E). It is a reverse fault that dips about 70° east (fig. 13). Palestine or basal Clore beds on the hanging wall are strongly folded and thrust over nearly horizontal beds of the upper Cora Member of the Clore Formation in the footwall. This fault continues southward at least 1/2 mile and gradually dies out.

A minor fault that strikes N25°E has been mapped in the S1/2 SW, Section 9, and the NW, Section 16, T12S, R4E. The Battery Rock Sandstone is displaced about 20 feet down to the west by the fault. Additional faults may be present along the steep northwest-dipping flank of the McCormick Anticline. Discordant dips measured in the W1/2, Section 20, T12S, R4E, strongly suggest faulting, but the attitudes and displacements of faults could not be determined.

Between Max Creek and Pond are several folds and faults en echelon. An anticline in Section 19, T12S, R4E, strikes northeast and is about 1 mile long. This anticline has dips of 15° to 25° on both flanks, and it plunges abruptly at both ends. West of the anticline are at least two northeast-trending faults that displace tilted Chesterian strata. These faults extend from the NW, Section 19, T12S, R4E, to near the center of Section 25, T12S, R4E. Overturned bedding adjacent to the southeasternmost fault suggests reverse displacement. The other faults are either reverse or normal. Strata northwest of the faults dip as steeply as 45° northwest; dips rapidly flatten away from faults.

South of Pond is a wedge-shaped block of rock partly outlined by faults. The east side of the wedge has been raised along a fault, thus tilting the wedge westward. The degree of tilting is greatest at the north tip of the wedge and decreases southward. Displacement on the east fault is as great as 300 feet near its north end. Southward, the throw decreases and the fault splits into two branches that curve southeastward and gradually die out. Another fault has been mapped south of McCorkle Creek along the west border of the tilted wedge. The attitudes of the faults are not known, but the absence of strong folding suggests normal faulting. Near the south edge of the quadrangle, the tilted wedge takes on the form of a north-trending asymmetrical anticline with dips of 5° to 6° on the west flank and 1° to 2° on the east limb.

**Interpretation** The McCormick Anticline contains elements indicative of both compression (anticlines and reverse faults) and of extension (normal faults). The en echelon arrangement of folds and faults suggests wrench faulting; however, both folds and faults exhibit the same sense of offset (left-handed) and give contrary indications as to the direction of strike-slip. Thus, compression and extension probably occurred in separate episodes of deformation. Observations along the McCormick Anticline in adjacent quadrangles and regional relationships point to an early episode of northwest-southeast compression, followed by an episode of northwest-southeast extension (Nelson et al. 1991).

A reflection seismic profile across the McCormick Anticline northeast of the study area was interpreted as showing folding and thrust faulting detached within the Paleozoic sedimentary rocks. Thrust faults flatten at depth and probably merge with bedding in shaley portions of the succession. Likely zones of decollement are the Mississippian–Devonian New Albany Shale and the upper Ordovician Maquoketa Shale. Anticlines were formed as fault-bend or fault-propagation folds overlying thrust faults that may not have extended to the surface.

Most of the deformation along the McCormick Anticline took place after the Caseyville Formation (Morrowan) was lithified. Stratigraphic relationships suggest that initial uplift of the anticline in the Bloomfield Quadrangle occurred in very late Chesterian or Morrowan time. The amount of downcutting on the sub-Pennsylvanian unconformity is greatest along the anticline. Close to the anticline, the Caseyville Formation rests on the Cave Hill Member of the Kinkaid Limestone; whereas away from the fold the Caseyville overlies the younger Goreville Member. The Wayside and Battery Rock Members of the Caseyville are thinnest near the anticline, a fact suggesting contemporaneous uplift. The younger "Drury" and Pounds Members do not thin, however, in the vicinity of the structure.

Early Pennsylvanian uplift of the McCormick Anticline northeast of the Bloomfield Quadrangle previously was proposed by Potter (1957) and Nelson et al. (1991). Evidence includes an angular unconformity between Wayside and Battery Rock Members, features suggestive of large-scale gravity sliding, and thinning of the Caseyville Formation along the crest of the fold.

The linear northwest-southeast valley segment of Max Creek in Section 19, T12S, R4E, prompts speculation. This valley segment corresponds with an en echelon offset of the McCormick Anticline. Also, the Palestine–Clore contact does not match on opposite sides of the valley. This valley possibly represents a concealed, right-lateral tear fault connecting offset segments of the McCormick Anticline. A nearly identical situation was noted in the northeast corner of the Stonefort Quadrangle, where a straight valley segment of Bill Hill Hollow connects two overlapping segments of the New Burnside Anticline (Nelson et al. 1991). The New Burnside Anticline, northwest of and parallel to the McCormick, is similar to the latter in structure; and it may share a common origin.

### Little Cache Fault Zone

Two faults along the west edge of the quadrangle, north of I-24, are part the Little Cache Fault Zone, named for Little Cache Creek (Nelson et al. 1991).

The northern fault, which passes through the western part of Sections 3, 10, and 15, T12S, R3E, offsets the Caseyville Formation and Kinkaid Limestone. The fault strikes slightly east of north, and its west side is downthrown. Throw increases from about 130 feet at the north edge of the Bloomfield Quadrangle, to about 280 feet where the fault exits the west edge of the quadrangle. Strata east of the fault dip west or northwest at 3° or less. West of the fault, the beds dip 4° to 7° west. The mapped fault forms the east edge of a graben, the west edge of which is outside the study area. The fault plane is not exposed. High angle fractures and silica veinlets occur in sandstone close to the fault in several places. Vertical (dip-slip) striations were noted on a north-trending fracture near the main fault near the center of the W1/2, Section 10.

The southern fault is entirely concealed by surficial deposits along Little Cache Creek east of Bloomfield. Evidence for this fault consists of northward offset of stratigraphic contacts east of the creek. The fault is most accurately located within the narrow valley segment in the NE SW, Section 27, T12S, R3E. The Tygett Sandstone Member of the Clore Formation crops out east of the creek; the Ford Station Member is exposed in a railroad cut west of the creek. Indicated displacement is a few tens of feet down to the west.

Good exposures of faults in the Little Cache Fault Zone occur in the Creal Springs Quadrangle (Nelson et al. 1990) and the Vienna Quadrangle (Nelson, ISGS unpublished field notes). These exposures reveal high angle, dip-slip, normal faults accompanied by narrow drag folds.

The Little Cache Fault Zone is interpreted as an extensional structure. It is nearly parallel with several of the faults along the McCormick Anticline. Probably both sets of faults developed under the same Mesozoic(?) extensional stress regime.

### Wartrace Fault Zone

The name Wartrace Fault Zone is given here to a pair of north-northwest-trending faults that form a graben near Wartrace in the southeast quarter of the quadrangle. S. Weller and Krey (1939) mapped the eastern fault of the pair and showed it extending from Section 19, T12S, R4E, to Section 35, T13S, R4E. Knight (1968) mapped the fault in nearly

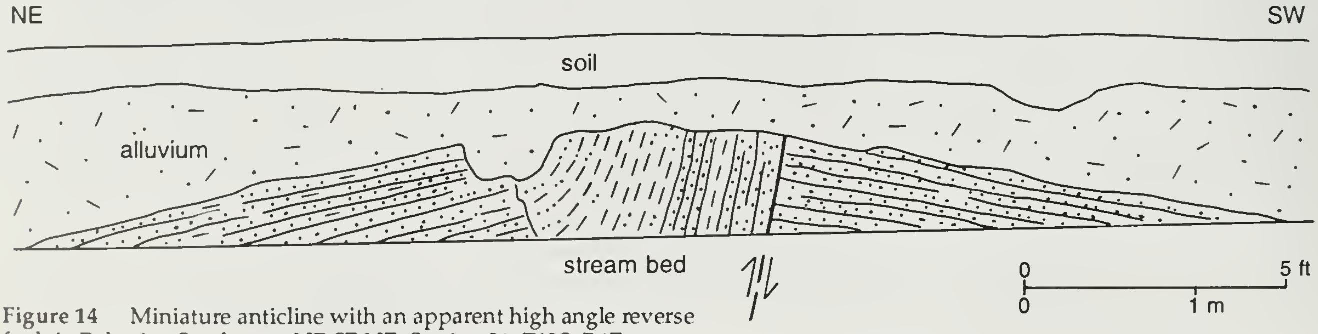


Figure 14 Miniature anticline with an apparent high angle reverse fault in Palestine Sandstone, NE SE NE, Section 31, T12S, R4E.

identical fashion in the Bloomfield Quadrangle. Neither of those authors named the fault.

The Wartrace Fault Zone comprises two faults that are essentially parallel and 900 to 1,500 feet apart. They have nearly equal displacement. Northwest of Wartrace, the central block is downdropped 100 to 150 feet. Southward, the displacement is uncertain because the central block is largely covered with alluvium, and the formations within it have not been positively identified. Faulting apparently dies out northward near the boundary of T12 and 13S, although the eastern fault continues about 3/4 mile farther north as a monocline. Strata outside the fault zone display regional, northward dip. Strata within the central block have been folded into a syncline.

Mapping of the faults is based on stratigraphic offsets; the fault surfaces are not exposed. Float of brecciated and slickensided sandstone crops out in a few places close to the fault traces. Close to the faults, strata strike parallel with faults and dip in the direction of throw, probably representing drag. The steepest dip measured was 40° along the eastern fault in Section 21, T13S, R4E. Jointing has been observed in a few localities close to the faults; joints and faults are generally parallel.

A proprietary, reflection seismic profile that was run along county roads from Wartrace to a point 4 miles south was examined. The fault zone is clearly indicated by offset reflectors. The faults are nearly vertical and appear to penetrate the entire Paleozoic sedimentary succession. Two additional vertical faults, outlining a horst, are indicated in the Mermet Quadrangle about 3 miles south of Wartrace. No faults have been mapped at the surface near the position of the horst shown on the seismic profile.

The Wartrace Fault Zone can be characterized as a zone of high angle, normal faulting. Thus, it is an extensional structure. Its strike direction is unusual, as compared to other normal faults in the area; and its role in regional tectonic history is uncertain.

## Miniature Anticlines

The term "miniature anticline" is applied here to ten small anticlines in the central and southwestern portion of the quadrangle. Characteristics of these folds have been compiled in table 1. Most of them are known from single outcrops. They are sharp chevron folds or box folds with steeply dipping to vertical limbs; several are faulted.

As shown on the table and the geologic map (Nelson 1992), most miniature anticlines are located away from major folds and faults, and they do not strike parallel with larger structures. The anticline at field station 419 is adjacent to the Wartrace Fault Zone, but its axis is inclined 50° to 60° to the large faults. Anticlines at stations 456 and 457 are nearly in line with a fault on the McCormick Anticline, but they trend nearly perpendicular to the fault and to the strike of bedding. Most miniature anticlines trend either approximately N30°E or N80°W. The significance of this observation is debatable, however, given the small size of the data set.

Three of the anticlines are faulted. The anticline at station 430 contains a northwest-dipping thrust fault that steepens upward. Anticlines at stations 456 and 457 contain south-dipping moderate to high angle, reverse faults (fig. 14). Other miniature anticlines exhibit nearly vertical bedding at their crests and may be faulted (fig. 15). Crests and the transitions from limbs to horizontal strata typically are sharp and hingelike. Some anticlines have closely spaced joints parallel to their axes and on one or both limbs.

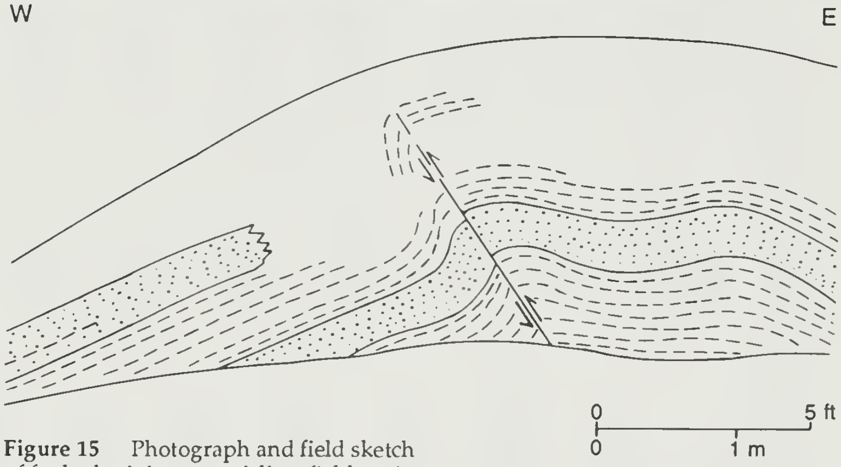


**Figure 15** Photograph and field sketch of faulted miniature anticline, field station 456, SE NE NW, Section 22, T13S, R3E.

**Table 1** Characteristics of miniature anticlines.

| Field station no. and location | Trend of axis | Dip of northern or eastern limb | Dip of western or southern limb | Width (ft) | Height (ft) | Lithology and formation | Remarks |
|---|---|---|---|---|---|---|---|
| 174 SW NE SE 25-12S-3E | N15°E | 30° | 15° | 8 | 1 | Thin bedded sandstone Tygett Member | |
| 188 NE SE NE 31-12S-4E | N60°W | 10° | 10° | 20 | 2 | Thin bedded sandstone and siltstone Palestine | Central zone faulted; vertical dips (see fig. 15) |
| 354 SE corner 11-13S-3E | N85°W | 25° | 45° | 10 | ? | Thin bedded sandstone Tar Springs | |
| 355 SW SE SE 11-13S-3E | N85°W | up to 90° | 40°–90° | 8–10 | ? | Thin bedded sandstone Tar Springs | |
| 419 SE NW NE 21-13S-4E | N30°E | 15°–90° | 15°–90° | 20+ | ? | Thin bedded sandstone Tar Springs | |
| 430 E 1/2 NE 13-13S-3E | N35°E | 10°–15° | 10°–15° | 2 | ? | Shale Tar Springs | Smooth crest, southeast-verging crest, fault at core |
| 431 SW SW NW 18-13S-4E | N25°E | 40°–90° | 30°–90° | ? | ? | Thin to medium bedded sandstone, Tar Springs | Incomplete exposures along 200 ft of ravine |
| 445 NW SW 12-13S-3E | N60°E not exposed | 30°NW | not exposed | ? | ? | Thin bedded sandstone Waltersburg | Questionable example, but beds definitely in place |
| 456 SE NE NW 22-24S-3E | N80°W | undulating | 45° | 25 | 5 | Sandstone and shale Hardinsburg | Incipient thrust fault verges south (see fig. 14) |
| 457 SE NE SW 22-13S-3E | N80°E | 0° | 35° | 5 | 3 | Medium bedded sandstone Hardinsburg | Hingelike limbs, possibly faulted |

Only in the Bloomfield and Glendale Quadrangles have miniature anticlines been observed. Devera (1991) noted three of these structures in the Glendale Quadrangle. All the known miniature anticlines are situated between the McCormick Anticline and the Lusk Creek Fault Zone.

The miniature anticlines are compressional structures that formed after the rocks were well lithified. They resemble the features called "pop-ups," described in quarries and outcrops and interpreted as products of contemporary tectonic stress. McFall et al. (1989) illustrated numerous pop-ups from southern Ontario. They are narrow, sharp-crested anticlines similar in many respects to the miniature anticlines of this report, except that in Ontario, pop-ups are preferentially oriented with their axes perpendicular to the present, major compressional stress axis. The major stress axis in southern Illinois is oriented east-west, to east-northeast to west-southwest (Nelson and Bauer 1987). None of the miniature anticlines have the expected north-south or north-northwest to south-southeast orientation of folds that are products of contemporary stress.

Accordingly, I propose that miniature anticlines occurring here are ancient tectonic structures. Supporting this view is the observation that they all occur between two major compressional structures, the McCormick Anticline and Lusk Creek Fault Zone. A negative point is that many of them are not parallel to the larger structures. Perhaps they formed at different times under different stress regimes.

## MINERAL RESOURCES

No production of metallic ores, fossil fuels, or industrial minerals is known to have occurred in the Bloomfield Quadrangle. Opportunities for future development of such resources, with the possible exception of limestone, appear remote.

One petroleum test hole has been drilled within the quadrangle: the Comanche Oil Corporation 1-C Branham Community well, located in the NE NW NW, Section 21, T13S, R4E. The well was drilled in 1975 to a total depth of 3,175 feet and finished in the Lower Devonian Clear Creek Chert. No production was achieved. The nearest oil production is in small fields near Marion, about 15 miles north of the study area. Several tests have been drilled on the McCormick Anticline northeast of the study area; all were dry.

Coal is present in the Tar Springs Sandstone, Waltersburg Formation, and "Drury" Member of Caseyville Formation. The coal beds are lenticular, shaley, and less than 18 inches thick. They have no current economic value.

The Bloomfield Quadrangle lies west of the Illinois-Kentucky fluorspar district. Prospect pits or small mines occur along the Lusk Creek Fault Zone about 5 miles east of the study area (Devera 1991). The large commercial deposits of fluorspar are farther east. No mineralization was observed during this study or reported by earlier researchers in the Bloomfield Quadrangle.

A sandstone quarry was formerly operated in the "Drury" Member of the Caseyville Formation along the railroad north of Bloomfield, immediately west of the study area. Use of the stone is uncertain; most likely it was used for fill along the railroad right-of-way.

Several formations of the Pope Group contain limestone that may be suitable for quarrying. Currently, a large quarry is active in the Kinkaid Limestone at Buncombe, 6 miles west of the report area. At Buncombe, the Negli Creek, Cave Hill, and Goreville Members all are quarried. The Goreville Member is largely eroded in the Bloomfield Quadrangle, and the Cave Hill Member contains more chert and shale here than at Buncombe. The Negli Creek Member is about 30 feet thick and contains little shale or chert, so it represents the best opportunities for quarrying. Limestone of the Kinkaid from southern Illinois has been used for road rock, aggregate, and agricultural lime. It may also be suitable for portland cement, bituminous pavement, and other uses (Lamar 1959).

The Menard, Glen Dean, and Golconda Formations also contain limestone that may be usable for certain purposes. The Menard contains an interval of dominantly limestone 100 to 110 feet thick. The limestone is commonly siliceous and contains numerous thin shale interbeds. Some of it can probably be used for road rock, aggregate, and agricultural lime (Lamar 1959). The upper 18 to 25 feet of the Glen Dean is almost entirely limestone; this rock was formerly quarried south of Vienna just west of the study area. A sample from that quarry contained about 93% carbonate (Lamar 1959). Limestone intervals 5 to 15 feet thick occur along Cave Creek in the upper part of the Golconda Formation. The extent and physical character of these limestones are not well known.

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BULLETIN 99 1993